OPERATOR ADVANCE MACHINE TOOL

NSQF LEVEL - 4

1st Year

TRADE THEORY

SECTOR : CAPITAL GOODS & MANUFACTURING

(As per revised syllabus July 2022 - 1200 Hrs)

Directorate General of Training

DIRECTORATE GENERAL OF TRAINING
MINISTRY OF SKILL DEVELOPMENT & ENTREPRENEURSHIP
GOVERNMENT OF INDIA

NATIONAL INSTRUCTIONAL MEDIA INSTITUTE, CHENNAI

Post Box No. 3142, CTI Campus, Guindy, Chennai - 600 032

Sector : **Capital Goods & Manufacturing**

Duration : **2 Years**

Trade : **Operator Advance Machine Tool - Trade Theory - 1st Year - NSQF Level - 4 (Revised 2022)**

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FOREWORD

The Government of India has set an ambitious target of imparting skills to 30 crores people, one out of every four Indians, by to help them secure jobs as part of the National Skills Development Policy. Industrial Training Institutes (ITIs) play a vital role in this process especially in terms of providing skilled manpower. Keeping this in mind, and for providing the current industry relevant skill training to Trainees, ITI syllabus has been recently updated with the help of Media Development Committee members of various stakeholders viz. Industries, Entrepreneurs, Academicians and representatives from ITIs.

The National Instructional Media Institute (NIMI), Chennai, has now come up with instructional material to suit the revised curriculum for **Operator Advance Machine Tool - Trade Theory** in **Capital Goods & Manufacturing** Sector. The NSQF Level - 4 (Revised 2022) Trade Theory will help the trainees to get an international equivalency standard where their skill proficiency and competency will be duly recognized across the globe and this will also increase the scope of recognition of prior learning. NSQF Level - 4 (Revised 2022) trainees will also get the opportunities to promote life long learning and skill development. I have no doubt that with NSQF Level - 4 (Revised 2022) the trainers and trainees of ITIs, and all stakeholders will derive maximum benefits from these Instructional Media Packages IMPs and that NIMI's effort will go a long way in improving the quality of Vocational training in the country.

The Executive Director & Staff of NIMI and members of Media Development Committee deserve appreciation for their contribution in bringing out this publication.

Jai Hind

Director General of Training
Ministry of Skill Development & Entrepreneurship,
Government of India.

New Delhi - 110 001

PREFACE

The National Instructional Media Institute (NIMI) was established in 1986 at Chennai by then Directorate General of Employment and Training (D.G.E & T), Ministry of Labour and Employment, (now under Directorate General of Training, Ministry of Skill Development and Entrepreneurship) Government of India, with technical assistance from the Govt. of Federal Republic of Germany. The prime objective of this Institute is to develop and provide instructional materials for various trades as per the prescribed syllabus under the Craftsman and Apprenticeship Training Schemes.

The instructional materials are created keeping in mind, the main objective of Vocational Training under NCVT/ NAC in India, which is to help an individual to master skills to do a job. The instructional materials are generated in the form of Instructional Media Packages (IMPs). An IMP consists of Theory book, Practical book, Test and Assignment book, Instructor Guide, Audio Visual Aid (Wall charts and Transparencies) and other support materials.

The trade practical book consists of series of exercises to be completed by the trainees in the workshop. These exercises are designed to ensure that all the skills in the prescribed syllabus are covered. The trade theory book provides related theoretical knowledge required to enable the trainee to do a job. The test and assignments will enable the instructor to give assignments for the evaluation of the performance of a trainee. The wall charts and transparencies are unique, as they not only help the instructor to effectively present a topic but also help him to assess the trainee's understanding. The instructor guide enables the instructor to plan his schedule of instruction, plan the raw material requirements, day to day lessons and demonstrations.

In order to perform the skills in a productive manner instructional videos are embedded in QR code of the exercise in this instructional material so as to integrate the skill learning with the procedural practical steps given in the exercise. The instructional videos will improve the quality of standard on practical training and will motivate the trainees to focus and perform the skill seamlessly.

IMPs also deals with the complex skills required to be developed for effective team work. Necessary care has also been taken to include important skill areas of allied trades as prescribed in the syllabus.

The availability of a complete Instructional Media Package in an institute helps both the trainer and management to impart effective training.

The IMPs are the outcome of collective efforts of the staff members of NIMI and the members of the Media Development Committees specially drawn from Public and Private sector industries, various training institutes under the Directorate General of Training (DGT), Government and Private ITIs.

NIMI would like to take this opportunity to convey sincere thanks to the Directors of Employment & Training of various State Governments, Training Departments of Industries both in the Public and Private sectors, Officers of DGT and DGT field institutes, proof readers, individual media developers and coordinators, but for whose active support NIMI would not have been able to bring out this materials.

Chennai - 600 032 **EXECUTIVE DIRECTOR**

ACKNOWLEDGEMENT

National Instructional Media Institute (NIMI) sincerely acknowledges with thanks for the co-operation and contribution extended by the following Media Developers and their sponsoring organisation to bring out this IMP **(Trade Theory)** for the trade of **Operator Advance Machine Tool 1st Year - NSQF Level - 4 (Revised 2022)** under the **CG & M** Sector for ITIs.

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NIMI records its appreciation of the Data Entry, CAD, DTP Operators for their excellent and devoted services in the process of development of this Instructional Material.

NIMI also acknowledges with thanks, the invaluable efforts rendered by all other staff who have contributed for the development of this Instructional Material.

NIMI is grateful to all others who have directly or indirectly helped in developing this IMP.

INTRODUCTION

TRADE PRACTICAL

The trade practical manual is intented to be used in workshop . It consists of a series of practical exercises to be completed by the trainees during the two years course of the **Operator Advance Machine Tool** in **Capital Goods & Manufacturing** trade supplemented and supported by instructions/ informations to assist in performing the exercises. These exercises are designed to ensure that all the skills in compliance with NSQF Level - 4 (Revised 2022).

The manual is divided into Nine modules.

Module 1	Safety
Module 2	Basic Fitting
Module 3	Basic Maintenance Skills
Module 4	Basic Turning
Module 5	Basic Milling
Module 6	Grinding
Module 7	Advanced Machining Skills Turning
Module 8	Milling
Module 9	Inspection

The skill training in the shop floor is planned through a series of practical exercises centred around some practical project. However, there are few instances where the individual exercise does not form a part of project.

While developing the practical manual a sincere effort was made to prepare each exercise which will be easy to understand and carry out even by below average trainee. However the development team accept that there is a scope for further improvement. NIMI looks forward to the suggestions from the experienced training faculty for improving the manual.

TRADE THEORY

The manual of trade theory consists of theoretical information for the two years course of the **Operator Advance Machine Tool** in **Capital Goods & Manufacturing** Trade. The contents are sequenced according to the practical exercise contained in the manual on Trade Theory. Attempt has been made to relate the theoretical aspects with the skill covered in each exercise to the extent possible. This co-relation is maintained to help the trainees to develop the perceptional capabilities for performing the skills.

The trade theory has to be taught and learnt along with the corresponding exercise contained in the manual on trade practical. The indications about the corresponding practical exercises are given in every sheet of this manual.

It will be preferable to teach/learn the trade theory connected to each exercise at least one class before performing the related skills in the shop floor. The trade theory is to be treated as an integrated part of each exercise.

The material is not for the purpose of self learning and should be considered as supplementary to class room instruction.

CONTENTS

LEARNING / ASSESSABLE OUTCOME

On completion of this book you shall be able to

Sl.No.	Learning Outcome	Exercise No.
1	Plan and organize the work to make job as per specification applying different types of basic fitting operation and check for dimensional accuracy following safety precautions. [Basic fitting operation – marking, Hack sawing, Chiseling, Filing, Drilling, Taping and Grinding etc. Accuracy: ± 0.25mm] (Mapped NOS:CSC/N0304)	1.1.01 - 1.2.72
2	Plan & perform simple repair, maintenance of different machines and check for functionality. [Different Machines – Drill Machine, Power Saw and Bench Grinder] (Mapped NOS: NOS:CSC/N0901)	1.3.73 - 1.3.76
3	Prepare different cutting tool to produce jobs to appropriate accuracy by performing different turning operations. [Different cutting tool – V tool, side cutting, parting, thread cutting (both LH & RH), Appropriate accuracy:- ±0.06mm, Different turning operation – Plain, facing, drilling, boring (counter & stepped), grooving, Parallel Turning, Step Turning, parting, chamfering, U -cut, Reaming, knurling.] (Mapped NOS: NOS:CSC/N0110)	1.4.75 - 1.4.85
4	Set the different machining parameters and cutters to prepare job by performing different milling operation and indexing. [Different machining parameters – feed, speed and depth of cut. Different milling operations – plain, face, angular, form, gang, straddle milling] (Mapped NOS: CSC/N0108)	1.5.86 - 1.5.91
5	Produce components of high accuracy by different operations using grinding. [Different operations – surface grinding, cylindrical grinding with an accuracy of ±0.01 mm] (Mapped NOS: CSC/N0109)	1.6.92 - 1.6.98
6	Set different components of machine & parameters to produce taper/angular components and ensure proper assembly of the components. [Different component of machine: Form tool, Compound slide, tail stock offset; Different machine parameters- Feed, speed, depth of cut.] (Mapped NOS: CSC/N0110)	1.7.99 - 1.7.103
7	Set the different machining parameters to produce screw & multi start threaded components applying method/ technique and test for proper assembly of the components.(Mapped NOS: CSC/N0110)	1.7.104 - 1.7.105
8	Set the different machining parameters and cutters to prepare components by performing different milling operation and indexing. [Different machining parameters – feed, speed and depth of cut. Different components – Rack, Spur Gear, External Spline, bevel gear, Helical Gear, worm & work wheel.] (Mapped NOS: CSC/N0108)	1.8.106 - 1.8.113
9	Measure components using different instrument/ gauge and test machine tool accuracy. [Different instrument/ gauges, limit gauges, Sine Bar, snip gauges, tool maker's microscope and profile projector; Simple Machines – Drill Machine, Power Saw and Lathe] (Mapped NOS: CSC/N0110)	1.9.114 - 1.9.119

SYLLABUS

Duration	Reference Learning Outcome	Professional Skills (Trade Practical) with Indicative hours	Professional Knowledge (Trade Theory)
Professional Skill 260 Hrs; Professional Knowledge 50Hrs	Plan and organize the work to make job as per specification applying different types of ba sic fitting operation and check for dimensional accuracy fol lowing safety precautions. [Ba sic fitting operation – marking, Hack sawing, Chiseling, Fil ing, Drilling, Taping and Grinding etc. Accuracy: ± 0.25mm] (Mapped NOS:CSC/ N0304)	1 Importance of trade training, List of tools & Machinery used in the trade. (2 hrs.) 2 Safety attitude development of the trainee by educating them to use Personal Protec tive Equipment (PPE). (2 hrs.) 3 First Aid Method and basic training. (2 hrs.) 4 Safe disposal of waste materials like cot ton waste, metal chips/ burrs etc. (1 hr.) 5 Hazard identification and avoidance. (1 hr.) 6 Identification of safety signs for Danger, Warning, caution & personal safety message. (1 hr.) 7 Preventive measures for electrical accidents & steps to be taken in such accidents. (1 hr.) 8 Use of fire extinguishers. (2 hrs.)	All necessary guidance to be provided to the newcomers to become familiar with the working of Industrial Training Institute system including store's procedures. Soft skills, its importance and job area after completion of training. Importance of safety and general pre-cautions observed in the industry/ shop floor. Introduction of first aid. Operation of electrical mains and electrical safety. Introduction of PPEs. Response to emergencies e.g. power failure, fire, and system failure. Importance of housekeeping & good shop floor practices. Introduction to 5S concept & its ap-plication. Occupational Safety & Health: Health, Safety and Environment guidelines, legislations & regulations as applicable. Basic understanding on Hot work, confined space work and material handling equipment. (05 hrs)
		Basic Fitting 9 Preparation of filing. (2 hrs.) 10 Marking lines on the job surface for filing to the marked lines. (4 hrs.) 11 Gripping the job suitably in the vice jaw for filing (4 hrs) 12 Balancing of file, using rough file. (4 hrs.) 13 Measurement by using inside/ outside calipers and scale. (4 hrs.)	**Basic Fitting** Vice - purpose, types, description, size, construction method to use and maintenance. File - purpose, types, description, size and method to use. Use of file card, printing of file, convexity of file and proper filing technique. Rule - purpose, types, description and method to use. (05 hrs)
		14 Use of simple measuring instruments such as steel rule, Vernier caliper, Inside/Outside Micrometer. (4 hrs.) 15 Care and precaution to be observed in handling these instruments. (1 hr.) 16 Exercises on measurement of various geometrical shapes. (8 hrs.)	Divider - purpose, types, description and method to use. Scriber - purpose, types, description and method to use. Marking Block - purpose, types, de-scription and method to use. Punch - purpose, types, description and method to use. Micrometer - purpose, types, construc tion, calculation of least count, method to use and read, care and maintenance.

Duration	Reference Learning Outcome	Professional Skills (Trade Practical) with Indicative hours	Professional Knowledge (Trade Theory)
		17 Exercise on marking out according to simple blue prints, using steel rule, scriber, marking blocks & divider. (4 hrs.) 18 Scribing lines on chalked or coloured (blue) surfaces of the work piece. (2 hrs.) 19 Marking location of the position of holes & scribing circles using dividers. (2 hrs.) 20 Use of Dot and Center Punch for punching the lines, centers and circles. (3 hrs.) 21 Demo on filing operation, using rough file. (3 hrs.) 22 Exercise of filing flanges of a channel for balancing of file.(4 hrs.) 23 Filing flat surface and flange of a channel maintaining parallelism between them using outside caliper within + or - 0.5mm. (9 hrs.)	Vernier Caliper - purpose, construction, calculation of vernier constant, method to use & read, care and maintenance. (5 hrs.)
		24 Exercises on filing to develop control and Field layout the dimensional features of the work piece using vernier height gauge, engineering square, angle plate and surface plate. (5 hrs.) 25 Exercise on filing the adjoining sides Squareness with respect to one reference surface. Filing faces for maintaining flatness, squareness of adjacent side using try- square, parallelism between opposite sides and reducing thickness. (6 hrs.) 26 Filing with second cut file to prepare smooth surfaces. (4 hrs.) 27 Exercise on filing for maintaining dimensions within + or -0.1mm using vernier caliper. (8 hrs.)	Vernier height gauge - purpose, types, Construction, method to use and read, care and maintenance. Engineer's square - purpose, de scription and method to use. Surface Plate - purpose, description, method to use, care and mainte nance. Angle Plate - purpose, de scription and method to use.(04 hrs.)
		28 Marking of profiles - combination of straight lines, circles, arcs and angles using scale, divider height gauge, protractor, combination set etc. (3 hrs.) 29 Marking geometrical profiles on sheet metal and filing to mark lines. (3 hrs.) 30 Sharpening of marking tools, use of bench grinder for sharpening of scriber, centre punch, dot punch, divider etc. (1 hr.)	Combination set - purpose, descrip tion and method to use. Vernier bevel protractor - purpose, description, calculation of vernier con stant, method to read and use, care and maintenance. Bench Grinder - purpose, description, proce dure and precautions to be observed during grinding of marking tools, chis els and drill bits.

Duration	Reference Learning Outcome	Professional Skills (Trade Practical) with Indicative hours	Professional Knowledge (Trade Theory)
		31 Marking on the job piece for saw cuts. (1 hr.) 32 Gripping the job suitably in the vice jaws for hack sawing to dimensions. (1 hr.) 33 Hack sawing various metallic pieces (mild steel, aluminum, copper, brass, stainless steel etc.) of different thickness and cross sections, within + or - 0.5mm using hack saw blades of different pitches. (5 hrs.) 34 Hack sawing different lengths with hack saw frame in horizontal & vertical positions Sawing along the parallel marked lines within 0.5mm allowance for filing. (5 hrs.) 35 Hack sawing and filing steps and slots and open fitting of finished pieces. (4 hrs.)	Hack saw - purpose, types, descrip tion, method to use and precautions to be taken during hack sawing. Hack saw blade - purpose, types, de scription, select ON/ OFFappropriate grade, fixing of blade and precautions to be observed. (04 hrs.)
		36 Hammering practice on vertical hold round job. (5 hrs.) 37 Blind hammering practice. Stamping letters and numbers on M.S. plates. (5 hrs.) 38 Exercise on stamping to develop judgment, control on hand and feel. (3 hrs.) 39 Stamping practice on flat and round surfaces using flat, cross cut and round nose chisels for chipping edges and square to the faces and edges.(8 hrs.) 40 Checking with Try- square, use of cross peen hammer for stretching of metal strip. (4 hrs.)	Hammer - purpose, types, description, method to use and precautions to be observed. Bending of solid selections using fixtures. Letters and Numbers - purpose, description, method to use and precautions to be observed. Hollow Punch - purpose, description, method to use for preparations of gaskets and other packing materials. Pipe Fitting -material and types of pipes used in the trade.Method to cut, to thread and preparation of pipes for 'T' fitting elbow fitting, reducers etc. using unions. Method to fill ferrule. (04 hrs.)
		41 Preparation for drilling, marking out the position of holes and dot punching. (2 hrs.) 42 Deepening the points with centre punch. (2 hrs.) 43 Checking for centre distance. (1 hr.) 44 Drilling practice on sensitive drilling machine using different types of drills and drill holding devices. (6 hrs.) 45 Safety to be observed while working on drilling machine. (1 hr.) 46 Marking, chain drilling and filing to produce square, round and triangular openings on 6mm thick plate. (6 hrs.)	Drills - purpose, types, description, drill holding devices, method to use a drill with or without drill chuck (or collet) and precaution to be observed. Reamer -purpose, types, description, method to use, reaming allowance, coolant used and precautions to be observed during reaming. Drilling Machine with manual infeed, its purpose, types, description, drilling fixtures, method to drill and precautions to be observed during drilling. Procedure to be followed for counter sinking, counter boring, spot facing and reaming using bench drilling machine.

Duration	Reference Learning Outcome	Professional Skills (Trade Practical) with Indicative hours	Professional Knowledge (Trade Theory)
		47 Preparing inserts and fitting in these openings.(2 hrs.) 48 Drilling practice on varying thickness and different materials such as M.S., C.I., S.S., Cu, Brass, Nylon, Epoxy etc. (6 hrs.) 49 Drilling on sheet metal, precautions and safety to be observed. (3 hrs.) 50 Counter Sinking, counter boring, and spot facing operations using bench drilling machine. (3 hrs.) 51 Exercise on reaming with hand reamers and machine reamers. (2 hrs.) 52 Internal threading by hand using tap sets. (2 hrs.) 53 External threading by split die and finishing of thread by die nut. (2 hrs.) 54 Marking centre of a round bar with the help of 'V' block and clamp. (1 hr.) 55 Drilling and reaming of blind holes along the axis of round jobs. (3 hrs.) 56 Grinding of drills to specifications and checking of angles with gauges. (4 hrs.) 57 Grinding of chisels. (1 hr.)	Screw Threads - elements and forms screw threads single and multi-start thread, right and left hand thread. Taps and Tapping - purpose, types, description, precaution to be observed and method to use hand and machine taps during tapping. Types of coolant to be used. Calculation to drill size for tapping. Method to tap a blind hole, reasons for breakage of tap and method to remove broken tap. Construction and method to use tap wrench. Die and dieing purpose, types, description and method to use and precaution to be observed. Description of die stock, procedure and precautions to be observed during dieing. (8 hrs.)
		58 Measurement of shaft and hole diameters using outside and inside micrometer. (2 hrs.) 59 Filing round out of square bar within ± 0.1mm. Filing to an accuracy of ±0.1 mm., checking with an outside micrometer. (6 hrs.) 60 Preparation of plates for a gauge fitting. (3 hrs.) 61 Exercise on filing radius and angular filing using templates and gauges. (5 hrs.) 62 Filing templates and gauges for checking lathe tool angles. (5 hrs.) 63 Exercise on step and taper turning. (4 hrs.)	Defining and explanation of the elements of interchangeable system basis size, limits, tolerance, allowances. System of limits, fit and tolerances types of fit. Hole basis and shaft basis. Newal, British, I.S.I. B.S.I. systems, examples of fixing limit for various types of fit commonly met within the machine. (04 hrs.)
		64 Filing of various angle & clearances of lathe tool on square blanks. (6 hrs.) 65 Checking with templates & gauge already prepared. (2 hrs.)	Gauges & Template-purpose, types, description and method to use dial test indicator. Limit gauges - purpose, types, construction and method to use limit gauges. (07 hrs.)

Duration	Reference Learning Outcome	Professional Skills (Trade Practical) with Indicative hours	Professional Knowledge (Trade Theory)
		66 Use of combination & round nose pliers to make different shapes profiles by bending wire to match the blue print to develop manipulative skills, hand control & eye judgment. (5hrs.) 67 Cold riveting. (3 hrs.) 68 Marking out location of holes for riveting. (2 hrs.) 69 Use of dolly and snap for forming rivet heads. (3 hrs.) 70 Lap and butt joint by cold riveting. (4 hrs.)	
		71 Cutting of sheet metal with chisel. Marking parallel clamp, 'C' clamp or micrometer stand using acquired skills. (8 hrs.) 72 Simple project work. (14 hrs.)	Sheet metal work-purpose, types, description and method to use snip & stake. Description and method to use hand shear. Rivets & riveting types & description of rivets. Method of lap & butt joint using dolly and snap. Cold & hot working of strips & pipesˆmethod of bending solid sections, using fixtures for different physical conditions. Use of cutters for pipes & method to bend in hot and cold condition using fixtures. (04 hrs.)
Professional Skill 25 Hrs; Professional Knowledge 05Hrs	Plan & perform simple repair, maintenance of different machines and check for functionality. [Different Machines – Drill Machine, Power Saw and Bench Grinder] (Mapped NOS: NOS:CSC/N0901)	**BASIC MAINTENANCE SKILLS** 73 Using hand tools such as screw driver, single end/double end spanners, box nut spanners, ratchet spanners, circlip, pliers, wrenches, pullers, extractors, drift. (6 hrs.) 74 Correct method to be used and care to be taken in using those tools. (9 hrs.) 75 Lubrication of different parts of machines. (4 hrs.) 76 Care and maintenance of machines. (6 hrs.)	**BASIC MAINTENANCE SKILLS** Screw drivers - purpose, types, description and method to use screw drivers. Spanners- purpose, types, description and method to use box, socket, tubular, hook spanner etc. Wrenches - purpose, types, description and method to use T socket, monkey, ratchet,pipe wrenches etc. Purpose, description, precautions to be observed and method to use drift, pullers and extractors. (05 hrs.)
Professional Skill 80Hrs; Professional Knowledge 15Hrs	Prepare different cutting tool to produce jobs to appropriate accuracy by performing different turning operations. [Different cutting tool – V tool, side cutting, parting, thread cutting (both LH & RH), Appropriate accuracy: - ±0.06mm, Different turning operation – Plain, facing, drilling, boring (counter &	**BASIC TURNING** 77 Safety precautions to be observed while handling machines. (3 hrs.) 78 Demonstration of change gear in the gearbox. (4 hrs.) 79 Practice of holding work piece and tool using different devices. (6 hrs.) 80 Exercises on plain, stepped, taper and form turning, knurling etc. (16 hrs.) 81 Exercises on drilling, reaming,	**TURNING** Types, construction features working principles, functions, use accessories and attachments of lathe machine. Driving mechanism – cone pulley, all geared headstock, quick-change gearbox and apron mechanism. Types, materials and angles of the lathe cutting tools. Purpose and method to perform various lathe operations. Using accessories and attachments.

Duration	Reference Learning Outcome	Professional Skills (Trade Practical) with Indicative hours	Professional Knowledge (Trade Theory)
	stepped), grooving, Parallel Turning, Step Turning, parting, chamfering, U cut, Reaming, knurling.] (Mapped NOS: NOS:CSC/N0110)	boring, counter boring etc. (15 hrs.) 82 Screw thread cutting both internal and external of different types. (10 hrs.) 83 Exercise on eccentric turning. (6 hrs.) 84 Grinding of lathe tools. (2 hrs.) 85 Simple projects such as hollow punch, pulleys, gear blanks, simple coupling etc. (18 hrs.)	Determination and use of cutting speed, feed. Coolant and its applications. Lubrication system. (15 hrs.)
Professional Skill 80Hrs; Professional Knowledge 15Hrs	Set the different machining parameters and cutters to prepare job by performing different milling operation and indexing. [Different machining parameters – feed, speed and depth of cut. Different milling operations – plain, face, angular, form, gang, straddle milling] (Mapped NOS: CSC/N0108)	**BASIC MILLING** 86 Safety precautions in handling machine. (5 hrs.) 87 Demonstration of various parts of the milling machines. (10 hrs.) 88 Practice on different work and tool holding devices. (15 hrs.) 89 Exercises on: (30 hrs.) i) Parallel and angular milling. ii) Grooving using mills. iii) Milling square/hexagon using indexing head. iv) Use of slotting attachment for cutting key ways. v) Simple projects such as jaw, claw, 90 Oldham coupling, spline cutting etc. (10 hrs.) 91 Lubrication of different parts. Care &maintenance of machine. (10 hrs.)	**MILLING :** Construction features, working principles, types, functions. Use of accessories and attachment of milling machine. Types of milling cutters. Different method of holding work piece and cutters. Milling operations such as plain, step, angular milling, slot and groove cutting. Gear nomenclature definitions, symbols, explanation and gear cutting calculations. Explanation of cutting speed, feed and depth of cut. C oolant for different materials. Common fault, defects and their rectification. (15 hrs.)
Professional Skill 125Hrs; Professional Knowledge 28Hrs	Produce components of high accuracy by different operations using grinding. [Different operations – surface grinding, cylindrical grinding with an accuracy of ±0.01 mm] (Mapped NOS: CSC/N0109)	**GRINDING** 92 Safety precautions to be observed while using machine. (7hrs.) 93 Demonstration of various parts of the grinding machines. (13 hrs.) 94 Use of drive - both mechanical and hydraulic. (8 hrs.) 95 Grinding wheel specifications, mounting, balancing, truing and dressing of grinding wheels. (18 hrs.) 96 Lubrication of different parts and care & maintenance of grinding machine. (18 hrs.) 97 Practice on different work holding devices and grinding various jobs.(36 hrs.)	Types of machines- Constructional features, working principle, types, functions and use of surface and cylindrical grinding machine. Grinding wheels and their specifications - grit, grain, size, structure, bond, grades etc. Procedure to use grinding wheels for balancing and truing. Method to hold work and grind wheel. Method to perform various grinding operation selecting proper speed, Feed. Importance of coolant. Method to detect common faults, their rectification and preventive maintenance of grinding machine. Study of hydraulic system used on the machine. (28 hrs.)

Duration	Reference Learning Outcome	Professional Skills (Trade Practical) with Indicative hours	Professional Knowledge (Trade Theory)
		98 Other machining process: (25 hrs.) • Shaping • Planning • Slotting • Hobbing • Broaching • Finish machining process like • Types • Coated Abrasives (Sandpaper, Emory Cloth) • Belt Grinders • Solid Belt • Mesh Belt (Hold Grinding Fluid via Surface Tension • Wire Brushing • Wire Provides Metal Cutting/ Burnishing Action • Wire (Metal) Acts as Abrasive • Honing (Interior of Holes) • Lapping (Flat Surfaces) • Polishing • Buffing • Electro-Polishing • Magnetic Float Polishing (Ceramic Ball Bearings) • Barrel Finishing • Abrasive Flow	
Professional Skill 60Hrs; Professional Knowledge 10Hrs	Set different components of machine & parameters to produce taper/ angular components and ensure proper assembly of the components. [Different component of machine: Form tool, Compound slide, tail stock offset; Different machine parameters- Feed, speed, depth of cut.] (Mapped NOS: CSC/N0110)	**ADVANCED MACHINING SKILLS** **TURNING** 99 Taper turning by using taper attachment. (10 hrs.) 100 Taper turning by using a form tool. (10 hrs.) 101 Internal and external taper turning and matching to mating parts. (10 hrs.) 102 Eccentric turning practice. (15 hrs.) 103 Boring and stepped boring, position boring. (15 hrs.)	**ADVANCED MACHINING SKILLS** **TURNING** Taper turning attachment and form tool. Care to be taken for boring, step boring and taper boring in a blind hole. Procedure and care to be taken eccentric turning. (10 hrs.)

Duration	Reference Learning Outcome	Professional Skills (Trade Practical) with Indicative hours	Professional Knowledge (Trade Theory)
Professional Skill 40 Hrs; Professional Knowledge 8Hrs	Set the different machining parameters to produce screw & multi start threaded components applying method/ technique and test for proper assembly of the components. (Mapped NOS: CSC/ N0110)	104 Various Screw threads cutting to suit male and female threaded components. (25 hrs.) 105 Multi start threads cuttingˆ2start. (15 hrs.)	Procedure for cutting various internal and external screw threads. Care to be taken during internal threading in a blind hole. (8 hrs.)
Professional Skill 130Hrs; Professional Knowledge 25Hrs	Set the different machining parameters and cutters to prepare components by performing different milling operation and indexing. [Different machining parameters – feed, speed and depth of cut. Different components – Rack, Spur Gear, External Spline, bevel gear, Helical Gear, worm & work wheel.] (Mapped NOS: CSC N0108)	**MILLING** 106Gang milling - milling jobs of different shapes and dimensions by using gang-milling process. (15 hrs.) 107Milling hexagonal holes on a plate by attachment. Milling splines (external). (15 hrs.) 108Milling gears by both simple and differential indexing (15hrs.) 109Helical milling - milling helical groove on vertical milling machine by end mill cutter. (15 hrs.) 110Milling helical gears. (15 hrs.) 111Milling bevel gears. (15 hrs.) 112Milling a rack. (15 hrs.) 113Cutting worm and worm wheel on a milling. (25 hrs.)	**MILLING** Different types of milling operations. Indexing methods and its applications. Different types of gear & its application. Different cutters used in gear cutting operations and cutter nomenclature. Procedures for milling helical groove by a slab mill cutter on vertical milling machine. Care and precautions to be taken during milling. Procedure for milling helical gears, bevel gears, rack, worm and worm wheel. (25 hrs.)
Professional Skill 40Hrs; Professional Knowledge 8Hrs	Measure components using different instrument/ gauge and test machine tool accuracy. [Different instrument/ gaugesˆlimit gauges, Sine Bar, snip gauges, tool maker's microscope and profile projector; Simple Machines – Drill Machine, Power Saw and Lathe] (Mapped NOS: CSC/ N0110)	**INSPECTION** 114Familiarization with inspection and master gauge checking of finished product with limit gauges for their accuracy and usability. (2 hrs.) 115Use of Sine Bar, snip gauges along with standard balls and rollers for measurement of taper. (5 hrs.) 116Measuring with tool maker's microscope. (3 hrs.) 117Testing of gears for its measurements and accuracy. (5 hrs.) 118Use of digital profile projector. (5 hrs.)	**INSPECTION** Definition, description and use of worker's inspection and master gauge. Principle, construction and use of sine bar and sine center. Types and description of slip gauges, purpose, construction and method to use tool makers. Microscope and profile projector. (04 hrs.)
		119Geometrical accuracy test of machine as per test chart. (20 hrs.)	Defects and remedies of turning, milling and grinding. Defects such as: Taper, Chattering, Poor Surface finish, Parallelism. (04 hrs.)

Familiarization with the working of Industrial Training Institute system including stores procedures

Objectives: At the end of this lesson you shall be able to
- **know the staff structure of the institute**
- **know the available trades in the institute and their activities**
- **state the concept of training skill to be acquired**
- **state the employability aspect of the training.**

The Industrial Training Institute throughout India follow the same syllabus pattern given by the National council for Vocational Training (NCVT). In India there are about 13,350 Government ITIs and Private ITI 's as per the Govt. of India, Ministry of Skill Development and Entrepreneurship (MSDE) Annual report of 2016-2017. The Government Industrial Training Institute in each state work under the Directorate of Employment and Training which is a department under the Labour Ministry in most of the states.

The Head of the industrial training institute is the Principal, under whom there is one vice-principal, Group Instructor(s) Training officers and a number of Vocational Instructor(s) Assistant Training Officer(s) and Junior Training Officer and so on as shown in the Organisation Chart of ITI. (Fig 1)

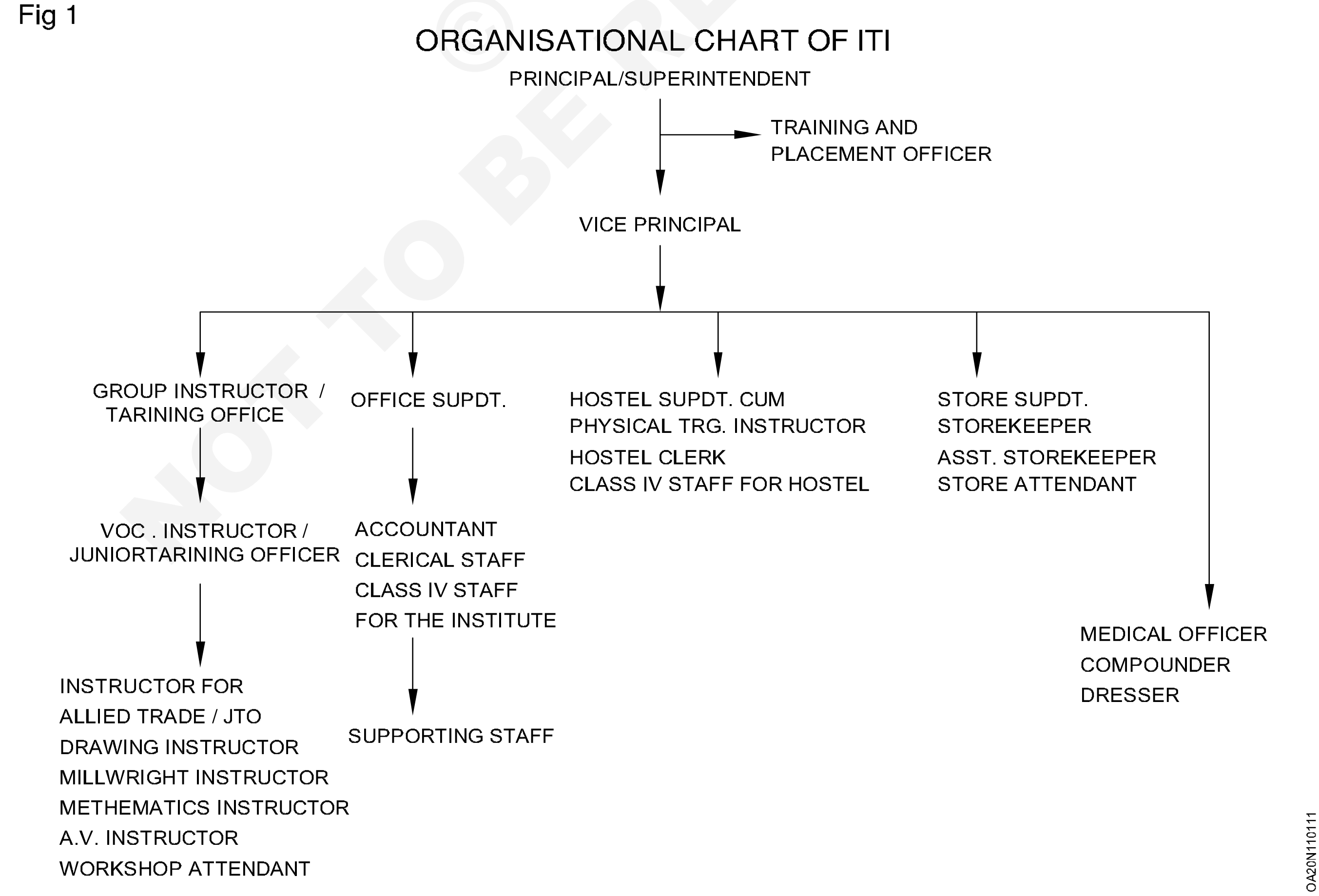
In every industrial training institute there is a store and the in charge of the store is storekeeper for inward and outward movement of tools, equipment and consumables. The instructor will indent the training requirement on receiving from stores, the instructor will issue the training requirement to the trainees according to the graded exercises as per syllabus.

The basic moto of providing industrial training is to give hands to training to the new trainees so as to make them as skilled labour/industrial workers/or self employed entrepreneur.

The function of stores in the ITI is to provide the raw material and machine tool equipments and to take care of machine and their maintenance.

Instructor gets the raw material and the tool equipments from the stores and issue to the trainees for training and to carryout the job.

Fig 1



Familiar with industrial training institute

Objectives: At the end of this lesson you shall be able to
- **explain about DGT affiliated institutions under MSDE**

Introduction

Directorate General of Training (DGT)

Directorate General of Training (DGT) in Ministry of Skill Development & Entrepreneurship is an apex organization for development and coordination of the vocational training including Women's Vocational Training of the employable youth in the country and to provide skilled manpower to the economy.

Two directorate general of employment and training working under Deputy Director General (Training) & Deputy Director General (Apprenticeship Training) along with their support systems were transferred to Ministry of Skill Development & Entrepreneurship (MSDE).

DGT affiliated institutions offers a wide range of training courses catering to the needs of different segments in the Labour market. Courses are available for school leavers, ITI pass outs, ITI instructors, industrial workers, technicians, junior and middle level executives, supervisors/foremen, women, physically disabled persons and SC/STs.

It also conducts training oriented research and develops instructional media packages for the use of trainees and instructors etc.

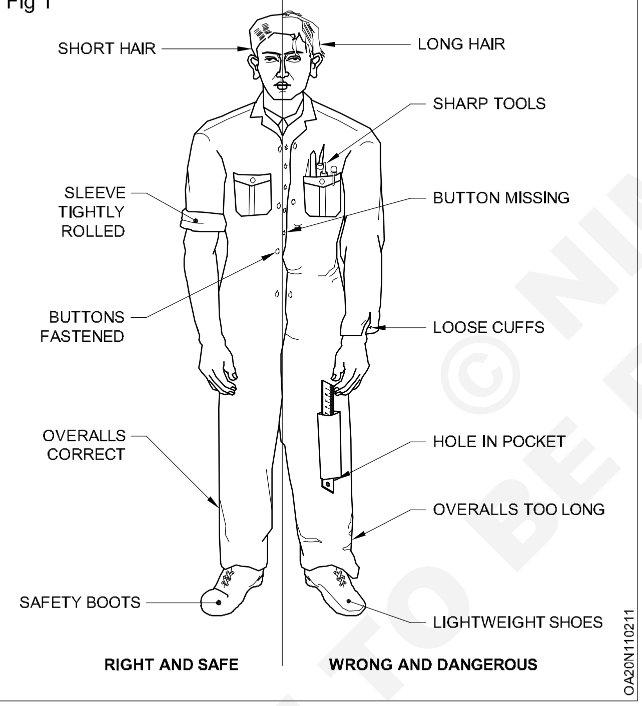
DGT acts as a secretariat and implementing arm of National Council for Vocational Training (NCVT).

Importance of safety and general precautions to be observed in the industry/ shop floor

Objectives: At the end of this lesson you shall be able to
- **state the importance of safety**
- **list out the safety precautions to be observed in a industry/shop floor**
- **list out the personal safety precautions to be observed in machine shop**
- **list out the safety precautions to be observed while working on the machines.**

Generally accidents do not happen; they are caused. Most accidents are avoidable. A good craftsman, having a knowledge of various safety precautions, can avoid accidents to himself and to his fellow workers and protect the equipment from any damage. To achieve this, it is essential that every person should follow safety procedure. (Fig 1)

Fig 1



Safety in a workshop can be broadly classified into 3 categories.

- General safety
- Personal safety
- Machine safety

General safety

Keep the floor and gangways clean and clear.

Move with care in the workshop, do not run.

Don't leave the machine which is in motion.

Don't touch or handle any equipment/ machine unless authorised to do so.

Don't walk under suspended loads.

Don't cut practical jokes while on work.

Use the correct tools for the job.

Keep the tools at their proper place.

Wipe out split oil immediately.

Replace worn out or damaged tools immediately.

Never direct compressed air at yourself or at your co-worker.

Ensure adequate light in the workshop.

Clean the machine only when it is not in motion.

Sweep away the metal cuttings.

Know everything about the machine before you start it.

Personal safety

Wear a one piece overall or boiler suit.

Keep the overall buttons fastened.

Don't use ties and scarves.

Roll up the sleeves tightly above the elbow.

Wear safety shoes or boots

Cut the hair short.

Don't wear a ring, watch or chain.

Never lean on the machine.

Don't clean hands in the coolant fluid.

Don't remove guards when the machine is in motion.

Don't use cracked or chipped tools.

Don't start the machine until

- the workpiece is securely mounted
- the feed machinery is in the neutral
- the work area is clear.

Don't adjust clamps or holding devices while the machine is in motion.

Never touch the electrical equipment with wet hands.

Don't use any faulty electrical equipment.

Ensure that electrical connections are made by an authorised electrician only.

Concentrate on your work. Have a calm attitude.

Do things in a methodical way.

Don't engage yourself in conversation with others while concentrating on your job.

Don't distract the attention of others.

Don't try to stop a running machine with hands.

Machine safety

Switch off the machine immediately if something goes wrong.

Keep the machine clean.

Replace any worn out or damaged accessories, holding devices, nuts, bolts etc as soon as possible.

Do not attempt operating the machine until you know how to operate it properly.

Do not adjust tool or the workpiece unless the power is off.

Stop the machine before changing the speed.

Disengage the automatic feeds before switching off.

Check the oil level before starting the machine.

Never start a machine unless all the safety guards are in position.

Take measurements only after stopping the machine.

Use wooden planks over the bed while loading and unloading heavy jobs.

Safety is a concept, understand it. Safety is a habit, cultivate it.

Approach on soft skills

Objectives: At the end of this lesson you shall be able to
- **state the concept of soft skill**
- **list the important common soft skills**
- **brief the employability aspect of training**
- **brief the further learning scope.**

Concept

Soft skills - refer to the cluster of personality traits, social graces, facility with language, personal habits, friendliness, and optimism that mark people to varying degrees. The same can also be defined as-ability to interact communicate positively and productively with others. sometimes called "character sills".

More and more business are considering soft skills as important job criteria. Soft skills are used in personal and professional life. Hard skills/technical skills so not consider without soft skills.

Common soft skills

Strong work ethic

Positive attitude

Good communication skills

Interpersonal skills

Time management abilities

Problem-solving skills

Team work

Initiative, Motivation

Self-confidence

Loyalty

Ability to accept and learn from criticism

Flexibility adaptability

Working well under pressure

Job are completion of training: This highlights the employability aspect completion of training. The trainee should be aware of various prospects available in present market scenario along with scope for self-employment. For example a trainee with NTC engineering trade may opt for.

Various job available in different industries in India and abroad

After successful completion of ITI training in any one of the engineering facile one can see appointment in engineering workshop/factories (Public sector, private sector and Government industries) In India and Abroad as technician/skilled worker.

Self employment

One can start his own factory/ancillary unit or design products manufacture and become an entrepreneur.

Further leaning scope

Apprentice training in designated trade.

Craft instructor certificate course

Diploma in Engineering

Opportunity of job after training

After completion of training there are so many companies & industries has offer to the trainees like Fitter, Turner, OAMT, Electrician and so many kinds of semi skilled worker, according to the demand there.

Therefore after training the future of trainee is so bright, he have many type of opportunity for selecting their carrier.

Some type of commercial popular industries like as. Maruti Ashok Leyland, Mahindra and Mahindra, TATA, NTPC, NLC, HAL, BHEL, BEL, industries under Defence & Atomic Energy depts and state transport undertakings etc....

First-aid

Objectives: At the end of this lesson you shall be able to
- **state what is first aid**
- **list the key aims of first aid**
- **explain the ABC of the first aid**
- **brief how to give first-aid for a victim who need first aid.**

First aid is defined as the immediate care and support given to an acutely injured or ill person, primarily to save life, prevent further deterioration or injury, plan to shift the victims to safer places, provide best possible comfort and finally help them to reach the medical centre/ hospital through all available means. It is an immediate life-saving procedure using all resources available within reach.

First aid procedure often consists of simple and basic life saving techniques that an individual performs with proper training and knowledge.

The key aims of first aid can be summarized in three key points:

- **Preserve life:** If the patient was breathing, a first aider would normally place them in the recovery position, with the patient leant over on their side, which also has the effect of clearing the tongue from the pharynx. It also avoids a common cause of death in unconscious patients, which is choking on regurgitated stomach contents. The airway can also become blocked through a foreign object becoming lodged in the pharynx or larynx, commonly called choking. The first aider will be taught to deal with this through a combination of 'back slaps' and 'abdominal thrusts'. Once the airway has been opened, the first aider would assess to see if the patient is breathing.
- **Prevent further harm:** Also sometimes called prevent the condition from worsening, or danger of further injury, this covers both external factors, such as moving a patient away from any cause of harm, and applying first aid techniques to prevent worsening of the condition, such as applying pressure to stop a bleed becoming dangerous.
- **Promote recovery:** First aid also involves trying to start the recovery process from the illness or injury, and in some cases might involve completing a treatment, such as in the case of applying a plaster to a small wound.

Training

Basic principles, such as knowing to use an adhesive bandage or applying direct pressure on a bleed, are often acquired passively through life experiences. However, to provide effective, life-saving first aid interventions requires instruction and practical training. This is especially true where it relates to potentially fatal illnesses and injuries, such as those that require cardiopulmonary resuscitation (CPR); these procedures may be invasive, and carry a risk of further injury to the patient and the provider. As with any training, it is more useful if it occurs before an actual emergency, and in many countries, emergency ambulance dispatchers may give basic first aid instructions over the phone while the ambulance is on the way. Training is generally provided by attending a course, typically leading to certification. Due to regular changes in procedures and protocols, based on updated clinical knowledge, and to maintain skill, attendance at regular refresher courses or re-certification is often necessary. First aid training is often available through community organization such as the Red cross and St. John ambulance.

ABC of first aid

ABC stands for airway, breathing and circulation.

- **Airway:** Attention must first be brought to the airway to ensure it is clear. Obstruction (choking) is a life-threatening emergency.
- **Breathing:** Breathing if stops, the victim may die soon. Hence means of providing support for breathing is an important next steps. There are several methods practiced in first aid.
- **Circulation:** Blood circulation is vital to keep person alive. The first aiders now trained to go straight to chest compressions through CPR methods.

When providing first aid one needs to follow some rule. There are certain basic norms in teaching and training students in the approach and administration of first aid to sick and injured.

1 **Not to get panic**: Panic is one emotion that can make the situation more worse. People often make mistake because they get panic. Panic clouds thinking and causes mistakes. First aider need calm and collective approach. If the first aider himself is in a state of fear and panic gross mistakes may result. It's far easier to help the suffering, when they know what they are doing, even if unprepared to encounter a situation. Emotional approach and response always lead to wrong doing and may cloud one to do wrong procedures. Hence be calm and focus on the given instruction. Quick and confident approach can lesser the effect of injury.

2 **Call medical emergencies**: If the situation demands, quickly call for the medical assistance. Prompt and quick approach may save the life.

3 **Surroundings play vital role**: Different surroundings require different approach. Hence first aider should study the surrounding carefully.

4 **Do no harm**: Patients often die due to wrong FIRST AID methods, who may otherwise easily survive. Do not move the injured person unless the situation demands. It is best to make him lie wherever he is because if the patient has back, head or neck injury, moving him would causes more harm. If the first aider is not confident of correct handling it is better not to intervene of do it. Hence moving a trauma victim, especially an unconscious one, need very careful assessment. Removals of an embedded objects (Like a knife, nail) from the wound may precipitate more harm (e.g. increased bleeding). Always it is better to call for help.

5 **Reassurance**: Reassure the victim by speaking encouragingly with him.

6 **Stop the bleeding**: If the victim is bleeding, try to stop the bleeding by applying pressure over the injured part.

7 **Golden hours**: India have best of technology made available in hospitals to treat devastating medical problem viz. head injury, multiple trauma, heart attack, strokes etc, but patients often do poorly because they don't gain access to that technology in time. The risk of dying from these conditions, is greatest in the first 30 minutes, often instantly. This period is referred to as Golden period. By the time the patient reach hospitals, they would have passed that critical period. First aid care come handy to save lives. It helps to get to the nearest emergency room as quickly as possible through safe handling and transportation. The shorter that time, the more likely the best treatment applied.

8 **Maintain the hygiene**: Most importantly, first aider need to wash hands and dry before giving and first aid treatment to the patient or wear gloves in order to prevent infection.

9 **Cleaning and dressing**: Always clean the wound thoroughly before applying the bandage lightly wash the wound with clean water.

10 **Not to use local medications on cuts or open wounds**: They are more irritating to tissue than it is helpful. Simple dry cleaning or with water and some kind of bandage are best.

11 **CPR (Cardio-Pulmonary Resuscitation) can be life-sustaining**: CPR can be life sustaining. If one is trained in CPR and the person is suffering from choking or finds difficulty in breathing, immediately begin CPR. However, if one is not trained in CPR, do not attempt as you can cause further injury. But some people do it wrong. This is a difficult procedure to do in a crowded area. Also there are many studies to suggest that no survival advantage when bystanders deliver breaths to victims compared to when they only do chest compressions. Second, it is very difficult to carry right maneuver in wrong places. But CPR, if carefully done by highly skilled first aiders is a bridge that keeps vital organs oxygenated until medical team arrives.

12 **Declaring death**: It is not correct to declare the victim's death at the accident site. It has to be done by qualified medical doctors.

How to report an emergency?

The first aiders need to adapt multitask strategy to control the crowd around, communicate to the rescue team, call ambulance etc., all to be done simultaneously. The mobile phones helps to a greater deal for such emergencies. Few guidelines are given below to approach the problems.

Assess the urgency of the situation. Before you report an emergency, make sure the situation is genuinely urgent. Call for emergency services if you believe that a situation is life-threatening or otherwise extremely disruptive.

- A crime, especially one that is currently in progress. If you're reporting a crime, give a physical description of the person committing the crime.
- A fire - If you're reporting a fire, describe how the fire stated and where exactly it is located. If someone has already been injured or is missing, report that as well.
- A life-threatening medical emergency, explain how the incident occurred and what symptoms the person currently displays.
- A car crash - Location, serious nature of injures, vehicle's details and registration, number of people involved etc.

1 **Call emergency service:** The emergency number varies - 100 for Police, 101 for fire and 108 for Ambulance.

2 **Report your location**: The first thing the emergency dispatcher will ask is where you are located, so the emergency services can get there as quickly as possible. Give the exact street address, if you're not sure of the exact address, give approximate information.

3 **Give the dispatcher your phone number:** This information is also imperative for the dispatcher to have, so that he or she is able to call back if necessary.

4 **Describe the nature of the emergency**: Speak in a calm, clear voice and tell the dispatcher why you are calling. Give the most important details first, then answer the dispatcher's follow-up question as best as you can.

5 **Do not hang up the phone**: Until you are instructed to do so. Then follow the instructions you were given.

Basic first aid

Basic first aid refers to the initial process of assessing and addressing the needs of someone who has been injured or is in physiological distress due to choking, a heart attack, allergic reactions, drugs or other medical emergencies. Basic first aid allows one to quickly determine a person's physical condition and the correct course of treatment.

Important guideline for first aiders

1 **Evaluate the situation**: Are there things that might put the first aider at risk. When faced with accidents like fire, toxic smoke, gasses, an unstable building, live electrical wires or other dangerous scenario, the first aider should be very careful not to rush into a situation, which may prove to be fatal.

2 **Remember A-B-Cs**: The ABCs of first aid refer to the three critical things the first aiders need to look for.

- Airway - Does the person have an unobstructed airway?
- Breathing - Is the person breathing?
- Circulation - Does the person show a pulse at major pulse points (wrist, carotid artery, groin)

3 **Avoid moving the victim**: Avoid moving the victim unless they are in immediate danger. Moving a victim will often make injuries worse, especially in the case of spinal cord injuries.

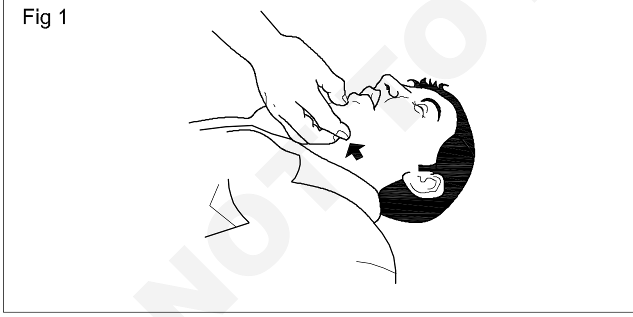
4 **Call emergency services**: Call for help or tell someone else to call for help as soon as possible. If alone in at the accident scene, try to establish breathing before calling for help, and do not leave the victim alone unattended.

5 **Determine responsiveness**: If a person is unconscious, try to rouse them by gently shaking and speaking to them.

If the person remains unresponsive, carefully roll them on the side (recovery position) and open his airway.

- Keep head and neck aligned.
- Carefully roll them onto their back while holding his head.
- Open the airway by lifting the chin. (Fig 1)

Fig 1



6 **Look, listen and feel for signs of breathing**: Look for the victim's chest to raise and fall, listen for sounds of breathing.

If the victim is not breathing, see the section below

- If the victim is breathing, but unconscious, roll them onto their side, keeping the head and neck aligned with the body. This will help drain the mouth and prevent the tongue or vomit from blocking the airway.

7 **Check the victim's circulation**: Look at the victim's colour and check their pulse (the carotid artery is a good option; it is located on either side of the neck, below the jaw bone). If the victim does not have a pulse, start CPR.

8 **Treat bleeding, shock and other problems as needed**: After establishing that the victim is breathing and has a pulse, next priority should be to control any bleeding. Particularly in the case of trauma, preventing shock is the priority.

- **Stop bleeding:** Control of bleeding is one of the most important things to save a trauma victim. Use direct pressure on a wound before trying any other method of managing bleeding.
- **Treat shock:** Shock, a loss of blood flow from the body, frequently follows physical and occasionally psychological trauma. A person in shock will frequently have ice cold skin, be agitated or have an altered mental status, and have pale colour to the skin around the face and lips. Untreated, shock can be fatal. Anyone who has suffered a severe injury or life-threatening situation is at risk for shock.
- **Choking victim:** Choking can cause death or permanent brain damage within minutes.
- **Treat a burn:** Treat first and second degree burns by immersing or flushing with cool water. Don't use creams, butter or other ointments, and do not pop blisters. Third degree burns should be covered with a damp cloth. Remove clothing and jewellery from the burn, but do not try to remove charred clothing that is stuck to burns.
- **Treat a concussion:** If the victim has suffered a blow to the head, look for signs of concussion. Common symptoms are: loss of consciousness following the injury, disorientation or memory impairment, vertigo, nausea, and lethargy.
- **Treat a spinal injury victim:** If a spinal injury is suspected, it is especially critical, not move the victim's head, neck or back unless they are in immediate danger.

Stay with the victim until help arrives

Try to be a calming presence for the victim until assistance can arrive.

Unconsciousness (COMA)

Unconscious also referred as Coma, is a serious life threatening condition, when a person lie totally senseless and do not respond to calls, external stimulus. But the basic heart, breathing, blood circulation may be still intact, or they may also be failing. If unattended it may lead to death.

The condition arises due to interruption of normal brain activity. The causes are too many.

The following symptoms may occur after a person has been unconscious:

- Confusion
- Drowsiness
- Headache

- Inability to speak or move parts of his or her body (see stroke symptoms)
- Light headedness
- Loss of bowel or bladder control (incontinence)
- Rapid heartbeat (palpitation)
- Stupor

Loss of consciousness may threaten life if the person is on his back and the tongue has dropped to the back of the throat, blocking the airway. Make certain that the person is breathing before looking for the cause of unconsciousness. If the injuries permit, place the casualty in the recovery position with the neck extended. Never give anything by mouth to an unconscious casualty.

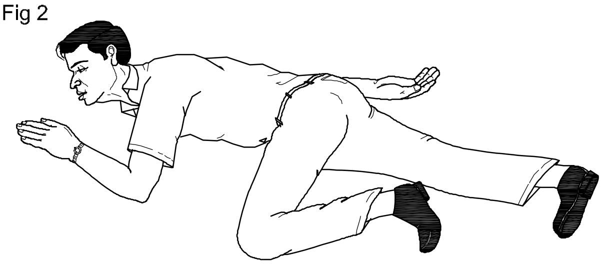
How to diagnose an unconscious injured person

- **Consider alcohol:** look for signs of drinking, like empty bottles or the smell of alcohol.
- **Consider epilepsy:** are there signs of a violent seizure, such as saliva around the mouth or a generally dishevelled scene?
- **Think insulin:** might the person be suffering from insulin shock (see 'How to diagnose and treat insulin shock")?
- **Think about drugs:** was there an overdose? Or might the person have under dosed - that is not taken enough of a prescribed medication?
- **Consider trauma:** is the person physically injured?
- **Look for signs of infection:** redness and/ or red streaks around a wound.
- **Look around for signs of Poison:** an empty bottle of pills or a snakebite wound.
- **Consider the possibility of psychological trauma:** might the person have a psychological disorder of some sort
- Consider stroke, particularly for elderly people.
- Treat according to what you diagnose.

First aid DO'S

- Call EMERGENCY number.
- Check the person's airway, breathing, and pulse frequently. If necessary, begin rescue breathing and CPR.
- If the person is breathing and lying on the back and after ruling out spinal injury, carefully roll the person onto the side, preferably left side. Bend the top leg so both hip and knee are at right angles. Gently tilt the head back to keep the airway open. If breathing or pulse stops at any time, roll the person on to his back and begin CPR.
- If there is a spinal injury, the victims position may have to be carefully assessed. If the person vomits, roll the entire body at one time to the side. Support the neck and back to keep the head and body in the same position while you roll.

Fig 2



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- Keep the person warm until medical help arrives.
- If you see a person fainting, try to prevent a fall. Lay the person flat on the floor and raise the level of feet above and support.
- If fainting is likely due to low blood sugar, give the person something sweet to eat or drink when they become conscious.

DONT'S

- Do not give an unconscious person any food or drink.
- Do not leave the person alone.
- Do not place a pillow under the head of an unconscious person.
- Do not slap an unconscious person's face or splash water on the face to try to revive him.

Shock (Fig 3)

A severe loss of body fluid will lead to a drop in blood pressure. Eventually the blood's circulation will deteriorate and the remaining blood flow will be directed to the vital organs such as the brain. Blood will therefore be directed away from the outer area of the body, so the victim will appear pale and the skin will feel ice cold.

Fig 3

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Operation of electrical mains/ Circuit breakers and electrical safety

Objectives : At the end of this lesson you shall be able to
- **explain the operation of electrical mains/circuit breaker**
- **state the importance of electrical safety.**

Electrical safety

Electric shock : If a person happens to come in contact with an electrical live wire and if he has not insulated himself, then electric current flows through his body. Since the human body cannot withstand current flow more than a few tens of milliamps, the human body suffers a phenomenon generally known as electric shock. Electric shock may turn out to be hazardous to some of the parts of the human body and some times even to the life of the person.

The severity of an electric shock depends on:

– the level of current passing through the body

– how long does the current keep passing through the body.

Therefore, the higher the current or longer the time, the shock may result in a causality.

In addition to the above factors, other factors which influences the severity of shock are:

– age of the person receiving a shock

– surrounding weather condition

– condition of the floor (wet or dry)

– voltage level of electricity

– insulating property of the footwear or wet footwear, and so on.

Effects of electric shock : The effect of electric shock at very low voltage levels (less than 40 V) may only be an unpleasant tingling sensation. But this shock itself may be sufficient to cause someone to lose his balance and fall, resulting in casualty.

At higher voltage levels the muscles may contract and the person will be unable to break off from the contact by himself. He may lose consciousness. The muscles of the heart may contract spasmodically (fibrillation). This may even turn out to be fatal.

At an excessive level of voltage, the person receiving a shock may be thrown off his feet and will experience severe pain and possibly burns at the point of contact. This in most cases is fatal.

Electric shock can also cause burning of the skin at the point of contact.

Action to be taken in case of an electric shock : If the victim of an electric shock is in contact with the supply, break the contact of the victim making with the electricity by any one or more of the following.

– Switch off the electric power, insulate yourself and pull away the person from the electrical contact

or

Remove the mains electric plug. Avoid direct contact with the victim. Wrap your hands using dry cloth or paper, if rubber gloves are not available.

or

Remove the electric contact made by wrenching the cable/ equipment/point free from contact using whatever is at hand to insulate yourself such as a wooden bar, rope, a scarf, the victim's coat-tails, any dry article of clothing, a belt, rolled up newspaper, non-metallic hose, PVC tubing, baked paper, tube etc. and break the contact by pushing or pulling the person or the cable/equipment/point free

or

Stand on some insulating material such as dry wood, rubber or plastic, or whatever is at hand to insulate yourself and break the contact by pushing or pulling the person or the cable/equipment/point free.

If you are uninsulated, do not touch the victim with your bare hands. Otherwise you also will get a shock and become a victim.

If the victim is aloft(working on a pole or at raised place), take suitable measures to prevent him from falling or atleast ensure that his fall is safe.

Treatment to be given for the victim of electric shock

Electric burns on the victim may not look big/large. But it may be deep rooted. Cover the burnt area with a clean, sterile dressing. Get a doctor's help to treat him as quickly as possible.

If the victim is unconscious after an electric shock, but is breathing, carry out the following first aid:

– loosen the clothing at the neck, chest and waist

– place the victim in the recovery position.

– Keep a constant check on the breathing and pulse rate. If you find them feeble, immediately give artificial respiration and press the lower rib to improve the heartbeat.

– Keep the casualty warm and comfortable.

– Send for a doctor immediately.

Do not give an unconscious person anything through the mouth.

Do not leave a unconscious person unattended.

A person having received electric shock may also have burn injuries. DO NOT waste time by applying first aid to the burns until breathing has been restored and the patient can breathe normally unaided.

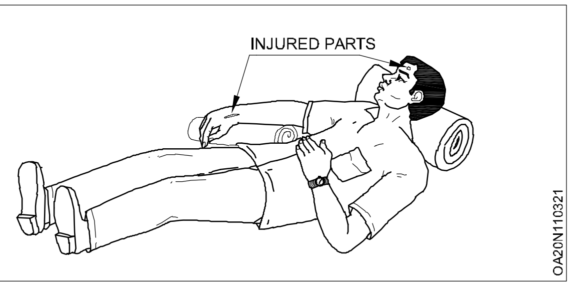
Treatment to be given in case of burns, severe bleeding : Burns caused due to electrical shock are very painful. If a large area of the body is burnt, clean the wound using clear water, or with clean paper, or a clean shirt. This treatment relieves the victim of pain. Do not give any other treatment on your own. Send for a doctor for further treatment.

A wound which is bleeding profusely, especially in the wrist, hand or fingers must be considered serious and must receive a doctor's attention. As an immediate first aid measure, carry out the following;

– make the patient lie down and rest

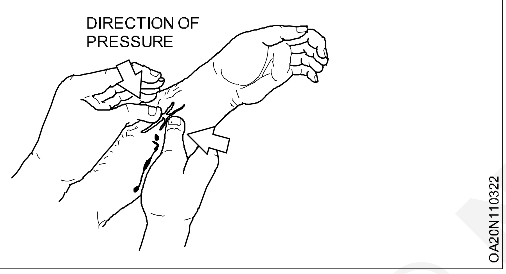
– if possible, raise the injured part above the level of the body as shown in Fig 1.

Fig 1



Squeeze together the sides of the wound as shown in Fig 2. Apply pressure as long as it is necessary to stop the bleeding.

Fig 2



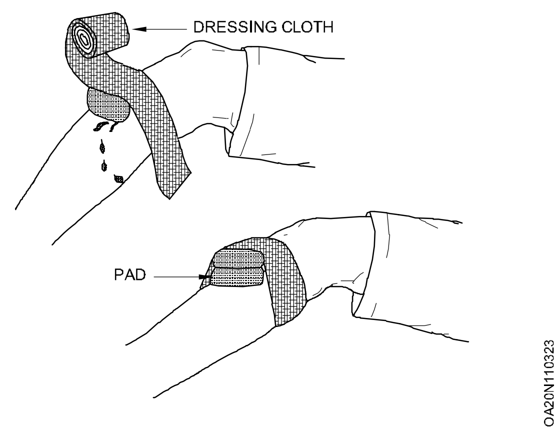
When the bleeding stops temporarily, put a dressing over the wound using sterilized cotton, and cover it with a pad of soft material as shown in Fig 3.

If the wound is in the abdominal area (stab wound), caused by falling on a sharp tool, keep the patient bending over the wound to stop internal bleeding.

General procedural steps to be adopted for treating a person suffering from an electrical shock

1 Observe the situation. Choose the appropriate method(listed in earlier paragraphs) to release the person from electrical contact.

Fig 3



Do not run to switch off the supply that is far away or start searching for the mains switch.

2 Move the victim gently to the nearest ventilated place.

3 Check the victim's breathing and consciousness. Check if there are injuries in the chest or abdomen. Give artificial respiration/applying pressure on the heart if found necessary (refer in this lesson/exercise).

Use the most suitable method of giving artificial respiration depending upon the injuries if any on the chest/abdomen.

4 Send for a doctor.

Till the doctor arrives, you stay with the victim and render help as best as you can.

5 Place the victim in the recovery position.

6 Cover the victim with a coat, socks or any such thing to keep the victim warm.

Actions listed above must be taken syst ematically and briskly. Delay in treating the patient may endanger his life.

Personal Protective Equipment (PPE)

Objectives: At the end of this lesson you shall be able to
- **state what is personal protective equipment and its purpose**
- **name the two categories of personal protective equipment**
- **list the most common type of personal protective equipment**
- **list the conditions for selection of personal protective equipment.**

Personal Protective Equipment (PPE) : Devices, equipments, or clothing used or worn by the employees, as a last resort, to protect against hazards in the workplace. The Factories Act, 1948 and several other labour legislations 1996 have provisions for effective use of appropriate types of PPE. Use of PPE is very important.

Ways to ensure workplace safety and use personal protective equipment (PPE) effectively

- Workers to get up-to date safety information from the regulatory agencies that oversees workplace safety in their specific area.
- To use all available text resources that may be in work area and for applicable safety information on how to use PPE best.

- When it comes to the most common types of personal protective equipment, like goggles, gloves or bodysuits, these items are much less effective if they are not worn at all times, or whenever a specific danger exists in a work process. Using PPE consistently will help to avoid some common kinds of industrial accidents.
- Personal protective gear is not always enough to protect workers against workplace dangers, Knowing more about the overall context of your activity can help to fully protect from anything that might threaten health and safety on the job.
- Inspection of gear thoroughly to make sure that it has the standard of quality and adequately protect the user should be continuously carried out.

Categories of PPE-Small's'

Depending upon the nature of hazard, the PPE is broadly divided into the following two categories.

Non- respiratory : Those used for protection against injury from outside the body, i.e. for protecting the head, eye, face, hand, arm, foot, leg and other body parts

Respiratory: Those used for protection from harm due to inhalation of contaminated air.

They are to meet the applicable BIS (Bureau of Indian Standards) standards for different types of PPE.

The guidelines on 'Personal Protective Equipment' is issued to facilitate the plant management in maintaining an effective programme with respect to protection of persons against hazards, which cannot be eliminated or controlled by engineering methods listed in table 1.

Table 1

No	Title
PPE1	Helmet
PPE2	Safety footwear
PPE3	Respiratory protective equipment
PPE4	Arms and hands protection
PPE5	Eyes and face protection
PPE6	Protective clothing and coverall
PPE7	Ears protection
PPE8	Safety belt harness

Proper use of PPEs

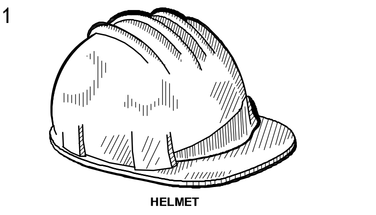
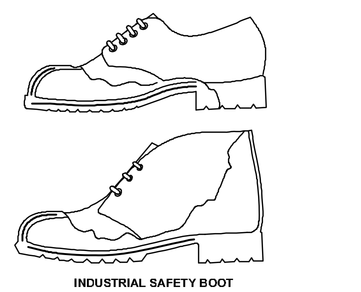
Having selected the proper type of PPE, it is essential that the workman wears it. Often the workman avoids using PPE. The following factors influence the solution to this problem.

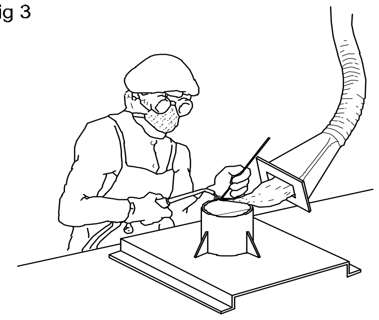
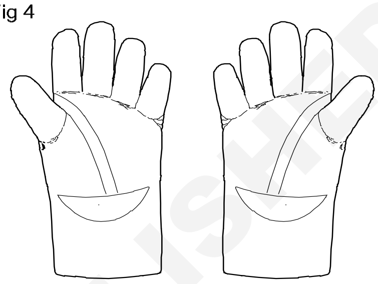
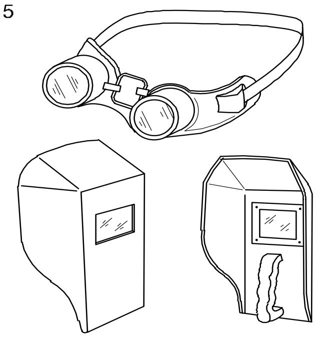
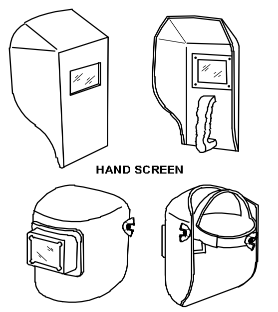
- The extent to which the workman understands the necessity of using PPE
- The ease and comfort with which PPE can be worn with least interference in normal work procedures
- The available economic, social and disciplinary sanctions which can be used to influence the attitude of the workman
- The best solution to this problem is to make wearing of PPE' mandatory for every employee.
- In other places, education and supervision need to be intensified. When a group of workmen are issued PPE for the first time.

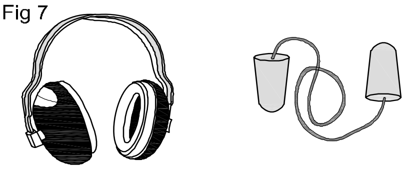
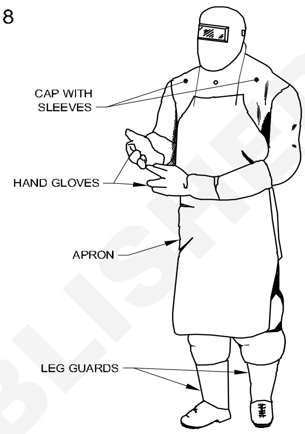
Quality of PPE's

PPE must meet the following criteria with regard to its quality-provide absolute full protection against possible hazard and PPE's be so designed and manufactured out of materials that it can withstand the hazards against which it is intended to be used.

Personal protective equipments and their uses and hazards are listed in **Table**

Types of protection	Hazards	PPE to be used
Head protection	1. Falling objects 2. Striking against objects 3. Spatter	Helmets Fig 1 
Foot protection	1. Hot spatter 2. Falling objects 3. Working wet area	Leather leg guards Safety shoes Gum boots Fig 2 

Nose	1. Dust particles 2. Fumes/gases/ vapours	Nose mask Fig 3 
Hand Protecion	1. Heat burn due to direct contact 2. Blows spark moderate heat 3. Electric shock	Hand gloves Fig 4 
Eye protection	1. Flying dust particles 2. UV rays, IR rays heat and High amount of visible	Goggles, Face shield Face shield radiation Hand shield, Head shield Fig 5 
Face protection	1. Spark generated during Welding, grinding 2. Welding spatter striking 3. Face protection from UV rays	Face shield Head shield with or without ear muff Helmets with welders Screen for welders Fig 6 

Ear protection	1. High noise level	Ear plug Ear muffs Fig 7 
Body protection	1. Hot particles	Leather aprons Fig 8 

Selection of PPE's requires certain conditions

- Nature and severity of the hazard
- Type of contaminant, its concentration and location of contaminated area with respect to the source of irrespirable air
- Expected activity of workman and duration of work, comfort of workman when using PPE
- Operating characteristics and limitation of PPE
- Easy of maintenance and cleaning
- Conformity to Indian / International standards and availability of test certificate.

Response to emergencies - Power failure, System failure & Fire

Objectives: At the end of this lesson you shall be able to
- **state the reason of emergency power failure**
- **state the cause of system failure**
- **state the fire safety and immediate actions.**

1 If there is a power failure, start the emergency generator. This provides power to close the shutter, which is the first priority. The generator will also keep the UPSs and the cryogenic compressors running,

- Get a flash light.
- Look out for power transfer switch and switch over to normal power to emergency power by pressing the latch.
- Check the fuel valves open or not - Open the valves.
- Check to see that the main breaker switch ON the generator is in OFF position.
- Move the starter switch of the generator to run position. The engine will start at once.
- Allow few minutes to warm up the engine.
- Check all the gauges, pressure, temperature, voltage and frequency.
- Check the "AC line" and "Ready" green light on the front panel.

2 System failure

- If the bug or virus, invades the system. The system failure happens.
- Several varieties of bugs are there

1 1 Assassin bug

2 Lightening bug

3 Brain bug

For more details refer instruction manual for "System failure".

3 Fire failure

When fire alarm sounds in your buildings

1 Evacuate to outside immediately.

2 Never go back

3 Make way for fire fighters and their trucks to come

4 Never use an elevator

5 Do not panic

Reporting emergency

Objectives : At the end of this lesson you shall be able to
- **explain and report an emergency**

Report an emergency

Reporting an emergency is one of those things that seems simple enough, until actually when put to use in emergency situations. A sense of shock prevails at the accident sites. Large crowd gather around only with inquisitive nature, but not to extend helping hands to the victims. This is common in road side injuries. No passerby would like to get involved to assist the victims. The first aiders need to adapt multitask strategy to control the crowd around, communicate to the rescue team, call ambulance etc, all to be done simultaneously. The mobile phones help to a greater deal for such emergencies. Few guidelines are given below to approach the problems.

Assess the urgency of the situation. Before you report an emergency, make sure that the situation is genuinely urgent. Call for emergency services if you believe that a situation is life-threatening or otherwise extremely disruptive.

- A fire - If you're reporting a fire, describe how the fire started and where exactly it is located. If someone has already been injured, missing, report that as well.
- A life - threatening medical emergency, explain how the incident occured and what symptoms the person currently displays.

Call emergency service

The emergency number varies - 100 for Police & Fire, 108 for Ambulance.

Report your location

The first thing the emergency dispatcher will ask where you are located, so that the emergency services can get there as quickly as possible. Give the exact street address, if you're not sure of the exact address, give approximate information like landmarked etc.

Guidelines for good shop floor maintenance

Objectives: At the end of this lesson you shall be able to
- **list the benefits of a shop floor maintenance**
- **state what is 5S**
- **list the benefits of 5S**

Benefits of a shop floor maintenance

Some of the benefits which may be derived from the utilization of a good Shop Floor Maintenance are as follows:

- Improved Productivity
- Improved operator efficiencies.
- Improved support operations such as replenishment moves and transportation of work in process and finished goods
- Reduction of scrap
- Better control of your manufacturing process
- More timely information to assist shop floor supervisors in managing their assigned production responsiblities.
- Reduction of down time due to better machine and tool monitoring.
- Better control of Work In Progress inventory, what is and where it is improved on time schedule performance.

5S Concept

5S is a Japanese methodology for workplace organisation. In Japanese it stands for seiri (SORT), seiton (SET), seiso (SHINE), seiketsu(STANDARDIZE), and shitsuke (SUSTAIN).

The list describes how to organize a work space for efficiency and effectiveness by identifying and storing the items used, maintaining the area and items, and sustaining the new order.

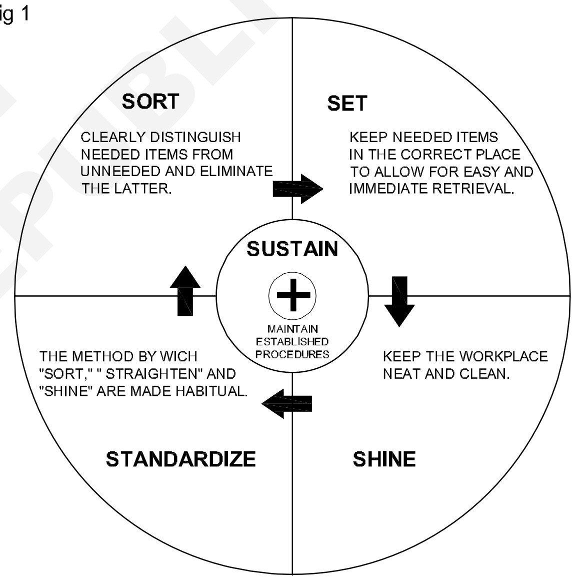
The list describes how to organize a work space for efficiency and effectiveness by identifying and strong the items used, maintaining the area and items, and sustaining the new order.

5S Wheel

The Benefits of the 5s system

- Increase in productivity
- Increase in quality
- Reduction in cost

Fig 1



5S WHEEL

Importance of housekeeping

Objectives: At the end of this lesson you shall be able
- **list the steps involved in house keeping**
- **state good shop floor practices followed in industry.**

House keeping

The following activities to be performed for better up keep of making environment:

- **Cleaning of shop floor:** Keep clean and free from accumulation of dirt and scrap daily
- **Cleaning of machines:** Reduce accidents by keeping machines cleaned well
- **Prevention of leakage and spillage:** Use splash guide in machine and collecting tray
- **Disposal of scrap:** Empty scrap, wastage, swarf from respective containers regularly
- **Tools storage -** Use special racks, holders for respective tools
- **Storage spaces :** Identify storage areas for respective same do not leave any material in gangway
- **Filling methods-** Do not overload platform, floor and keep material at safe height.
- **Material handling :** Use forklifts, conveyors and hoist according to the volume and weight of the package.

Good shop floor practices followed in industry

- Good shop floor practices are motivating action plans for environment of the manufacturing process.
- All workers are communicated with daily target on manufacturing, activities.
- Informative charts are used to post production, quality and safety result compared to achievements.
- workers are trained on written product quality standards
- manufactured parts are inspected to ensure adherence to quality standards.
- production processes are planned by engineering to minimize product variation.
- 5s methods are used to organize the shop floor and production lines.
- workers are trained on plant safety practices in accordance with occupational safety Health (OSH) standards.
- Workers are trained on "root cause" analysis for determining the causes of not following.
- A written preventive maintenance plan for upkeep of plant, machinery & equipment
- Management meets with plant employees regularly to get input on process improvements
- Process improvement Teams are employed to implement "best practices"

Disposal of waste material

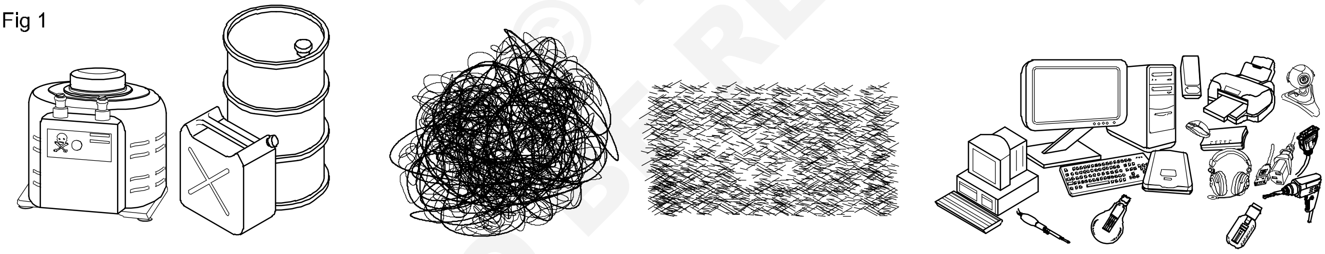
Objectives: At the end of this lesson you shall be able to
- **state what is waste material**
- **list the waste materials in a work shop**
- **explain the methods of disposal of waste material**
- **state advantage of disposal of waste material.**

Waste material : industrial waste is the waste produced by industrial activity such as that of factories, mills and mines.

List of waste material (Fig 1)

- Cotton waste
- Metal chips of different material.
- Oily waste such as lubricating oil, coolant etc.
- Other waste such electrical, glass etc.

Fig 1



Methods of waste disposal (Fig 2)

Recycling : Recycling is one of the most well known method of managing waste. It is not expensive and can be easily done by you. If you carry out recycling. you will save a lot of energy, resources and thereby reduce pollution.

Composting : This is a natural process that is completely free of any hazardous by-products. This process involves breaking down the materials into organic compounds that can be used as manure.

Landfills : Waste management through the use of landfills involves the use of a large area. This place is dug open and filled with the waste.

Burning the waste material : If you cannot recycle or if there are no proper places for setting up landfills, you can burn the waste matter generated in your household. Controlled burning of waste at high temperatures to produce steam and ash is a preferred waste disposal techinque.

Advantage of waste disposal:

- Ensures workshop neat & tidy
- Reduces adverse impact on health
- Improves economic efficiency
- Reduces adverse impact on environment

Incineration (Fig 3) : It is the process of controlled combustion of garbage to reduce it to incombustible matter, ash, waste gas and heat. It is treated and released into the environment (Fig.3). This reduces 90% volume of waste, some time the heat generated used to produce electric power. :

Waste compaction : The waste materials such as cans and plastic bottles compact into blocks and send for recycling. This process need space thus making transportation and positioning easy.

Fig 2

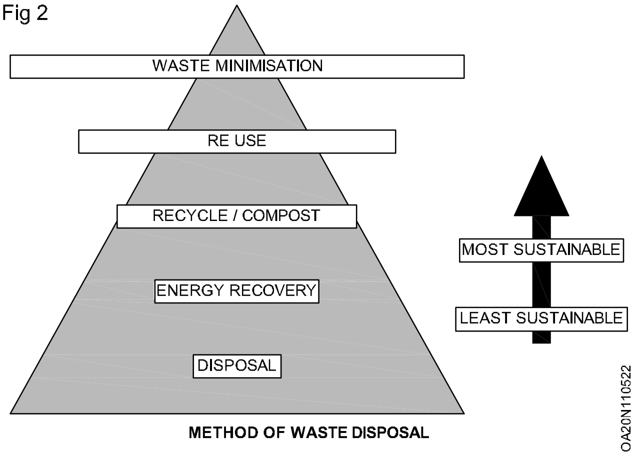
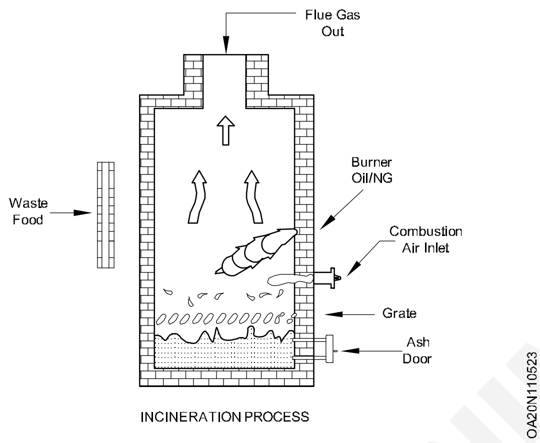


Fig 3



Colour code for bins for waste segregation given in Table 1

Table 1

Sl.No.	Waste Material	Color code
1	Paper	Blue
2	Plastic	Yellow
3	Metal	Red
4	Glass	Green
5	Food	Black
6	Others	Sky blue

Occupational safety and health

Objectives: At the end of this lesson you shall be able to
- **define safety**
- **state the goal of occupational health and safety**
- **explain need of occupational health and safety**
- **state the occupational hygiene**
- **explain occupational hazards**

Safety

Safety means freedom or protection from harm, danger, hazard, risk, accident, injury or damage.

Occupational health and safety

- Occupational health and safety is concerned with protecting the safety, health and welfare of people engaged in the work or employment.
- The goal is to provide a safe work environment and to prevent hazards.
- It may also protect co-workers, family members, employers, customers, suppliers, nearby communities, and other members of the public who are affected by the workplace environment.
- It involves interactions among many related areas, including occupational medicine, occupational (or industrial) hygiene, public health, and safety engineering, chemistry, and health physics.

Need of occupational health and safety

- Health and safety of the employees is an important aspect of a company's smooth and successful functioning.
- It is a decisive factor in organizational effectiveness. It ensures an accident-free industrial environment.
- Proper attention to the safety and welfare of the employees can yield valuable returns.
- Improving employee morale
- Reducing absenteeism
- Enhancing productivity
- Minimizing potential of work-related injuries and illnesses
- Increasing the quality of manufactured products and/ or rendered services.

Occupational (Industrial) hygiene

- Occupational hygiene is anticipation, recognition, evaluation and control of work place hazards (or) environmental factors (or) stresses
- This is arising in (or) from the workplace.
- Which may cause sickness, impaired health and well being (or) significant discomfort and inefficiency among workers.

Anticipation (Identification): Methods of identification of possible hazards and their effects on health

Recognition (Acceptance): Acceptance of ill-effects of the identified hazards

Evaluation (Measurement & Assessment): Measuring or calculating the hazard by Instruments, Air sampling and Analysis, comparison with standards and taking judgement whether measured or calculated hazard is more or less than the permissible standard.

Control of workplace hazards: Measures like Engineering and Administrative controls, medical examination, use of Personal Protective Equipment (PPE), education, training and supervision

Occupational hazards

"Source or situation with a potential for harm in terms of injury or ill health, damage to property, damage to the workplace environment, or a combination of these".

Types of occupational health hazards

- Physical Hazards
- Chemical Hazards
- Biological Hazards
- Physiological Hazards
- Mechanical Hazards
- Electrical Hazards
- Ergonomic Hazards.

1 Physical hazards

- Noise
- Heat and cold stress
- Radiation (ionising & Non-ionising)
- Vibration
- Illumination etc.,

2 Chemical hazards

- Inflammable
- Explosive
- Toxic
- Radioactive
- Corrosive

3 Biological hazards

- Bacteria
- Virus
- Fungi
- Plant pest
- Infection.

4 **Physiological**

- Old age
- Sex
- Ill health
- Sickness
- Fatigue.

5 **Psychological**

- Wrong attitude
- Smoking
- Alcoholism
- Unskilled
- Poor discipline
  - absentism
  - disobedience
  - aggressive behaviours
- Accident proneness etc,
- Emotional disturbances
  - violence
  - bullying
  - sexual harassment

6 **Mechanical**

- Unguarded machinery
- No fencing
- No safety device
- No control device etc.,

7 **Electrical**

- No earthing
- Short circuit
- Current leakage
- Open wire
- No fuse or cut off device etc,

8 **Ergonomic**

- Poor manual handling technique
- Wrong layout of machinery
- Wrong design
- Poor housekeeping
- Wrong tools etc,

Safety Slogan

A Safety rule breaker, is an accident maker

Safety, health and environment guidelines

Objectives : At the end of this lesson you shall be able to
- **state safety, health and environment guidelines**
- **state various section provided in factories act, 1948 on occupational safety and health.**

Safety, Health and Environment guidelines as per

Rules & regulations followed in India are listed as follows:

1 The Environment (Protection) Act, 1986
2 The Environment (Protection) Rules, 1986
3 Environmental Impact Assessment of Development Projects 1994
4 The Prevention and control of pollution (uniform consent procedure) Rules,1999
5 Manufacture, Storage and Import of Hazardous chemicals Rules, 1989
6 Manufacture, Storage and Import of Hazardous chemical (Amendment) Rules, 2000
7 Hazardous Wastes (Management and Handling) Rules, 1989
8 Bio-Medical Waste (Management and Handling) Rules, 1998
9 Batteries (Management & Handling) Rules, 2000
10 Ozone Depleting Substances (Regulation) Rules, 2000
11 The Air (Prevention and Control of Pollution) Act, 1981 as amended by Amendment Act, 1987
12 The Air (Prevention and Control of Pollution) Act, 1982
13 The Air (Prevention and Control of Pollution) Rules, 1982
14 The Tamil Nadu Air (Prevention and Control of Pollution) Rules, 1983
15 Noise Pollution (Regulation and Control) Rules, 2000
16 The Water (Prevention and Control of Pollution) Act, 1974 as amended in 1978 & 1988
17 The Tamil Nadu Water (Prevention and Control of Pollution) Rules,1983
18 The Water (Prevention and Control of Pollution) Cess Act, 1977 as amended by Amendment Act, 1991.
19 The Water (Prevention and Control of Pollution) Cess Rules, 1978
20 Factories Act, 1948
21 Tamilnadu Factories Rules, 1950
22 The Gas Cylinders Rules, 1981
23 The Indian Electricity Act, 1910
24 The Indian Electricity Rules, 1956

25 The Petroleum Act, 1934

26 The Petroleum Rules,1976

27 The Public Liability Insurance Act, 1991

28 The Public Liability Insurance Rules, 1991

29 Hazardous Wastes (Management and Handling) Rules,2000

Poor working conditions affect a worker's health and safety. Unsafe or unhealthy working conditions are not isolated to industries and can be anywhere. Whether inside or outside, the workshop workers may face many health and safety hazards. It also affects the environment of the workers. Occupational hazards have harmful effects on workers, their families, and other people in the community, as well as on the physical environment around the workplace.

The provisions made in as applicable to the Factories Act, 1948 (Act No.63 of 1948), as amended by the Factories (Amendment) Act, 1987 (Act 20 of 1987) are as follows:

Occupational safety and health

various sections provided in factories act, 1948 are under the following headings:

- Fencing of machinery
- Work on or near machinery in motion
- Employment of young persons on dangerous machines
- Striking gear and devices for cutting off power
- Self-acting machines
- Casing of new machinery
- Prohibition of employment of women and children near cotton-openers
- Hoist and lifts
- Lifting machines, chains, ropes and lifting tackles
- Revolving machinery
- Pressure plant
- Floors, stairs and means of access
- Excessive weights
- Protection of eyes
- Precautions against dangerous fumes, gases, etc
- Precautions regarding the use of portable electric light
- Explosive or inflammable dust, gas, etc
- Precautions in case of fire
- Power to require specifications of defective parts or test of stability
- Safety of buildings and machinery
- Maintenance of buildings
- Power to make rules to supplement this Chapter
- Cleanliness
- Disposal of wastes and effluents
- Ventilation and temperature
- Dust and fume
- Artificial humidification
- Overcrowding
- Lighting
- Drinking water
- Latrines and urinals
- Spittoon

Basic understanding on hot work, confined space work and material handling equipment

Objectives: At the end of this lesson you shall be able to
- **state what is hot working**
- **brief confined space work**
- **state the material handling equipments.**

Hot work

Hot work is defined as forging, gas cutting, welding, soldering and brazing operations for construction, maintenance/repair activities.

Hot work fire and explosive hazards. Workers performing hot work such as welding, gas cutting, brazing, soldering are exposed to the risk of fires from ignition or flammable or combustible materials in the space, and from leaks of flammable gas into the space, from hot work equipment.

A confined space also has limited or restricted means for entry or exist and is not designed for continuous occupancy. It includes but are not limited to tanks, vessels, silos, storage bins, hoppers, vaults, pits, manholes, tunnels, equipment housings, duct work, pipelines, etc.

Materials handling equipment

Materials handling equipment is a mechanical equipment used for the movement, storage, control and protection / protecting of materials, goods and products throughout the process of manufacturing, distribution, consumption and disposal.

Different types of material handling equipment

- Tools
- Vehicles
- Storage units
- Appliance and accessories

Racks

Pallet racks, drive-through or drive-in racks, push back racks, and sliding racks.

Truck/Trolley

Conveyor system

- Fork lift
- Cranes
- Pallet truck

Lifting and handling loads

Objectives : At the end of this lesson you shall be able to
- **state the types of injury caused by the improper method of lifting and carrying loads and how to prevent them**
- **state the 6 points in the process of manual lifting methods.**

Many of the accidents reported involve injuries caused by lifting and carrying loads. An Electrician may need to install motors, lay heavy cables, do wiring, which may involve a lot of lifting and carrying of loads. Wrong lifting techniques can result in injury.

A load need not necessarily be very heavy to cause injury The wrong way of lifting may cause injury to the muscles and joints even though the load is not heavy.

Further injuries during lifting and carrying may be caused by tripping over and object and falling or striking an object with a load.

Type of injury and how to prevent them?

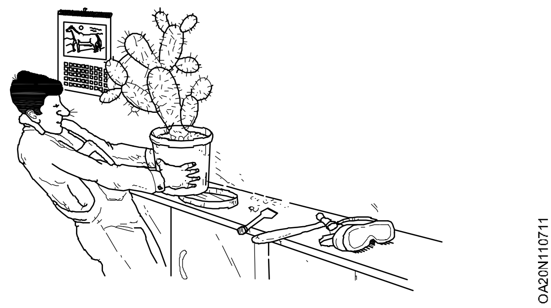
Cuts and abrasions

Cuts and abrasions are caused by rough surfaces and jagged edges:

By splinters and sharp or pointed projections. (Fig 1)

Leather hand gloves will usually be suffcient for protection, but the load should be checked to make sure of this, since large or heavy loads may invovle body contact as well.

Fig 1



Crushing of feet or hands

Feet or hands should be so positioned that they will not be trapped by the load. Timber wedges can be used when raising and lowering heavy loads to ensure fingers and hands are not caught and crushed.

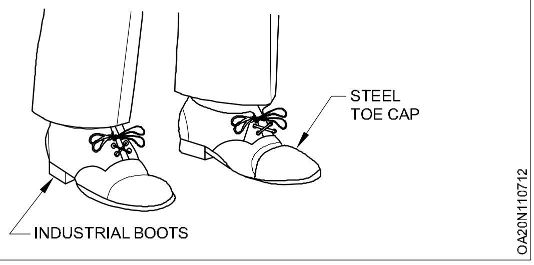
Safety shoes with steel toe caps will protect feet (Fig 2)

Strain to muscles and joints

Strain to muscles and joints may be result of:

- Lifting a load which is too heavy, or lifting incorrectly.

Fig 2



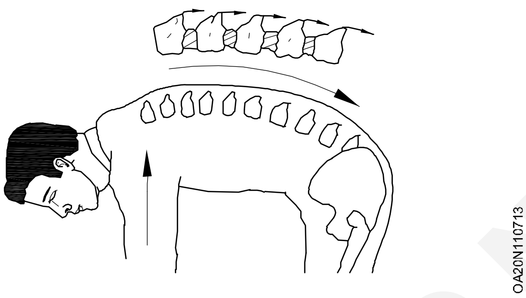
Sudden and awkward movements such as twisting or jerking during a lift can put severe strain on muscles.

Stop lifting'-lifting from a standing position with the back rounded increases the chance of back injury.

The human spine is not an efficient weight lifting machine and can be easily damaged if incorrect techniques are used.

The stress on a rounded back can be about six times greater than if the spine is kept straight. Fig 3 shows and example of stoop lifting.

Fig 3



Preparing to lift

Before lifting or handling any load ask yourself the following questions.

What has to be moved?

Where from and where to?

Will assistance be required?

Is the route through which the load has to be moved is clear of obstacles?

Is the place where the load has to be kept after moving is clear of obstacles?

Load which seems light enough to carry at first will become progressively heavier, the further you have to carry it.

The person who carries the load should always be able to see over or around it.

The weight that a person can lift will vary according to:

- Age
- Physique, and
- Condition

It will also depend on whether one is used for lifting and handling heavy loads.

What makes an object difficult to lift and carry?

1 Weight is not the only factor which makes it difficult to lift and carry.

2 The size and shape can make an object awkward to handle.

3 Loads high require the arms to be extended in front of the body, place more strain on the back and stomach.

4 The absence of hand holds or natural handling points can make it difficult to raise and carry the object.

Correct manual lifting techniques

1 Approach the load squarely, facing the direction of travel

2 The lift should start with the lifter in a balanced squatting position, with the legs slightly apart and the load to be lifted held close to the body.

3 Ensure that a safe firm hand grip is obtained. Before the weight is taken, the back should be straightened and held as near the vertical position as possible. (Fig 4)

Fig 4

4 To raise the load, first straighten the legs. This ensures that the lifting strain is being correctly transmitted and is being taken by the powerful thigh muscles and bones.

5 Look directly ahead, not down at the load while straightening up, and keep the back straight, this will ensure a smooth, natural movement without jerking or straining (Fig 5)

Fig 5

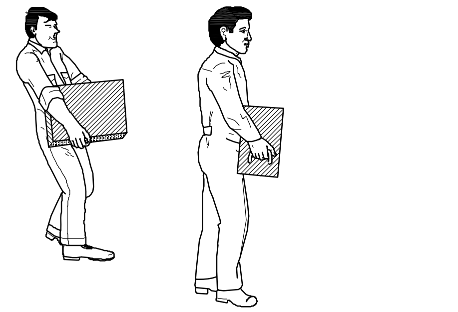
6 To complete the lift, raise the upper part of the body to the vertical position. When a load is nearer to an individual's maximum lifting capacity it will be necessary to lean back on the hips slightly (to counter balance the load) before straightening up.(Fig 6)

Keeping the load well near to the body, carry it to the place where it is to be set down. When turning, avoid twisting from the waist- turn the whole body in one movement.

Lowering the load

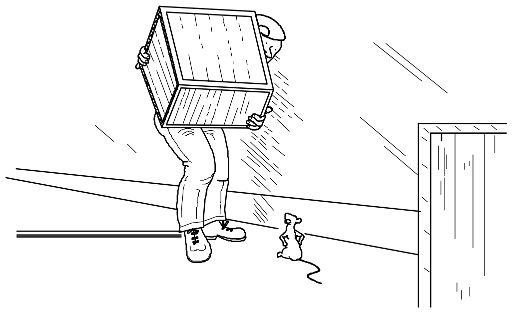
Make sure the area is clear of any obstructions. (Fig 7)

Fig 6



Bend the knees to a semi- squatting position, keep the back and head erect by looking straight ahead, not down at the load. It may be helpful to rest the elbows on the thighs during the final stage of lowering.

Fig 7



Moving heavy equipment

Objectives: At the end of this lesson you shall be able to
- **explain the methods followed in industry to move heavy equipment**
- **describe the procedure to be followed for moving heavy equipment on layers and rollers**
- **list the safety consideration while raising a load and moving a load.**

Heavy equipments are moved in industry using any of the following methods.

Crane and slings

Winches

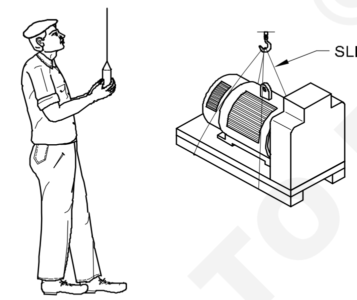
Machine moving platforms

Layers and rollers

Using crane and slings

This method is used whenever loads are to be lifted and moved. (Fig 1)

Fig 1



Examine the steel rope sling for any cut, abrasion, wear fraying or corrosion.

Damaged slings must not be used.

Distribute the weight as evenly as possible between the slings when using more than one sling. (Fig 1)

Keep the slings as near to vertical as possible.

Winches : Winches are used to pull heavy loads along the ground. They may be power-driven (Fig 2) or hand operated. (Fig 3)

Ensure that the safe working load (SWL) of the winch is adequate for the task.

Secure the winch to a structure which is strong enough to withstand the pull.

Fig 2

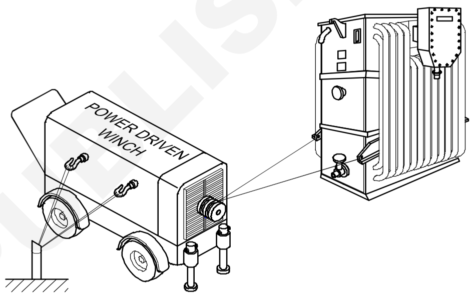
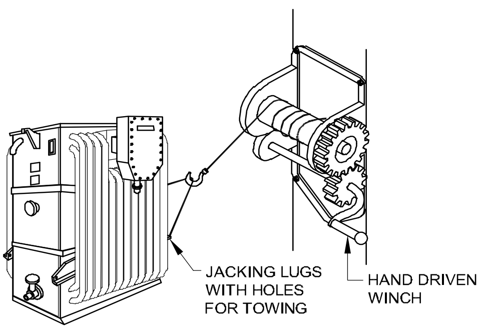


Fig 3



Ensure that the safe working load (SWL) of the Winch is adequate for the task.

Secure the Winch to a structure which is strong enough to withstand the pull

On open ground, drive long stakes into the ground and secure the winch to them.

Choose a suitable sling and pass it around the base of the load. Secure it to the hook of the winch.

Some heavy items have special legs welded to them for jacking and towing purposes.

Safety consideration

Before using any winch, check that the brake and ratchet mechanism are in working order. Practise how to use the brakes.

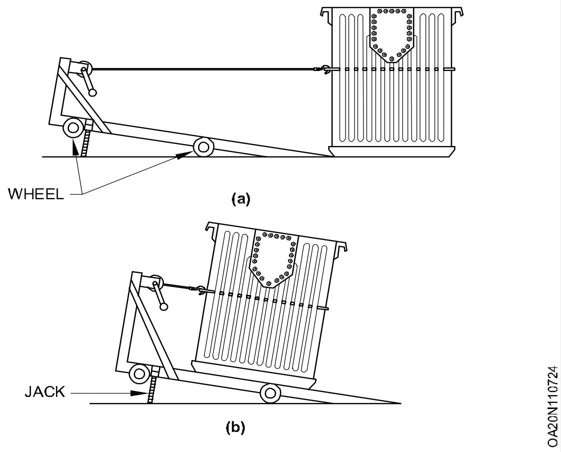
Keep hands and fingers well away from the gear wheels.

Keep the bearings and gears oiled or greased.

Machine moving platforms

This is a special device made to move heavy equipment in industry. Fig 4 shows the method of loading a heavy transformer.

Fig 4



Pass a suitable sling round the load at a convenient height.

Attach the sling to the hook of the winch and draw the load on the platform until its centre of gravity lies between the front and rear wheels.

Lower the jacks so that the platform rests on its wheels.

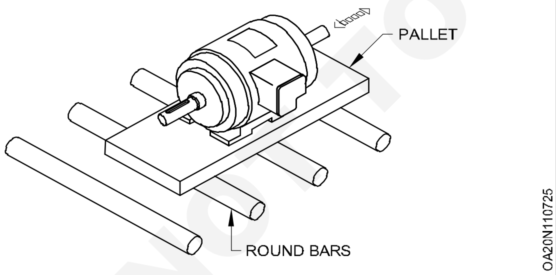
For unloading follow the procedure in the reverse order.

Using layers and rollers

Sometimes a load cannot be moved along the ground because of the irregular shape of its base or because it is not rigid enough.

Place such a load on a flat-bottomed pallet or 'layer' resting on the round bars. (Fig 5)

Fig 5



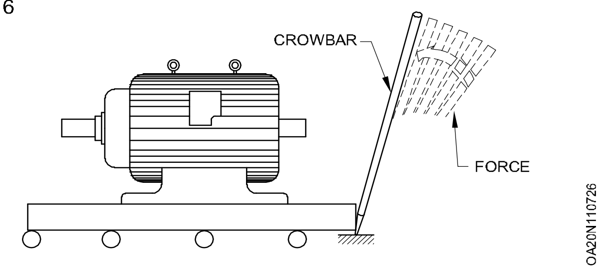
Ensure the bars (rollers) are long enough to project at each side of the load, for ease of handling.

They should be large enough to roll easily over any uneven surface along the route but should be small enough to be handled easily.

Two or three bars of equal diameter are sufficient for most loads but if four or more are used, the load may be moved faster as there is no delay when moving the rear bar to the front. (Fig 5)

Move the load by using a crowbar as shown in Fig 6. Keep the crowbar at the end of the pallet with an angle and a firm grip on the ground. Apply the force at the top of the bar as shown.

Fig 6



Caution

When a load is on rollers, only shallow slopes can be negotiated.

Hold the load in check all the time if it is on the slope.

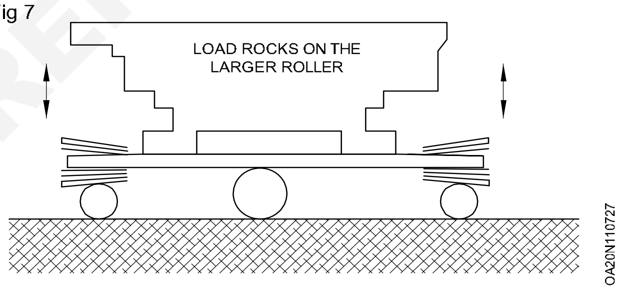
Use a winch with an effective brake for this operation.

To negotiate a corner on rollers

For a moderate load, insert one roller a little larger in diameter than the others as the corner is approached.

When this roller is under the centre of gravity of the load, the load can be rocked to and fro on the roller and swivelled around sideways. (Fig 7)

Fig 7

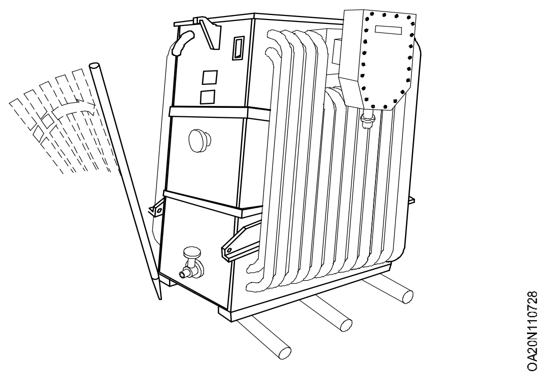


For heavier loads

Stop the load on the roller at the beginning of the corner.

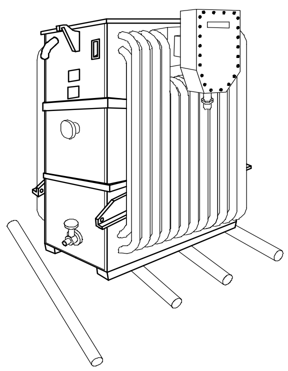
Twist the load round on the rollers by pushing the sides with crowbars until the load is just over the ends of the rollers. (Fig 8)

Fig 8



Place some rollers at an angle to the front of the load. (Fig 9)

Fig 9



Push the load forward on to these rollers.

Twist the load further round and place the freed rollers in front of and at an angle to the load.

Continue until the load is pointing in the desired direction.

Safety consideration

Moving heavy loads with crowbars or jacks

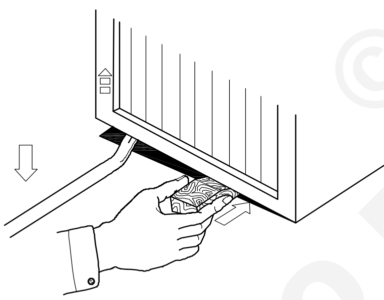
Make sure your hands are clear of the load before lowering it on to the packing or rollers.

Do not use your hands underneath the packing when positioning it. Use a push block.

Place the packing on the floor and push it under the load. (Fig 10)

Hold it by its side faces keeping the fingers well away from the lower edge of the load and from the floor. (Fig 10)

Fig 10



Raising a load

Check that the slings are correctly secured to the load and to the hook. Ensure they are not twisted or caught on a projecting part of the load.

Before starting to lift a load, if you cannot see an assistant on the far side of the load, verify that he is ready to lift the load and ensure that his hands are clear of the slings.

Warn nearby workers that the lifting is about to begin.

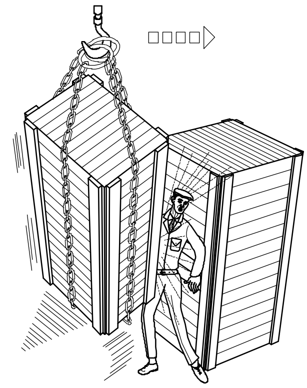
Lift slowly

Take care to avoid being crushed against other objects as the load rises. (Fig 11) It may swing or rotate as it leaves the ground.

Minimise such movement by location the hooks as accurately as possible above the centre of gravity of the load.

Keep the floor clear of unnecessary objects.

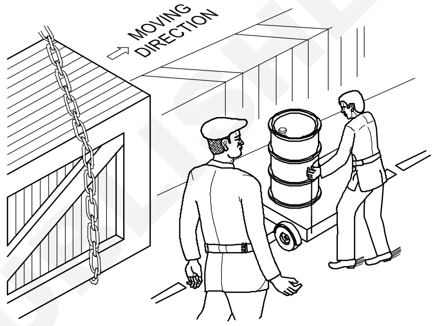
Fig 11



Moving a load

Check that there are no obstacles in the way of the crane and load. (Fig 12)

Fig 12



Stand clear off the load and move it steadily.

Be prepared to stop the load quickly if somebody moves into its path.

Allow for the natural swing of the load when changing speed or direction.

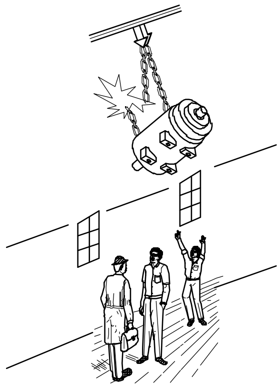
Ensure that the load will not pass over the head of other people. (Fig 13)

The tackle or sling may fall or slip.

Warn other workers to stand clearly away from the route of the load.

Remember that accidents do not happen, they are caused.

Fig 13

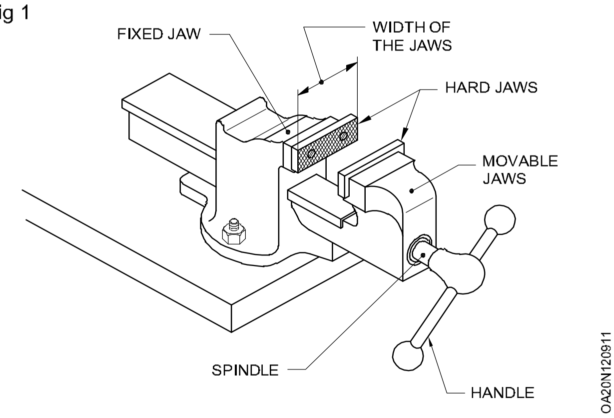


Parts of a bench vice

Objectives: At the end of this lesson you shall be able to
- **explain the size of the bench vice**
- **state the parts of the bench vice**
- **state the uses of vice clamps.**
- **explain the care and maintenance of vices.**

Parts of a bench vice (Fig 1)

Fig 1



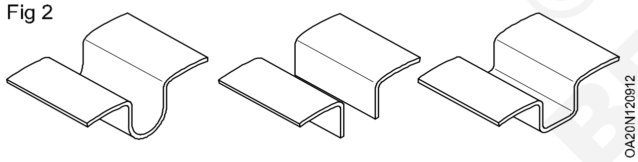
The following are the parts of a vice.

Fixed jaw, movable jaw, hard jaws, spindle, handle, box-nut and spring are the parts of a vice.

The box-nut and the spring are the internal parts.

Vice clamps or soft jaws (Fig 2)

Fig 2



To hold a finished work use soft jaws (vice clamps) made of aluminium over the regular jaws. This will protect the work surface from damage.

Do not over-tighten the vice as, the spindle may be damaged.

Care and maintenance of vices

- Always keep all threaded and moving parts clean by wiping the vice with a cloth after each use.
- Make sure to oil and lubricate the joints and sliding parts.
- To oil the sliding section, open the jaws completely and apply a layer of grease to the screen.
- Remove the rust if appears on the vice using rust remover chemical.
- When the vice is not in use bring the jaws lightly gap together and place the handle in a vertical position.
- Avoid striking the handle of the vice by a hammer for tightening fully, otherwise the handle will become bend or damaged.

Types of vices

Objectives: At the end of this lesson you shall be able to
- **state the different types of vices**
- **state the uses of quick releasing vice, pipe vice, hand vice, pin vice and leg vice.**

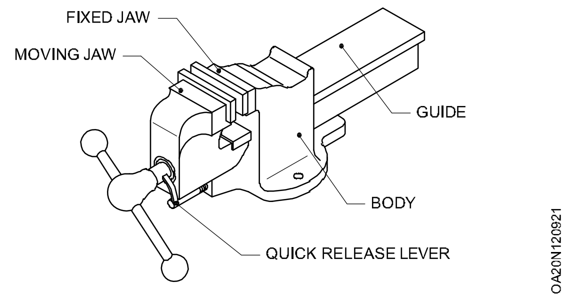
There are different types of vices used for holding work-pieces. They are quick releasing vice, pipe vice, hand vice, pin vice and toolmaker's vice.

Quick releasing vice (Fig 1)**:** A quick releasing vice is similar to an ordinary bench vice but the opening of the movable jaw is done by using a trigger (lever). If the trigger at the front of the movable jaw is pressed, the nut disengages the screw and the movable jaw can be set in any desired place quickly.

Pipe vice (Fig 2)**:** A pipe vice is used for holding round sections of metal, tubes and pipes. In the vice, the screw is vertical and movable. The jaw works vertically.

The pipe vice grips the work at four points on its surface. The parts of a pipe vice are shown in Fig 2.

Fig 1



Hand vice (Fig 3)**:** Hand vices are used for gripping screws, rivets, keys, small drills and other similar objects which are too small to be conveniently held in the bench vice. A hand vice is made in various shapes and sizes. The length varies from 125 to 150 mm and the jaw width from 40 to 44 mm. The jaws can be opened and closed using the wing nut on the screw that is fastened to one leg, and passes through the other.

Fig 2

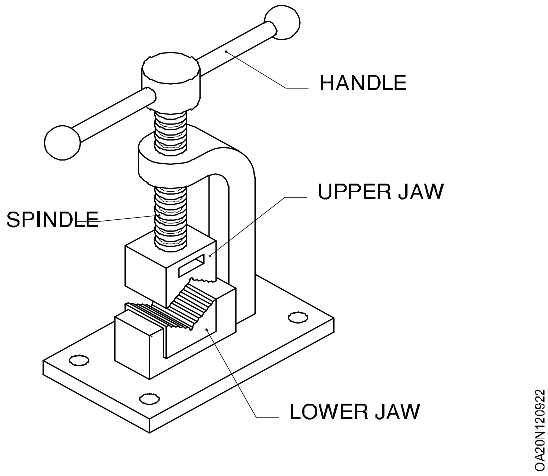
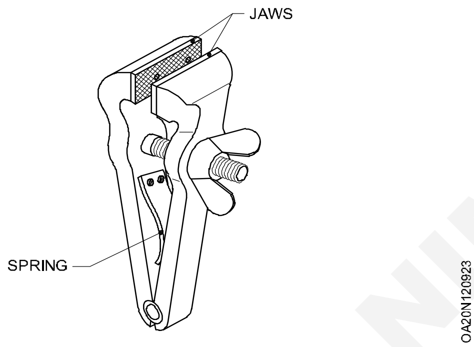
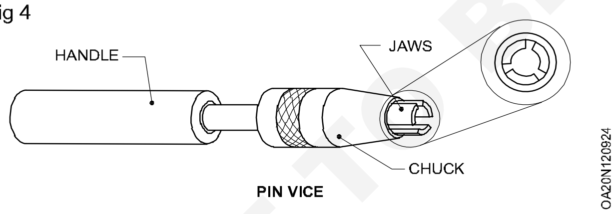


Fig 3



Pin vice (Fig 4)**:** The pin vice is used for holding small diameter jobs. It consists of a handle and a small collet chuck at one end. The chuck carries a set of jaws which are operated by turning the handle.

Fig 4



Toolmaker's vice (Fig 5)**:** The toolmaker's vice is used for holding small work which requires filing or drilling and for marking of small jobs on the surface plate. This vice is made of mild steel.

Toolmaker's vice is accurately machined.

Leg vice

A leg vice is a holding device generally used in a forge shop for bending and forging work. It is made fo mild steel to avoid breakage while hammering.

Main pats of a leg vice (Fig 6**)**

The following are the main parts of a leg vice.

1 Solid jaw

2 Movable jaw

3 Threaded jaw

4 Spindle

Fig 5

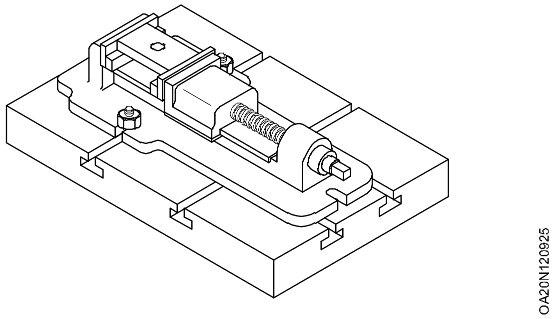
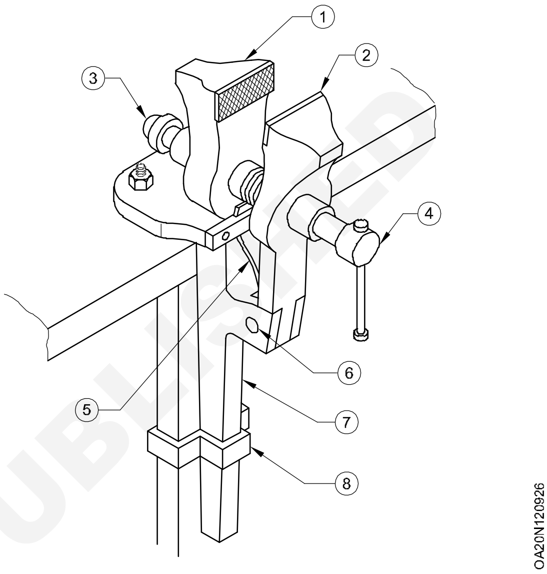


Fig 6



5 Spring

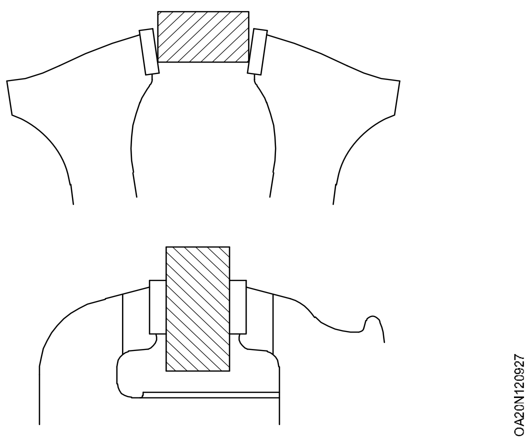
6 Pivot

7 Leg

8 Clamp

Since the hinged jaw moves in a radial path, the job held in this vice is not gripped properly because of the line contact. (Fig 7) Hence a work which can be carried out on a bench vice is not held on a leg vice. Jobs which require hammering only are held on a leg vice.

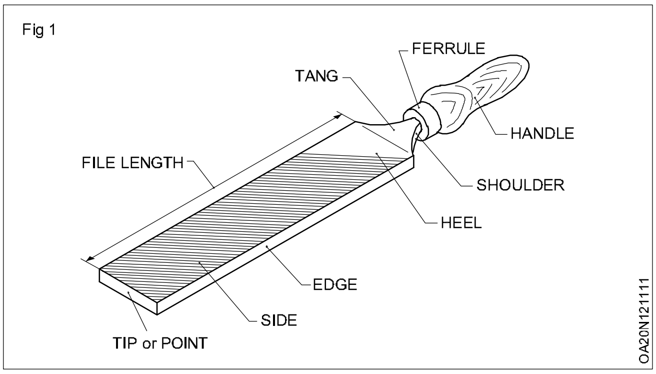
Fig 7



Elements of a file

Objectives: At the end of this lesson you shall be able to
- **state the parts of a file**
- **state the material of a file**

Parts of a file (Fig 1)



The parts of a file can be seen in figure 5, are

Tip or Point

the end opposite to tang

Face or side

The broad part of the file with teeth cut on its surface

Edge

The thin part of the file with a single row of parallel teeth

Heel

The portion of the broad part without teeth

Shoulder

the curved part of the file separating tang from the body

Tang

The narrow and thin part of a file which fits into the handle

Handle

The part fitted to the tang for holding the file

Ferrule

A protective metal ring to prevent cracking of the handle.

Materials

Generally files are made of high carbon or high grade cast steel. The body portion is hardened and tempered. The tang is however not hardened.

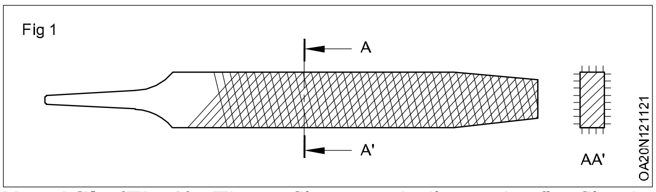
Types of files

Objectives: At the end of this lesson you shall be able to
- **explain the different shape of files(types)**
- **state the uses of flat files, Hand files square, round, half round, triangular and knife-edge files**
- **state the correct shape of files for filing different profiles.**

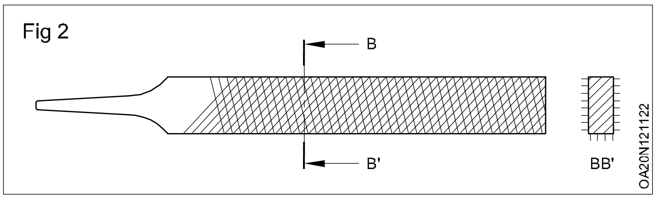
For filing and finishing different profiles, files of different shapes are used : The shape of files is stated by its cross section.

Common files of different shapes: Flat file, Hand file, Square file, Round file, Half round file, Triangular file and Knife-edge file.

Flat file (Fig 1): These files are of a rectangular cross section. The edges along the width of these files are parallel up to two-thirds of the length, and then they taper towards the point. The faces are double cut, and the edges single cut. These files are used for general purpose work. They are useful for filing and finishing external and internal surfaces.



Hand file (Fig 2) : These files are similar to the flat files in their cross section. The edges along the width are parallel throughout the length. The faces are double cut. One edge is single cut whereas the other is safe edge. Because of the safe edge, they are useful for filing surfaces which are at right angles to surfaces already finished.



Flat files are general purpose files. They are available in all grades. Hand files are particularly useful for filing at right angles to athe finished surface.

Square File: The square file is square in its cross section. It is used for filing square holes, internal square corners, rectangular openings, keyways and splines. (Fig 3)

Round file: A round file is circular in its cross section. It is used for enlarging the circular holes and filing profiles with fillets. (Fig 4)

Fig 3

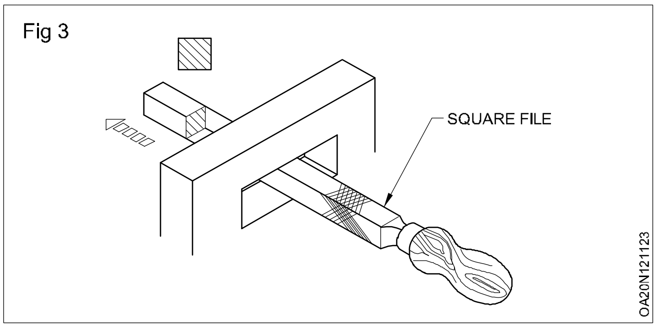
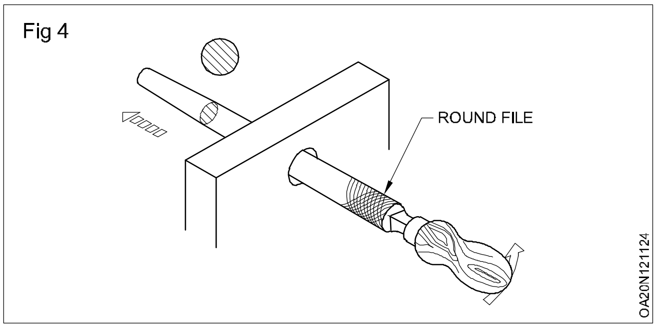
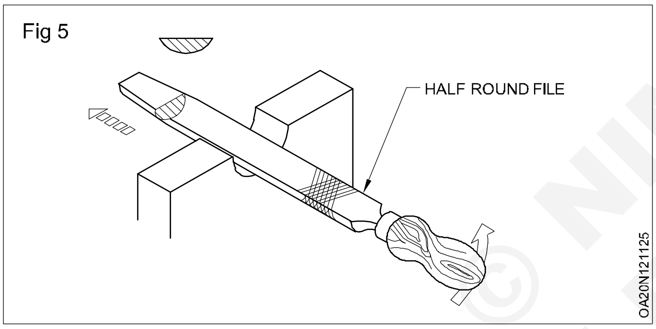


Fig 4



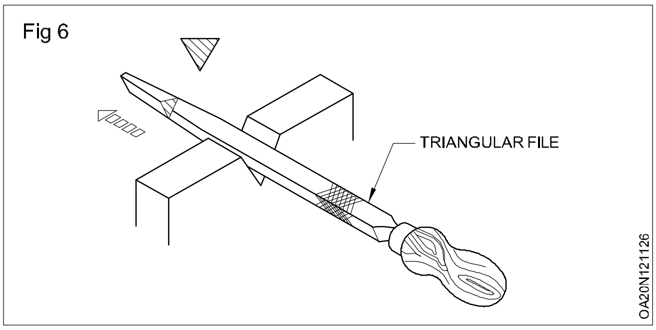
Half round file: A half round file is in the shape of a segment of a circle. It is used for filing internal curved surfaces. (Fig 5)

Fig 5



Knife edge file: A knife edge file has the cross section of a sharp triangles. It is used for filing narrow grooves and angles above 10^o (Fig 6)

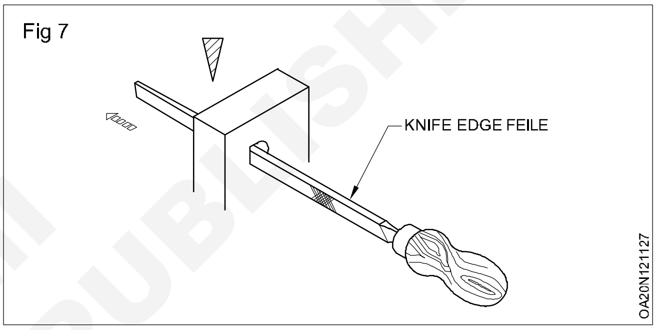
Fig 6



The above files have one third of their lengths tapered. They are available both single and double cuts.

Triangular file: A triangular file is of a triangular cross section. It is used for filing corners and angles which are more than 60^o. (Fig 7)

Fig 7



Square, round, half-round and triangular files are available in lengths of 100, 150, 200, 250, 300 and 400mm. These files are made in bastard, second cut and smooth grades.

Cut of files

Objectives: At the end of this lesson you shall be able to
- **explain the different cuts of files**
- **state the uses of each type of cut.**

The teeth of all file are formed by cuts made on its face. Files have cuts of different types. Files with different cuts have different uses.

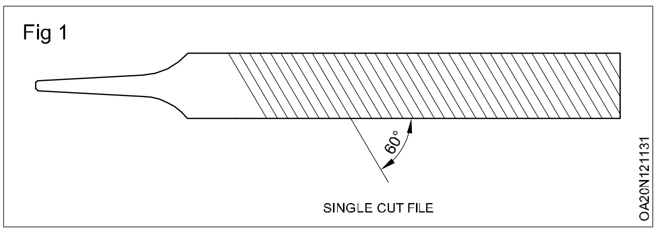
Types of cuts

Basically there are four types.

Single cut, Double cut, Rasp cut and Curved cut.

Single cut file (Fig 1) : A single cut file has rows of teeth cut in one direction across its face. The teeth are at an angle of 60^0 to the centre line. It can cut chips as wide as the cut of the file. Files with this cut are useful for filing soft metals like brass, aluminium, bronze and copper.

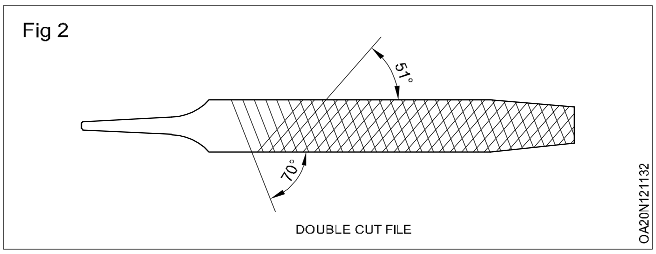
Fig 1



Single cut files do not remove stock as fast double cut files, but the surface finish obtained is much smoother.

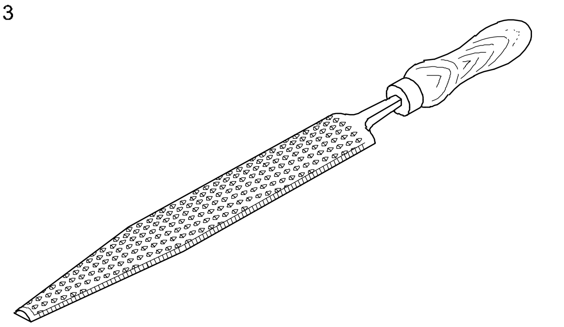
Double cut file (Fig 2) : A double cut file has two rows of teeth cut diagonal to each other. The first row of teeth is known as OVERCUT and they are cut at an angle of 70^0. The other cut, made diagonal to this, is known as UPCUT, and is at an angle of 51^0. This removes stock faster than the single cut file.

Fig 2



Rasp cut file (Fig 3) : The rasp cut has individual, sharp, pointed teeth in a line, and is useful for filing wood, leather and other soft materials. These files are available only in half round shape.

Fig 3



RASP CUT FILE

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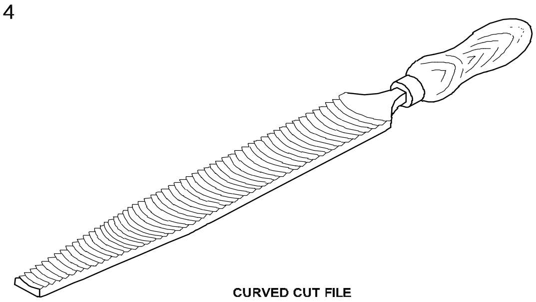
Fig 4



CURVED CUT FILE

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Curved cut file (Fig 4) : These files have deeper cutting action and are useful for filing soft materials like - aluminium, tin, copper, and plastic.

The curved cut files are available only in a flat shape.

The selection of a file with a particular type of cut is based on the material to be filed. Single cut files are used for filing soft materials. But certain special files, for example, those used for sharpening saws, are also of single cut.

File specifications and grades

Objectives: At the end of this lesson you shall be able to
- **state how files are specified**
- **explain the different grades of files**
- **state the application of each grade of file.**

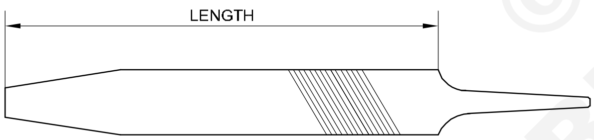
Files are manufactured in different types and grades to meet the various needs.

Files are specified according to their length, grade, cut and shape.

Length is the distance from the tip of a file to the heel.

File grades are determined by the spacing of the teeth.

Fig 1



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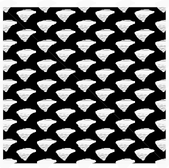
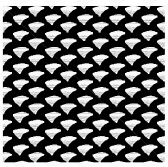
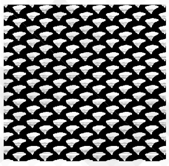


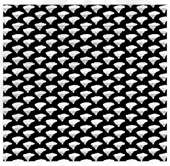
A **rough file** is used for removing rapidly a larger quantity of metal. It is mostly used for trimming the rough edges of soft metal castings.



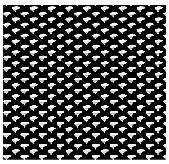
A **bastard file** is used in cases where there is a heavy reduction of material



A **second cut file** is used to give a good finish on metals. It is excellent to file hard metals. It is useful for bringing the jobs close to the finishing size.



A **smooth file** is used to remove small quantity of material and to give a good finish.



A **dead smooth** file is used to bring the material to accurate size with a high degree of finish.

The most used grades of files are bastard, second cut, smooth and dead smooth. These are the grades recommended by the bureau of Indian standards (BIS) : Different sizes of files with the same grade will have varying sizes of teeth. In longer files, the teeth will be coarser.

The number of cutting edge in rows in each of the above grades over a Length of 10mm as shown in Table (1).

TABLE (1)

Grade of files (Number of cuts over the length of 10mm)

Length of file	Rough	Bastard	Second cut	Smooth	Dead smooth
150mm	8	13	17	24	33
200mm	7	11	16	22	31
250mm	6	10	15	20	30
300mm	5	9	14	19	28

Convexity of files

Objectives: At the end of this lesson you shall be able to
- **list the reasons for convexity on files.**

Most files have the faces slightly belied lengthwise. This is known as convexity of files. This should not be confused with the taper of a file. A flat file has faces which are convex and it also tapers slightly in width and thickness.

Purpose: If the file is parallel in thickness, all the teeth on the surface of the work a ill cut. This would require more downward pressure to make the file 'bite' and also more forward pressure to make the file to cut.

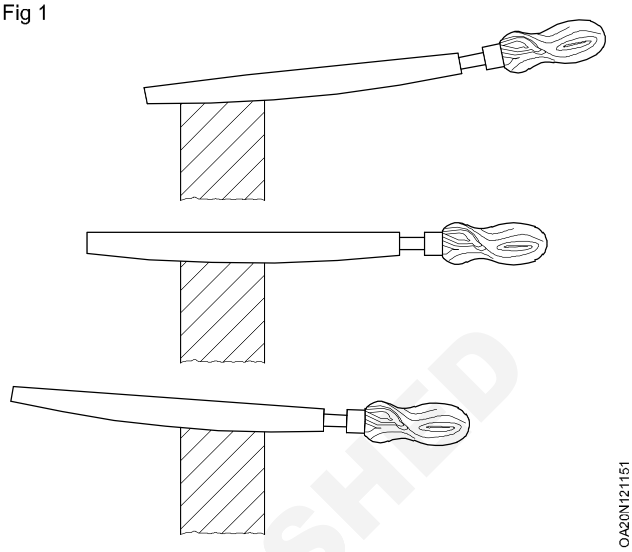
It is more difficult to control a file of uniform thickness.

To produce a flat surface with a file of parallel thickness, every stroke should be straight. But it is not possible due to the see - saw action of the hand.

If the file is made with parallel faces, while giving heavy treatment, one face may warp and become concave and the file will be useless for flat filing.

Excessive chip removal at the front or rear workpiece edge is prevented and filing of the flat surface is made easier because of the convexity on the cutting faces (Fig 1).

Fig 1



Pinning of files

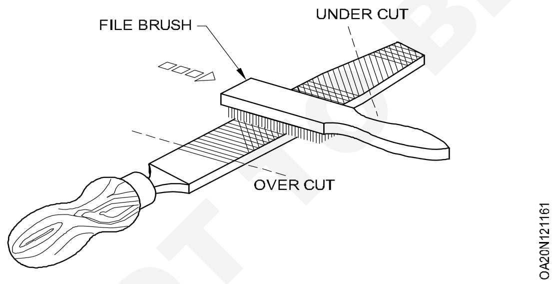
Objective: At the end of this lesson you shall be able to
- **explain the pinning of file.**

During filing, sometimes the metal chips (filings) will clog between the teeth of files. This is known as 'pinning' of files.

Files which are pinned will produce scratches on the surface being filed, and also will not bite well.

Pinning of the files is removed by using a file brush also called a file card, (Fig 1) with either forward or backward stroke.

Fig 1



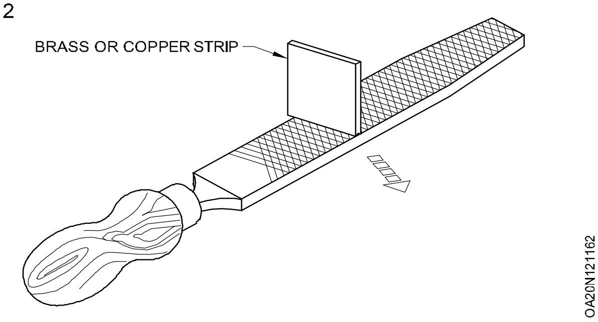
Filings which do not come out easily by the file card should be taken out with a brass or copper strip. (Fig 2)

For new files, use only soft metal strips (brass or copper) for cleaning. The sharp cutting edges of the files will wear out quickly if a steel file card is used. When filing a workpiece to a smooth finish more 'pinning' will take place because the pitch and depth of the teeth are less.

Application of chalk on the face of the file will help reduce the penetration of the teeth and 'pinning'.

Clean the file frequently in order to remove the filings embedded in the chalk powder.

Fig 2



Care and maintenance of file

Objective: At the end of this lesson you shall be able to
- **state the care and maintenance of file.**

- Do not use files having the blunt cutting edge
- Remember that files cut on the push stroke. Never apply the pressure on the pull stroke, or you could crush the file teeth, blunt them or cause them to break off.
- Prevent from pinning.
- Giving your files teeth a light brush with oil during long storage.
- Normally do not apply any oil while filing.
- Files should be stored separately so that their faces cannot rub against each other or against other tools.

Rule

Objectives: At the end of this lesson you shall be able to
- **explain the base unit of linear measurement as per the international system of units of measurement (SI)**
- **state the multiples of a metre and their values**
- **state the purpose of steel rule**
- **state the types of steel rule**
- **state the precautions to be followed while using a steel rule.**

When we measure an object , we are actually comparing it with a known standard of measurement.

The base unit of length as per SI units is METRE.

Length - SI UNITS and MULTIPLES

Base unit

The base unit of length as per the International Systems of units (SI) is metre. The table given below lists some multiples of a metre.

METRE(m) = 1000 mm

CENTIMETRE (μm) = 10 mm

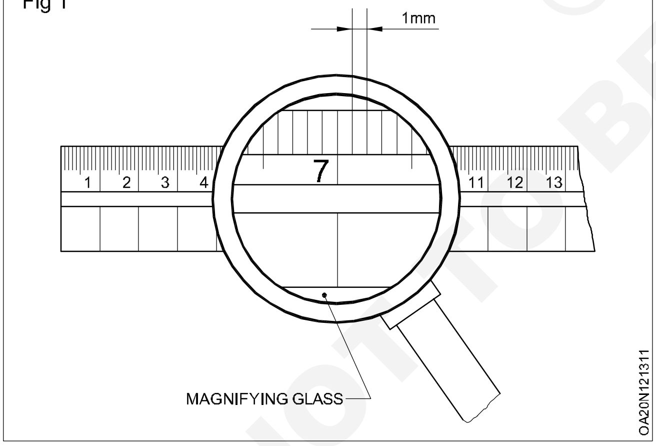
MILLIMETRE (mm) = 1000 μm

MICROMETRE (μm) = 0.001 mm

Measurement in engineering practice

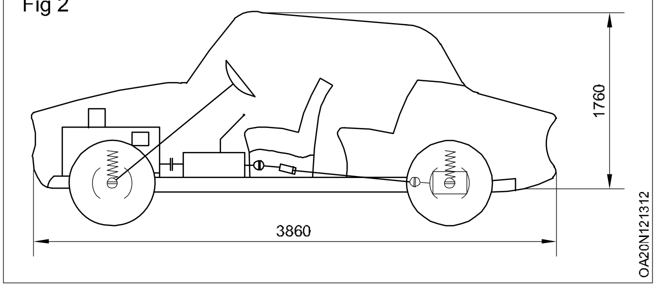
Usually, in engineering practice, the preferred unit of length measurement is millimetre. (Fig 1)

Fig 1



Both large and small dimensions are stated in millimetres. (Fig 2)

Fig 2

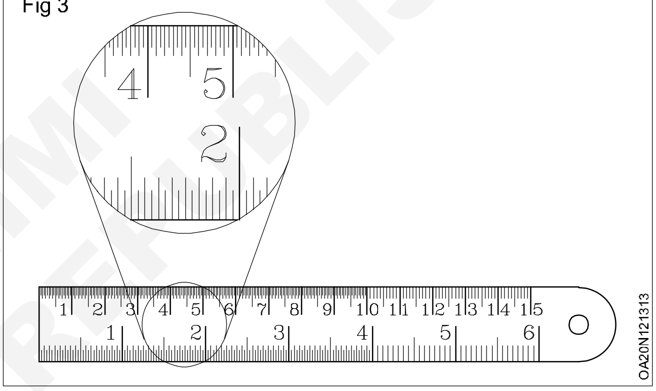


The British system of length measurement

An alternative system of length measurement is the British system. In this system, the base unit is the Imperial Standard yard. Most countries, including Great Britain itself, have, however, in the last few years, switched over to SI units.

Engineer's steel rule (Fig 3) are used to measure the dimensions of work pieces.

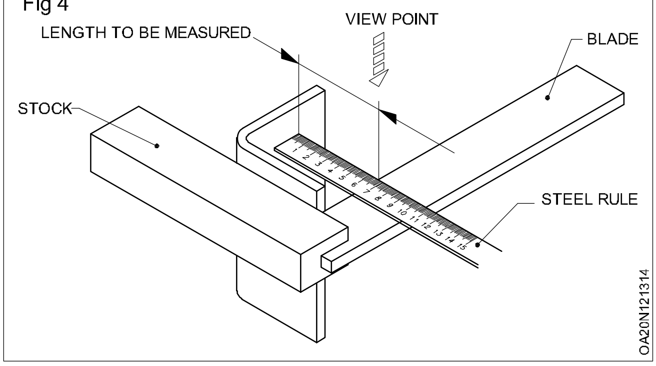
Fig 3



Steel rules are made of spring steel or stainless steel. These rules are available in length 150mm, 300mm and 600mm. The reading accuracy of steel rule is 0.5 mm and 1/64 inch.

For accurate reading it is necessary to read vertically to avoid errors arising out of parallax. (Fig 4)

Fig 4

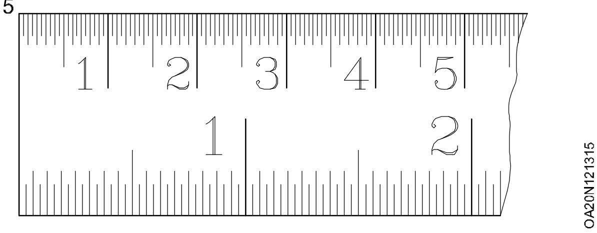


Steel rule in English measure, they can also be available with metric and English graduation in a complete range of sizes 150, 300, 500 and 1000 mm. (Fig 5)

Other types of rule

- Narrow steel rules

Fig 5

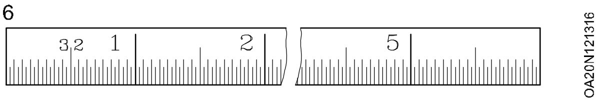


- Short steel rules
- Full flexible steel rule with tapered end.

Narrow steel rule

Narrow steel rule is used to measure the depth of keyways and depth of smaller dia, blind holes of jobs, where the ordinary steel rule can not reach. Its width is approximately 5 mm and thickness 2 mm. (Fig 6)

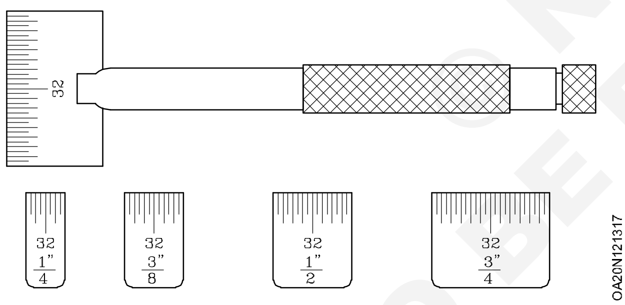
Fig 6



Short steel rule (Fig 7)

This set of five small rules together with a holder is extremely useful for measurements in confined or hard to reach locations which prevent the use of ordinary steel rules. It is used suitably for measuring grooves, short shoulder, recesses, key ways etc. In machining operation on shapers, millers and tool and die work.

Fig 7

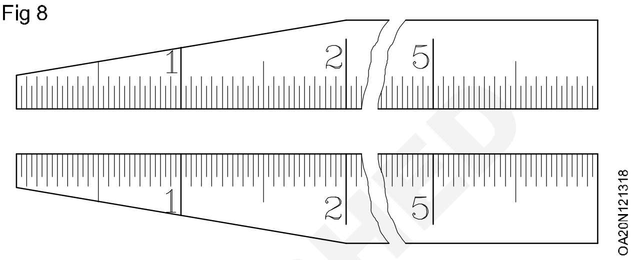


The rules are easily inserted in the slotted end of the holder and are rigidly clamped in place by a slight turn of the knurled nut at the end of the handle. Five rule lengths are provided 1/4", 3/8" and 1" and each rule is graduated in 32nds on one side and 64ths on the reverse side.

Steel rule with tapered end

This rule is a favourate with all mechanics since its tapered end permits measuring of inside size of small holes, narrow slots, grooves, recesses etc. This rule has a taper from 1/2 inch width at the 2 inch graduation to 1/8 inch width at the end. (Fig 8)

Fig 8



For maintaining the accuracy of a steel rule, it is important to see that its edges and surfaces are protected from damage and rust.

Do not place a steel rule with other cutting tools. Apply a thin layer of oil when not in use.

Angular measurement

Angular measurement of angles of an object is usually expressed in degrees, minutes and seconds. One degree is divided into 60 minutes and one minute is to 60 seconds.

Measurements of fundamental, derived units

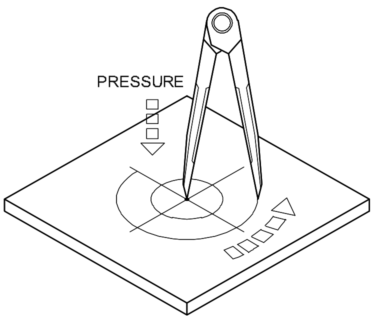
Metric	British
Micron 1μ = 0.001 mm	Thousandth of an inch = 0.001"
Millimetre 1 mm = 1000μ	Inch = 1"
Centimetre 1 cm = 10 mm	Foot 1 ft = 12"
Decimetre 1 dm = 10 cm	Yard 1 yd = 3 ft
Metre 1 m = 10 dm	1 furlong 1 fur = 220 yds
Decametre 1 dam = 10 metre	1 mile = 8 furlong

Dividers

Objectives : At the end of this lesson you shall be able to
- **state the parts of a divider**
- **state the uses of dividers**
- **state the specifications of divider**
- **state the important hints on divider points.**

Dividers are used for scribing circles, arcs and for transferring and stepping off distances. (Fig 1,2 and 3)

Fig 1



SCRIBING CIRCLES

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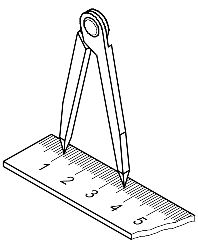
Fig 2



SETTING MEASUREMENT

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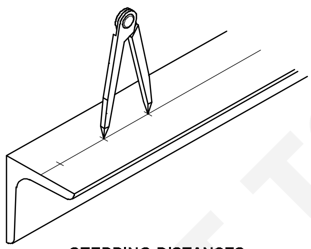
Fig 3



STEPPING DISTANCES

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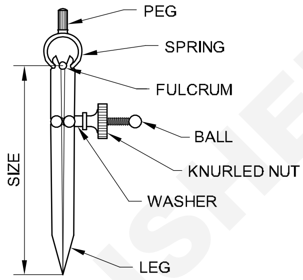
Dividers are available with firm joints and spring joints. (Figs 1 & 4). The measurements are set on the dividers with a steel rule. (Fig 2)

The sizes of dividers range between 50mm to 200mm.

Fig 4



SPRING JOINT DIVIDER

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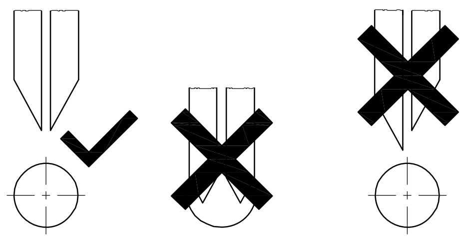
The distance from the point to the centre of the fulcrum roller (pivot) is the size of the divider. (Fig 4)

For the correct location and seating of the divider point prick punch marks of 30° are used.

The two legs of the divider should always be of equal length. (Fig 5) Dividers are specified by the type of their joints and length.

The divider point should be kept sharp in order to produce fine lines. Frequent sharpening with an oilstone is better than sharpening by grinding. Sharpening with an oilstone is better than sharpening by grinding. Sharpening by grinding will make the points soft.

Fig 5



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Scribers

Objectives: At the end of this lesson you shall be able to
- **state the features of scribers**
- **state the uses of scribers.**

Scribers

In lay out work it is necessary to scribe lines to indicate the dimensions of the workpiece to be filed or machined. The scriber is a tool used for this purpose. It is made of high carbon steel and is hardened. For drawing clear and sharp lines, the point should be ground and honed frequently for maintaining its sharpness.

Scribers are available in different shapes and sizes. The most commonly used one is the plain scriber. (Fig 1)

While scribing lines, the scriber is used like a pencil so that the lines drawn are close to the straight edge. (Fig 2)

Scriber points are very sharp; therefore, do not put the plain scriber in your pocket.

> **Place a cork on the point when not in use to prevent accidents.**

Fig 1

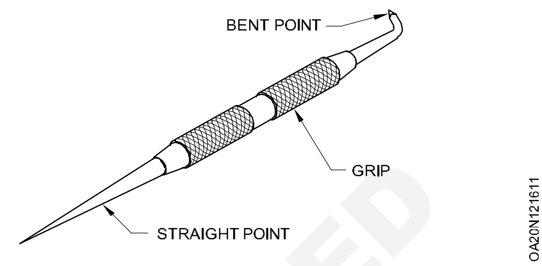
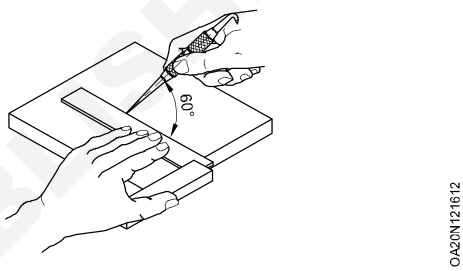


Fig 2



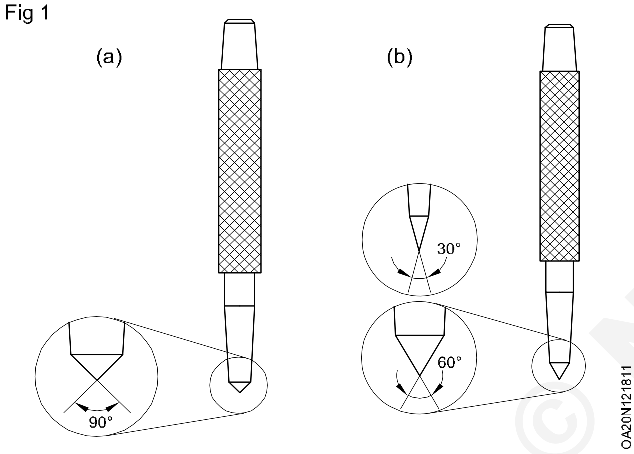
Types of marking punches

Objectives: At the end of this lesson you shall be able to
- **explain the different punches in marking**
- **state the features of each punch and its uses.**

Punches are used in order to make certain dimensional features of the layout permanent. There are two types of punches. They are centre punch and prick punch made of high carbon steel, hardened and ground.

Centre Punch: The angle of the point is 90° in a centre punch. This punch mark made by this is wide and not very deep. This punch is used for locating centre of the holes. The wide punch mark gives a good seating for starting the drill. (Fig 1a)

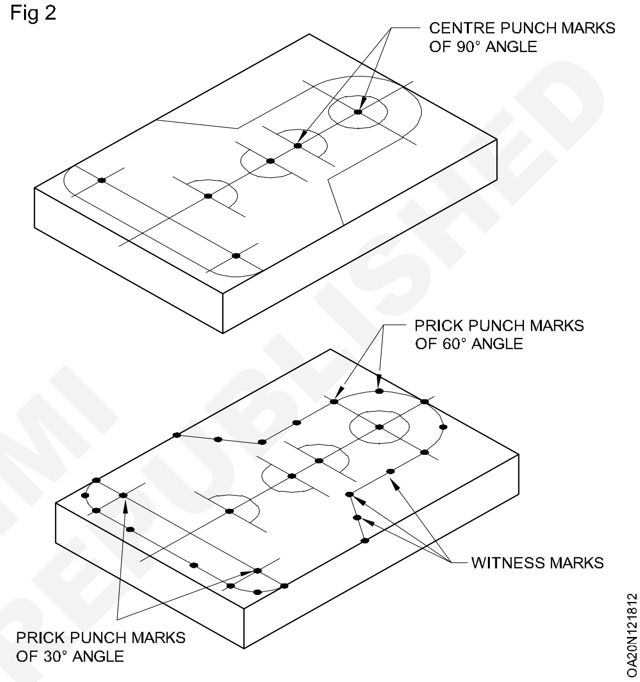
Fig 1



Prick Punch / Dot punch: The angle of the prick punch is 30° or 60°. (Fig 1b) The 30° point punch is used for making light punch marks needed to position dividers. The divider point will get a proper seating in the punch mark. The 60° punch is used for marking witness marks and called as dot punch. (Fig 2)

The witness marks should not be too close to one another.

Fig 2



Outside micrometer

Objectives: At the end of this lesson you shall be able to
- **name the parts of an outside micrometer**
- **state the functions of the main parts of an outside micrometer.**

A micrometer is a precision instrument used to measure a job, generally within an accuracy of 0.01 mm.

Micrometers used to take the outside measurements are known as outside micrometers. (Fig 1)

The parts of a micrometer are listed here.

Frame : The frame is made of drop-forged steel or malleable cast iron. All other parts of the micrometer are attached to this.

Barrel/Sleeve : The barrel or sleeve is fixed to the frame. The datum line and graduations are marked on this.

Thimble : On the bevelled surface of the thimble also, the graduation is marked. The spindle is attached to this.

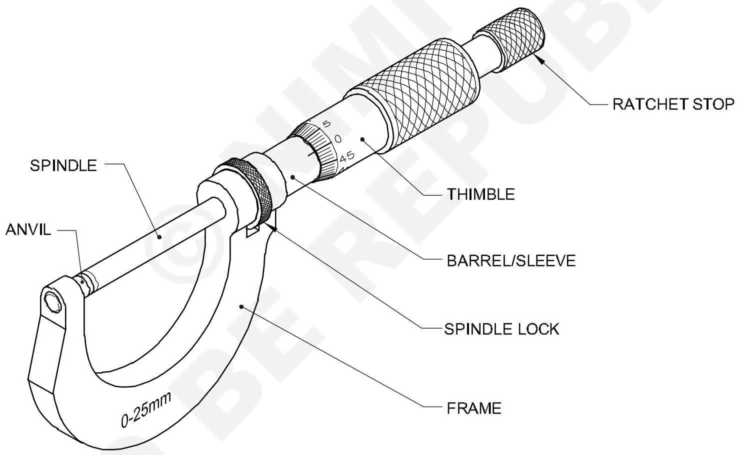
Spindle : One end of the spindle is the measuring face. The other end is threaded and passes through a nut. The threaded mechanism allows for the forward and backward movement of the spindle.

Anvil : The anvil is one of the measuring faces which is fitted on the micrometer frame. It is made of alloy steel and finished to a perfectly flat surface.

Spindle lock nut : The spindle lock nut is used to lock the spindle at a desired position.

Ratchet stop : The ratchet stop ensures a uniform pressure between the measuring surfaces.

Fig 1



Graduations of metric outside micrometer

Objectives: At the end of this lesson you shall be able to
- **state the principle of a micrometer**
- **determine the least count of an outside micrometer.**

Working principle : The micrometer works on the principle of screw and nut. The longitudinal movement of the spindle during one rotation is equal to the pitch of the screw. The movement of the spindle to the distance of the pitch or its fractions can be accurately measured on the barrel and thimble.

Graduations (Fig 1) : In metric micrometers the pitch of the spindle thread is 0.5 mm.

Thereby, in one rotation of the thimble, the spindle advances by 0.5 mm.

On the barrel a 25 mm long datum line is marked. This line is further graduated to millimetres and half millimetres (i.e. 1 mm & 0.5 mm). The graduations are numbered as 0, 5, 10, 15, 20 & 25 mm.

The circumference of the bevel edge of the thimble is graduated into 50 divisions and marked 0-5-10-15 .... 45-50 in a clockwise direction.

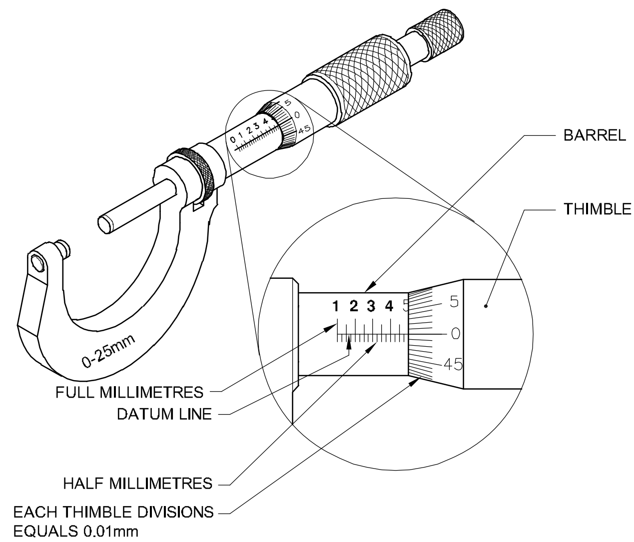
The distance moved by the spindle during one rotation of the thimble is 0.5 mm.

Movement of one division of the thimble = 0.5 x 1/50

= 0.01 mm

Accuracy or least count of a metric outside micrometer is 0.01 mm.

Fig 1



OUTSIDE MICROMETER

Reading dimensions with outside micrometer

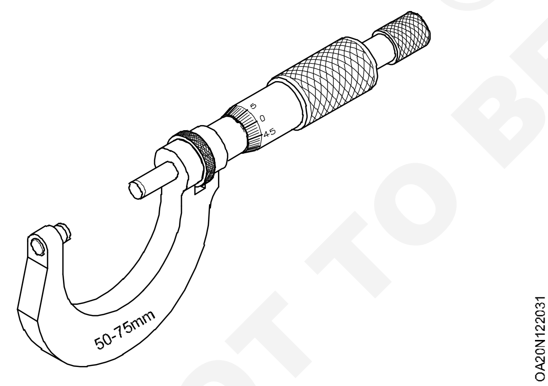
Objectives: At the end of this lesson you shall be able to
- **select the required range of a micrometer**
- **read micrometer measurements.**

Ranges of outside micrometer

Outside micrometers are available in ranges of 0 to 25 mm, 25 to 50 mm, 50 to 75 mm, 75 to 100 mm, 100 to 125 mm and 125 to 150 mm.

For all ranges of micrometers, the graduations marked on the barrel is only 0-25 mm. (Fig 1)

Fig 1



Reading micrometer measurements

How to read a measurement with an outside micrometer? (Fig 2)

First note the minimum range of the outside micrometer. While measuring with a 50 to 75 mm micrometer, note it as 50 mm.

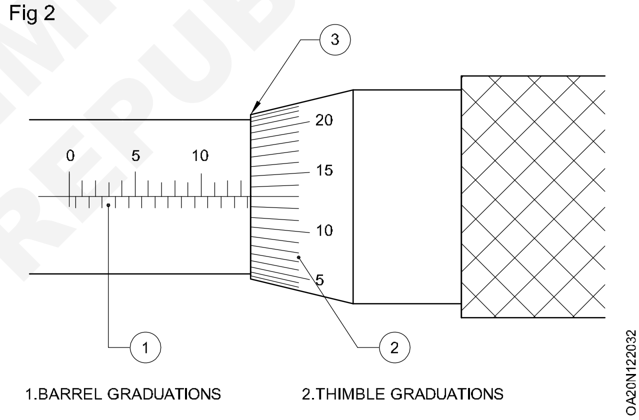
Then read the barrel graduations. Read the value of the visible lines on the left of the thimble edge.

13.00 mm (Main divison reading on barral)

+ 00.50 mm (Sub division reading on barral)

13.50 mm (Main division + sub - division value)

Fig 2

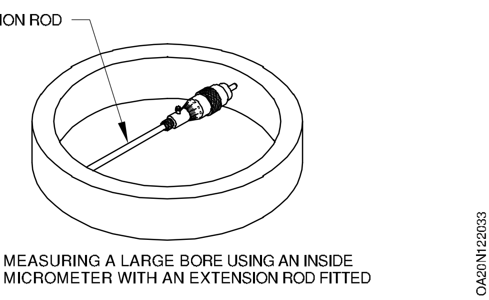


An inside micrometer is a precision measuring instrument which measures with an accuracy of 0.01mm.

Purpose

An inside micrometer is used to measure the diameter of holes. (Fig 3)

Fig 3



MEASURING A LARGE BORE USING AN INSIDE MICROMETER WITH AN EXTENSION ROD FITTED

To measure the distance between internal parallel surfaces like slots (Fig 4)

Parts (Fig 5) : The following are the parts of an inside micrometer .

Fig 4

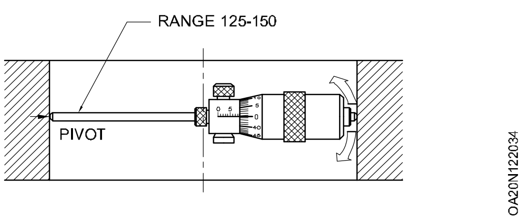
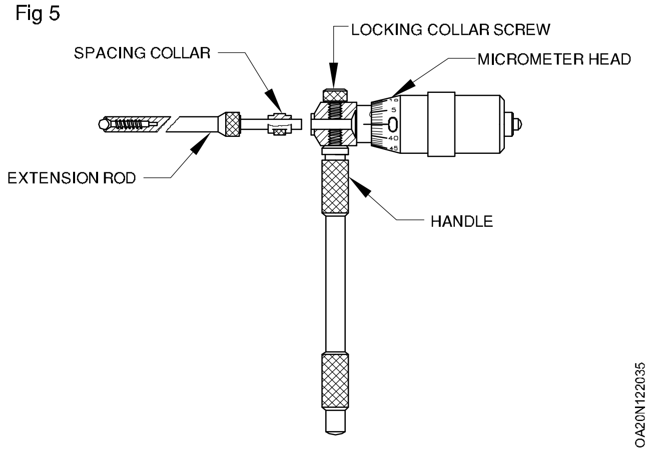


Fig 5



Micrometer head: It consists a sleeve, a thimble, an anvil and locking screw for extension rods.

Extension rod: This is fitted in the hole provided in the barrel of the micrometer head. It provides another measuring surface. It is available in different sizes.

Locking Screw It is used to lock the extension rods.

Handle It is fitted in the threaded hole provided in the micrometer head. It is used to hold the micrometer assembly while measuring deep bores.

Spacing collar It is added to the extension rod for additional length. It is available in different sizes.

The range of inside micrometer

Using the different sizes of extension rods and spacing collars the following ranges of measurement can be taken

25-50mm, 50-200mm, 50-300mm, 200-500mm,200-1000mm

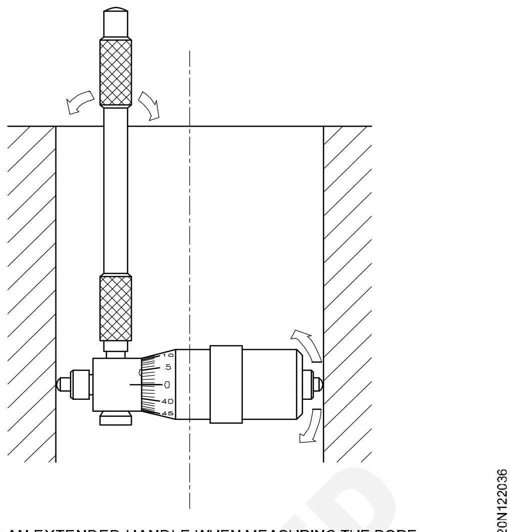
Inside micrometer

Ranges of extension rod for (50 - 200mm) Inside micrometer

Checking parallelism of surfaces of deep bores

An extended handle can be used while measuring deep bores. (Fig 6) for checking the parallelism of surfaces of the bore.

Fig 6



USING AN EXTENDED HANDLE WHEN MEASURING THE BORE

Find out the readings at 2 or 3 places i.e. one reading at the top, another reading at the middle and the third reading at the bottom of the bore. If all the three readings are the same, then the surfaces of the bore are parallel. Any variation in the readings shows an error in the bore.

Precautions

Ensure that the extension rod/spacing collar are fitted correctly.

Check the 'O" setting of the inside micrometer with an outside micrometer.

Ensure that the measuring faces are perpendicular to the axis, and the handle parallel to the axis of the above.

When measuring bores the micrometer must be set for the largest value. While measuring between flat surfaces, the micrometer should be set for the smallest value. (Fig 7)

Ensure that the wall surfaces of the bore are free from burrs, oil etc. before using an inside micrometer. Set the inside micrometer in the bore to the correct FEEL. Do not drag or force the inside micrometer in the bore.

Fig 7

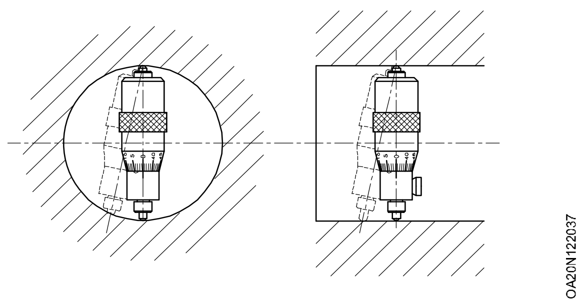
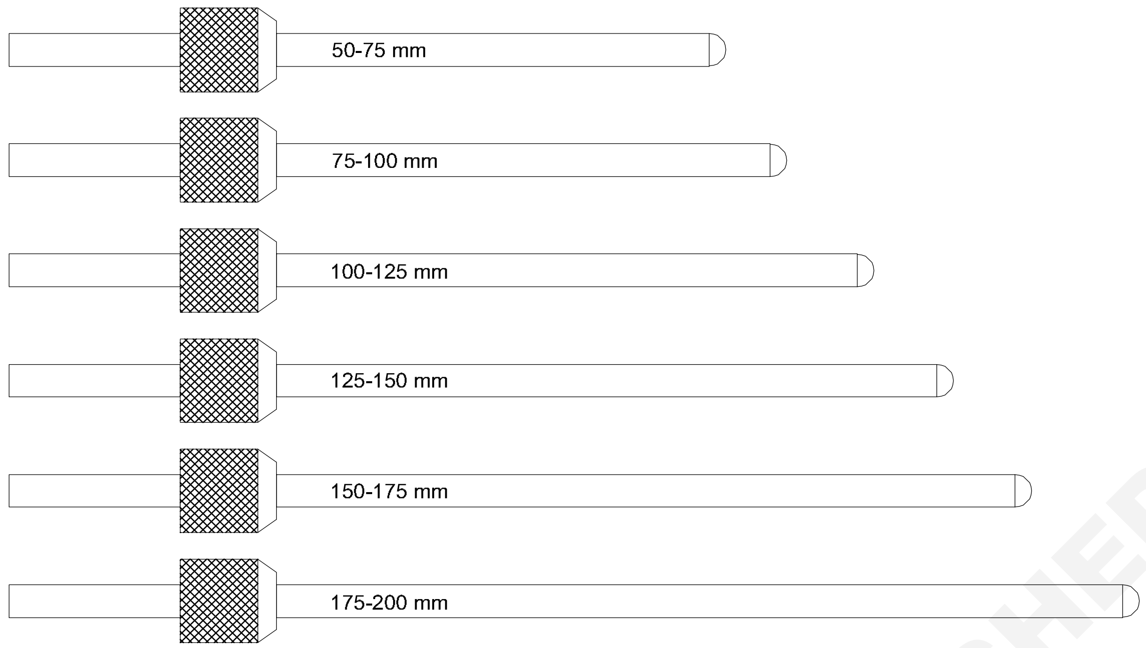


Fig 8



EXTENSION RODS

Depth micrometer

Objectives: At the end of this lesson you shall be able to
- **name the parts of a depth micrometer**
- **state the constructional features of a depth micrometer**
- **read depth micrometer measurements.**

Constructional features

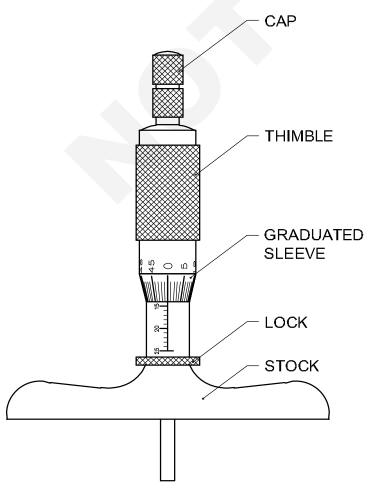
The depth micrometer consists of a stock on which a graduated sleeve is fitted.

The other end of the sleeve is threaded with a 0.5 mm pitch `V' thread.

A thimble which is internally threaded to the same pitch and form, mates with the threaded sleeve and slides over it.

The other end of the thimble has an external step machined and threaded to accommodate a thimble cap. (Fig 1)

Fig 1



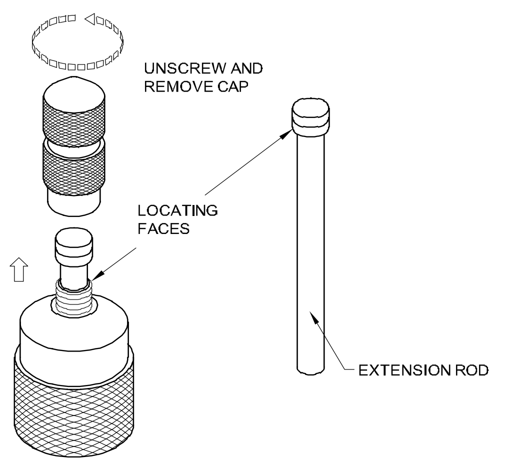
DEPTH MICROMETER

A set of extension rods is generally supplied. On each of them the range of sizes that can be measured with that rod, is engraved as 0-25, 25-50, 50-75, 75-100, 100-125 and 125-150.

These extension rods can be inserted inside the thimble and the sleeve.

The extension rods have a collar-head which helps the rod to be held firmly. (Fig 2)

Fig 2



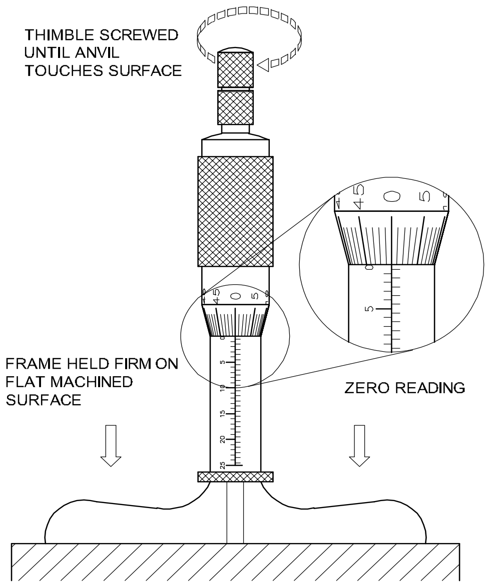
The measuring faces of the stock and the rods are hardened, tempered and ground. The measuring face of the stock is perfectly machined flat.

The extension rods may be removed and replaced according to the size of depth to be measured.

Graduation and least count

On the sleeve a datum line is marked for a length of 25 mm. This is divided into 25 equal parts and graduated, each line representing one millimetre. Each fifth line is drawn a little longer and numbered. Each line representing 1 mm is further subdivided into two equal parts. Hence each sub-division represents 0.5 mm. (Fig 3)

Fig 3



CHECKING THE ZERO SETTING

The graduations are numbered in the reverse direction, to that marked on an outside micrometer.

The zero graduation of the sleeve is on the top and the 25 mm graduation near the stock.

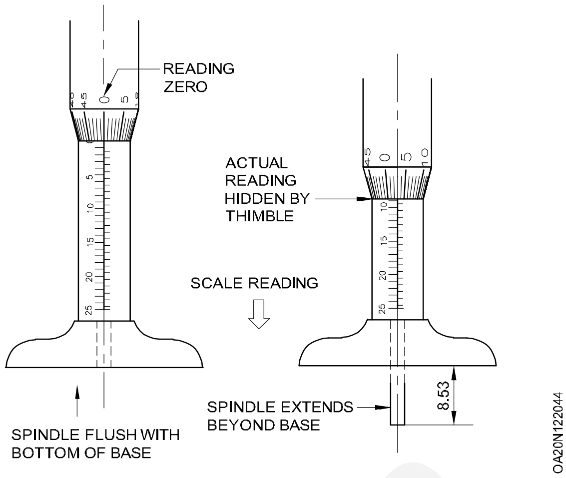
The bevel edge of the thimble is also graduated. The circumference is equally divided into 50 equal parts and every 5th division line is drawn a little longer and numbered. The numbering is in the reverse direction and increases from 0, 5,10,15, 25, 30, 35, 40,45 and 50 (0). (Fig 4)

The advancement of the extension rod for one full turn of the thimble is one pitch which is 0.5 mm.

Therefore, the advancement of the extension rod for one division movement of the thimble will be equal to 0.5 / 50 = 0.01 mm.

This will be the smallest measurement that can be taken with this instrument, and so, this is the accuracy of this instrument.

Fig 4



Reading of depth micrometer

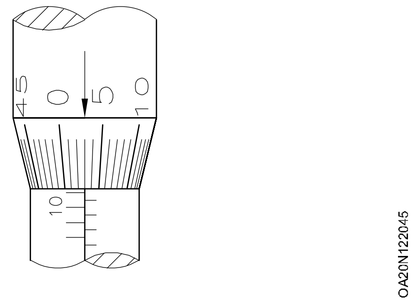
Barrel reading (1 mm division)	=	8 x 1 mm	= 8.00 mm
Sub division (0.5 mm division)	=	1 x 0.5 mm	= 0.50 mm
Thimble reading	=	3 x 0.01 mm	= 0.03 mm
(Thimble division x L.C) Total reading			= 8.53 mm

In barrel reading main division and sub division have been hidden covered by thimble

Uses of depth micrometer

- Depth micrometers are special micrometers used to measure
- the depth of holes.
- the depth of grooves and recesses
- the heights of shoulders or projections.

Fig 5



Digital micrometers

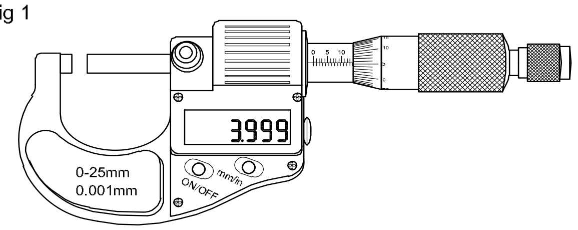
Objectives: At the end of this lesson you shall be able to
- **state the uses of digital micrometer**
- **list the parts of digital micrometer**
- **read the reading from LED display and thimble and barrel**
- **brief the maintenance, maintenance of digital micrometers.**

Digital micrometers is one of the simplest and most widely used measuring equipment in any manufacturing industry. Its simplicity and the versatile nature make Digital Micrometers so popular. Different kinds of Digital

Micrometers available in the market.

Feature of digital micrometers (Fig 1)

Fig 1



FEATURE OF DIGITAL MICROMETERS

- LCD displays measuring data and makes direct read out with resolution of 0.001mm.
- Origin setting mm/inch conversion, switch for absolute and incremental measurement.
- Carbide tipped measuring faces.
- Ratchet ensures invariable measurement and accurate repeatable reading

Accuracy of digital micrometers

Digital micrometers provide 10 times more precision and accuracy : 0.00005 inches or 0.001mm resolution, with 0.0001 inches or 0.001mm accuracy.

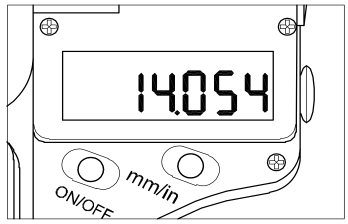
Reading of the digital micrometer

The digital micrometers are provided with high precision reading with LCD display. The reading is 14.054 mm as shown in Fig 2.

Reading also by reading the marks on the sleeve and the thimble. Usually, the reading from the large LCD display for the digital micrometer because the digital reading is more accurate. The reading on the sleeve and the thimble is just for reference. Read the markings on the sleeve and the thimble, firstly, read the point which the thimble stops at it on the right of the sleeve (It is 14mm here, because each line above the centre long line represents 1mm while each line below the centre long line represent 0.5mm) (Fig 3)

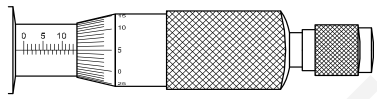
Secondly, read the markings on the thimble, It is between 5 and 6, So you need to estimate the reading. (It is 0.054mm for each line here represents 0.001mm). At last, add all the reading up : 14mm + 0.054 mm = 14.054mm. So the total reading is 14.054mm.

Fig 2



READING OF THE DIGITAL MICROMETERS

Fig 3



Maintenance of a digital micrometers

Never apply voltage (e.g. engraving with an electric pen) on any part of the Digital Micrometers for fear of damaging the circuit.

Press the ON/OFF button to shut the power when the Digital Micrometers stands idle; take out the battery if it stands idle for a long time.

As for the battery, abnormal display (digit flashing or even no display) shows a flat battery. Thus you should push the battery cover as the arrow directing and then replace with a new one. Please note that the positive side must face out If the battery bought from market doesn't work well (the power may wear down because of the long-term storage or the battery's automatic discharge and etc.) Please do not hesitate to contact the supplier.

Flashing display shows dead battery. If this is the case please replace the battery at once. No displace shows poor contact of a battery or short circuit of both poles of the battery. Please check and adjust pole flakes and battery insulator cover. In case water enters the battery cover, open the cover immediately and blow the inside of the battery cover at a temperature of not more than 40°C till it gets dry.

Vernier calipers

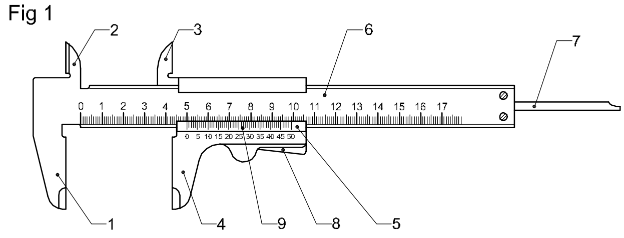
Objectives : At the end of this lesson you shall be able to
- **name the parts of a vernier caliper**
- **describe the parts of a vernier calipers**
- **state the uses of a vernier caliper.**

A vernier caliper is a precision measuring instrument. It is used to measure up to an accuracy of 0.02 mm. (Fig 1)

Parts of a vernier caliper

(Numbers as per Fig 1)

Fig 1



Fixed jaws (1 and 2): Fixed jaws are part of the beam scale. One jaw is used for taking external measurements, and the other for taking internal measurements.

Movable jaws (3 and 4): Movable jaws are part of the vernier slide. One jaw is used for external measurements, and the other for internal measurements. (Figs 2 and 3)

Fig 2

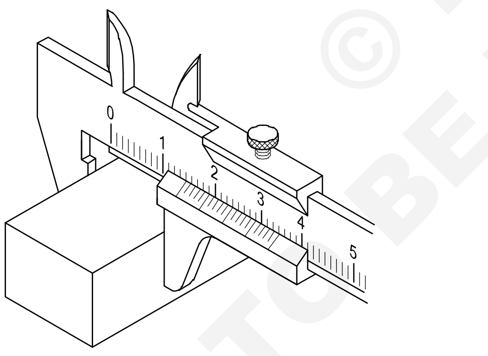
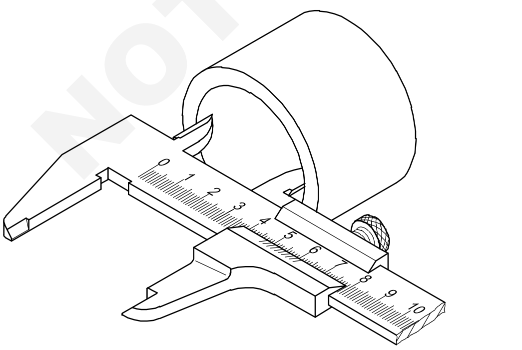


Fig 3

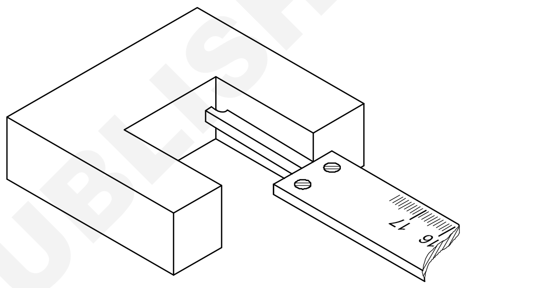


Vernier slide (5): A vernier slide moves over the beam and can be set in any position by means of a spring-loaded thumb lever.

Beam (6): The vernier slide and the depth bar attached to it, slide over the beam. The graduations on the beam are called the main scale divisions.

Depth bar (7) (Fig 4)**:**The depth bar is attached to the vernier slide and is used for measurement of depth.

Fig 4



Thumb lever (8): The thumb lever is spring-loaded which helps to set the vernier slide in any position on the beam scale.

Vernier scale (9): The vernier scale is the graduation marked on the vernier slide. The divisions of this scale are called vernier divisions.

Main scale: The main scale graduations or divisions are marked on the beam.

Sizes: Vernier calipers are available in sizes of 150 mm, 200, 250, 300 and 600 mm. The selection of the size depends on the measurements to be taken. Vernier calipers are precision instruments, and therefore, extreme care should be taken while handling them.

Never use a vernier caliper for any purpose other than measuring.

Vernier calipers should be used only to measure machined or filed surfaces.

They should never be mixed with any other tools.

Clean the instrument after use, and store it in a box.

Graduations and reading of vernier calipers

Objectives : At the end of this lesson you shall be able to
- **determine the least count of a vernier caliper**
- **state how graduations are made on a vernier caliper with 0.02 mm least count**
- **read vernier caliper measurements.**

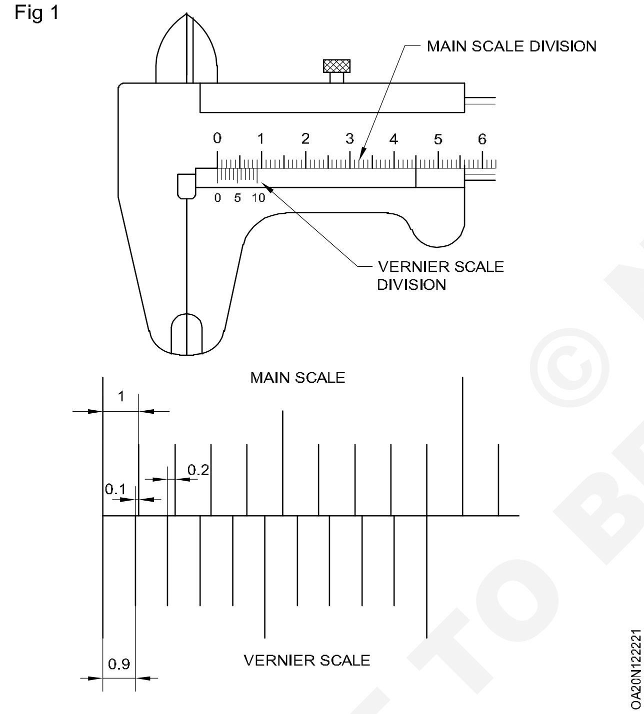
Vernier calipers: Vernier calipers are available with different accuracies. The selection of the vernier caliper depends on the accuracy needed and the sizes of the job to be measured.

This accuracy/least count is determined by the graduations of the main scale and the vernier scale divisions.

Vernier Principle: The vernier principle states that two different scales are constructed on a single known length of line and the difference between them is taken for fine measurements.

Determining the least count of vernier calipers: In the vernier caliper shown in Fig 1 the main scale divisions (9 mm) are divided into 10 equal parts in the vernier scale.

Fig 1



i.e. One main scale division (MSD) = 1 mm

One vernier scale division (VSD) = 9/10 mm

Least count = 1 MSD - 1 VSD

= 1 mm - 9/10 mm

= 0.1 mm

The difference between one MSD and one VSD = 0.1 mm

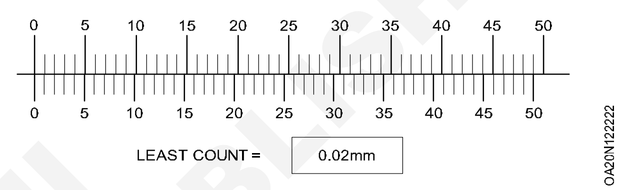
Reading vernier measurements: Vernier calipers are available with different graduations and least counts. For reading measurements with a vernier caliper, the least count should be determined first. (The least count of calipers is sometimes marked on the vernier slide)

Fig 2 shows the graduations of a common type of vernier caliper with a least count of 0.02 mm. In this, 50 divisions of the vernier scale occupy 49 divisions (49 mm) on the main scale.

Example

Calculate the least count of the vernier given in Fig 2.

Fig 2



Least count = 1 mm - 49/50 mm

= 1/50 mm

= 0.02 mm.

Example for reading vernier caliper (Fig 3)

Main scale reading = 60 mm

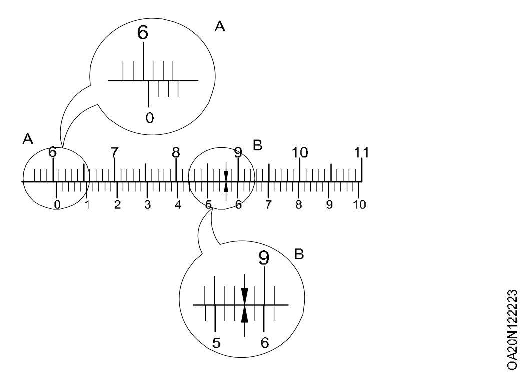
The vernier division coinciding with the main scale is the 28th division, value = 28 x 0.02mm

= 0.56 mm

Reading = 60 + 0.56

Total Reading = 60.56 mm

Fig 3

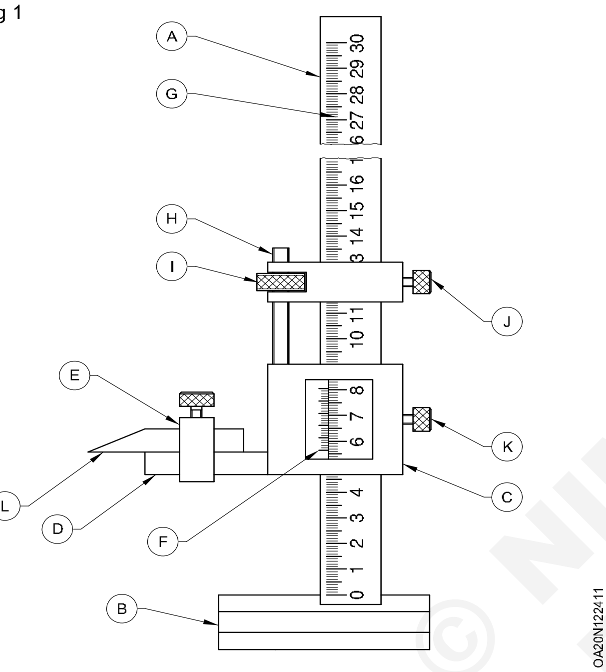


Vernier height gauge

Objectives: At the end of this lesson you will be able to
- **name the parts of a vernier height gauge**
- **state the constructional features of a vernier height gauge**
- **state the functional features of a vernier height gauge**
- **state the various applications of the vernier height gauge in engineering.**

Parts of a vernier height gauge (Fig 1)

Fig 1



A	Beam
B	Base
C	Main slide
D	Jaw
E	Jaw clamp
F	Vernier scale
G	Main scale
H	Finer adjusting slide
I	Finer adjusting nut
J&K	Locking screws
L	Scriber blade

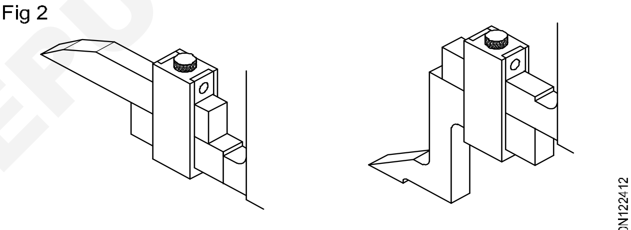
Constructional features of a vernier height gauge: The construction of a vernier height gauge is similar to that of the vernier caliper that it is vertical with a rigid base. It is graduated on the same vernier principle which is applied to the vernier caliper.

The beam is graduated with the main scale in mm as well as in inches. The main slide carries a jaw upon which various attachments may be clamped. The jaw is an integral part of the main slide.

The vernier scale is attached to the main slide which has been graduated, to read metric dimensions as well as the inch dimensions. The main slide is attached with the finer adjusting slide. The movable jaw is most widely used with the chisel pointed scriber blade for accurate marking out as well as for checking the height, steps etc. Care should be taken to allow for the thickness of the jaw depending on whether the attachment is clamped on the top or under the jaw for this purpose.

The thickness of the jaw is marked on the instrument. As like in a vernier caliper, the least count of this instrument is also 0.02 mm. An offset scriber is also used on the movable jaw when it is required to take measurement from the lower planes. (Fig 2) The complete sliding attachment along with the jaw can be arrested on the beam to the desired height with the help of the locking screws. The vernier height gauges are available in ranges of capacities reading from zero to 1000 mm.

Fig 2



Functional features of the vernier height gauge: Vernier height gauges are used in conjunction with the surface plate. In order to move the main slide, both the locking screws of the slide and the finer adjusting slide have to be loosened. The main slide along with the chisel pointed scriber has to be set by hand, for an approximate height as required.

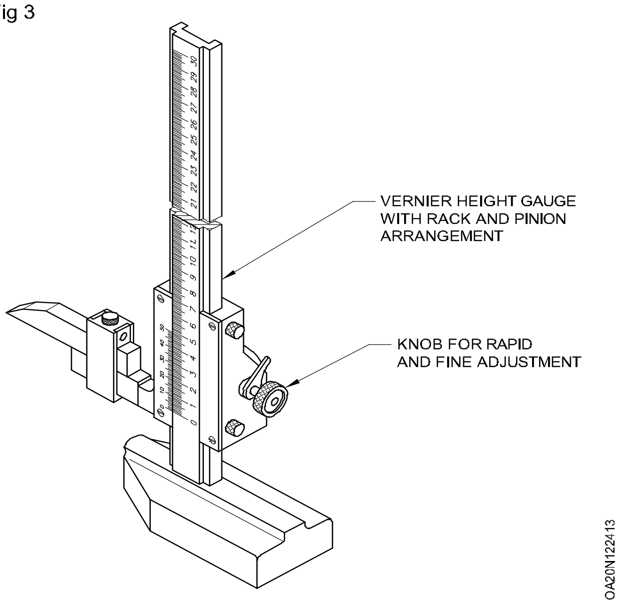
The finer adjusting slide has to be locked in position, for an approximate height as required. To get an exact markable height, the finer adjustments have to be carried on the slider with the help of the adjusting nut. After obtaining the exact markable dimension, the main slide is also to be locked in position.

Modern vernier height gauges are designed on the screw rod principle. In these height gauges, the screw rod may be operated with the help of the thumb screw at the base. In order to have a quick setting of the main slide, it is designed with a quick releasing manual mechanism. With the help of this, it is possible to bring the slide to a desired approximate height without wastage of time. For all other purposes, these height gauges work as ordinary height gauges. In order to set the 'zero' graduation of the main scale for the initial reading.

Some vernier height gauges are equipped with a sliding main scale which may be set immediately for the initial reading. This minimises the possible errors in reading the various sizes in the same setting.

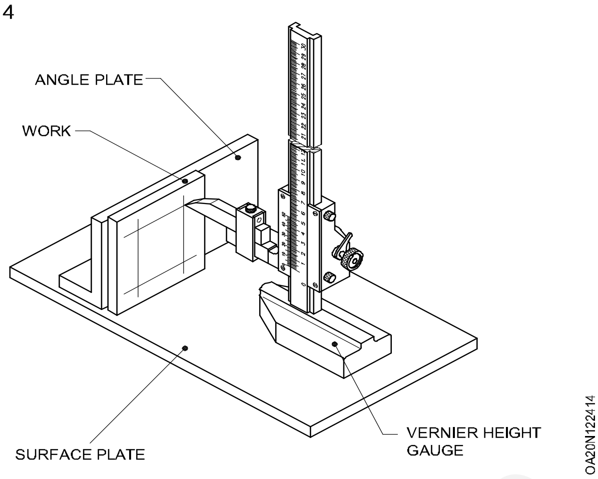
Another kind of modern vernier height gauge has a rack and pinion set up for operating the sliding unit. This is shown in Fig 3.

Fig 3



Various applications of a vernier height gauge: The vernier height gauge is mainly used for layout work. (Fig 4)

Fig 4



It is used for measuring the width of the slot and external dimension.

The vernier height gauge is used with the dial indicator to check hole location, pitch dimensions, concentricity and eccentricity.

It is also used for measuring depth, with a depth attachment.

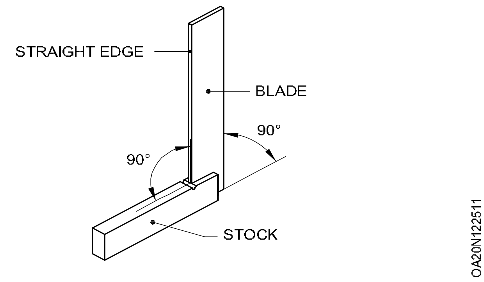
It is used to measure sizes from the lower plane with the help of an offset scriber.

Engineers square

Objectives: At the end of this lesson you shall be able to
- **name the parts of a engineers square**
- **state the uses of a engineers square.**

The try square (Fig 1) is an instrument which is used to check squareness (angles of 90°) of a surface.

Fig 1



The accuracy of measurement by a try square is about 0.002 mm per 10 mm length, which is accurate enough for most workshop purposes. The try square has a blade with parallel surfaces. The blade is fixed to the stock at 90°.

Try squares are made of hardened steel.

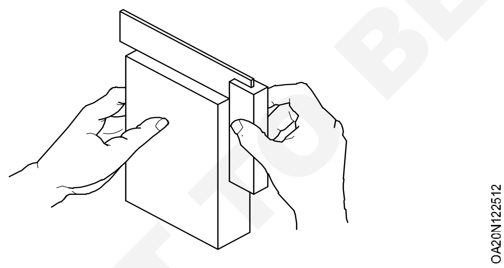
Try squares are specified according to the length of the blade i.e. 100 mm, 150 mm, 200 mm.

Uses:

The try-square is used to:

– check the squareness (Fig 2)

Fig 2



– check the flatness (Fig 3)

– mark lines at 90° to the edges of workpieces (Fig 4)

– set workpieces at right angles. (Fig 5)

Fig 3

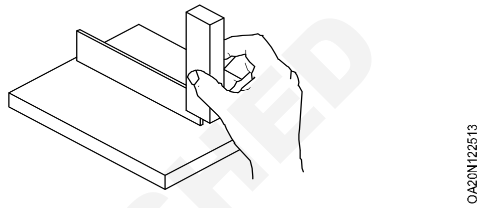


Fig 4

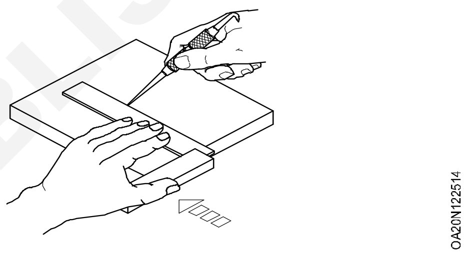
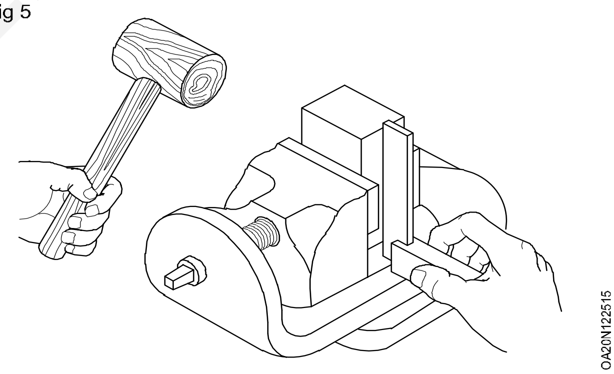


Fig 5



Precision engineer's square

Objectives: At the end of this lesson you shall be able to
- **name the different standard engineer's square**
- **distinguish the features of different engineer's square**
- **state the different grades of try square and their uses**
- **specify engineer's squares as per Indian standard**
- **state the features and uses of cylindrical squares.**

Engineer's squares of different types are available for checking squareness of components. ISI recommends three types of square.

Types

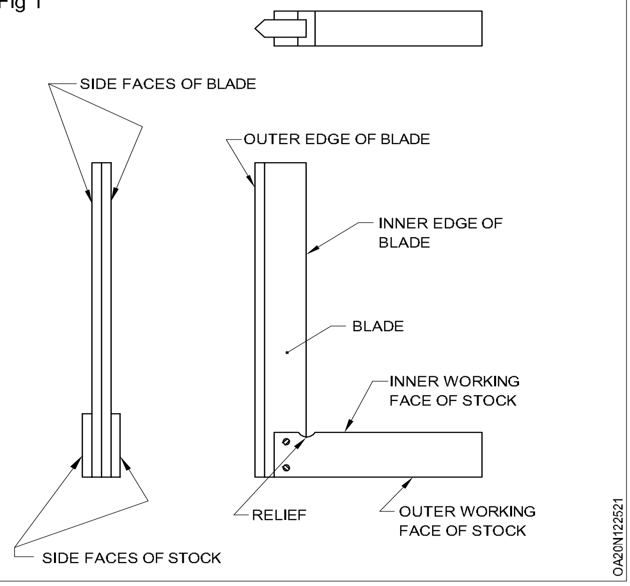
Type 1: Engineer's square bevel edged with stock

Type 2: Engineer's square with flat edge and without stock.

Type 3: Engineer's square with flange.

Type 1: Engineer's square bevel edged with stock : The outer edge of the blade is bevelled, and the blade is tilted on to a stock (Fig 1)

Fig 1



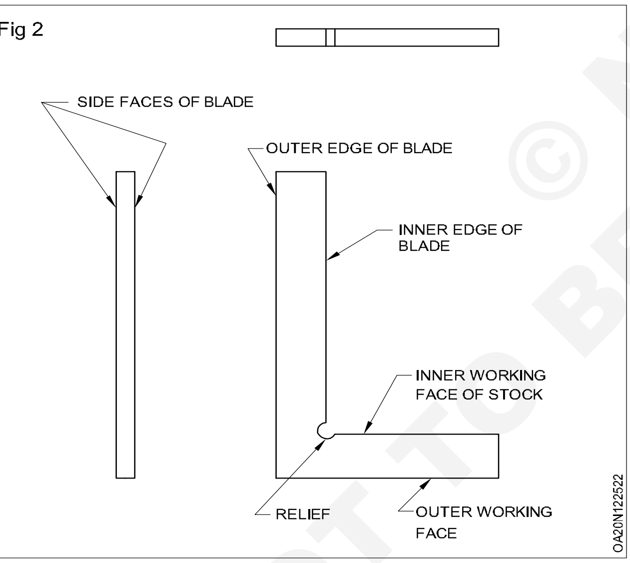
Since the blade is bevelled it makes only a line contact and therefore it is useful for precision work.

Type 2: Engineer's square with flat edge and without stock

In this case, the blade and stock are integral (Fig 2)

The blade and stock are of uniform thickness. The blade is thicker than that provided in type 1.

Fig 2



Type 3: Engineer's square with flange

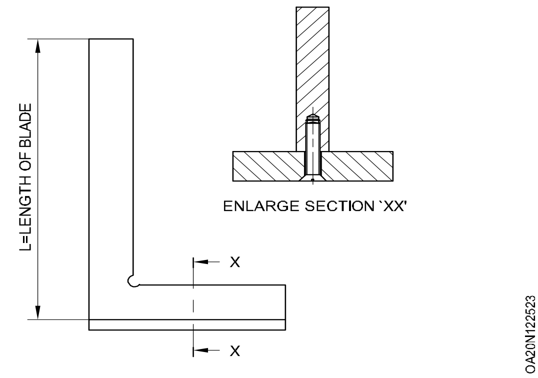
These try squares are available from 500mm and above. These are particulry useful on marking tables. (Fig 3)

Grades

Engineer's square are made in three grades

- Grade A
- Grade B
- Grade C

Fig 3



Grade A is the most accurate

Grades A and B are used in fine tool room inspection and reference work and Grade C for eneral machine shop work.

NOTE :

Unless otherwise specified Grade A squares shall be supplied with bevelled edges and Grade B and C squares with flat edges.

Designation of engineers squares

Engineers squares are specified by their nominal length, grade of accuracy and type. The length of the blade is taken from the outer working face of the stock to the end of the blade. (Fig 3)

- Grade of accuracy A,B or C
- Type (i.e) Type 1 ,2 or 3)

Examples:

Engineer's square

200 A - 1 - IS : 2103

300 B - 2 - IS : 2103

500 C - 3 - IS : 2013

IS : 2103 indicates the Indian standard number related to the specification.

Cylinder squares

Cylinder squares are not commercially available many inspection rooms favour the use of these for use surface plates or on marking tables.

These are made from hardened die steel or mild steel case hardened.

They have a cylindrical surface and the end faces precision ground.

These squares have better stability than the other precision engineer's squares.

They also give a line contact when checking flat surface.

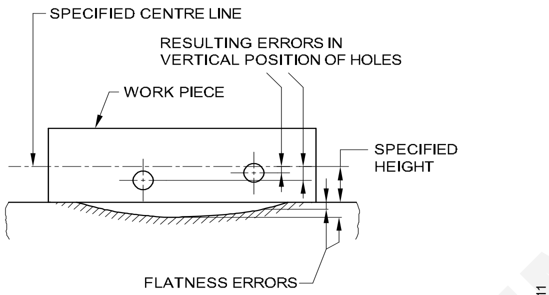
Surface plates

Objectives: At the end of this lesson you shall be able to
- **state the necessity of surface plate**
- **state the material of surface plate**
- **state the specification of surface plate.**

Surface plates - their necessity

When accurate dimensional features are to be marked, it is essential to have a datum plane with a perfectly flat surface. Marking using datum surfaces which are not perfectly flat will result in dimensional inaccuracies. (Fig 1) The most widely used datum surfaces in machine shop work are the surface plates and marking tables.

Fig 1



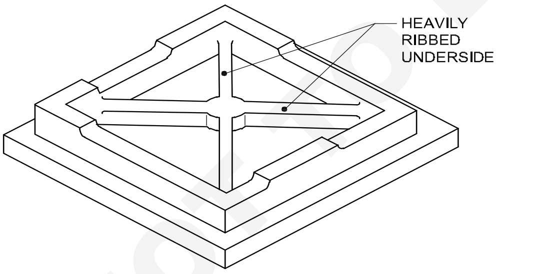
EFFECT OF MARKING-OUT FROM NON-FLAT SURFACE. NOTE THAT THE ERRORS IN THE HOLE POSITIONS ARE EQUAL TO THE FLATNESS ERRORS

Materials and construction

Surface plates are generally made of good quality cast iron which are stress-relieved to prevent distortion.

The work-surface is machined and scraped. The underside is heavily ribbed to provide rigidity. (Fig 2)

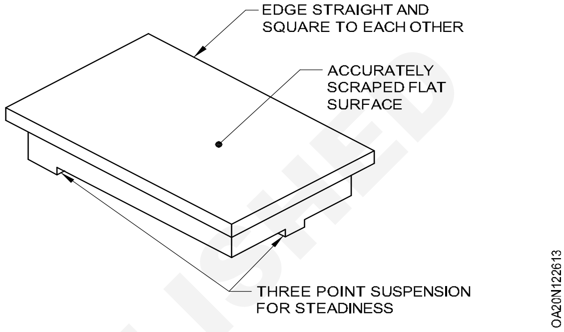
Fig 2



CAST IRON SURFACE PLATE

For the purpose of steadiness and convenience in levelling, a three point suspension is given. (Fig 3)

Fig 3



Smaller surface plates are placed on benches while the larger surface plates are placed on stands.

Other materials used : Granite is also used for manufacturing surface plates. Granite is a dense and stable material. Surface plates made of granite retain their accuracy, even if the surface is scratched. Burrs are not formed on these surfaces.

Classification and uses : Surface plates used for machine shop work are available in three grades - Grades 1, 2 and 3. The grade 1 surface plate is more acceptable than the other two grades.

Specifications : Cast iron surface plates are designated by their length, breadth, grade and the Indian Standard number.

Example : Cast iron surface plate 2000 x 1000 Gr1. I.S. 2285.

Care & maintenance

- Clean before and after use.
- Do not keep job on the surface plate.
- Don't keep any cutting tool on the table.

Angle plates

Objectives: At the end of the lesson you shall be able to
- **state the constructional features of different types of angle plates**
- **name the types of angle plates**
- **state the uses of different types of angle plates**
- **state the grades of angle plates**
- **specify angle plates.**

Constructional features

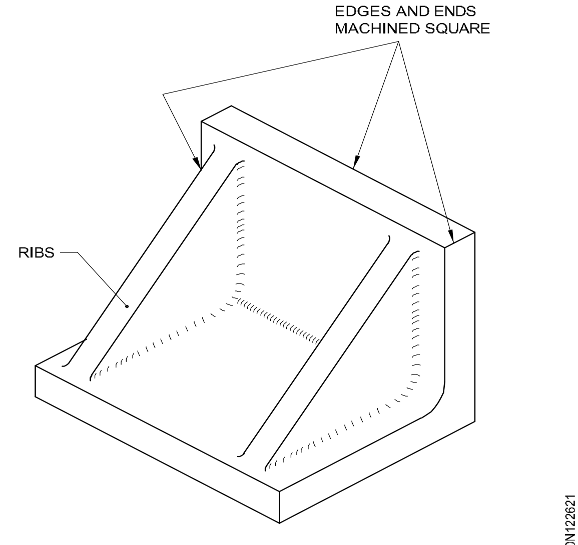
Angle plates have two plane surfaces, machined perfectly flat and at right angles. Generally these are made of closely grained cast iron or steel. The edges and ends are also machined square. They have ribs on the unmachined part for good rigidity and to prevent distortion.

Types of angle plates

Plain solid angle plate (Fig 1)

Among the three types of angle plates normally used, the plain solid angle plate is the most common. It has the two plane surfaces perfectly machined at 90° to each other. Such angle plates are suitable for supporting work-pieces during layout work. They are comparatively smaller in size.

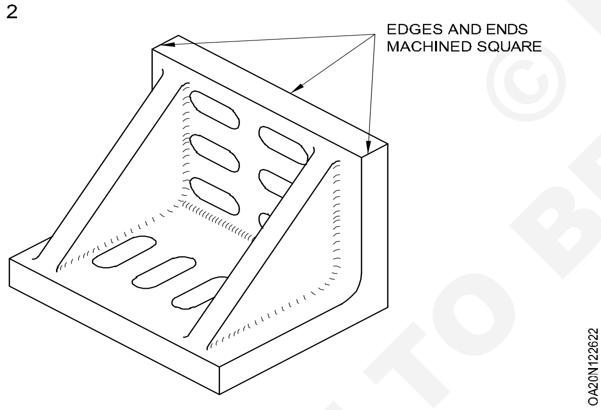
Fig 1



ANGLE PLATE

Slotted type angle plate (Fig 2)

Fig 2



The two plane surfaces of this type of angle plate have slots milled. It is comparatively bigger in size than the plain solid angle plate.

The slots are machined on the top plane surfaces for accommodating clamping bolts. This type of angle plate can be tilted 90° along with the work for marking or machining. (Figs 3a & b)

Swivel type angle plate (Fig 4)

This is adjustable so that the two surfaces can be kept at an angle. The two machined surfaces are on two separate pieces which are assembled. Graduations are marked on one to indicate the angle of tilt with respect to the other. When both zeros coincide, the two plane surfaces are at 90° to each other. A bolt and nut are provided for locking in position.

Fig 3

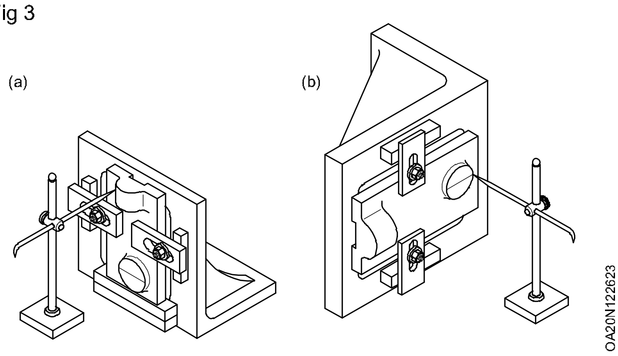
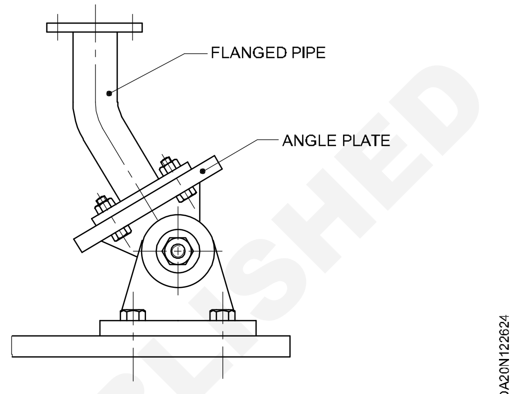
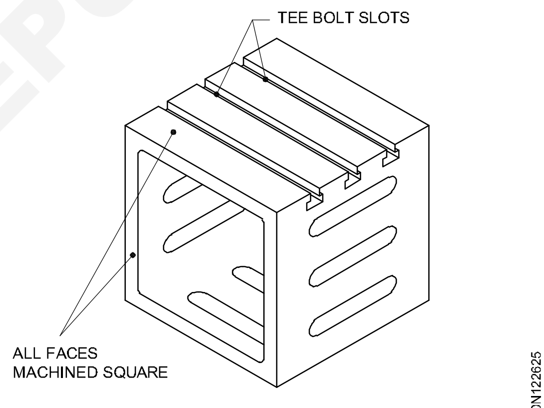


Fig 4



Box angle plate (Fig 5)

Fig 5



BOX ANGLE PLATE

They have applications similar to those of other angle plates. After setting, the work can be turned over with the box enabling further marking out or machining. This is a significant advantage. This has all the faces machined square to each other.

Grades

Angle plates are available in two grades - Grade 1 and Grade 2. The Grade 1 angle plates are more accurate and are used for very accurate tool room type of work. The Grade 2 angle plates are used for general machine shop work. In addition to the above two grades of angle plates, precision angle plates are also available for inspection work.

Sizes

Angle plates are available in different sizes. The sizes are indicated by numbers. Table 1 gives the number of the sizes and the corresponding size proportions of the angle plates.

TABLE 1

Size No.	L	B	H
1	125	75	100
2	175	100	125
3	250	150	175
4	350	200	250
5	450	300	350
6	600	400	450
7	700	420	700
8	600	600	1000
9	1500	900	1500
10	2800	900	2200
Grade 2 only			

Specification of angle plates

a Size 6 Grade 1

Box plate will be designated as - box angle plate 6 Gr 1 IS 623.

b Size 2 - Grade 2 angle plate will be designated as

Angle plate 2 Gr 2 I.S 623.

Care & Maintenance

– Clean before and after use.

– Apply oil after the use.

Combination set

Objectives: At the end of this lesson you shall be able to
- **identify the parts of a combination set**
- **state the uses of each attachment in a combination set.**

Combination sets can be used for different types of work, like layout work, measurement and checking of angles.

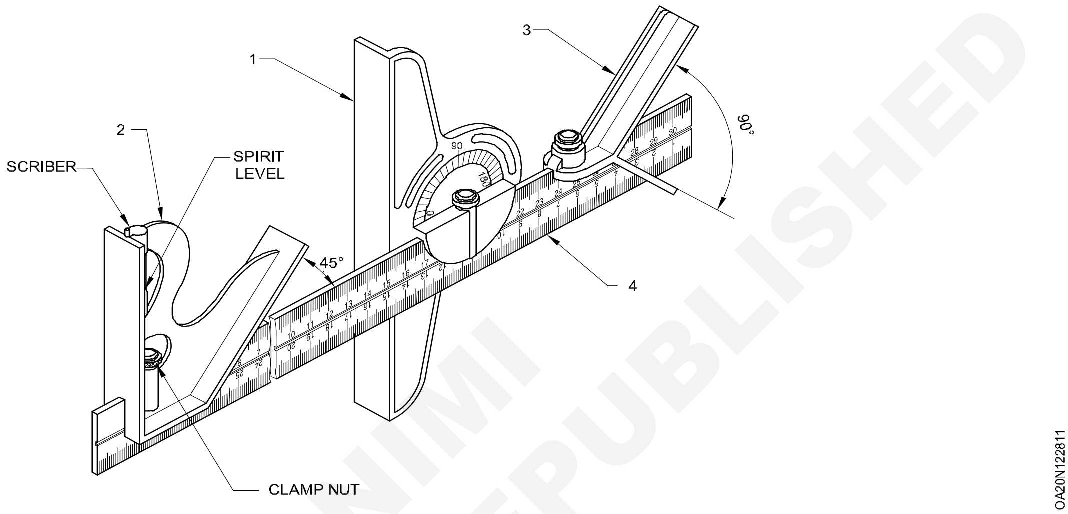
The combination set (Fig 1) has a

Protractor head (1)

Square head (2)

Center head (3) and a rule (4)

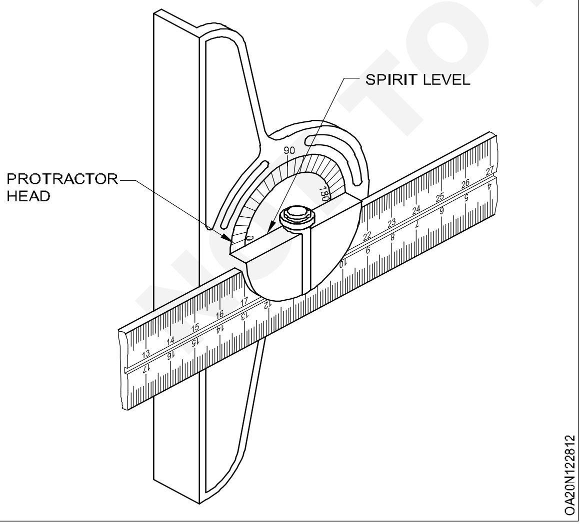
Fig 1



Protractor head : The protractor head can be rotated and set to any required angle (Fig 2).

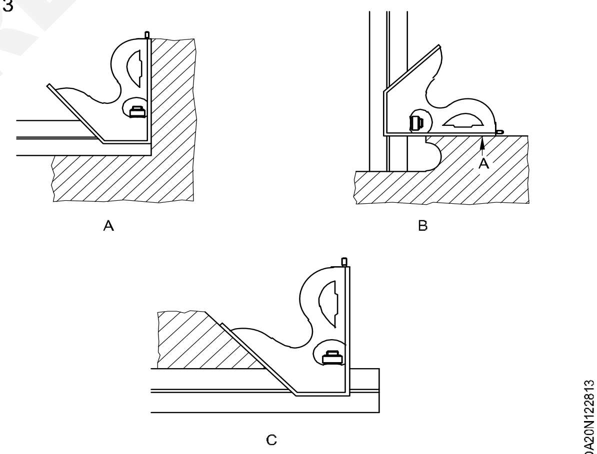
The protractor head is used for marking and measuring angles within an accuracy of 1°. The spirit level attached to this is useful for setting jobs in a horizontal plane. (Fig 2)

Fig 2



Square head: The square head has one measuring face at 90° and another at 45° to the rule. It is used to mark and check 90° & 45° angles. It can also be used to set workpieces on the machines and measure the depth of slots. (Figs 3A,B,C)

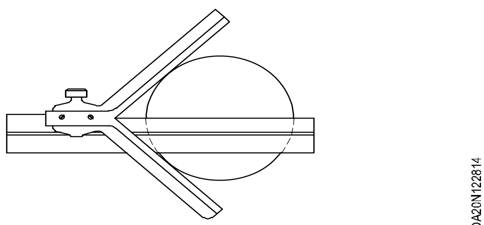
Fig 3



Center head: This along with the rule is used for locating the center of cylindrical jobs. (Fig 4)

For ensuring accurate results, the combination set should be cleaned well after use and should not be mixed with cutting tools, either while using or storing.

Fig 4



Vernier bevel protractor

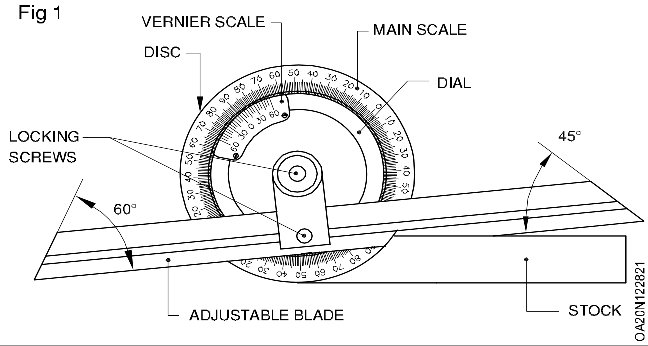
Objectives : At the end of this lesson you shall be able to
- **name the parts of a vernier bevel protractor**
- **state the functions of each part**
- **list out the uses of a vernier bevel protractor.**

The vernier bevel protractor is a precision instrument meant for measuring angles to an accuracy of 5 minutes. (5')

Parts of a vernier bevel protractor

The following are the parts of a vernier bevel protractor. (Fig 1)

Fig 1



Stock: This is one of the contacting surfaces during the measurement of an angle. Preferably it should be kept in contact with the datum surface from which the angle is measured.

Dial: The dial is an integrated part of the stock. It is circular in shape, and the edge is graduated in degrees.

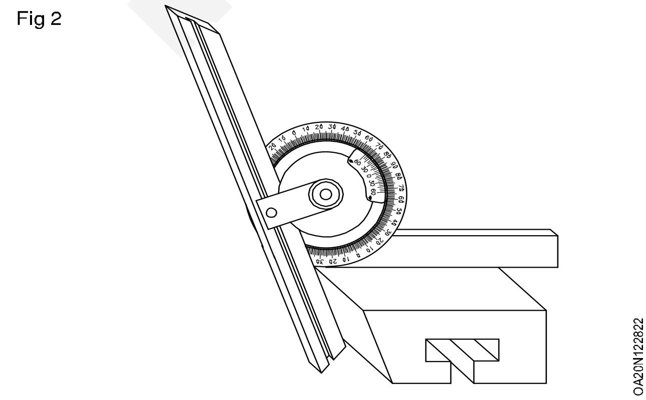
Blade: This is the other surface of the instrument that contacts the work during measurement. It is fixed to the dial with the help of the clamping lever. A parallel groove is provided in the centre of the blade to enable it to be longitudinally positioned whenever necessary.

Locking screws: Two knurled locking screws are provided, one to lock the dial to the disc, and the other to lock the blade to the dial..

All parts are made of good quality steel, properly heat-treated and highly finished. A magnifying glass is sometimes fitted for clear reading of the graduations.

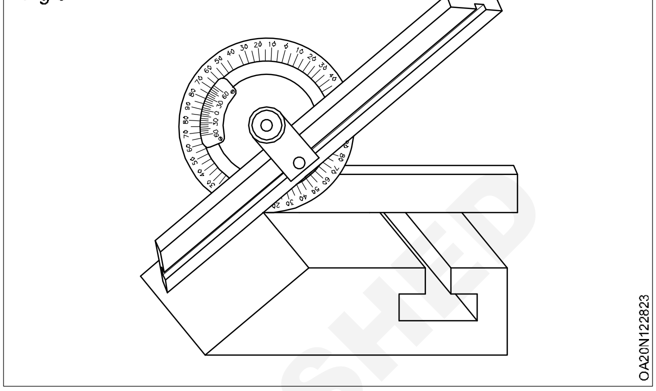
U**ses of a vernier bevel protractor (Fig 2):** Apart from being used for measuring angles a vernier bevel protractor is also used for setting work-holding devices on machine tools, work-tables etc.

Fig 2



The vernier bevel protractor is used to measure acute angles than 90° (Fig 2) obtuse angles more than 90° (Fig 3).

Fig 3



For setting work-holding devices to angles on machine tools, work tables etc., (Fig 4 & Fig 5)

Fig 4

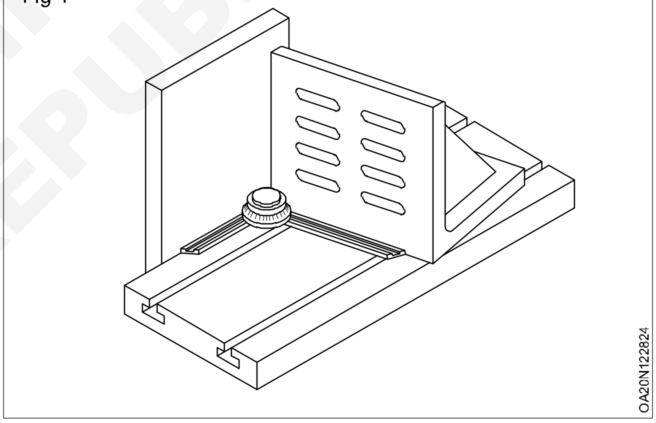
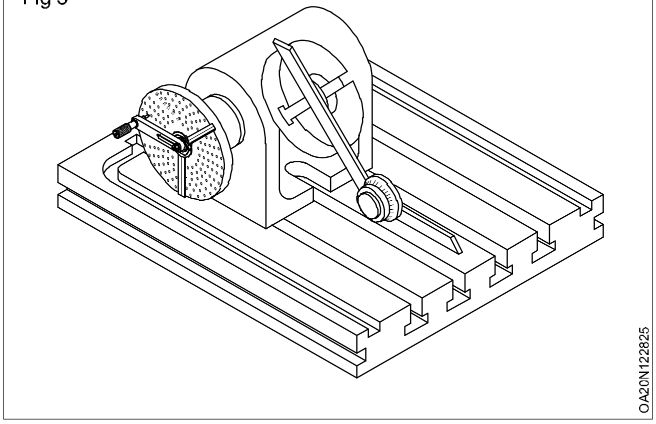


Fig 5



Graduations on universal bevel protractor

Objectives: At the end of this lesson you will be able to
- **state the main scale graduations on the disc**
- **state the vernier scale graduations on the dial**
- **determine the least count of the vernier bevel protractor.**

The main scale graduations (Fig 1 & 2): For purposes of taking angular measurements, the full circumference of the dial is graduated in degrees. The 360° are equally divided and marked in four quadrants, from '0' degree to 90 degrees, 90 degrees to '0' degree. Every tenth division is marked longer and numbered. Each division represents 1 degree. The graduations on the dial are known as the main scale divisions. On the disc, 23 divisions spacing of the main scale is equally divided into 12 equal parts on the vernier. Each 3^{rd} line is marked longer and numbered as 0, 15, 30, 45, 60. This constitutes the vernier scale. Similar graduations are marked to the left of '0' also. (Fig 1)

Fig 1

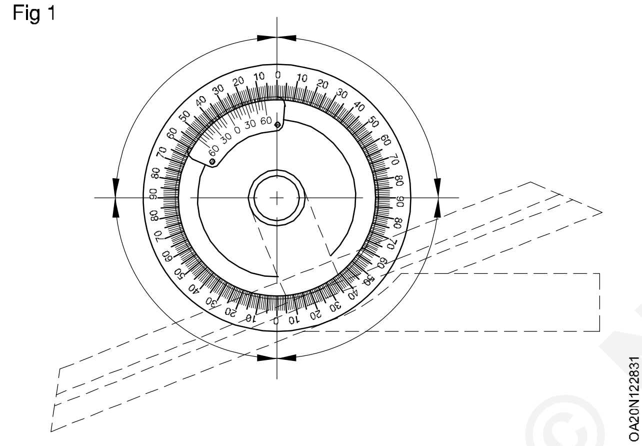
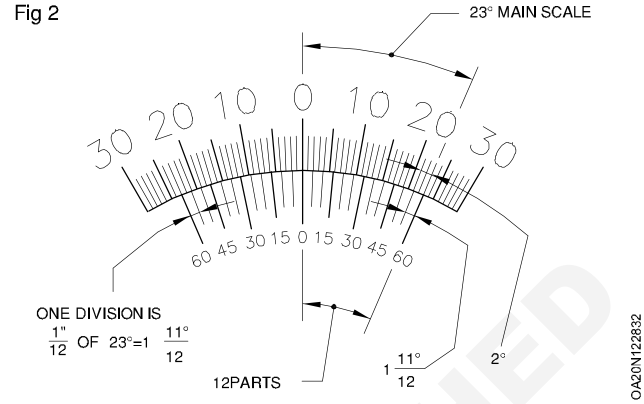


Fig 2



i.e the least count = 2°

$$= \frac{24}{12} - \frac{23^0}{12} = \frac{1^0}{12} \text{ or } 5'$$

For any setting of the blade and stock, the reading of the acute angle and the supplementary obtuse angle is possible, and the two sets of the vernier scale graduations on the disc assist to achieve this. (Fig 3)

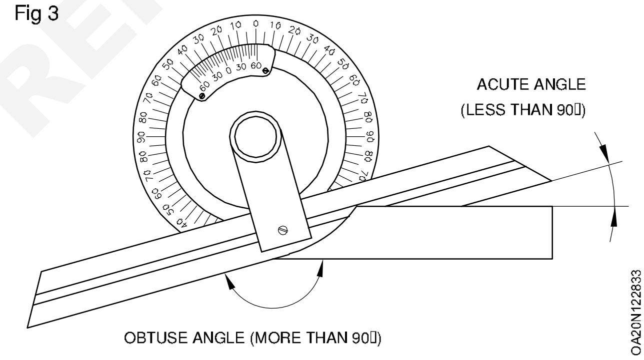
One vernier scale division VSD (Fig 2)

The least count of the vernier bevel protractor: When the zero of the vernier scale coincides with the zero of the main scale, the first division of the vernier scale will be very close to the 2^{nd} main scale division. (Fig 2)

Hence the least count is

2 MSD - 1 VSD

Fig 3



Reading of universal bevel protractor

Objectives: At the end of this lesson you will be able to
- **read a vernier bevel protractor for acute angle setting**
- **read a vernier bevel protractor for obtuse angle setting.**

For reading acute angle set up (Fig 1)**:** First read the number of whole degrees between zero of the main scale and zero of the vernier scale.

Note the line on the vernier scale that exactly coincides with any one of the main scale divisions and determine its value in minutes. (Fig 2)

To take the vernier scale reading, multiply the coinciding divisions with the least count.

Example

10 x 5' = 50'

Total up both the readings to get the measurements=41°50'.

If you read the main scale in an anticlockwise direction, read the vernier scale also in an anticlockwise direction from zero.

For obtuse angle set up (Fig 3**)**

The vernier scale reading up is taken on the left side as indicated by the arrow (Fig 4). The reading value is subtracted from 180° to get the obtuse angle value.

Reading 22°30'

Measurement 180°-22°30'=157"30'

Fig 1

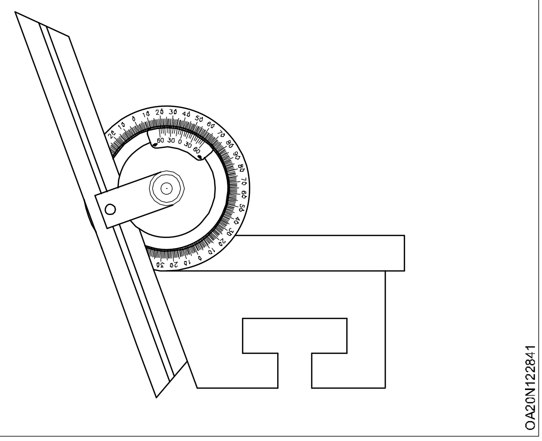


Fig 2

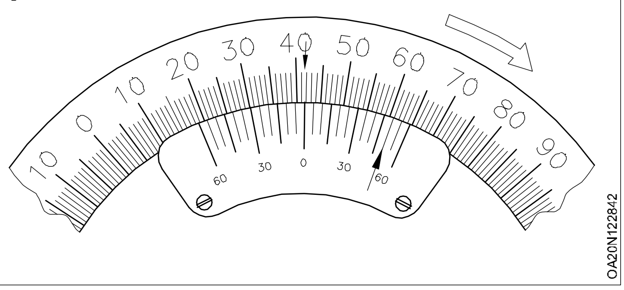
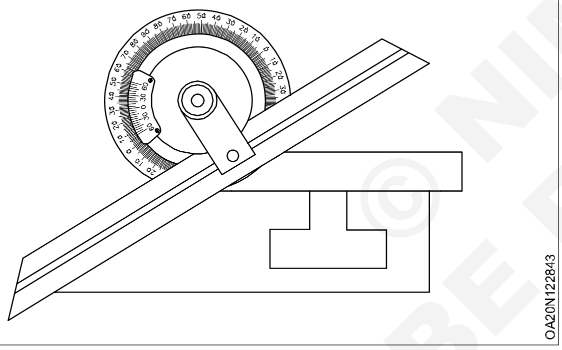


Fig 3



Care and maintenance of vernier bevel protractor

1 Clean the vernier bevel protractor before use.

2 Loosen the locking screw of dial to move the blade according to the angle measurement.

3 While taking a measure ment apply light pressure on vernier bevel protractor

4 Heavy pressure will force the two scales out of parallel and show the false reading.

5 After using vernier bevel protractor wipe it clean and apply a thin coating of oil and keep it in safe place.

Calculation Vernier Constant (VC)

The least count (LC) of the vernier calipers is known as Vernier Constant (VC). It is difference one main scale division and one vernier scale division, i.e VC = IM SD - IV SD

If n divisions on vernier scale coincide with (n - 1) main scale divisions so the Vernier constant will be

$$V_C = \left[1 - \frac{(n-1)}{n}\right] MSD$$

$$= \frac{MSD}{n}$$

Bench and pedestal grinders

Objectives: At the end of this lesson you shall be able to
- **state the purpose of off-hand grinding**
- **state the machines with which off-hand grinding is done**
- **state the features of bench and pedestal grinders.**

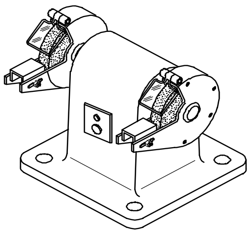
Off-hand grinding is the operation of removing material which does not require great accuracy in size or shape. This is carried out by pressing the workpiece by hand against a grinding wheel.

Off-hand grinding is performed for rough grinding of jobs and resharpening of

- scribers
- punches
- chisels
- twist drills
- single point cutting tools etc.

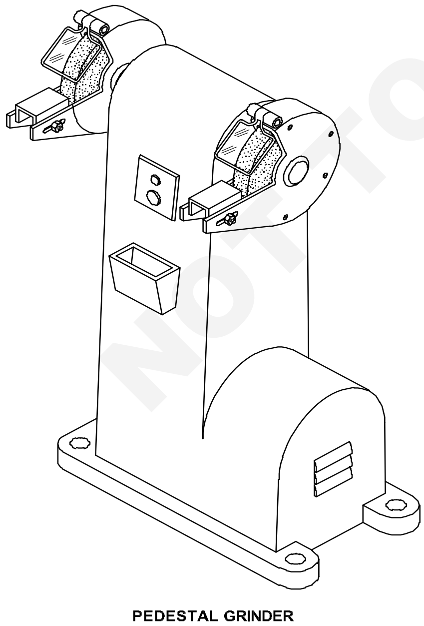
Off-hand grinding is performed with a bench or pedestal grinder. (Figs 1 and 2)

Fig 1



BENCH GRINDER

Fig 2



PEDESTAL GRINDER

Bench grinders

Bench grinders are fitted to a bench or table, and are useful for light duty work.

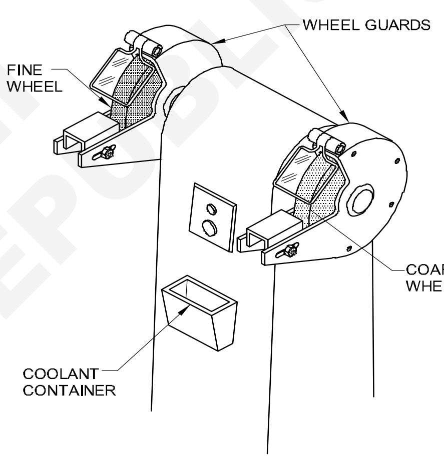
Pedestal grinders

Pedestal grinders are mounted on a base (pedestal), which is fastened to the floor. They are used for heavy duty work.

These grinders consist of an electric motor and two spindles for mounting grinding wheels. On one spindle a coarse-grained wheel is fitted, and on the other, a fine grained wheel. For safety, while working, wheel guards are provided. (Fig 3)

A coolant container is provided for frequent cooling of the work. (Fig 3)

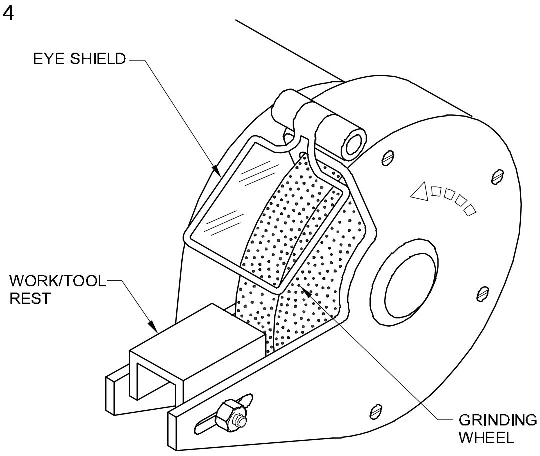
Fig 3



Adjustable work-rests are provided for both wheels to support the work while grinding. These work-rests must be set very close to the wheels. (Fig 4)

Extra eye shields are also provided for the protection of the eyes. (Fig 4)

Fig 4



Maintaining grinding wheels

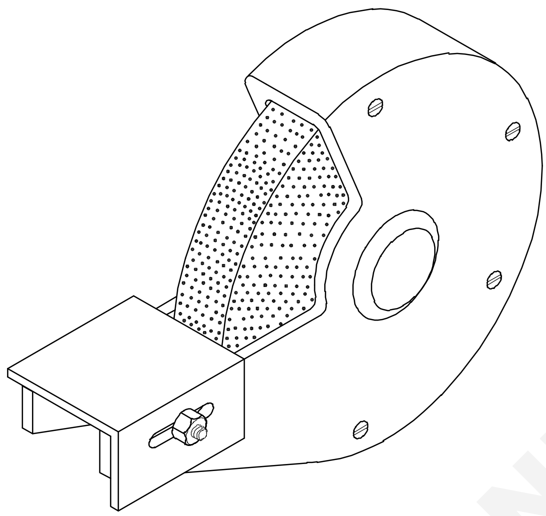
Objectives: At the end of this lesson you shall be able to
- **explain difference between loading and glazing**
- **state the effects of loading and glazing**
- **explain difference between dressing and truing.**

Grinding wheels become inefficient due to two main causes known as loading and glazing.

Loading

When soft materials such as aluminium, copper, lead etc. are ground, the metal particles get clogged in the pores of the wheel. This condition is called loading. (Fig 1)

Fig 1



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Glazing : When a surface of the wheel develops a smooth and shining appearance, it is said to be glazed. This indicates that the wheel is blunt, i.e. the abrasive grains are not sharp.

When such grinding wheels are used, there is a tendency to exert extra pressure in order to make the wheels cut. Excessive pressure on the grinding wheel will lead to the fracture of the wheel, excessive heating of the wheel, weakening of bonding of the wheel and bursting of the wheel.

Dressing : The purpose of dressing is to restore the correct cutting action of the wheel. Dressing removes the clogs on the surface of the wheel and the blunt grains of the abrasive, exposing the new sharp abrasive grains of the wheel which can be cut and brought to shape efficiently.

Truing : Truing refers to the shaping of the wheel to make it run concentric with the axis. When a new grinding wheel is mounted, it must be trued before use. The cutting surface of a new wheel may run out slightly due to the clearance between the bore and the machine spindle. Grinding wheels, which are in use, can also run out of true, due to uneven loading while grinding.

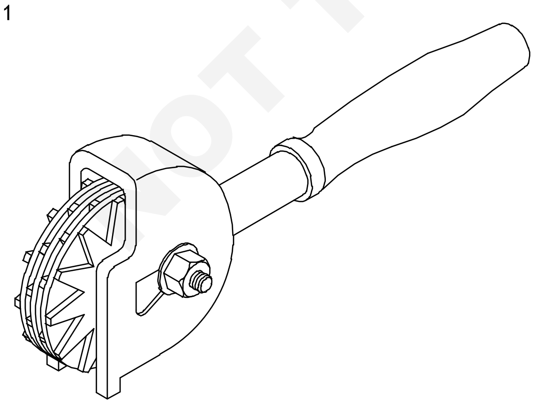
Dressing and truing are done at the same time.

Grinding wheel dressers

Objectives: At the end of this lesson you shall be able to
- **explain the common types of wheel dressers**
- **state the uses of each type of wheel dresser.**

The wheel dressers used for off-hand grinders are star wheel dressers (Fig 1) (Huntington type wheel dresser) and diamond dressers.

Fig 1



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The star wheel dresser consists of a number of hardened star-shaped wheels mounted on a spindle at one end and a handle at the other end.

While dressing, the star wheel is pressed against the face of the revolving grinding wheel. The star wheel revolves and digs into the surface of the grinding wheel. This releases the wheel loading and dull grains, exposing sharp new abrasive grains.

Star wheels are useful for pedestal grinders in which a precision finish is not expected.

> **Star wheel dressers should be used only on wheels which are large enough to take the load.**

Diamond dressers (Fig 2)

Bench type off-hand grinders used for sharpening cutting tools are usually fitted with smaller and rather delicate wheels.

These wheels are dressed and trued with diamond dressers.

Diamond dressers consist of a small diamond mounted on a holder which can be held rigidly on the work-rest.

How to use a wheel dresser (Fig 3)

For dressing and truing, the dresser is slowly brought in contact with the wheel face and moved across.

Fig 2

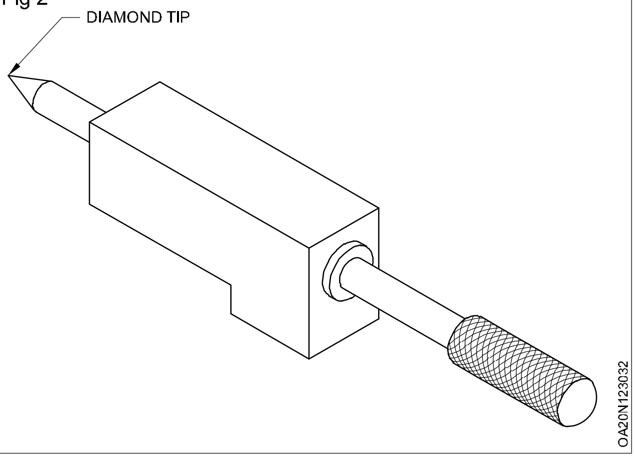
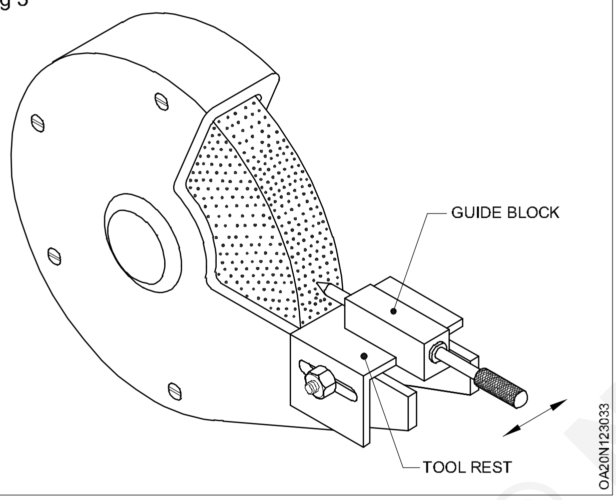


Fig 3



The finish obtained depends on the rate at which the dresser is moved across the face.

For roughing, the dresser is moved faster.

For fine finish, the dresser is moved slowly.

Roughing will be efficient with a dresser that has a sharp point, while, for fine finishing, a blunt diamond dresser is more suitable.

Abrasive stick

When only a light dressing is required, abrasive sticks can also be used. There are abrasive materials made in the form of sticks for the convenience of handling.

Diamond dressers, if moved too slowly, can glaze the wheel.

Hacksaw frames and blades

Objectives: At the end of this lesson you shall be able to
- **explain the different types of hacksaw frames**
- **explain the different type of hacksaw blades**
- **describe the method of sawing.**

Hacksaw frame: A hacksaw frame is used along with a blade to cut metals of different sections, and is specified by the type and maximum length of the blade that can be fixed.

Example

Adjustable hacksaw frame - tubular - 250 - 300mm or 8" - 12"

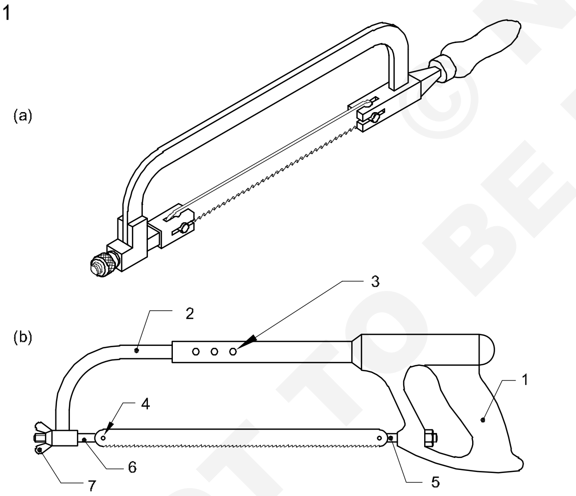
Types of hacksaw frames

Solid frame (Fig 1a)**:** Only a blade of a particular standard length can be fitted to this frame. e.g 300 mm or 250 mm.

Adjustable frame (flat type)**:** Different standard lengths of blades can be fitted to this frame i.e. 250 mm and 300 mm.

Adjustable frame (tubular type) (Fig 1b)**:** This is the most commonly used type. It gives a better grip and control, while sawing.

Fig 1

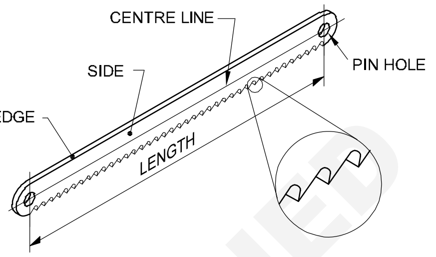


Parts of a hacksaw frame

1 Handle
2 Frame
3 Tubular frame with holes for length adjustment
4 Retaining pins
5 Fixed blade-holder
6 Adjustable blade-holder
7 Wing-nut

A hacksaw blade is made of either low alloy steel (LA) or high speed steel (HSS), and is available in standard lengths of 250 mm and 300mm. (Fig 2)

Fig 2



Parts of a hacksaw blade (Fig 2)

1 Back edge
2 Side
3 Centre line
4 Pin holes

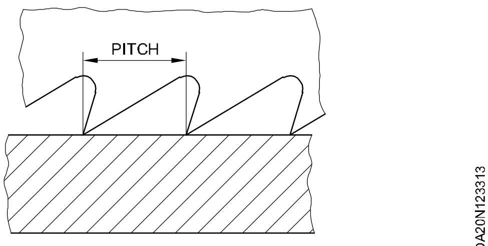
Type of hacksaw blades

All-hard blade: The full length of the blade between the pins is hardened and it is used for harder metals such as tool steel, die steel and HCS.

Flexible blade: Only the teeth are hardened. Because of their flexibility these blades are useful for cutting along curved lines. Flexible blades should be thinner than all-hard blades.

Pitch of the blade (Fig 3)**:** The distance between adjacent teeth is known as the 'pitch' of the blade.

Fig 3



Classification	Pitch
Coarse	1.8 mm
Medium	1.4 mm & 1.0 mm
Fine	0.8 mm

Specification: Hacksaw blades are specified by the length, pitch and type of material. (The width and thickness of blade is standardised)

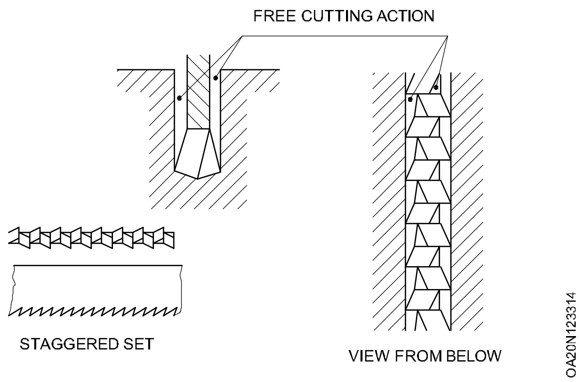
Example

300 x 1.8 mm pitch LA all-hard blade.

To prevent the hacksaw blade binding when penetrating into the material, and to allow free movement of the blade, the cut is to be broader than the thickness of the hacksaw blade. This is achieved by the setting of the hacksaw teeth. There are two types of hacksaw teeth settings.

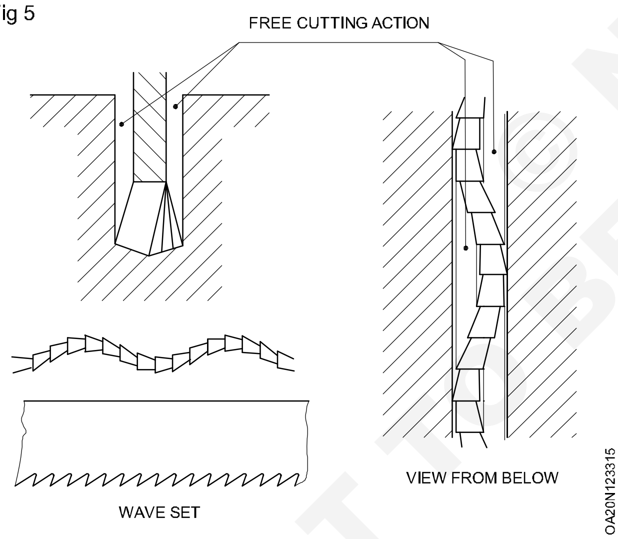
Staggered set (Fig 4)**:** Alternate teeth or groups of teeth are staggered. This arrangement helps for free cutting, and provides for good chip clearance.

Fig 4



Wave set (Fig 5)**:** In this, the teeth of the blade are arranged in a wave-form. The types of sets for different pictures are as follows:

Fig 5



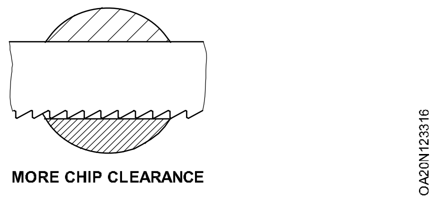
Pitch	Type of set
0.8 mm	Wave-set
1.0 mm	Wave-set or staggered
Over 1.0 mm	Staggered

For the best results, the blade with the right pitch should be selected and fitted correctly.

Selection of blade: The selection of the blade depends on the shape and hardness of the material to be cut.

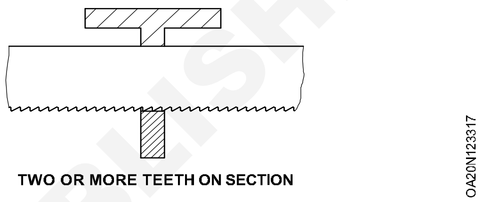
Pitch selection (Fig 6)**:** For soft materials such as bronze, brass, soft steel, cast iron, heavy angles etc. use a 1.8 mm pitch blade.

Fig 6



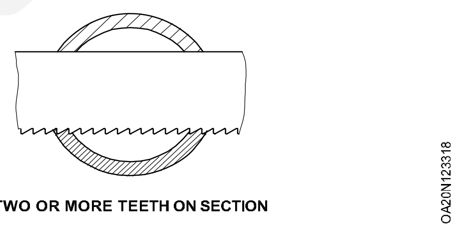
For tool steel, high carbon, high speed steel etc. use a 1.4 mm pitch. For angle iron, brass tubing, copper, iron pipe etc. use a 1 mm pitch blade. (Fig 7)

Fig 7



For conduit and other thin tubing, sheet metal work etc. use a 0.8 mm pitch. (Fig 8)

Fig 8



Method of sawing : Select the correct blade for the material to be cut.

HSS - Blades are used for tough resistant materials

High Carbon Steel - General cutting

Select the correct number of teeth / inch the general rule is that atleast 3 teeth should extend across the surface of the material to be cut.

The hand holds the hacksaw handle, and the index finger is support the handle and also points in the direction of cutting.

The other hand holds the frame, near the wing nut. Cutting/ sewing should be carried out close to the jaws of the vice. This ensures that the metal does not flex or bend under the force of the hacksaw and the sawing motion.

Hammers

Objectives: At the end of this lesson you shall be able to
- **state the uses of an engineer's hammer**
- **identify the parts of an engineer's hammer**
- **name the types of engineer's hammer**
- **specify the engineer's hammer.**

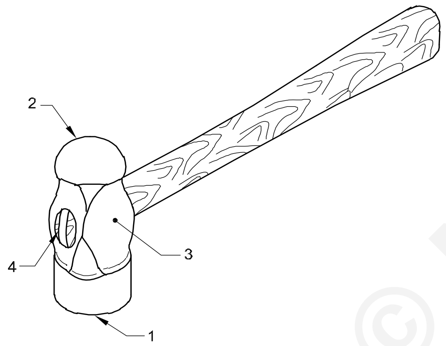
An engineer's hammer is a hand tool used for striking purposes while punching, bending, straightening, chipping, forging or rivetting.

Major parts of a hammer: The major parts of a hammer are the head and the handle.

Hammer is made of drop - forged carbon steel, while the wooden handle must be capable of absorbing shock.

The parts of a hammer - head are face (1), pein (2) cheek (3) and the eyehole (4). (Fig 1)

Fig 1



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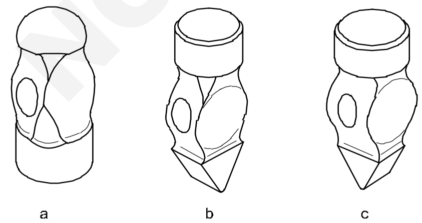
Face: The face is the striking portion. A slight convexity is given to it to avoid digging of the edge. It is used for striking while chipping, bending, punching, etc.

Pein: The pein is the other end of the head. It is used for shaping and forming work like riveting and bending. The pein is of different shapes such as:

- ball pein (Fig 2a)
- cross - pein (Fig 2b)
- straight pein. (Fig 2c)

Fig 2



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The face and the pein are case hardened.

Cheek: The cheek is the middle portion of the hammer head. The weight of the hammer is stamped here.

This portion of the hammer - head is left soft.

Eyehole: The eyehole is meant for fixing the handle. It is shaped to fit the handle rigidly. The wedges fix the handle in the eyehole. (Figs 3 and 4)

Fig 3

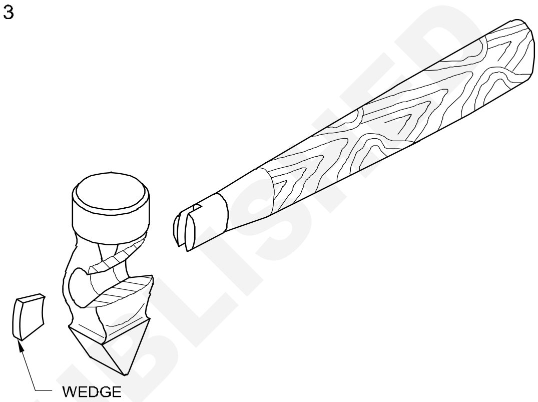

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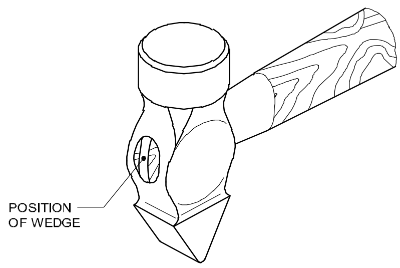
Fig 4



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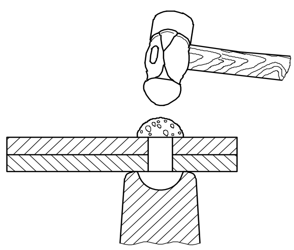
Application of hammer pein: The ball pein is used for riveting. (Fig 5)

Fig 5



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The cross- pein is used for spreading the metal in one direction. (Fig 6)

The straight pein is used at the corners. (Fig 7)

The ball pein hammer is used for driving a chisel in parting metal. (Fig 8)

Specification: An engineer's hammers are specified by their weight and the shape of the pein. Their weight varies from 125 gms to 750 gms.

Fig 6

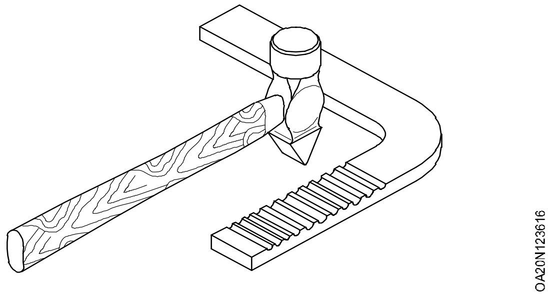


Fig 7

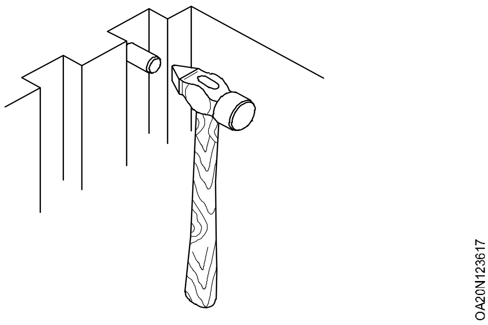
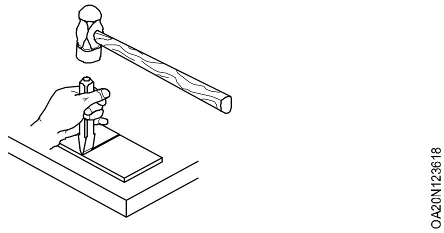


Fig 8



The weight of an engineer's hammer, general work in a machine/ fitting shop.

The ball pein hammers are used for general work in a machine/ fitting shop.

Before using a hammer

- make sure the handle is properly fitted
- select a hammer with the correct weight suitable for the job
- check the hammer head and handle whether any crack is there
- ensure that the face of the hammer is free from oil or grease.

Bending of solid and elections using fixture

Objectives: At the end of this lesson you shall be able to
- **state the properties of solid**
- **locate the solid member for bending.**

A solid is one of the states of matter.

Examples of solids include wood, glass, clay, ice and metals such as steel.

The particles in a solid are closely packed together.

- Solids can retain their shape without a container (unlike liquids). They have a stable, definite shape.
- Solids do not expand to fill the entire available volume (unlike gases). They have a definite volume.

How changes occur in solid materials

This lesson focuses on physical changes that solid materials undergo.

Solid materials can be changed by,

- bending
- breaking
- cutting
- folding
- hammering
- twisting
- stretching

These are really just terms that we use to describe what is being done to a solid material, and a lot these processes are similar results, such as breaking and cutting, or bending and twisting.

A fundamental concern in metal working is locating the part to be machined, punched, bent, or stamped relative to the work platform (fixture). Hence, the accuracy with which a part is machined is quite dependent on the accuracy with which it is positioned in the fixture.

Accurate locating of not just one part, but each and every part that is loaded into the fixture is crucial. Any variation in part location on the fixture adds to the dimensional tolerance that must e assigned to the finished parts.

Additionally, the method of supporting and securing the part in the fixture affects not only dimensional tolerances, but surface finishes as well. This is true because improper supporting or clamping can temporarily or permanently deform the part. Hence, techniques for supporting and clamping must be considered together with the method of locating in order to assure repeatability from part to part.

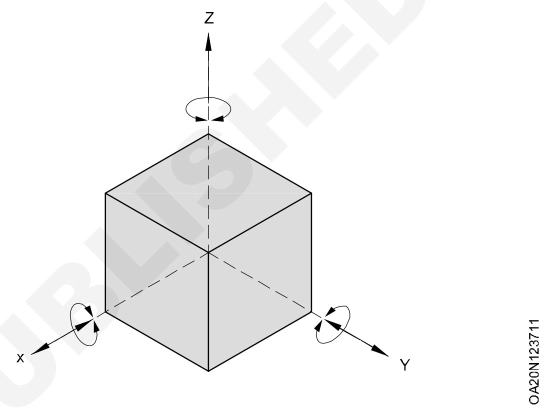
Locating of a part to be machined is a three step process

1 Supporting

2 Locating (positioning)

3 Holding (clamping) (Fig 1)

Fig 1



The locating process

Degrees of freedom

In order to completely specify the position in space of a three dimensional object (such as the cube shown in Fig 1), we refer to six coordinates.

- Translational position along the X axis
- Translational position along the Y axis
- Translational position along the Z axis
- Rotational position along the X axis
- Rotational position along the Y axis
- Rotational position along the Z axis

These six coordintes are known as the six degrees of freedom of a three dimensional object. As the double headed arrows indicate, the translational and rotational positions can vary in either direction with respect to each of the three axes.

To completely prevent movement, all six degrees of freedom must be restricted.

Letter punch and number punch

Objective: At the end of this lesson you shall be able to
- **state the uses of letter punch and number punch.**

Metal stamps are used to mark or identify work pieces. They are available for stamping letters (Letter Punch) and Numbers (Number punch). They can not be used on hardened metal surfaces (Fig 1)

The letter punch set consists of A, B, C, D, E, F, G, H, N, I, J, K, L, M, N, O, P,Q, R, S, T, U, V, W, X, Y, Z, and '&' (Symbol) of 27 Letter punches in a set. The Number punch set consists of 0,1,2,3,4,5,6,7,8, the number punch 6 will the used for punching number both 6 and 9 .

The letters and numbers are formed in the reverse order. So that while punching letters and numbers will be in correct position. A base line should be scribed on the metal surface, before stamping the letter or number using these punches. Also to locate the position of middle letter (Fig 2) or number (Fig 3) or space (Fig 4) a centre line should be scribed on the base line (Fig 2) Letters or numbers before stamping should be placed on either side of the line from center line, so that middle letter is stamped over the centreline large size letter number punches are used for better impression by applying more than one stroke. While Punching on cast iron or hot rolled steel, the hard outer layer of the metal should the removed by grinding or filing or machining for better impression are visibility.

Fig 1

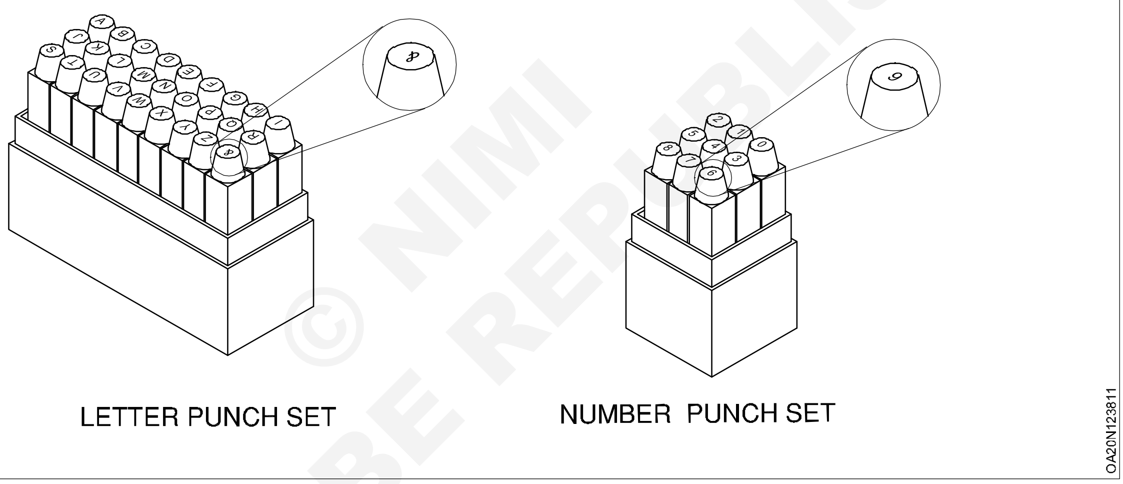
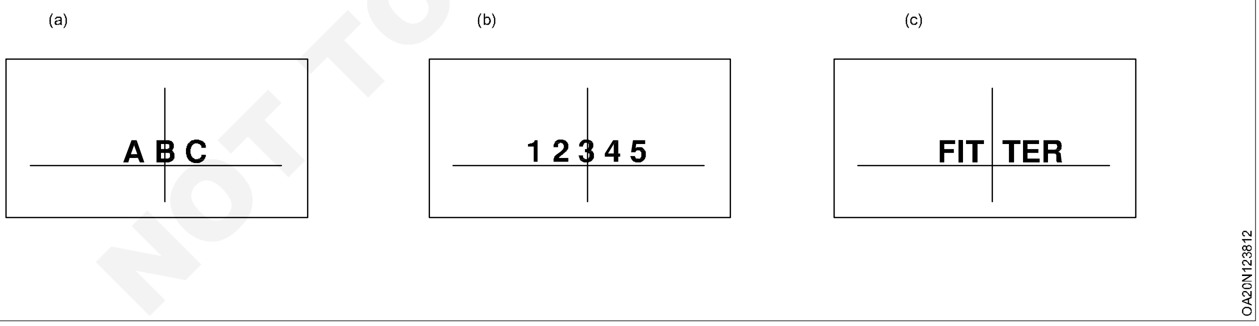


Fig 2



Pipes and pipe fittings

Objectives: At the end of this lesson you shall be able to
- **state the uses of pipes**
- **name the common types of pipes**
- **identify the standard pipe fittings and state their uses.**

Various types of pipes and tubes are used for the following purposes.

- Domestic hot and cold water supplies.
- Waste water outlets.
- High pressure steam supplies.
- Hydraulic oil supplies.
- Lubricating oil supplies.
- Special fluid and gases for industrial processes.
- Pneumatic systems.
- Refrigeration systems.
- Fuel oil supplies.

The common types of pipes classified according to material are:

- galvanized iron pipes
- mild steel pipes
- cast iron pipes
- C.I. soil pipes
- copper pipes
- aluminium pipes
- brass pipes
- lead pipes
- P.V.C. pipes
- rubber pipes
- plastic pipes
- stoneware pipes.

Standard pipe fitting

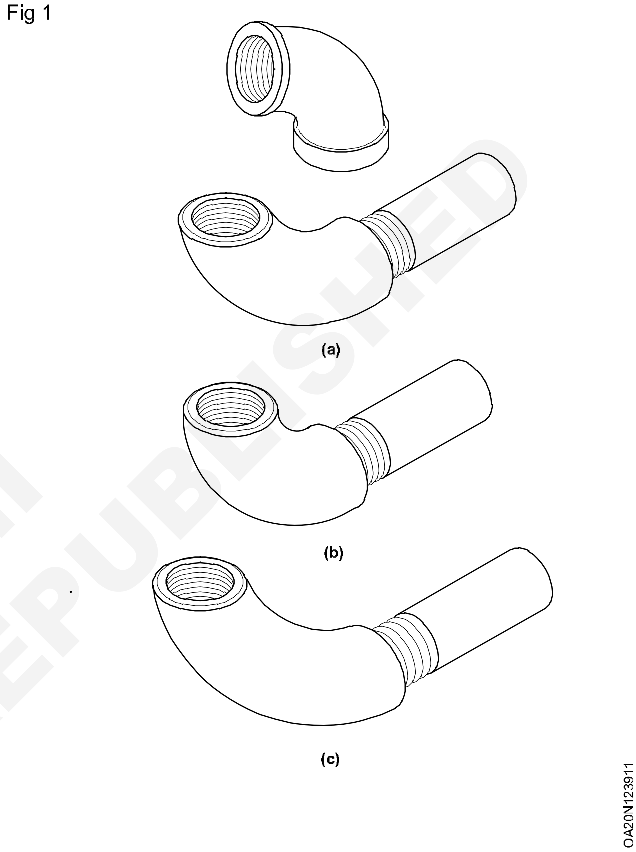
'Pipe fittings' are those fittings that may be attached to water pipes in order to:

- change the direction of the pipe
- connect a branch with a main water supply pipe
- connect two or more pipes of different sizes
- close the pipe ends.

Standard pipe fittings

Elbows (Fig 1) : Elbows and bends provide deviations of 90° and 45° in pipe work systems.

Fig 1



Long radius elbows have a radius equal to 1½ times the bore of the pipe. (Fig 1a)

Short radius elbows have a radius equal to the bore of the pipe.(Fig 1b)

The 45° elbows allow pipe deviation of 45°. (Fig 1c)

Tee branch

A tee joint helps the pipe line to branch off at 90°. The branches may be equal in diameter or there may be one reducing branch.

The dimensions of a branch are always quoted as A x B x C. (Fig 2)

Reducing tee branch

Reducers are fitted where a change in pipe diameter is required. (Fig 3)

Eccentric reducer

Used mainly in horizontal position.(Fig 4)

Concentric reducer

Used mainly in vertical position. (Fig 5)

Fig 2

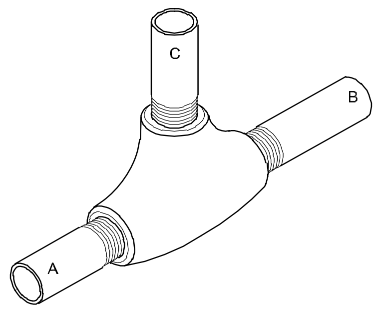


Fig 3

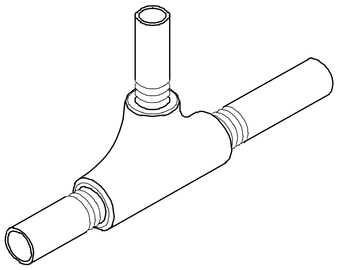


Fig 4

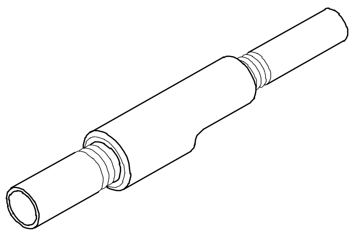
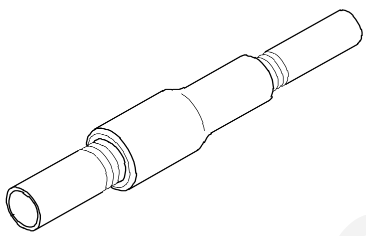


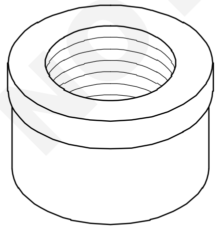
Fig 5



Caps

Caps are used for closing the end of a pipe or fitting which has an external thread. (Fig 6)

Fig 6



Plug

A plug is used for closing a pipeline which has an internal thread.(Fig 7)

Coupling (Fig 8) : A coupling is used to connect two pipes. Couplings have internal threads at both ends to fit the external threads on pipes.

Fig 7

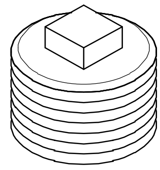
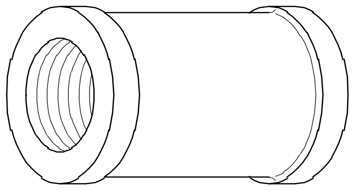


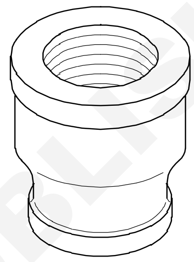
Fig 8

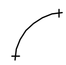
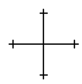
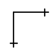
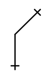
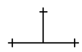
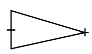
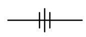
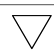
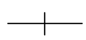


Reducer (Fig 9)

A reducer coupling is used to connect two pipes with different diameters.

Fig 9



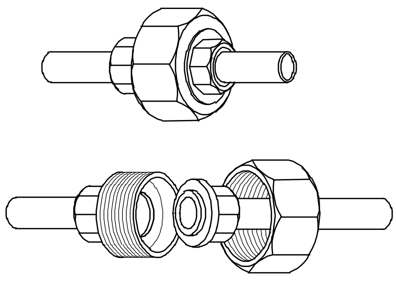
FITTING	SYMBOL
BEND, 90 DEGREES	
BEND, 45 DEGREES	
CROSS	
ELBOW, 90 DEGREES	
ELBOW, 45 DEGREES	
TEE	
REDUCER,CONCENTRIC	
UNION,SCREWED	
PLUG OR CAP	
JOINT/SOCKET	

Union

A device used to connect pipes. Unions are inserted in a pipe-line to permit connections with little change to the position of the pipe. (Fig 10)

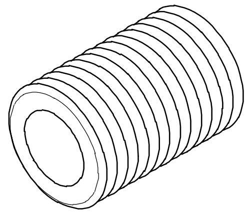
Pipe nipples : Pipe nipples are tubular pipe fittings used to connect two or more pipes of different sizes.

Fig 10



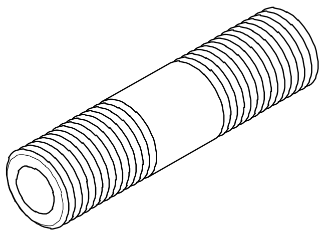
1 Close nipple (Fig 11)

Fig 11



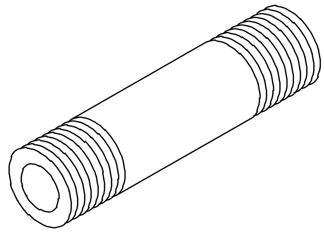
2 Short nipple (Fig 12)

Fig 12



3 Long nipple (Fig 13)

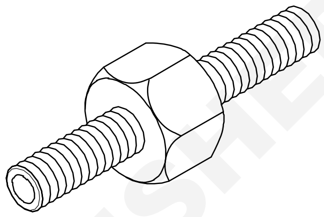
Fig 13



The hexagonal nut

The hexagonal nut in the centre of the nipple is for tightening with a spanner or wrench.(Fig 14)

Fig 14



British standard pipe threads

Objectives: At the end of this lesson you shall be able to
- **state parallel and taper pipe threads**
- **determine the wall thickness and threads per inch TPI of BSP threads**
- **state the method of sealing pipe joints**
- **determine blank sizes for threading as per B.S 21-1973 and I.S.2643-1964.**

Pipe threads

The standard pipe fittings are threaded to British Standard pipe gauge (BSP). The internal pipe threads have parallel threads whereas the external pipes have tapered threads as shown in Fig 1.

B.S.P. threads

Galvanized iron pipes are available in sizes ranging from 1/2" to 6" in several different wall thicknesses. The table shows outside diameters and threads per inch from 1/2" to 4". (Fig 2)

Sealing pipe joint

Fig 3 shows that the pipe has several fully formed threads at the end. (A)

The next two threads have fully formed bottoms but flat tops. (B)

BSP - Pipe sizes or DIN 2999 (inside) (B)	Threads/ + inch	Outside diameter / mm of the pipe(A)+
1/2”	14	20.955mm
3/4”	14	26.441
1”	11	33.249
1 1/4”	11	41.910
1 1/2”	11	47.803
2”	11	59.614
2½”	8	75.184
3”	8	87.884
4”	8	113.030

The last four threads have flat tops and bottoms. (C)

The pipe joint shown in Fig 4 consists of the following.

1 Parallel female thread

2 Tapered male thread

3 Hemp packing

Fig 1

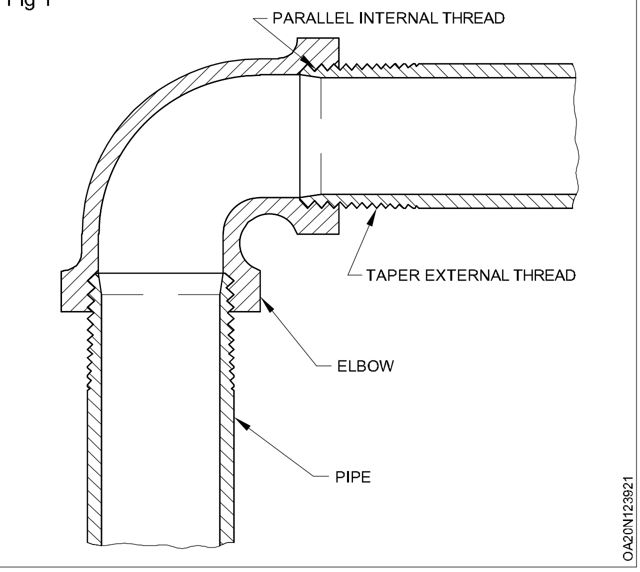


Fig 2

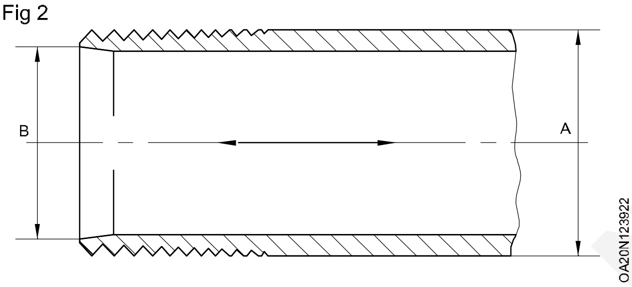


Fig 3

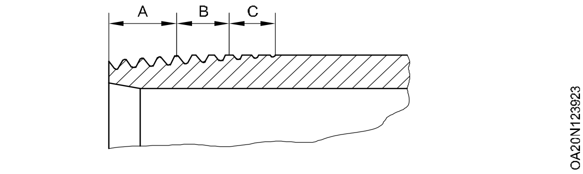
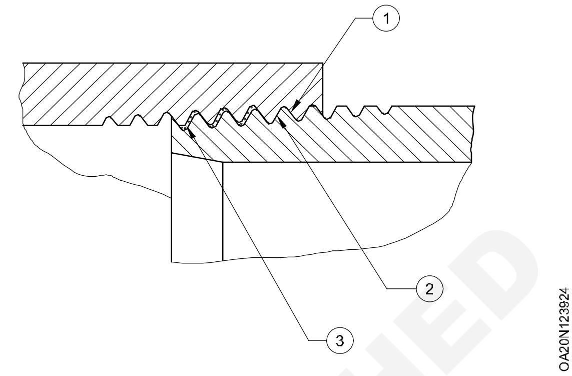


Fig 4



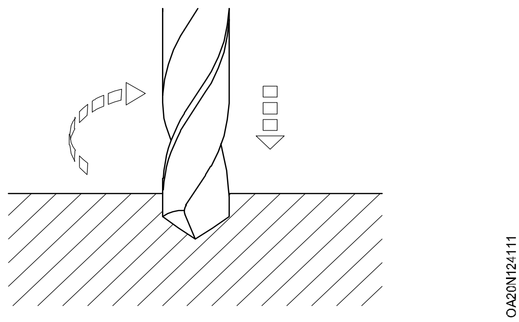
The hemp packing is used to ensure that any small space between two metal threads (male and female threads) is sealed to prevent any leakage.

Drill (parts and functions)

Objectives: At the end of this lesson you shall be able to
- **state the functions of drills**
- **identify the parts of a drill**
- **state the functions of each part of the drill.**

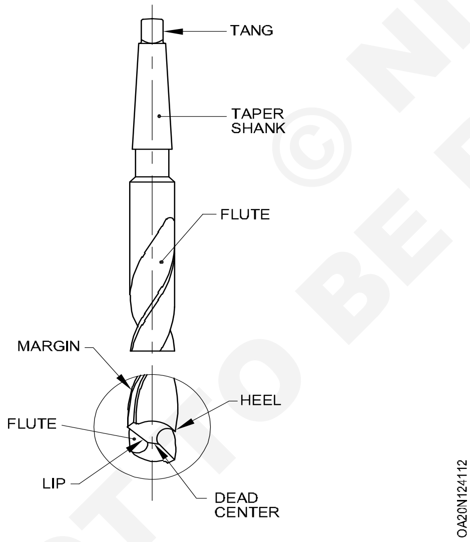
Drilling is a process of making holes on workpieces. The tool used is a drill. For drilling, the drill is rotated with a downward pressure causing the tool to penetrate into the material. (Fig 1)

Fig 1



Parts of a drill (Fig 2) : The various parts of a drill can be identified from figure 2.

Fig 2



Point : The cone-shaped end which does the cutting is called the point. It consists of a dead centre, lips or cutting edges, and a heel.

Shank : This is the driving end of the drill which is fitted on the machine. Shanks are of two types.

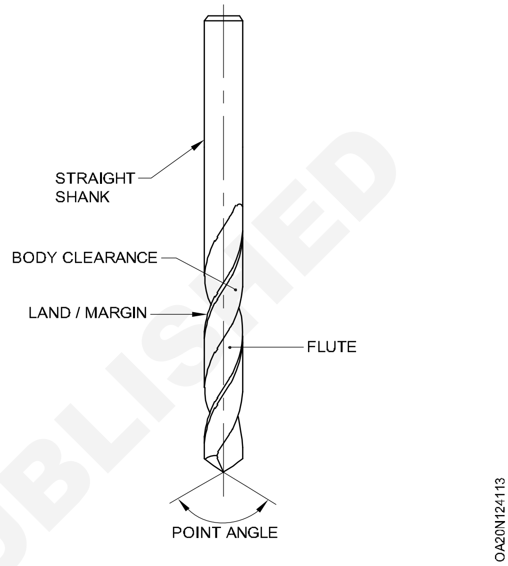
Taper shank used for larger diameter drills, and straight shank used for smaller diameter drills. (Fig 3)

Tang : This is a part of the taper shank drill which fits into the slot of the drilling machine spindle.

Body : The portion between the point and the shank is called the body of a drill.

The parts of the body are flute, land/margin, body clearance and web.

Fig 3



Flutes (Fig 3) :Flutes are the spiral grooves which run to the length of the drill. The flutes help:

- to form the cutting edges
- to curl the chips and allow these to come out
- the coolant to flow to the cutting edge.

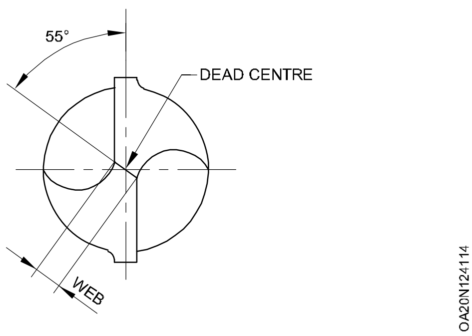
Land/margin (Fig 3) : The land/margin is the narrow strip which extends to the entire length of the flutes.

The diameter of the drill is measured across the land/ margin.

Body clearance (Fig 3) : Body clearance is the part of the body which is reduced in diameter to cut down the friction between the drill and the hole being drilled.

Web (Fig 4) : Web is the metal column which separates the flutes. It gradually increases in thickness towards the shank.

Fig 4



Drill-holding device

Objectives: At the end of this lesson you shall be able to
- **name the types of drill-holding devices**
- **state the features of drill chucks**
- **state the functions of drill sleeves**
- **state the function of drift.**

For drilling holes on materials, the drills are to be held accurately and rigidly on the machines.

The common drill-holding devices are drill chucks and sleeves and sockets.

Drill chuck : Straight shank drills are held in drill chucks. For fixing and removing drills, the chucks are provided either with a pinion and key or a knurled ring.

The drill chucks are held on the machine spindle by means of an arbor fitted on the drill chuck. (Fig 1)

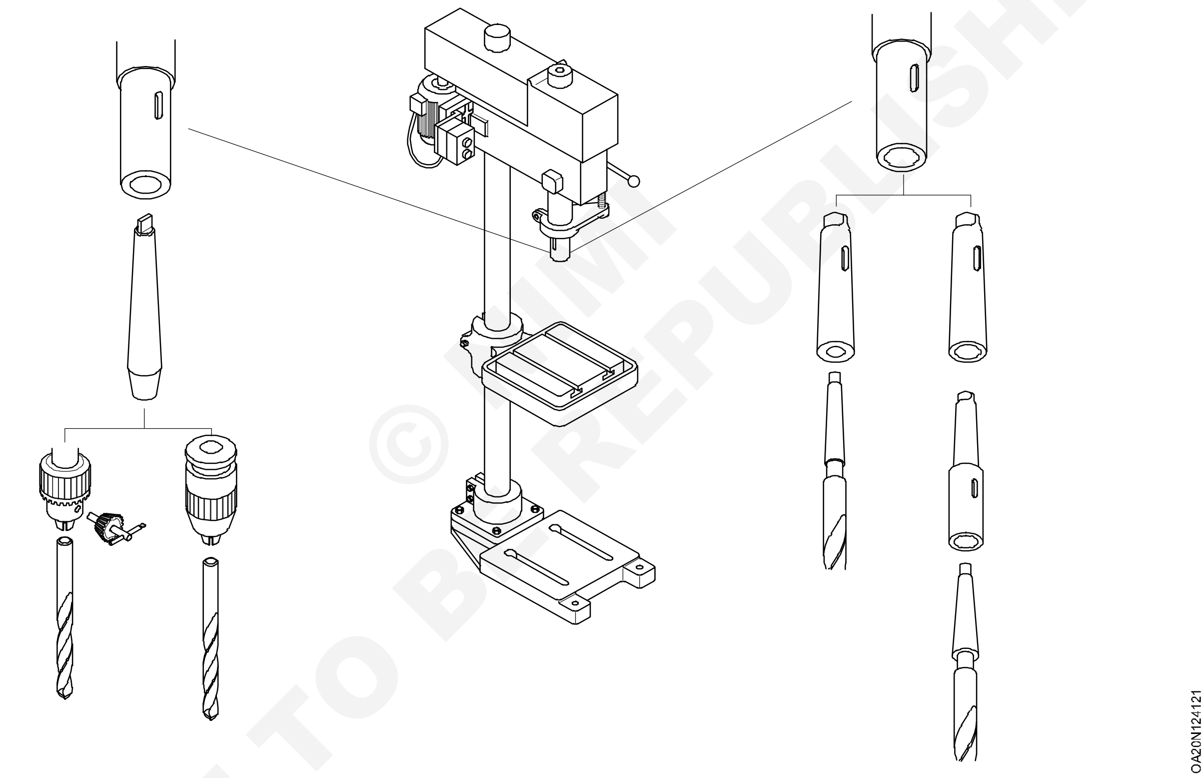
Taper sleeves and sockets (Fig 1)

Taper shank drills have a Morse taper.

Sleeves and sockets are made with the same taper so that the taper shank of the drill, when engaged, will give a good wedging action. Due to this reason Morse tapers are called self-holding tapers.

Drills are provided with five different sizes of Morse tapers, and are numbered from MT1 to MT5.

Fig 1



In order to make up the difference in sizes between the shank of drills and the type of machine spindles, sleeves of different sizes are used. When the drill taper shank is bigger than the machine spindle, taper sockets are used. (Fig 1)

While fixing the drill in a socket or sleeve, the tang portion should align in the slot. (Fig 2).

This will facilitate the removal of drill or sleeve from the machine spindle.

Use a drift to remove drills and sockets from the machine spindle. (Fig 3)

While removing the drill from the sockets/ sleeves, don't allow it to fall on the table or jobs. (Fig 4)

Fig 2

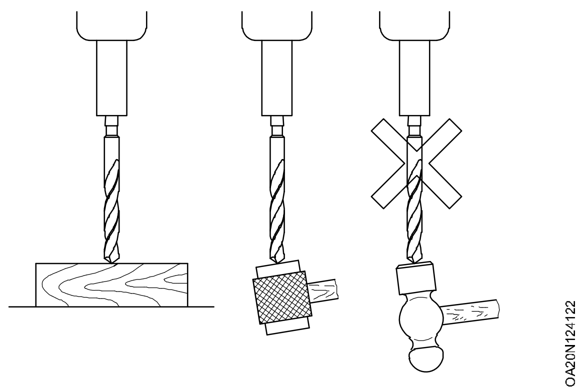


Fig 3

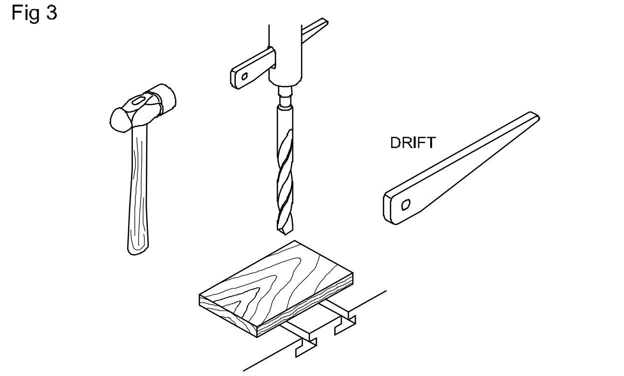
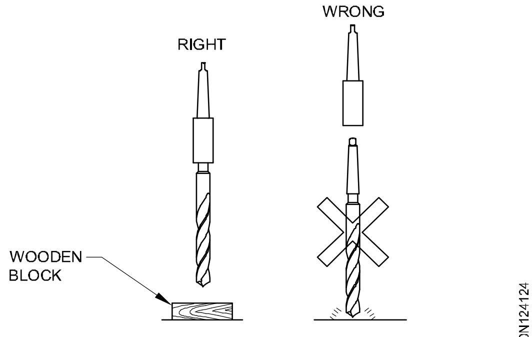


Fig 4



REMOVING A TAPER SHANK DRILL

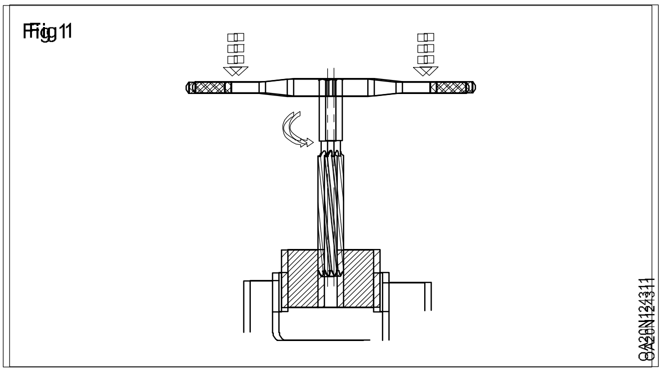
Reamers

Objectives: At the end of this lesson you shall be able to
- **state the use of reamers**
- **state the advantages of reaming**
- **explain difference between hand and machine reaming**
- **explain the elements of a reamer and state their functions.**

What is a reamer?

A reamer is a multi-point cutting tool used for enlarging by finishing previously drilled holes to accurate sizes.(Fig 1)

Fig 1



Advantages of 'reaming'

Reaming produces

- high quality surface finish
- dimensional accuracy to close limits.

Also small holes which cannot be finished by other processes can be finished.

Classification of reamers

Reamers are classified as hand reamers and machine reamers. (Figs 2 and 3)

Fig 2

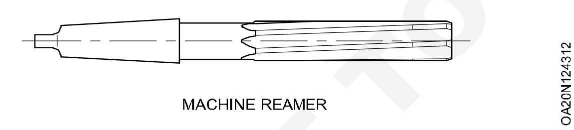
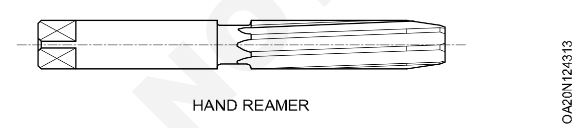


Fig 3



Reaming by using hand reamers is done manually for which great skill is needed.

Machine reamers are fitted on spindles of machine tools and rotated for reaming.

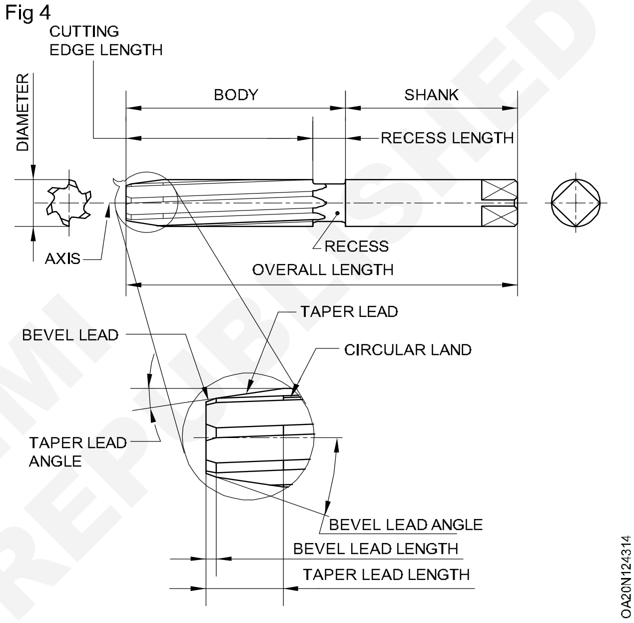
Machine reamers are provided with morse taper shanks for holding on machine spindles.

Hand reamers have straight shanks with 'square' at the end, for holding with tap wrenches. (Figs 2 & 3)

Parts of a hand reamer

The parts of a hand reamer are listed hereunder. Refer to Fig 4.

Fig 4



Axis

The longitudinal centre line of the reamer.

Body

The portion of the reamer extending from the entering end of the reamer to the commencement.

Recess

The portion of the body which is reduced in diameter below the cutting edges, pilot or guide diameters.

Shank

The portion of the reamer which is held and driven. It can be parallel or tapered.

Circular land

The cylindrically ground surface adjacent to the cutting edge on the leading edge of the land.

Bevel lead

The bevel lead cutting portion at the entering end of the reamer cutting its way into the hold. It is not provided with a circular land.

Taper lead

The tapered cutting portion at the entering end to facilitate cutting and finishing of the hole. It is not provided with a circular land.

Bevel lead angle

The angle formed by the cutting edges of the bevel lead and the reamer axis.

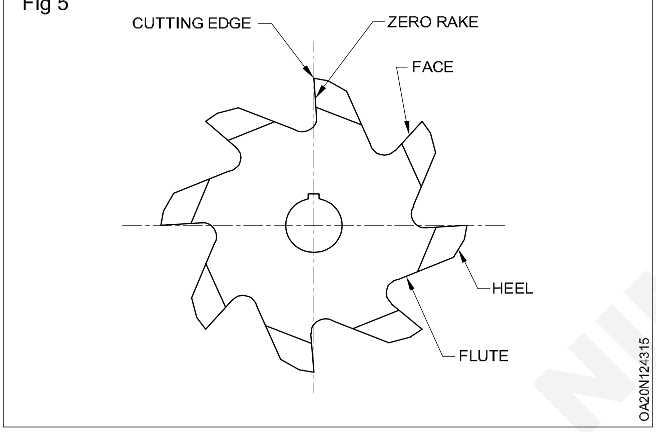
Taper lead angle

The angle formed by the cutting edges of the taper and the reamer axis.

Terms relating to cutting geometry flutes

The grooves in the body of the reamer to provide cutting edges, to permit the removal of chips, and to allow the cutting fluid to reach the cutting edges. (Fig 5)

Fig 5



Heel

The edge formed by the intersection of the surface left by the provision of a secondary clearance and the flute. Fig 5)

Cutting edge

The edge formed by the intersection of the face and the circular land or the surface left by the provision of primary clearance. (Fig 5)

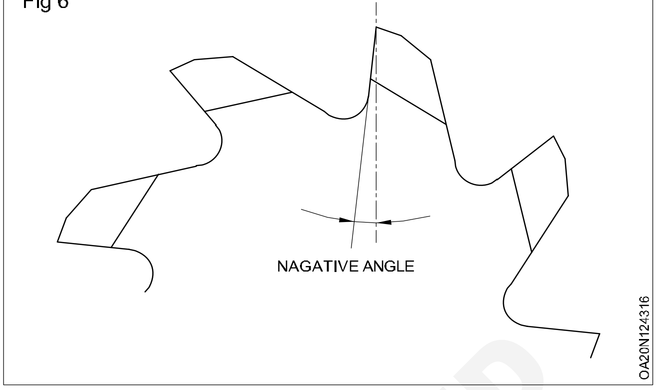
Face

The portion of the flute surface adjacent to the cutting edge on which the chip impinges as it is cut from the work. (Fig 5)

Rake angles

The angles in a diametric plane formed by the face and a radial line from the cutting edge. (Fig 6)

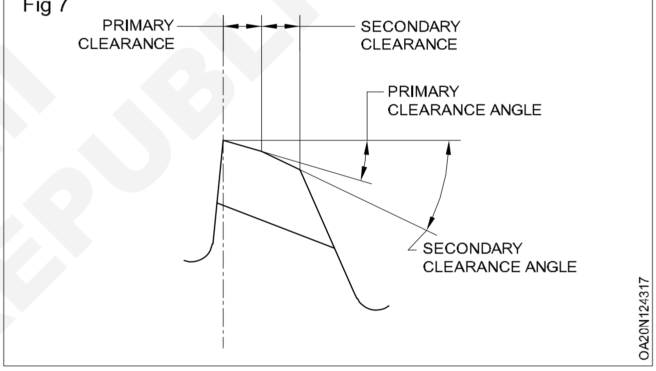
Fig 6



Clearance angle

The angles formed by the primary or secondary clearances and the tangent to the periphery of the reamer at the cutting edge. They are called primary clearance angle and secondary clearance angle respectively. (Fig 7)

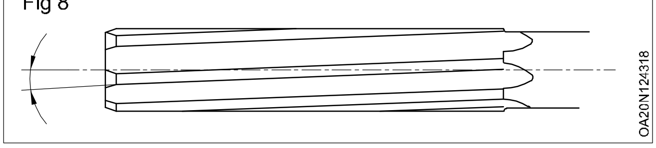
Fig 7



Helix angle

The angle between the edge and the reamer axis. (Fig 8)

Fig 8



Hand reamers

Objectives: At the end of this lesson you shall be able to
- **state the general features of hand reamers**
- **explain the types of hand reamers**
- **explain difference between the uses of straight fluted and helical fluted reamers**
- **state the materials from which reamers are made and specify reamers.**

General features of hand reamers (Fig 1)

Hand reamers are used to ream holes manually using tap wrenches.

These reamers have a long taper lead. (Fig 2) This allows to start the reamer straight and in alignment with the hole being reamed.

Most hand reamers are for right hand cutting.

Helical fluted hand reamers have left hand helix. The left hand helix will produce smooth cutting action and finish.

Most reamers, machine or hand, have uneven spacing of teeth. This feature of reamers helps to reduce chattering while reaming. (Fig 3)

Fig 1

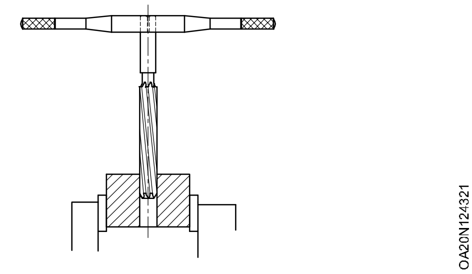


Fig 2

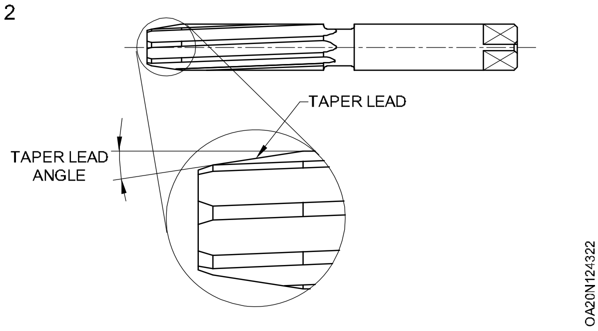
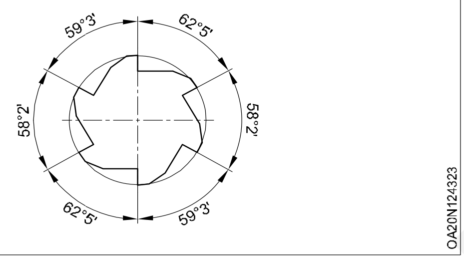


Fig 3



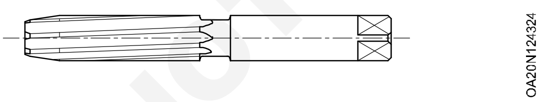
Types, Features and Functions

Hand reamers with different features are available for meeting different reaming conditions. The commonly used types are listed here under.

Parallel hand reamer with parallel shank (Fig 4)

A reamer which has virtually parallel cutting edges with taper and bevel lead. The body of the reamer is integral with a shank. The shank has the nominal diameter of the cutting edges. One end of the shank is square shaped for tuning it with a tap wrench. Parallel reamers are available with straight and helical flutes. This is the commonly used hand reamer for reaming holes with parallel sides.

Fig 4

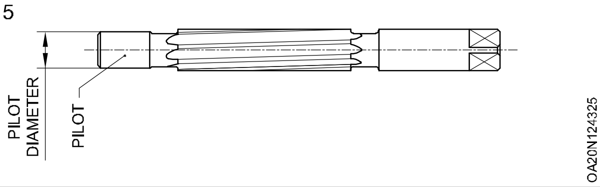


Reamers commonly used in workshop produce H8 holes.

Hand reamer with pilot (Fig 5)

For this type of reamer, a portion of the body is cylindrically ground to form a pilot at the entering end. The pilot keeps the reamer concentric with the hole being reamed.

Fig 5



Socket reamer with parallel shank (Figs 6 & 7)

This reamer has tapered cutting edges to suit metric morse tapers. The shank is integral with the body, and is square shaped for driving. The flutes are either straight or helical. The socket reamer is used for reaming internal morse tapered holes.

Fig 6

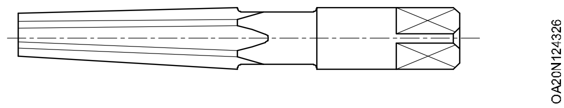
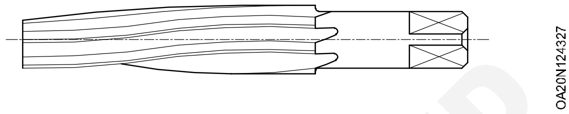


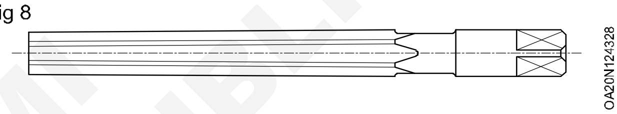
Fig 7



Taper pin hand reamer (Fig 8)

This reamer has tapered cutting edges for reaming taper holes to suit taper pins. A taper pin reamer is made with a taper pin of 1 in 50. These reamers are available with straight or helical flutes.

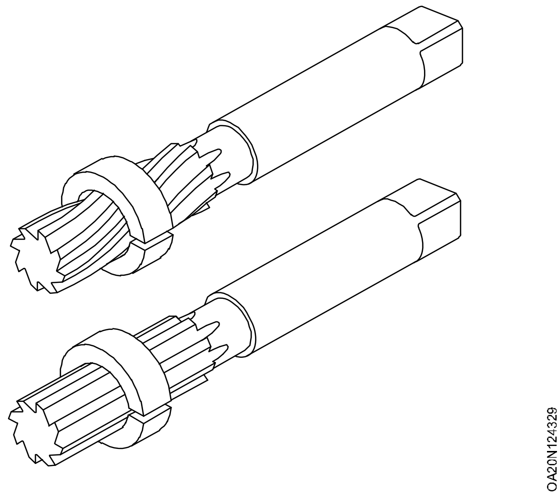
Fig 8



Use of straight and helical fluted reamers (Fig 9)

Straight fluted reamers are useful for general reaming work. Helical fluted reamers are particularly suitable for reaming holes with keyway grooves or special lines cut into them. The helical flutes will bridge the gap and reduce binding and chattering.

Fig 9



Material of hand reamers

When the reamers are made as a one-piece construction, high speed steel is used. When they are made as two-piece construction then the cutting portion is made of high speed steel while the shank portion is made of carbon steel. They are butt-welded together before manufacturing.

Specifications of a reamer

To specify a reamer the following data is to be given.

- Type
- Flute
- Shank end
- Size

Example

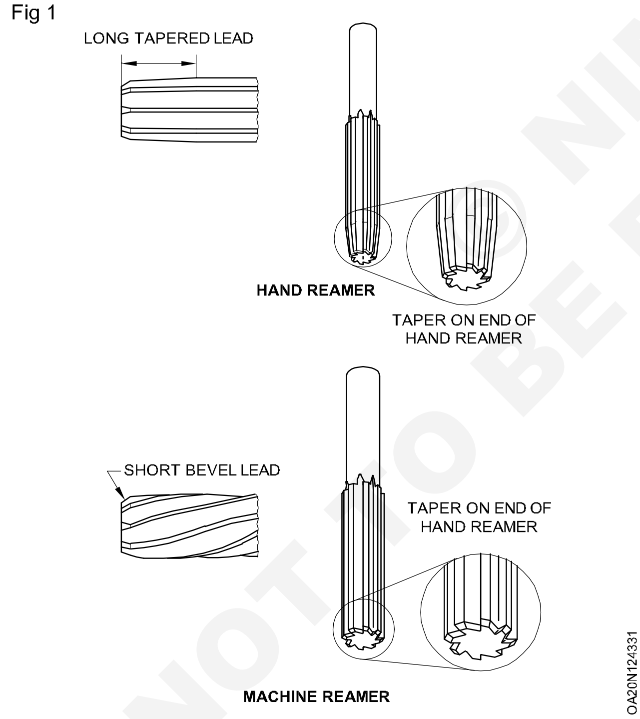
Hand reamer, Straight flute, Parallel shank of Ø 20 mm.

Machine reamers

Objectives: At the end of this lesson you shall be able to
- **state the different types of commonly used machine reamers**
- **state the features and uses of machine jig reamers**
- **state the features and advantages of shell reamers**
- **explain the different types of machine reamers**
- **state the advantages of adjustable reamers**
- **state the advantages of floating reamer-holders**
- **explain the different taper reamers**
- **state the advantages of step drilling while taper reaming.**

Reamers are used to finish previously drilled holes accurately to smooth finish. This can be done either by hand or on machine. Reamers used on machines are called machine reamers. The basic difference between hand and machine reamers is the lead angle at the cutting end. (Fig 1) Hand reamers will have long taper lead while machine reamers will have a short bevel lead.

Fig 1



The shank end of the hand reamers will be square to facilitate reaming using tap wrenches. Machine reamers of small diameters will have parallel shank and the larger reamers are provided with taper shanks.

TYPES OF MACHINE REAMERS

Solid fluted machine reamer (jobber reamer)

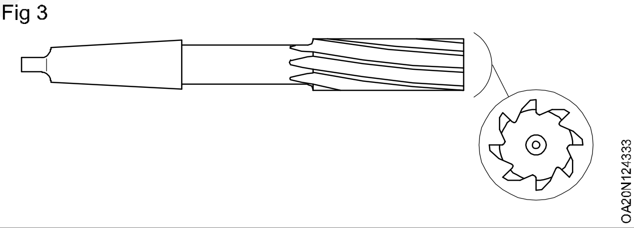
This is identical to a hand reamer. These reamers are either straight fluted or with left hand helix to prevent the tendency of 'cork screwing' when rotated clockwise for reaming. (Fig 2)

Fig 2

Chucking reamers (Fig 3)

These reamers are similar to jobber's reamers but have shorter and deeper flutes, and are available as straight or helical fluted. This is a side cutting reamer and cuts along the full length of the land and produces smooth and accurately sized holes. The ends of these reamers are slightly chamfered to initiate the cutting action.

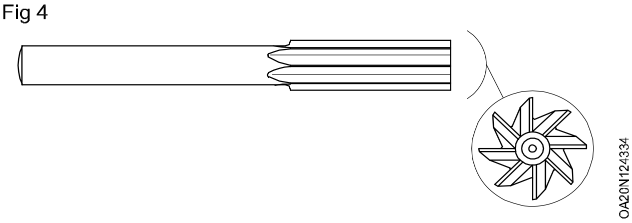
Fig 3



Rose reamer/rose chucking reamer (Fig 4)

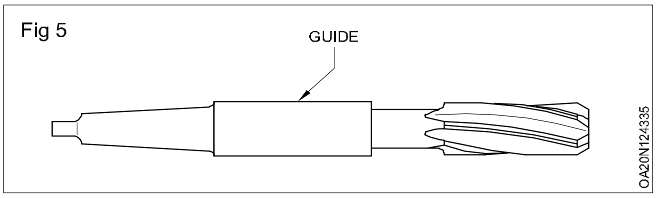
This reamer is designed to cut on its end. The flutes help in chip clearance and act as guides while cutting. This is used when a considerable amount of metal is to be removed, and the finish is not very critical. This is sometimes used as a roughing tool. Final finishing is done with other finishing reamers.

Fig 4

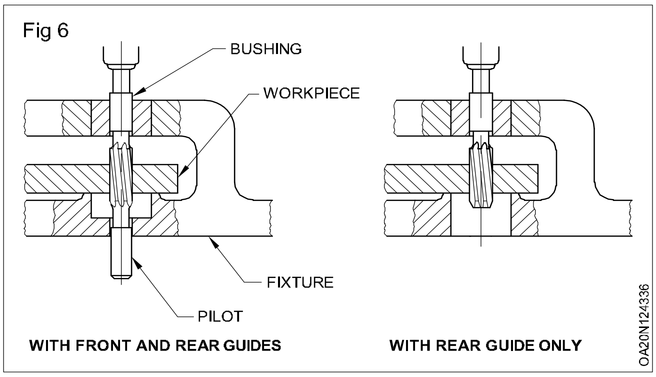


Machine jig reamers (Fig 5)

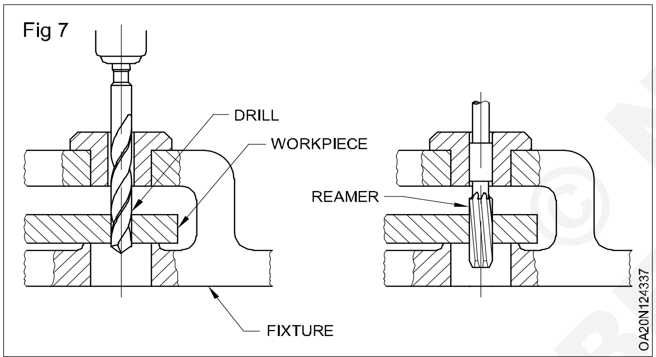
When reaming is done using jigs, the bushings of the jigs can be used to guide the reamer. Machine jig reamers are provided with special, long guide surfaces of standard diameters according to the diameter of the reamer.



Reamers of this type are available with rear guides only or with front and rear guides. (Fig 6) They can produce very accurate holes in the spindle and bushes are aligned accurately. While reaming deep holes it is better to select the jig reamers with guides on both ends.



When reaming is carried out immediately after drilling in the same setting, renewable bushes are used on the jig. (Fig 7)



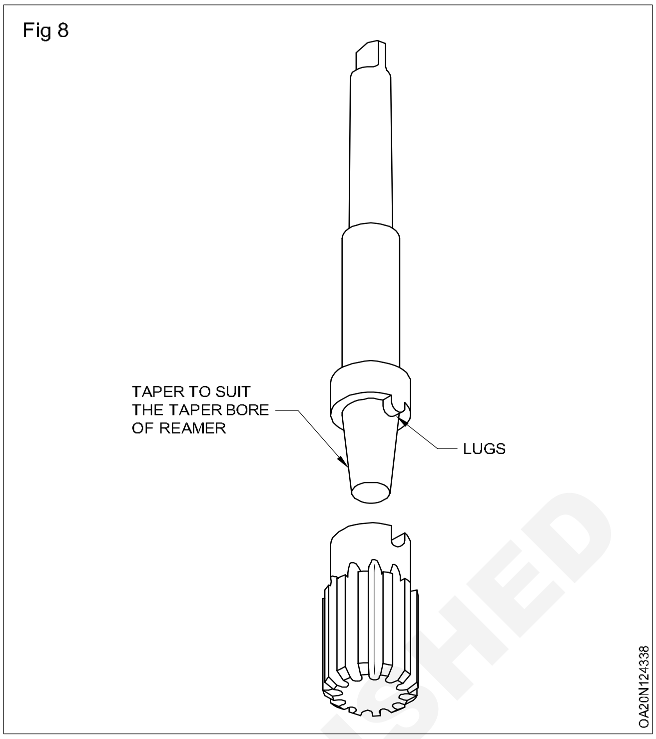
Shell reamer (Fig 8) :The shell reamer is an independent reaming unit which has a slightly tapered hole through the centre that permits the reamer to be held on a separate shank or arbor that has driving lugs. Several sizes of reamers may be used with one shank. Shell reamers are made with either fluted teeth having clearance, or the rose chucking type which cuts on the end only.

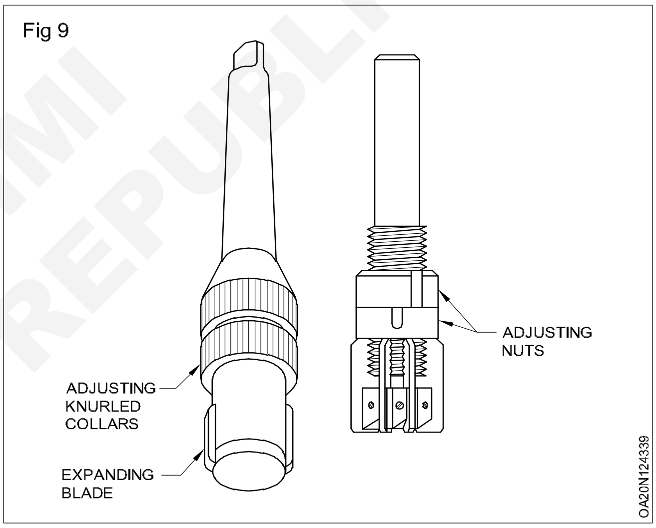
Adjustable machine reamer : These reamers are easy to adjust when worn out. They can be re- sharpened and adjusted back to the correct size. As such these reamers have longer working life than ordinary reamers.

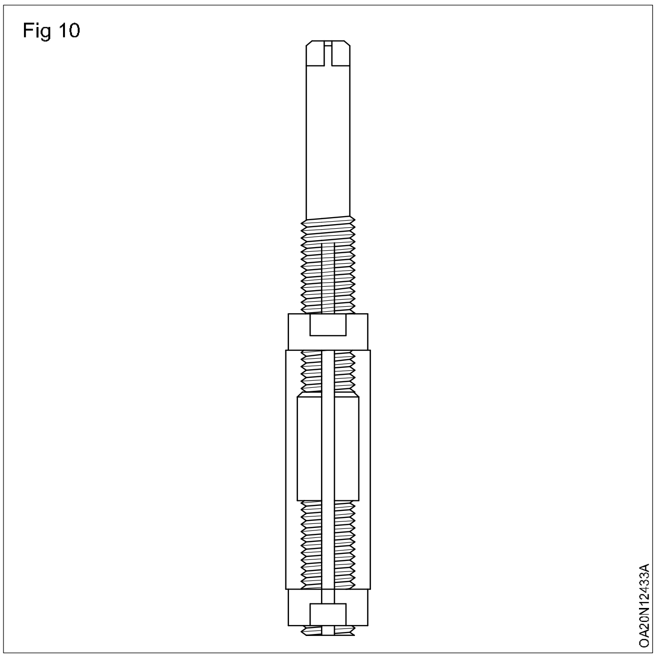
Adjustable reamers have adjustable insert blades. (Fig 9) When worn out or damaged, the blade can be easily replaced. These reamers are not meant to produce holes of different sizes. However, they can be used to increase the hold sli ghtly.

NOTE : Similarly, adjustable reamers are also available for hand reaming. (Fig 10)

The size of the reamer can be adjusted by moving the blades in the tapered slots using the nuts provided on either end of the blade.







Reamers with floating holders

While machine reaming, the taper lead at the reamer end guides into the hole being reamed. In the event of any misalignment, the hole being reamed can enlarge at the starting end. (Fig 11) This can be avoided by the use of reamers with floating holders. Floating holders compensate minor discrepancies in the axis alignment. Floating holders are available with angular floats and parallel floats. (Fig 12)

Fig 11

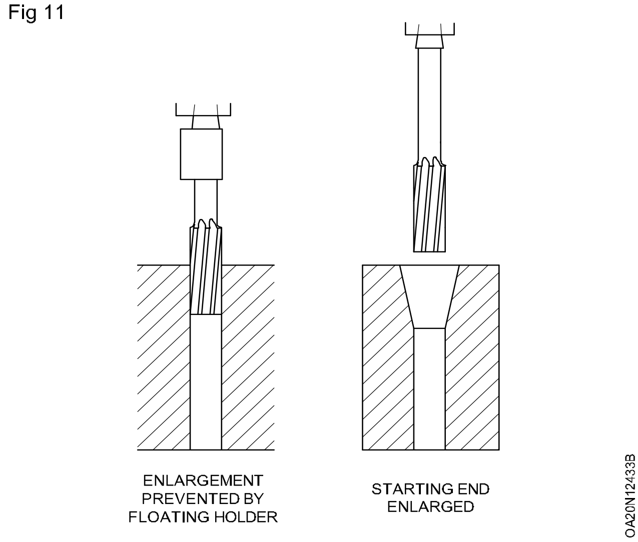
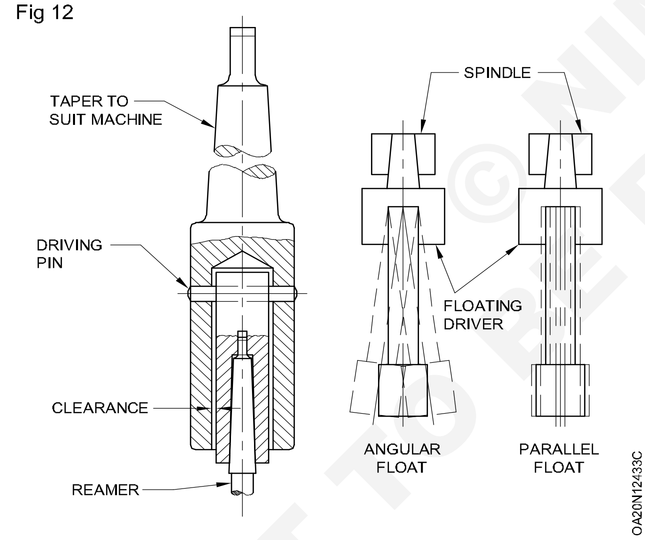


Fig 12

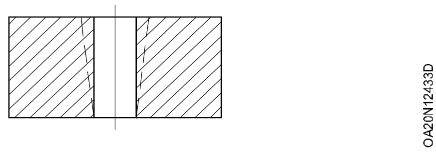


Taper reamers : Taper machine reamers are manufactured in all standard tapers and with tapered shank. They can be mounted directly in the spindle of the machine.

For taper reaming the diameter on the hole drilled is slightly smaller than the finished diameter of the small end. of the taper.

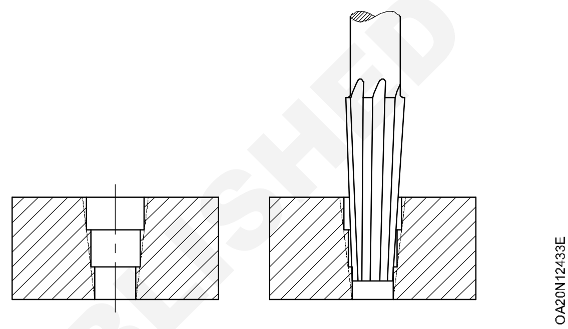
While reaming, the taper reamer will have to remove more material at the big end and less material at the small end. (Fig 13) While cutting, the entire length of the reamer will be in contact will the workpiece. This can cause chatter marks and poor finish.

Fig 13



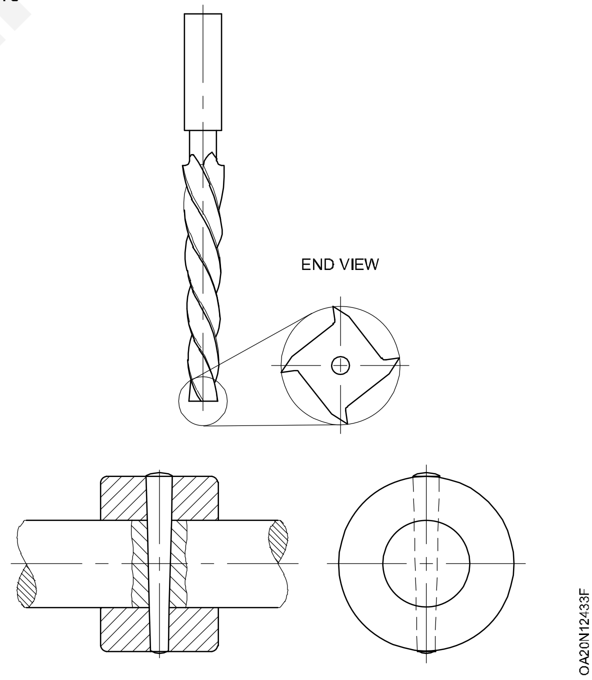
For better results use a roughing reamer first and then finish with a finishing reamer. Step drilling the hole will help to reduce the strain on taper reamers. (Fig 14)

Fig 14



Taper pin machine reamers (Fig 15) : These reamers are used for reaming taper holes needed for fitting taper pins.

Fig 15



Drill size for reaming

Objective: At the end of this lesson you shall be able to
- **state the hole size for reaming.**

For reaming with a hand or a machine reamer, the hole drilled should be smaller than the reamer size.

The drilled hole should have sufficient metal for finishing with the reamer. Excessive metal will impose a strain on the cutting edge of the reamer and damage it.

Calculating drill size for reamer

A method generally practised in workshop is by applying the following formula.

Drill size = Reamed size – (Undersize + Oversize)

Finished size

Finished size is the diameter of the reamer.

Undersize

Undersize is the recommended reduction in size for different ranges of drill diameter. (Table 1)

TABLE 1

Undersizes for reaming	
Diameter of ready reamed hole (mm)	**Undersize of rough bored hole (mm)**
under 5	0.1.....0.2
5......20	0.2.....0.3
21....50	0.3.....0.5
over 50	0.5.....1

Drilling machines - Types & Application

Objectives: At the end of this lesson you shall be able to
- **state types of drilling machines**
- **explain application of drilling machines.**

The drilling machine is one of the most important machine tools in a workshop and second to lathe. It was primarily designed to originate a hole.

Types of drilling machine

Drilling machines are made in many different types and sizes, each designed to handle a class of work or specific job to the best advantage.

The different types of drilling machines are

1 Portable drilling machine
2 Sensitive drilling machine
   a Bench mounting
   b Floor mounting
3 Upright drilling machine
4 Radial drilling machine
5 Gang drilling machine
6 Multiple spindle drilling machine
7 Automatic drilling machine
8 Deep hole drilling machine

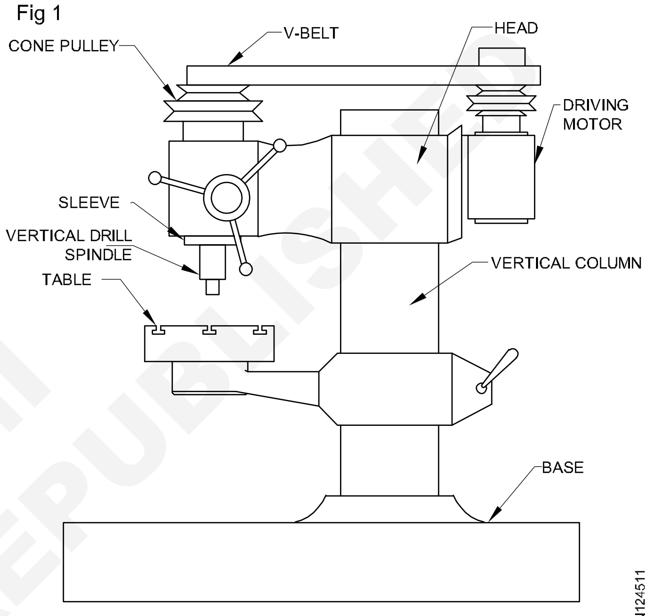
Portable Drilling machine

As the name implies this type of drilling machine can be operated with ease anywhere in the workshop and is used for drilling holes in work pieces in any position which cannot be drilled in a standard in a standard drilling machine. Some of the portable machines are operated by hand power, but most of the machines are driven by individual motor. The entire drilling mechanism including the motor is compact and small in size. The motor is usually of universal type which may be driven by both A.C. and D.C. The maximum size of the drill that it can be accommodated is not more than 12 to 18mm. the machine is operated at high speed as smaller size drills are only used. Some of the portable machines are driven by pneumatic power.

Sensitive Drilling Machine

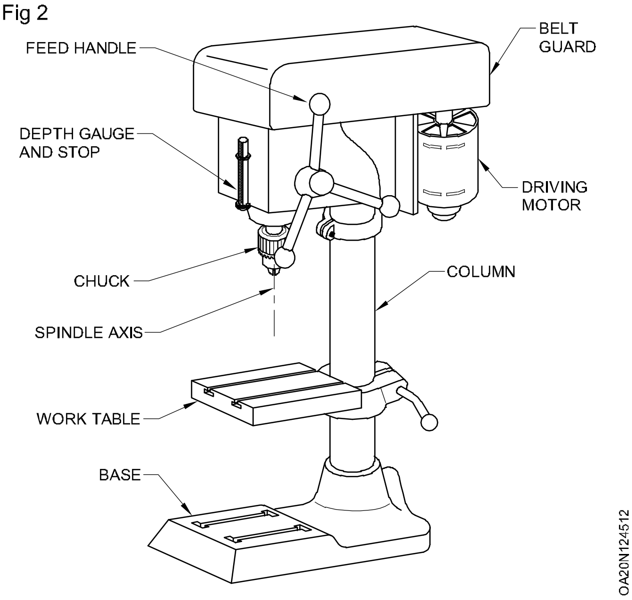
The sensitive drilling machine is a small machine designed for drilling a small hole at high speed in light jobs, the base of the machine may be mounted on a bench or on the floor. It consists of a vertical column, a horizontal table, a head supporting the motor and driving mechanism, and a vertical spindle for driving and rotating the drill. There is no arrangement for any automatic feed of the drill spindle. The drill is fed into the work by purely hand control. High speed and hand feed are necessary for drilling small holes. High speeds are necessary to attain required cutting speed by small diameter drill. Hand feed permits the operator to feel or sense the progress of the drill into the work, so that the drill becomes worn out or jams on any account, the pressure on the drill may be released immediately to prevent it from breaking. (Figs 1 & 2)

Fig 1



SENSITIVE DRILLING MACHINE

Fig 2

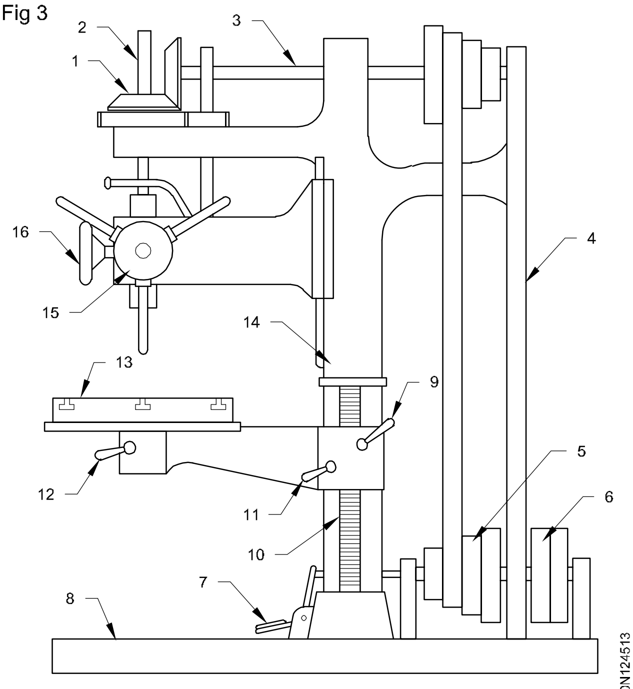


Box column section upright drilling machine

The upright drilling machine with box column section has square table fitted on the slides at the front face of the machine column. Heavy box column gives the machine strength and rigidity. The table is raised or lowered by an elevating screw that gives additional support to the table.

These special features permit the machine to work with heavier workpieces, and holes more than 50mm in diameter can be drilled by it. (Fig 3)

Fig 3

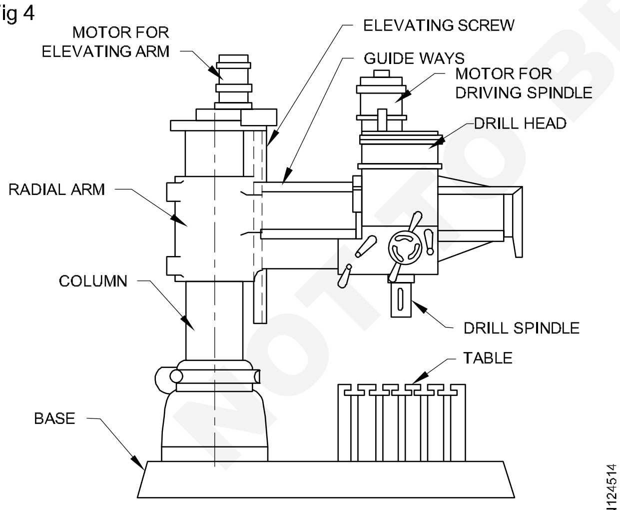


UPRIGHT PILLAR DRILLING MACHINE

1. Bevel gear drive to spindle, 2 Spindle, 3 Overhead shaft, 4 Back stay, 5 Counter shaft cone pulley, 6. Fast and loose pulley, 7. Table elevating handle, 8. Foot pedal, 9.Base, 10. Rack 11. Table elevating clamp handle, 12. Table clamp, 13. Table, 14. Column, 15. Handwheel for quick hand feed, 16. Handwheel for sensitive hand feed.

Radial Drilling machine (Fig 4)

Fig 4



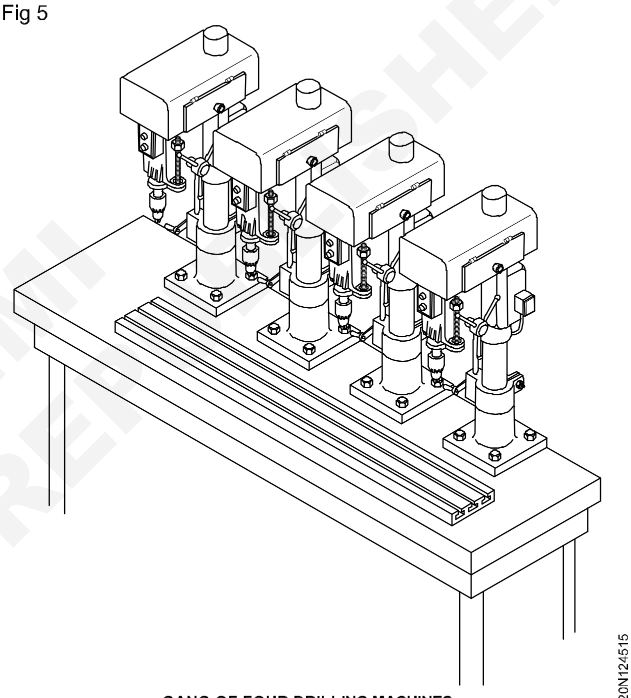
RADIAL DRILLING MACHINE

The radial drilling machine is intended for drilling medium to large and heavy workpieces. The machine consists of a heavy, round, vertical column mounted a radial arm which can be raised and lowered to accommodate work pieces of different heights. The arm may be swung around to any position over the work bed. The drill head containing mechanism for rotating and feeding the drill is mounted on a radial arm and can be moved horizontally on the guide - ways and clamped at any desired position. These three movements in a radial drilling machine when combined when combined together permit the drill to be located at any desired point on a large work piece, the position of the arm and the drill head is altered so that the drill spindle may be moved from one position to the other after drilling the hole without altering the setting of the work. This versality of the machine allows it to work on large work pieces. The work may be mounted on the table or when the work is very large it may be placed on the floor or in a pit. Fig 4 illustrates a radial drilling machine.

1. Base, 2. column, 3. Radial arm , 4. Motor for elevating the arm, 5. Elevating screw, 6. Guide ways, 7. Motor for driving the drill spindle, 8. Drill head, 9. Drill spindle, 10. Table

Gang Drilling Machine (Fig 5)

Fig 5



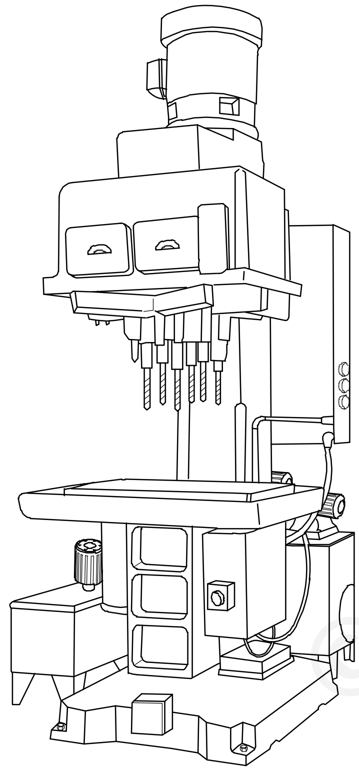
GANG OF FOUR DRILLING MACHINES

When a number of single spindle drilling machine columns are placed side by side on a common base and have a common work table, the machine is known as the gang drilling machine. In a gang drilling machine four to six spindles may be mounted side by side. In some machines the drill spindles are permanently spaced on the work table, and in others the position of the columns may be adjusted so that the space between the spindles may be varied. The speed and feed of the spindles are controlled independently. This type of machine is specially adapted for production work. A series of operations may be performed on the work by simply shifting the work from one position to the other on the work table. Each spindle may be set up properly with different tools for different operations.

Multiple Spindle Machine (Fig 6)

The function of a multiple spindle drilling machine is to drill a number of holes in a piece of work simultaneously and to reproduce the same pattern of holes in a number of identical pieces in a mass production work. Such machine shave several spindles driven by a single motor and all the spindles holding drills are fed into the work simultaneously. Feeding motion is usually obtained by raising the work table. But the feeding motion may also be secured by lowering the drill heads. The spindles are so constructed that their centre distance may be adjusted in any position as required by various jobs within the capacity of the drill head. For this purpose, the drill spindles are connected to the main drive by universal joints. Drill jigs may be used for guiding the drills in mass production work.

Fig 6

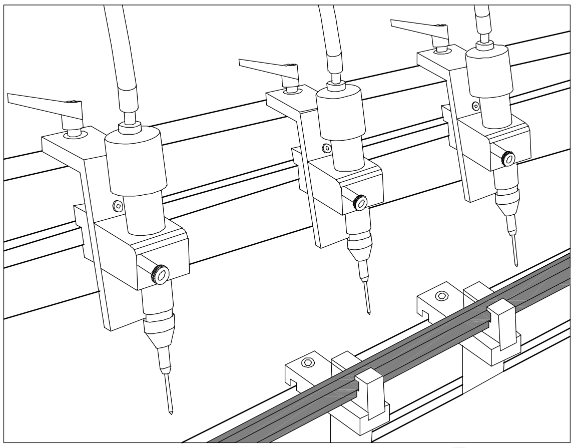


MULTISPINDLE DRILLING MACHINE

Automatic Drilling machine (Fig 7)

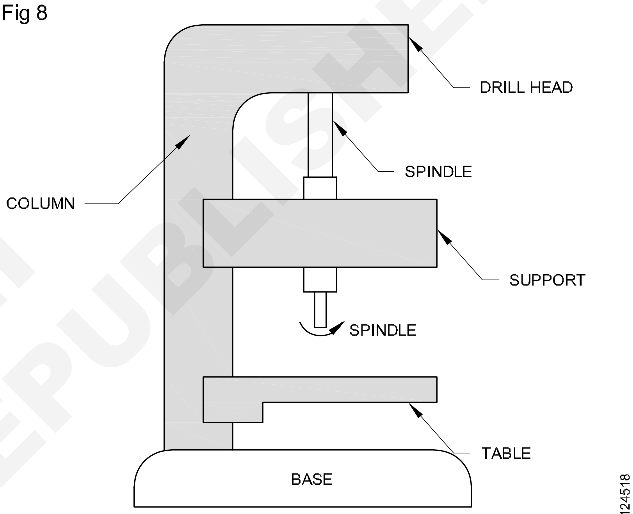
Automatic drilling machine can perform a series of machining operations at successive units and transfer the work from one unit to the other automatically. Once the work is loaded at the first machine, the work will move from one machine to the other where different operations can be performed and the finished work comes out from the last unit without any manual handling. This type of machine is intended purely for production purposes and may be used for milling, honing and similar operations in addition to drilling and tapping.

Fig 7



Deep Hole Drilling Machine (Fig 8)

Fig 8



DEEP HOLE DRILLING MACHINE

Special machines and drills are required for drilling deep holes in rifle barrels, crank shafts, etc. The machine is operated at high speed and low feed. Sufficient quantity of lubricant is pumped to the cutting points for removal of chips and cooling the cutting edges of the drill. A long job is usually supported at several points to prevent any deflection. The work is usually while the drill is fed into the work. This helps in feeding the drill in a straight path. The machine may be horizontal or vertical type In some machines step feed is applied. The drill is withdrawn automatically each time when it penetrates into the work on a depth equal to its diameter. This process permits the chip to clear out from the work.

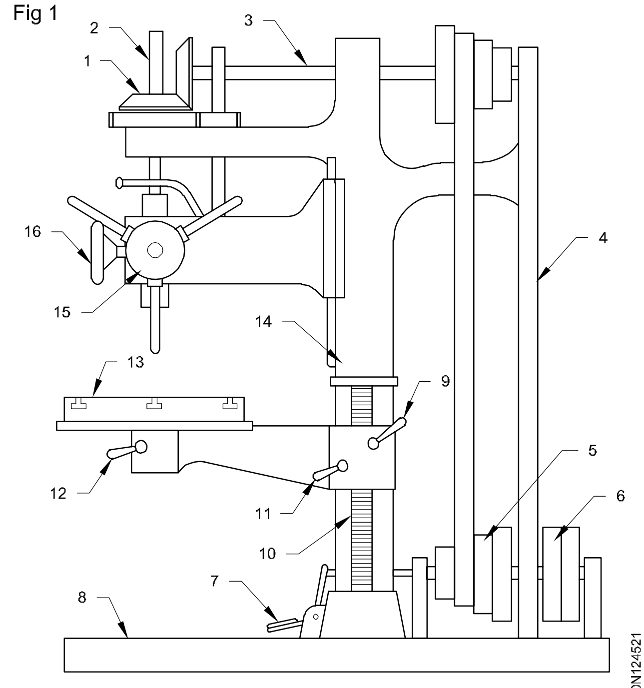
Construction of Pillar type drilling machine

Objectives : At the end of this lesson you shall be able to
- **state the features of a pillar drilling machine**
- **state the parts and uses of pillar drilling machine**
- **explain the features and function of a pillar drilling machine.**

Upright Drilling Machine

The upright drilling machine is designed for handling medium sized workpieces. In Construction the machine is very similar to a sensitive drilling machine for having a vertical column mounted upon the base. But this is larger and heavier than a sensitive drilling machine and is supplied with power feed arrangement. In an upright drilling machine a large number of spindle speeds and feeds may be available for drilling different types of work. The table of the machine also have different types of adjustments. There are two general classes of upright drilling machine. (Fig 1)

Fig 1



UPRIGHT PILLAR DRILLING MACHINE

- Round column section or pillar drilling machine.
- Box column section

Construction of Pillar drilling machine: The round column section upright drilling machine or pillar drilling machine consists of a round column that rises from the base which rests on the floor, an arm and a round table assembly, and a drill head assembly.

The arm and the table have three adjustments for locating workpieces under the spindle. The arm and the table may be moved up and down on the column for accommodating workpieces of different heights. The table and the arm may be moved in an arc upto 180º around the column and may be clamped at any position. This permits setting of the work below the spindle. Moreover, heavy and odd-size work may be supported directly on the base of the machine and drilled after the arm is swung out the way. The table may be rotated 360º about its own centre independent of the position of the arm for locating workpieces under the spindle.

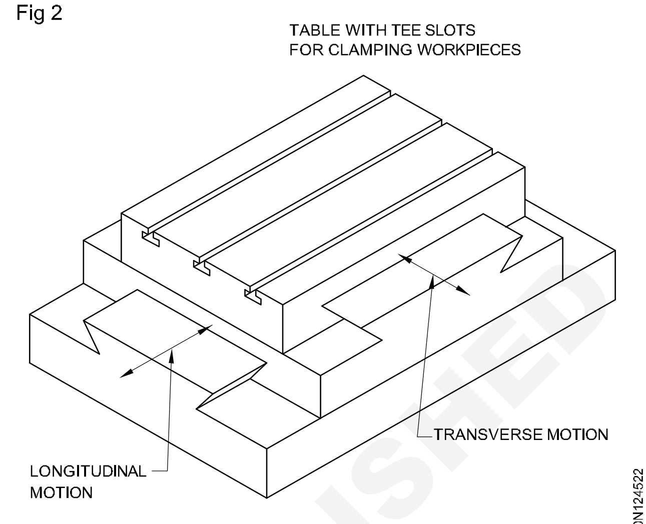
The construction of the machine being not very rigid and the table being supported on a horizontal arm, this is particularly intended for lighter work. The maximum size of holes that the machine can drill is not more than 50mm

1 Bevel gear drive to spindle, 2. Spindle . 3. Overhead shaft, 4. Nack stay counter shaft cone pulley, 6. Fast and loose pulley, 7. Table elevating handle foot pedal, 9. Base, 10. Rack on column, 11. Table elevating clamp handle Table clamp, 13. Table, 14. Column, 15. Handwheel for quick hand feed and Handwheel for sensitive hand feed.

The compound table for a pillar type drilling machine (Fig 2)

This is a development of the box-column type pillar drilling machine with a table mounted on the two sideways to give horizontal motions at 90° to each other, and controlled by the operating screws.

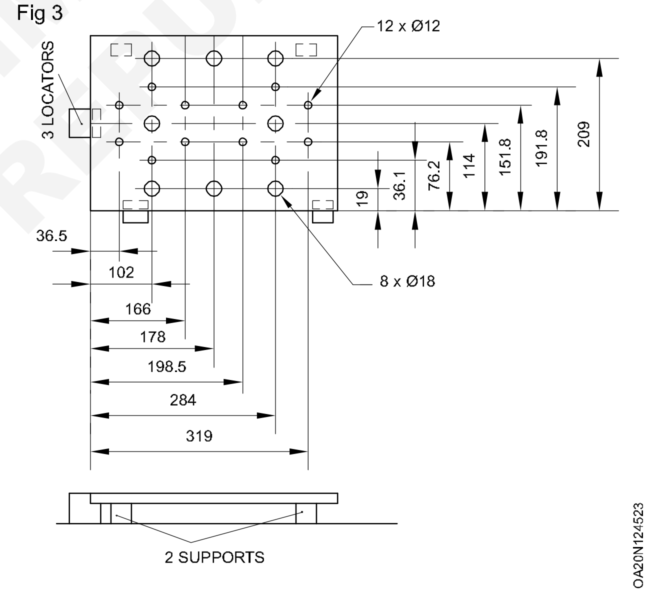
Fig 2



BASE REPLACES NORMAL MACHINE TABLE

A typical component for drilling on a compound table machine is shown in Fig 3.

Fig 3



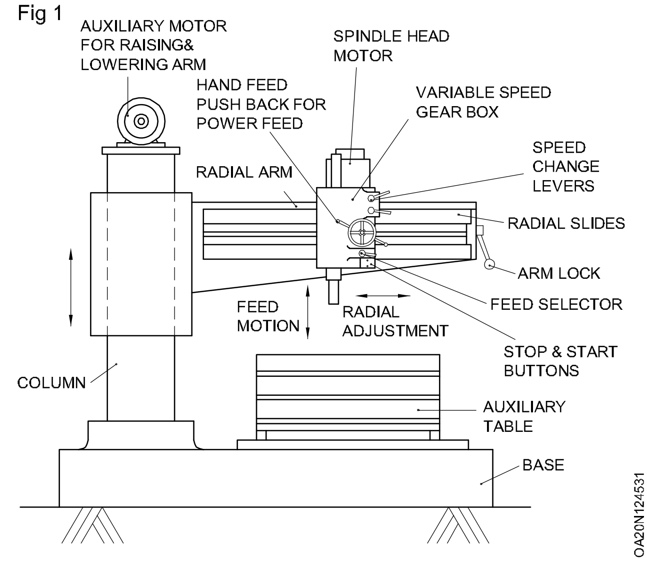
The work is clamped to the compound table which can then be accurately adjusted to bring each hole under the spindle axis, in turn for drilling. If the work is located accurately on the table by locators in the ‘T’ slots, once the position to the first hole is fixed the remaining holes can be positioned by means of table movements without recourse to marking out.

Radial drilling machines

Objectives: At the end of this lesson you shall be able to
- **state the features of a radial drilling machine**
- **state the uses of a radial drilling machine.**

Features (Fig 1)

Fig 1



The radial drilling machine has a radial arm on which the spindle head is mounted.

The spindle head can be moved along the radial arm and can be locked in any position.

The arm is supported by a pillar (column). It can be rotated about with the pillar as centre. Therefore, the drill spindle can cover the entire working surface of the table. The arm can be lifted or lowered. (Fig 2)

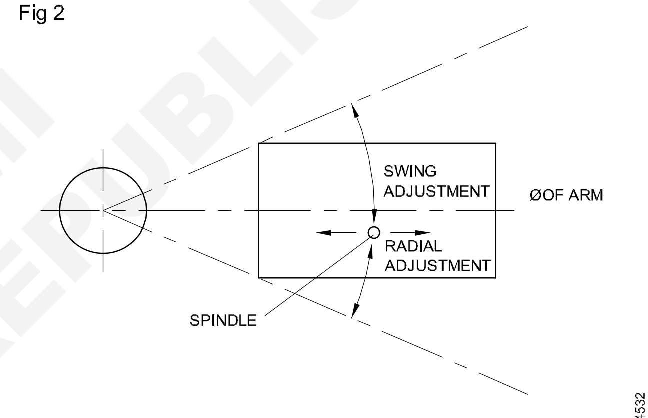
The motor mounted on the spindle head rotates the spindle. The variable speed gearbox provides a large range of r.p.m.

The spindle can be rotated in both clockwise and anti-clockwise directions.

The base of the machine itself is the work table and is provided with 'T' slots for clamping large workpieces. An auxiliary table is usually provided to which smaller workpieces can be clamped, and in some cases, two such tables are used. One is placed on the machine while drilling is in progress and the other is on one side, with the previously finished work removed and new work positioned. When the work is completed the tables are interchanged by a hoist, the radial arm being swung clear for the purpose.

Radial drilling machines are used to drill
- large diameter holes
- multiple holes in one setting of the work
- heavy and large workpieces.
- angular holes on machines having tilting tables.

Fig 2



PLAN DIAGRAM SHOWING HOW ADJUSTMENTS ENABLE COMPLETE TABLE AREA TO BE COVERED

Cutting speed and r.p.m.

Objectives: At the end of this lesson you shall be able to
- **define cutting speed**
- **state the factors for determining the cutting speed**
- **explain difference between cutting speed and r.p.m.**
- **state the r.p.m./spindle speed**
- **explain the r.p.m. for drill sizes from tables.**

For a drill to give a satisfactory performance, it must operate at the correct cutting speed and feed.

Cutting speed is the speed at which the cutting edge passes over the material while cutting, and is expressed in metres per minute.

Cutting speed is also sometimes stated as surface speed or peripheral speed.

The selection of the recommended cutting speed for drilling depends on the materials to be drilled, and the tool material.

Tool manufacturers usually provide a table of cutting speeds required for different materials.

The recommended cutting speeds for different materials are given in the table. Based on the cutting speed recommended, the r.p.m. at which a drill has to be driven, is determined.

Materials being drilled for HSS	Cutting speed(m/min)
Aluminium	70 - 100
Brass	35 - 50

Bronze(phosphor)	20 - 35
Cast iron (grey)	25 - 40
Copper	35 - 45
Steel (medium carbon/mild steel)	20 - 30
Steel (alloy,high tensile)	5 - 8
Thermosetting plastic (low speed due to abrasive properties)	20 - 30

Calculating r.p.m.

$$v = \frac{n \times d \times \pi}{1000} \text{ m/min}$$

$$n = \frac{v \times 1000}{d \times \pi}$$

n - r.p.m.

v - cutting speed in m/min.

d - diameter of the drill in mm

p = 3.14.

Examples

Calculate the r.p.m. for a high speed steel drill Ð24 to cut mild steel.

The cutting speed for MS is taken as 30 m/min. from the table.

$$n = \frac{1000 \times 30}{3.14 \times 24} = 398 \text{ r.p.m.}$$

It is always preferable to set the spindle speed to the nearest available lower range. The selected spindle speed is 300 r.p.m.

The r.p.m. will differ according to the diameter of the drills. The cutting speed being the same, larger diameter drills will have lesser r.p.m. and smaller diameter drills will have higher r.p.m.

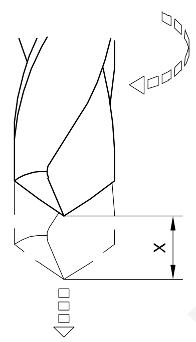
The recommended cutting speeds are achieved only by actual experiments.

Feed in drilling

Objectives: At the end of this lesson you shall be able to
- **state what is meant by feed**
- **state the factors that contribute to an efficient feed rate.**

Feed is the distance (X) a drill advances into the work in one complete rotation. (Fig 1)

Fig 1



Feed is expressed in hundredths of a millimetre.

Example - 0.040 mm

The rate of feed is dependent upon a number of factors.

Finish required

Type of drill (drill material)

Material to be drilled

the feed rate. If these are not to the required standard, the feed rate will have to be decreased.

It is not possible to suggest a particular feed rate if all the factors are not taken into account.

The table for the feed rate given here is based on the average feed values suggested by the different manufacturers of drills. (Table 1)

TABLE 1

Drill diameter (mm) H.S.S.	**Rate of feed** (mm/rev)
1.0 - 2.5	0.040 - 0.060
2.6 - 4.5	0.050 - 0.100
4.6 - 6.0	0.075 - 0.150
6.1 - 9.0	0.100 - 0.200
9.1 -12.0	0.150 - 0.250
12.1 - 15.1	0.200 - 0.300
15.1 - 18.0	0.230 - 0.330
18.1 - 21.0	0.260 - 0.360
21.1 - 25.0	0.280 - 0.380

Too coarse a feed may result in damage to the cutting edges or breakage of the drill.

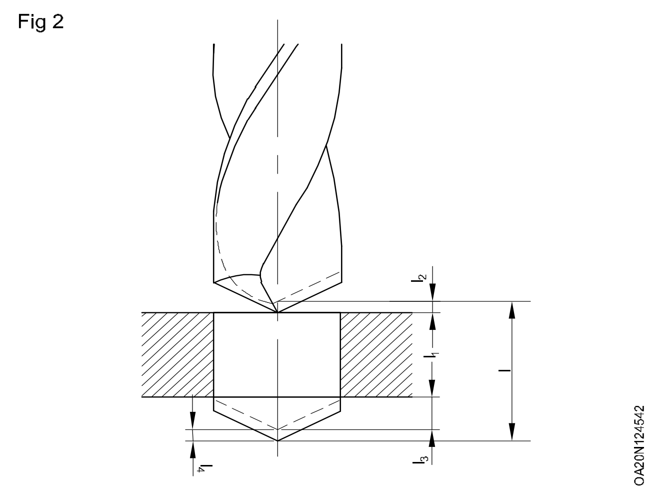
Too slow a rate of feed will not bring improvement in surface finish but may cause excessive wear of the tool point, and lead to chattering of the drill.

For optimum results in the feed rate while drilling, it is necessary to ensure the drill cutting edges are sharp. Use the correct type of cutting fluid.

Cutting speed, feed, drilling time calculation

Machining Time in drilling (Fig 2)

Fig 2



Machining time in drilling is determined by the formula:

$$T = \frac{L}{n \times s_r} \text{ min.}$$

Where, n = r.p.m. of the drill

Sr = Feed per revolution of the drill in mm

L = Length of travel of the drill in mm

and T = Machining time in min.

$L = l_1 + l_2 + l_3 + l_4$

Where, l_1 = length of the workpiece

l_2 = approach of the drill,

l_3 = length of the drill point (0.29d)

l_4 = over travel

Example:

Calculate the drilling time to drill 12mm dia hole in a plate of thickness 62mm, cutting speed 30m/min and federate is 0.05mm/ rev

Formulae for drilling time $= T = \frac{L}{n \times sr}$

$L = l_1 + l_2 + l_3 + l_4$

= 62 + 5 + 4 + 2

= 73mm

$$n = \frac{1000 \times 30}{3.143 \times 12} = 795$$

sr - 0.05 mm

$$T = \frac{73}{0.5 \times 795} = 1.84 \text{ minutes}$$

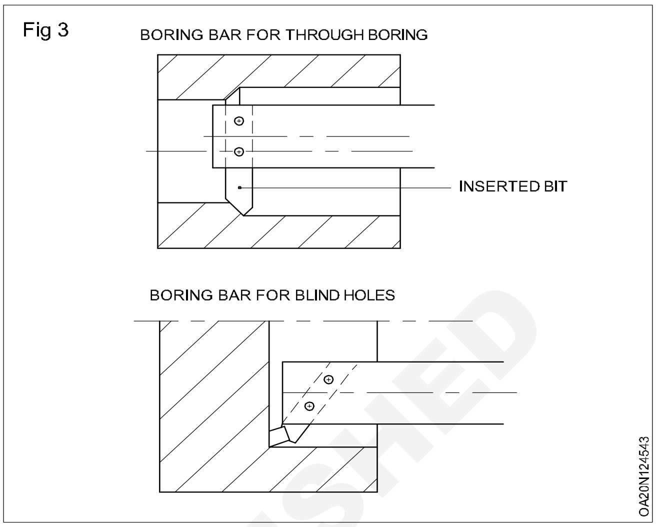
= 1 minute 50 secs

Factors like rigidity of the machine, holding of the workpiece and the drill, will also have to be considered while determining

Occasionally tungsten carbide or high speed steel tips are brazed to low carbon bars, for economy.

Boring bars with inserted bit (Fig 3)

Fig 3



The boring bar tool-holder is mounted in the tool post and is used for heavier cuts than those for the forged boring tool.

The square tool bits are set at angles of 30°, 45° or 90° in the broached holes in the bar.

The boring bars may be plain type or end cap type. The cutting tool of the plain type is held in position by a set screw. The cutting tool of the end-cap type is held in position by the wedging action of a hardened plug.

The round or square section tool bits may be inserted in boring bars, the size depending on the diameter of the bar.

The tool bit may be square to the axis of the bar for plain boring or at an angle for facing shoulder, or threading up to a shoulder.

The bar is held in a split or 'V' block holder.

The advantages of different boring tools

Solid boring tools

Available with square and round shank.

Enables to mount on the tool post easily.

Re-grinding is easy.

As the tool is integral, alignment is easy.

Can be easily forged to the required shape and angle.

Boring bars and inserted bits

Used for heavy duty boring operation.

Used for deep boring operation.

Tool changing is faster, thereby re-sharpening time is avoided.

Cost is less because the boring bar is made out of low carbon steel.

Boring tools can be set square to the axis of the boring bar or at an angle very quickly.

Counter sinking

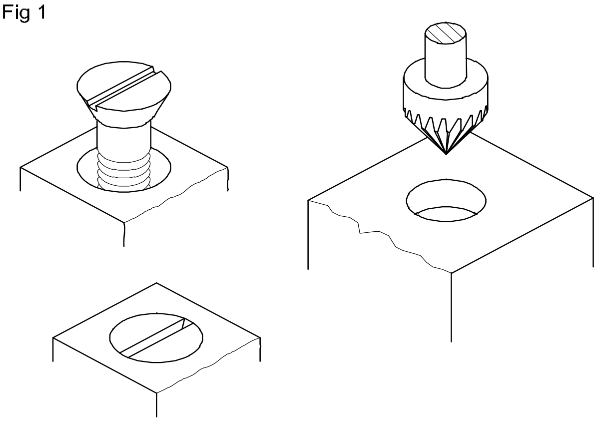
Objectives: At the end of this lesson you shall be able to
- **state what is countersinking**
- **list the purpose of countersinking**
- **state the angles of countersinking for the different applications**
- **name the different types of countersinks**
- **distinguish between Type A and Type B countersink holes.**

What is countersinking?

Countersinking is an operation of beveling the end of a drilled hole. The tool used is called a countersink.

Countersinking is carried out for the following purposes, to provide a recess for the head of a countersink screw, so that it is flush with the surface after fixing. (Fig 1)

Fig 1



to deburr a hole after drilling

for accommodating countersink rivet heads

to chamfer the ends of holes for thread cutting and other machining processes.

Angles for countersinking

Countersinks are available in different angles for different uses.

75° countersink riveting

80° countersink self tapping screws

90° countersink head screws and deburring

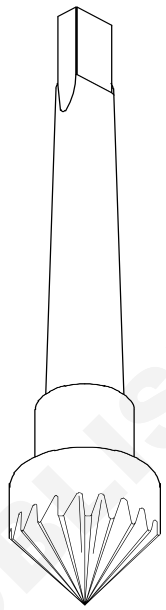
120° chamfering ends of holes to be threaded or other machine processes.

Countersinks

Countersinks of different types are available

The commonly used countersinks have multiple cutting edges and are available in taper shank and straight shank. (Fig 2)

Fig 2

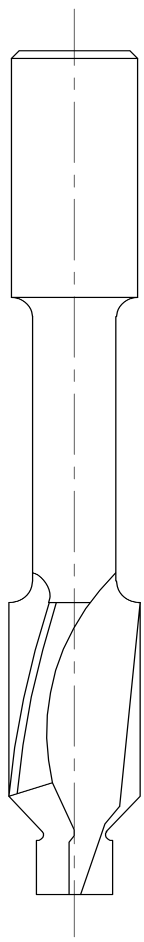


For countersinking small diameter holes special counter-sinks with two or one flute are available. This will reduce the vibration while cutting.

Countersinks with pilot (Fig 3)

For precision countersinking, needed for machine tool assembling and after machining process, countersinks with pilots are used.

Fig 3



They are particularly useful for heavy duty work.

The pilot is provided at the end for guiding the countersink concentric to the hole.

Countersinks with pilots are available with interchange able and solid pilots.

Countersink hole sizes

The countersink holes according to Indian Standard IS 3406 (Part 1) 1986 are of four types: Type A, Type B, Type C and Type E.

Type A is suitable for slotted countersink head screws, cross recessed and slotted raised countersink head screws.

These screws are available in two grades i.e. medium and fine.

The dimensions of various features of the Type 'A' countersink holes, and the method of designation are given in Table 1.

Type 'B' countersink holes are suitable for countersink head screws with hexagon socket.

The dimensions of the various features and the method of designation are given in Table II.

Type 'C' countersink holes are suitable for slotted raised countersink (oval) head tapping screws and for slotted countersink (flat) head tapping screws.

The dimension of the various features and the method of designation are given in Table III.

Type 'E' countersinks are used for slotted countersink bolts used for steel structures.

The dimensions of the various features and the method of designation are given in Table IV.

Methods of Representing countersink holes in drawings : Countersink hole sizes are identified by code designation or using dimension. IS details are given in Table 1 to Table IV

TABLE I

Dimensions and designation of countersink - Type A according to IS 3406 (Part 1) 1986

Fig 4

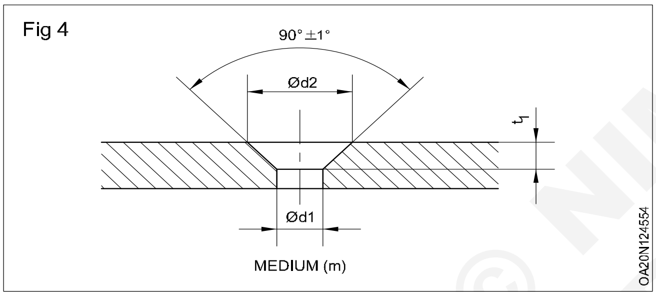
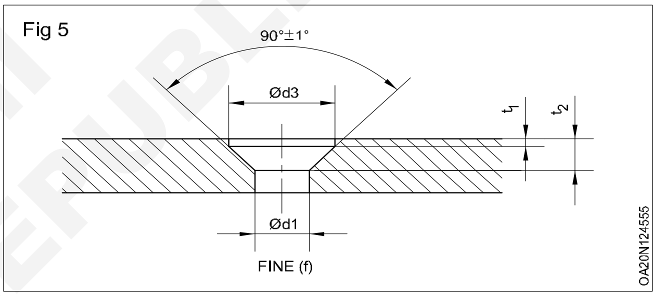


Fig 5



For Nominal Size		1	1.2	(1.4)	1.6	(1.8)	2	2.5	3	3.5	4	(4.5)
Medium	d_1 H13	1.2	1.4	1.6	1.8	2.1	2.4	2.9	3.4	3.9	4.5	5
Series	d_2 H13	2.4	2.8	3.3	3.7	4.1	4.6	5.7	6.5	7.6	8.6	9.5
(m)	t_1[3]	0.6	0.7	0.8	0.9	1	1.1	1.4	1.6	1.9	2.1	2.3
Fine	d_1 H12	1.1	1.3	1.5	1.7	2	2.2	2.7	3.2	3.7	4.3	4.8
Series	d_3 H12	2	2.5	2.8	3.3	3.8	4.3	5	6	7	8	9
(f)	t_1[3]	0.7	0.8	0.9	1	1.2	1.2	1.5	1.7	2	2.2	2.4
	t_2 + 0.1 0	0.2	0.15	0.15	0.2	0.2	0.15	0.35	0.25	0.3	0.3	0.3

TABLE I (Contd)

Designation : A countersink Type A with clearance hole of fine (f) series and having nominal size 10 shall be designated as - Countersink A f 10 - IS : 3406.

For Norminal Size		5	6	8	10	12	(14)	16	(18)	20
Medium	d_1 H13	5.5	6.6	9	11	13.5	15.5	17.5	20	22
Series	d_2 H13	10.4	12.4	16.4	20.4	23.9	26.9	31.9	36.4	40.4
(m)	t_1^3	2.5	2.9	3.7	4.7	5.2	5.7	7.2	8.2	9.2
Fine	d_1 H12	5.5	6.4	8.4	10.5	13	15	17	19	21
Series	d_3 H12	10	11.5	15	19	23	26	30	34	37
(f)	t_1^3	2.6	3	4	5	5.7	6.2	7.7	8.7	9.7
	t_2 + 0.1 0	0.2	0.45	0.7	0.2	0.7	0.7	1.2	1.2	1.7

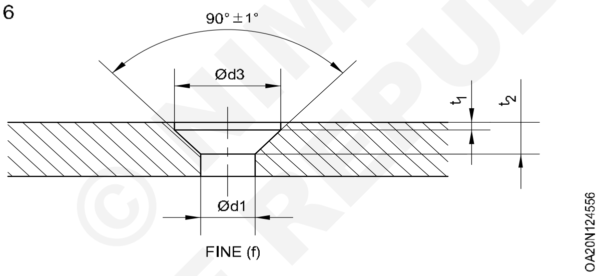
Note 1 : Size shown in brackets are of second preference.

Note 2 : Clearance hold d_1 according to medium and fine series of IS : 1821 'Dimensions for clearance clearance holes for bolts and screws (second revision)'

TABLE II

Dimensions and designation of countersink - Type B according to IS 3406 (Part 1) 1986

Fig 6



For Nominal Size		3	4	5	6	8	10	12	(14)	16	(18)	20	22 24
Medium	d_1 H12	4.3	5.3	6.4	8.4	10.5	13	15	17	19	21	23	25
Series	d_2 H12	6.3	8.3	10.4	12.4	16.5	20.5	25	28	31	34	37	48.2
52 (f)	t_1^3	1.7	2.4	2.9	3.3	4.4	5.5	6.5	7	7.5	8	8.5	13.1
14	t_2 + 0.1												
	0	0.2		0.3		0.4			0.5				1

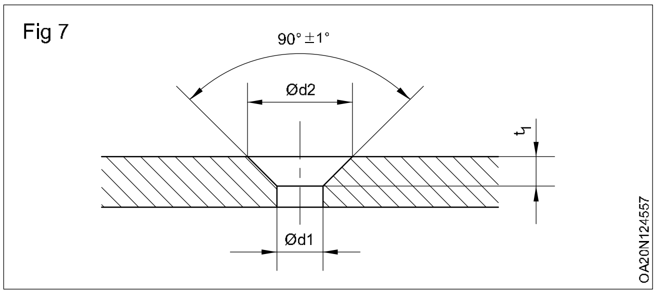
Note 1 : Sizes shown in brackets are of second preference.

Note 2 : Clearance hole d_1 according to medium and fine series of IS : 1821 - 1982.

Designation : A countersink Type B with clearance hole of fine (f) series and having nominal size 10 shall be designated as - Countersink B f 10 - IS : 3406.

TABLE III

Dimensions and designation of countersink - Type C according to IS 3406 (Part 1) 1986

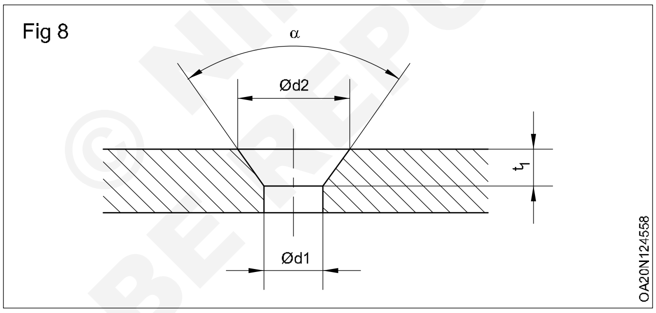


For Screw Size No.	(0)	(1)	2	(3)	4	(5)	6	(7)	8	10	(12)	14	(16)
d_1 H12	1.6	2	2.4	2.8	3.1	3.5	3.7	4.2	4.5	5.1	5.8	6.7	8.4
d_1 H12	3.1	3.8	4.6	5.2	5.9	6.6	7.2	8.1	8.7	10.1	11.4	13.2	16.6
t_1^{3}	0.9	1.1	1.3	1.5	1.7	1.9	2.1	2.3	2.6	3	3.4	3.9	4.9
Note : Size given in brackets are of second preference.													

Designation : A countersink Type C for screw size 2 shall be designated as - Countersink C 2 - IS : 3406.

TABLE IV

Dimensions and designation of countersink - Type E according to IS 3406 (Part 1) 1986



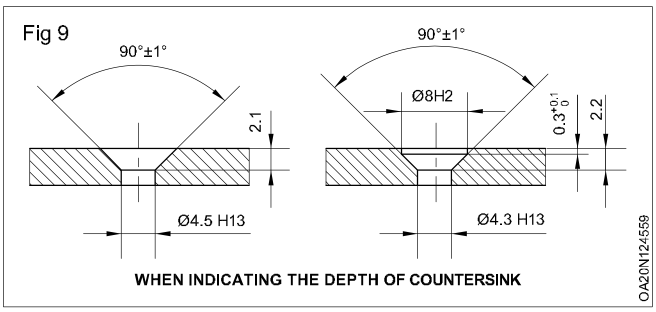
For Screw size no.	10	12	16	20	22	24
d_1 H12	10.5	13	17	21	23	25
d_2 H12	19	24	31	34	37	40
t_1^{3}	5.5	7	9	11.5	12	13
	75°			60°		
Note: Clearance hold d_1 according to fine series of IS : 1821 - 1982						

Designation : A countersink Type C for screw size 2 shall be designated as - Countersink C 2 - IS : 3406.

Use of code designation

Use of dimension

The dimension of the countersink can be expressed by diameter of the countersink and the depth of the countersink.



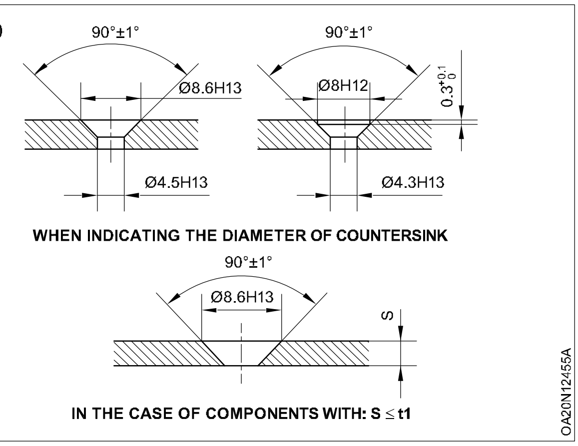


Fig 10

Counterboring and spot facing

Objectives: At the end of this lesson you shall be able to
- **differentiate counterboring and spot facing**
- **state the types of counterbores and their uses**
- **determine the correct counterbore sizes for different holes.**

Counterboring

Counterboring is an operation of enlarging a hole to a even depth to house heads of socket heads or cap screws with the help of a counterbore tool. (Fig 1)

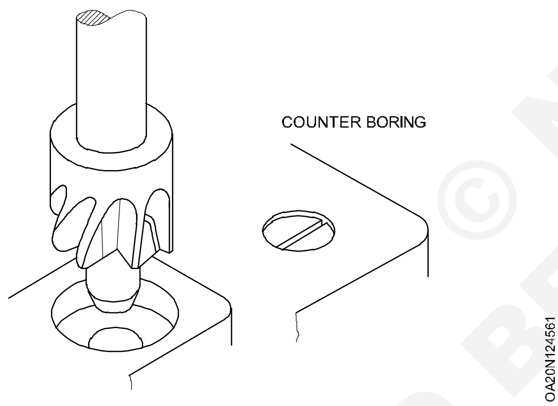


Fig 1

Counterbore (Tool) : The tool used for counterboring is called a counterbore. (Fig 2). Counterbores will have two or more cutting edges.

At the cutting end, a pilot is provided to guide the tool concentric to the previously drilled hole. The pilot also helps to avoid chattering while counterboring. (Fig 3)

Counterbores are available with solid pilots or with interchangeable pilots. The interchangeable pilot provides flexibility of counterboring on different diameters of holes.

Spot facing : Spot facing is a machining operation for producing a flat seat for bolt head, washer or nut at the opening of a drilled hole. The tool is called a spot facer or a spot facing tool. Spot facing is similar to counterboring, except that it is can be used for spot facing as well. (Fig 4)

Spot facing is also done by fly cutters by end-cutting action. The cutter blade is inserted in the slot of the holder, which can be mounted on to the spindle. (Fig 5)

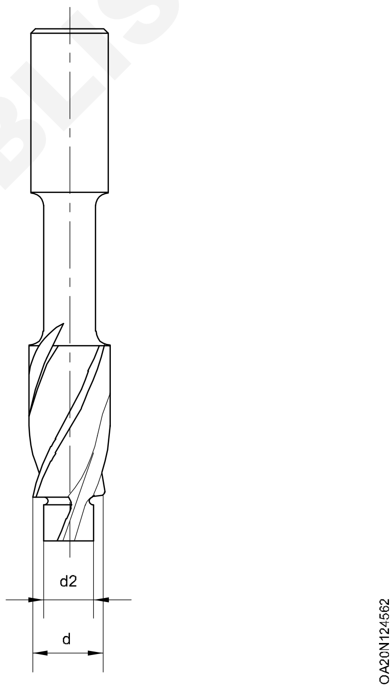


Fig 2

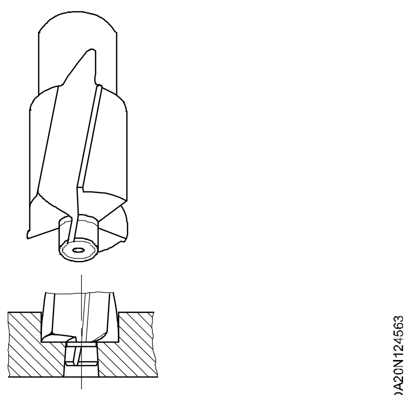


Fig 3

Counterbore sizes and specification : Counterbore sizes are standardised for each diameter of screws as per BIS.

Fig 4

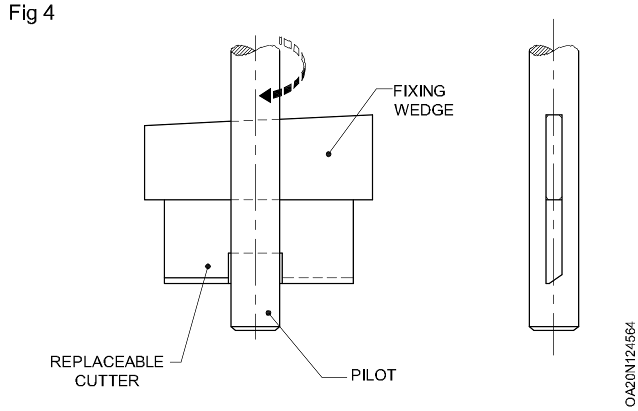
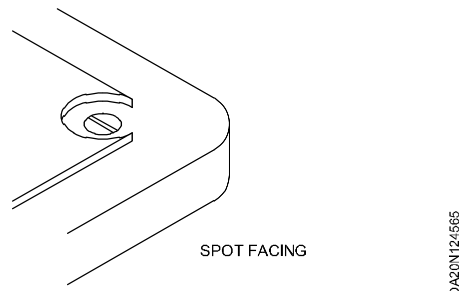


Fig 5



There are two main types of counterbores. Type H and Type K.

The type H counterbores are used for assemblies with slotted cheese head, slotted pan head and cross recessed pan head screws. The type K counterbores are used in assemblies with hexagonal socket head cap-screws.

For fitting different types of washers the counterbore standards are different in Type H and Type K.

The clearance hole d1 are of two different grades i.e. medium (m) and fine (f) and are finished to H13 and H12 dimensions.

The table given below is a portion from I S 3406 (Part 2) 1986. This gives dimensions for Type H and Type K counterbores.

Counterbore and Clearance Hole Sizes for Different Sizes of Screws.

Screw thread and elements

Objectives : At the end of this lesson you shall be able to
- **state the uses of screw threads**
- **differentiate between external and internal screw threads**
- **state the elements of screw threads.**

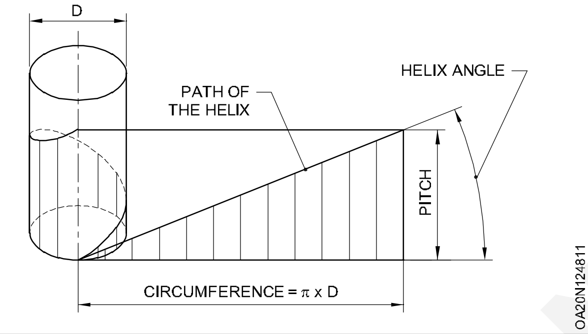
What is a screw thread?

A screw thread is a ridge of uniform section formed helically on the surface of a cylindrical body. (Fig 1)

An external screw thread is formed on the outer surface of a cylindrical part.

Examples: bolts, screws, studs, threaded spindles, etc. (Fig 1)

Fig 1

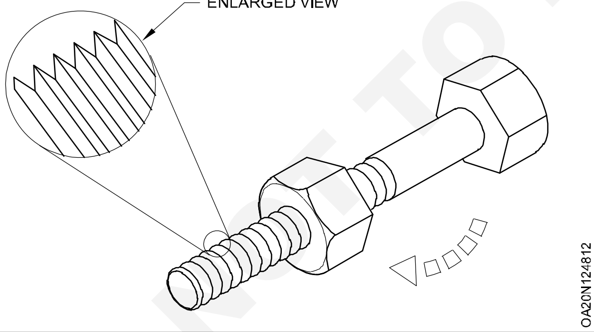


An internal screw thread is formed on the inner surface of a hollow cylindrical part.

Examples: nuts, threaded lids etc.

External threads and internal threads are assembled together for different engineering uses. (Fig 2)

Fig 2



Uses of screw threads

Screw threads are used:

- as fasteners to hold together and dismantle components when needed (Fig 3)
- to transmit motion on machines from one unit to another (Fig 4)
- to make accurate measurements (Fig 5)
- to apply pressure (Fig 6)

Fig 3

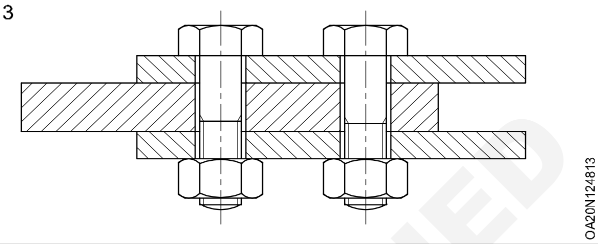


Fig 4

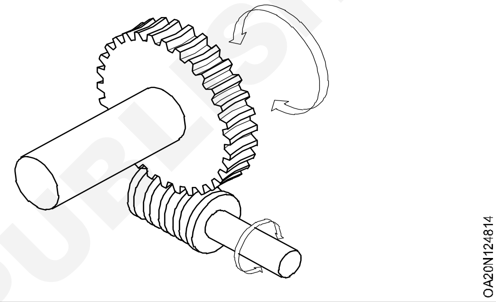


Fig 5

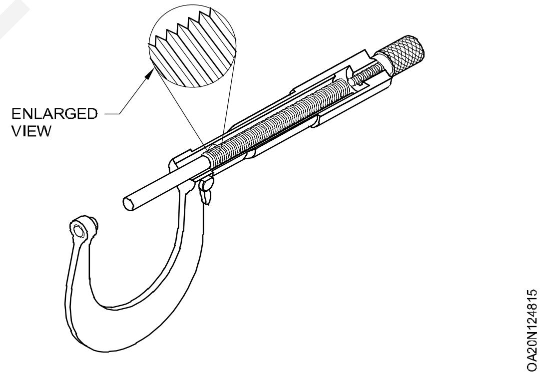
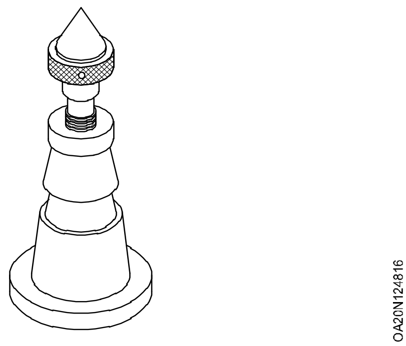


Fig 6



- to make adjustments. (Fig 7)

Parts of a screw thread (Fig 8A)

Crest (Fig 8B) : This is the top surface joining the two sides of a thread.

Fig 7

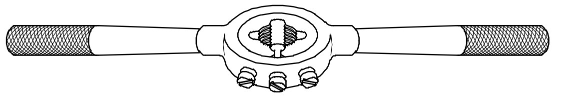
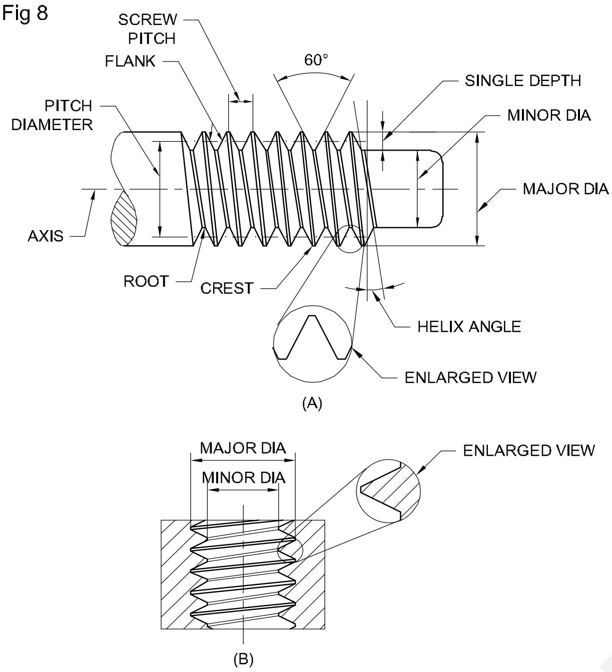


Fig 8



Root

This is the bottom surface joining the two sides of adjacent threads.

Flank

The surface joining the crest and the root is known as the flank.

Thread angle

The included angle between the flanks of adjacent threads is the thread angle.

Depth

The perpendicular distance between the roots and crest of the thread is the depth.

Major diameter

In the case of external threads it is the diameter of the blank on which the threads are cut, and in the case of internal threads it is the largest diameter after the threads are cut that is known as the major diameter. (Fig 8A)

This is the diameter by which the sizes of screws are stated.

Minor diameter

For external threads, the minor diameter is the smallest diameter after cutting the full thread. In the case of internal threads, it is the diameter of the hole drilled for forming the thread which is the minor diameter.

Pitch diameter (effective diameter)

The diameter of the thread at which the thread thickness is equal to one half of the pitch.

Pitch (Fig 8A)

It is the distance from a point on one thread to the corresponding point on the adjacent thread measured parallel to the axis.

Lead

Lead is the distance a threaded component moves along the matching component during one complete revolution. For a single start thread the lead is equal to the pitch and in multi start thread the lead is equal to pitch multiply with number of starts.

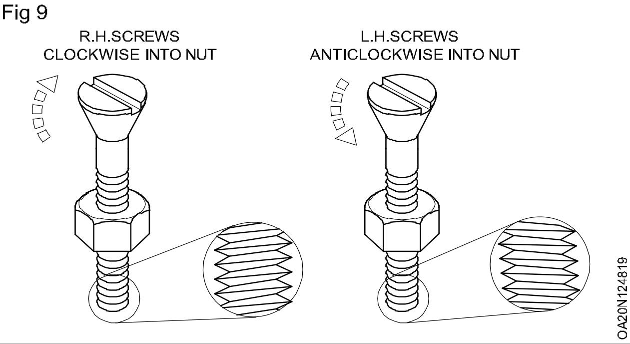
Helix angle

Helix angle is the angle of inclination of the thread to the imaginary perpendicular line.

Hand

The direction in which the thread is turned to advance is known as the hand. A right hand thread is turned clockwise to advance, while a left hand thread is turned anticlockwise. (Fig 9)

Fig 9



Forms of screw threads

Objectives: At the end of this lesson you shall be able to
- **name the different forms of screw threads**
- **state the uses of the different forms of screw threads**
- **state the features of each form of screw thread.**

Basic forms of screw threads

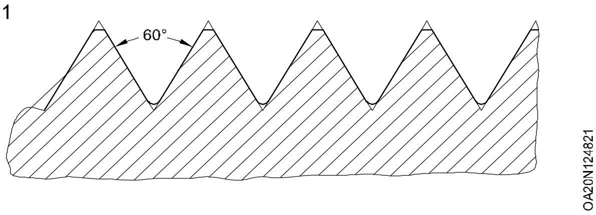
Screw threads of different forms are available for meeting the various requirements. The basic forms of screw threads are:

- vee threads
- square threads
- trapezoidal threads.

Vee threads (Fig 1)

These threads are of a ‘V’ shape. Vee threads of different types are available. A Vee thread is the most commonly used form of screw threads, and is used for domestic and industrial applications like bolts, nuts and spindles for micrometers etc.

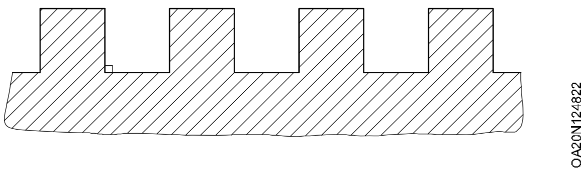
Fig 1



Square threads (Fig 2)

The cross-section of these threads is square in shape. These threads are very strong, and are used on fly presses, screw jacks, vices and spindles etc.

Fig 2

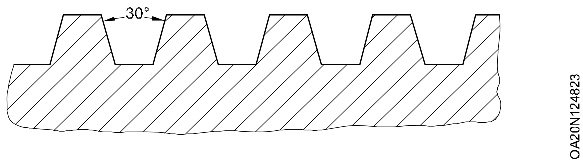


The knuckle thread is a modified form of square thread. In this case the crest and root are rounded to form a semi-circle. An example of the use of this thread is the one used for railway wagon couplings.

Trapezoidal threads (Fig 3)

This is also a modified square thread. The angle between the flanks is 30°.

Fig 3



These threads are also strong and are used for easy engagement and disengagement in transmission.

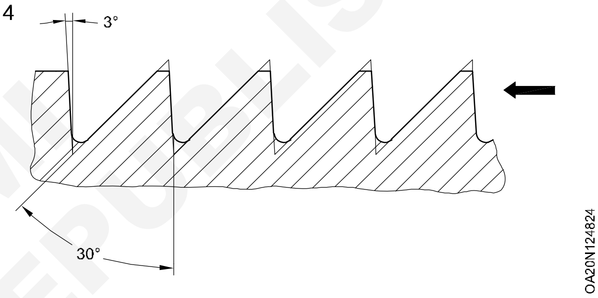
Lead screws of machine tools are made of trapezoidal thread. Acme thread is another type of trapezoidal thread with 29° angle between flanks.

Saw-tooth thread (Fig 4)

This form of thread has an inclination of 3° on the other side. These threads are used in places where sliding forces act in one direction.

Spindles of carpenter’s vices and quick release presses have saw-tooth threads. Buttress thread is another thread which is similar to saw-tooth thread. This thread has one flank vertical, and the other at 45°.

Fig 4



Multi-start threads and methods of producing them

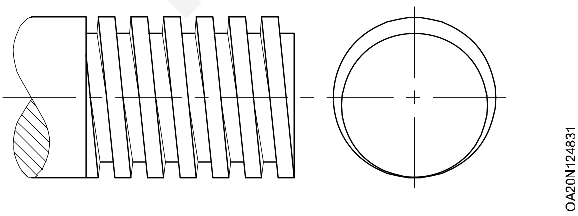
Objectives: At the end of this lesson you shall be able to

- **state the purpose of multi-start threads**
- **mention the various methods of identifying multi-start threads**
- **state the methods of cutting multi-start threads.**

Multi-start threads are used where quick transmissions is required. Such threads are used on pen caps, fly presses, thermos flask caps, hand presses, telescopes and camera focusing devices.

The lead on a single start thread is equal to the pitch. (Fig 1)

Fig 1



The lead on a double start thread is twice the pitch. (Fig 2)

The lead on a triple start thread is three times the pitch. (Fig 3)

Fig 2

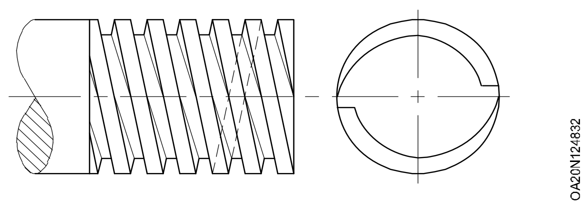
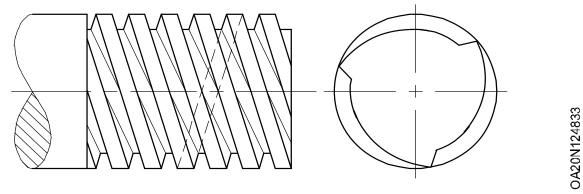


Fig 3



A triple start thread will advance 3 times the distance of a single start thread for a single turn.

The threads are specified by stating the diameter, pitch and number of starts.

Methods of cutting multi-start thread

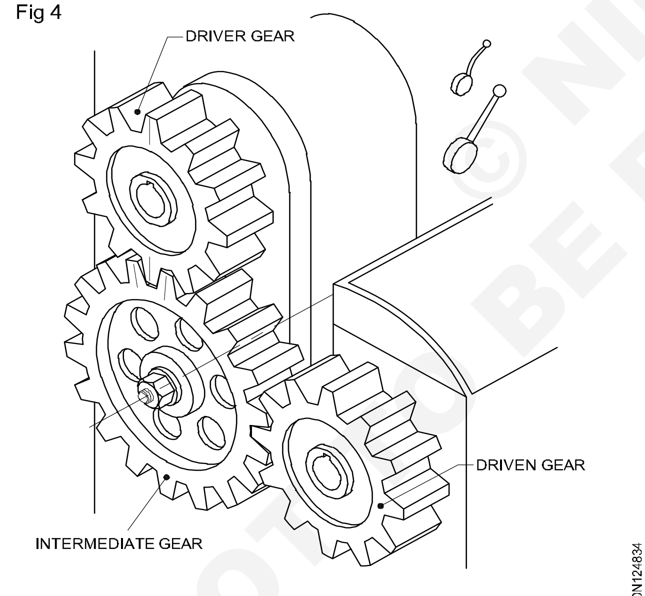
- Dividing the 1st driver of the change gear train
- Using a slotted face plate
- Moving the top slide to a new position (compound slide)
- Using a thread chasing dial

Dividing the first driver method

As regards the gear train it becomes necessary to arrange the layout so that the first driver is a multiple of the number of starts required. Thus for a double start thread, the gear teeth must be divisible by two.

After finishing the first start, the lathe is stopped. One tooth of the 1st driver and the space of the first driven gear in which it is seating are marked. By counting the number of teeth from the marked tooth of the 1st driver, make another mark on the tooth which is exactly 180° away. Loosen the swing plate and disengage the idler gear from the 1st driver. Rotate the spindle by hand to bring the second mark of the first driver to mesh in the previously marked space of the 1st driven gear. The lathe is now ready for cutting the 2nd start. This procedure is applicable to cut threads of more than two starts also. Figs 4 and 5 illustrate marking on change gears.

Fig 4



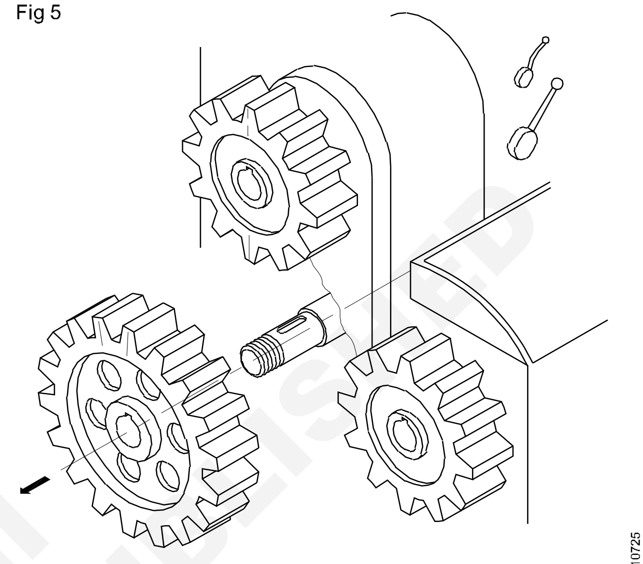
GEAR TEETH MARKED FOR INDEXING

Using slotted faceplate (Fig 6)

A slotted faceplate (illustrated) is used to cut threads of 2 starts, 3 starts, 4 starts etc.

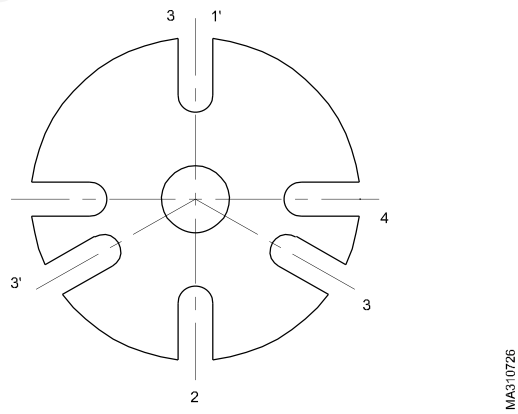
Slots are provided on the faceplate at convenient distances. Two opposite slots to cut double start thread, 3 slots 120 degree apart to cut 3 start thread and 4 slots 90 degree apart to cut 4 start thread, and so on and so forth, are provided.

Fig 5



DISENGAGE THE INTERMEDIATE GEAR

Fig 6



Multi start, right hand and left hand threads

Objectives: At the end of this lesson you shall be able to
- **distinguish between the features of single start and multi start threads**
- **give examples of a multi start threads applications**
- **distinguish between the features of right hand and left hand threads**
- **give examples on the applications of right hand and left hand threads**
- **identify right hand and left hand threads.**

Threads are formed on screws in a helix. Helix is the path of a point travelling around an imaginary cylinder such, that its axial and circumferential velocities maintain a constant ratio.

When a single helix is making a screw, it is called a single start thread. In a single start thread the lead and pitch are the same. (Fig 1) In the case of two start (Double start) threads, one thread is wound within the other exactly in the middle (Fig 2). This enables the lead of the helix increased without increasing the pitch!

Fig 1

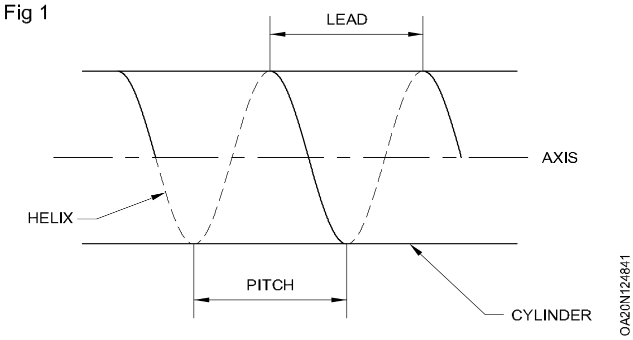
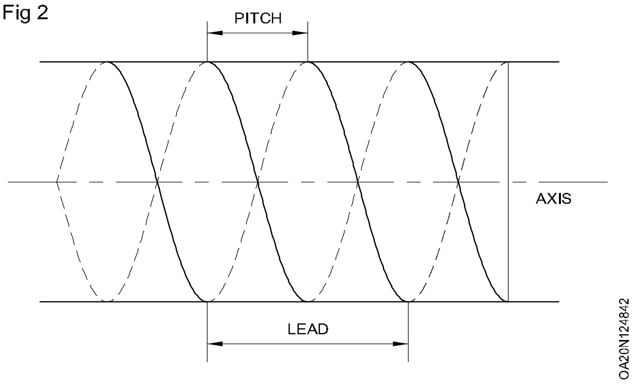


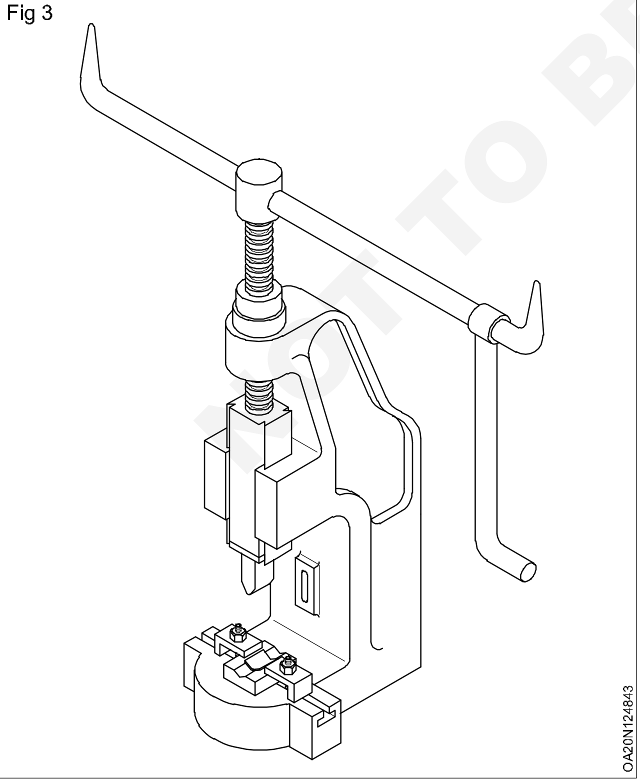
Fig 2



Lead = Pitch X Number of starts

A screw-thread may have any number of starts. The general term for such threads other than single start is Multi-start. Application of multi-start threads can be in fly presses, pen caps etc. (Fig 3) A multi start makes it possible to keep the dept of thread less, and provides a rapid axial movement of the screws.

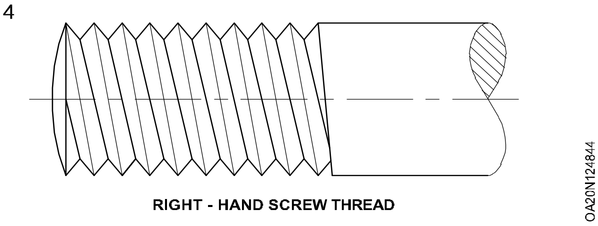
Fig 3



Right hand and left hand screw threads

The threads which are found on bolts and screws are generally right handed. (Fig 4)

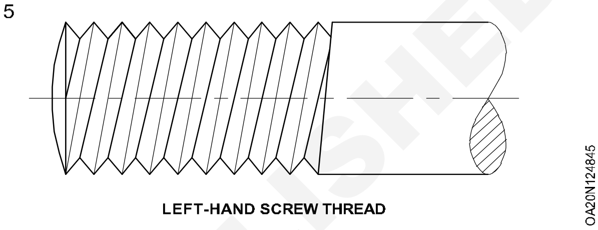
Fig 4



In this case when the bolt is rotated clockwise, it advances into the nut.

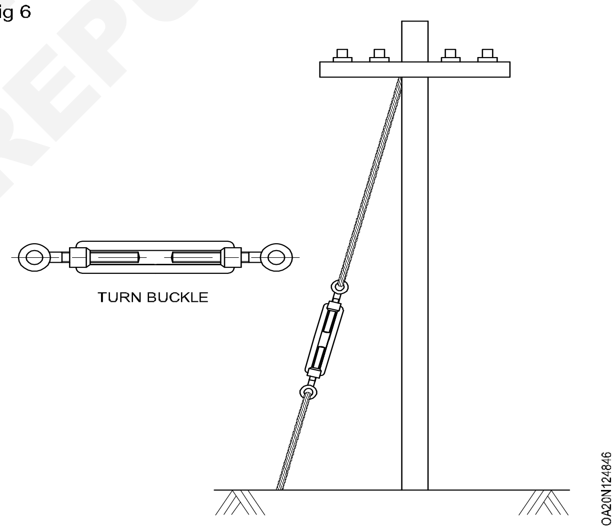
A left handed bolt thread screws into the nut when it is rotated anticlockwise. (Fig 5)

Fig 5



Application of right and left hand threads can be found in the turn buckles used for tightening the slay wires of telephone line, railway carriage couplings etc.(Fig 6)

Fig 6



When you go to the shop floor, study the following machines and indicate the hand of the thread.

Lathe tailstock spindle

Lathe spindle nose

Lathe cross-slide

Cross-feed screw of a shaper

Spark plug od a scoter engine

Lathe lead screw

Fountain pen top

Cotter pin of cycle pedal

Bench vice spindle screw

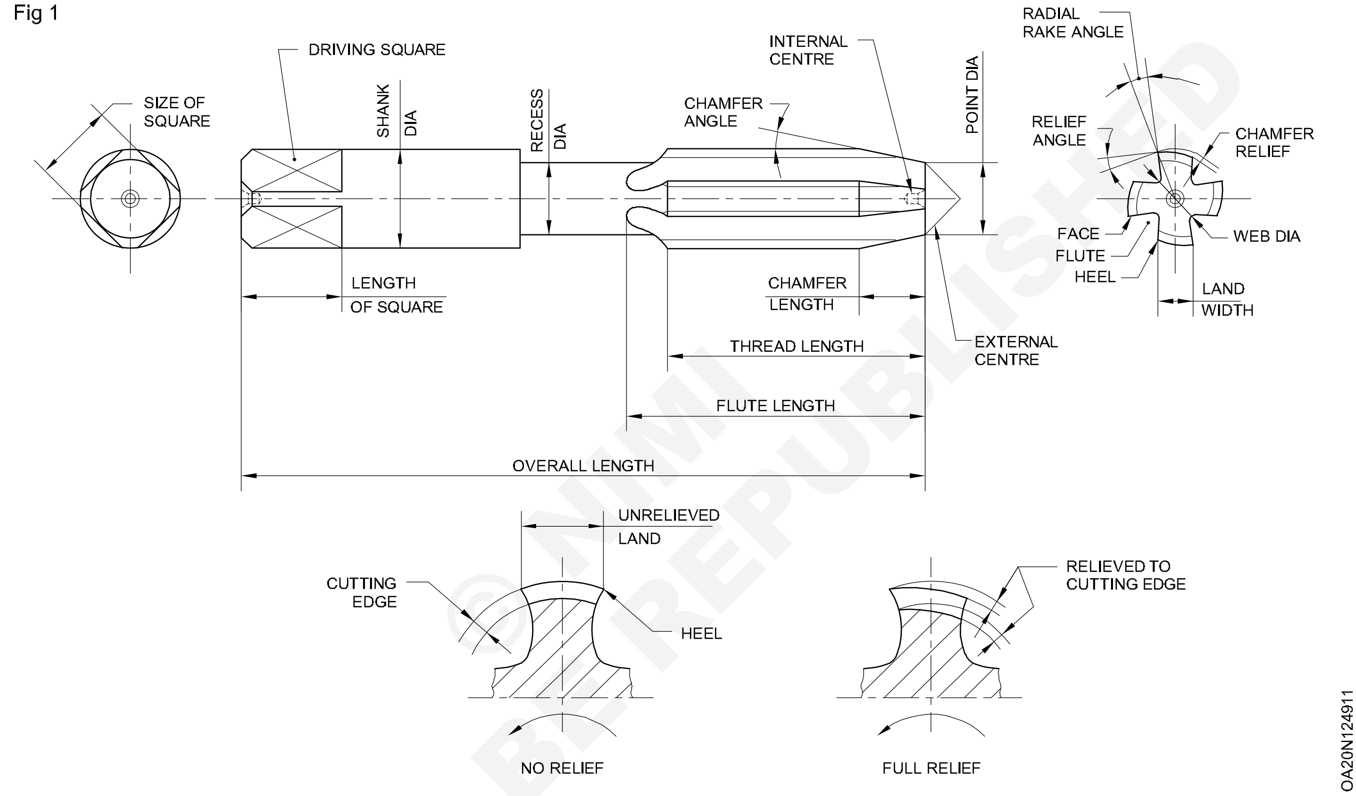
Hand taps and wrenches

Objectives: At the end of this lesson you shall be able to
- **state the uses of hand taps**
- **state the features of hand taps**
- **explain the different types of tap wrenches**
- **state the uses of the different types of wrenches.**

Use of hand taps: Hand taps are used for internal threading of components.

Features (Fig 1): They are made from high carbon steel or high speed steel, hardened, tempered and ground.

Fig 1



The threads are cut on the periphery and are accurately finished.

To form the cutting edges, flutes are cut across the thread.

The end of the shank of the tap is made of square shape for the purpose of holding and turning the taps.

The end of the taps are chamfered (taper lead) for assisting, aligning and starting of the thread.

The size of the taps, the thread standard, the pitch of the thread, the diameter of the tapping hole are usually marked on the shank.

Marking on the shank are also made to indicate the type of tap i.e. first, second and plug.

Types of taps in a set: Hand taps for a particular thread are available as a set consisting of three pieces. (Fig 2)

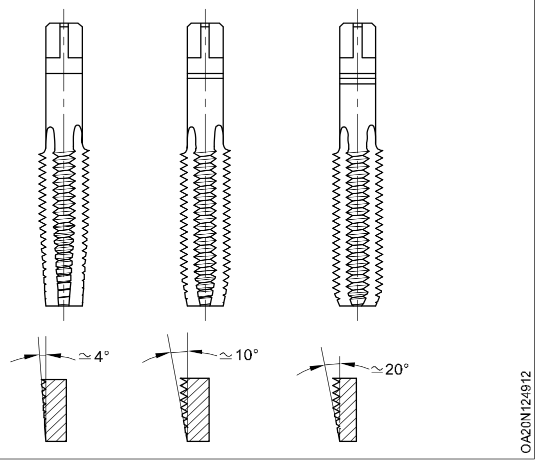
These are:

– first tap or taper tap

– second tap or intermediate tap

– plug or bottoming tap

Fig 2



These taps are identical in all features except in the taper lead.

The taper tap is to start the thread. It is possible to form full threads by the taper tap in through holes which are not deep.

The bottoming tap (plug) is used to finish the threads of a blind hole to the correct depth.

For identifying the type of taps quickly - the taps are either numbered 1,2 and 3 or rings are marked on the shank.

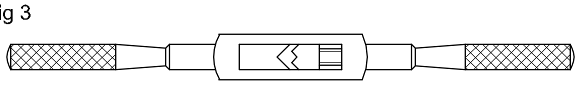
The taper tap has one ring, the intermediate tap has two and the bottoming tap has three rings. (Fig 2)

Tap wrenches: Tap wrenches are used to align and drive the hand taps correctly into the hole to be threaded.

Tap wrenches are of different types, such as double-ended adjustable wrench, T-handle tap wrench, solid type tap wrench etc.

Double-ended adjustable tap wrench or bar type tap wrench (Fig 3)**:** This is the most commonly used type of tap wrench. It is available in various sizes - 175, 250, 350 mm long. These tap wrenches are more suitable for large diameter taps, and can be used in open places where there is no obstruction to turn the tap.

Fig 3



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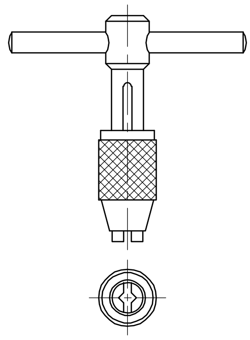
It is important to select the correct size of wrench.

T-handle tap wrench (Fig 4)**:** These are small, adjustable chucks with two jaws and a handle to turn the wrench.

This tap wrench is useful to work in restricted places, and is turned with one hand only. Most suitable for smaller sizes of taps.

Fig 4



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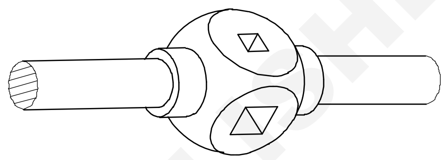
Solid type tap wrench (Fig 5)**:** These wrenches are not adjustable.

They can take only certain sizes of taps. This eliminates the use of wrong length of the tap wrenches, and thus prevents damage to the taps.

Fig 5



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Tap drill size

Objectives: At the end of this lesson you shall be able to
- **state tap drill size**
- **state the tap drill sizes for metric and BSW thread tables**
- **state the tap drill sizes for ISO metric ISO inch.**

What is tap drill size? :Before a tap is used for cutting internal threads, a hole is to be drilled. The diameter of the hole should be such that it should have sufficient material in the hole for the tap to cut the thread.

Tap drill sizes for different threads

ISO metric thread

Tap drill size for M 10 x 1,5 thread

Minor diameter = Major diameter - (2 x depth)

Depth of thread = 0.6134 x pitch of a screw

2 depth of thread = 0.6134 x 2 x pitch

= 1.226 x 1.5 mm

= 1.839 mm

Minor dia. = 10 mm - 1.839 mm

= 8. 161 mm or 8.2 mm.

This tap drill will produce 100% thread because this is equal to the minor diameter of the tap. For most fastening purposes a 100% formed thread is not required.

A standard nut with 60% thread is strong enough to be tightened until the bolt breaks without stripping the thread. Further it also requires a greater force for turning the tap if a higher percentage formation of thread is required.

Considering this aspect, a more practical approach for determining the tap drill sizes is

Tap drill size = major diameter minus pitch

= 10mm - 1.5 mm

= 8.5 mm.

Compare this with the table of tap drill sizes for ISO metric threads.

BSW inch (unified) threads formula

Tap drill size =

$$\text{Major diameter} - \frac{1 \text{ inch}}{\text{No.of threads per inch}}$$

For calculating the tap drill size for 5/8” UNC thread

Tap drill size = 5/8” - 1/11”

= 0.625” - 0.091”

= 0.534”

The next drill size is 17/32” (0.531 inches).

Compare this with the table of drill sizes for unified inch threads.

What will be the size for the following threads?

a M20

b BSW 3/8

Refer to the chart for determining the pitches of the thread.

Table for tap drill size

Nominal diameter M.M	**ISO Metric (60°)**		**B.S.W. (55°)**		**Tap drill sizes**
	Pitch	**Tap drill sizes**	**Nominal diameter (inch)**	**Threads per inch (mm)**	
3	0.5	2.05	1/8	40	2.5
4	0.7	3.30	5/32	32	3.2
5	0.8	4.20	3/16	24	4.0
6	1.0	5.00	1/4	20	5.0
8	1.25	6.80	5/16	18	6.0
10	1.50	8.0	3/8	16	8.0
12	1.75	10.20	1/2	12	10
14	2.00	12.00	9/16	12	12.5
16	2.00	14.00	5/8	11	14.00
18	2.50	15.50	3/4	10	16.00
20	2.50	17.50	13/16	10	18.00
22	2.50	19.50	7/8	9	19.5
24	3.00	21.00	1	8	22.2

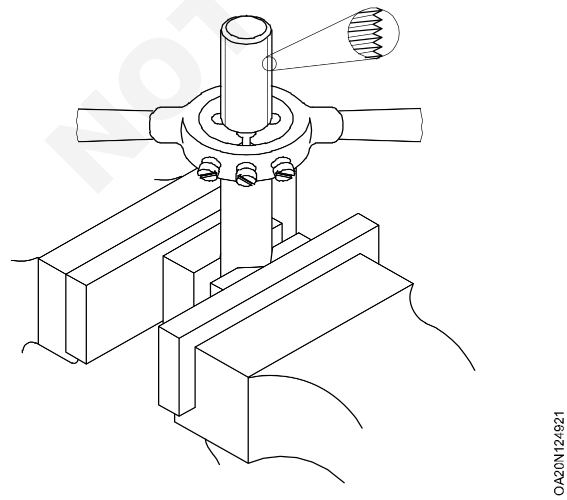
Die and die stock

Objectives: At the end of this lesson you shall be able to
- **explain the different types of dies**
- **state the features of each type of die**
- **state the use of each type of die**
- **name the type of die stock for each type of die.**

Uses of dies

Threading dies are used to cut external threads on cylindrical workpieces. (Fig 1)

Fig 1



Types of Dies

The following are the different types of dies.

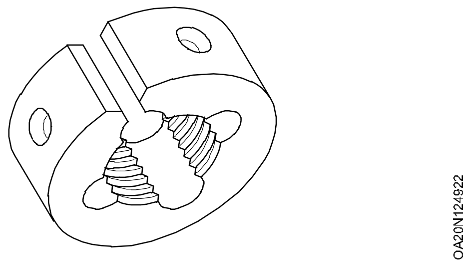
– Circular split die (Button die)

– Half die

– Adjustable screw plate die

Circular split die/button die (Fig 2)

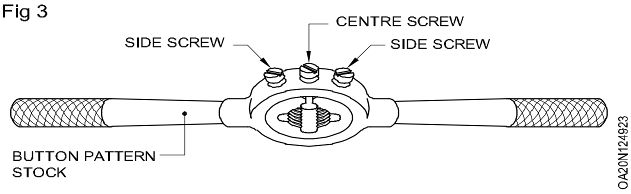
Fig 2



This has a slot cut to permit slight variation in size.

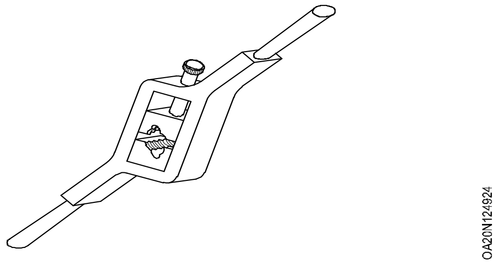
When held in the die stock, variation in the size can be made by using the adjusting screws. This permits increasing or decreasing of the depth of cut. When the side screws are tightened the die will close slightly.(Fig 3) For adjusting the depth of the cut, the centre screw is advanced and locked in the groove. This type of die stock is called button pattern stock.

Fig 3



Half die (Fig 4)

Fig 4



Half dies are stronger in construction.

Adjustments can be made easily to increase or decrease the depth of cut.

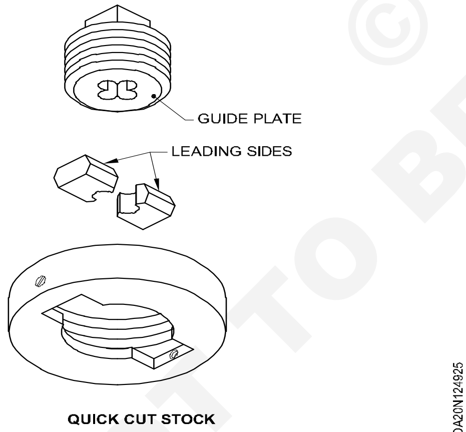
These dies are available in matching pairs and should be used together.

By adjusting the screw of the die stock, the die pieces can be brought closer together or can be moved apart.

They need a special die holder.

Adjustable screw plate die (Fig 5)

Fig 5



This is another type of a two-piece die similar to the half die.

This provides greater adjustment than the split die.

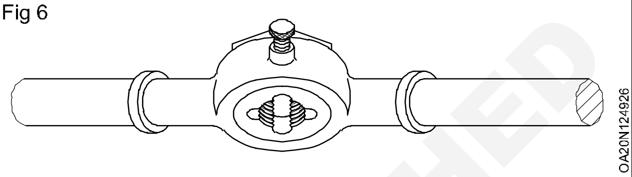
The two die halves are held securely in a collar by means of a threaded plate (guide plate) which also acts as a guide while threading.

When the guide plate is tightened after placing the die pieces in the collar, the die pieces are correctly located and rigidly held.

The die pieces can be adjusted, using the adjusting screws on the collar.

This type of die stock is called quick cut die stock.(Fig 6)

Fig 6

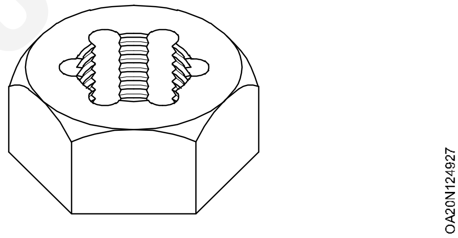


The bottom of the die halves is tapered to provide the lead for starting the thread. On one side of each die head, the serial number is stamped.

Both pieces should have the same serial numbers.

Die nut (Solid die) (Fig 7)

Fig 7



The die nut is used for chasing or reconditioning the damaged threads.

Die nuts are not to be used for cutting new threads.

The die nuts are available for different standards and sizes of threads.

The die nut is turned with a spanner.

Blank size for external threading

Objective: At the end of this lesson you shall be able to
- **state the diameter of blank size for external thread cutting.**

Why should the blank size be less? : It has been observed from practice that the threaded diameters of steel blanks show a slight increase in diameter. Such increase in the diameter will make the assembly of external and internal threaded components very difficult. To overcome this, the diameter of the blank is slightly reduced before commencing the threading.

What should be the blank size? : The diameter of the blank should be less by 1/10th of the pitch of the thread.

Example

For cutting the thread of M12 with 1.75 mm pitch the diameter of the blank is 11.80.

Formula, $D = d - p/10$

$= 12\ mm - 0.175\ mm$

$= 11.825$ or $11.8\ mm$.

d = diameter of bolt, D = the blank diameter

p = pitch of thread

Calculate the blank size for preparing a bolt of M16 x 1.5.

Answer

Removing broken taps

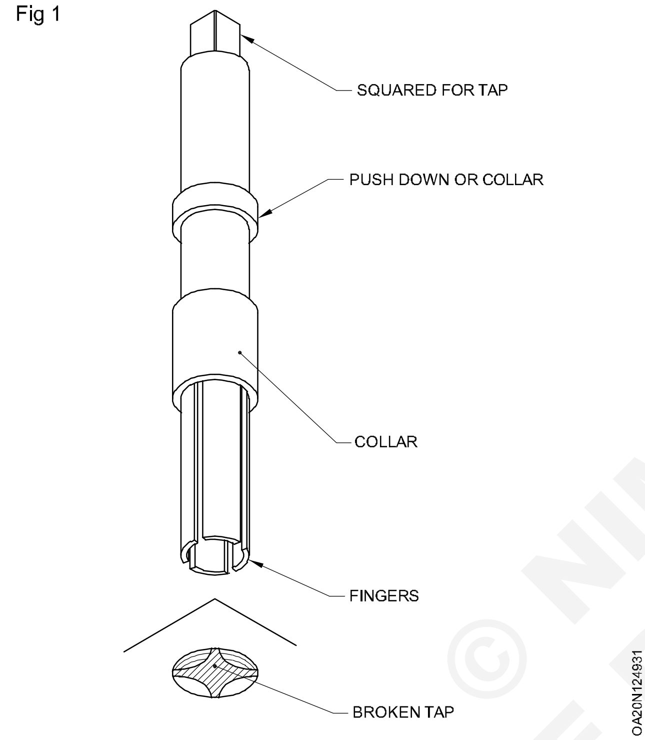
Objectives : At the end of this lesson you shall be able to
- **name the different methods of removing broken taps**
- **state the methods for removing broken taps.**

A tap broken above the surface of the workpiece can be removed using gripping tools like pliers.

Taps broken below the surface pose a problem for removing. Any one of the several methods given below can be used.

Use of tap extractor (Fig 1)

Fig 1



This is a very delicate tool and needs very careful handling.

This extractor has fingers which can be inserted on the flutes of the broken tap. The sliding collar is then brought to the surface of the work and the extractor turned anticlockwise to take out the broken tap.

A light blow on the broken tap with a punch will help to relieve the tap if it is jammed inside the hole.

Use of punch (Fig 2)

In this method the point of the punch is placed in the flute of the broken tap in an inclination and struck with a hammer. The positioning of the punch should be such that the broken tap is rotated anticlockwise when struck.

Annealing and drilling the tap

This is a method adopted when other methods fail. In this process the broken tap is heated by flame or by other methods for annealing. A hole is then drilled on the annealed tap. The remaining piece can be removed either by using a drift or using EZY-OUT (extractor). This method is not suitable for workpieces with low melting temperatures such as aluminium, copper etc.(Fig 3)

Fig 2

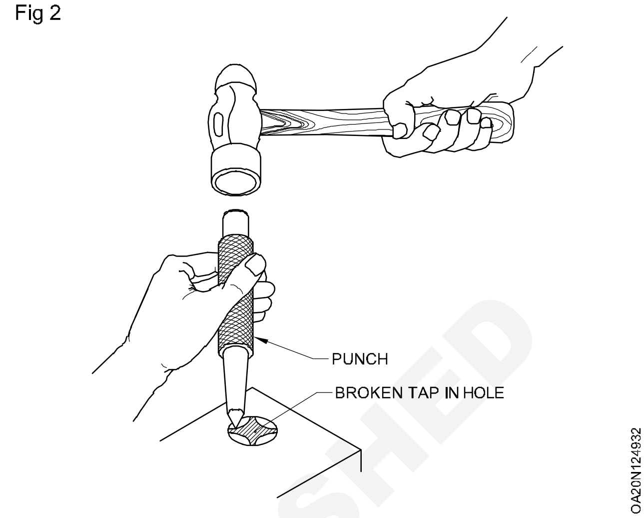
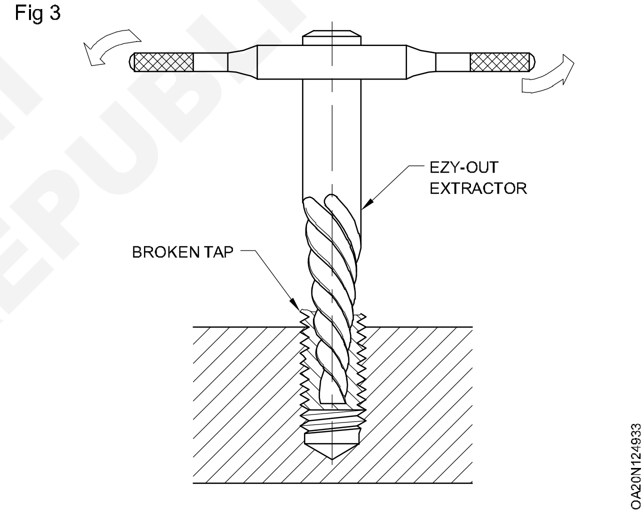


Fig 3



Use of arc welding

This is a suitable method when a small tap is broken at the bottom of materials like copper, aluminium etc.

In this method the electrode is brought in contact with the broken tap and struck so that it is attached with the broken tap. The tap may be removed by rotating the electrode.

Use of nitric acid

In this method nitric acid diluted in a proportion of about one part acid to five parts of water is injected inside. The action of the acid loosens the tap and then it is removed with an extractor or with a nose plier.

The workpiece should be throughly cleaned for preventing further action of the acid.

While diluting acid mix acid to water.

Use of spark erosion

For salvaging certain precision components damaged due to breakage of taps, spark erosion can be used.

In this process, the metal (broken tap) is removed by means of repetitive spark discharges. The electrical discharge occurs between an electrode and the electro-conductive workpiece (tap) and the minute particles are eroded both from the electrode and the workpiece. In many cases it may not be necessary to remove the broken tap completely. (After a small portion has been eroded, a screwdriver or punch can be used to remove the remaining portion of the tap.) The shape of the electrode also need not be round. It can be square or in the form of a slot on the workpiece for assisting the tools for rotating the broken tap.

Machine taps

Objectives: At the end of this lesson you shall be able to
- **state the characteristics of machine taps**
- **name the different types of machine taps**
- **state the features and uses of different types of machine taps.**

Machine taps of different types are available. The two important features of machine taps are the

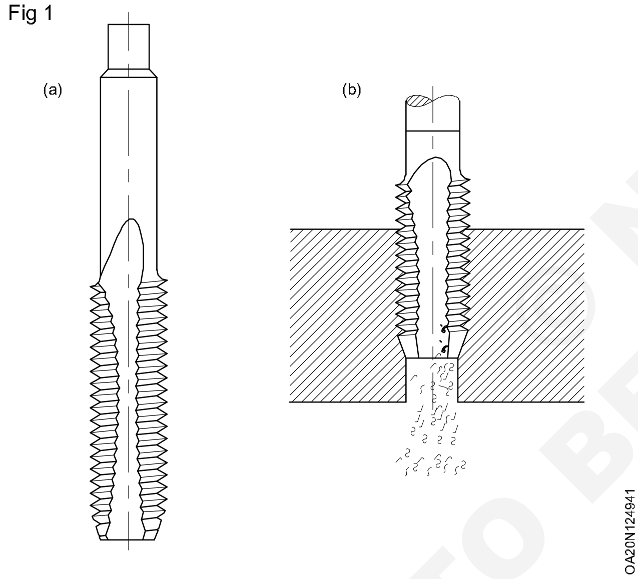
– ability to withstand the torque needed for threading holes

– provision for eliminating chip jamming.

Types of Machine Taps

Gun tap (Spiral pointed tap) (Fig 1)

Fig 1



These taps are especially useful for machine tapping of through holes.

While tapping, the chips are forced out ahead of the tap. (Fig 2)

In the case of blind hole tapping, there should be sufficient space below to accommodate the chips. This prevents the clogging of the chips, and thus reduces the chances of tap breakage. These taps are stronger since the flutes are shallower.

Fluteless spiral pointed tap (Stub flute taps) (Fig 3)

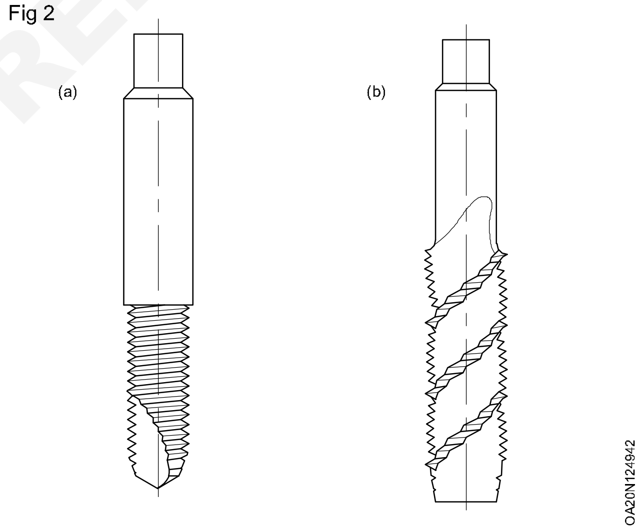
These taps have short angular flutes ground on the chamfered end and the rest of the body is left solid. These taps are stronger than gun taps.

Fluteless taps are used for tapping through holes on materials which are not thicker than the diameter of the holes. Fluteless spiral point taps are best suited for tapping soft materials or thin metal sections.

Helical fluted taps/spiral fluted taps

These taps have spiral flutes which bring out the chips from the hole being tapped. (Fig 4)

Fig 2



Elements of interchangeable system

Objectives: At the end of this lesson you shall be able to
- **state the advantages and disadvantages of mass production**
- **outline the meaning of the term, 'interchangeability'**
- **state the necessity for the limit system**
- **name the different standards of system of limits and fits.**

Mass production

Mass production means production of a unit, component or part in large numbers.

Advantages of mass production

Time for the manufacture of components is reduced.

The cost of a piece is reduced.

Spare parts can be made available quickly.

Gauges are used to check the components.

Even unskilled workers can be employed for checking.

Measuring time is saved.

Disadvantages of mass production

Special purpose machines are necessary.

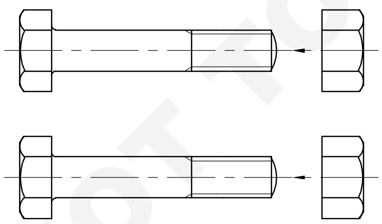
Jigs and fixtures are needed.

Gauges are to be used, hence the initial expenditure will be high.

Selective assembly

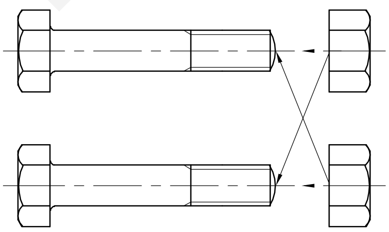
Figures 1 & 2 illustrate the difference between a selective assembly and a non-selective assembly. It will be seen in Fig 1 that each nut fits only one bolt. Such an assembly is slow and costly, and maintenance is difficult because spares must be individually manufactured.

Fig 1



SELECTIVE ASSEMBLY

Fig 2



NON-SELECTIVE ASSEMBLY INTERCHANGABILITY

Non-selective assembly

Any nut fits any bolt of the same size and thread type. Such an assembly is rapid, and costs are reduced. Maintenance is simpler because spares are easily available. (Fig 2)

Non-selective assembly provides interchangeability between the components.

In modern engineering production, i.e. mass production, there is no room for selective assembly. However, insome special circumstances, selective assembly is still justified.

Interchangeability

When components are mass-produced, unless they are interchangeable, the purpose of mass production is not fulfilled. By interchangeability, we mean that identical components, manufactured by different personnel under different environments, can be assembled and replaced without any rectification during the assembly stage and without affecting the functioning of the component when assembled.

Necessity of the limit system

If components are to be interchangeable, they need to be manufactured to the same identical size which is not possible, when they are mass-produced. Hence, it becomes necessary to permit the operator to deviate by a small margin from the exact size which he is not able to maintain for all the components. At the same time, the deviated size should not affect the quality of the assembly. This sort of dimensioning is known as limit dimensioning.

A system of limits is to be followed as a standard for the limit dimensioning of components.

Various standard systems of limits and fits are followed by different countries based on the ISO (International Standards Organisation) specifications.

The system of limits and fits followed in our country is that which is stipulated by the BIS. (Bureau of Indian Standards)

Other systems of limits and fits

- British Standard System (BSS)
- German Standard (DIN)

The Indian standard system of limits and fits - terminology

Objectives: At the end of this lesson you shall be able to
- **state the terms used under the BIS system of limits and fits**
- **define each term under the BIS system of limits and fits.**

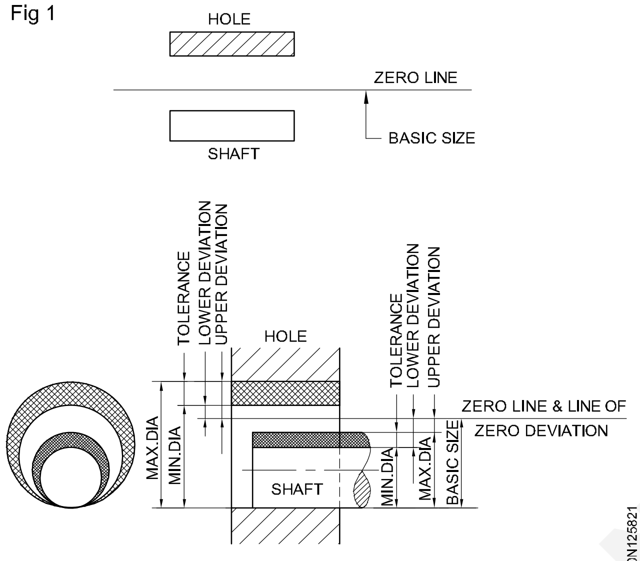
Size

It is a number expressed in a particular unit in the measurement of length.

Basic size

It is the size based on which the dimensional deviations are given. (Fig 1)

Fig 1



SIMPLIFIED SCHEMATIC DIAGRAM OF CLEARANCE FIT

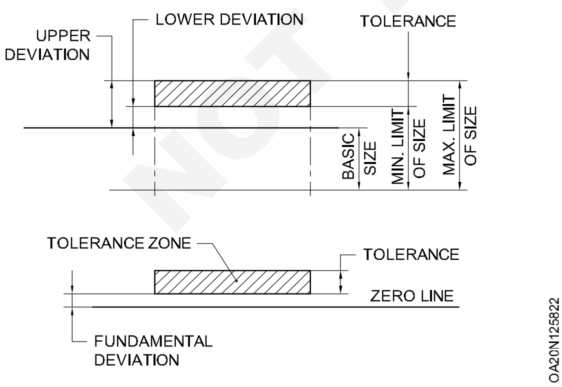
Actual size

It is the size of the component by actual measurement after it is manufactured. It should lie between the two limits of size if the component is to be accepted.

Limits of size

These are the extreme permissible sizes within which the operator is expected to make the component. (Maximum and minimum limits) (Fig 2)

Fig 2



Maximum limit of size

It is the greater of the two limits of sizes. (Fig 2) (Table 1)

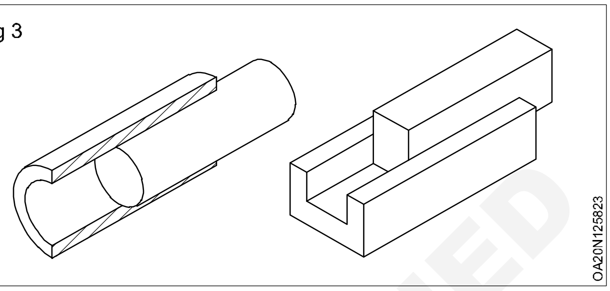
Minimum limit of size

It is the smaller of the two limits of size. (Fig 2) (Table 1)

Hole

In the BIS system of limits and fits, all internal features of a component including those which are not cylindrical are designated as hole. (Fig 3)

Fig 3



Shaft

In the BIS system of limits and fits, all external features of a component including those which are not cylindrical are designated as shaft. (Fig 3)

Deviation

It is the algebraic difference between a size and its corresponding basic size. It may be positive, negative or zero. (Fig 2)

Upper deviation

It is the algebraic difference between the maximum limit of size and its corresponding basic size. (Fig 2) (Table 1)

Lower deviation

It is the algebraic difference between the minimum limit of size and its corresponding basic size. (Fig 2) (Table 1)

Upper deviation is the deviation which gives the maximum limit of size. Lower deviation is the deviation which gives the minimum limit of size.

Actual deviation

It is the algebraic difference between the actual size and its corresponding basic size. (Fig 2)

Tolerance

It is the difference between the maximum limit of size and the minimum limit of size. It is always positive and is expressed only as a number without a sign. (Fig 2)

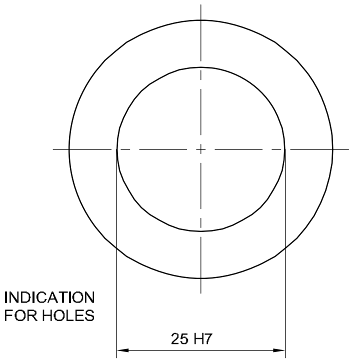
Zero line

In the graphical representation of the above terms, the zero line represents the basic size. This line is also called the line of zero deviation. (Figs 1 and 2)

Fundamental deviation

There are 25 fundamental deviations in the BIS system represented by letter symbols (capital letters for holes and small letters for shafts), i.e. for holes - ABCD .... Z excluding I,L,O,Q and W. (Fig 4)

Fig 4

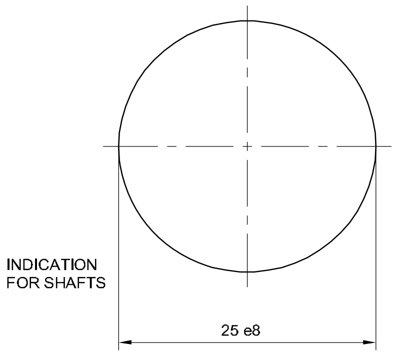


CAPITAL LETTERS REFER TO HOLES OR INSIDE DIMENSIONS, e.g. 25H7

In addition to the above, four sets of letters JS,ZA,ZB and ZC are included.

For shafts, the same 25 letter symbols but in small letters are used. (Fig 5)

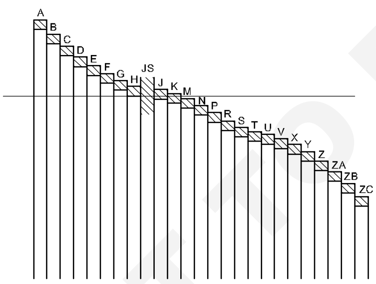
Fig 5



SMALL LETTERS REFER TO SHAFTS OR OUTSIDE DIMENSIONS, e.g. 25 e8

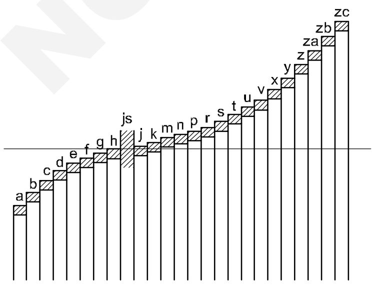
The position of tolerance zone with respect to the zero line is shown in Figs 6 and 7.

Fig 6



CAPITAL LETTERS INDICATE FUNDAMENTAL DEVIATION FOR HOLES

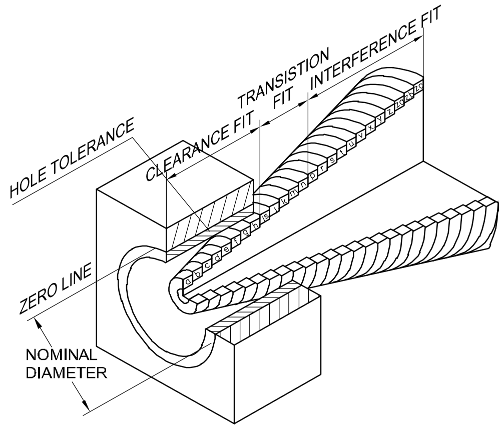
Fig 7



SMALL LETTERS INDICATE FUNDAMENTAL DEVIATION FOR SHAFTS

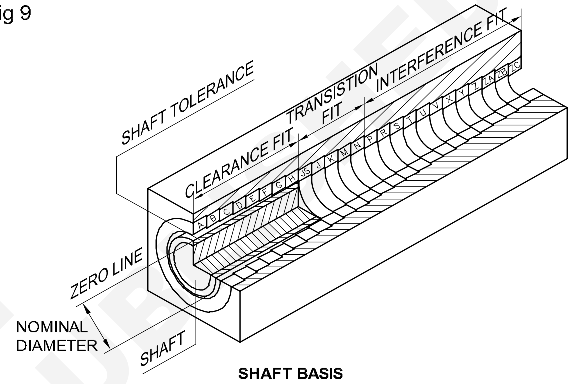
The fundamental deviations are for achieving the different classes of fits. (Figs 8 and 9)

Fig 8



HOLE BASIS

Fig 9



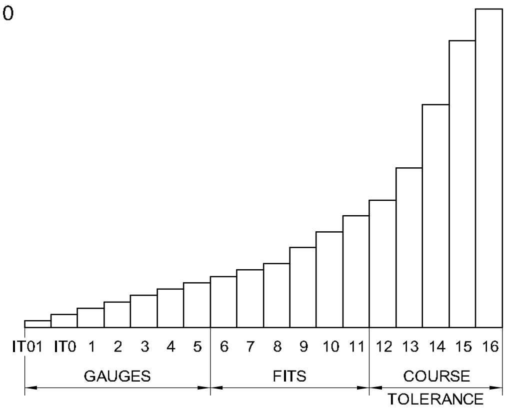
SHAFT BASIS

Fundamental tolerance

This is also called 'grade of tolerance'. In the B.I.S. system, there are 18 grades of tolerances represented by number symbols both for hole and shaft, denoted as IT01, IT0, IT1, IT2 .... IT16 (Fig 10)

A higher number gives a larger tolerance.

Fig 10



Grade of tolerance refers to the accuracy of manufacture.

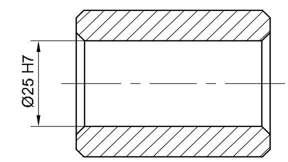
In a standard chart, the upper and lower deviations for each combination of fundamental deviation and fundamental tolerance are indicated for sizes ranging up to 500 mm. (Refer to IS 919.)

Tolerance size : This includes the basic size, the fundamental deviation and the grade of tolerance.

Examples

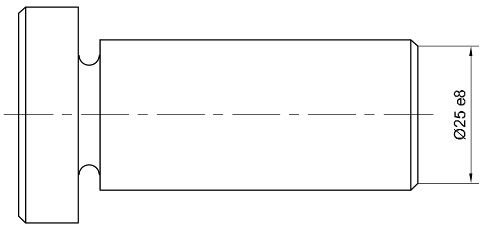
25 H7 - is the tolerance size of a hole whose basic size is 25. The fundamental deviation is represented by the letter symbol H and the grade of tolerance is represented by the number symbol 7. (Fig 11)

Fig 11



25 e8 - is the tolerance size of a shaft whose basic size is 25. The fundamental deviation is represented by the letter symbol and the grade of tolerance is represented by the number 8. (Fig 12)

Fig 12

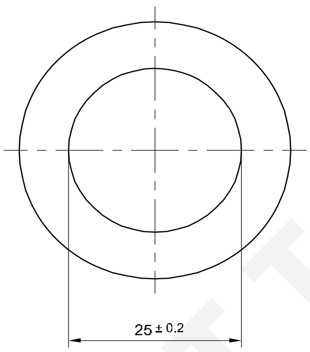


A very wide range of selection can be made by the combination of the 25 fundamental deviations and 18 grades of tolerances.

Example

In figure 13, a hole is shown as 25 ± 0.2 which means that 25 mm is the basic dimension and ± 0.2 is the deviation.

Fig 13



TOLERANCED SIZES OF HOLES

As pointed out earlier, the permissible variation from the basic dimension is called 'DEVIATION'.

The deviation is mostly given on the drawing with dimensions.

In the example, 25 ± 0.2, ± 0.2 is the deviation of the hole of 25 mm diameter. (Fig 13) This means that the hole is of acceptable size if its dimension is between

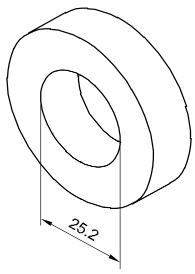
25 + 0.2 = 25.2 mm

or

25 - 0.2 = 24.8 mm.

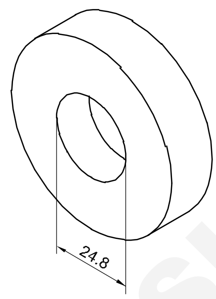
25.2 mm is the maximum limit. (Fig 14)

Fig 14



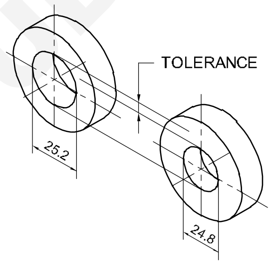
24.8 mm is the minimum limit. (Fig 15)

Fig 15



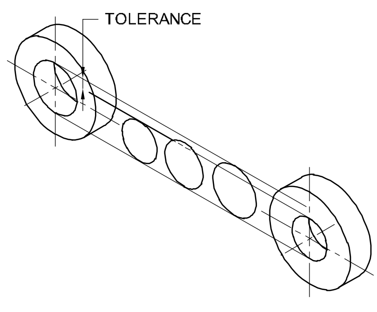
The difference between the maximum and minimum limits is the TOLERANCE. Tolerance here is 0.4 mm. (Fig 16)

Fig 16



All dimensions of the hole within the tolerance zone are of an acceptable size as shown in Fig 17.

Fig 17



As per IS 696, while dimensioning the components as a drawing convention, the deviations are expressed as tolerances.

Fits and their classification as per the indian standard

Objectives: At the end of this lesson you shall be able to
- **define 'fit' as per the Indian Standard**
- **list out the terms used in limits and fits as per the Indian Standard**
- **state examples for each class of fit**
- **interpret the graphical representation of different classes of fits.**

Fit

It is the relationship that exists between two mating parts, a hole and a shaft, with respect to their dimensional differences before assembly.

Expression of a fit

A fit is expressed by writing the basic size of the fit first, (the basic size which is common to both the hole and the shaft) followed by the symbol for the hole, and the symbol for the shaft.

Example

30 H7/g6 or 30 H7 – g6 or 30

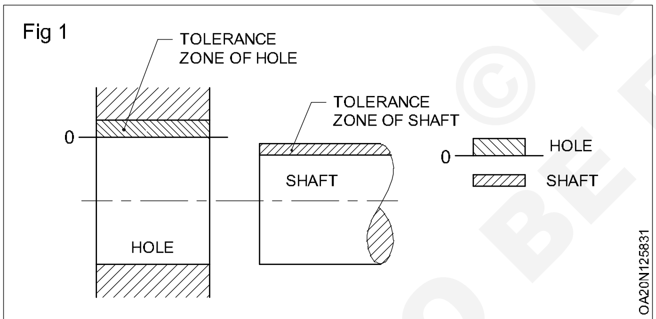
Clearance

In a fit the clearance is the difference between the size of the hole and the size of the shaft, when the hole is bigger than the shaft.

Clearance fit

It is a fit which always provides clearance. Here the tolerance zone of the hole will be above the tolerance zone of the shaft. (Fig 1)

Fig 1



Example

20 H7/g6

With the fit given, we can find the deviations from the chart.

For a hole 20 H7 we find in Table 1, +21.

These numbers indicate the deviations in microns. (1 micron = 0.001 mm)

The limits of the hole are 20 + 0.021 = 20.021 mm and 20 + 0 = 20.000 mm. (Fig 2)

For a shaft 20 g6 we find in the Table – 7
– 20.

So the limits of the shaft are

20 – 0.007 = 19.993 mm

and 20 – 0.020 = 19.980 mm.(Fig 3)

Fig 2

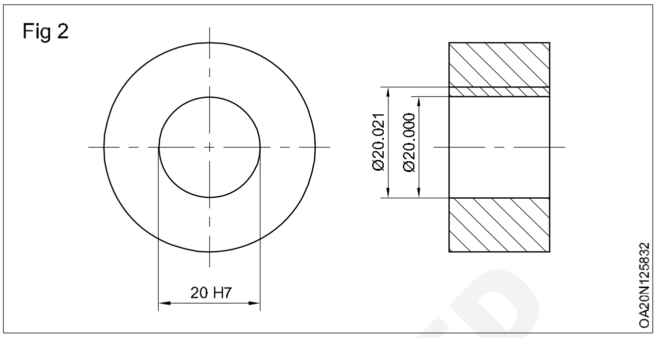
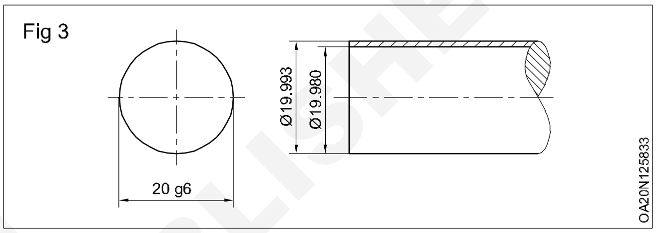


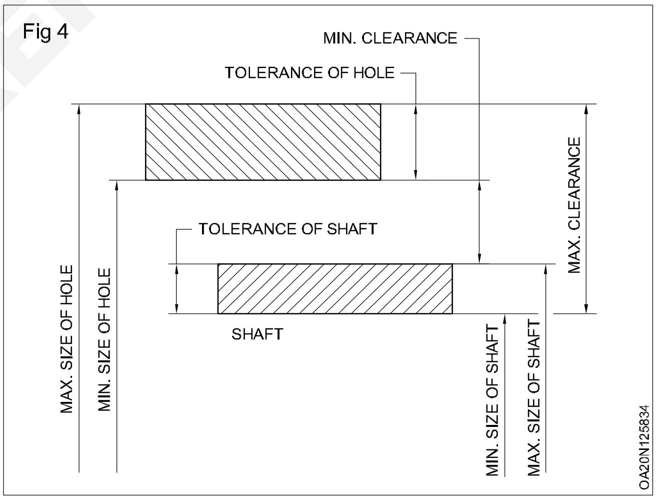
Fig 3



Maximum clearance

In a clearance fit or transition fit, the maximum clearance is the difference between the maximum size hole and the minimum size shaft. (Fig 4)

Fig 4



Minimum clearance

In a clearance fit, the minimum clearance is the difference between the minimum hole and the maximum shaft. (Fig 4)

The minimum clearance is 20.000 – 19.993 = 0.007 mm. (Fig 4)

The maximum clearance is 20.021 – 19.980 = 0.041 mm. (Fig 4)

There is always a clearance between the hole and the shaft. This is the clearance fit.

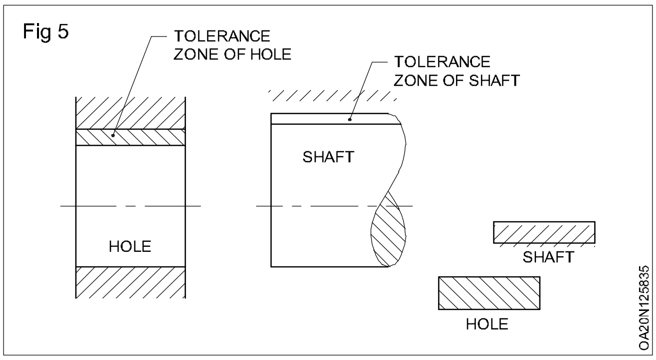
Interference : It is the difference between the size of the hole and the shaft before assembly, and this is negative.

In this case, the shaft is always larger than the hole size.

Interference fit

It is a fit which always provides interference. Here the tolerance zone of the hole will be below the tolerance zone of the shaft. (Fig 5)

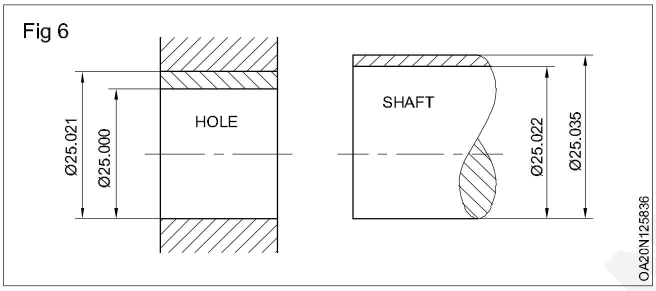
Fig 5



Example

Fit 25 H7/p6 (Fig 6)

Fig 6

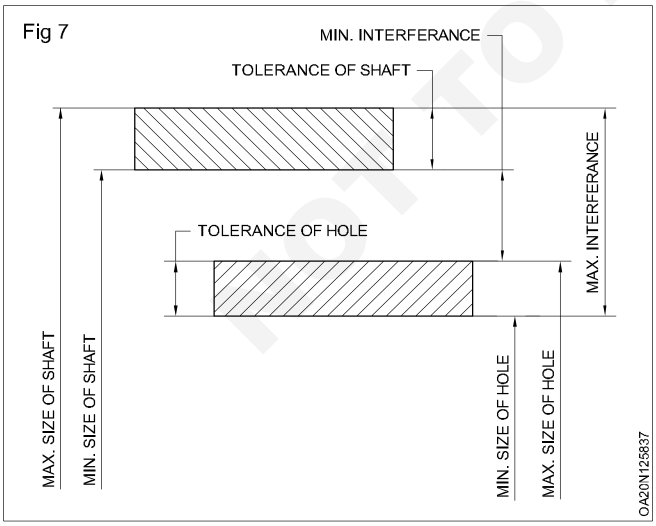


The limits of the hole are 25.000 and 25.035 mm. and the limits of the shaft are 25.022 and 25.035. The shaft is always bigger than the hole. This is an interference fit.

Maximum interference

In an interference fit, it is the algebraic difference between the minimum hole and the maximum shaft. (Fig 7)

Fig 7

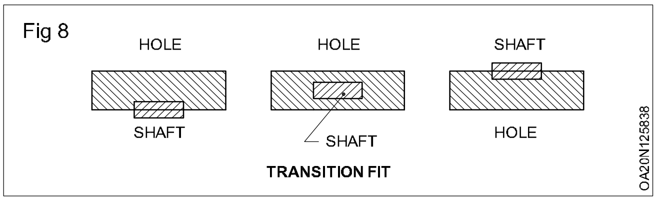


Minimum interference

In an interference fit, it is the algebraic difference between the maximum hole and minimum shaft. (Figs 7 & 8)

In the example shown in figure 6,

Fig 8



the maximum interference is = 25.035 – 25.000

= 0.035.

the minimum interference is = 25.022 – 25.021

= 0.001.

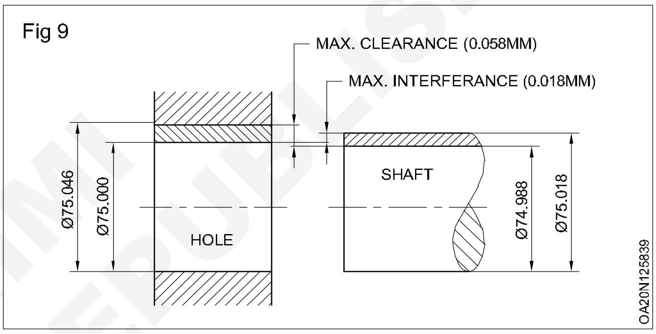
Transition fit

It is a fit which may sometimes provide clearance, and sometimes interference. When this class of fit is represented graphically, the tolerance zones of the hole and shaft will overlap each other. (Fig 8)

Example

Fit 75 H8/j7 (Fig 9)

Fig 9



The limits of the hole are 75.000 and 75.046 mm and those of the shaft are 75.018 and 74.988 mm.

Maximum clearan

ce = 75.046 – 74.988

= 0.058 mm.

If the hole is 75.000 and the shaft 75.018 mm, the shaft is 0.018 mm bigger than the hole. This results in interference. This is a transition fit because it can result in a clearance fit or an interference fit.

Hole basis system

In a standard system of limits and fits, where the size of the hole is kept constant and the size of the shaft is varied to get the different classes of fits, it is known as the hole basis system.

The fundamental deviation symbol 'H' is chosen for the holes, when the hole basis system is followed. This is because the lower deviation of the 'H' hole is zero. It is known as the 'basic hole'. (Fig 10)

Shaft basis system

In a standard system of limits and fits, where the size of the shaft is kept constant and the variations are given to the hole for obtaining different classes of fits, then it is known as shaft basis system. The fundamental deviation symbol 'h' is chosen for the shaft when the shaft basis is

Fig 10

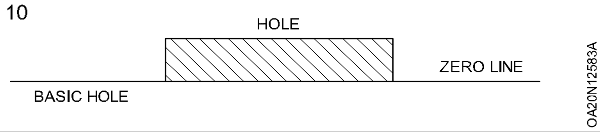
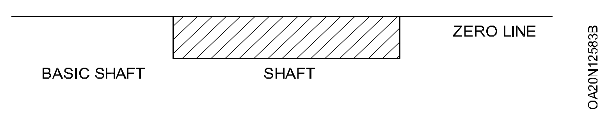


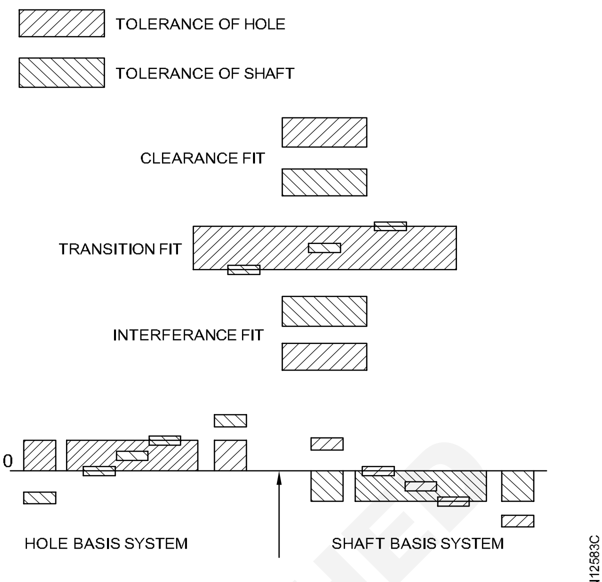
Fig 11



followed. This is because the upper deviation of the 'h' shaft is zero. It is known as the 'basic shaft'. (Fig 11)

The hole basis system is followed mostly. This is because, depending upon the class of fit, it will be always easier to alter the size of the shaft as it is external, but it is difficult to do minor alterations to a hole. Moreover the hole can be produced by using standard toolings.

Fig 12



EXAMPLES ILLUSTRATING THE HOLE BASIS AND SHAFT BASIS SYSTEMS

The three classes of fits, both under the hole basis and the shaft basis, are illustrated in figure 12.

The B.I.S. system of limits and fits - reading the standard chart

Objective: At the end of this lesson you shall be able to

- **refer to the standard limit system chart and determine the limits of sizes.**

The standard chart covers sizes up to 500 mm (I.S.919 of 1963) for both holes and shafts. It specifies the upper and lower deviations for a certain range of sizes for all combinations of the 25 fundamental deviations, and 18 fundamental tolerances.

The upper deviation of the hole is denoted as ES and the lower deviation of the hole is denoted as EI. The upper deviation of the shaft is denoted as 'es' and the lower deviation of shaft is denoted as 'ei'.

Note

es is expanded as ECART SUPERIOR and *ei* as ECART INFERIOR.

Determining the limits from the chart

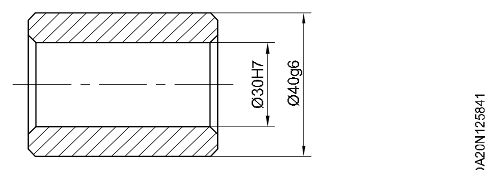
Note whether it is an internal measurement or an external measurement.

Note the basic size.

Note the combination of the fundamental deviation and the grade of tolerance.

Then refer to the chart and note the upper and lower deviations which are given in microns, with the sign. Accordingly add or subtract from the basic size and determine the limits of size of the components.

Fig 1



Example

30H7 (Fig 1)

It is an internal measurement. So we must refer to the chart for 'holes'.

The basic size is 30 mm. So see the range 30 to 40.

Look for es, and ei values in microns for H7 combination for 30 mm basic size.

It is given as +25

+ 0.

Therefore, the maximum limit of the hole is 30 + 0.025 = 30.025 mm.

Table 1 for Tolerance Zones & Limits (Dimensions in mm)

NOMINAL SIZE RANGE mm	s6	r6	p6	n6	k6	js6	h6	h7	h9	h11	g6	f7	e8	d9	c11	b11	a11	S7	R7	P7	N7	K7	JS7	H7	H8	H9	H11	G7	F8	E9	D10	C11	B11	A11
From 1 up to 3	+20 +14	+16 +10	+12 +6	+10 +4	+6 0	+3 −3	0 −6	0 −10	0 −25	0 −60	−2 −8	−6 −16	−14 −28	−20 −45	−60 −120	−140 −200	−270 −330	−14 −24	−10 −20	−6 −16	−4 −14	0 −10	+5 −5	+10 0	+14 0	+25 0	+60 0	+12 +2	+20 +6	+39 +14	+60 +20	+120 +60	+200 +140	+330 +270
Over 3 up to 6	+27 +19	+23 +15	+20 +12	+16 +8	+9 +1	+4 −4	0 −8	0 −12	0 −30	0 −75	−4 −12	−10 −22	−20 −38	−30 −60	−70 −145	−140 −215	−270 −345	−15 −27	−11 −23	−8 −20	−4 −16	+3 −9	+6 −6	+12 0	+18 0	+30 0	+75 0	+16 +4	+28 +10	+50 +20	+78 +30	+145 +70	+215 +140	+345 +270
Over 6 up to 10	+32 +23	+28 +19	+24 +15	+19 +10	+10 +1	+4.5 −4.5	0 −9	0 −15	0 −36	0 −90	−5 −14	−13 −28	−25 −47	−40 −76	−80 −170	−150 −240	−280 −370	−17 −32	−13 −28	−9 −24	−4 −19	+5 −10	+7.5 −7.5	+15 0	+22 0	+36 0	+90 0	+20 +5	+35 +13	+61 +25	+98 +40	+170 +80	+240 +150	+370 +280
Over 10 up to 14	+39	+34	+29	+23	+12	+5.5	0	0	0	0	−6	−16	−32	−50	−95	−150	−290	−21	−16	−11	−5	+6	+9	+18	+27	+43	+110	+24	+43	+75	+120	+205	+260	+400
Over 14 up to 18	+28	+23	+18	+12	+1	−5.5	−11	−18	−43	−110	−17	−34	−59	−93	−205	−260	−400	−39	−34	−29	−23	−12	−9	0	0	0	0	+6	+16	+32	+50	+95	+150	+290
Over 18 up to 24	+48	+41	+35	+28	+15	+6.5	0	0	0	0	−7	−20	−40	−65	−110	−160	−300	−27	−20	−14	−7	+6	+10.5	+21	+33	+52	+130	+28	+53	+92	+149	+240	+290	+430
Over 24 up to 30	+35	+28	+22	+15	+2	−6.5	−13	−21	−52	−130	−20	−41	−73	−117	−240	−290	−430	−48	−41	−35	−28	−15	−10.5	0	0	0	0	+7	+20	+40	+65	+110	+160	+300
Over 30 up to 40	+59	+50	+42	+33	+18	+8	0	0	0	0	−9	−25	−50	−80	−120 −280	−170 −330	−310 −470	−34	−25	−17	−8	+7	+12.5	+25	+39	+62	+160	+34	+64	+112	+180	+280 +120	+330 +170	+470 +310
Over 40 up to 50	+43	+34	+26	+17	+2	−8	−16	−25	−62	−160	−25	−50	−89	−142	−130 −290	−180 −340	−320 −480	−59	−50	−42	−33	−18	−12.5	0	0	0	0	+9	+25	+50	+80	+290 +130	+340 +180	+480 +320
Over 50 up to 65	+72 +53	+60 +41	+51	+39	+21	+9.5	0	0	0	0	−10	−30	−60	−100	−140 −330	−190 −380	−340 −530	−42 −72	−30 −60	−21	−9	+9	+15	+30	+46	+74	+190	+40	+76	+134	+220	+330 +140	+380 +190	+530 +340
Over 65 up to 80	+78 +59	+62 +43	+32	+20	+2	−9.5	−19	−30	−74	−190	−29	−60	−106	−174	−150 −340	−200 −390	−360 −550	−48 −78	−32 −62	−51	−39	−21	−15	0	0	0	0	+10	+30	+60	+100	+340 +150	+390 +200	+550 +360
Over 80 up to 100	+93 +71	+73 +51	+59	+45	+25	+11	0	0	0	0	−12	−36	−72	−120	−170 −390	−220 −440	−380 −600	−58 −93	−38 −73	−24	−10	+10	+17.5	+35	+54	+87	+220	+47	+90	+159	+260	+390 +170	+440 +220	+600 +380
Over 100 up to 120	+101 +79	+76 +54	+37	+23	+3	−11	−22	−35	−87	−220	−34	−71	−126	−207	−180 −400	−240 −460	−410 −630	−66 −101	−41 −76	−59	−45	−25	−17.5	0	0	0	0	+12	+36	+72	+120	+400 +180	+460 +240	+630 +410
Over 120 up to 140	+117 +92	+88 +63													−200 −450	−260 −510	−460 −710	−77 −117	−48 −88													+450 +200	+510 +260	+710 +460
Over 140 up to 160	+125 +100	+90 +65	+68 +43	+52 +27	+28 +3	+12.5 −12.5	0 −25	0 −40	0 −100	0 −250	−14 −39	−43 −83	−85 −148	−145 −245	−210 −460	−280 −530	−520 −770	−85 −125	−50 −90	−28 −68	−12 −52	+12 −28	+20 −20	+40 0	+63 0	+100 0	+250 0	+54 +14	+106 +43	+185 +85	+305 +145	+460 +210	+530 +280	+770 +520
Over 160 up to 180	+133 +108	+93 +68													−230 −480	−310 −560	−580 −830	−93 −133	−53 −93													+480 +230	+560 +310	+830 +580
Over 180 up to 200	+151 +122	+106 +77													−240 −530	−340 −630	−660 −950	−105 −151	−60 −106													+530 +240	+630 +340	+950 +660
Over 200 up to 225	+159 +130	+109 +80	+79 +50	+60 +31	+33 +4	+14.5 −14.5	0 −29	0 −46	0 −115	0 −290	−15 −44	−50 −96	−100 −172	−170 −285	−260 −550	−380 −670	−740 −1030	−113 −159	−63 −109	−33 −79	−14 −60	+13 −33	+23 −23	+46 0	+72 0	+115 0	+290 0	+61 +15	+122 +50	+215 +100	+355 +170	+550 +260	+670 +380	+1030 +740
Over 225 up to 250	+169 +140	+113 +84													−280 −570	−420 −710	−820 −1110	−123 −169	−67 −113													+570 +280	+710 +420	+1110 +820
Over 250 up to 280	+190 +158	+126 +94	+88	+66	+36	+16	0	0	0	0	−17	−56	−110	−190	−300 −620	−480 −800	−920 −1240	−138 −190	−74 −126	−36	−14	+16	+26	+52	+81	+130	+320	+69	+137	+240	+400	+620 +300	+800 +480	+1240 +920
Over 280 up to 315	+202 +170	+130 +98	+56	+34	+4	−16	−32	−52	−130	−320	−49	−108	−191	−320	−330 −650	−540 −860	−1050 −1370	−150 −202	−78 −130	−88	−66	−36	−26	0	0	0	0	+17	+56	+110	+190	+650 +330	+860 +540	+1370 +1050
Over 315 up to 355	+226 +190	+144 +108	+98	+73	+40	+18	0	0	0	0	−18	−62	−125	−210	−360 −720	−600 −960	−1200 −1560	−169 −226	−87 −144	−41	−16	+17	+28.5	+57	+89	+140	+360	+75	+151	+265	+440	+720 +360	+960 +600	+1500 +1200
Over 355 up to 400	+244 +208	+150 +114	+62	+37	+4	−18	−36	−57	−140	−360	−54	−119	−214	−350	−400 −760	−680 −1040	−1350 −1710	−187 −244	−93 −150	−98	−73	−40	−28.5	0	0	0	0	+18	+62	+125	+210	+760 +400	+1040 +680	+1710 +1350
Over 400 up to 450	+272 +232	+166 +126	+108	+80	+45	+20	0	0	0	0	−20	−68	−135	−230	−440 −840	−760 −1160	−1500 −1900	−209 −272	−103 −166	−45	−17	+18	+31.5	+63	+97	+155	+400	+83	+165	+290	+480	+840 +440	+1160 +760	+1900 +1500
Over 450 up to 500	+292 +252	+172 +132	+68	+40	+5	−20	−40	−63	−155	−400	−60	−131	−232	−385	−480 −880	−840 −1240	−1650 −2050	−229 −292	−109 −172	−108	−80	−45	−31.5	0	0	0	0	+20	+68	+135	+230	+880 +480	+1240 +840	+2050 +1650

The minimum limit of the hole is 30 + 0.000 = 30.000 mm.

Refer to the chart and note the values of 40 g6.

Note

The table for tolerance zones and limits as per IS2709 is attached. (Table 1)

Geometric tolerance

Objectives: At the end of this lesson you shall be able to
- **define geometrical tolerance**
- **state the necessity of using geometrical tolerances**
- **identify the recommended symbols for tolerance under three groups of form, attitude and location.**

Form

Straightness, flatness, roundness, cylindricity and profile of a line and a surface.

Attitude

Parallelism, sqaureness and angularity.

Location

Position, concentricity and symmetry.

Definition of geometrical tolerance

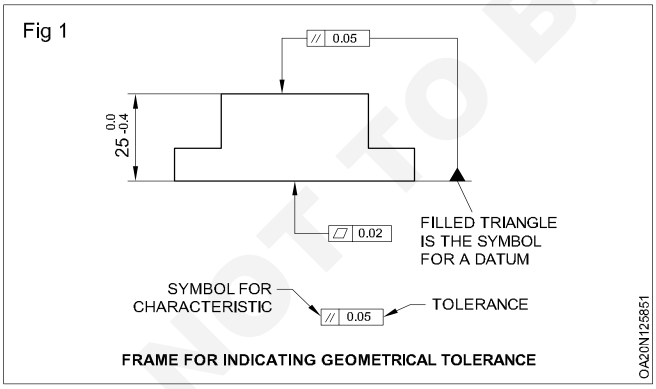
Geometrical tolerance is the maximum permissible overall variation of form or position of a feature.

Reason for using geometrical tolerance

This will help the operator to produce the components, particularly those parts which must fit together precisely.

The idea is to have an international system which will overcome the usual language barrier. This is achieved by the use of symbols which represent geometrical characteristics.

Fig 1



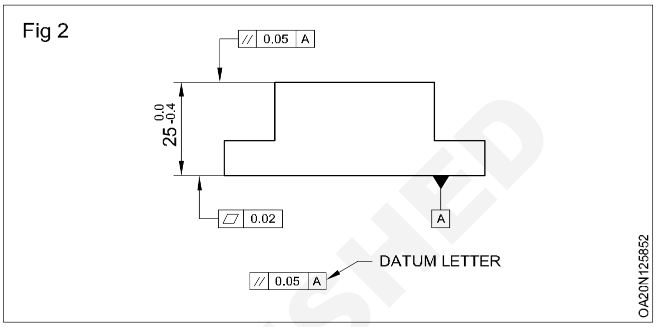
General principles of geometrical tolerances

The geometrical tolerance consists of a frame which contains a symbol, representing the geometrical tolerance zone; in this instance 0.05, for the characteristic of parallelism. The symbol for flatness is shown accompanied by the tolerance zone figure of 0.02 in the lower frame. (Fig 1)

You will notice that from each of the frames a leader is drawn so that it is normal, i.e. at 90° to the relevant face and ending with an arrowhead against the face.

Notice also that from the 'parallelism' frame, another leader is drawn terminating in a blacked-in equilateral triangle on a projection drawn out from the base line. The blacked-in triangle (about 4.5 mm high from base to apex) is the symbol used to represent a datum face or line.

Fig 2



An alternate method of arranging the frames and symbols is shown in Fig 2 where the datum is given a letter and a frame of its own with an independent leader line ending in the blacked-in triangle, inverted and drawn against the actual component base line. The datum letter 'A' is then added as an extra component in the geometrical tolerance frame.

Recommended symbols for geometrical tolerancing

Geometrical tolerances are arranged into three groups.

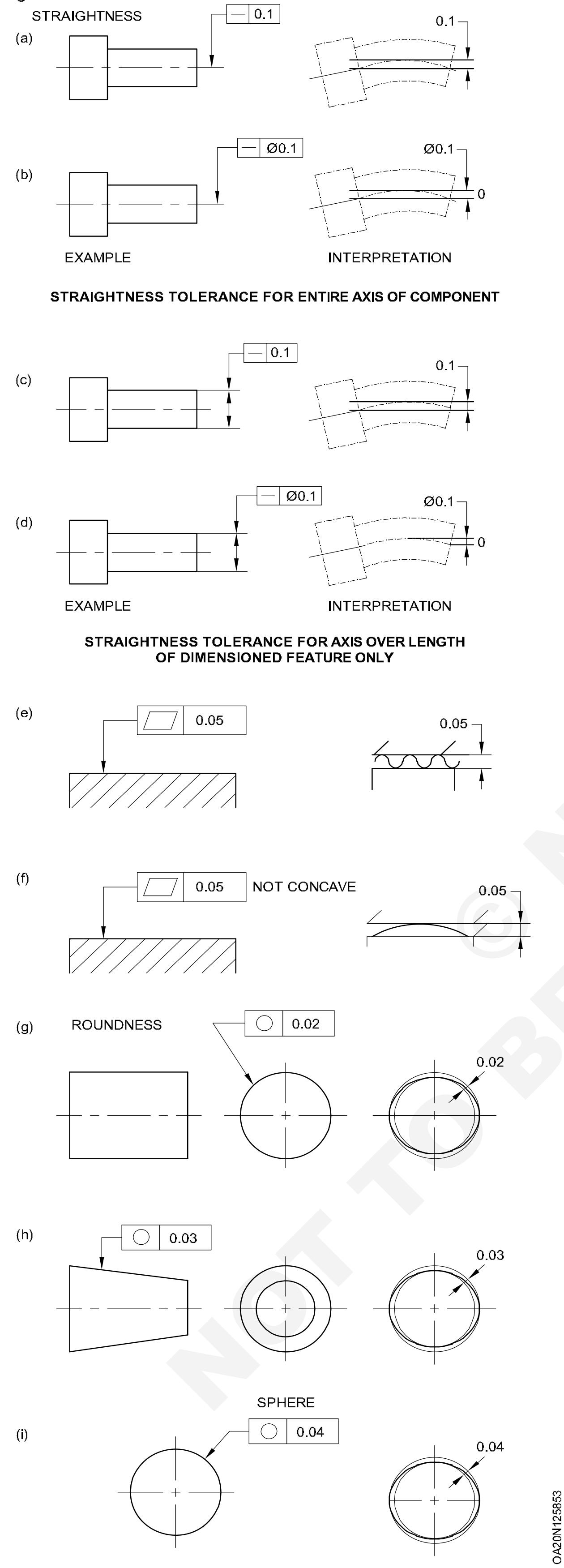
They are tolerances of form, attitude and location.

Tolerances of FORM are identified by the use of symbols for the following characteristics.

Characteristics	Symbol
Straightness	
Flatness	
Roughness	
Cylindricity	
Profile of a line	
Profile of a surface	

The application of symbols is indicated in Fig 3, where (3a), (3b), (3c) and (3d) show the use of geometrical tolerances controlling the straightness of a circular section part. In (3a) and (3b) the leader lines from the tolerance frame end in an arrowhead against the axis of the part. This means that the geometrical tolerance applies to the full length of the part. The interpretation at (3a) shows that for functional acceptance, the entire main axis must

Fig 3



lie between two parallel straight lines 0,1 apart in that plane. At (3b) the symbol for the diameter ϕ precedes the tolerance. This means that the entire main axis must lie within a cylindrical tolerance zone 0.1 mm diameter.

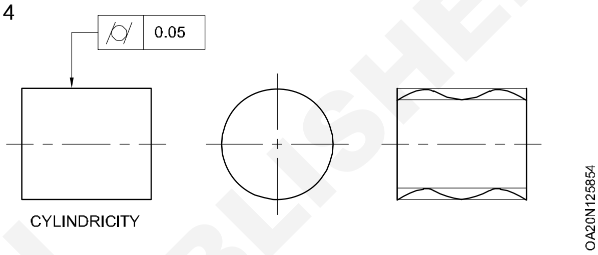
Figures (3c) and (3d) show the same geometrical tolerance, applied this time to the diameter dimension of the smaller diameter of the part.

This means that the geometrical tolerance applies over the length of the dimensional feature only.

Figure (3e) and figure (3f) deal with the geometrical tolerance for flatness of a surface, where the symbol for flatness is followed by the tolerance figure of 0.05. This figure indicates that the actual surface (as previously shown in Figure 1) must be between two parallel planes 0.05 apart. If a particular form of direction is prohibited, then this is stated in a note form against the tolerance frame. Eg. 'Not concave'.

The geometrical tolerance controlling the roundness of a part is shown in figures (3g), (3h) and (3j). The interpretation for (3g) and (3h) is that the true form of the periphery of the

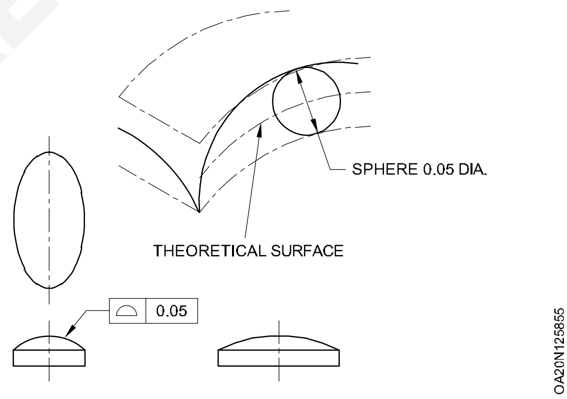
Fig 4



part at any cross-section perpendicular to the axis must lie between two concentric circles whose radial distance apart is 0.02 for (3g) and 0.03 for (3h).

For the sphere shown in (3i) the geometrical tolerance

Fig 5

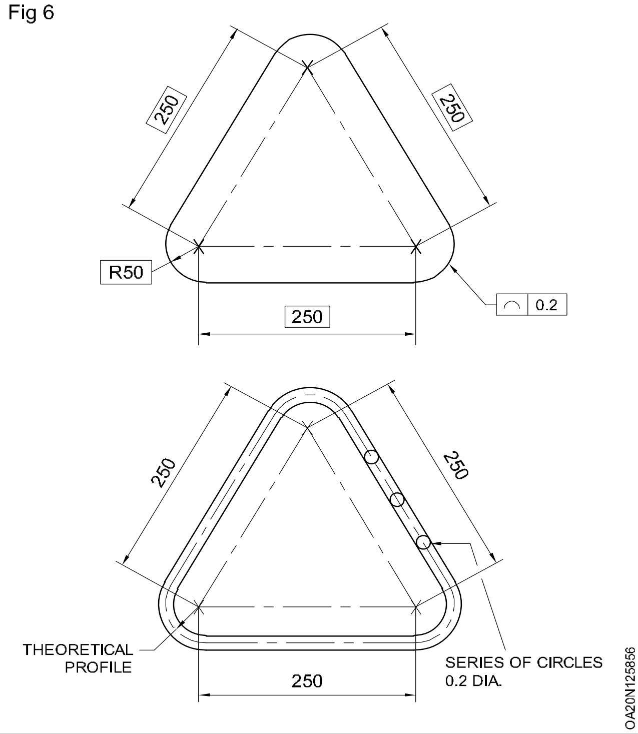


applies to concentric circles with the radial distance 0.04 apart at the periphery at any section of maximum diameter.

The sphere controlling cylindricity is shown in Fig 4. Here the interpretation shows, that for acceptance, the surface of the part must be within two coaxial cylinders, whose radial distance apart is 0.05.

Fig 5 shows the method of applying a geometrical tolerance to a curved surface. The symbol is followed by the tolerance 0.05 which means that the actual surface must lie between two surfaces enveloping a succession of sphere 0.05 diameter whose centre lies on the theoretical surface.

Fig 6



In Fig 6 the geometrical tolerance is applied to linear dimensions controlling the profile. The rectangular 'boxes' around the 250 centre dimension and the 50 radius is the method used to indicate theoretical dimensions i.e. the dimensions relevant to perfect form.

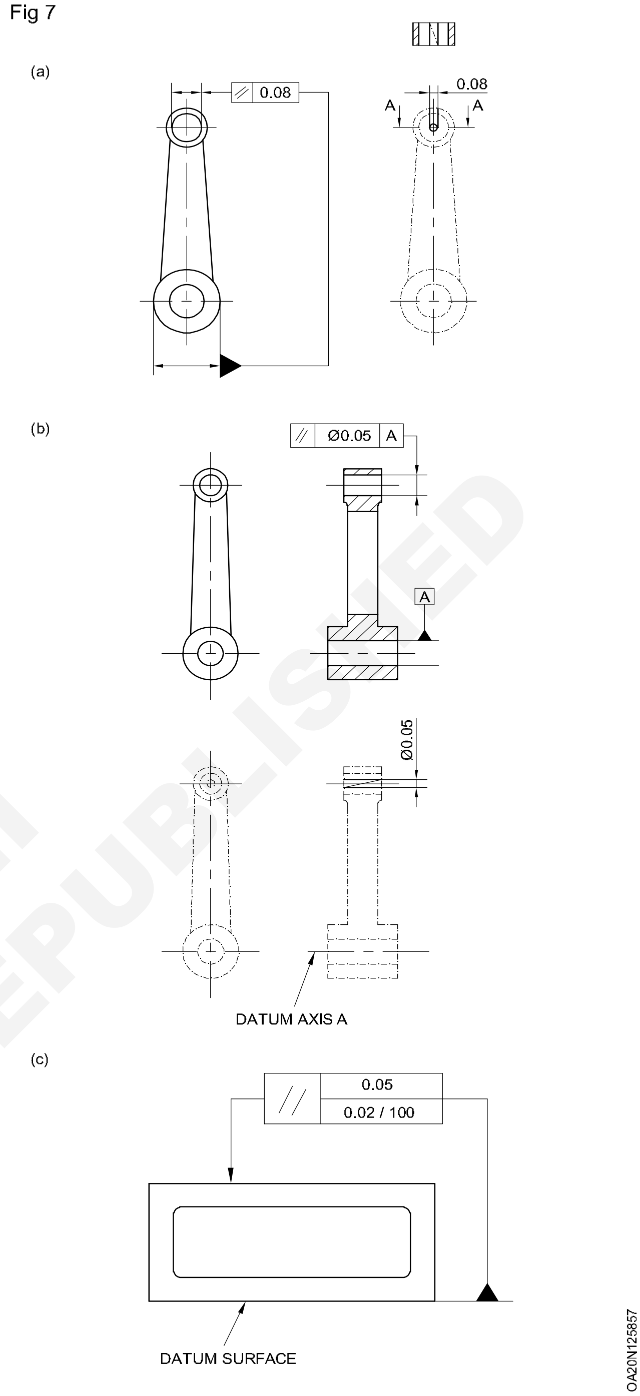
The interpretation of the geometrical tolerance is that the actual profile must be between two lines which touch a succession of circles 0.2 dia. whose centre lies on the theoretical profile.

Tolerances of attitude are indentified and indicated by the use of symbols for the following.

Characteristic	Symbol
Parallelism	
Squareness	
Angularity	

A typical application of tolerances for these three characteristics is shown in figures 7, 8 and 9. Figs (7a), (7b) and (7c) show the application of tolerancing to control 'parallelism'. (7a) shows that the axis of the upper hole must lie between the two lines 0.08 apart the lower hole, as indicated by the leader ending in the blacked-in triangle. In (7b) the method uses a separate datum letter 'A' which is added to the frame after the tolerance of 0.05 diameter. (Note the symbol is m.) The requirement is that the upper hole axis must lie within a cylindrical zone 0.05 diameter with its axis parallel with the axis of the datum hole 'A'. Fig (7c) shows a component whose upper surface must be between two parallel planes 0.05 apart, parallel with the bottom datum surface. While the overall tolerance zone is 0.05 as shown in the upper section of the frame, the figures in the lower section of the frame stipulate that over any length of 100 the parallelism tolerance is reduced to 0.02.

Fig 7



Examples of the application of the geometrical tolerance for 'squareness' are shown in (8a), (8b), (8c) and (8d) with (8a), (8b) and (8c) using the separate box method for indicating the datum.

The interpretation is as follows.

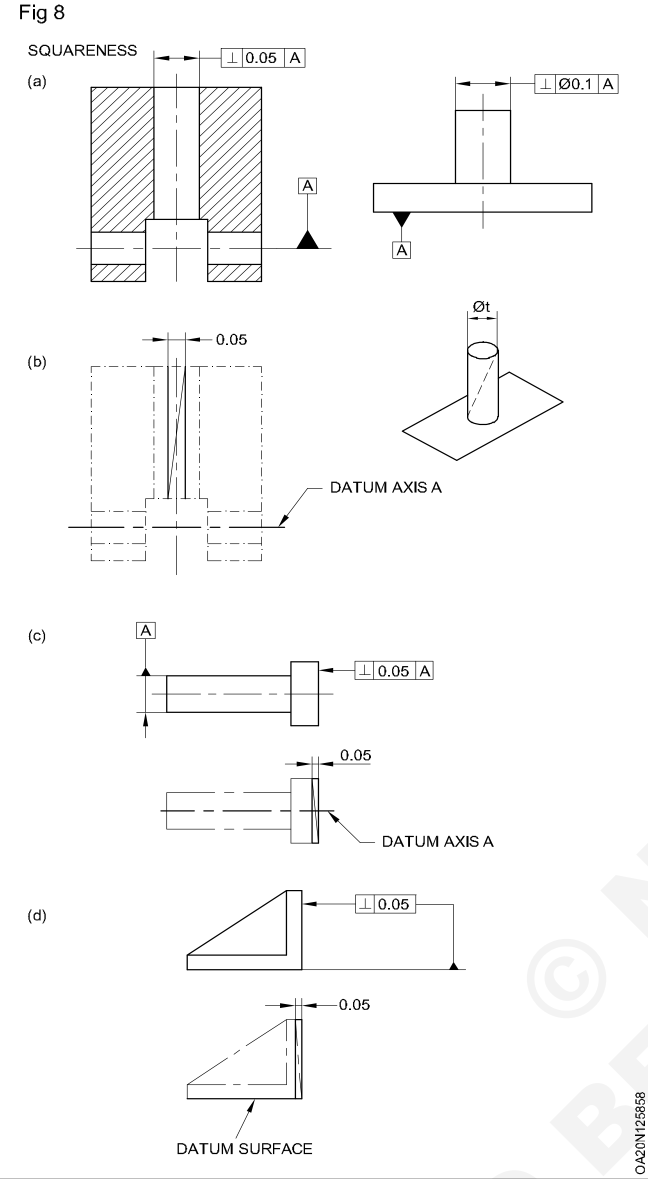
The axis of the vertical hole must be between two parallel lines, 0.05 apart, which are perpendicular to the common datum axis 'A' of the two horizontal holes. (8a)

The axis of the upper cylindrical portion must lie within a cylindrical tolerance zone of 0.1 diameter, the axis of which is perpendicular to the datum axis 'A'. (8b)

This shows that the right hand end face must lie between two parallel planes 0.05 apart, which are perpendicular to the datum axis, (8c).

Here the datum surface is indicated by a leader from the frame. The requirement is that the right hand face must

Fig 8



lie within the two parallel planes, 0.05 apart, which are perpendicular to the datum surface. (8d)

Geometrical tolerances for the control of ANGULARITY are shown in figures (9a), (9b) and (9c).

The figure (9a) shows that the requirement is the axis of the hole must lie within the cylindrical tolerance zone 0.1 diameter, the axis of which must be included at the theoretical angle of 60°to the datum surface A.

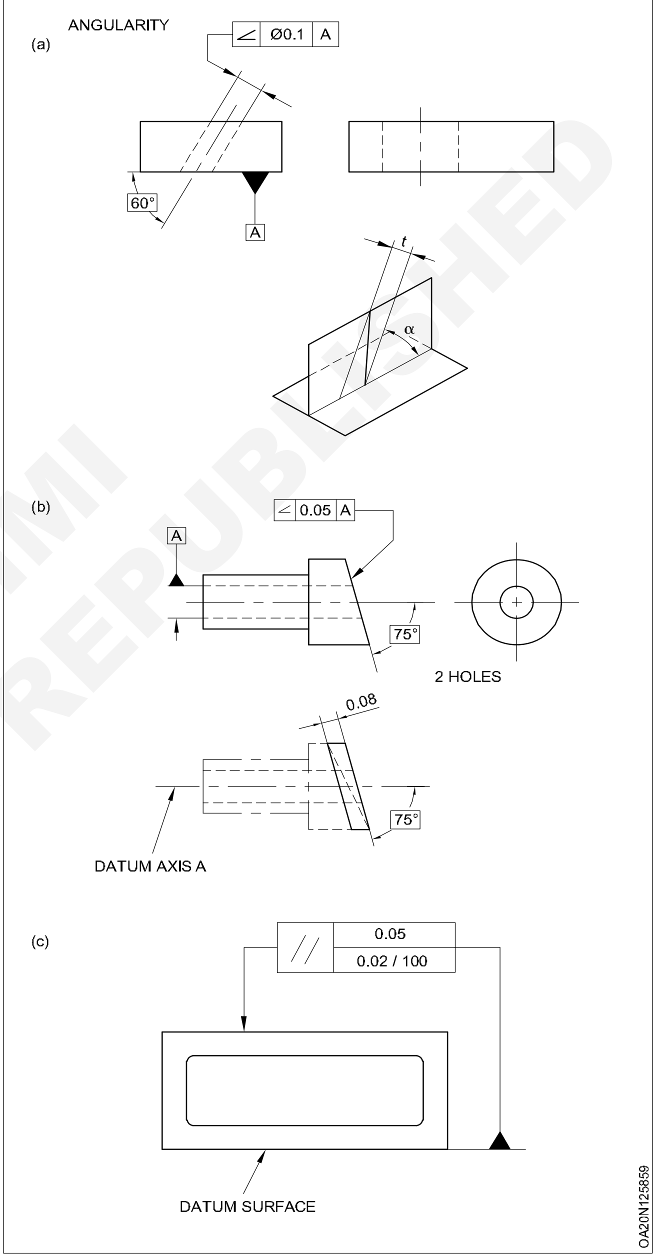
In (9b) the requirement is that the right hand end face must lie within the two parallel planes 0.08 apart which are inclined at the theoretical angle of 75°to the datum axis A of the through hole.

Figure (9c) shows a component whose upper angle face, must lie between the two parallel planes 0.05 apart which are inclined at the theoretical of 35° to the base, the datum surface. Notice that the theoretical angle in each example is boxed.

Tolerances of location are identified and indicated by the use of symbols for the following characteristics.

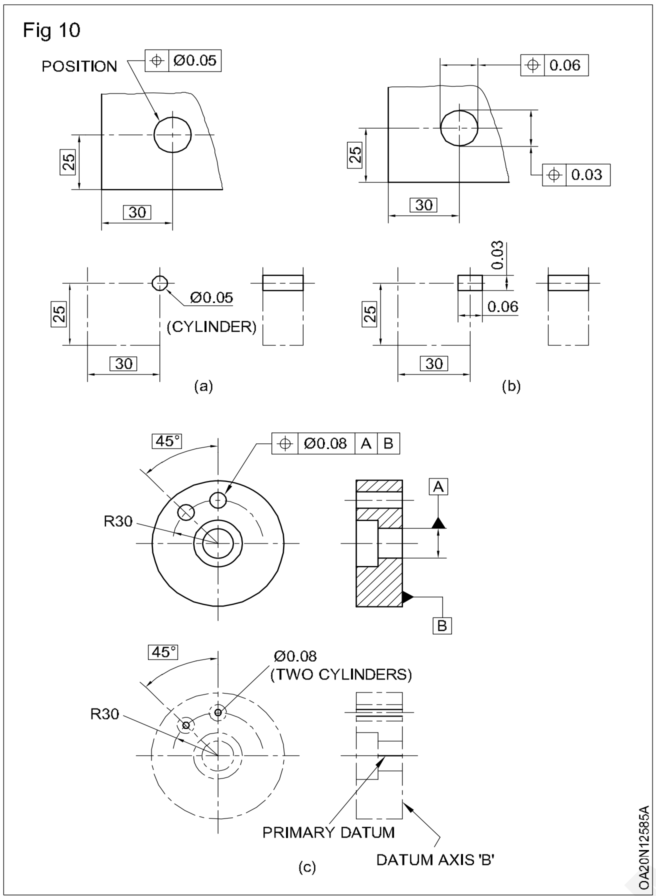
Characteristics	Symbol
Position	

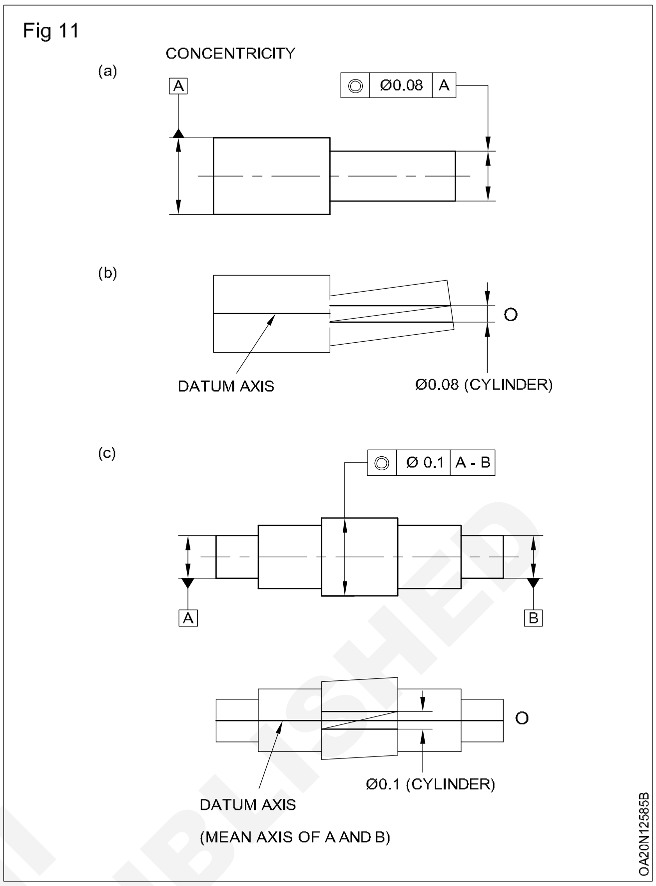
Fig 9



Concentricity	
Symmetry	

Figures (10), (11), (12) show typical examples of these characteristics and symbols. In figure (10a) the hole centre dimensions of 25 and 30 are boxed to show that these are the theoretical dimensions. The geometrical toler-





ance requires that the hole centre must lie within a cylindrical zone 0.05 diameter. The use of theoretical positions, also known as 'true positions', implies that the axis of the cylinder is square with the plane of the drawing. Figure (10b) shows the hole with the same true positions, but with the geometrical tolerances arranged to give greater tolerance along the horizontal axis. The resulting requirement is that the axis of the hole must lie within a rectangular box whose sides are 0.03 and 0.06, and length equal to the width of the component.

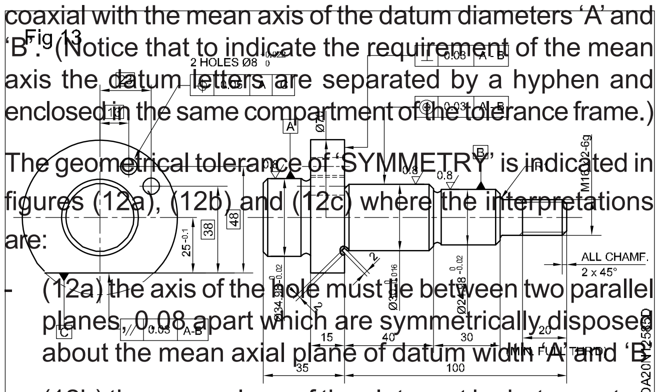
In (10c) the two holes are shown with their true position spaced at 45° on a 30 mm pitch circle radius. The geometrical tolerance shows that each actual hole centre must lie within a cylindrical zone 0.08 diameter whose axis lies at the therotically exact true centre position. The tolerance cylinders are disposed relative to the two datum features, namely the axis of the smaller bore and the right hand end face. The datum letters are included in the tolerance frame.

Examples of geometrical tolerance for 'CONCENTRICITY' are given in figures (11a), (11b) and (11c). The interpretations are as follows.

In figure (11a) the axis of the smaller diameter must lie within the cylindrical zone 0.08 diameter which must be coaxial with the datum axis i.e. the axis of datum diameter 'A'.

In figure (11b) the axis of two end portions must lie within a cylindrical tolerance zone 0.08 dia.

Figure (11c) shows that the axis of the large central portion must lie within a cylindrical zone 0.1 diameter which is coaxial with the mean axis of the datum diameters 'A' and 'B'. (Notice that to indicate the requirement of the mean axis the datum letters are separated by a hyphen and enclosed in the same compartment of the tolerance frame.)

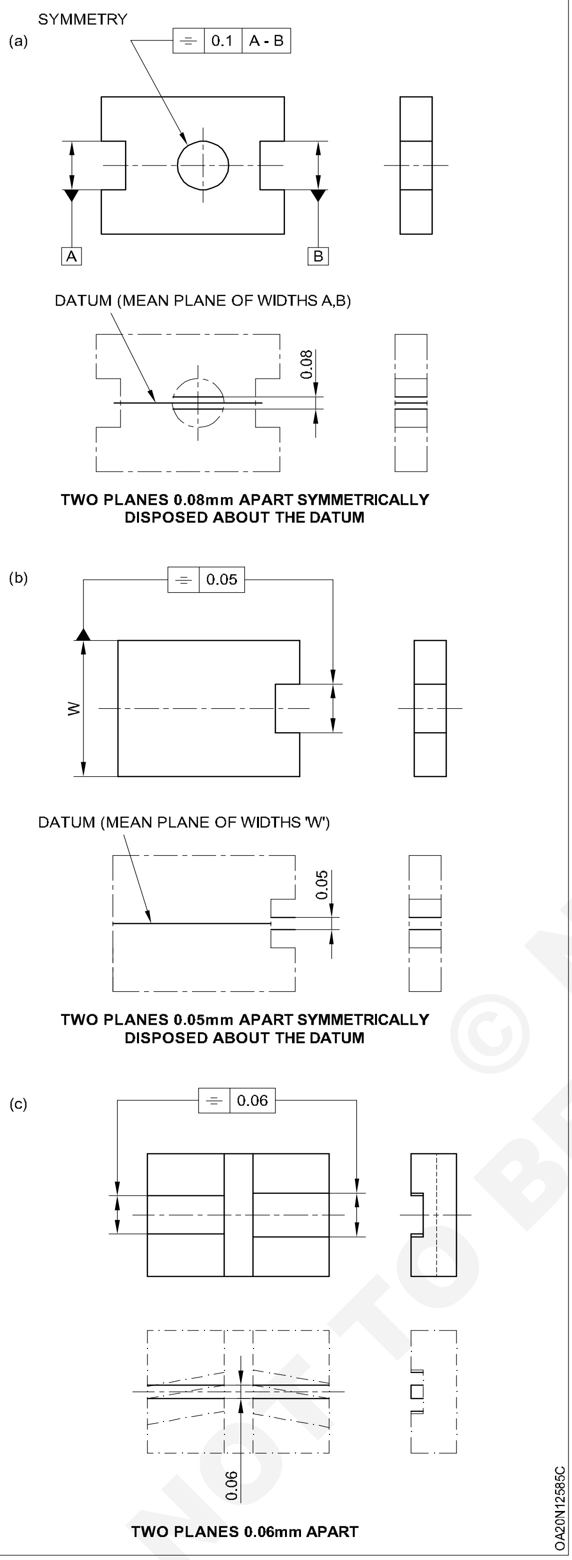


The geometrical tolerance of 'SYMMETRY' is indicated in figures (12a), (12b) and (12c) where the interpretations are:

- (12a) the axis of the hole must lie between two parallel planes, 0.08 apart which are symmetrically disposed about the mean axial plane of datum width 'A' and 'B'
- (12b) the mean plane of the slot must be between two parallel planes 0.05 apart symmetrically disposed about the mean plane of the datum width 'W'.
- (12c) the median planes of the two end slots must be between two parallel planes, 0.06 apart.

Figure 13 gives details of geometrical tolerances.

Fig 12



SYMMETRY
(a)
0.1
A - B
A
B
DATUM (MEAN PLANE OF WIDTHS A,B)
0.08
TWO PLANES 0.08mm APART SYMMETRICALLY DISPOSED ABOUT THE DATUM
(b)
0.05
W
DATUM (MEAN PLANE OF WIDTHS 'W')
0.05
TWO PLANES 0.05mm APART SYMMETRICALLY DISPOSED ABOUT THE DATUM
(c)
0.06
0.06
TWO PLANES 0.06mm APART
OA20N12585C

Care and maintenance of gauges

Objectives: At the end of this lesson you shall be able to
- **list the various type of gauges**
- **state the features of the 'Go' and 'No - Go' limit gauges**
- **brief the uses of gauges.**

Materials for gauges

The material used for manufacturing the gauge must fulfil the following requirements, either by virtue of its own properties, or by a heat treatment process.

- Hardness to resist wear.
- Stability to ensure that its size and shape will not change over a period of time.
- Corrosion resistance
- Machinability to enable it to be machined easily into the required shape and to the required degree of accuracy.
- Low coefficient of linear expansion to avoid effect of temperature.
- The parts of the gauge which are to be held in the hand should have low thermal conductivity.

A good quality high carbon steel is usually used for gauge manufacture. Suitable heat treatment can produce a high degree of hardness coupled with stability. High carbon steel is relatively inexpensive, it can be readily machined and brought to a high degree of accuracy and surface finish.

Gauges can also be made from steels, special wear resisting materials, like hard chrome plated surfaces and tungsten carbide, Invar etc. Glass gauges were used during World War. Chromium plating makes the gauge corrosion and wear resistant. Also, the size of worn gauging surface can be increased by this method. The gauge surfaces can also be plated to provide hardness, toughness and stainless properties.

Care of Gauges : While using the gauges proper care should be taken to prolong their maximum useful life. Some suggestions for their use and care are:

- Master, inspection and working gauge should be employed only to the uses for which they are intended, as follows:

Type of gauge	intended use
Master gauge	To check inspection and working gauges
Inspection gauge	To check the finished product
Working gauge	To check he product as it is being manufactured.

Care and maintenance of gauges

- A plain cylindrical gauge should be cleaned properly, and a thin film of light oil should be applied to the gauging surfaces before it is used.
- The work should also be cleaned before checking with the gauges. Then the gauge should be aligned with the hole to be measured and given a forward motion combined with a slight rotation. To Go plug gauge will enter the hole if the hole is of correct size otherwise, it will not enter it. The same procedure may be applied while using plane cylindrical gauges.
- Force should not be applied in gauging operation as it tends to harm the gauge, the work or both. Therefore, the snap gauge should not be forced over the work because it will cause the gauge to pass on oversized parts and it may also spring the frame of the gauge.
- A gauge should be properly cleaned after use and prepared for storage. It should be coated with a rust preventive oil, if it is to be stored for a short time only. However, if it is to be stored for a longer period, it should be dipped in a molten plastic material designed as a protective coating for tools, and gauges.

Angle gauges

Objectives: At the end of this lesson you shall be able to
- **state the purpose of angle gauges**
- **state the advantages of using angle gauges**
- **state the method of selecting angle gauges to a required angle**
- **state the precautions to be observed while handling angle gauges.**

Angle gauges are wedge-shaped steel blocks made from hardened non-creep alloy steel to prevent wear and expansional errors.(Fig 1) Its faces are lapped in the same manner as slip gauges, enabling them to be wrung together in combinations.

Applications

– To measure the angle of a workpiece. (Fig 2a)

– To set up a component upon a machine table. (Fig 2b)

Fig 1

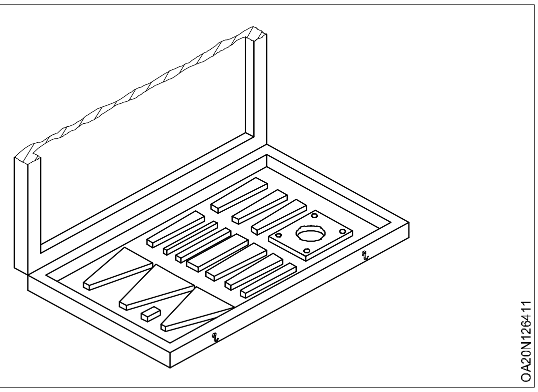
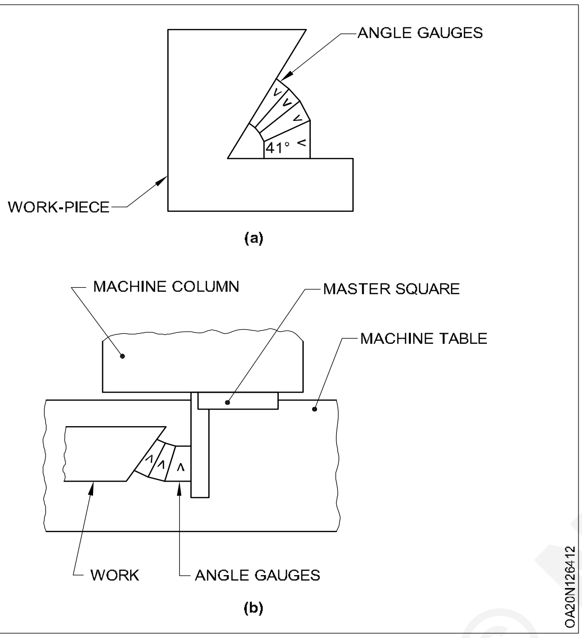


Fig 2



– To calibrate adjustable angular measuring instruments.

Advantages

– They can be used either horizontally or vertically.

– They do not require a datum surface or reference plane.

– They can be used to check jobs on which it is not easy to use other precision instruments.

– They are not restricted to angles smaller than 45°.

As is the case with slip gauges, angle gauges are also available in different sets.

A typical set comprises of twelve pieces divided into three series - degrees, minutes and seconds as follows.

Pieces

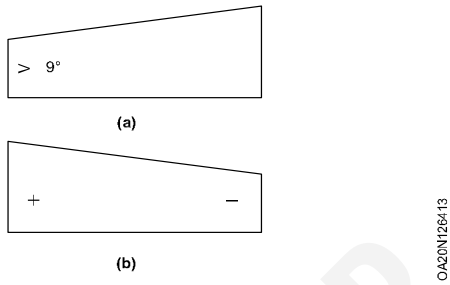
Degrees	-	1,3,9,27 and 41	5
Minutes	-	1,3,9 and 27	4
Seconds	-	6,18 and 30	3
			12

There are two sets of angle gauges available in the above typical set, designated as 'A' and 'B'. The standard 'B' contains all the 12 gauges, while standard 'A' contains one additional gauge of 3 seconds which enables combinations to be built up to 3 seconds.

The angle of the gauge and the arrowheads are etched on each gauge to indicate the angle direction and size. (Fig 3a)

Some types of angle gauges are etched + and – instead of arrow head to indicate the direction of the angle. (Fig 3b)

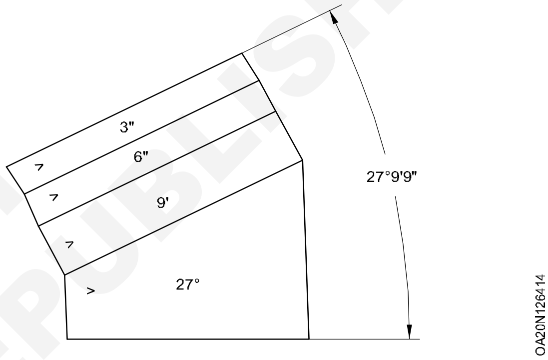
Fig 3



Building up a combination

To build up a size of 27^0 9' 9" (Fig 4)

Fig 4

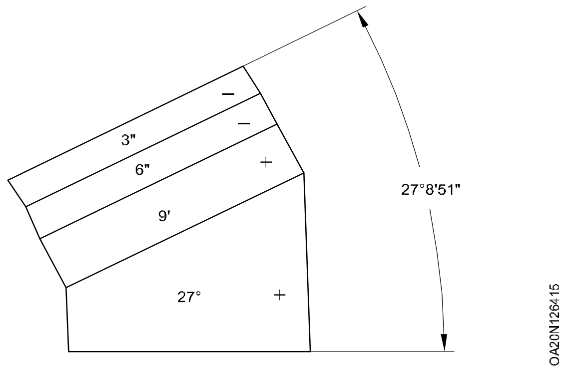


Gauges required

1st series	-	27^0 0' 0"
2nd series	-	0^0 9' 0"
3rd series	-	0^0 0' 6"
Additional block	-	0^0 0' 3"
		27^0 9' 9"

To obtain an angle of 27^0-8'-51" the same gauges may be used, but they must be wrong together as shown in Fig 5.

Fig 5



Work out the gauges required for	27^0 8' 51"	
1st series	27^0 0' 0"	
2nd series	0^0 9' 0"	To be added

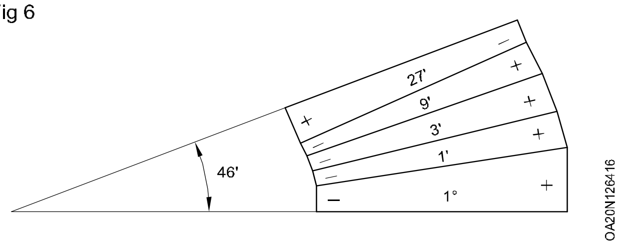
3rd series	0^0	0'	6"	To be subtracted
4th series	0^0	0'	3"	from the sum of the 1st and 2nd series as these two are positio ned in the opposite way.

If the angle includes minutes, and is greater than 40 minutes, increase the angle by 1° and subtract the number of minutes necessary to obtain the required minute.

This is because the total minutes available with the pieces in the series is 40' only.

To obtain 46' the build up will be as shown in Fig 6.

Fig 6

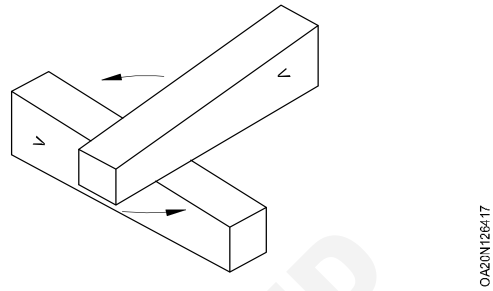


Handling and wringing : Gloves of cotton fabric or chamoise leather must be worn to prevent corrosion.

Before the gauges are wrung together the faces should be wiped clean using soft muslin cloth or chamois leather.

The wringing of the angle gauges should be carried as shown in Fig 7.

Fig 7



After use, clean the gauges thoroughly with a soft cloth and white spirit.

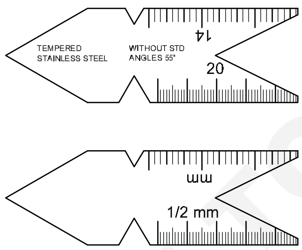
Apply vaseline lightly and store the gauges in a box.

Centre gauges

Objectives: At the end of this lesson you shall be able to
- **check the angle of single point cutting tool while grinding profile**
- **list the uses of centre gauge.**

Centre gauges are used in lathe work for checking the angles when grinding the profile of single point screw cutting tool bits and centres.(Fig 1)

Fig 1



SETTING 60° CUTTING TOOL SQUARE TO THE WORK
USING A CENTRE GAUGE

These gauges are most commonly used when hand grinding threading tool bits on a bench grinder, although they may be used with tool of cutter grinders. When the tool bit has been ground to the correct angle, then may be used to set the tool perpendicular to the work piece. (Fig 2)

They can incorporate a range of sites and types on the one gauge. The two most common being metric at 60° and BS wat 55° gauges also exist for the acme thread form.(Fig 3)

Fig 2

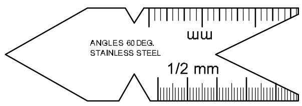
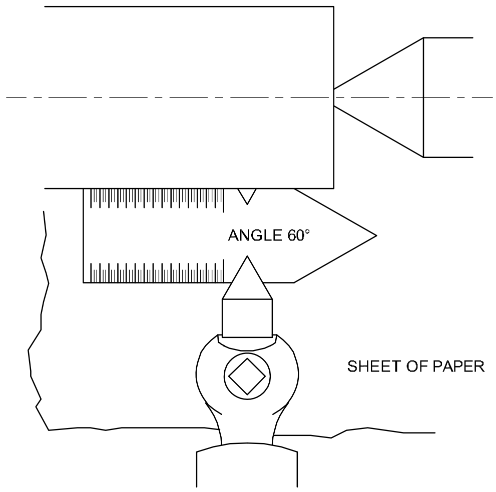


Fig 3



SETTING 60° CUTTING TOOL SQUARE TO THE WORK
USING A CENTRE GAUGE

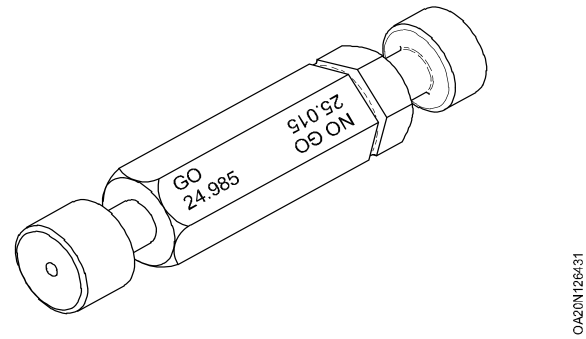
Limit Gauges

Objectives: At the end of this lesson you shall be able to
- **state the features of the 'Go' and 'No-Go' limit gauges**
- **identify the common types of limit gauges and state their uses.**

When a number of components have to be checked, it is not necessary to measure the size exactly but only to check whether the components' size lies within the limits. The most economical method of checking a component is with a limit gauge. These gauges are used in inspection because they provide a quick means of checking a specific dimension.

'**Go' and 'No-Go' limit gauges** (Fig 1)

Fig 1



The dimensions of the 'Go' and 'No-Go' ends of gauges are determined from the limits stated on the dimension to be gauged.

In the 'Go' and 'No-Go' method of gauging, the 'Go' end of the gauge must go into the feature being checked and the 'No-Go" end must not go into the same feature.

The dimension of the 'Go' end is equal to the maximum permissible dimension and that of the 'No-Go'end is equal to the minimum permissible dimension of the component being checked.

Essential features : These gauges must be easy to handle and accurately finished. They are generally finished to one-tenth the tolerance it is designed to control.

For example, if the tolerance is to be maintained to 0.02 mm, then the gauge must be finished to one-tenth the tolerance it is designed to control.

For example, if the tolerance is to be maintained to 0.02 mm, then the gauge must be finished to within 0.002 mm of the required size.

They must be resistant to wear, corrosion and expansion due to temperature.

Their production cost must be low.

The 'Go' end is made longer than the 'No-Go' end for easy identification. Sometimes a groove is cut on the handle near the 'No-Go'end to distinguish it from the 'Go' end.

Types

Cylindrical plug gauges

Double ended plug gauge (Fig 2)

Progressive plug gauge (Fig 3)

Fig 2

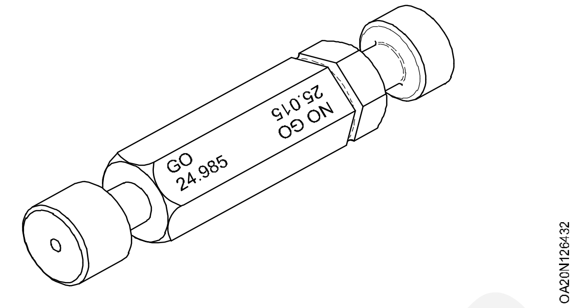
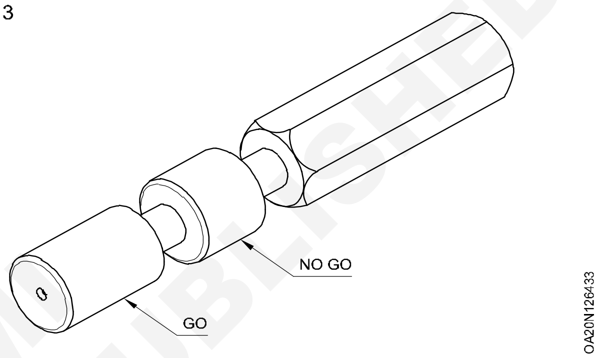
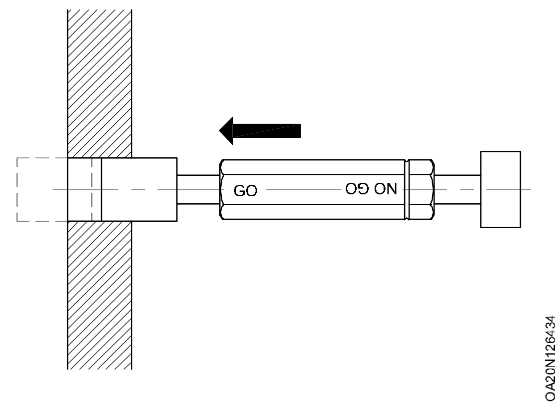


Fig 3



Plain cylindrical plug gauges are used for checking the inside diameter of the straight hole. the 'Go' gauge checks the lower limit of the hole and the 'No-Go" gauge checks the upper limit. The plugs are ground and lapped. (Fig 4)

Fig 4



Plain ring gauges (Fig 5)

They are used to check the outside diameter of pieces. Seperate gauges are used for checking 'Go' and 'No-Go' sizes. The 'No-Go' gauge is identified by an annular groove on the knurled surface.

Taper plug gauges (Fig 6)

These are made with standard or special tapers and are used to check the size of the hole and the accuracy of the taper. The gauge must slide into the hole for a prescribed depth and fit perfectly. An incorrect taper is evidenced by a wobble between the plug gauge and the hole.

Fig 5

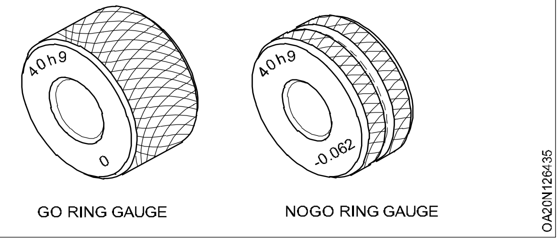
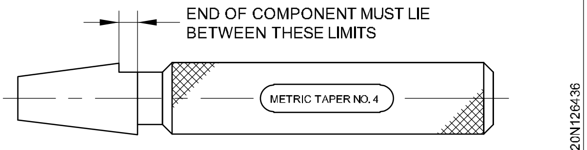


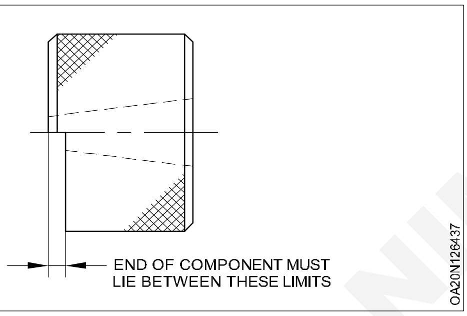
Fig 6



Taper ring gauges (Fig 7)

They are used to check both the accuracy and the outside diameter of an external taper. Taper ring gauges often have scribed lines or a step ground on the small end to indicate the 'Go' and 'No-Go' dimensions.

Fig 7



Thread plug gauges (Figs 8 & 9)

Internal threads are checked with thread plug gauges of 'Go' and 'No-Go' variety and employ the same principle as cylindrical plug gauges.

Fig 8

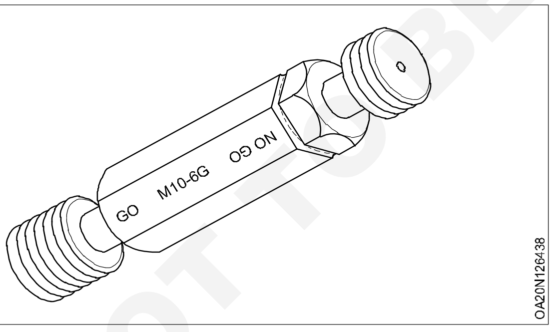
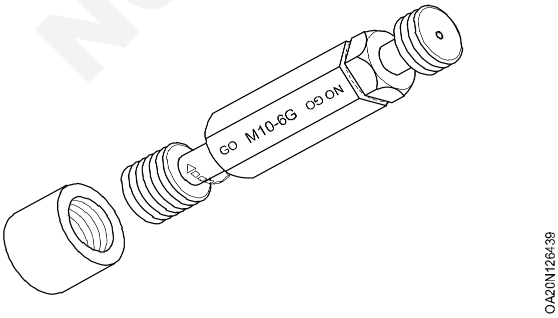


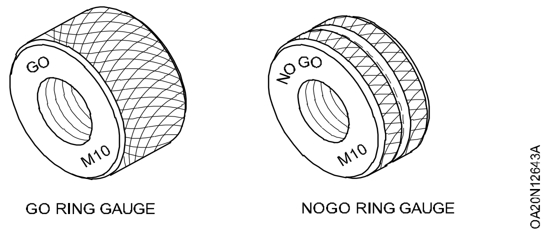
Fig 9



Thread ring gauges (Fig 10)

These gauges are used to check the accuracy of external threads and have a threaded hole in the centre.

Fig 10



Snap gauges (Figs 11 & 12)

Snap gauges are a quick means of checking diameters and thickness within certain limits by comparing the part size, to the dimension of the snap gauge.

Fig 11

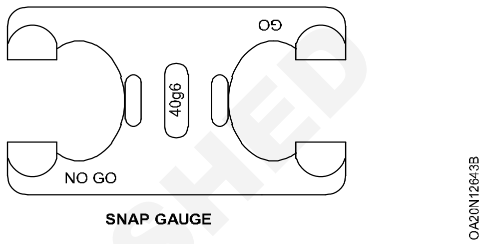
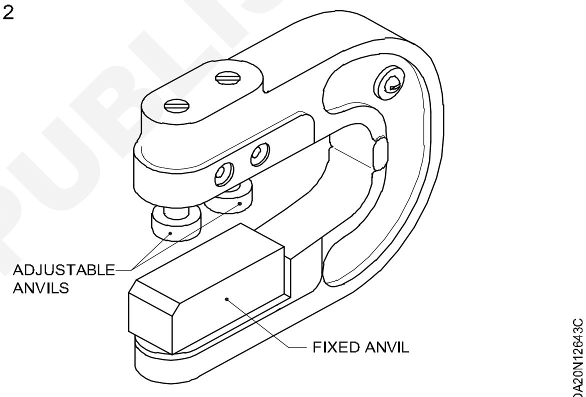


Fig 12



Snap gauges are generally C-shaped and are adjustable to the maximum and minimum limits of the part being checked. When in use, the work should slide into the 'Go' gauge but not into the 'No-Go' gauge.

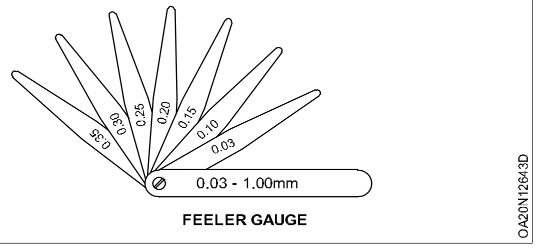
Feeler gauge

Feeler gauge is used to measure/check the clearance between the two mating parts. For example, it can be used in gauging of the clearance between the piston and cylinder and also for adjusting the spark gap between the distributor points of an automobile. The feeler gauge set consists of narrow strips of sheet steel of different thickness assembled (hinged) together in a holder. (Fig 13)

Their working entirely depends upon the sense of feel. In using the strips (blades), it is essential that the strips should neither be forced between the surfaces nor slide freely. The Correct strip or a combination of strips will give a characteristic 'gauge fit' type of feel.

A set of feeler gauge generally consists of series of blades of thickness varying from 0.03 to 1mm. The blades are made of heat treated bright polished tool steel. The width of the blade in 12mm at the heal and tapered for outer part of their length so that the width at the tip is approximately 6mm. The holder protects the blade when not is used. The nominal thickness of the blade is marked on it legibly.

Fig 13

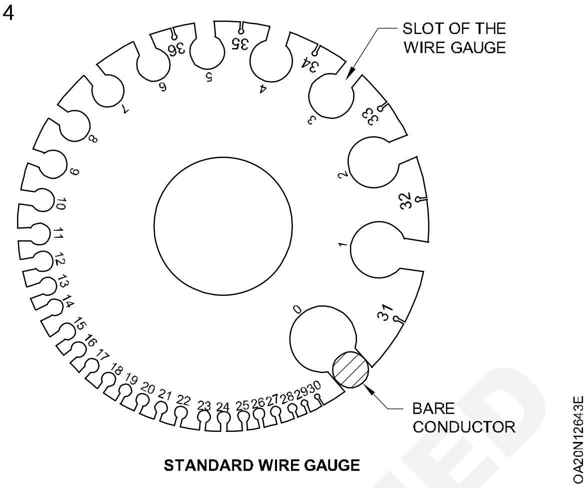


IS: 3179 recommands seven sets of feeler gauges with thickness from 0.03. to 1.00mm. Each set is devised so as to permit maximum utility with minimum number of blades. Table below gives the thickness and number of blades in each set as recommend by Indian standard IS: 3179.

Wire Gauge

Wire gauge (Fig 14) are used for finding diameters of wires by inserting the wire in the notches provided and finding out which it fits. The diameter and the number marked on the disc are read off from the gauge. The wire gauge has the range from 0.1mm to 10mm.

Fig 14

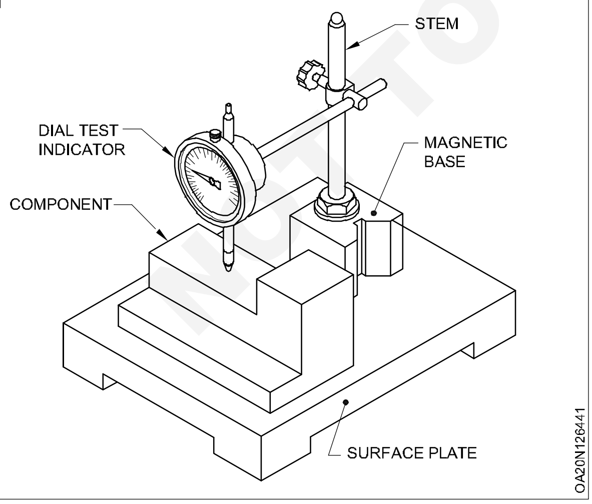


Dial test indicators

Objectives: At the end of this lesson you shall be able to
- **state the principle of a dial test indicator**
- **state the parts of a dial test indicator**
- **state the important features of a dial test indicator**
- **state the functions of a dial test indicator**
- **explain the different types of stands.**

Dial test indicators are instruments of high precision, used for comparing and determining the variation in the sizes of a component. (Fig 1) These instruments cannot give the direct reading of the sizes like micrometers and vernier calipers. A dial test indicator magnifies small variations in sizes by means of a pointer on a graduated dial. This direct reading of the deviations gives an accurate picture of the conditions of the parts being tested.

Fig 1



Principle of working

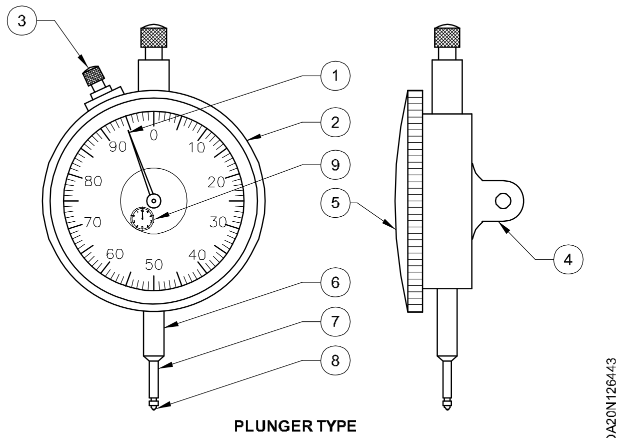
The magnification of the small movement of the plunger or stylus is converted into a rotary motion of the pointer on a circular scale. (Fig 2)

Types

Two types of dial test indicators are in use according to the method of magnification. They are

- plunger type (Fig 3)

Fig 3



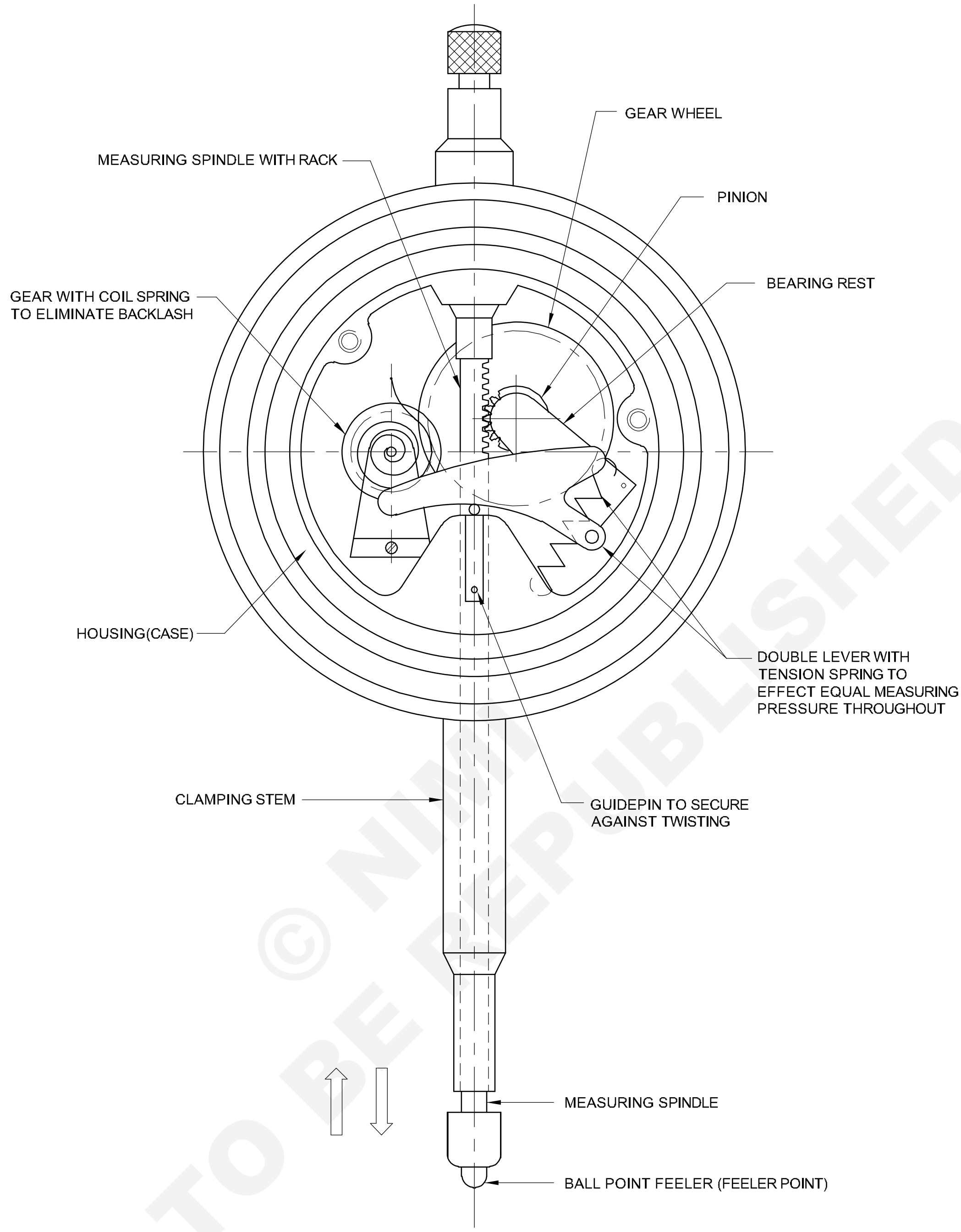
- lever type. (Fig 4)

The plunger type dial test indicator

The external parts and features of a dial test indicator areas shown in figure 3.

1 Pointer	2 Rotatable bezel
3 Tezel clamp	4 Back lug
5 Transparent dial cover	6 Stem

Fig 2



7 Plunger   8 Anvil

9 Revolution counter

For converting the linear motion of the plunger, a rack and pinion mechanism is used.

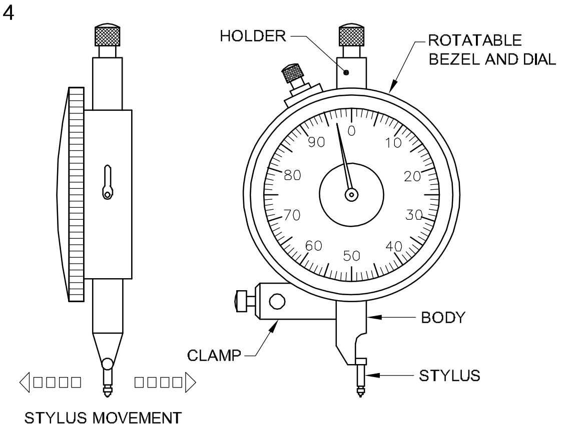
The lever type dial test indicator (Fig 4)

In the case of this type of dial test indicators, the magnification of the movement is obtained by the mechanism of the lever and scroll. (Fig 5)

It has a stylus with a ball- type contact, operating in the horizontal plane.

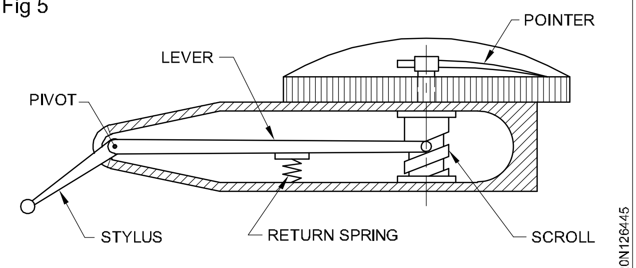
This can be conveniently mounted on a surface gauge stand, and can be used in places where the plunger type dial test indicator application is difficult. (Fig 6)

Fig 4



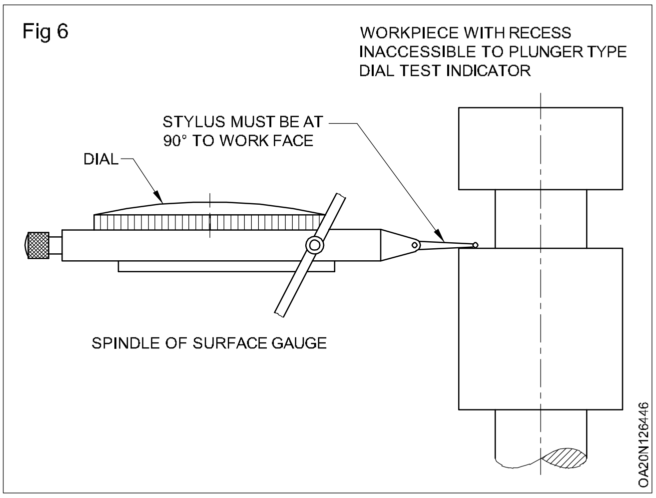
LEVER TYPE DIAL TEST INDICATOR

Fig 5



MECHANISM OF THE LEVER TYPE DIAL TEST INDICATOR

Fig 6



Important features of dial test indicators

An important feature of the dial test indicator is that the scale can be rotated by a ring bezel, enabling it to be set readily to zero.

Many dial test indicators read plus in a clockwise direction from zero, and minus in the anticlockwise directions so as to give plus and minus indications.

Uses (Figure 7 shows a few applications.)

- To compare the dimensions of a workpiece against a known standard, eg.slip gauges.
- To check plane surfaces for parallelism and flatness.
- To check parallelism of shafts and bars.
- To check concentricity of holes and shafts.

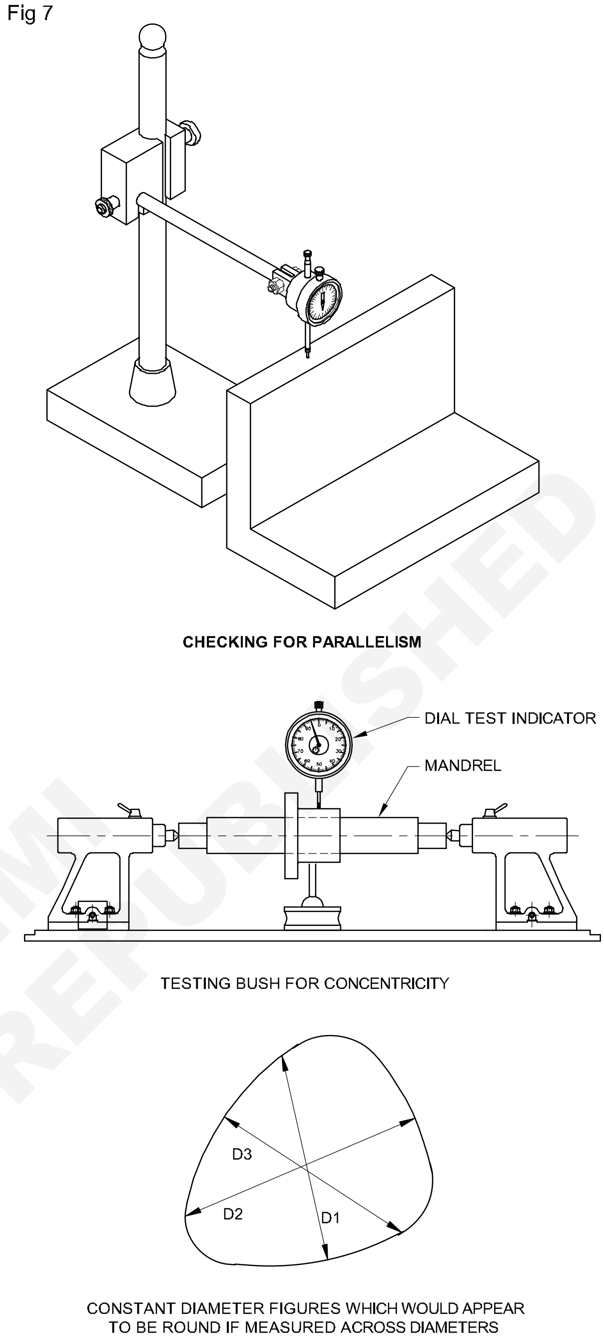
Indicator stands

Dial test indicators are used in conjunction with stands for holding them so that the stand itself may be placed on a datum surface or machine tools. (Fig 8)

The different types of stands are (Fig 9)

- magnetic stand with universal clamp

Fig 7



- magnetic stand with flexible post
- general purpose holder with cast iron base.

The arrows indicate the provisions in the clamps for insertion of the dial test indicator.

Fig 8

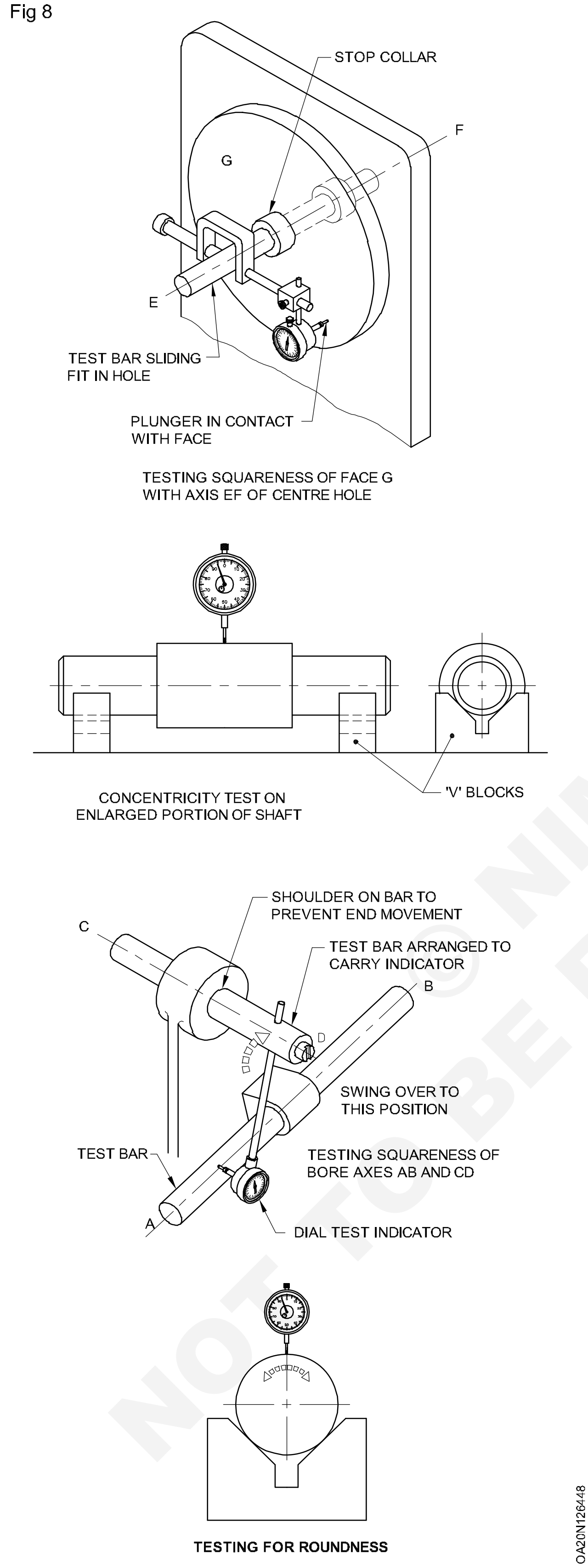
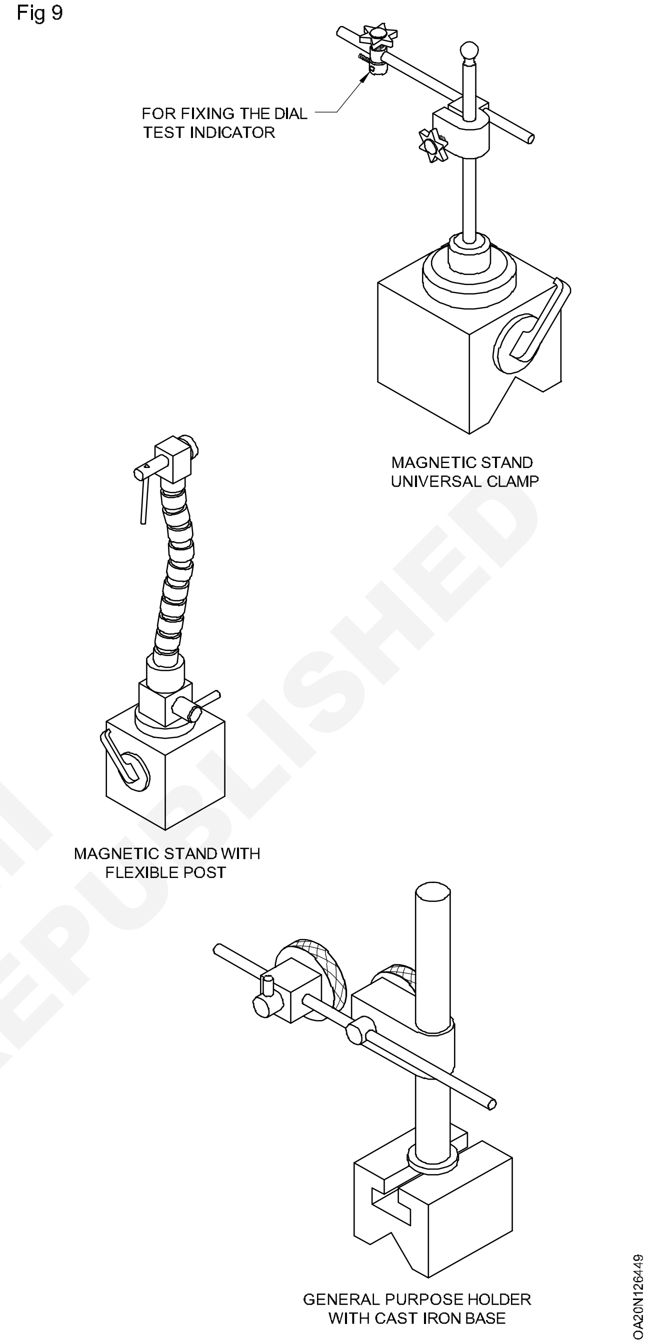

STOP COLLAR
F
G
E
TEST BAR SLIDING
FIT IN HOLE
PLUNGER IN CONTACT
WITH FACE
TESTING SQUARENESS OF FACE G
WITH AXIS EF OF CENTRE HOLE
CONCENTRICITY TEST ON
ENLARGED PORTION OF SHAFT
'V' BLOCKS
C
SHOULDER ON BAR TO
PREVENT END MOVEMENT
TEST BAR ARRANGED TO
CARRY INDICATOR
B
D
SWING OVER TO
THIS POSITION
TEST BAR
TESTING SQUARENESS OF
BORE AXES AB AND CD
A
DIAL TEST INDICATOR
TESTING FOR ROUNDNESS
OA20N126448

Fig 9


FOR FIXING THE DIAL
TEST INDICATOR
MAGNETIC STAND
UNIVERSAL CLAMP
MAGNETIC STAND WITH
FLEXIBLE POST
GENERAL PURPOSE HOLDER
WITH CAST IRON BASE
OA20N126449

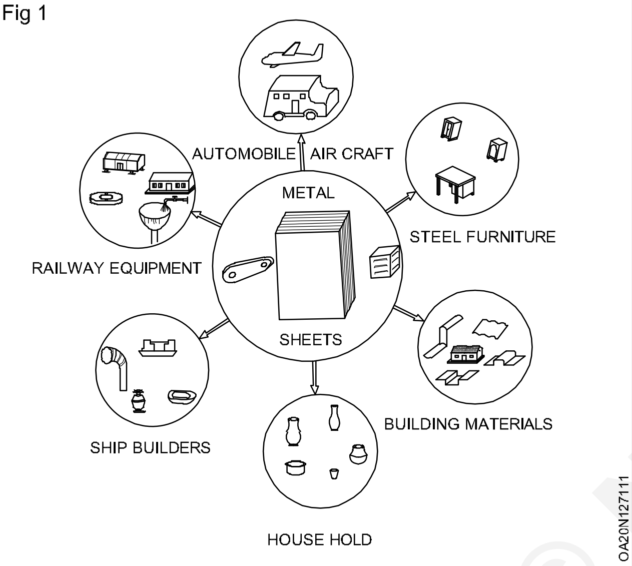
Importance of sheet metal work in industries

Objective : At the end of this lesson you shall be able to
- **state the scope and the importance of the trade.**

Introduction

Many engineering products are made out of sheet metal. The person who works on metal sheets is called sheet metal worker. The skilled sheet metal worker make and install various kind of sheet metal products. (Fig 1)

Fig 1



– roofings

– ductings

– vehicles body buildings like 3 wheelers, 4 wheelers, ships, air crafts etc.

– furnitures

– house hold articles

– railway equipment

Also repairing of the above items.

To carry out these works, the sheet metal worker has to plan, layout and determine the size and the type of the sheet metal to be used.

The sheet metal worker carries out the operations such as cutting, folding, forming, fastening and assembling manually and by means of power machines.

The above requirements needs proper training and to know the basic principles of operation and process. All the advance technologies are developed from basic principles only. The advance technologies facilitates for mass production, consistance in accuracy of product and the volume of needs.

Technical terms in sheet metal work

Objective : At the end of this lesson you shall be able to
- **state the meaning of various terms used in sheet metal work.**

1 **Beading**: The process of raising a strip of metal around the end of a round pipe.

2 **Bench machines**: Machines clamped to a bench and operated by turning a crank. Used by the sheet metal worker to turn edges on circles and round pipes.

3 **Bench stakes**: Steel anvils of various specialized shapes that the sheet metal worker uses to form and seam sheet metal objects.

4 **Black iron**: Iron and steel sheets covered with an oxidized coating only.

5 **Braising**: The process of stretching a piece of metal by hitting it with a round head hammer, as in forming a bowl.

6 **Brake**: A machine that the sheet metal worker uses for bending and folding edges on metal.

7 **Burring**: The process of turning an edge on a circular piece of metal.

8 **Clips**: Special strips of sheet metal bent in a manner to connect two pieces of sheet metal duct.

9 **Crimping**: The process of corrugating the end of a round pipe to make it smaller so it will fit into the end of another pipe.

10 **Cut acid**: Zinc chloride, made by putting strips of zinc in hydrochloric acid.

11 **Edges**: Bends on the edges of sheet metal to eliminate sharp edges and provide stiffening.

12 **Embossing**: A stamping process that produces a shallow relief design on sheet metal.

13 **Flux**: Chemical used to clean metal and remove the oxides from the metal surface prior to soldering.

14 **Forming**: The process of rolling sheet metal into pipe or making bends to form objects.

15 **Gauge**: The system of classifying the thickness in which sheet metal is produced. Also a tool used for measuring and determining the thickness of a metal sheet.

16 **Hem**: A folded edge on a sheet metal object.

17 **Layout work**: The process of developing the pattern for a sheet metal object.

18 **Longitudinal seam**: A seam running the long length of a pipe.

19 **Miter**: The joining of two pieces at an evenly divided angle.

20 **Nibble**: Nibble to piece metal along or on its edge.

21 **Oxides of metal**: A chemical formed by a combination of the oxygen in the air with the metal. Iron rust is iron oxide.

22 **Parallel line development**: A method of pattern drafting employing parallel lines.

23 **Pattern**: The shape of an object to be made out of sheet metal as it appears when marked out on the flat sheet. Also, the exact size and shape that a piece of sheet metal must be in order to be formed into the object desired.

24 **Pickle**: To clean dirt and oxide from metal by immersing it in an acid bath.

25 **Pictorial drawings**: A drawing of an object in three dimensions as it actually appears after being formed into shape.

26 **Pierce**: To cut out interior waste stock from a metal part with a die.

27 **Planish**: To make a metal surface smooth by hammering it over a stake or block.

28 **Press brake**: A power machine used by the sheet metal worker to form sheet metal.

29 **Press forming**: Creating sheet metal products using dies to cut and shape the metal and presses to power the dies. Also called stamping.

30 **Primer**: A first coat of finish on a metal, it binds and adhers to the metal giving good base for later coats.

31 **Punching**: The process of making holes in sheet metal by the use of dies.

32 **PVC (polyvinyl/chloride)**: A plastic often used for hoods and tanks that require high corrosion resistance.

33 **Radial line development**: A method of pattern drafting using lines radiating from a center and using arcs.

34 **Raw acid**: Hydrochloric acid (HCI)

35 **Rivets**: Fasteners used to join two pieces of sheet metal together. The rivet is inserted in a hole and a head is formed by pounding the rivet with a hammer.

36 **Seams**: Various types of bent and hooked edges used to join two pieces of sheet metal. For lighter sheet metal, mechanical joints are used. In medium and heavy gauge metal, a riveted or welded seam is used.

37 **Seam welding**: A kind of resistance welding in which rollers are used instead of electrodes.

38 **Sheet metal**: Any type of metal sheets that are 1/8" thick or less.

39 **Sheet metal screws**: Special screws used for joining sheet metal. Also called self-tapping because the screws tap their own threads in the drilled hole.

40 **Overlapping parts**: Resistance to electricity generates heat producing the weld.

41 **Square-to-round**: The name of a common sheet metal fitting that is square or rectangular on one end and round on the other end.

42 **Stainless steel**: A special steel containing other types of metals such as chromium, nickel and molybdenum. There are many types of stainless steel sheets. All of them vary in corrosion resistance.

43 **Swage**: A special forging tool used for smoothening and finishing.

44 **Sweat soldering**: The process of soldering two pieces of metal together by making the solder "sweat" completely through the seam.

45 **Tinning**: Covering an area of metal with molten solder.

46 **Transition piece**: A sheet metal fitting that changes size or shape from one end to the other.

47 **Triangulation**: A method of pattern drafting employing the use of triangles.

48 **Wired edge**: A sheet metal edge folded around a piece of wire for added strength.

Metal sheets and their uses

Objectives: At the end of this lesson you shall be able to
- **state the types of metals used in sheet metal work**
- **state the uses of the different types of metals.**

In sheet metal work, different types of metal sheets are used. The sheets are specified by their standard gauge numbers.

It is very essential to know the different uses and applications of these metal sheets.

Black iron sheets: The cheapest sheet metal is the black iron, which is rolled to the desired thickness. The sheets are rolled in two conditions. When it is rolled in cold state, it is called cold rolled and when it is rolled in hot state, it is called hot rolled. Hot rolled sheets have a bluish black appearance, and are often referred to as uncoated sheets, since they are uncoated. They corrode rapidly.

Cold rolled sheets have plain silver whitish appearance and are uncoated. To decrease the work hardness, the cold ruled sheets are annealed in a closed atmosphere. These sheets are known as C.R.C.A (Cold roled close annealed) sheets.

The use of this metal is limited to making articles that are to be painted or enamelled such as tanks, pans, stoves, pipes etc.

Galvanised iron sheets: Zinc coated iron is known as 'galvanised iron'. This soft iron sheet is popularly known as G.I.sheet. The zinc coating resist corrosion and improves the appearance of the metal and permit it to be soldered with greater ease. Because it is coated with zinc, galvanised iron sheet withstands contact with water and exposure to weather.

Articles such as pans, buckets, furnaces, heating ducts, cabinets, gutters etc. are made mainly from G.I.sheets.

Stainless sheets: This is an alloy of steel with nickel, chromium and other metals. It has good corrosive resistance and can be welded easily. Stainless steel used in a sheet metal shop can be worked similar to galvanised iron sheets, but is tougher than G.I. sheets. The cost of stainless steel is very high.

Stainless steel is used in dairies, food processing, chemical plants, kitchenware etc.

Copper sheets: Copper sheets are available either as cold rolled or hot rolled. They have a very good resistance to corrosion and can be worked easily. They are commonly used in sheet metal shops. Copper sheet has better appearance than other metals.

Gutters, expansion joints, roof flashings, hoods, utensils and boiler plates are some of the common examples where copper sheets are used.

Aluminium sheets: Aluminium cannot be used in its pure form, but is mixed with very small amount of copper, silicon, manganese and iron. Aluminium sheets are whitish in colour and light in weight. They are highly resistant to corrosion and abrasion.

Aluminium is now widely used in the manufacture of articles such as household appliances, refrigerator trays, lighting fixtures, windows and also in the construction of airplanes and in many electrical and transport industries.

Tinned plate: Tinned plate is sheet iron coated with tin, to protect it against rust. This is used for nearly all solder work, as it is the easiest metal to join by soldering.

This metal has a very bright silvery appearance and is used in making roofs, food containers, dairy equipment, furnace fittings, cans and pans etc.

Lead sheets: Lead is very soft and heavy in weight.

Lead sheets are used for making the highly corrosive acid tanks.

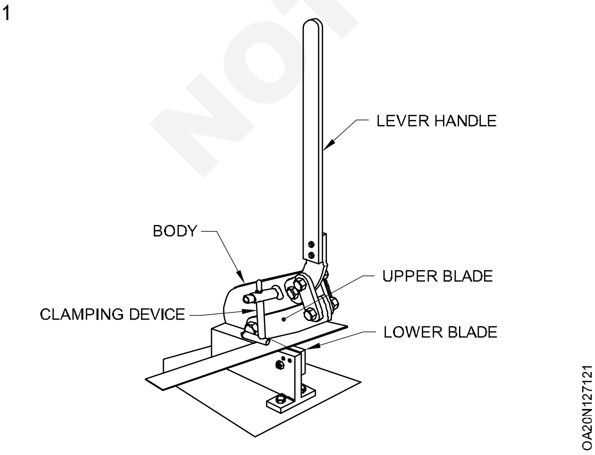
When lead is coated on black iron sheets, they are called Terne sheets. They are highly anti-corrosive and commonly used in preservation of chemicals.

Hand lever shears

Objectives: At the end of this lesson you shall be able to
- **identify the hand lever shear**
- **state the principle of working**
- **state the constructional feature parts and their functions.**

Hand lever shear is a hand operated machine used to cut sheet metal upto a thickness of 3 mm (10 SWG). When the machine is mounted on the bench, it is called a hand lever bench shear. It may also be mounted on the floor, over a small platform. It is used for cutting along straight lines and convex cutting of sheet metal. (Fig 1)

Fig 1



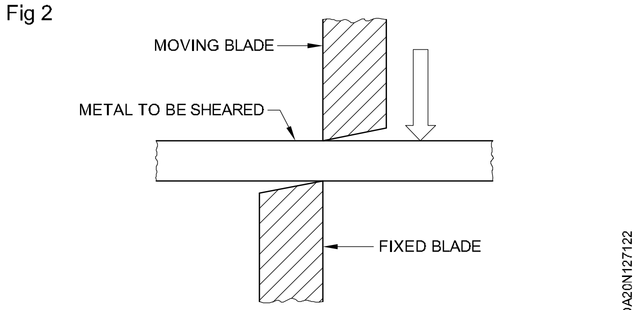
The lower blade of the hand lever shear is fixed (bottom blade) and the upper blade is pivoted at an angle.

The sheet being cut is prevented from tilting by a clamping device, which can be adjusted to the thickness of the sheet.

The knife cutting edge of the upper blade is curved so that the opening angle at the point of cut remains constant.

As the upper blade moves down on the sheet metal, the metal is subjected to shearing force, which causes deformation of the metal. (Fig 2 & 3) Increase in force causes plastic deformation of metal.

Fig 2



After a certain amount of plastic deformation, the cutting member begin to penetrate. The uncut metal work, harden at the edge (Fig 4).

Fig 3

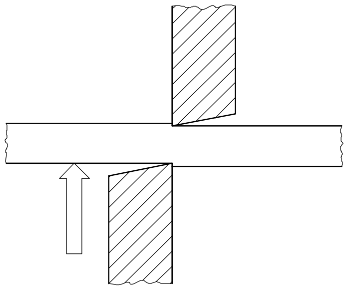
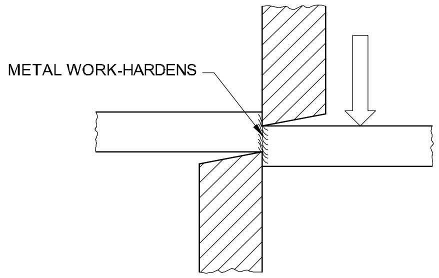
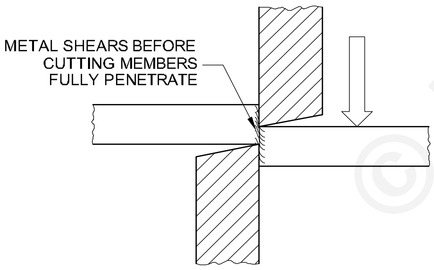


Fig 4



Fracture begins to run into the work hardened metal from the point of contact of the cutting members. When these fractures meet, the cutting members penetrate the whole of the metal thickness. (Fig 5)

Fig 5

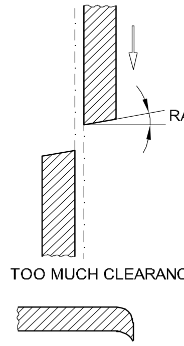


Blade clearance is very important and should not exceed 10 percent of the thickness to be cut and should suit the particular material.

Results of incorrect and correct setting of shear blade are as follows.

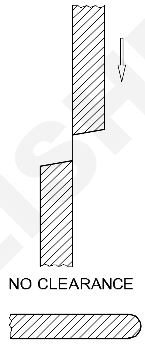
1 Excessive clearance causes a burr to form on the underside of the sheet as shown in the (Fig 6).

Fig 6



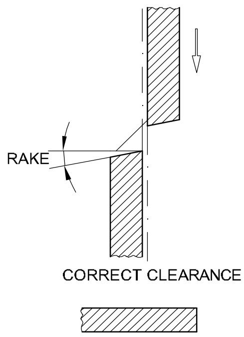
2 With no clearance, over strain is caused, the edge of the sheet becomes flattened on the under sides as shown in (Fig 7).

Fig 7



3 With the correct clearance, optimum shearing results are obtained as shown in (Fig 8).

Fig 8



Straight snips

Objectives: At the end of this lesson you shall be able to
- **state the uses of straight snips**
- **state the parts of straight snips**
- **state care and maintenance.**

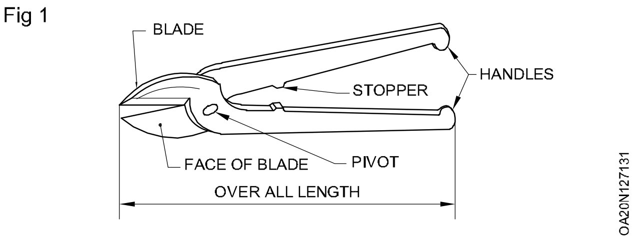
A snip is also called a hand shear. It is used like a pair of scissors to cut thin soft metal sheets. Snips are used to cut sheet metal upto 20 S.W.G.

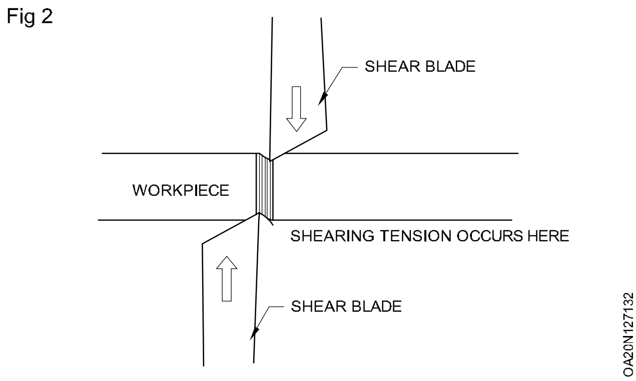
Uses of straight snips: The straight snips are used to cut sheet metal along straight lines and outer sides of curves.

Parts of straight snips are shown in Fig 1.

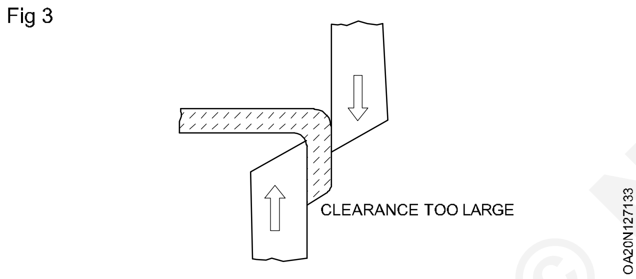
While cutting a sheet metal, blades are pressed against the sheet, which causes shearing tension from both sides as shown in Fig 2 and the cutting action takes place.

Cutting edge of the blade and clearance: Clearance between the blades should be free but without gap. For straight snips, cutting angle is 87°.





If the clearance is too large it cause unclean cut, chamfered and jamming of workpiece as shown in Fig 3.



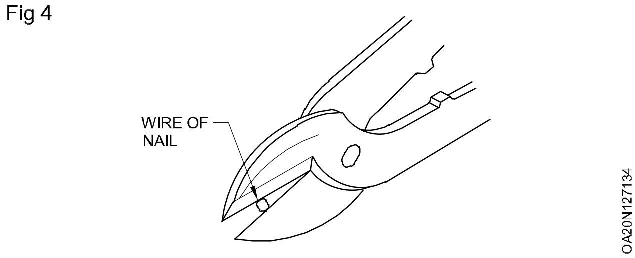
Types: There are two types of snips

1 Straight snip

2 Bent snip

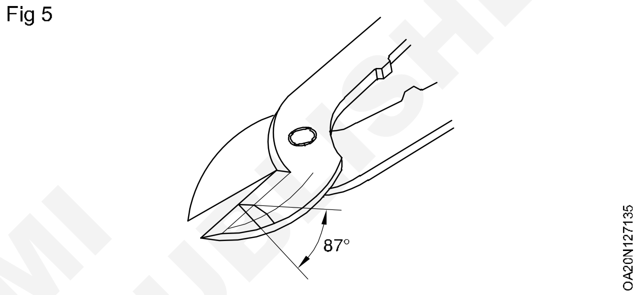
Specification: Snips are specified by its overall length and the shape of the blade. (snips are available in 150 mm, 200mm, 300 and 400 mm overall length) Ex.200 mm, straight snips.

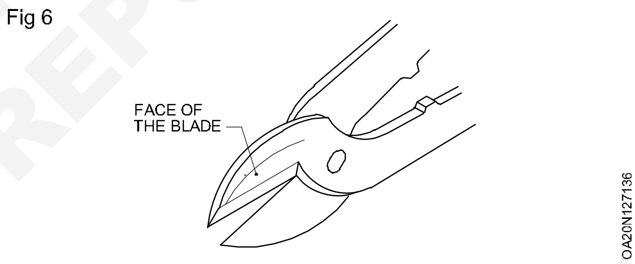
Safety: Avoid cutting wires and nails, if so the cutting edge of the blade becomes damaged (Fig 4).



Avoid cutting hard sheet metal, if so the blade becomes blunt.

Due to wear and tear, the cutting edge of the blades becomes blunt. To resharpen the blade, the cutting angle alone should be ground to an angle of 87° (Fig 5) and should not grind the face of the cutting side of the blade. (Fig 6)





Bend snips

Objectives: At the end of this lesson you shall be able to
- **state the use of the bend snips**
- **state the parts of the bend snips**
- **state the specification of the bend snips**
- **state types of shears and their application.**

The bend snips are used to cut the inside curved lines and for trimming curved edges as shown in (Fig 1).

Parts of the bend snips are shown in fig 2. The blades of the bend snips are curved. (Fig 2)

Specification: Bend snips are specified by their overall length. Bend snips are available in 150, 200, 300 and 400 mm length.

Type of shears

1 Tinman's shears is sometimes called straight shears.

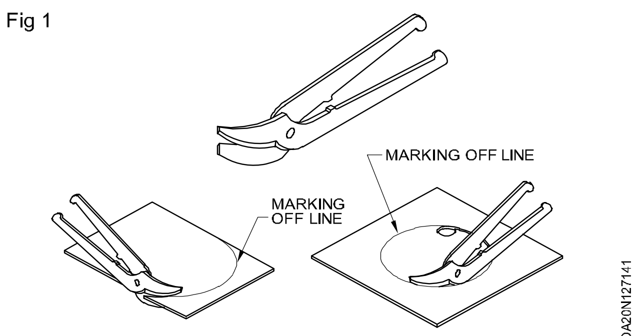
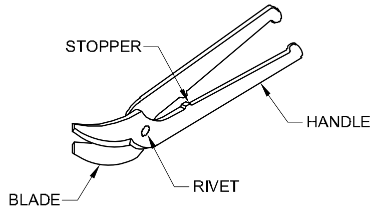


Fig 2



2 Universal combination shears or Gilbow shears.

3 Pipe shears

4 Scotch shears

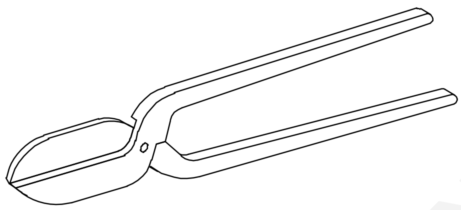
5 Block shears

6 Rohdes shears

Uses

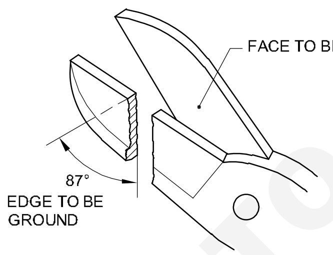
Tinmans shears (Fig.3): It is used for making straight cuts and large external curves upto the thickness of 18 SWG. Cutting angle of a shears is 87°. The cross sectional view of the cutting blades is shown in Fig 3. Never grind the face of the blade.

Fig 3



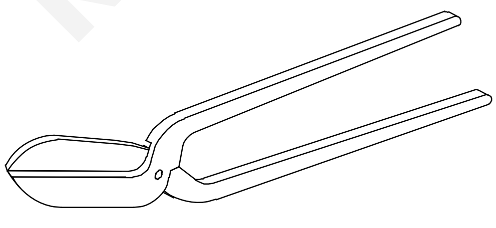
Universal combination shears or Gilbow shears (Fig 4)

Fig 4



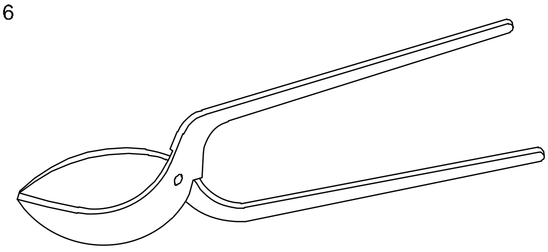
Its blades are designed for universal cutting, straight line or internal and external cutting of curves may be right hand or left hand, easily identifiable as the top blade is either on the right or the left. (Fig 5)

Fig 5



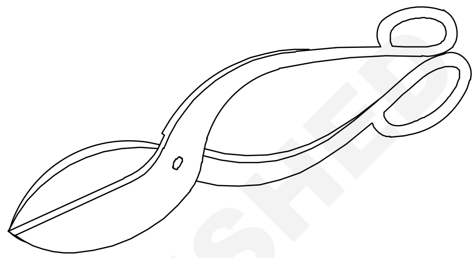
Pipe shears (Fig.6): It is applied as bend shears in all cases. Particularly it is used to time the edges of the pipes.

Fig 6



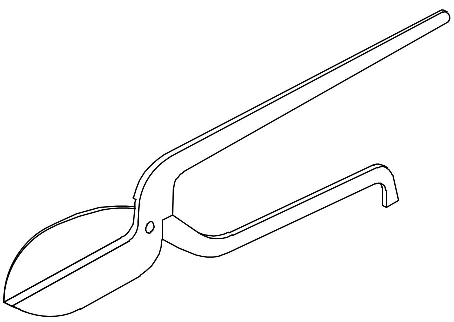
Scotch shears (Fig.7): It is a shape as shown in the fig.9 its handles are formed as eye holes to give extra grip to the hands. It is also used as Tinman's shears.

Fig 7



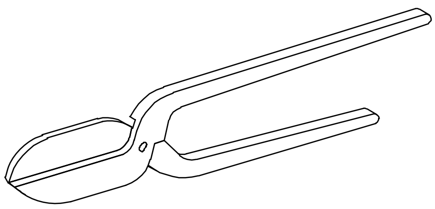
Block shears (Fig.8): One of the handle of the shear is bent downwards as shown in the figure. The bending portion should be fixed on the iron plates hole and the upper handle will be held by the worker. It is used in mass production purposes.

Fig 8



Rohdes shears: Its one handle is shorter in length as compared with the other handle as shown in Fig.9.

Fig 9

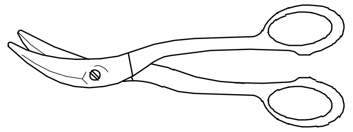


The short handle is to be pressed by the right leg of the worker and the other handle should be held by the right hand. It is used to cut lengthy sheets.

Shearing force: To produce the maximum cutting force, the hand must be kept far from the rivet and the metal being cut must be kept close to the rivet.

Hawk billed shears (Fig.10): It is used for the inside cutting of an intricate work. The snips have narrow curved blades that allow you to make sharp turns without bending the metal.

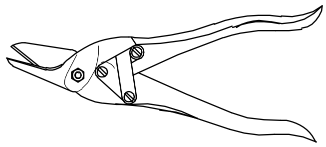
Fig 10



HAWK-BILLED SHEAR

Aviation shears (Fig.11)**:** It can be used for all kinds of cutting. These are made with left, right or universal cutting blades.

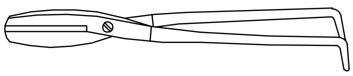
Fig 11



AVIATION SHEAR

Bench shears (Fig.12)**:** These are designed to have one handle held in a vice or bench plate, while the other handle is moved up and down.

Fig 12

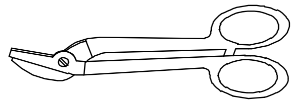


BENCH SHEAR

They can cut 16 gauge to 18 gauge thickness sheet metal.

Double cutting shears (Fig.13)**:** These shears have three blades used to cut around cylindrical objects, such as cans and pipes. A single blade is pushed through the metal to sheet to cut.

Fig 13



DOUBLE CUTTING SHEAR

Electric portable shear (Fig.14)**:** Electric shears are used to cut corrugated metal sheets or a sheet metal of 18 gauge thickness or lighter sheet metals.

The shear point can be inserted with a light hammer blow. Successive blows will drive the shear on a scribed line for almost any shape like inner circles, zig zag, curvature line easily. A strip of metal about 3"/32 (2.5 mm) wide is removed in this shearing operations.

Fig 14

Stakes and their uses

Objectives: At the end of this lesson you shall be able to
- **state what is a stake**
- **state the different types of stakes and their uses.**

Stakes are the sheet metal workers anvils used for bending, seaming or forming. They actually work as supporting tools as well as forming tools.

Stakes are made in different shapes and sizes to suit the types of operations for which machines are not readily available or readily adaptable.

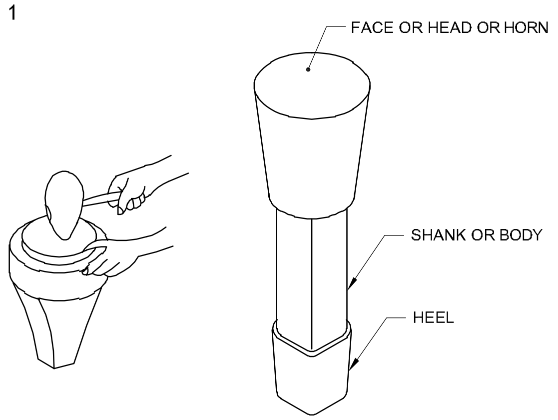
Some stakes are made of forged mild steel, faced with cast steel. The better class stakes are made either of forged steel or of cast steel.

A stake used in sheet metal working consists of a head (or) a horn. (shank or body and heel) The shanks are designed to fit into a tapered bench socket. (Fig 1)

Round bottom stake (Fig 1): It has a round and a concave face head. It is used for hollowing the sheet.

Hatchet stake (Fig 2): The hatchet stake has a sharp, straight edge, bevelled along one side. It is very useful for making sharp bends, folding the edges of sheet metal, forming boxes and pans by hand.

Fig 1

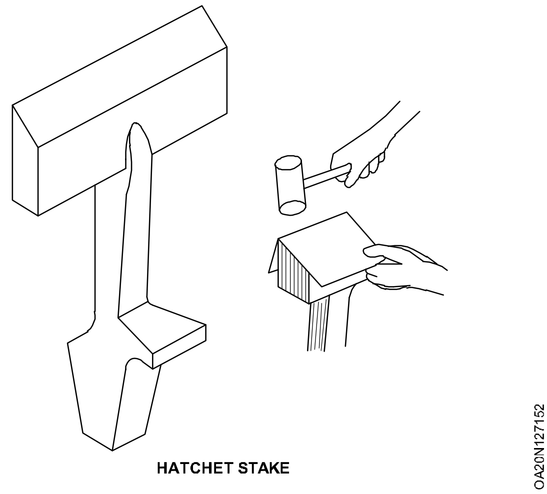


ROUND BOTTOM STAKE

Half moon stake (Fig 3): This stake has a sharp head in the form of an arc of a circle, bevelled along one side. It is used for turning up flanges on metal discs.

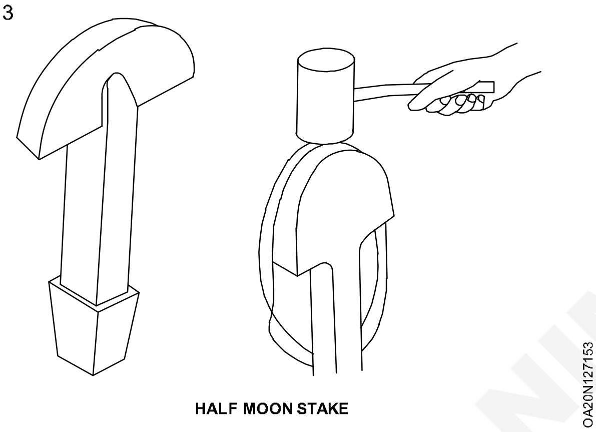
Funnel stake (Fig 4): This stake is used when shaping and seaming funnels and tapered articles.

Fig 2



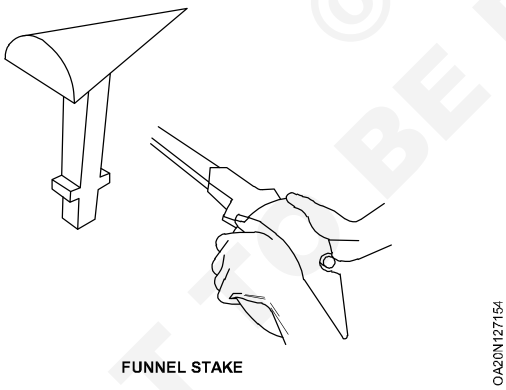
HATCHET STAKE

Fig 3



HALF MOON STAKE

Fig 4



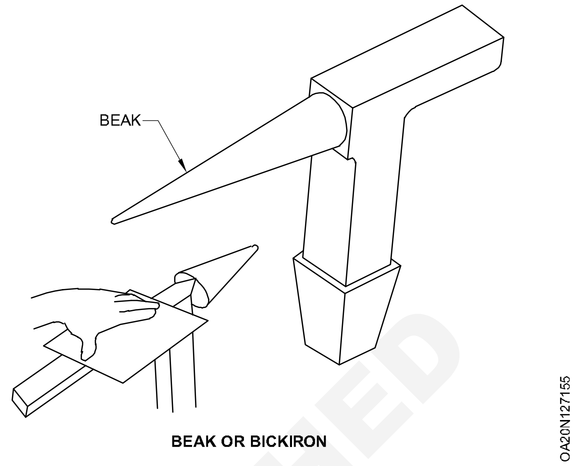
FUNNEL STAKE

Beak or Bick Iron stake (Fig 5): This stake has two horns, one of which is tapered the other is a rectangular shaped anvil. The thick tapered horn or beak is used when making spouts and sharp tapered articles. The anvil may be used for squaring corners, seaming and light riveting.

Creasing Iron (Fig 6): This stake has two rectangular shaped horns, one of which is plain. The other horn contains a series of grooving slots of various sizes. The grooves are used when 'Sinking' a bead on a straight edge of a flat sheet. This is also used when making small diameter tubes with thin gauge metal.

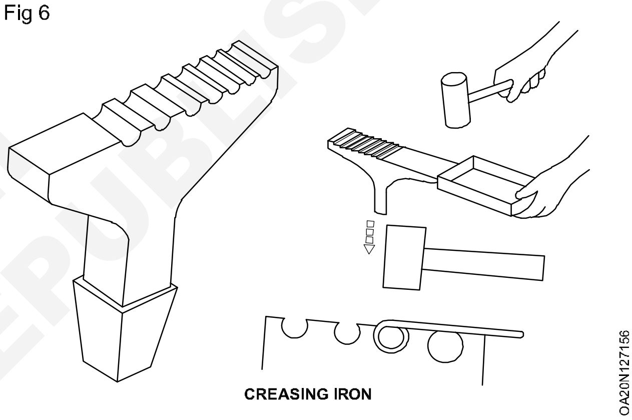
Pipe stake or Square edge stake (Fig 7): This stake has the horn and the shank. The horn is available in two types. one is with flat face as shown in (Fig 7A). Other one is with curved face as shown in (Fig 7B) Flat face horn stake is used to fold the edges, and to turn up straight edges. The curved face horn stake is used to turn circular disc or curved edges and to make knocked up joints.

Fig 5



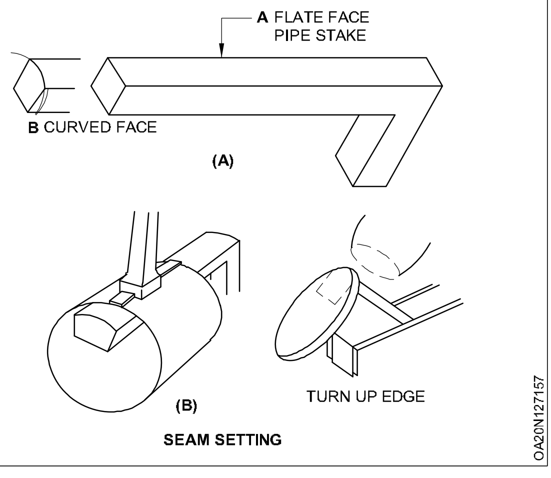
BEAK OR BICKIRON

Fig 6



CREASING IRON

Fig 7



SEAM SETTING

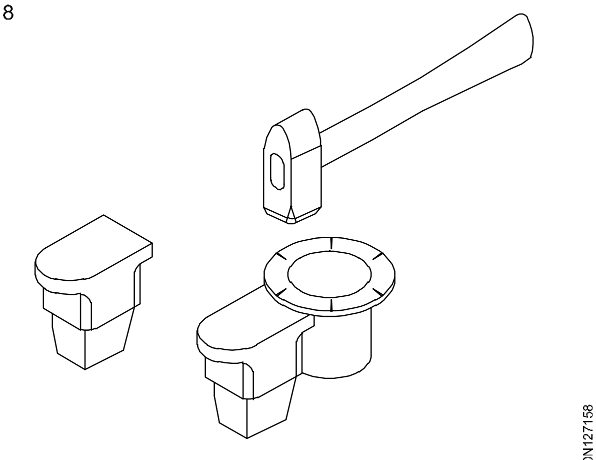
Tinman's Anvil (Fig 8): It is used for planishing all types of flat shaped works. It is highly polished on its working surface.

Tinman's Horse (Fig 9): This stake has two arms at its both ends, one of which is usually cranked downwards for clearance purpose. There is a square hole for the reception of a wide variety of heads. (Fig 10)

The surface of the stake is important for the workmanship of the finished article. Therefore, care must be taken to avoid any damage to the surface of the stake when centre punching or cutting with a cold chisel.

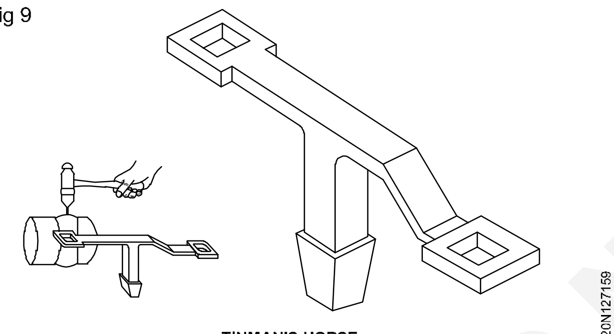
Apart from these stakes, special types of stakes are also available to suit different types of jobs.

Fig 8



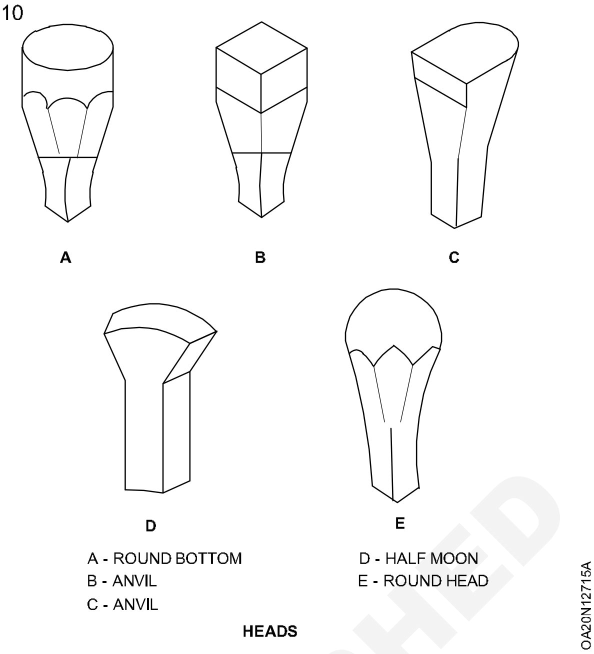
TINMAN'S ANVIL

Fig 9



TINMAN'S HORSE

Fig 10



HEADS

Copper smith stake

Objectives: At the end of this lesson you shall be able to
- **identify a copper smith stake**
- **state the constructional features of a copper smith stake**
- **state the uses of a copper smith stake**
- **state safety, care and maintenance while using a copper smith stake.**

It is not economical to have too many stakes for simple operations in a sheet metal shop.

Hence, an economical way of tooling is adopted and designed by combining two edges of different cross sections on a common head as in Fig 1. This stake is called a copper smith stake or tinman's anvil. It is a very useful stake used in sheet metal work, due to its constructional features.

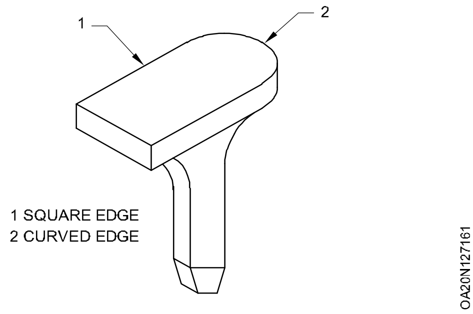
This stake is used for flattening the surfaces of the sheet metal, bending, flanging, finishing wired edges on both straight and curved edges.

These stakes are made of medium carbon steel and case hardened.

Safety care and maintenance

1 Fix the stake firmly in the bench plate or stake holder to avoid slipping and causing accidents.

Fig 1



2 Do not use it for heavy work.

3 Do not spoil the surface of the stake by chiseling and punching.

4 Do not spoil the edges by cutting wire or nails on the edges of the stake.

5 Remove and keep it in its place after use.

Bottom round stake

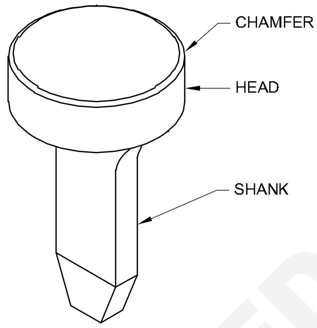
Objectives: At the end of this lesson you shall be able to
- **identify the Round Bottom Stake**
- **state the constructional features of this stake**
- **state the uses of this stake.**

Bottom round stake (Fig 1): This is a very common stake used in a sheet metal shop. This stake is round in shape with a flat face, slightly chamfered to avoid the cracking or tearing of sheets while using it.

It is used for turning edge on circular discs, seaming and fixing bottom to cylindrical parts, making a paned down joint at the bottom of the cylindrical parts. The tail is designed to fit in the square slot made in the work bench or stake holder.

> **Do not cut wires or nails on the edge of the stake. This will spoil the edge and the same impression will be formed on the sheet or the part formed on it.**

Fig 1



Stake holders

Objectives: At the end of this lesson you shall be able to
- **name the different types of stake holders**
- **state the constructional features of stake holders**
- **state the uses of stake holders**
- **state safety, care and maintenance when using stake holders.**

There are three types of stake holders

1 Bench plate

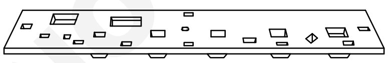
2 Revolving bench plate

3 Universal stake holder

Bench plate: Stakes are held in position while using them by means of a plate which is fastened to the work bench with bolts and nuts. These plates are called bench plates or stake holders.

These bench plates are made of cast iron and are rectangular in shape as in Fig 1. The tapered holes are conveniently arranged so that the shanks of the stakes may be fixed and used in any convenient position. The smaller holes are used to support the bench shears.

Fig 1



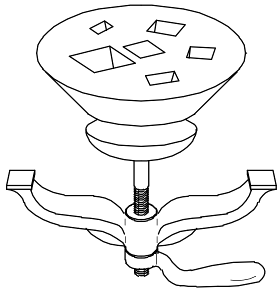
BENCH PLATE

Revolving bench plate: Revolving bench plate consists of a revolving plate with tapered holes to support the shanks of the stakes while using them.

This revolving bench plate can be held in any convenient position by clamping it on to the work bench, with the clamping provision provided on it as in Fig 2.

Universal stake holder: Universal stake holder can be clamped to any desired position on the work bench. So it is preferred by most of the mechanics.

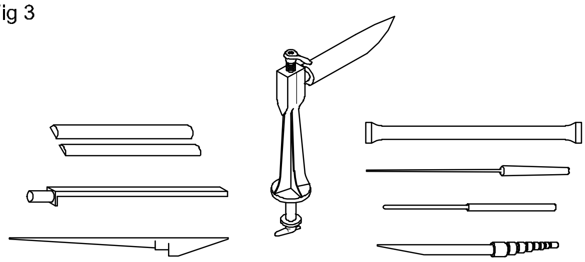
Fig 2



REVOLVING BENCH PLATE

This stake holder is designed with a set of stakes which can be easily fixed on to the stake holder and hence it is termed as universal stake holder set as shown in Fig 3. One stake may be replaced by another very quickly by simply turning the swivel handle and replacing the stake.

Fig 3



UNIVERSAL STAKE HOLDER

When placing an order to purchase this type of stake holder set, we should specify clearly the type of stakes to be supplied along with the stake holder.

Safety, care and maintenance:

- Fix the stake holder firmly on to the work bench.
- Do not use it for very heavy work.
- Do not overtighten the locking arrangements which may spoil the threads on the device.
- Do not place the unnecessary accessories on the work table. Place only the required ones.
- Avoid chiseling or punching on this stake holder.
- Remove and keep it in its place after use.

Rivets and riveting

Objectives : At the end of this lesson you shall be able to
- **define rivets**
- **specify rivets**
- **name the materials from which rivets are made**
- **name the different types of rivets and state their uses.**

Rivets are used to join together two or more sheets of metal permanently. In sheet metal work riveting is done where:

brazing is not suitable,

the structure changes owing to welding heat,

the distartion due to welding cannot be easily removed etc.

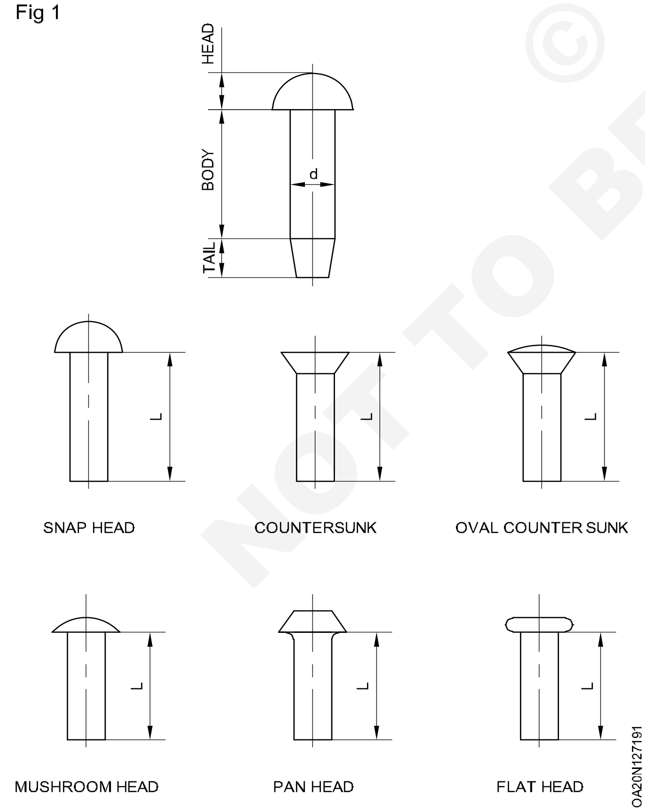
Specification of rivets

Rivets are specified by their length, material, size and shape of head.

Rivets

There are various kinds of rivets as shown in Fig 1. Snap head rivets, countersink rivets and thin bevelhead rivets are widely used in sheet metal work.

Fig 1



Material: Rivets are made of ductile materials like low carbon sheet (mild steel), brass, copper, yellow brass, aluminium are their alloys.

The length of the rivets 'L" is indicated by the shank length. (Fig 1)

Rivets are cylindrical rods having heads of various shapes. They are used for assembling the parts of a workpiece together.

Parts of the rivet (Fig 1)

Shape of head

The shape of the rivet head is to be selected according to the intended use of the workpiece to be riveted.

Diameter

The diameter is to be selected depending on the required strength.

Length

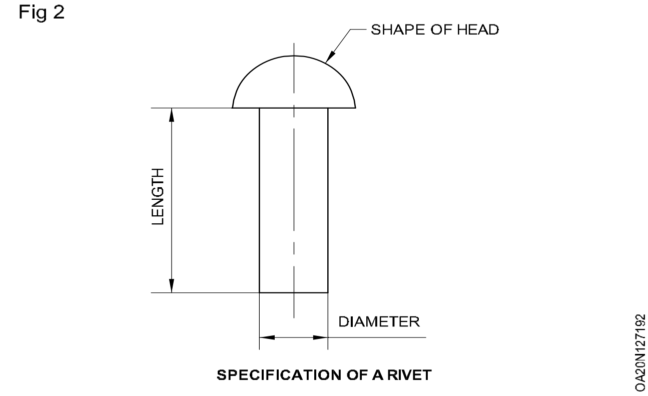
Length is to be selected depending upon the thickness of the components to be riveted.

Types and uses

Snap head (Fig 2)

It is the most commonly used form, and it gives a very strong joint.

Fig 2



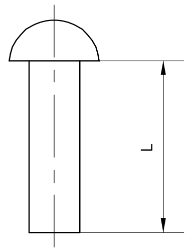
Pan head (Fig 3)

It is used in heavy structural work where the strength of rivet is very important.

Conical head (Fig 4)

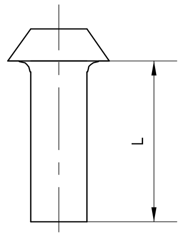
It is generally used in light assembly where riveting is done by hand hammering.

Fig 3



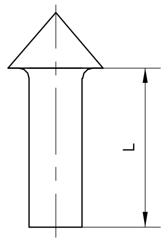
SNAP HEAD RIVET

Fig 4



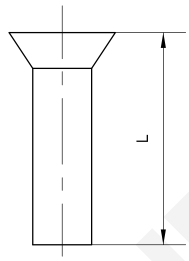
PAN HEAD RIVET

Fig 5



CONICAL HEAD RIVET

Fig 6



COUNTERSHANK HEAD RIVET

Countersunk head (Fig 5) : It is used where projection of the rivet head is to be avoided.

Bifurcated rivet (Fig 6) : The shape of the head is shown in the figure and the bifurcated portion is used for fastening light parts- tin plates, leather, plastics, etc.

Riveted Joint

Objectives: At the end of this exercise you shall be able to

- **define 'riveting'**
- **state the use of riveting**
- **name the materials from which rivets are made**
- **name the different types of rivets used in sheet metal work**
- **follow rules and formulas for riveting process**
- **name the orienting process.**

Riveting: Riveting is one of the methods of making permanent joints of two or more pieces (Metal strips). It is customary to use rivets of the same metal as that of the parts that are being joined together.

Uses: Rivets are used for joining metal sheets and plates in fabrication work, such as bridges, ship building, games, structural steel work.

Types of rivets:

Tinman's rivet

Flat head rivet

Round head rivet

Countersunk head rivet

Each rivet consists of a head and cylindrical body.

Sizes of rivets: Sizes of rivets are determined by the diameter and length of the shank.

Selection of rivet size: The diameter of the rivet is calculated by using the formula D= (21/2 to 3) xT where T is total thickness

Lapping allowance: Normally in sheet metal trade, we will use the following formula that is Three times of the dia of rivet +2 times the sheet thickness on thin sheets

Pitch allowance: Three or four times the diameter of rivet +Sheet thickness 1 time

The shank length is given by

Length :- L= T+D where T is the Sheet thickness and D is the diameter of the rivet.

Normally Tinman's rivets are designated by numbers.

Thickness of sheet 14, 16, 18,20,22,25

Dia of rivet 22, 24,26, 27, 28, 30

Sketch

Draw a straight line of 1.25" and add sheet thickness, for total distance find out centre, and draw a semi circle with spring divider, Draw a perpendicular line projecting the line upto semi circle the distance is taken as a dia of rivet.

Rivet hole size and clearance: A rivet hole should be formed a little bigger than the nominal diameter of the rivet. The hole diameter will be bigger than the rivet shank nominal diameter by 0.2 to 0.3 mm for cold riveting and by 0.5 to 1.5mm for high temperature (Red) for hot riveting process.

Working condition

Cold Riveting

Hot Riveting Process

Rivet Nominal

2 3 4 5 -6

8 10 12 15 15 to 40

diameter (MM)

Tolerance (DA)

0.2+ + 0.2 +0.5-0.2+0.5-0.2

0.2++0.2

Bigger than nominal diameter

by 1.5 to 2.0 mm plates.

Hole diameter

2.2 3.2 4.2

8.5 11 13 16.5

5.3 6.3

Annealing of rivet: Riveting is usually performed in the normal temperature when the rivet diameter is less than 6mm. To prevent the breakage and failure of rivets and to faciltates the operation, rivets are used in the normal temperature. Rivets are annealed in the temperature of 650° C to 700°C and allow them to cool slowly. Generaly M.S Rivets are heated in furnaces uniformly. Aluminium rivets are used without annealing. High strength aluminium alloyed Rivets in the Duralumin group are heated to 480°C and 500°C and, coded in water. Generally Electric furnaces are used for heating the rivets.

Method of riveting: Riveting may be done by hand or to machine. While riveting by hand it can be done with a ball pane hammer and a rivet set.

Rivet set: The shallow, cup shape hole is used to draw the sheet and the rivet together . The output on the side allows the slug to drop out.

The cup strap is used for forming the rivet head. The set selected should have a hole slightly larger than diameter of the rivet.

Spacing of rivets: The space of distance from the edge of the metal to the centre of any rivet should be atleast the twice diameter of the rivet to avoid tearing.

The maximum distance should never exceed 24 time thickness of the sheet. Otherwise buckling will take place.

Rivets proportions

Objectives: At the end of this lesson you shall be able to
- **determine the hole sizes for different diameters of rivets**
- **choose the rivet diameters according to the thickness of the plates/sheets**
- **calculate the length and rivet interference for different diameter rivets and plate sizes.**

Riveting: In order to produce efficient and good quality riveted joints the following aspects are important.

The size of the hole drilled for inserting the rivets.

The diameter of the rivet in proportion to the thickness of the plates/sheets to be joined.

The length of the rivet according to the type of the rivet and the thickness of the plates/sheets.

The size of the rivet and hole: The size of the hole to be drilled is according to the diameter of the rivet used.

A formula generally used for determining the diameter a solid rivet is

D.Min = T

to D.Max = 2T

The actual value used will depend upon the actual joint features and service conditions.

The size of the hole has to be slightly larger than the nominal diameter of the rivet. (Table 1)

TABLE 1

Hole diameter for rivets

Rivet nominal dia	2	3	4	5	6	8	10	12	15	15-40
Hole dia	2.2	3.2	4.2	5.3	6.3	8.5	11	18	16.5	Holes larger than the nominal dia by 1.5 to 2.0 mm

For hot working, rivets will have holes with more clearance than for cold working.

Length of rivets: The length of a rivet is the shank length. This will vary according to the thickness of the plates to be riveted and the type of the rivet head.(Fig 1 & 2)

A formula generally used in the shop floor is length of snap-head rivets.

L = T + 1.5D

Length of countersunk head rivets L = T + 0.6 D

L = shank length

T = total thickness of the number of plates used

D = rivet diameter

D_1 = hole diameter

Rivet interference: The length required to form the head in riveting is called rivet interference.

Fig 1

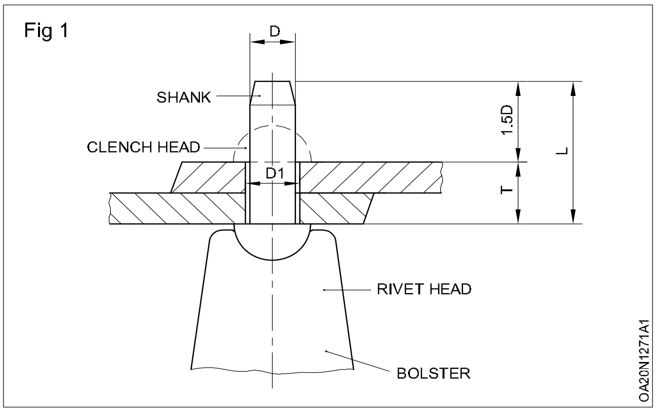
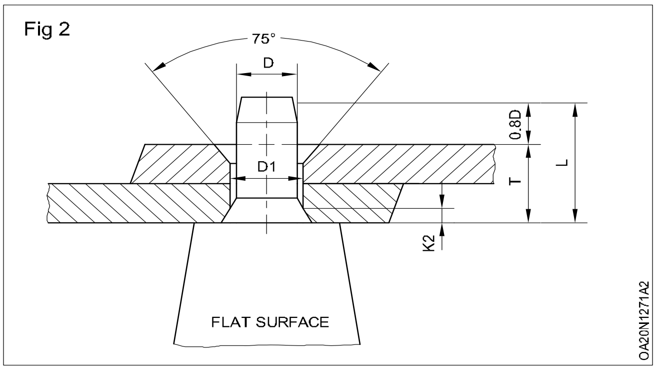


Fig 2



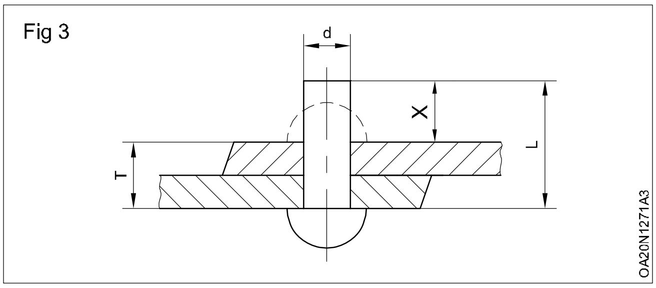
When forming a round head (Fig 3) the interference x is given as

x = d x (1.3, - 1.6)

where x = rivet interference (mm)

d = rivet diameter (mm)

Fig 3



Therefore, the length of the rivet (L mm) to form a round head when the total thickness of the piled plates is T mm will be, as given below.

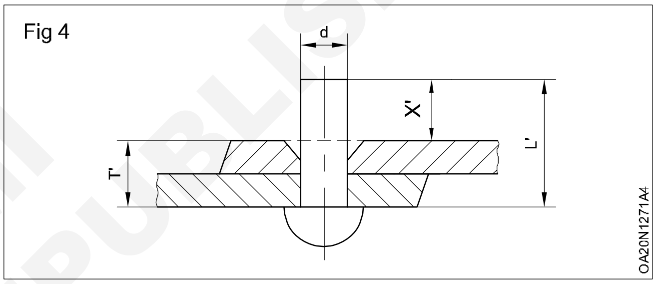
L = T + d (1.3 ~ 1.6)

When forming a flat head (Fig 4) the length of the rivet (L'mm) will be as given below.

L' = T + d (0.8 ~ 1.2)

When he appropriate values of the rivet diameter and the length for the plate thickness are found out, choose the rivets with the standard size close to the calculated values.

Fig 4



Types of riveted joints

Objectives: At the end of this lesson you shall be able to
- **state the different types of riveted joints**
- **state the features of different types of riveted joints**
- **distinguish between chain riveting and zigzag riveting.**

In construction and fabrication work different types of riveted joints are made.

The commonly used joints are:

– single riveted lap joint

– double riveted lap joint

– single strap butt joint

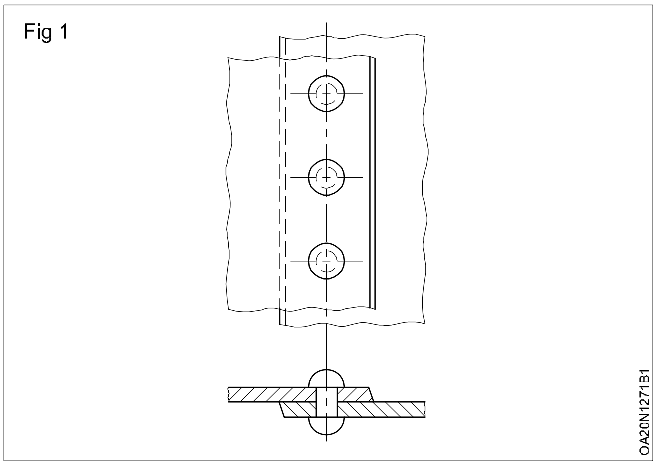
– double strap butt joint

Single riveted lap joint: This is the simplest and most commonly used type of joint. This joint is useful for joining both thick and thin plates. In this, the plates to be joined are overlapped at the ends and single row of rivets is placed in the middle of the lap.(Fig 1)

Double riveted lap joint: This type of joint will have two rows of rivets. The overlap is large enough to accommodate two rows of rivets.(Fig 2)

Double riveted (Zigzag) lap joint: This provides a stronger joint than a single lap joint. The rivets are placed either in a square formation or in a triangular formation. The square formation of rivet placement is called CHAIN riveting. The triangular formation of rivet placement is called zigzag riveting.(Fig 3)

Fig 1



Single strap butt joint: This method is used in situations where the edges of the components are to be joined by riveting.(Fig 4)

A separate piece of metal called STRAP is used to hold the edges of the components together.

Fig 2

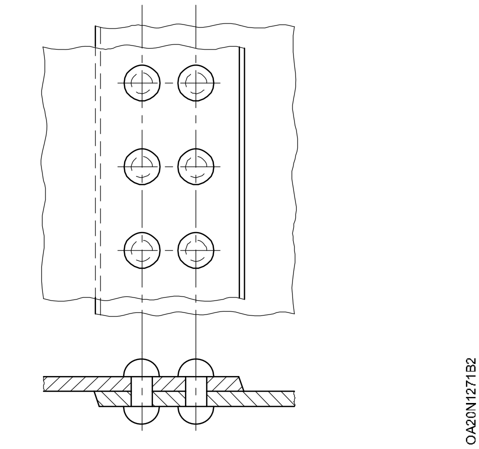


Fig 3

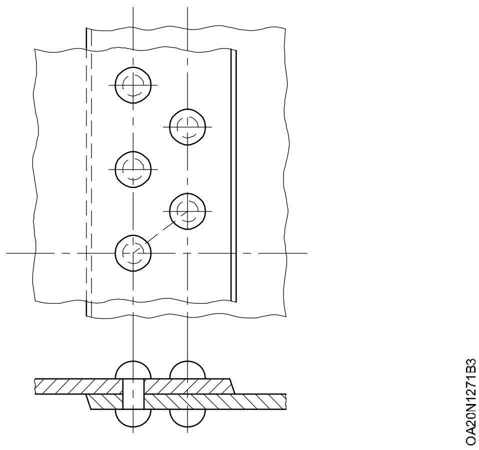
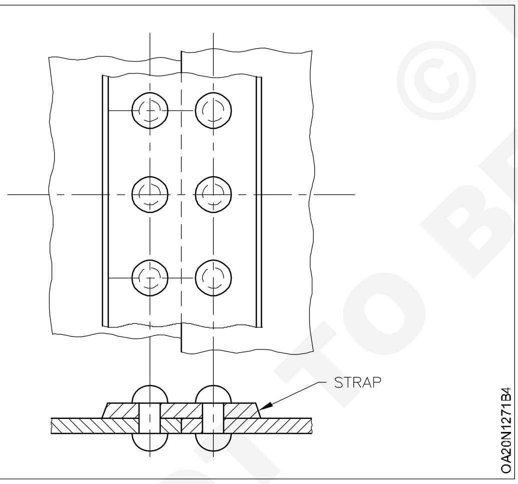


Fig 4



This joint is also used for joining the edges of components together. This is stronger than the single strap butt joint. This joint has two cover plates placed on either side of the components to be assembled.(Fig 5)

When single or double straps are used for riveted butt joints, the arrangement of rivets may be:

– Single riveted i.e one row on either side of the butt.

– double or triple riveted with chain or zigzag formation. (Fig 6)

Fig 5

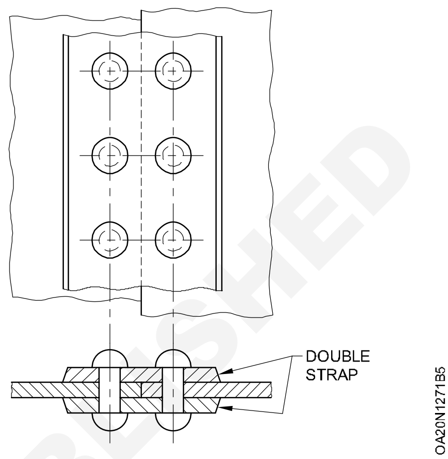
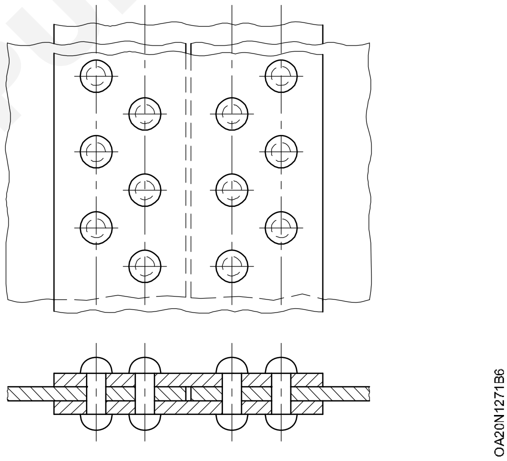


Fig 6



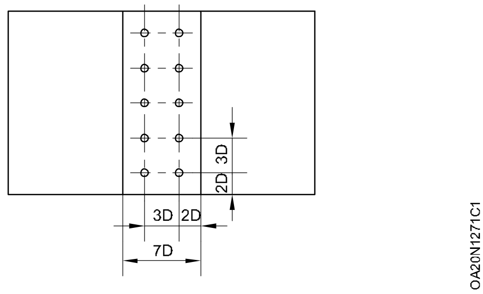
Layout the spacing of rivet holes in chain riveting

Objectives: At the end of this exercise you shall be able to
- **lay out the spacing of rivet holes to make chain riveting**

Fig1 shows the layout of the spacing of rivets holes in chain riveting

In chain riveting, square formation of rivets is formed in placement of rivets.

Fig 1



Zig Zag Riveting

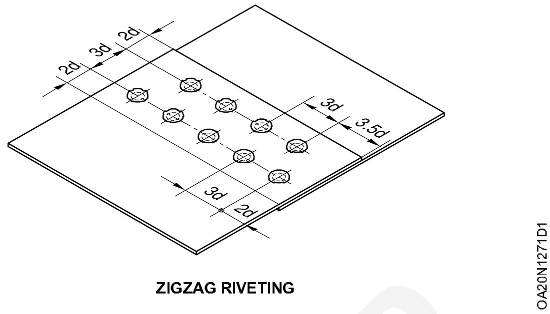
objectives: At the end of this exercise you shall be able to
- **state what is zigzag riveting**
- **draw the layout for the spacing of rivets in zigzag riveting**

Zig zag riveting is one type of layout of rivet spacing in riveted joint

Zig zag riveting, triangular formation of rivets is formed in placement of rivets.

Layout of spacing for zig zag riveting is shown in Fig 1.

Fig 1



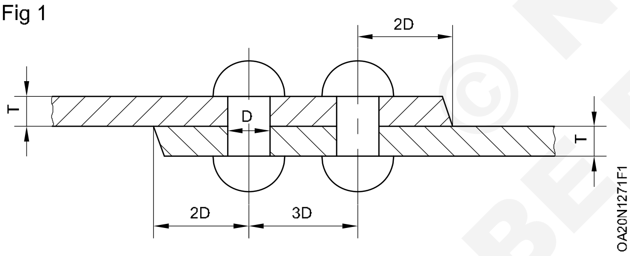
Spacing of rivets in joints

Objectives: At the end of this lesson you shall be able to
- **determine the distance between the rivet and the edge of the joint**
- **state the effect on the joints when the rivets are too close or too far from the edge**
- **determine the pitch of rivets in joints**
- **state the effect of too close and too far a pitch of rivets in joints.**

The spacing of the rivet holes depends upon the job. Given below is a general approach in determining this.

Distance from the edge to the centre of the rivet. (Fig 1)

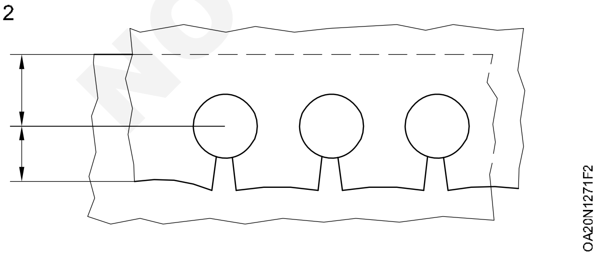
Fig 1



The space or distance from the edge of the metal to the centre of any rivet should be atleast twice the diameter of the rivet.

The purpose of this is to prevent the splitting of the edges. The maximum distance from the edge should not be more than ten times the thickness of the plate.(Fig 2)

Fig 2



Too much distance from the edge will lead to GAPING. (Fig 3)

Pitch of rivet: The minimum distance between rivets should be three times the diameter of the rivet. (3D) (Fig 4)

The distance will help to drive the rivets without interference.(Fig 5)

Fig 3

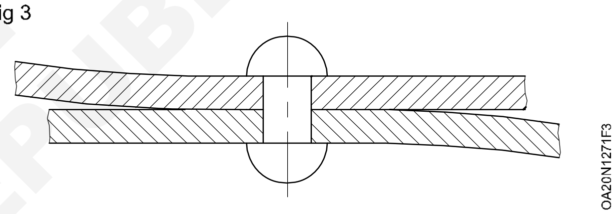


Fig 4

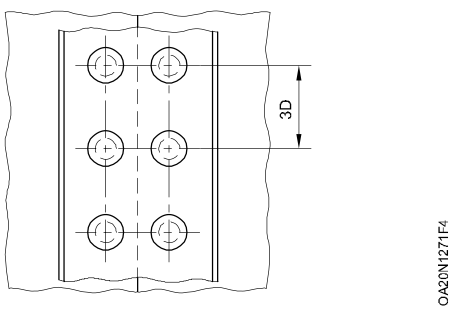
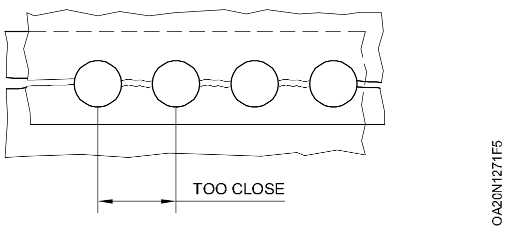


Fig 5

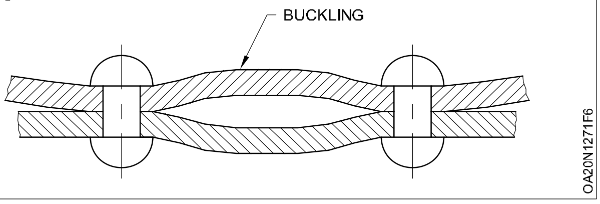


Too closely spaced rivets will tear the metal along the centre line of the rivets.

The maximum distance between the rivets should exceed twenty four times the thickness of the metal.(Fig 6)

Too far a pitch will allow the sheet/plate to buckle between the rivets.

Fig 6



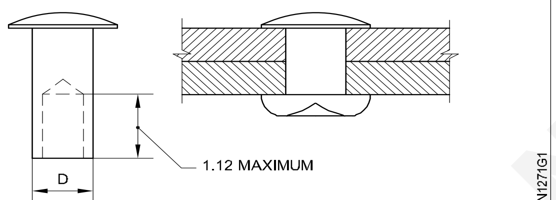
Tubular bifurcated and metal piercing rivets

Objectives: At the end of this lesson you shall be able to
- **state different types of tubular and bifurcated rivets**
- **state the constructional features of them**
- **state the application of them.**

Tubular and bifurcated rivets: These rivets are used in low tension joints or for joining softer materials to sheet metals, as given hereunder.

Semi-Tubular rivets: This rivet has straight hole or tapered hole at the end of the shank. The depth of the hole must not exceed 1.12 time shank diameter as shown in Fig 1. The rivet shank should extend upto the full thickness of the joint, with the hollow portion set to give correct upsetting.

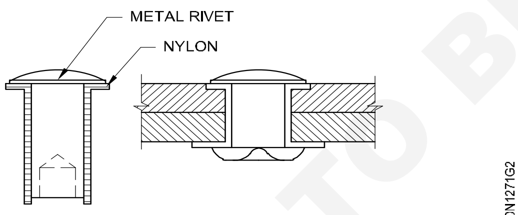
Fig 1



SEMI-TUBULAR RIVET

Insulated rivets: This rivet is semi-tubular and under the rivet head, it is covered with thick nylon as shown in Fig 2.

Fig 2

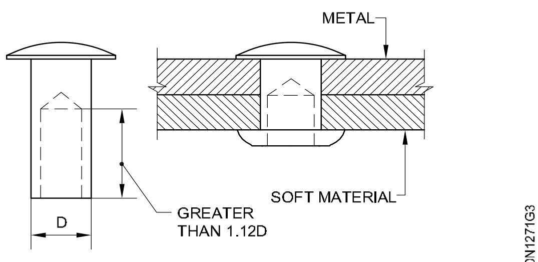


INSULATED RIVET

The main application of these rivets are in electrical assemblies, where the rivet needs to be insulated from the workpiece, and also for air tight or water tight joints.

Full Tubular rivets: This rivet has a hole greater than 1.12D and is designed for use, where the rivets is desired to punch the rivet through soft materials as shown in Fig 3.

Fig 3

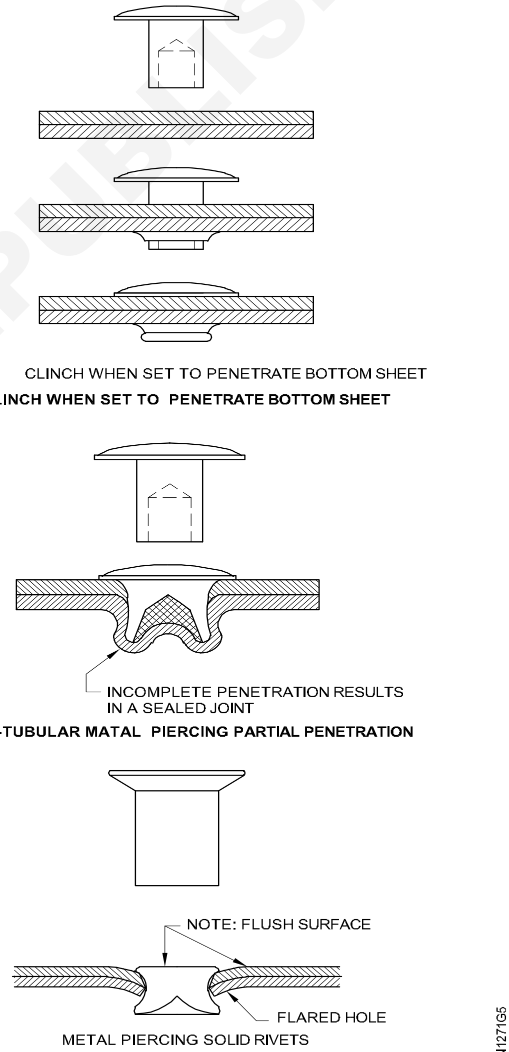


FULL TUBULAR RIVET

Bifurcated or Split rivet: The bifurcated or split rivet is machined to produce two prongs at the shank end to pierce soft materials as shown in Fig 4.

Metal piercing rivets (Fig 5)**:** These rivets pierce their own holes into the sheet metal joints.

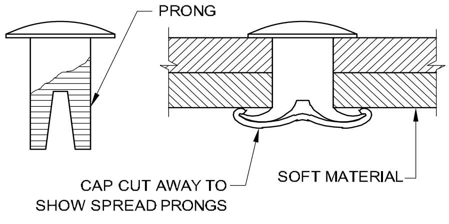
Fig 5



METAL PIERCING RIVETS

These are similar to solid rivets and have good tension and shear characteristics. These are economical as they produce their own holes and are used in mass production applications.

Fig 4



BIFURCATED OR SPLIT RIVET

Semi-tubular metal piercing rivets: These rivets are designed to use as punches to penetrate fully or partially on both pieces of the metal.

If the rivet fully penetrates the metal, it then completes the joint as shown in Fig . When the rivet partially penetrates the metal, the tail of the rivet forms a sealed joint.

Total sheet metal base thickness upto 2.5 mm can be used for semi-tubular metal piercing rivets.

Metal-piercing solid rivets: In this countersunk solid rivets can be driven into the sheet steel upto 3.2 mm total thickness with out the need of a hole. Penetration by the rivet, counter sinking and clinching the rivet against an upsetting tool, are completed in a single stroke. The counter sunk head produces a flashed hole which improves joint shear strength.

Expansion of the rivet end on the other side of the workpiece, prevents pull out.

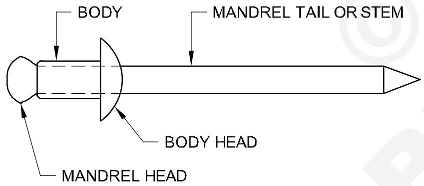
Blind rivet or pop rivet

Objectives: At the end of this lesson you shall be able to
- **state the types of blind rivets, their parts and application**
- **state the blind riveting equipment**
- **state the steps in riveting the blind rivets.**

Blind rivets are designed to allow them to be installed in joints which are accessible from one side only. However, for many reasons including simplicity and good appearance, they are used for joints from both sides are accessible. Prepared holes are required for blind riveting.

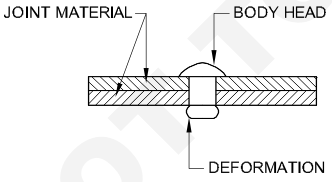
The parts of the rivet is shown in the Fig 1. The mandrel portion is used for assembly purposes only and after use, it is either totally or partially discorded. (Fig 2)

Fig 1



BLIND RIVET

Fig 2



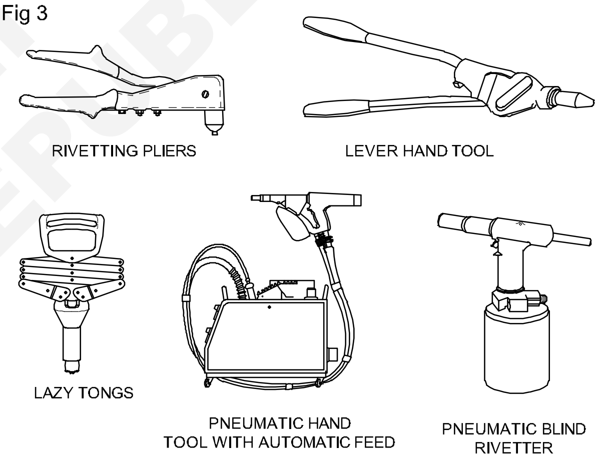
BLIND RIVET SET IN PLACE

Blind riveting equipment: The equipment used for blind rivets are blind rivet pliers, lazy tongs, lever hand tools, pneumatic and hydraulic magazine feed and semi-automatic fasteners as shown in Fig 3.

Types of Blind or Pop rivets: In setting a blind rivet, the body of the rivet is inserted into a hole and the mandrel is pulled deforming the tail which pulls and fixes the joint together. Blind rivets are available in many types and systems. Some of these are given here-under.

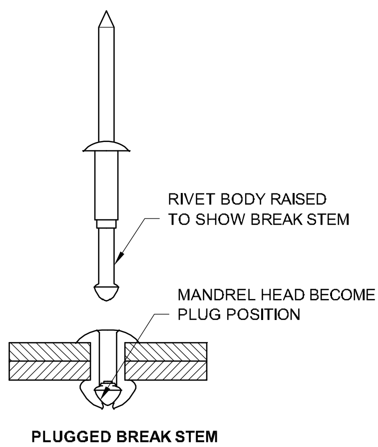
Plugged break stem: After the rivet tail has been deformed by the action of the mandrel, the mandrel stem breaks, leaving the head behind forming a plug as shown in Fig 4.

Fig 3



BLIND RIVETTING EQUIPMENT

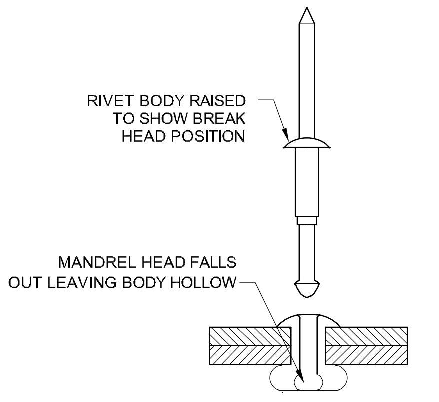
Fig 4



PLUGGED BREAK STEM

Open break stem: It is similar to the break stem, but the head breaks off and falls out after deforming the tail, leaving the hollow body open. (Fig 5)

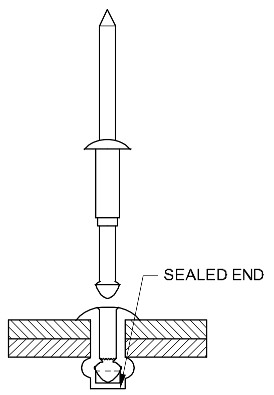
Fig 5



OPEN BREAK STEM

Sealed: The sealed type rivet is hollow cored with a closed blind end and is used where a water or pressure tight rivet is essential. (Fig 6)

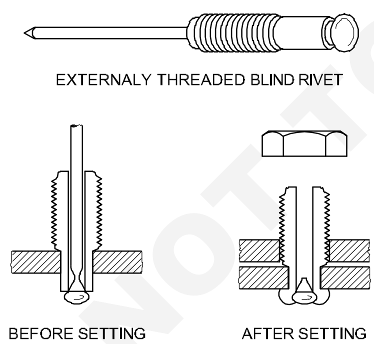
Fig 6



SEALED

Externally threaded blind rivets: This rivet is a conventional pull mandrel blind rivet. When the rivet is set, the head section protrudes providing a metric thread stud into which a nut can be fastened. (Fig 7)

Fig 7

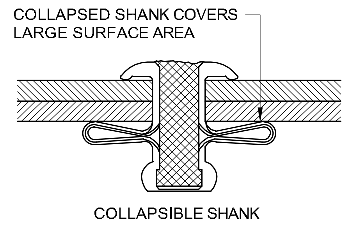


SETTING THE EXTERNALY THREADED BLIND RIVET

Collapsible shank: The tail or shank of this rivet is designed to deform into three segments. (Fig 8) It spreads the clamp up load over a wide area, making it suitable for assemblies having bigger size hole and also to prevent pull out in soft materials.

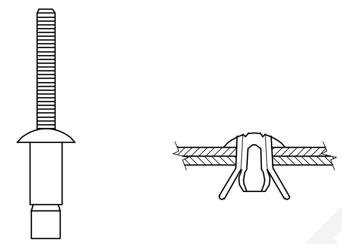
Flush break high strength: This blind rivet in 3 to 6 mm diameters has a mandrel with specially designed head that breaks off flush with the top of the rivet. (Fig 9)

Fig 8



BLIND RIVET TYPES

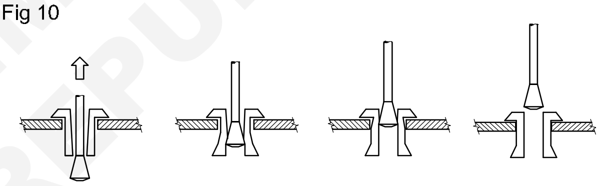
Fig 9



FLUSH BREAK HIGH STRENGTH

Repetition blind riveting systems: Rivet is loaded onto a mandrel which is placed into a pneumatic setting tool with a rivet in the ready position. This rivet is inserted into a preformed hole, the tool trigger is actuated, drawing the mandrel through the rivet, expanding the rivet tail. Sequence of rivet setting is shown in Fig 10.

Fig 10

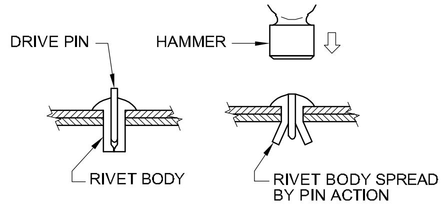


SEQUENCE OF RIVET SETTING REPETITION BLIND RIVETTING SYSTEMS

BLIND RIVET TYPES

Drive pin rivets: Drive pin rivets consist of a hollow body and a pin. In the manufactured condition itself, the pin projects from the rivet head. A hammer blow forces the rivet into the prepared hole, the pin expands the rivet and spreads pre-slotted shank prongs. (Fig 11)

Fig 11



DRIVE PIN RIVETS

Riveting blind rivet

Riveting steps

1 Select a rivet for the correct size of dia and length.

2 Drill a hole to the recommended diameter.

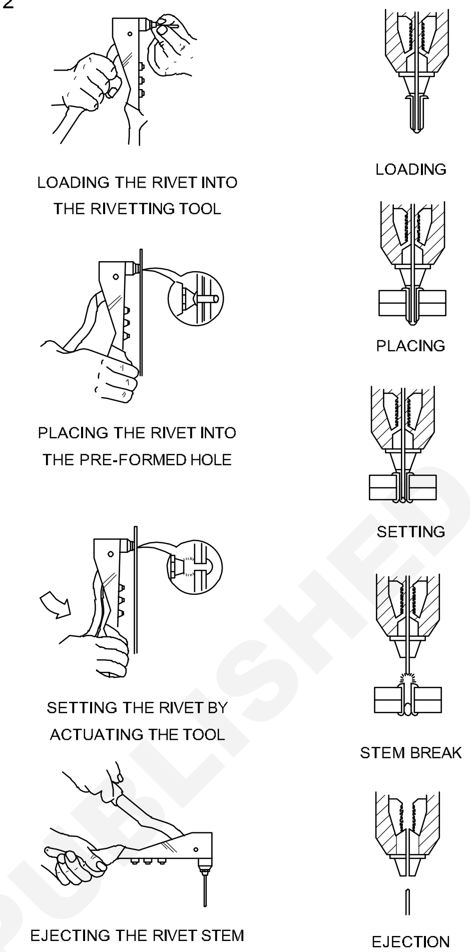
3 Open the riveting tool and insert the rivet stem into the tool nozzle.

4 Place the rivet body into the preformed hole.

5 Squeeze the rivet tool handles together to set the rivet, at the correct point of tension, the rivet stem will break.

6 When the rivet stem has broken, remove the tool from the job. Allow the tool to open fully to eject the spent rivet stem. (Fig 12)

Fig 12



SETTING A STANDARD BLIND RIVET

OA20N1271KC

Lazy tong

Objectives: At the end of this lesson you shall be able to
- **state what is a lazy tong**
- **state parts and mechanism of a lazy tong**
- **state the operating instructions.**

Lazy tong is a hand operated tool, used for setting 1/8", 5/32" and 3/16" diameter standard open type blind rivets. It is important to use the correct nosepiece for the diameter of the rivet to be placed, to ensure the best performance of the tool. The parts list is shown in the figure and all parts are fully interchangeable.

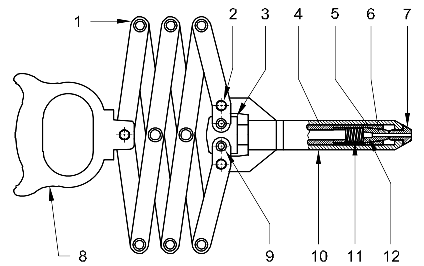
Description of mechanism: The mandrel gripping mechanism consists of a set of jaws (6) fitted into the jaw case (5) and screwed on to the power coupling assembly. The jaws are kept in the forward position by the jaw pusher (12) AND JAW PUSHER SPRING (11).

The lazy tong mechanism is connected to the power coupling in such a way that the operation of the handle (8) which draws the jaws, is gripping the rivet mandrel, thus setting the rivet.

Operating instructions: Check that the suitable nosepiece is fitted to the tool and firmly screwed into the threads.

When the mandrel breaks, the rivet is set.

Fig 1



PARTS LIST OF LAZY TONG

NO.	DESCRIPTION	QTY.
1	LINKAGES	1 SET
2	LOCK NUT	2
3	YOKE	1
4	POWER COUPLING	1
5	JAW CASE	1
6	JAWS	1 SET
7	NOSE PIECE	1
8	HANDLE	1
9	FULCRUM PINS	2
10	BODY	1
11	JAW PUSHER SPRING	1
12	JAW PUSHER	1

OA20N1271L1

Hand-riveting tools

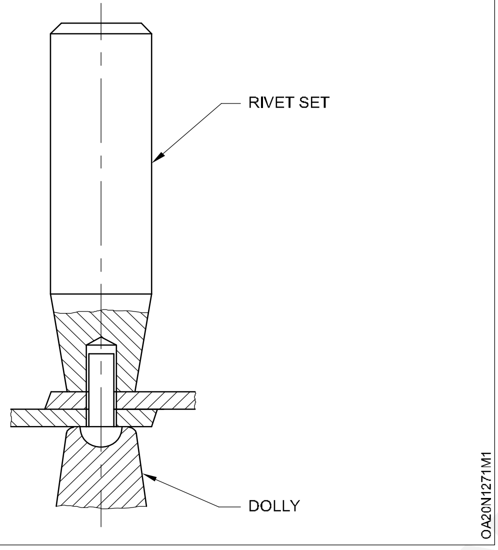
Objectives: At the end of this exercise you shall be able to
- **name the different hand-riveting tools**
- **state the uses of different hand -riveting tools.**

Rivet set

It is used for bringing the sheet metal closely together after inserting the rivet in the hole

This is required while riveting thin plates or sheet with small rivets (Fig 1)

Fig 1



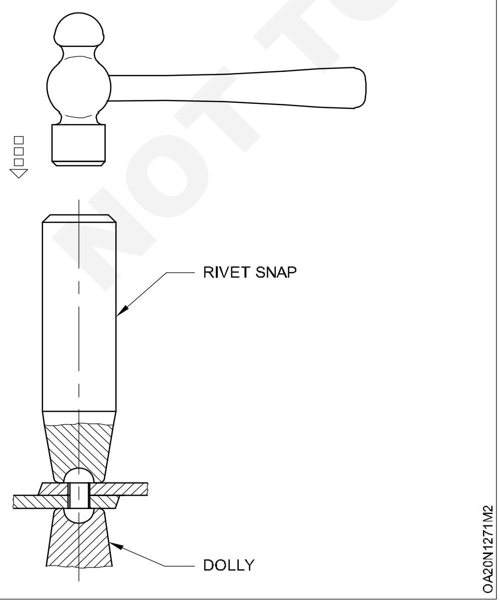
Dolly

It is used to support the head of the rivet which is already formed and also to prevent damage to the shape of the rivet head (Fig 1)

Rivet snap

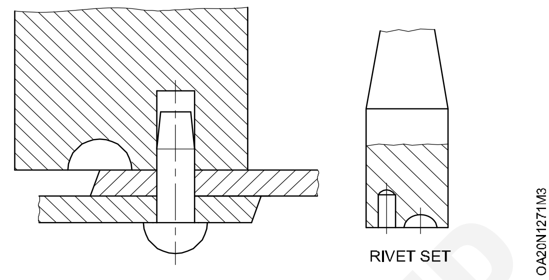
It is used to form the final shape of the rivet during riveting. Rivet snaps are available to match the different shapes of rivet heads (Fig 2)

Fig 2



Combined rivet set: This is a tool which can be used for setting and forming the head (Fig 3)

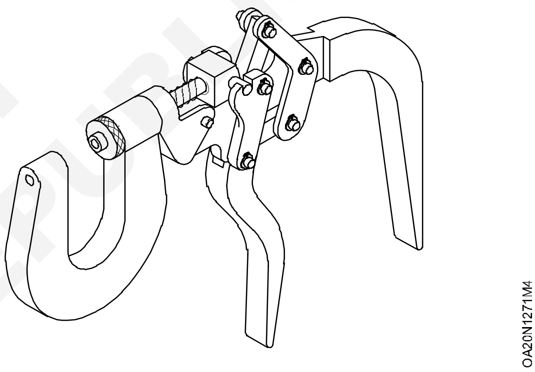
Fig 3



Hand riveter: This has a lever mechanism which exerts pressure between the jaws when the handle is pressed.

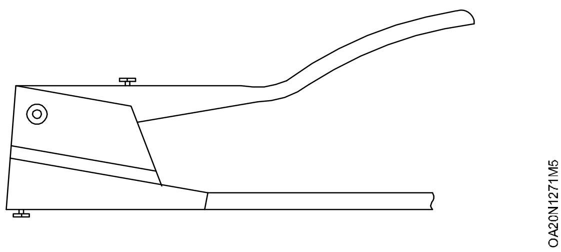
This is useful for riveting copper or aluminium rivets. Interchangeable anvils can be provided.(Fig 4)

Fig 4



Pop riveter: This is used for riveting pop rivets by hand. The trigger mechanism squeezes the rivet and separates the mandrel of the rivet. In this method as the mandrel is being separated from the rivet, the head is formed on the other end (Fig 5)

Fig 5



Drift

It is used to align the holes to be riveted. (Fig 6)

Caulking tool

It is used for closing down the edges of the plates and heads of the rivets to form a metal-to-metal joint (Fig 7)

Fullering tool

It is used for pressing the surface of the edge of the plate (Fig 8) Fullering helps to make fluid-tight joints.

Fig 6

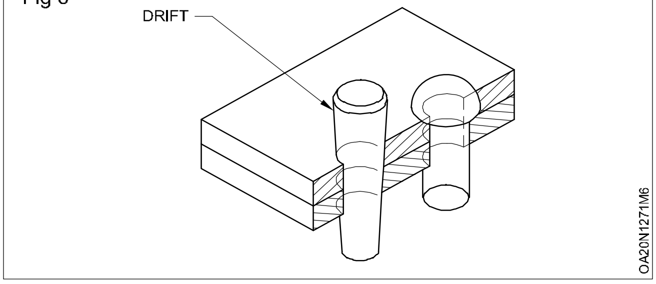


Fig 7

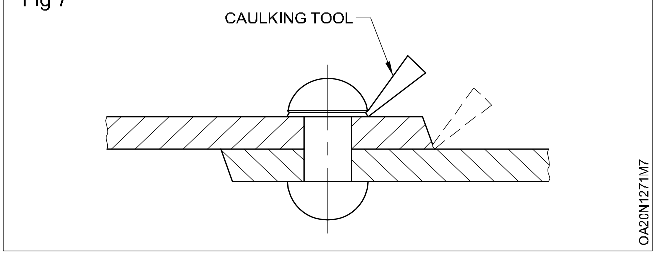
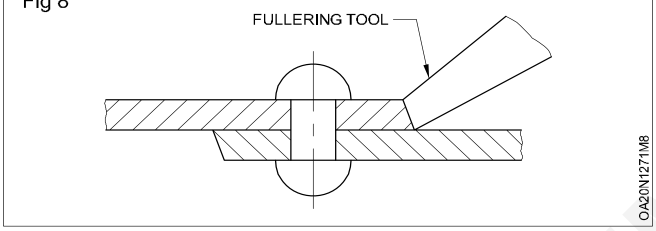


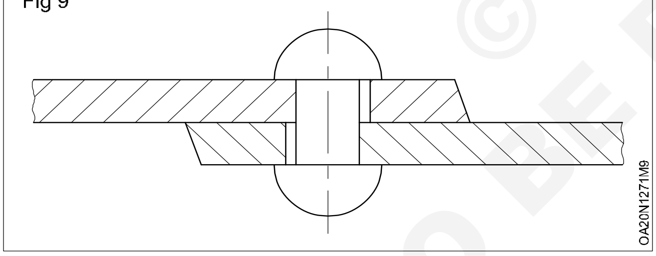
Fig 8



Reasons for faulty rivetting

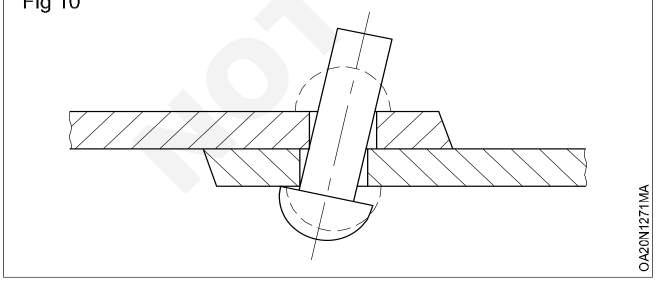
The holes on the plate are not in line (Fig 9)

Fig 9



The shank or body of the rivet is not perpendicular to the plate before riveting (Fig 10)

Fig 10



Too much or too little allowance has been given. (Fig 11 and 12)

Rivet head is not centered with the shank or body of the rivet (Fig 13)

Improper joining of plates.(Fig 14) plates are not brought closely together using rivet set.

Fig 11

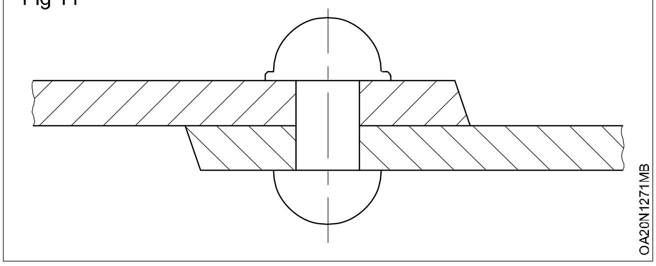


Fig 12

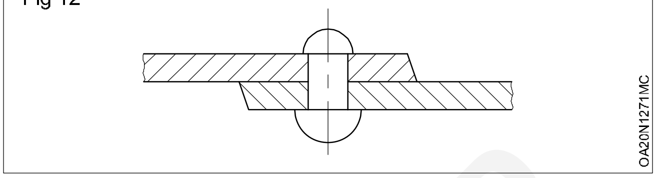


Fig 13

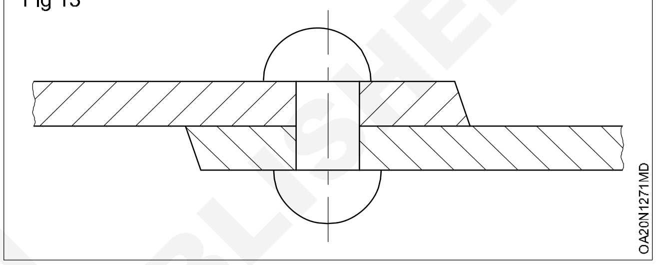
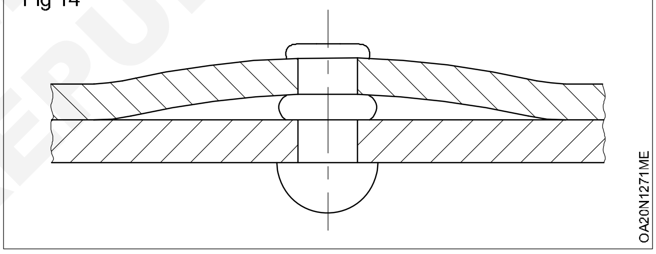


Fig 14



Burrs between plates and in drilled holes.(Fig 15 and 16)

Fig 15

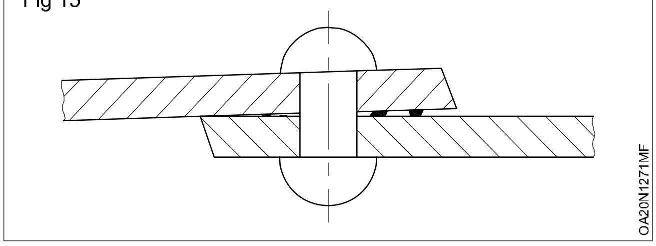
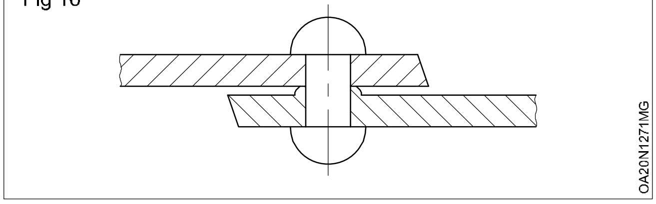


Fig 16

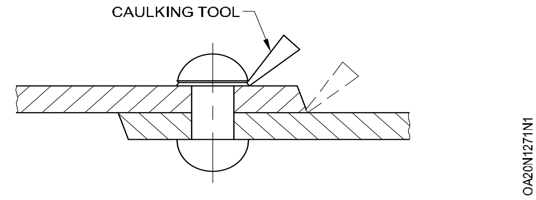


Caulking and fullering

Objectives: At the end of this lesson you shall be able to
- **state the purpose of caulking and fullering**
- **distinguish between caulking and fullering processes.**

Caulking: Caulking is an operation of closing down the edges of the plates and heads of the rivets to form a metal-to-metal joint.(Fig 1)

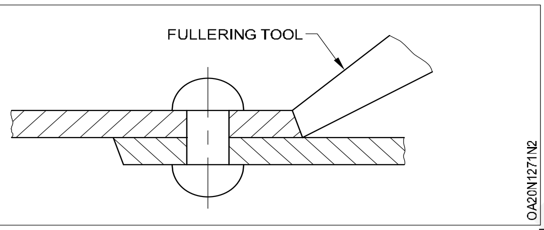
Fig 1



The edge of the rivet head is tightly pressed and expanded on the plate by a caulking tool which looks like a fattened cold chisel.

Fullering: Fullering is an operation of pressing the whole surface of the edge of the plate. It is done by a fullering tool.(Fig 2)

Fig 2



When the caulking tool is about as thick as the plate, it is called a fullering tool.

The whole surface of the edge of the first plate is tightly pressed on the second plate.

A better fluid-tight joint is achieved by fullering.

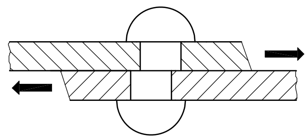
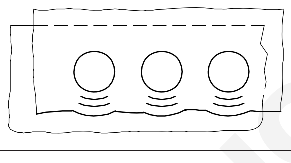
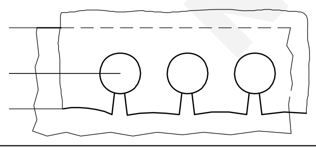
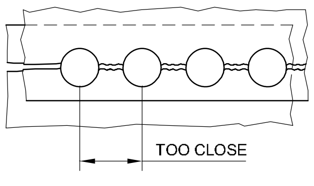
Caulking is done on the edges of the plates as well as on the edges of the rivet heads. But fullering is done on the edges of the plate only. To facilitate caulking and fullering on the plates, the edges of the plates are bevelled about 80^0 to 85^0.

The strength of riveted joints: A riveted joint is only as strong as its weakest part and it must be borne in mind that it may fail in one of the following four ways.

- Shearing of the rivet
- Crushing of the metal
- Spliting of the metal
- Rupture or tearing of the plate

These four undesirable effects are illustrated in the table below.

Table

Riveted joints	Effects	Causes	Prevention
	Shearing of the rivet	Diameter of the rivet too smal compared with the thickness of the plate. The diameter of the rivet must be greater than the thickness of the plate, in which it is to be riveted. Strength of trivet material is less when compared to the materials of the plates.	Select the correct diameter rivet to suit thickness of the plate. Select a suitable material visit.
	Crussing of the rivet	Diameter of the rivet too large compared with the thickness of the plate. The rivets when driven tend to bulge and cursh the metal in front of them.	Select the correct diameter rivet for the thickness of the metal plate.
	Splitting of the metal	Rivet holes punched or drilled too near the edge of the plate. Metal is likely to fail by splitting in front of the rivets.	Drill or punch the rivet at the correct distance from the edge and use the correct lap allowance for the diameter of the rivet.
	Tearing of the plate	Plates weakened by rivet holes being too close together. Plates tend to rupture along the centre line of the rivets	Punch or drill rivet holes at the correct spacing or or pitch. In addition remove all burrs from the holes before final assembly.

Pipe bending machines

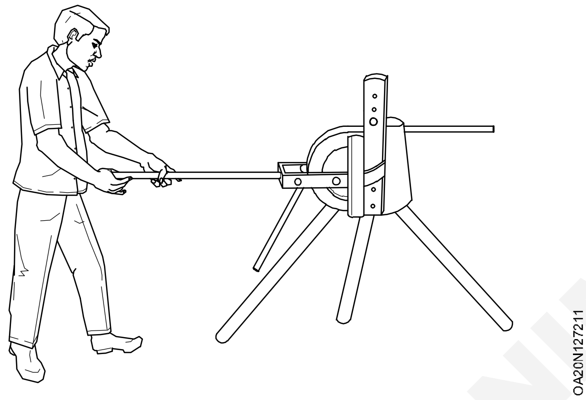
Objectives: At the end of this lesson you shall be able to
- **identify the three most common pipe benders**
- **differentiate their constructional features**
- **name the parts of bending machines**
- **state the uses of bending machines.**

There are some situations in plumbing jobs, where it is preferable to bend a pipe rather than use a pipe fitting.

The most common pipe benders are listed here.

Portable hand operated pipe bender (Fig 1)

Fig 1

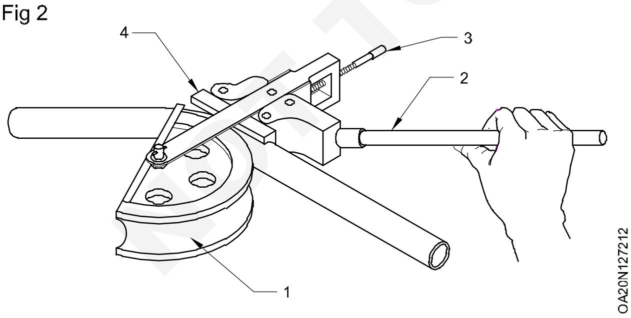


The portable hand-operated pipe bender consists of the following parts

1 Tripod stand
2 Pipe stop lever
3 Handle or lever
4 Inside former

Bench type hand operated pipe bender (Fig 2)

Fig 2



This consists of the following parts. It is used for bending galvanized iron and steel pipes.

1 Inner former
2 Lever or handle
3 Adjusting screw with lock nut
4 Pipe guide

Hydraulic bending machine (Fig 3)

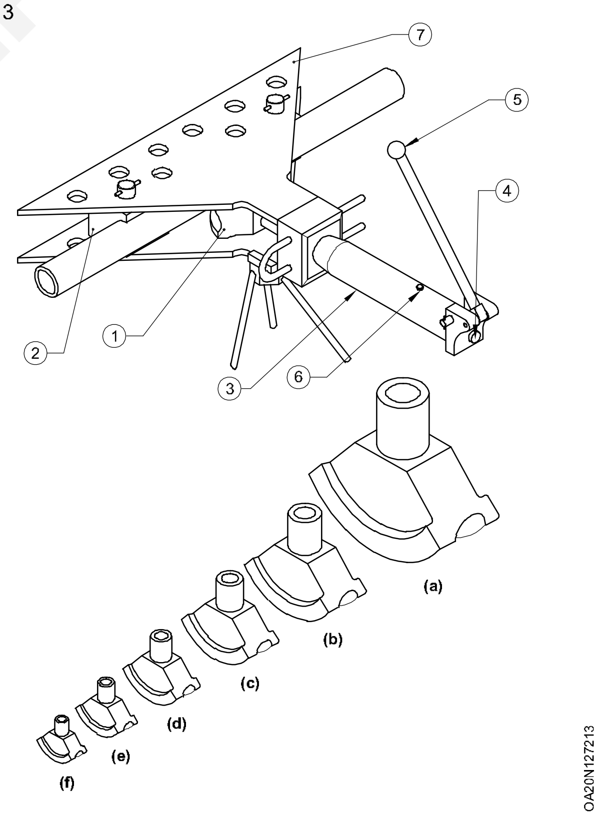
This machine can be used for bending G.I and M.S.pipes without sand filling to any direction.

It consists of the following the parts.

1 Inner former
2 Back former
3 Hydraulic ram
4 Pressure release valve
5 Operating lever
6 Bleed screw
7 Base plate

Inner formers are interchangeable and are able to bend pipes up to 75 mm diameters. (Figs 3a, b, c, d, e & f)

Fig 3



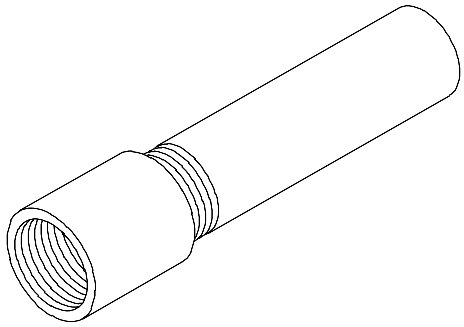
Pipes, dies, die stocks and taps

Objectives : At the end of this lesson you shall be able to
- **identify die sets, die stocks and pipe taps**
- **name the parts of a die stock**
- **state the method of checking pipe threads.**

Pipe dies

Most of the G.I. pipes that plumbers install are threaded at both ends. The pipes are available in lengths of 6 metres and it will be necessary to cut the pipe to the required length and thread it. (Fig 1)

Fig 1



OA20N127231

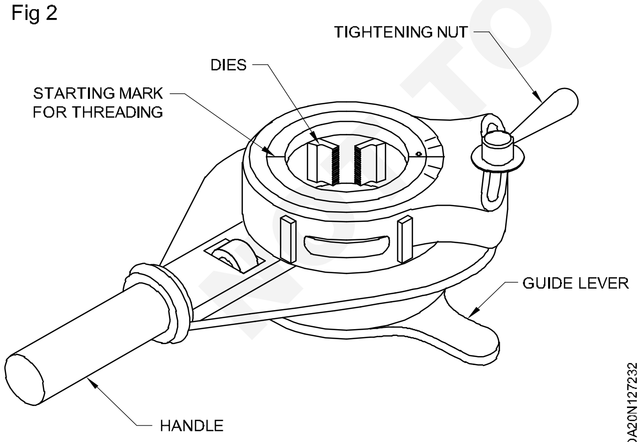
The threads on G.I. pipes and fittings for water supply systems are the standard pipe threads. External pipe threads are cut by pipe dies available in sizes from 1/4" to 4".

The dies must be sharp so that they will cut metal rather than push it around. Dies which push the metal around instead of cutting freely cause threads to break.

Die stocks

Die stocks are required to turn the dies. The ratchet type die stock is preferred because it permits the operator to use his body weight to rotate the die while standing to one side of the pipe. (Fig 2) Die stocks are adjustable.

Fig 2



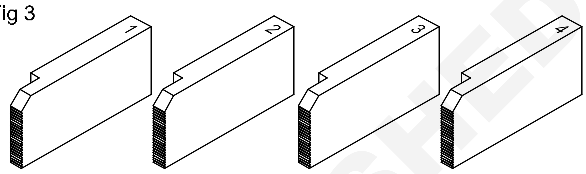
OA20N127232

Die sets

Each die is clearly marked with its type of thread and range of pipe for which it is suitable. Each die has an identification number, that is 1 to 4. Die sets are available in various sizes.

These dies must always be used and stored as a set. (Fig 3)

Fig 3



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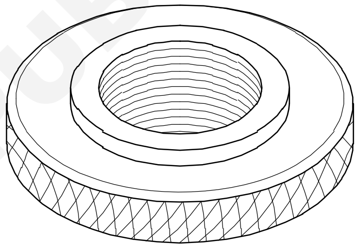
Pipe threads are usually cut with threading dies and can be checked by using the pipe ring gauge.(Fig 4)

Fig 4



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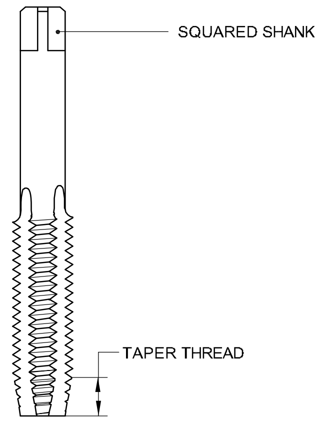
Pipe taps

Internal pipe threads are usually cut with standard taper pipe taps. (Fig 5)

Fig 5



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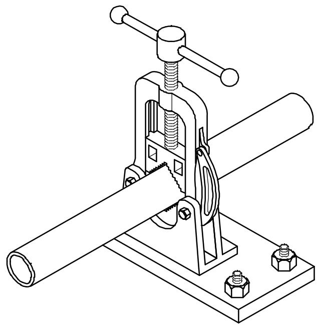
Pipe vices and pipe cutters

Objectives : At the end of this lesson you shall be able to
- **name the different types of pipe vices**
- **state the uses of pipe vices**
- **name the parts of a pipe cutter**
- **compare the constructional features of a pipe**
- **cutter and a multi-wheel chain pipe cutter**
- **state the care and maintenance aspects**
- **concerning pipe cutters.**

Pipe vice (Fig 1)

Fig 1

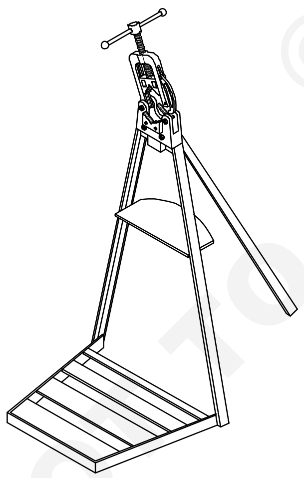


The pipe to be cut/bent/threaded must be held steadily and it must be prevented from rotating by holding it in a pipe vice.

It is a device used for holding and locating pipes. It can be used to hold pipes up to 63mm diameter.

Portable folding pipe vice (Fig 2)

Fig 2



This vice can be folded and carried easily to any working place. This is similar to the quick-releasing type pipe vice.

Chain pipe vice (Fig 3)

This vice is used to hold larger diameter pipes up to 200mm diameter. The pipe is gripped by means of a chain and the ser-rations provided on the vice jaws.

Pipe cutter

The wheel pipe cutter is used to make a square cut on the pipe. It consists of (1) a cutter wheel, (2) two guide rollers and (3) an adjusting screw. (Fig 4)

Fig 3

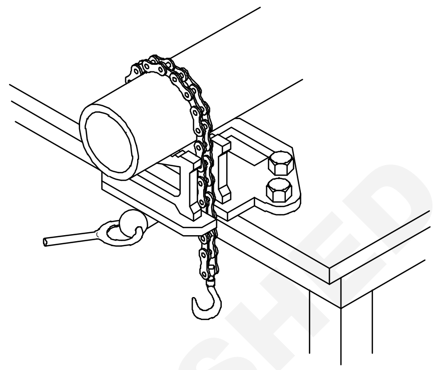
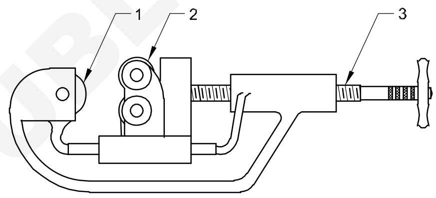


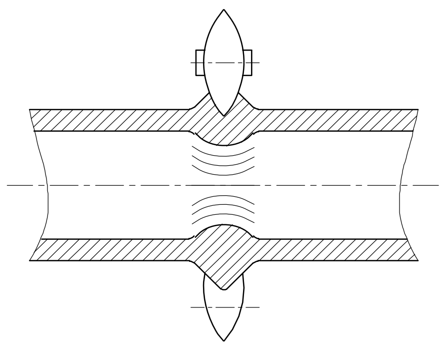
Fig 4



The cutter wheel tends to crush rather than cut the pipe. If it is blunt, it needs replacement.

This type of pipe cutter does not remove any materials but the cutter squeezes the metal and forces it ahead of the cutter until the pipe is cut through the wall thickness. (Fig 5)

Fig 5



This type of cutting leaves a large ridge on the inside of the pipe which would obstruct the flow. (Fig 6) The pipe must be deburred or reamed by a pipe reamer.

Multi-wheel chain pipe cutter

A multi-wheel chain pipe cutter can be adjusted to cut any diameter of pipe by adding on extra wheels and links. (Fig 7) The type and the size of the cutter is selected according to the diameter of pipe to be cut.

Fig 6

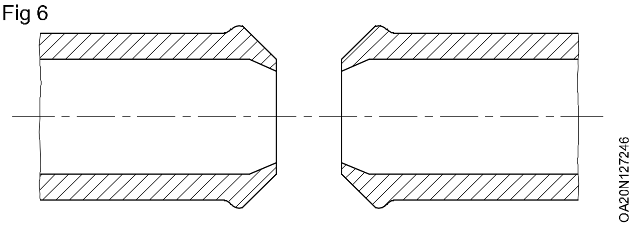
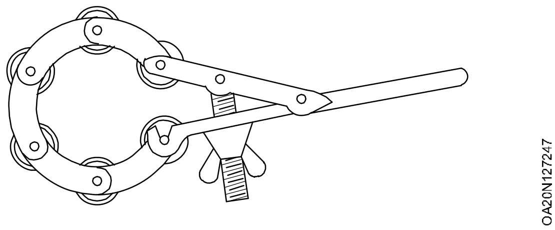
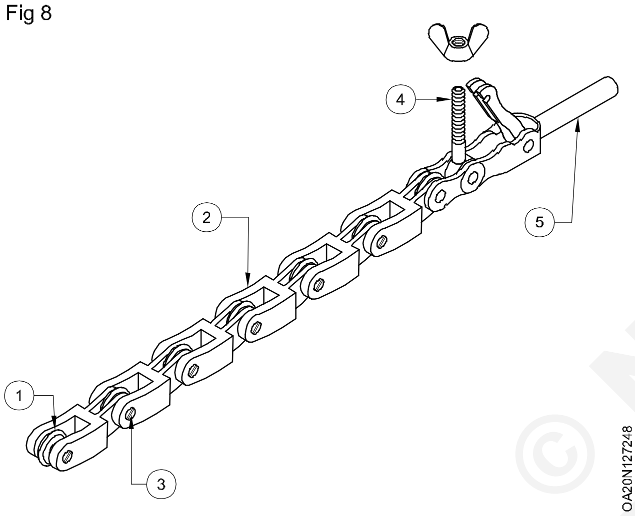


Fig 7



It consists of the following parts. (Fig 8)

Fig 8



1 Hardened cutting wheels
2 Links
3 Screw for joining links and wheels
4 Tension adjustment screw
5 Cutter handle

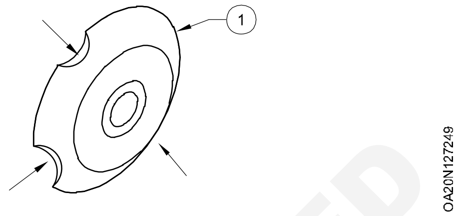
Care and maintenance of pipe cutters

Before using the cutter check the wheels, pins and links for any damage. Replace the wheels, pins and links if damaged.

As the wheel revolves around the pin, any wear on the pin will cause the wheel to wobble and the cut will not run square to the pipe. This may result in a:

- chipped wheel (Fig 9)

Fig 9



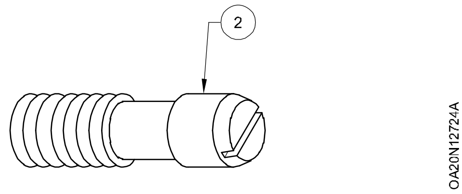
- worn out pin. (Fig 10)

During pipe cutting, small flakes of metal break away and clog up the links and cutting wheels. Clean the links and wheels using a wire brush and soak the cutter in paraffin or kerosene to wash out the small particles of dirt and flakes.

After cleaning, apply a light oil on all moving parts, links and wheels for easy cutting operation and to prevent rust forming on the tool.

Store the cutter and protect the wheels from possible damage when not in use.

Fig 10



Screwdriver

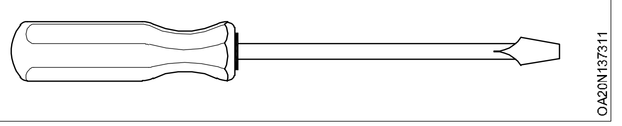
Objectives: At the end of this lesson you shall be able to
- **state the different types of screwdrivers and their uses**
- **specify a screwdriver**
- **list the precautions to be observed while using screwdrivers.**

Screwdrivers are used to tighten or loosen screws and are available in various lengths.

Hand-held screwdrivers are of the following types.

Standard screwdriver (Light duty) (Fig 1)

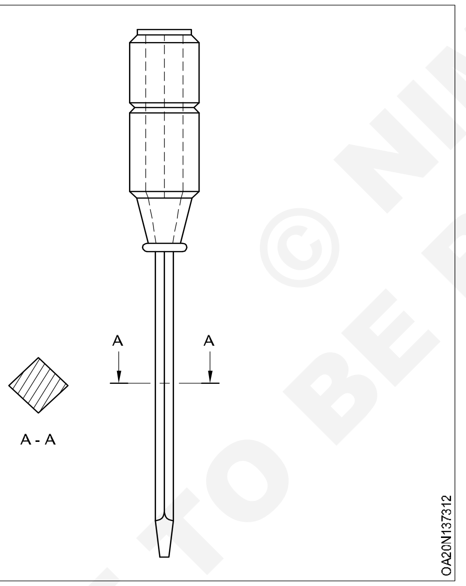
Fig 1



It is made of a round shank/blade with metal, wood or moulded insulated material handle.

Standard screwdriver (Heavy duty) (Fig 2)

Fig 2



The shank is of square section for applying extra twisting force with the end of a spanner. (Fig 3)

Heavy duty screwdriver (London pattern) (Fig 4)

It has a flat blade and is mostly used by carpenters for fixing and removing wood screws.

Philips screwdriver (Fig 5)

These are made with cruciform (Fig 6) tips from the matching slots. (Fig 7) philips recess head screws are shown in Fig 8.

The sizes of Philips screwdrivers are specified by point size 1,2,3 and 4.

Offset screwdrivers (Fig 9)

These are useful in some situations (Fig 10) where the normal screwdriver cannot be used because of the length of the handle. They are also useful for applying greater turning force.

Fig 3

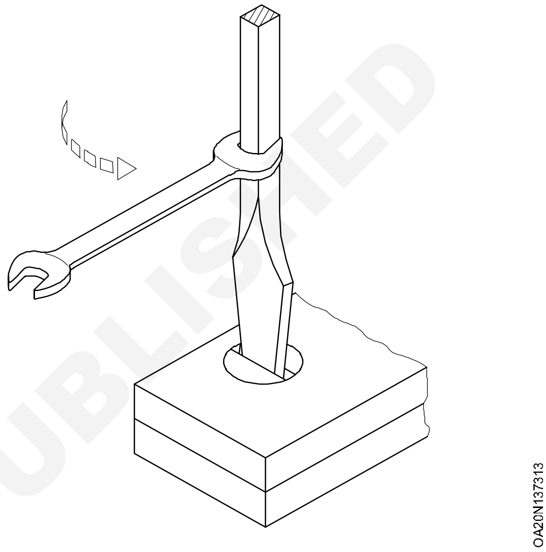


Fig 4

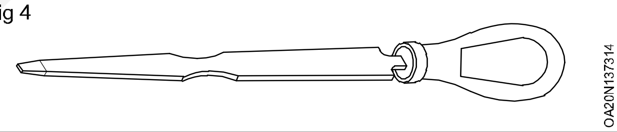
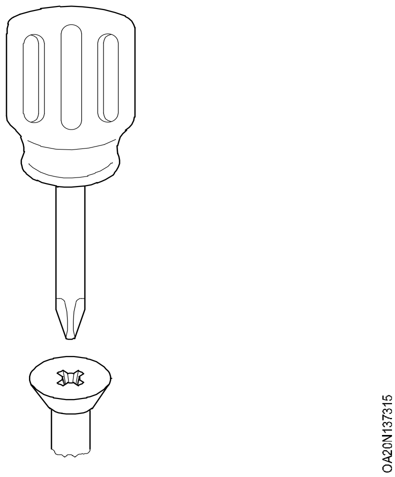


Fig 5



For quicker application ratchet offset screwdrivers are also available with renewable tips. (Fig 11)

Specification

Screwdrivers (Fig 12) are specified according to the

- length of the blade
- width of the tip.

Fig 6

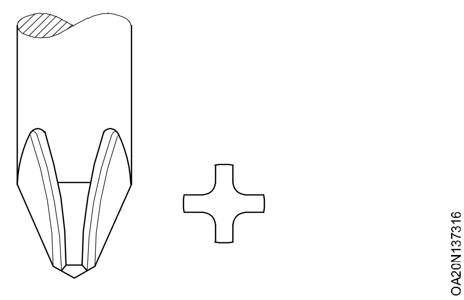


Fig 7

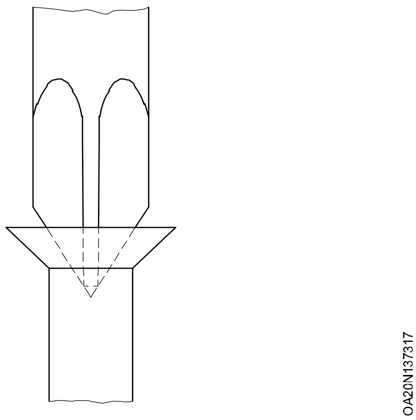


Fig 8

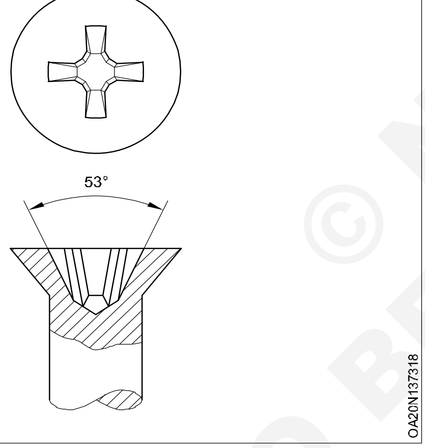


Fig 9

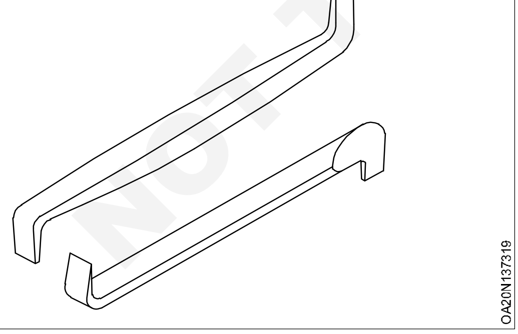


Fig 10

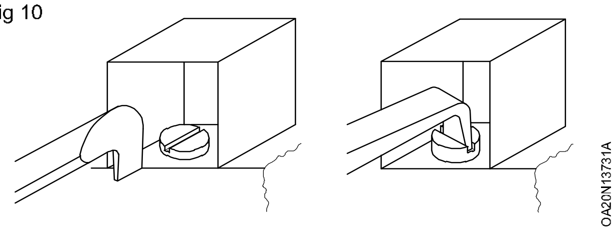


Fig 11

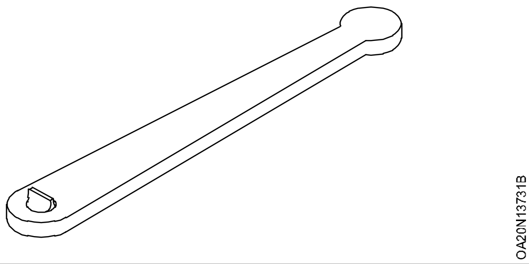
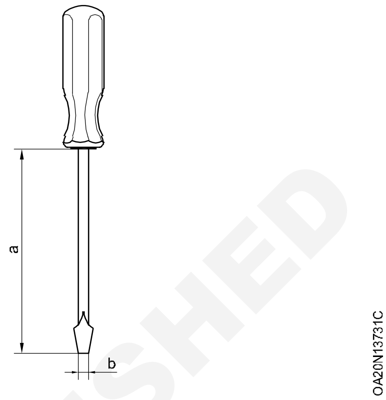


Fig 12



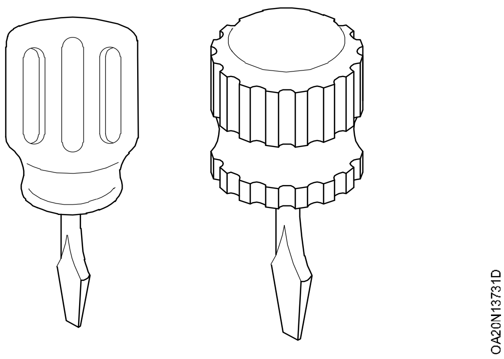
Normal blade length: 45 to 300 mm. Width of blade: 3 to 10mm.

The blades of screwdrivers are made of carbon steel or alloy steel, hardened and tempered.

Screwdrivers for special uses

Small sturdy screwdrivers are available for use where there is limited space. (Fig 13)

Fig 13



Screwdrivers with blades sheathed in insulation are available for the use of electricians. (Fig 14)

Precautions

Use screwdrivers with tips correctly fitting into the screw slot. (Fig 15)

Make sure your hand and the handle are dry.

Hold the screwdriver axis in line with the axis of the screw.

While using a Philips screwdriver apply more downward pressure.

Keep your hand away to avoid injury due to slipping of the screwdriver. (Fig 16)

Do not use screwdrivers with split or defective handles. (Fig 17)

Fig 14

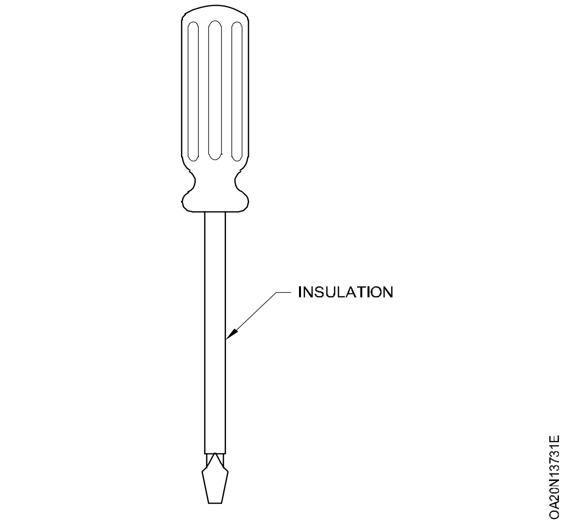


Fig 15

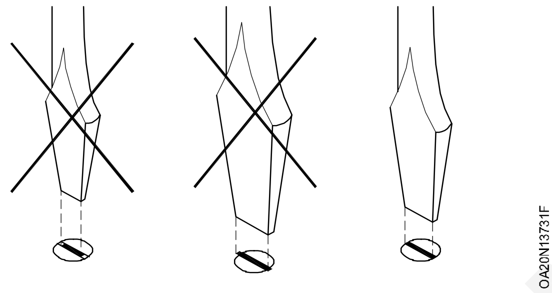


Fig 16

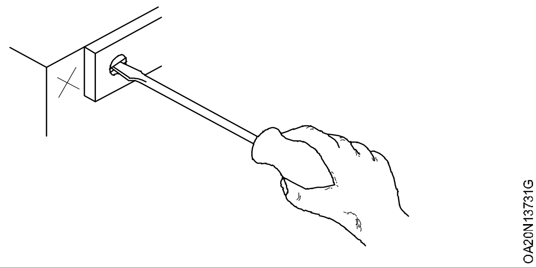
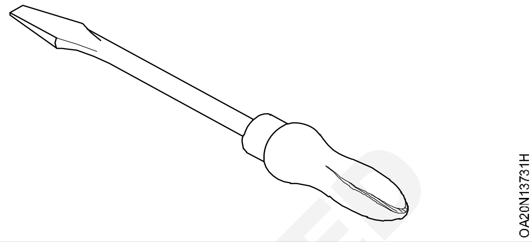


Fig 17



In the case of damaged screwdrivers, the blades can be ground (the faces will be parallel with the sides of the screwslot) and used. While grinding ensure the end of the tips is as thick as the slot of the screw.

While using screwdrivers on small jobs, brace the job on the bench or hold them in a vice.

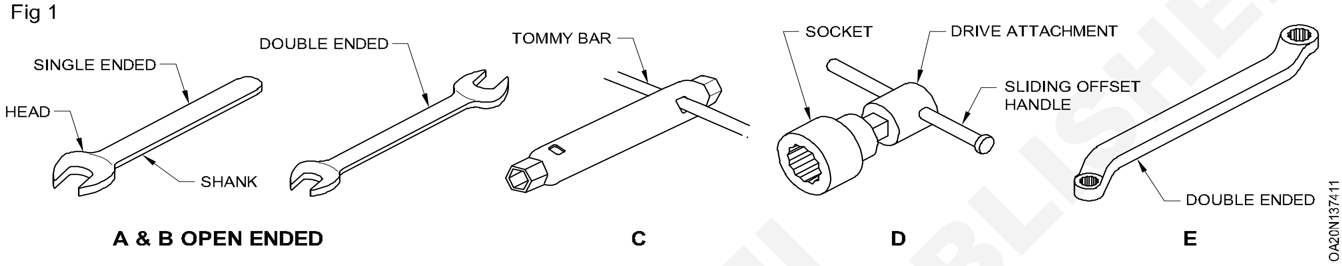
Spanners and their uses

Objectives: At the end of this lesson you shall be able to
- **state the necessity of the spanners**
- **identify the different types of spanners**
- **specify the spanners**
- **identify the parts of adjustable spanners**
- **state the features of 'C' spanners and their uses**

Spanners are used for operating threaded fasteners, bolts and nuts. They are made with jaws or openings that fit square on hexagonal nuts and bolts and screw threads. They are made if high tensile or alloy steel. They are drop forged and heat-treated for strength. Finally they are given a smooth surface finish for ease of gripping.

Spanners vary considerably in shape to provide ease of operation under different conditions (Fig 1)

Fig 1



The five basic types of spanners are

- Open end spanners
  - Single ended (A)
  - Double ended (B)
- Tube or tubular box spanners (C)
- Socket spanners (D)
- Ring spanners (E)

The correct spanner to use is the one that fits exactly and allows room for use. They should also permit the job to be done in a shorter time.

The following are the points to be noted for using spanners in a safe way.

Use open end and ring spanners by pulling on the shank. It is to pull as there is less chances of hitting your knuckles if the spanner or nut slips suddenly. If you are forced to push the spanner use the base of your hand and keep your hand open.

Use both hands for large spanners.

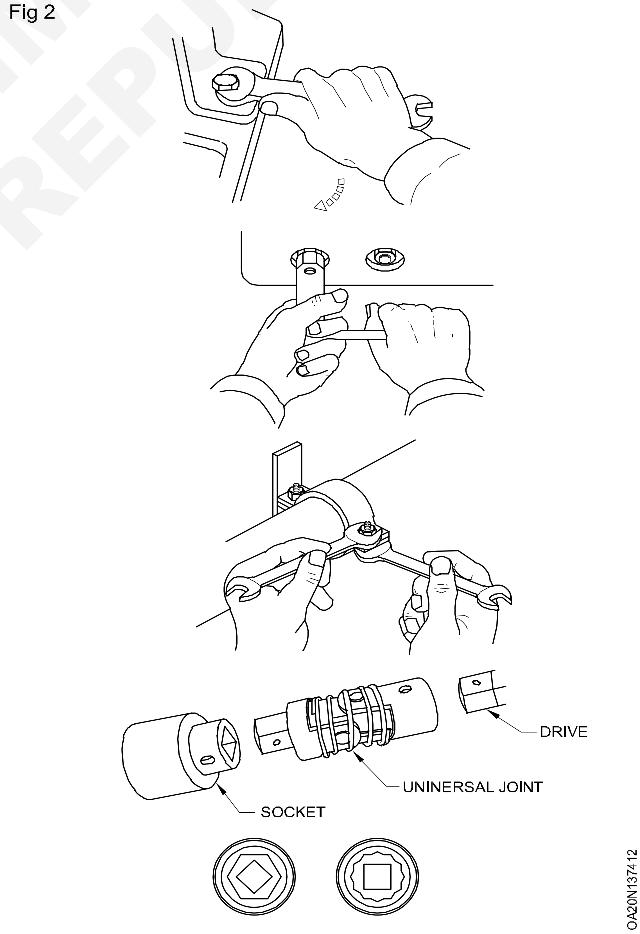
Keep yourself balanced and firm to avoid slipping yourself, if the spanner slips suddenly. Hold on to some support, if there is any change of falling.

Use both hands as shown in Fig 2, when using tubular box spanners.

Use two spanners as shown in the figure to stop head of the bolt rotating as the nut is operated. (Fig 2)

Socket spanners may be turned by accessories which have square driving ends. (Fig 2)

Fig 2

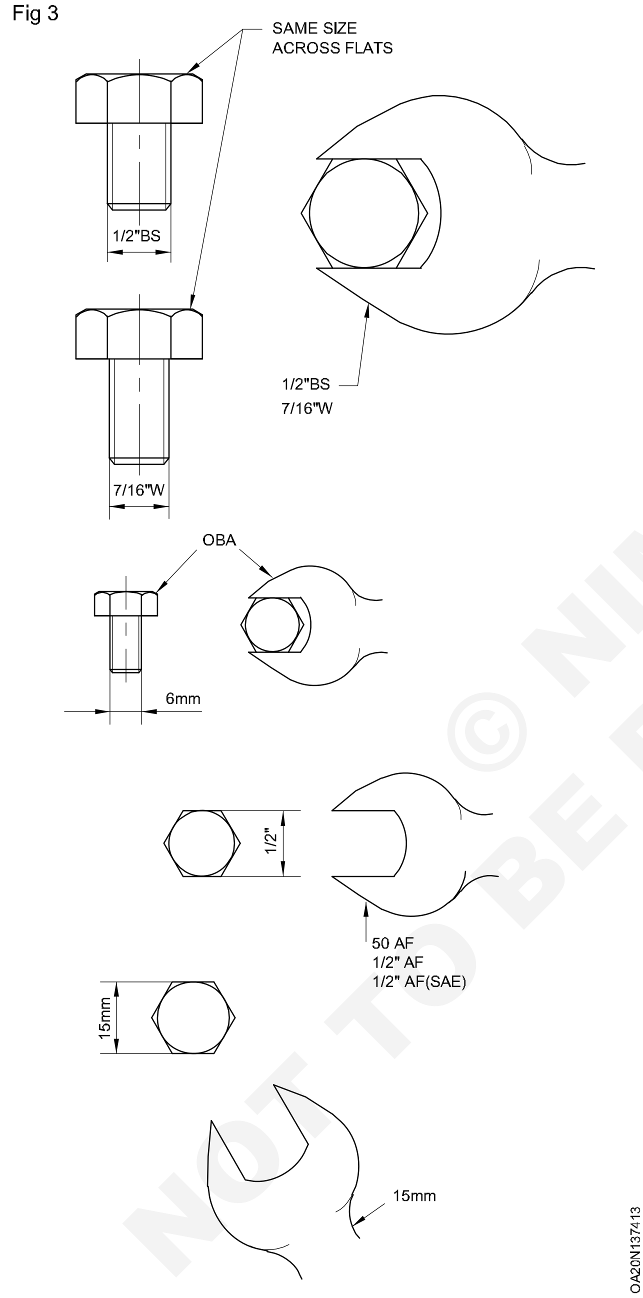


Size and identification of spanners : The size of spanner is determined by the nut or bolt or fits. The distance across the flats of a nut or bolt varies both with the size and the thread system.

In the British system the nominal size of the bolt is used to identify the spanner.

In the unified standard system, the spanners are marked with a number based on the decimal equivalent of the nominal fractional size across the flats of the hexagon, following the sigh A/F or with the fractional sixe across the flats following the sign A/F. In the metric system, spanners are marked with the size across the jay opening followed by the abbreviation 'mm' (Fig 3)

Fig 3



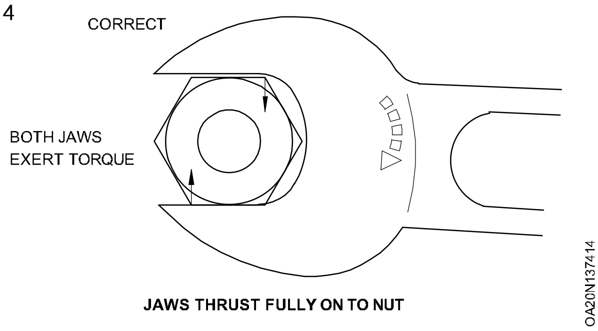
To fit exactly, a spanner must be:

- Of the correct size
- Placed correctly on the nut
- In good condition

Spanners have their jaws slightly wider than the width of the nut so that they can be placed into position easily. Any excess more than a few hundredths of a millimetre clearance could cause the spanner to slip under the pressure.

Place the spanner so that its jaws bear fully on the flats of the nut (Fig 4)

Fig 4



Incorrect use damages the spanners.

Discard any defective spanners. The spanners illustrated here are dangerous for use (Fig 5).

Choose spanners that allow room for use. (Fig 6)

Fig 5

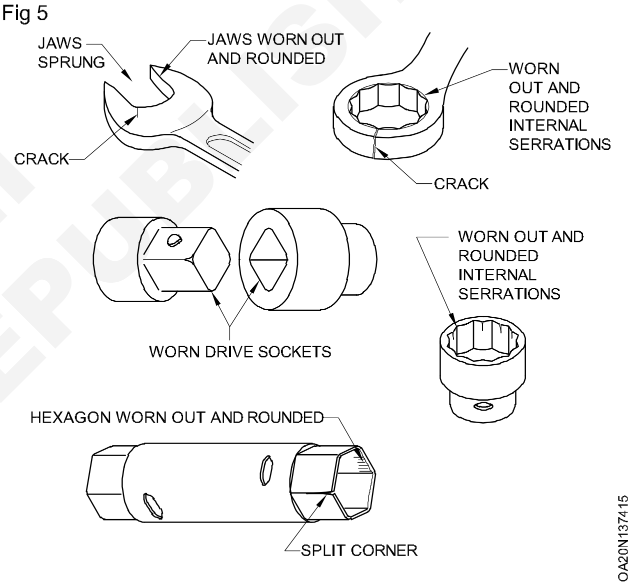
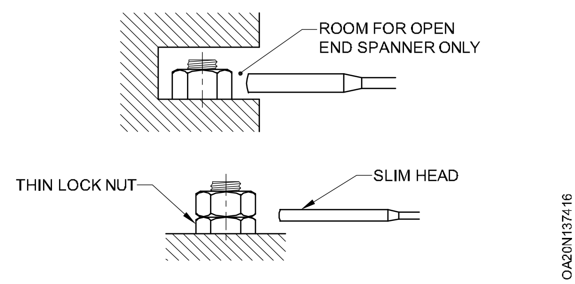


Fig 6



Nuts in inaccessible positions may be reached with socket spanners, with special drawing accessories (Fig 7)

Length of spanners : Normally spanners have a length that is about ten times the width of the jaw opening.

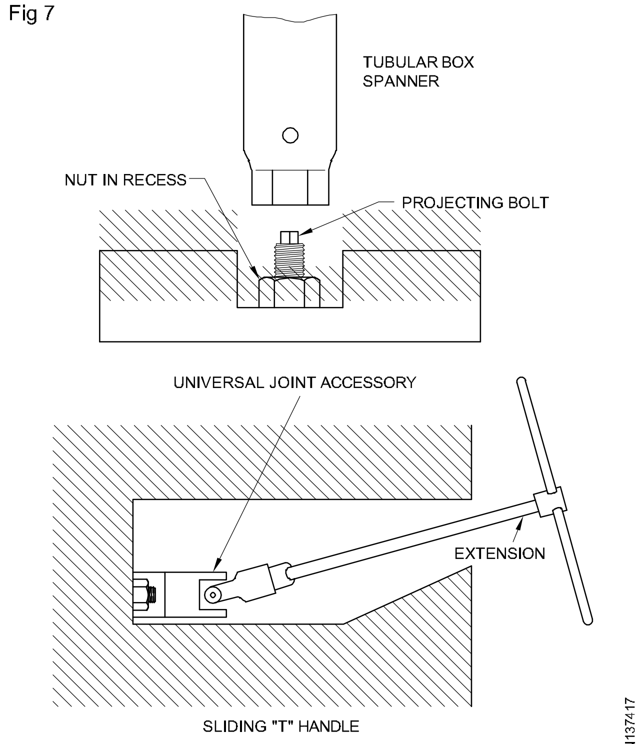
Never exert excessive pull on a spanner, particularly by using a pipe to extend the length of a spanner.

Excess turning effect of the spanner could result in:

- Striping of the thread
- Shearing the bolt

- Straining the jaws of the spanner
- Making the spanner slip and cause an accident

Fig 7



SOCKET SPANNER

Adjustable spanners (Fig 8) : Most common types of adjustable spanners are similar to open end spanners, but they have one movable jaw. The opening between the jaws of a typical 250 mm spanners can be adjusted from zero to 28.5 mm. Adjustable spanners may range in length from 100 mm to 760 mm. The type illustrated has its jaws set an an angle of 22 ½ to the handle. Adjustable spanners are convenient for use where a full kit of spanners cannot be carried about. They are not intended to replace fixed spanners which are most suitable for heavy service. If the movable jaw or knurled screw is cracked or worn out, replace them with spare ones.

When using the adjustable spanner follow the steps given below.

Place it on the nut so that the jaw opening points in the same general direction as the handle is to be pulled. In this position the spanners are less liable to slip and the required turning force can be exerted without damage to the moving jaw and knurl.

Push the jaws into full contact with the nut (Fig 9)

Use the thumb to tighten the adjusting knurl so that the jaws fit the nut snugly

Pull continuously. The length of the handle is designed to suit the maximum opening of the jaws. With small nuts, a very small pull on the handle will produce the required torque (Fig 9)

'C' spanners (Hook spanners) (Fig 10)

It has a lug that fits in a notch, cut in the outer edge of a round nut. The 'C' section is placed around the nut in the direction in which it is to be turned. In adjustable hook wrenches, part of the 'C' section pivots to fit nuts with a range of diameters. A set of three spanners is needed to cover diameters from 19 mm to 120 mm.

Fig 8

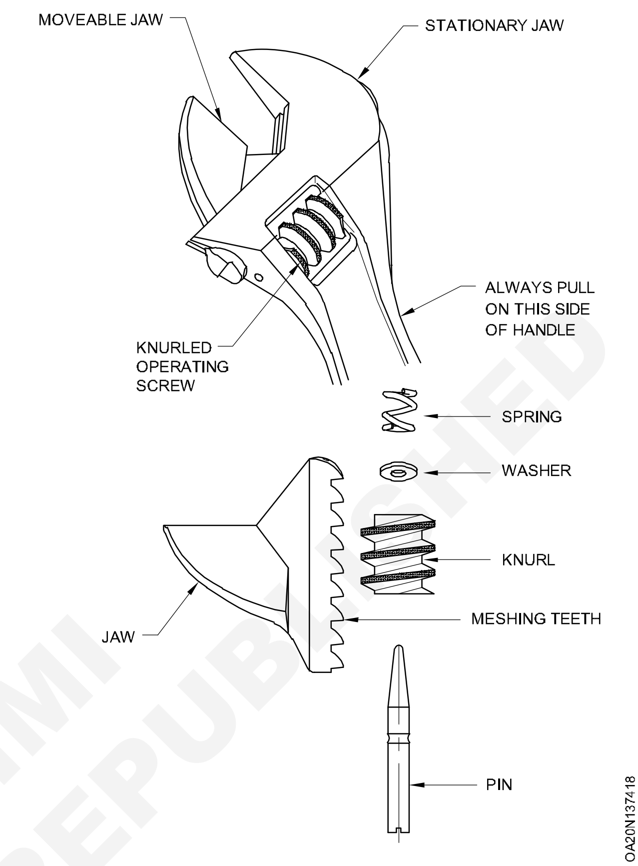
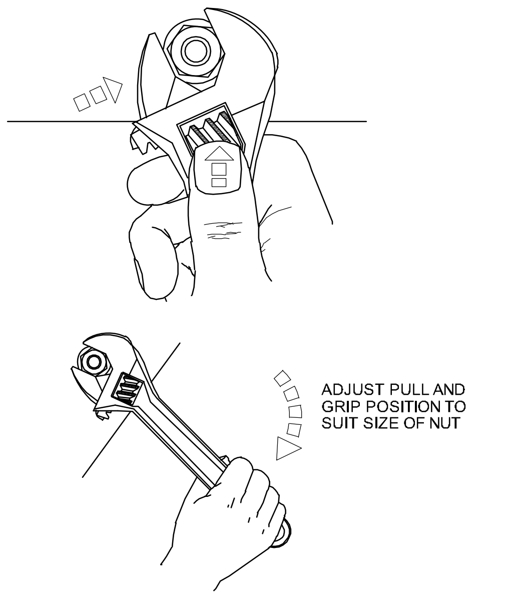


Fig 9



The applications of 'C' spanners are shown in figure 0. With socket spanners, use the reversible ratchet handle for doing fast work, where turning space is restricted. (Fig 11)

Fig 10

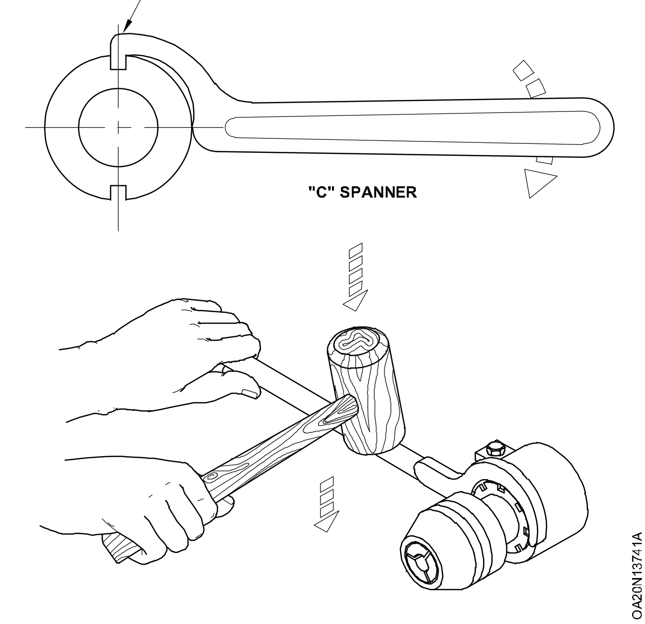
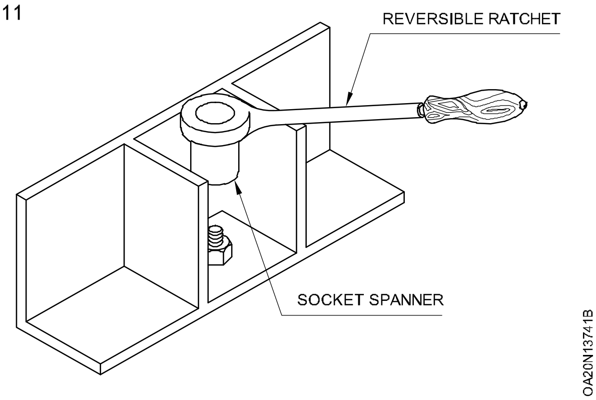

PUSH LUG RIGHT INTO SLOT
"C" SPANNER
OA20N13741A

Fig 11

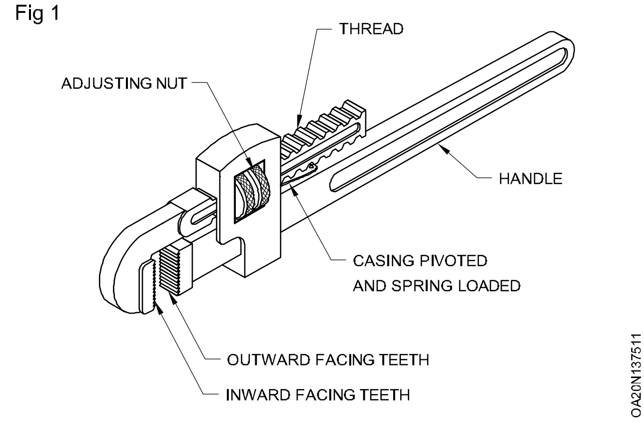

REVERSIBLE RATCHET
SOCKET SPANNER
OA20N13741B

Wrenches

Objectives: At the end of this lesson you shall be able to
- **state the different types of pipe wrenches**
- **state the uses of each type of wrench.**

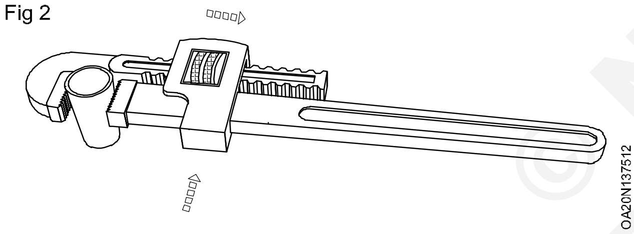
Stillson pipe wrench (Fig 1)

Fig 1



This pipe wrench is used for gripping and turning pipes tubes and cylindrical rods of different diameters (Fig 2)

Fig 2

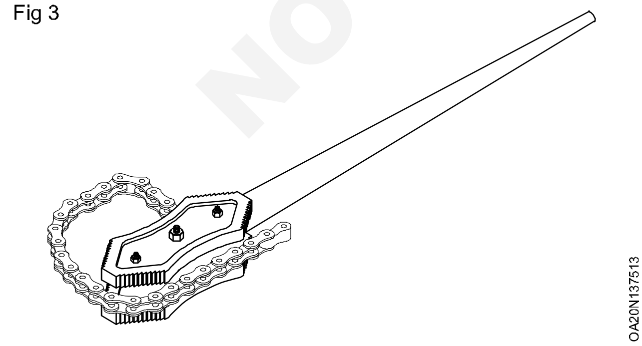


This is made of high tensile steel drop-forged, hardened and tempered. Stillson pipe wrenches are available in sizes from 6" to 24" inches (150 to 600 mm). The size refers to the overall length of the wrench when the jaws are opened to the maximum width.

These wrenches have sharp serrated teeth and will damage polished or plated surfaces.

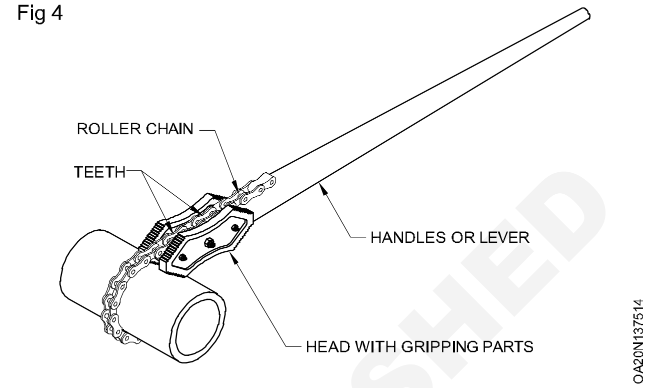
Chain wrench (Figs 3 & 4)

Fig 3



The chain wrench is used for holding or gripping large diameter pipes (Fig 4) where the Stillson wrench cannot be used.

Fig 4



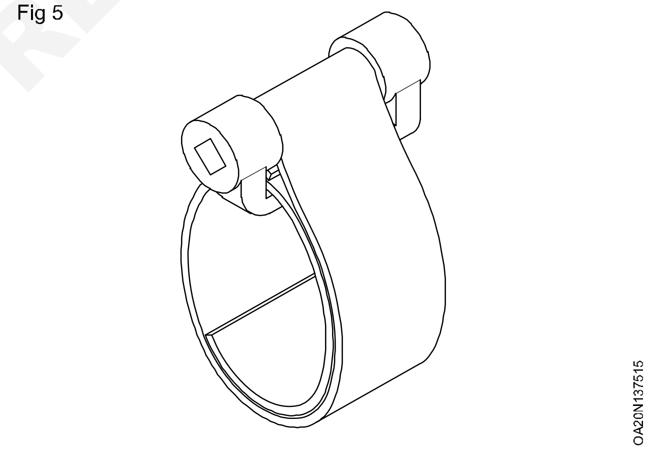
This wrench is made out of high tensile steel with hardened and tempered double-ended reversible jaws. A long tapered handle is bolted with the jaws.

The capacity of the chain wrench is approximately from 50 mm to 150 mm.

This can also be used for gripping irregular surfaces.

Strap wrench (Fig 5)

Fig 5



Strap wrenches are used on finished tubular surfaces to avoid marking or damaging. These wrenches have metallic straps by which the surfaces can be tightly gripped.

Foot print wrench (Fig 6) : These are used for gripping and turning pipes and round stocks in confined places.

The required size is adjusted by placing the pivot pin in the different holes of the solid handle.

The grip is obtained by squeezing both the solid handles together (Fig 7)

The selection of the hold should be such that the handles are not too far as this may result in uncomfortable holding of the handles.

Fig 6

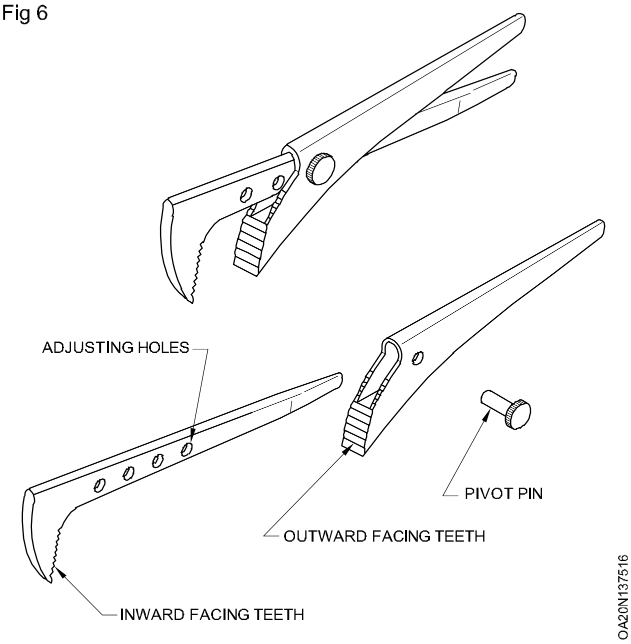
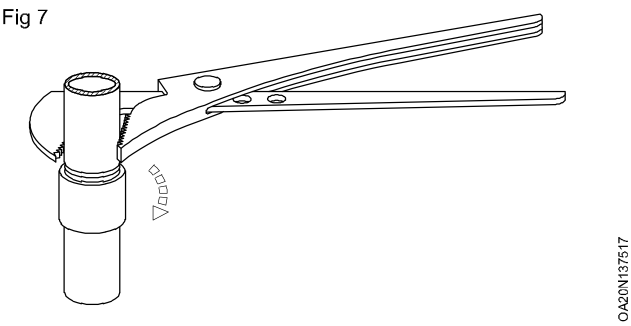

ADJUSTING HOLES
PIVOT PIN
OUTWARD FACING TEETH
INWARD FACING TEETH
OA20N137516

Fig 7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Purpose of drift, pullers and extraction

Objectives: At the end of this lesson you shall be able to
- **state the working principles of pulley**
- **describe the uses of drift**
- **how to use extraction.**

Drift

A drill drift key is tapered piece of steel that's used to knock the taper drill bit out of the drill shank. The taper drill often gets stuck in the shank, so the drill drift key is an essential tool to have.

The drill drift is intended to help get the chuck out, by sliding into a socket aligned with the top of the tapered rod inside the sleeve.

Hydraulic pulley

Working principle

Hydraulic pullers are popular with everyone because they are easy to operate and labor-saving to use.

The hydraulic puller moves directly forward with the hydraulic starting rod, so the push rod itself does not rotate. The hook seat can be adjusted forward and backward directly with the thread. During operation, as long as the handle is slightly swayed back and forth, the hydraulic starter rod moves forward, and the hook correspondingly retreats to pull out the pulled object.

Hydraulic puller is an ideal new tool to replace a traditional puller. The hydraulic puller is compact in structure, flexible in use, light in weight, small in size, easy to carry, labor-saving and non-slip. And it is not limited by venue, direction (0-360°), and position (2 claws, 3 claws). Widely used in dismantling various discs, flanges, gears, bearings, pulleys, etc.

How to use it

1 When using the integrated hydraulic puller, first put the slotted end of the handle into the oil return valve stem, and tighten the oil return valve stem in a clockwise direction.

2 Adjust the hydraulic puller hook claw seat so that the claw hook grasps the object being pulled.

3 The handle is inserted into the lifter hole, and the piston starter rod is tilted back and forth to move forward smoothly, and the claw hook retreats accordingly to pull out the pulled object.

4 The effective distance of the piston starting rod of the hydraulic puller is only 50mm, so the extension distance should not be greater than 50mm during use. Stop when it is not pulled out, loosen the oil return valve, let the piston start rod retract, and repeat steps 1, 2, and 3 for the second time after adjustment until it is pulled out.

5 To retract the piston start rod, just use the slotted end of the handle to slightly loosen the oil return valve rod in a counterclockwise direction, and the piston start rod gradually retracts under the action of the spring.

Hydraulic puller operation precautions

1 Before use, the hydraulic puller of the corresponding tonnage should be selected according to the outer diameter, pulling distance and load force of the object to be pulled, and it should not be overloaded to avoid damage.

2 In order to prevent equipment damage caused by overload, there is an overload automatic unloading valve in the hydraulic device. When the object being pulled exceeds the rated load, the overload valve will automatically unload, and a larger tonnage hydraulic puller will be used instead.

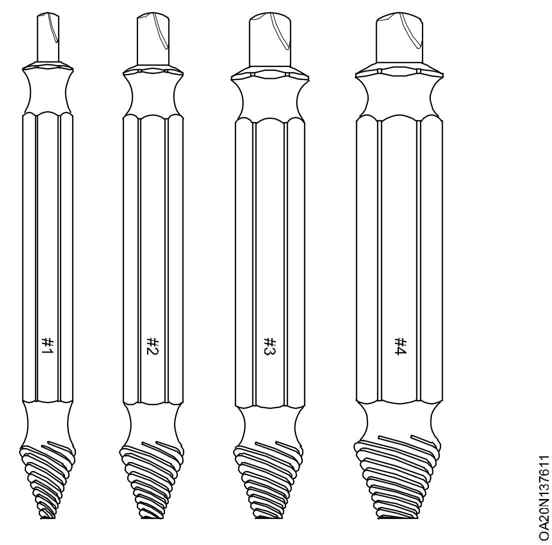
3 The hydraulic puller uses oil as the medium, and the maintenance of the oil and tools must be done well to avoid blockage or oil leakage, which will affect the use effect.

Screw Extractor

How a screw extractor removes damaged screws

The key to the screw extractor's usefulness lies in its general design. While brands vary, the most common design uses a tapered drill bit with reverse threading. This helps it lock into and remove damaged screws. (Fig 1)

Fig 1



Basically, after punching or drilling into the top of your busted-up screw, you'll use a screw extractor to bite down into the screw and twist it back out of whatever it was holding together.

HOW TO USE A SCREW EXTRACTOR – STEP BY STEP

Gather Some Needed Tools

You need a few tools depending on the type and size of fastener as well as the material you're trying to remove it from:

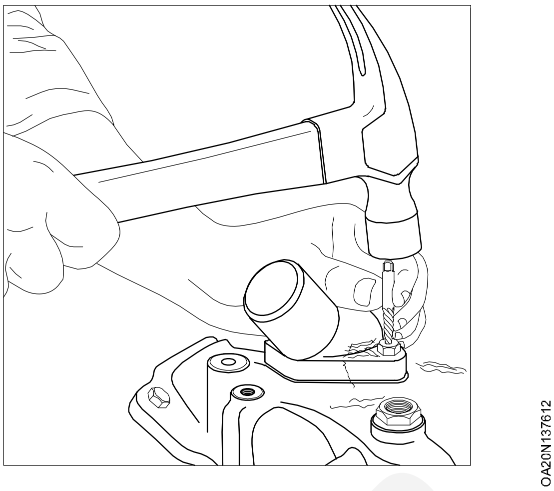
- Screw extractor
- Hammer
- Center punch
- Drill bits
- Thread cutting oil and/or penetrating oil
- Wrench
- Safety glasses

Punch It Out : With a basic screw extractor, you may need to provide some space in the screw head for it to work. That means drilling or expanding a hole in that old screw.

To do this, you align a punch to the center of the screw and hammer it down lightly. This will create an indentation in the very center of the screw that will help guide the drill bit. (Fig 2)

Drilling a Guide Hole : Next, find a drill bit that has a smaller diameter than the screw you need to remove. To make your life easier, add a little bit of thread cutting oil to the head of the screw.

Fig 2



Keeping your drill bit straight, drill down slowly into the screw. Depending on the size of the screw extractor you plan to use, you probably only need to drill down about 1/8" to 1/4".

Screw It

If you're using a drill in reverse, turn the screw extractor into the guide hole you've drilled. The screw extractor will twist down until it grabs hold of the screw. Once that happens, just keep turning until your screw is safely out. Go very slow.

Types of lathe

Objectives: At the end of this lesson you shall be able to
- **state the different types of lathes and their uses**
- **state the method of specifying a centre lathe.**

Types of lathes

There are different types of lathes, employed for different applications. They are:

- speed lathes
- engine lathes
- bench lathes
- tool room lathes
- capstan and turret lathes
- special purpose lathes
- automatic lathes.

Speed lathe

This is the simplest of all types of lathes. This is designed to operate at high spindle speeds. There are no conventional parts like carriage, lead screw, feed rod and tool post. Hence the tool can be controlled by hand. This type is used in wood working, spinning and polishing work.

Engine or centre lathe

An engine lathe or centre lathe is the type mostly used in industries. This is used to do general turning operations like turning, facing, drilling, boring and screw cutting.

Bench lathe

This is similar to the engine lathe but is smaller in size and is fitted on a bench. This is suitable for simple, small, accurate works.

Tool room lathe (Fig 1)

This has similar features as those of an engine lathe. But this is built more accurately with a high range of speeds, feeds and has various attachments. This is costlier than the regular engine lathe.

Capstan and turret lathe (Fig 2 & 3)

In this type the tailstock is replaced with a turret head which accommodates a number of tools and equipments. Hence multiple tools can be mounted and fed in sequence. This is suitable for mass production where a number of operations are to be done in sequence without disturbing the tool setting.

Fig 1

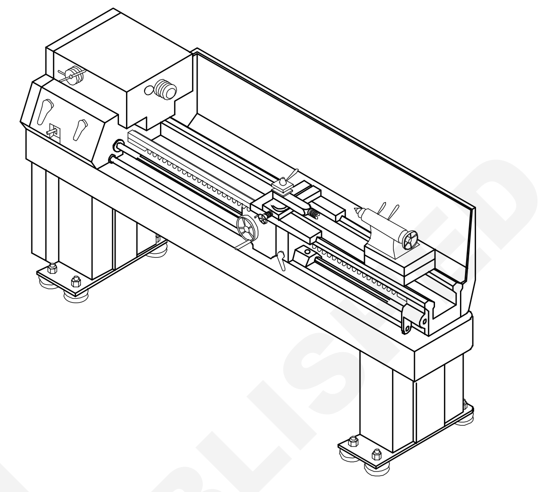
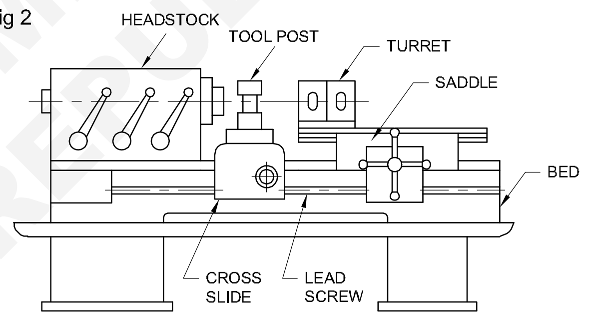


Fig 2



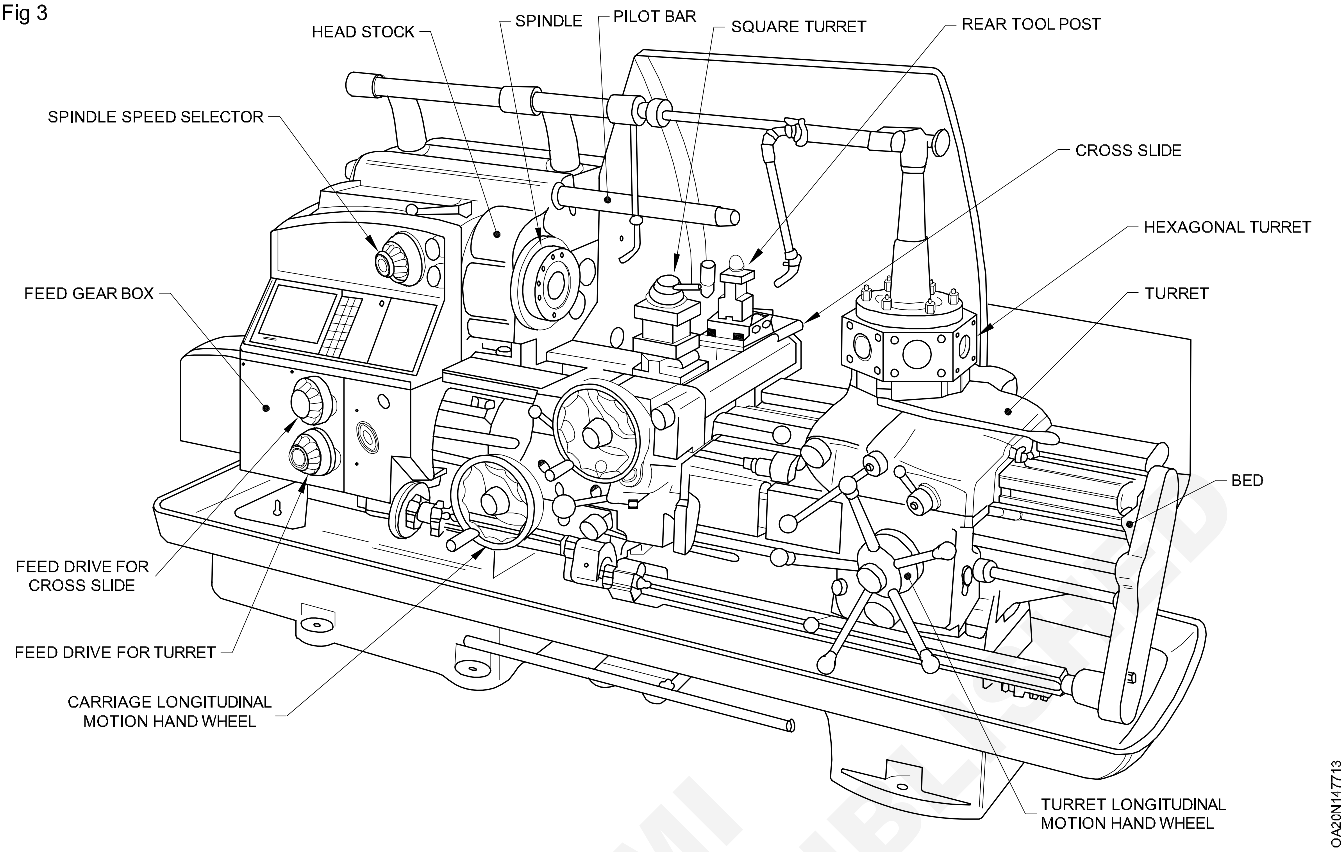
Special purpose lathe

These types of lathes are specially designed and built to manufacture a particular part. Normally they will not be suitable for a different type of operation. These are essentially mass production lathes.

Automatic lathe

In these machines all or most of the actions are performed automatically. For example feeding the raw material, tool change, feed, speed change, unloading the work etc. are all performed without manual operation. These lathes are used only for mass production. Initially the operator has to set the tools and load the long bar-stock. Once the machine is set it can work non-stop until the entire bar is used up.

Fig 3



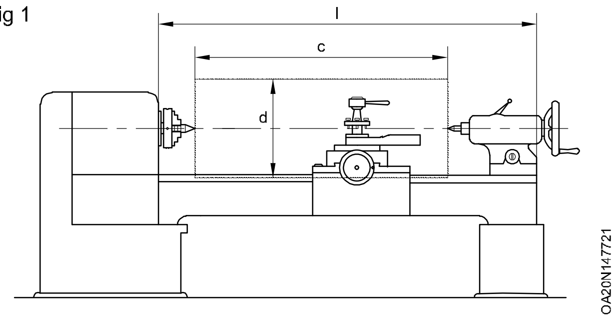
Centre lathe specification

Objective : At the end of this lesson you shall be able to
- **specify the size of a lathe.**

The size of a lathe is specified by (Fig 1)

- the length of the bed (l)
- the maximum diameter (swing) of the work that can be turned (d)
- the length between centres (c) and
- the pitch of the lead screw.
- the maximum diameter of bar that passes through hole of the head stock spindle.
- number of spindle speeds and feeds available.
- power input.
- floor space required.

Fig 1



Centre lathe parts

Objective : At the end of this lesson you shall be able to
- **identify the main parts of a lathe.**

Turning and centre lathe

Turning is a machining process to bring the raw material to the required cylindrical shape and size by metal removal. This is done by feeding a cutting tool against a rotating work.

The machine tool on which turning is carried out is known as a lathe.

Constructional features of a lathe

A lathe has provisions to:

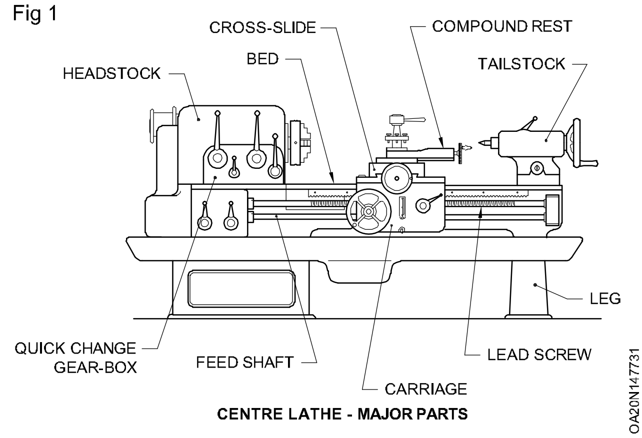
- hold the cutting tool and feed it against the direction of rotation
- have the parts fixed and sliding to get a relative movement of the cutting tool with respect to the rotation of the work

- fit accessories and attachments for performing the different operations.

Main parts (Fig 1)

The main parts of a lathe are drawn in Fig 1.

Fig 1



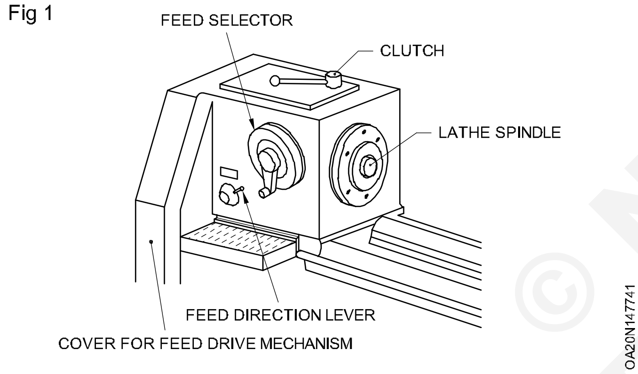
CENTRE LATHE - MAJOR PARTS

Head stock

Objectives : At the end of this lesson you shall be able to
- **state the functions of the headstock**
- **differentiate between cone pulley headstock and all-geared headstock**
- **state the uses and functioning of tailstock.**

The following are the functions of a headstock (Fig 1)

Fig 1



- Provide a means to assemble the work-holding devices.
- Transmit the drive from the main motor to the work.
- Accommodate shafts, gears and levers for a wide range of varying work speeds.
- Ensure arrangement for lubricating the gears, shafts and bearings.

Types of headstocks

The following are the two types of headstocks.

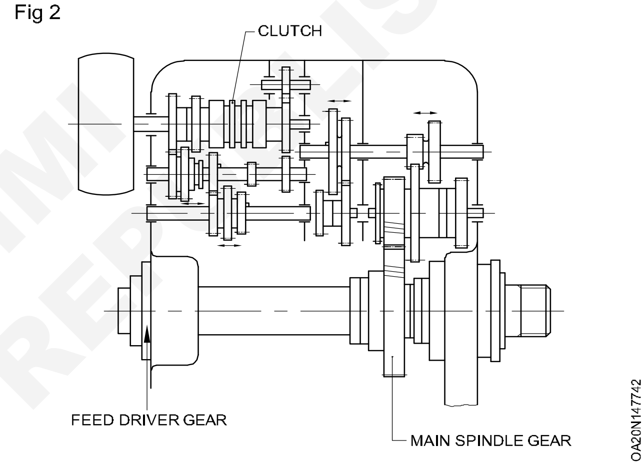
- All-geared headstock.
- Cone pulley drive headstock.

All geared headstock (Fig 2)

It is a box section casting having a removable top cover. It has internal webs for stiffening, and to take shaft bearings. It has an input shaft which is connected by means of 'V' belts to the main motor, and it runs at a constant speed. It is equipped with clutches and a brake.

There may be two or more intermediate shafts on which sliding gears are mounted. The main spindle is the last drive shaft in the headstock assembly. The nose of the spindle is outside the headstock casting, and is designed to accommodate the work-holding devices.

Fig 2



The levers operating the forks for the sliding gears are situated in front of the headstock casting.

In the all-geared headstock, lubricating oil is filled for splash lubrication of the internal gears. A sight glass with an oil level mark is provided to see the oil level.

Cone pulley headstock (Fig 3)

It has a stepped cone pulley mounted on the main spindle, and it is free to revolve. It is connected by means of a flat belt to a similar cone pulley, with steps arranged in the reverse order. This cone pulley gets the drive from the main motor.

The spindle is mounted on the bearing on the headstock casting and has a gear wheel called 'bull gear' keyed to it. A pinion is coupled to the cone pulley.

The back gear unit has a shaft which carries a gear and a pinion. The number of teeth of the gear and pinion on the back gear shaft corresponds to the number of teeth on the bull gear and pinion on the cone pulley. The axis of the back gear shaft is parallel to the axis of the main spindle. The back gear is engaged or disengaged with the cone pulley system by means of a lever. The back gear unit is engaged for reducing the spindle speeds. (Fig 4)

Fig 3

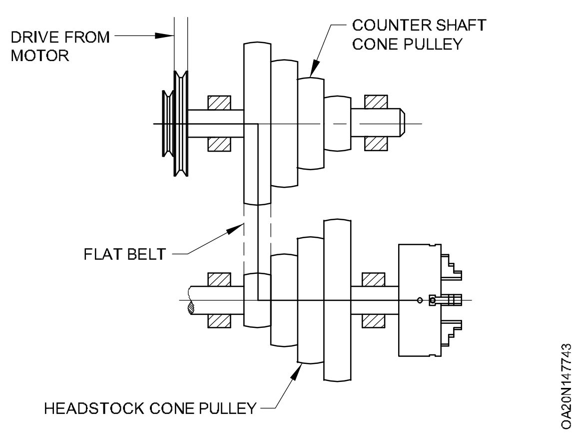
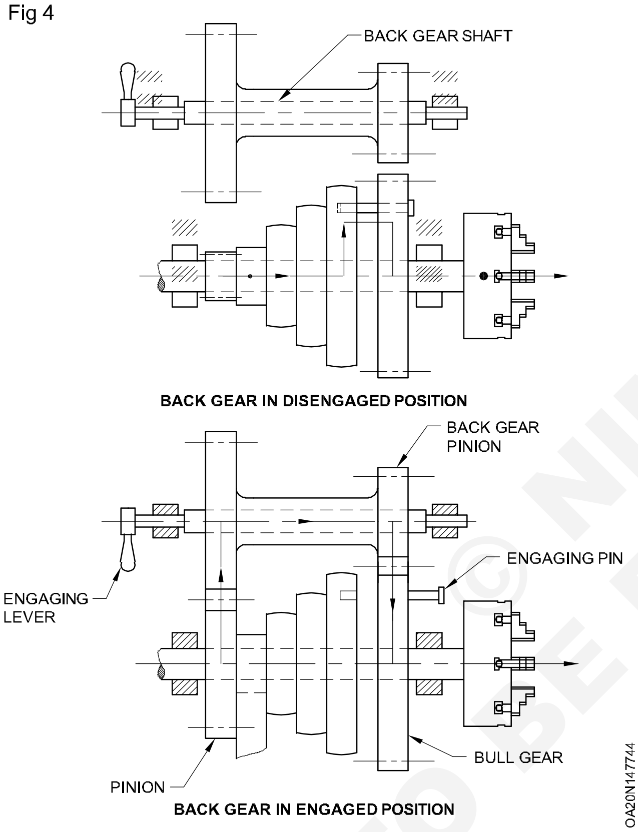


Fig 4



A three-stepped cone pulley headstock provides 3 direct ranges of speeds through a belt connection. With the back gear in engagement, 3 further ranges of reduced speeds can be obtained.

Advantages

- Can take heavy load.
- Less noise during working.
- Easy to maintain.

Disadvantages

- The number of spindle speeds is limited to the number of steps in the cone pulley.
- It takes time to change the spindle speeds.

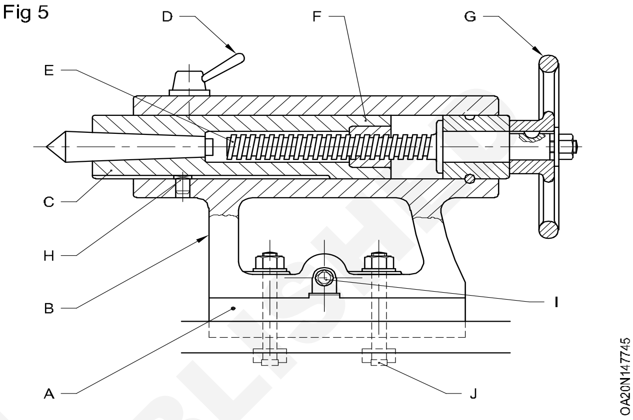
Tailstock

It is a sliding unit on the bed-ways of the lathe bed. It is situated on the right hand side of the lathe. It is made in two parts namely the 'base' and the 'body'. The base bottom is machined accurately and has 'V' grooves corresponding to the bed-ways. It can slide over the bed and can be clamped at any position on the bed by means of the clamping unit. The body of the tailstock is assembled to the base. Graduations are marked on the rear end of the base and a zero line is marked on the body.

When both zero lines coincide, the axis of the tailstock is in line with the axis of the headstock.

The body and base are made out of cast iron. The parts of a tailstock are: (Fig 5)

Fig 5



- base (A)
- body (B)
- spindle (barrel) (C)
- spindle locking lever (D)
- operating screw rod (E)
- operating nut (F)
- tailstock hand wheel (G)
- key (H)
- adjusting screws (J)
- clamping unit (I)

Functioning of a tailstock

By rotating the hand wheel, the barrel can be moved forward or backward. The barrel can be locked in any required position. The hollow end of the barrel at the front is provided with a Morse taper to accommodate the cutting tools with a taper shank. Graduations are sometimes marked on the barrel to indicate the movement of the barrel. With the help of the adjusting screws, the body can be moved over the base laterally, and the amount of movement may be read approximately referring to the graduations marked. This arrangement is to offset the centre of the tailstock as required for taper turning.

Purpose of the tailstock

- To accommodate the dead centre to support lengthy works to carry out lathe operations.
- To hold cutting tools like drills, reamers, drill chucks provided with taper shank.
- To turn external taper by offsetting the body of the tailstock with respect to the base.

Lathe bed

Objectives : At the end of this lesson you shall be able to
- **state the functions of a lathe bed**
- **identify the different types of bed - ways**
- **state the advantage of gap beds.**

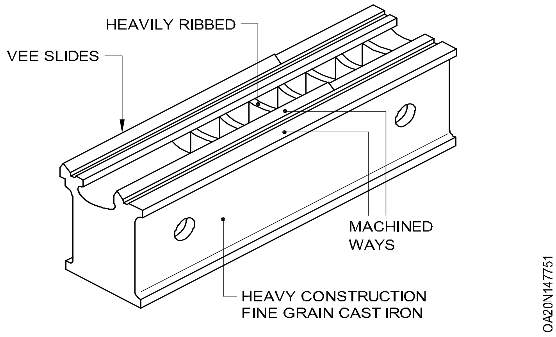
Functions of a lathe bed

The functions of a lathe bed are:

- to locate the fixed units in accurate relationship to each other
- to provide slideways upon which the operating units can be moved.

Constructional features of a lathe bed (Fig 1)

Fig 1



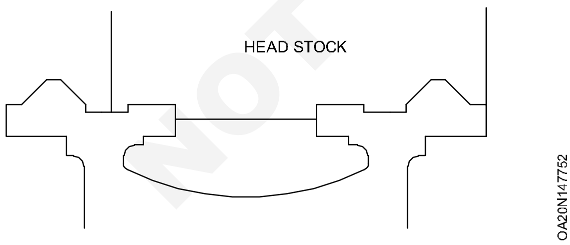
The lathe bed generally consists of a single casting. In larger machines, the bed may be in two or more sections accurately assembled together. Web bracings are employed to increase the rigidity. For absorbing shock and vibration, the beds are made heavy.

A combined swarf and coolant tray is provided on the lathes. This may be an integral part with the lathe bed.

The bed is generally carried by cast iron or welded sheet metal legs of box section. This provides the necessary working height for the lathe. Very often the electrical switchgear unit and the coolant pump assembly are housed in the box section of the legs at the headstock end.

Bed-ways (Fig 2)

Fig 2



The bed-ways or slideways assist in accurate location and sliding of the accessories/parts mounted on this. The bed-ways are of three types.

- Flat bed-ways (Fig 3)
- 'V' bed-ways (Fig 4)
- Combination bed-ways (Figs 5A & 5B)

Fig 3

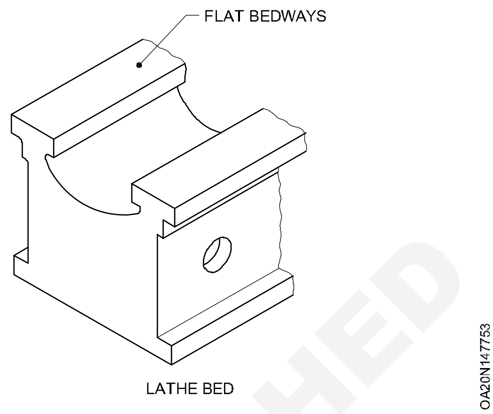


Fig 4

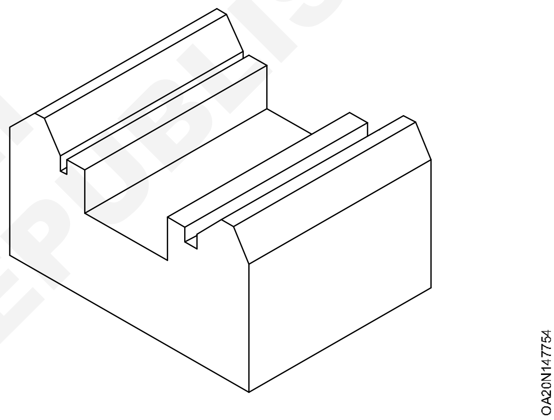
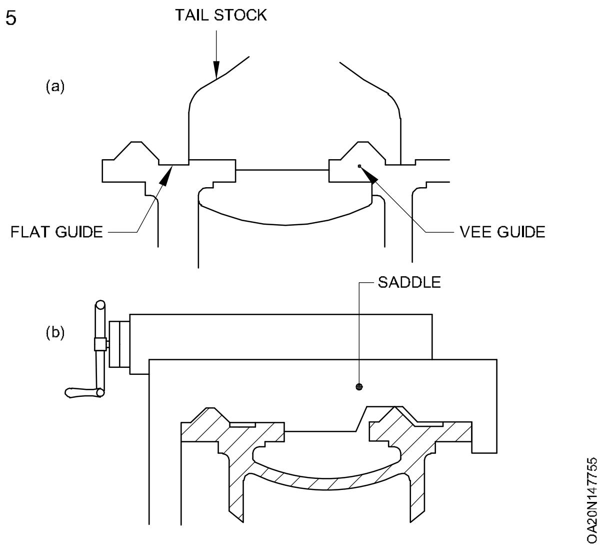


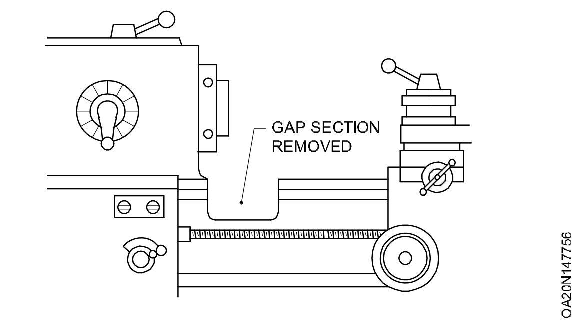
Fig 5



Normally the bed-ways stop at a distance away from the headstock with a gap at this point. This enables to mount larger diameters of works.

Some lathes have detachable section of the bed, which can be fitted when desired, to enable the saddle to operate close to the headstock. (Fig 6)

Fig 6



Some bed-ways are fine finished by grinding. Some lathes have their bed-ways hand-scraped. Some have their bed-ways hardened and ground. The wear-resisting qualities of bearing surfaces are improved by employing chilled iron castings.

The beds are mostly made up of close grained grey cast iron.

Lathe carriage

Objectives: At the end of this lesson you shall be able to
- **state the parts of a lathe carriage**
- **state the functions of the apron**
- **state the parts and functions of the saddle**
- **state the functions of the feed shaft, lead screw and feed lever.**

Carriage (Fig 1)

The carriage is the lathe feature that provides the method of holding and moving the cutting tool. It consists of two major parts.

- The apron
- The saddle

The apron (Fig 1)

The apron is bolted to the front end of the saddle. It contains the mechanism for moving and controlling the carriage.

The saddle (Fig 1)

The saddle is that part of the carriage that fits the bed slideways and moves along the bed between the head and the tailstock.

It is an assembly consisting of the following parts.

- Cross-slide
- Compound rest
- Top slide
- Tool post

Cross-slide (Figs 1 & 2)

This part is mounted on the top of the saddle base and it moves along the saddle base in a direction perpendicular to the bed. This movement is accomplished by means of a screwed spindle and hand wheel.

Compound rest (Figs 1 & 2)

This is fitted on the top of the cross-slide and may be swivelled horizontally, clockwise or anticlockwise through 360°.

Top slide (Fig 1)

This part is connected to the compound rest by means of a screwed spindle and it has a short travel on the compound rest. It provides a means of supporting the tool post which holds the cutting tool.

Fig 1

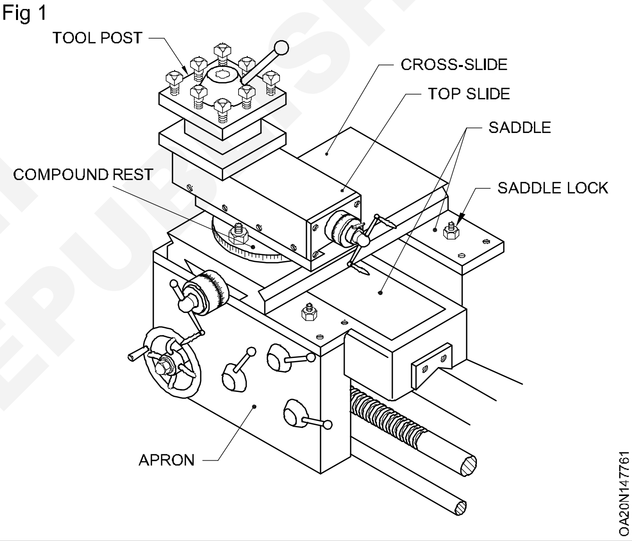
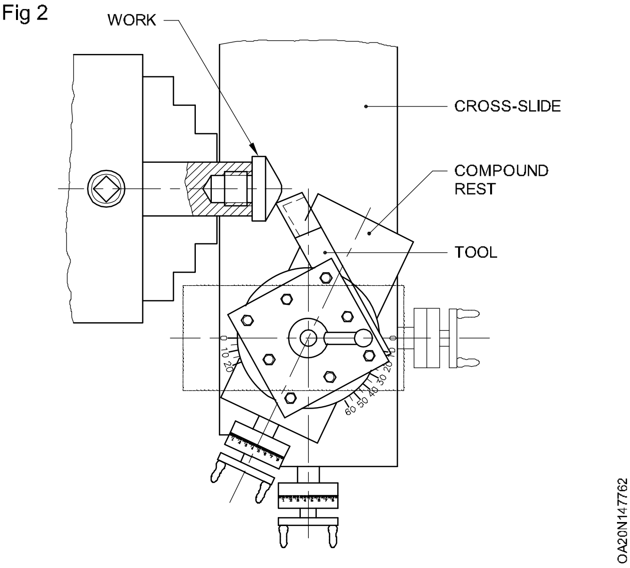


Fig 2



By swivelling the compound rest the top slide may be set to a desired angle to the cross-slide and fed at that angle, and turn tapers.

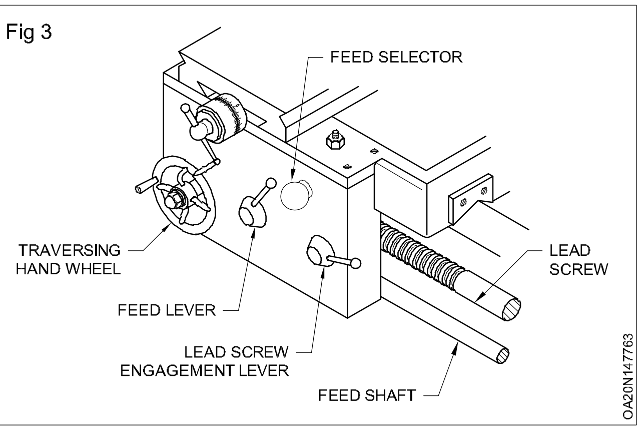
In the normal case the compound rest is set so that the top slide is at right angles to the cross-slide and in this position the setting angle is 0°.

Feed shaft (Fig 3)

Usually the carriage is moved manually by means of a hand wheel. But the carriage can also be moved by power (automatic feed). The power for automatic feed comes from the headstock and is transmitted to the carriage through the feed shaft.

Lead screw (Fig 3)

Fig 3



Centre lathes, equipped with power feed, also have a provision for screw cutting. A special threaded spindle called lead screw, mounted on the front of the lathe bed and driven through the quick change gearbox, helps to cut screw threads.

In some small lathes the lead screw and feed shafts are combined.

Both the lead screw and the feed shaft pass through the apron of the carriage. Controls on the apron enable the feed shaft or the lead screw to be connected to the carriage at the operator's will.

Feed lever

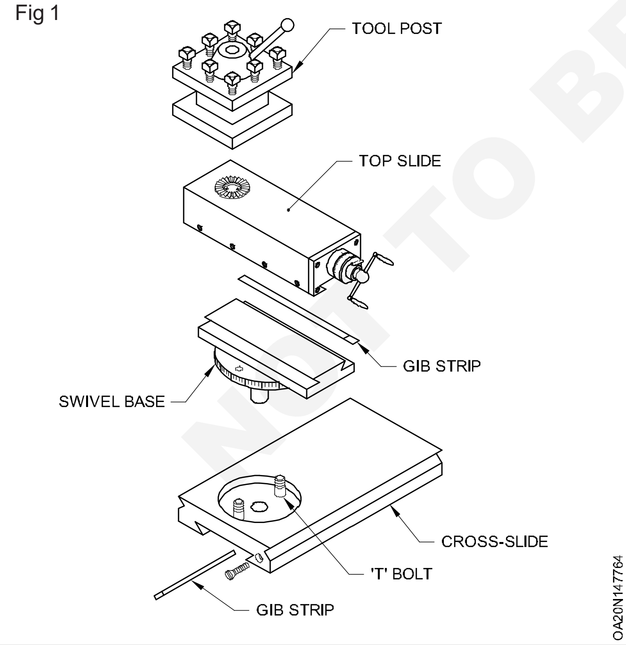
This lever is used to engage and disengage the automatic feed mechanism which provides automatic feeding for both facing and turning operations.

Tool posts

Objectives: At the end of this lesson you shall be able to
- **name the commonly used types of tool posts**
- **compare the features of the different types of tool posts.**

The tool post fitted on the top slide holds and supports the tool firmly. (Fig 1)

Fig 1

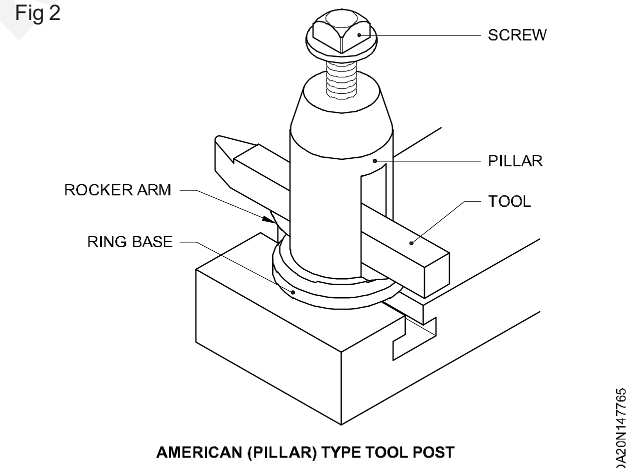


The commonly used types of tool posts are:

- American type tool post or single way tool post
- indexing type tool post or square tool post
- quick change tool post.

Single way tool post (Fig 2)

Fig 2



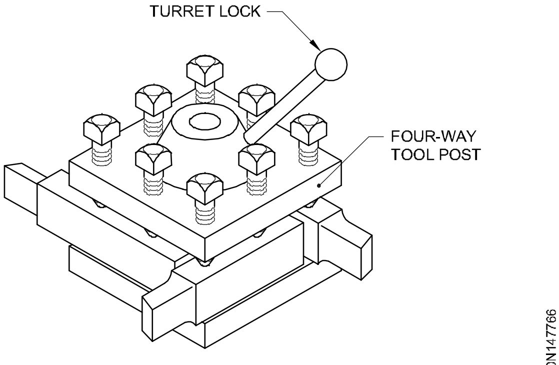
AMERICAN (PILLAR) TYPE TOOL POST

It consists of a circular tool post body and a pillar with a slot for accommodating the tool or tool-holder. A ring base, a rocker arm (boat piece) and a tool-clamping screw complete the assembly of this type of tool post.

The tool is positioned on the boat piece and is clamped by the screw. The centre height of the tool tip can be adjusted with the help of the rocker arm and the ring base. Only one tool can be fixed in this type of tool post. The rigidity of the tool is less as it is clamped with only one screw.

Indexing type tool post (Fig 3)

Fig 3



INDEXING TYPE TOOL POST

It is also called a square tool post or a four-way tool post. Four tools can be fixed in this type of tool post, and any one of them can be brought into the operating position. The indexing may be manual or automatic.

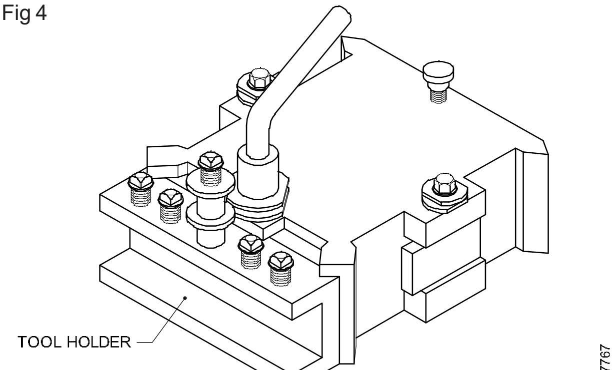
The advantages are as follows.

Each tool is secured in the tool post by more than one screw and, therefore, the rigidity is more.

Frequent changing of the tool for different operations need not be done as all the four tools can be clamped at the same time.

The disadvantage is that skill is required to set the tools, and it takes more time to set to the centre height.

Fig 4



QUICK CHANGE TOOL POST

Quick change tool post (Fig 4)

Modern lathes are provided with this type of tool post. Instead of changing the tools, the tool-holder is changed in which the tool is fixed. This is expensive as a number of tool-holders may be needed to preset various tools. But it can be set to the centre height easily, and has the best rigidity for the tool.

Lathe accessories - lathe centres

Objectives : At the end of this lesson you shall be able to
- **state what is a lathe centre**
- **distinguish between live centre and dead centre**
- **state the purpose of lathe centres**
- **identify and name the different types of lathe centres**
- **indicate the specific uses of each type of centre.**

Lathe centre

It is a lathe accessory. It is used to support lengthy works for carrying out lathe operations. When the work is held in the chuck, the centre assembled in the tailstock supports the overhanging end of the work. The work is to be provided with a centre drilled hole on the face of the overhanging end. The centre, which is accommodated in the main spindle sleeve, is known as the 'live centre' and the centre fixed in the tailstock spindle is known as the 'dead centre'. In construction, both centres are identical. Lathe centres have a conical point of 60° included angle, the body provided with a Morse taper shank and a tang. (Fig 1 and 2).

Types of centres and their uses

The dead centre is made of high carbon steel, hardened and ground whereas the live centre need not have its conical tip hardened as it revolves with the work. A good lubricant should be used for the dead centre.

The Table 1 gives the names of the most widely used types of lathe centres, their illustrations and specific uses.

Fig 1

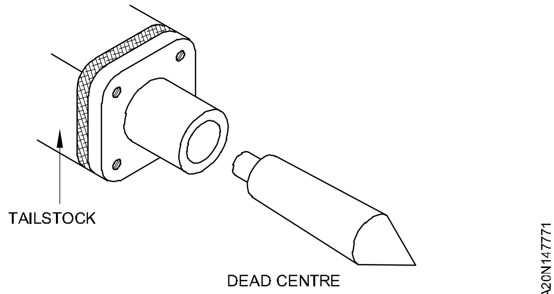


Fig 2

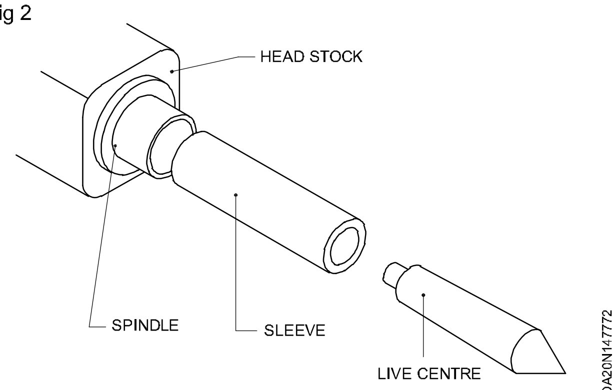
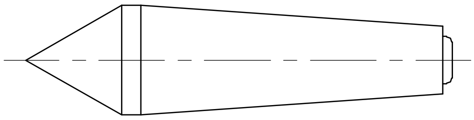
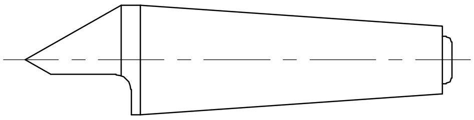
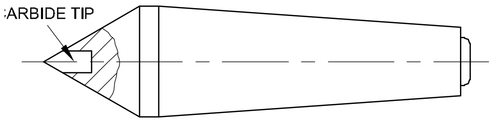
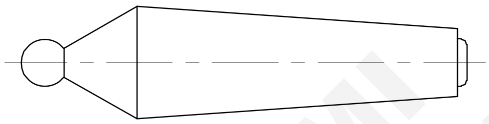
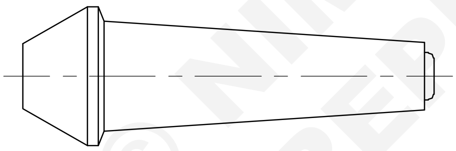
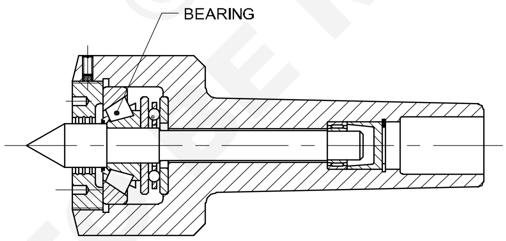
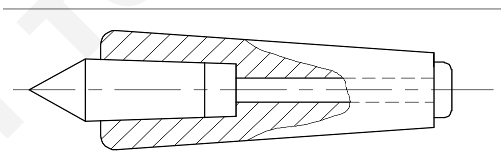
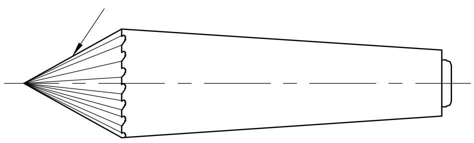
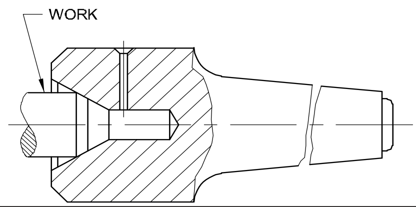
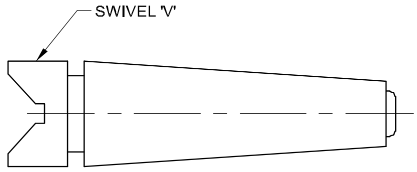


TABLE 1

Types of lathe centres

Sl. No	Name	Sketch	Uses
1	Ordinary Centres		Used for general purposes. (Common type)
2	Half Centre		Though it is termed as half entre, little less than half is relieved at the tip portion. Used while facing the job without disturbing the setting
3	Tipped Centre		A carbide or a hard alloy tip is brazed into an ordinary steel shank. the hard tip is wear - resistant.
4	Ball centre		Minimum wear and strain. Particularly suitable for taper turning by tailstock offset method.
5	Pipe Centre		Used for supporting pipes, shells and hollow end jobs.
6	Revolving centre		Frictionless. Used for centre supporting heavy jobs revolving with high speeds. A high speed steel inserted centre, it is supported by two bearings housed in a body. It is also called the revolving dead centre.
7	Insert type centre		Economical. Only the small high speed steel insert is replaced.
8	Self - Driving live		Usually mounted on the headstock spindle. Used Centre while machining the entire length of he job in one setting. Grooves cut around the circumference of the centre point provide for good gripping for the job. This centre can be used only for soft metal jobs and not for hardened jobs.

9	Female Centre		This centre is used to support the end of the job where no countersink hole is permitted.
10	Swivel 'V' Centre		This centre is used to support a job in the'V' portion and to drill holes across the round job by using a drill bit in the headstock spindle

Lathe accessories - steady rest

Objectives : At the end of this lesson you shall be able to
- **state what is a steady rest**
- **identify and name the types of steady rests**
- **distinguish between fixed steady rest and follower steady rest**
- **state the uses of a steady rest.**

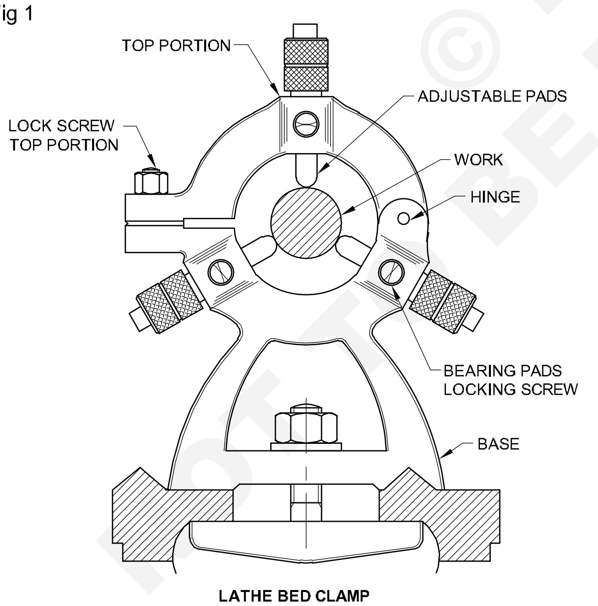
A steady rest is a lathe accessory used to give extra support for a long slender workpiece in addition to the centre support during turning.

The most commonly used steady rests are the:

- fixed steady rest
- follower steady rest (travelling steady).

Fixed steady rest (Fig 1)

Fig 1



The figure shows the parts of a fixed steady rest.

A fixed steady rest is fixed to the lathe bed and it is stationary. It gives support at one fixed place only.

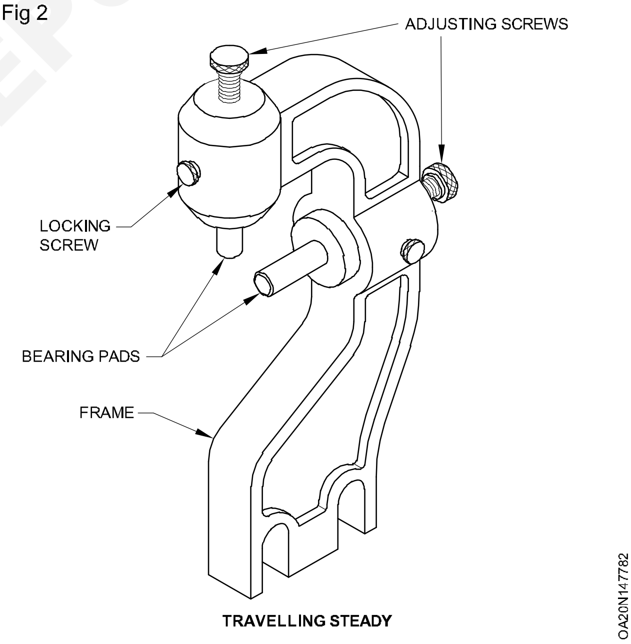
It consists of a frame containing three adjustable pads.

The base of the frame is machined to suit the inside ways of the lathe bed. The top portion is hinged at the back to permit the top to be lifted or assembled to the bottom half for allowing the work to be mounted or removed. The fixed steady can be clamped at any desired position on the lathe bed by the base clamping screw.

The three adjustable pads can be moved radially in or out by means of adjusting screws. The three pads are adjusted on a trued cylindrical face of the workpiece.

Follower steady rest (Fig 2)

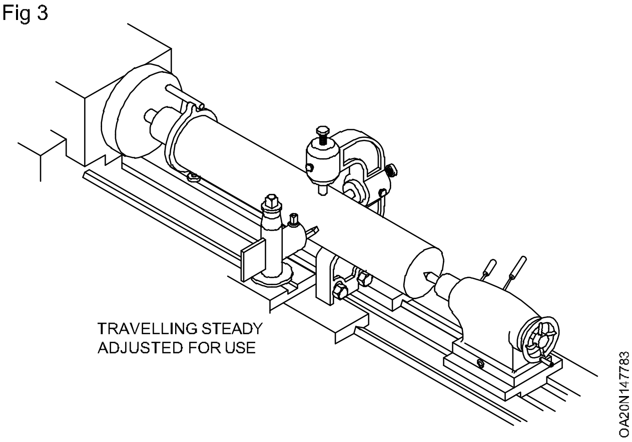
Fig 2



A follower steady is fixed to the saddle of the lathe. As it follows the tool it gives support just behind the cutting point. In the case of the follower steady the support is continuous to the entire length of cutting.

It has usually two pads. One pad is located opposite to the cutting tool and the other pad bears the top of the workpiece to prevent it from springing up. Fig 3 shows the travelling steady rest in position.

Fig 3

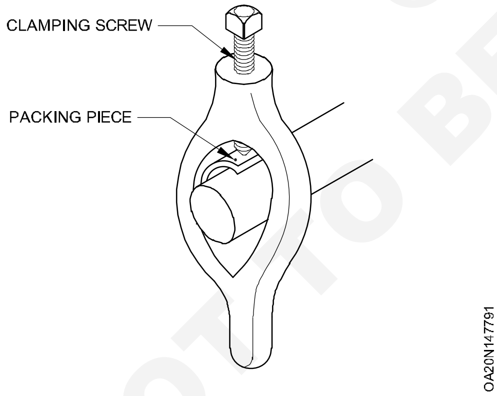


Lathe carriers

Objectives: At the end of this lesson you shall be able to
- **state the functions of lathe carriers**
- **name the different types of lathe carriers**
- **state the features of different types of lathe carriers**
- **distinguish between the uses of different types of lathe carriers.**

Lathe carriers are otherwise called lathe dogs. They are used to drive the work during turning between centres. The work is clamped firmly in the lathe carrier. The lathe carrier consists of a cast iron body and a clamping screw. It is available with a straight or bent tail. They are available in a set of 10, capable of accommodating works with a wide range of diameters. The tails of the carriers are meant to locate and drive the workpiece for turning. (Fig 1) To protect the finished surface from damage, a packing piece (made of soft material) is used under the clamping screw.

Fig 1



The types of lathe carriers commonly used are:

- straight tail carrier
- bent tail carrier
- clamp type carrier.

The tail of the straight tail carrier locates against the driving pin of the driving plate and provides a positive drive for the workpiece. (Fig 2)

A bent tail lathe carrier engages into a ‘u’ slot of the catch plate and drives the workpiece. (Fig 3)

The clamp type lathe carrier (Fig 4) is designed with a clamping plate and adjustable screws. It holds a wide range of diameters of work because it is provided with a ‘V’ groove and adjustable bolts and nuts. This carrier may be used to hold square and rectangular sectioned rods also. It is also very useful to hold small diameter jobs because of the provision of the ‘V’ groove. (Fig 4)

Fig 2

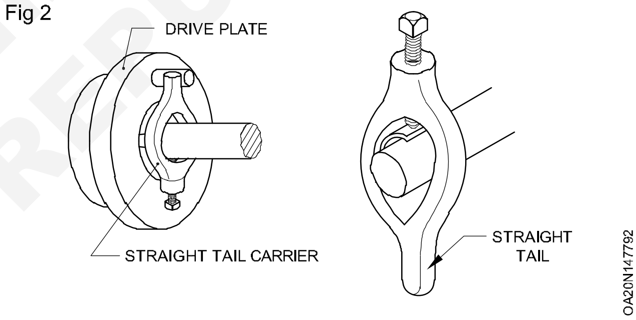


Fig 3

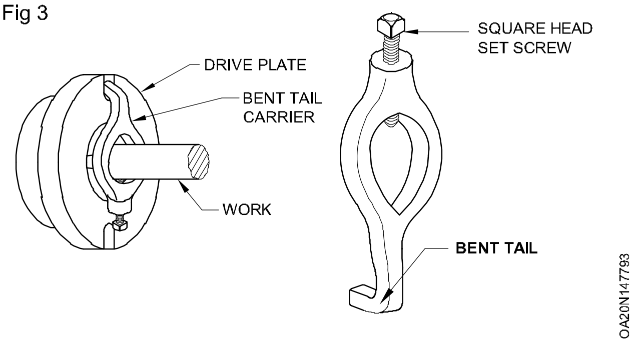
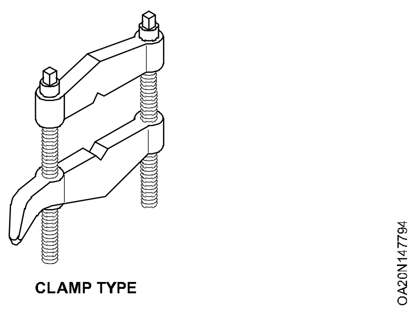


Fig 4



Driving plate and face plate

Objectives : At the end of this lesson you shall be able to
- **distinguish between the features and the uses of different driving plates**
- **identify and name the parts of a face-plate**
- **distinguish between the features and uses of different face-plates**
- **identify the face-plate accessories.**

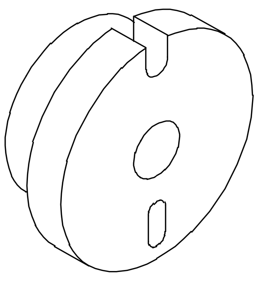
When turning jobs in between centres, driving plates are used. They are:

- catch plates
- driving plates
- safety driving plates.

Catch plate

It is designed with a 'U' slot and an elongated slot to accommodate the bent tail of the lathe carrier. (Fig 1)

Fig 1

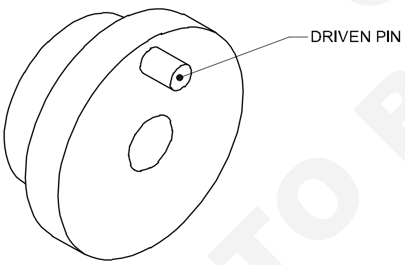


CATCH PLATE

Driving plate with pin

It is designed with a projected pin which locates the straight tail of the lathe carrier. (Fig 2)

Fig 2

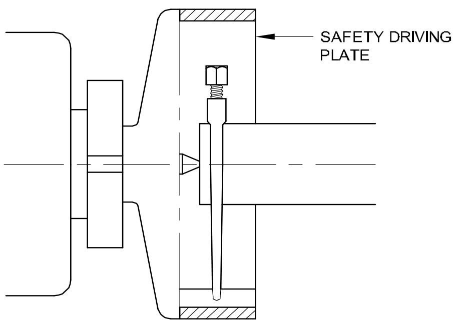


DRIVE PLATE

Safety driving plate

It is similar in construction to that of a driving plate but is equipped with a cover to protect the operator from any injuries. (Fig 3)

Fig 3



It is made of cast steel and is machined to have its face perfectly at right angles to the bore. It is provided with a stepped collar at the back. The bore is designed to suit the spindle nose to which the plate has to be mounted.

Uses

The driving plate with a straight tail carrier provides a positive drive for the workpiece.

Catch plates with bent tail carriers use a minimum length of the workpiece for clamping purposes.

A safety driving plate protects the operator from likely injuries.

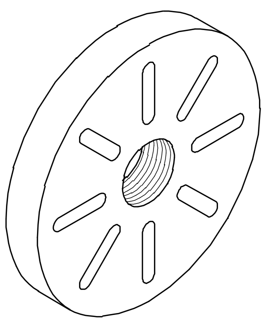
Face-plates

They are similar in construction to that of the lathe catch plates but are larger in diameter.

The different types of face-plates are:

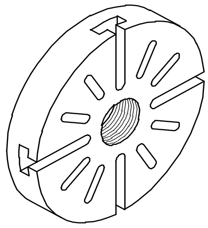
- face-plates with only elongated radial slots (Fig 4)

Fig 4



- face-plates with elongated slots and 'T' slots (Fig 5)

Fig 5



- face-plates with elongated radial slots and additional parallel slots. (Fig 6)

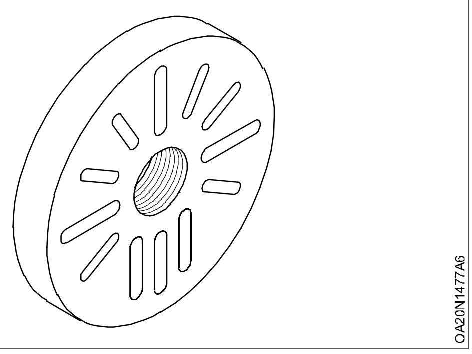
Face-plates are used along with the following accessories.

Clamps, 'T' bolts, angle plates, parallels, counterweights, stepped blocks, 'V' blocks etc.

Uses

Large, flat, irregular shaped workpieces, castings, jigs and fixtures may be firmly clamped to a face-plate for various turning operations.

Fig 6



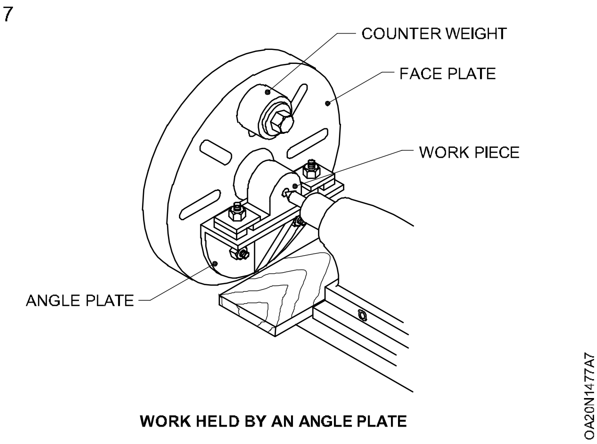
A work can be mounted on a face-plate while the face-plate is on the lathe spindle or on the workbench. If the workpiece is heavy or awkward to hold, the workpiece is mounted while the face-plate is on the workbench. Before mounting the face-plate and it is set up to the spindle, it is advantageous to locate the workpiece on the face-plate and centre the workpiece. Centre a punch mark or hole approximately on the face of the workpiece. This makes it easier to true the work after the face-plate is mounted on to the spindle.

The position of the bolts and clamps is very important, if a workpiece is to be clamped effectively.

If a number of duplicate pieces are to be machined, the face-plate itself can be set up as a fixture, using parallel strips and stop blocks.

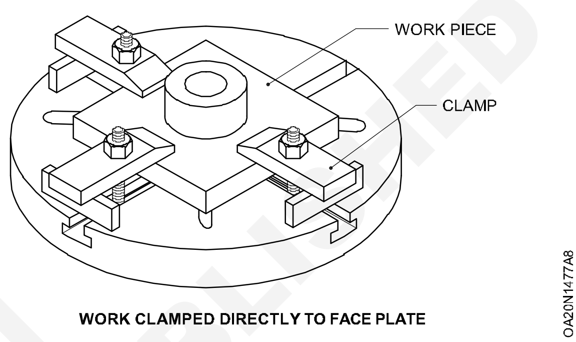
The application of the face-plate with the accessories in different set ups is shown in the sketches below. (Figs 7,8 and 9)

Fig 7



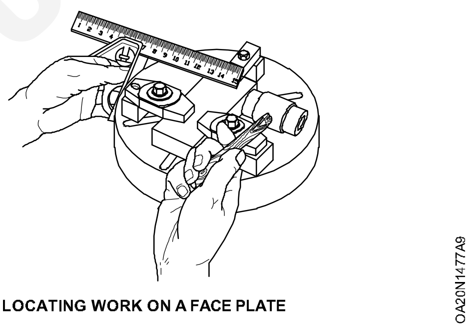
WORK HELD BY AN ANGLE PLATE

Fig 8



WORK CLAMPED DIRECTLY TO FACE PLATE

Fig 9



LOCATING WORK ON A FACE PLATE

Lathe accessories - work holding devices : four jaw chuck

Objectives : At the end of this lesson you shall be able to

- **identify the parts of a Four jaw chuck**
- **state the constructional features of a Four jaw chuck.**

Four-jaw chuck (Fig 1)

The four-jaw chuck is also known as an independent chuck, since each jaw can be adjusted independently; a work can be trued to within 0.001" or 0.02 mm accuracy, using this chuck.

This type of chuck is much more heavily constructed than the self-centering chuck, and has much greater holding power. Each jaw is moved independently by a square thread screw. The jaws are reversible for holding large diameter jobs. The independent four-jaw chuck has four jaws each working independently of the others in its own slot in the chuck body and actuated by its own separate square threaded screw. By suitable adjustment of the jaws, a workpiece can be set to run either true or eccentric with the machine centre.

Finished jobs when held in a four-jaw chuck can be trued with the help of a dial test indicator.

The checking of the workpiece should be carried out near the chuck and repeated as far from it as the workpiece permits, to ensure that the work is not held in the chuck at an angle to the axis of rotation.

The independent adjustment also provides the facility of deliberately setting the work off-centre to produce an eccentric workpiece. (Fig 2)

The parts of a four-jaw chuck are the:

- back plate
- body
- jaws

- square threaded screw shaft.

Fig 1

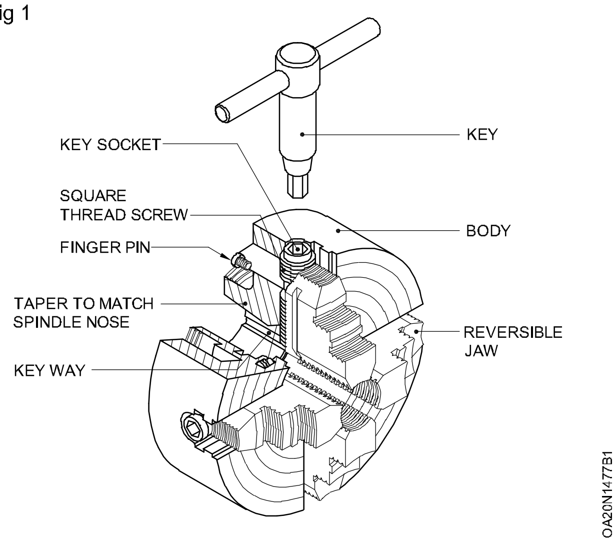
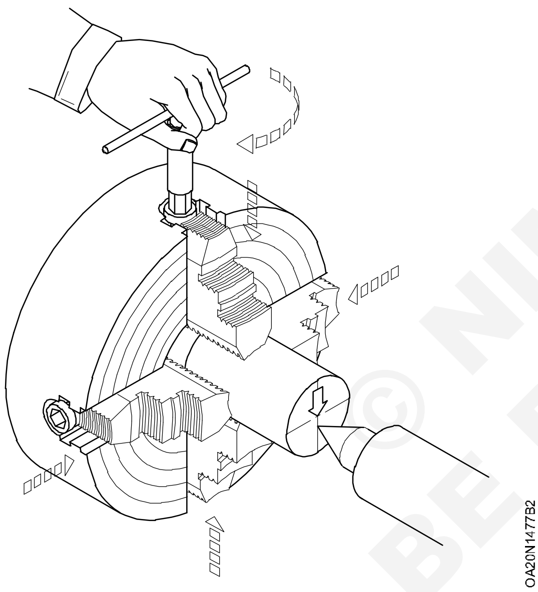


Fig 2



Back plate

The back plate is fastened to the back of the body by means of Allen screws. It is made out of cast iron/steel. Its bore is tapered to suit the taper of the spindle nose. It has a keyway which fits into the key provided on the spindle nose. There is a step in front on which the thread is cut. A threaded collar, which is mounted on the spindle, locks the chuck by means of the thread, and locates by means of the taper and key. Some chucks do not have back plates.

Body

The body is made out of cast iron/cast steel and the face is flame-hardened. It has four openings 90° apart to assemble the jaws and operate them. Four screw shafts are fixed on the periphery of the body by means of finger pins. The screw is rotated by means of a chuck key. The body, hollow in the cross-section, has equi-spaced circular rings provided on the face, which are marked by numerical numbers. Number 1 starts in the middle, and increases towards the periphery.

Jaws

The jaws are made out of high carbon steel, hardened and tempered, which slide on the openings of the body. These jaws are reversible for holding hollow work.

The back side of the jaw is square-threaded which helps in fixing the jaws with the operating screws.

Screw shaft

The screw shaft is made out of high carbon steel, hardened, tempered and ground. The top portion of the screw shaft is provided with a square slot to accommodate the chuck key. On the body portion, a left hand square thread is cut. In the middle of the screw shaft, a narrow step is made and held by means of finger pins. The finger pins permit the screws to rotate but not to advance.

Lathe accessories - work holding devices : three jaw chuck

Objectives : At the end of this lesson you shall be able to
- **identify the parts of a three jaw chuck**
- **state the constructional features of a three jaw chuck**
- **distinguish between a three jaw chuck and a four jaw chuck**
- **state the merits and demerits of the four jaw chuck over a 3 jaw chuck**
- **specify a chuck.**

he three jaw chuck (Fig 1)

The three jaw chuck is also known as self-centering chuck. The majority of the chucks have two sets of jaws for holding internal and external diameters. Only perfectly round work, or work with equally spaced flats, divisible by three, should be held in a three jaw chuck.

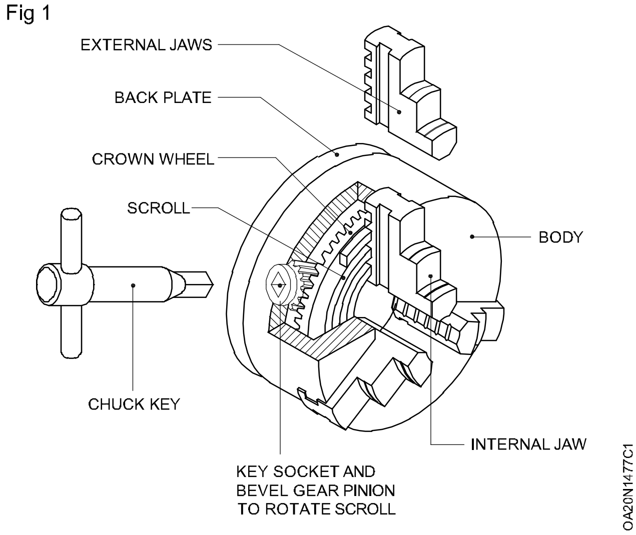
The construction of a three jaw chuck shows that the scroll not only clamps a component in place but also locates the component. This is fundamentally a bad practice, since any wear in the scroll and / or the jaws impairs the accuracy of location. Further, there is no means of adjustment possible to compensate for this wear.

The jaws of this type of chuck are not reversible, and separate internal and external jaws have to be used.

Parts of a three jaw chuck (Fig 1)

- Back plate
- Body
- Jaws
- Crown wheel
- Pinion

Fig 1



Back plate

The back plate is fastened at the back of the body by means of allen screws. It is made out of cast iron. Its bore is tapered to suit the taper of the spindle nose. It has a key-way which will fit into the key provided on the spindle nose. There is a step in the front on which the thread is cut. The threaded collar, which is mounted on the spindle, locks the chuck by means of the thread, and locates by means of the taper and the key.

Body

The body is made out of cast steel, and the face is hardened. The body has three openings - 120° apart to assemble the jaws and operate them. Three pinions are fixed on the periphery of the body to operate the jaws by means of a chuck key. The body is hollow in cross-section. The crown wheel is housed inside the body.

Jaws

The jaws are made out of high carbon steel, hardened and tempered, which slide on the openings of the body. Generally there are two sets of jaws, viz. external jaws and internal jaws. External jaws are used for holding solid works. Internal jaws are used for holding hollow works. The steps on the jaws increase the clamping range. The back side of the jaws are cut out of scroll thread. Each jaw is numbered in a sequential manner, which will help in fixing the jaws in the corresponding numbered slots.

Crown wheel

The crown wheel is made out of alloy steel, hardened and tempered. On one side of the crown wheel a scroll thread is cut to operate the jaws and the other side is tapered on which bevel gear teeth are cut to mesh the pinion. When the pinion is rotated by means of the chuck key, the crown wheel rotates, thus causing the jaws to move inward or outward depending upon the rotation.

Pinion

The pinion is made out of high carbon steel, hardened and tempered. It is fitted on the periphery of the body. On the top of the pinion, a square slot is provided to accommodate the chuck key. It has a tapered portion on which the bevel gear teeth are cut, which match with the crown wheel.

Merits of a Four jaw chuck

- A wide range of regular and irregular shapes can be held.
- Work can be set to run concentrically or eccentrically at will.
- Has considerable gripping power; hence, heavy cuts can be given.
- The jaws are reversible for internal and external work.
- Work can be readily performed on the end face of the job.
- There is no loss of accuracy as the chuck gets worn out.

Demerits of a Four jaw chuck

- Workpieces must be individually set.
- The gripping power is so great that a fine work can be easily damaged during setting.

Merits of a Three jaw chuck

- Work can be set quickly and trued easily.
- A wide range of cylindrical and hexagonal work can be held.
- Internal and external jaws are available.

Demerits of a Three jaw chuck

- Accuracy decreases as chuck gets worn out.
- Run out cannot be corrected.
- Only round and hexagonal components can be held.
- When accurate setting or concentricity with an existing diameter is required, a self-centering chuck is not used.

Specification of a chuck

To specify a chuck, it is essential to provide details of the:

- type of chuck
- capacity of the chuck
- diameter of the body
- width of the body
- the method of mounting to the spindle nose.

Examples

Three jaw self-centering chuck

Gripping capacity 450 mm

Diameter of the body 500 mm

Width of the body 125 mm

Tapered or threaded method of mounting

Comparison between a 3 jaw chuck and 4 jaw chuck

Three Jaw chuck	Four Jaw chuck
Only cylindrical or hexagonal work can be held.	A wide range of regular and irregular shaped jobs can be held.
Internal and external jaws are available.	Jaws are reversible for external and internal holding.
Setting up of work is easy.	Setting up of work is difficult.
Less gripping power.	More gripping power
Depth of cut is comparatively less.	More depth of cut can be given.
Heavier jobs cannot be turned.	Heavier jobs can be turned.
Workpieces cannot be set for eccentric turning.	Workpieces can be set for eccentric turning.
Concentric circles are not provided on the face.	Concentric circles are provided.
Accuracy decreases as chuck gets worn out.	There is no loss of accuracy as the chuck gets worn out.

Chucks other than three jaw and four jaw types and their uses

Objectives : At the end of this lesson you shall be able to
- **identify and name the chucks other than the three jaw and four jaw types**
- **state their constructional features**
- **state the uses of each of these chucks.**

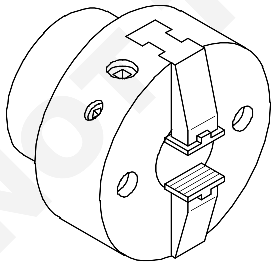
Apart from the four jaw independent chucks and self-centering chucks, other types of chucks are also used on a centre lathe. The choice depends upon the component, the nature of the operation, the number of components to be machined.

Some of the other types of chucks are:

- two jaw concentric chuck
- combination chuck
- collect chuck
- magnetic chuck
- hydraulic chuck or air operated chuck.

Two jaw concentric chuck (Fig 1)

Fig 1



TWO JAW CONCENTRIC CHUCK

The constructional features of this chuck are similar to those of Three jaw and Four jaw chucks.

Each jaw is an adjustable jaw which can be operated independently. In addition to this feature, both jaws may be operated concentric to the centre. Irregular shaped works can be held. The jaws may be specially machined to hold a particular type of job.

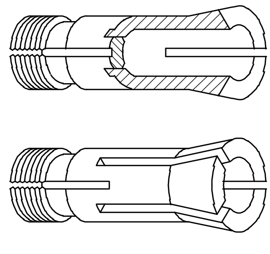
Combination chuck

The combination chuck is normally a four jaw chuck in which the jaws may be adjusted either independently as done in a four jaw chuck, or together, as done in a three jaw universal chuck.

This kind of chuck is used in places where duplicate workpieces are to be machined. One piece is accurately set as done in a four jaw chuck, and the subsequent jobs are held by operating the centering arrangement.

Collet chuck (Fig 2)

Fig 2



SPLIT COLLET

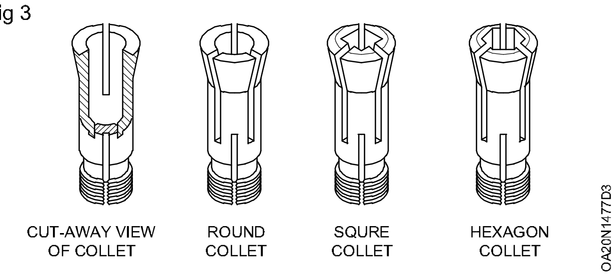
A collet is a hardened steel sleeve having slits cut partly along its length. It is held by a draw-bar which can be drawn in or out in the lathe spindle. The collet is guided in the collet sleeve, and held with the nose cap. It is possible to change the collet for different cross-sections depending on the cross-section of the raw material.

There are three most commonly used types of collet chucks.

- Push-out chucks
- Draw-in chucks
- Dead length bar chucks

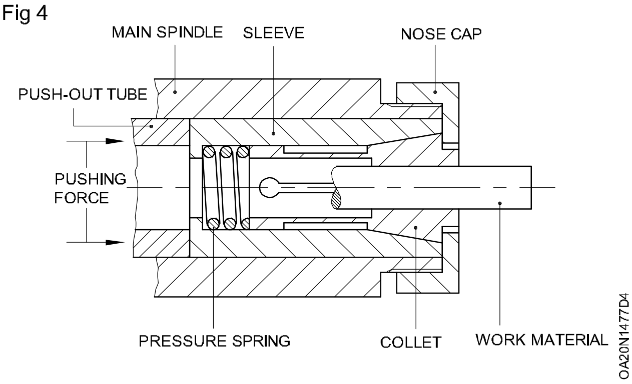
The operation of these chucks may be manual, pneumatic, hydraulic or electrical. They are mainly used to hold round, square, hexagonal or cast profile bars. (Fig 3)

Fig 3



Push-out chucks (Fig 4)

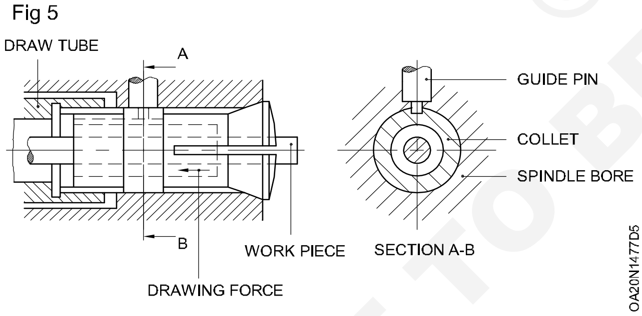
Fig 4



The collet closes on the workpiece in a forward direction and consequently an end-wise movement of the work results. The cutting pressure tends to reduce the grip of the collet on the workpiece.

Draw-in chuck (Fig 5)

Fig 5



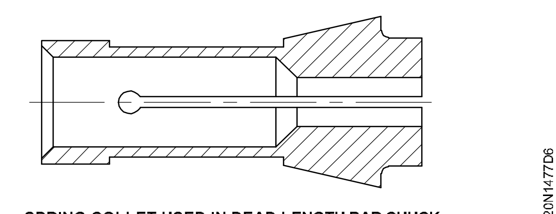
The collet closes on the workpiece in a backward direction and movement of the work. Take special care to avoid errors of length due to this fault. The cutting pressure increases the grip of the collet on the workpiece.

Dead length bar chucks (Fig 6)

These chucks are widely used in modern machines as they provide an accurate end-wise location of the workpiece. The chuck does not move end-wise during gripping or closing operation. These chucks are made to hold round, hexagonal or square bars, and when they are not gripping, they maintain contact with the core thus preventing swarf and chips collecting between the collet and the core.

The disadvantage with these chucks is that each collet cannot be made to grip bars which vary by more than about 0.08 mm without adjustment.

Fig 6

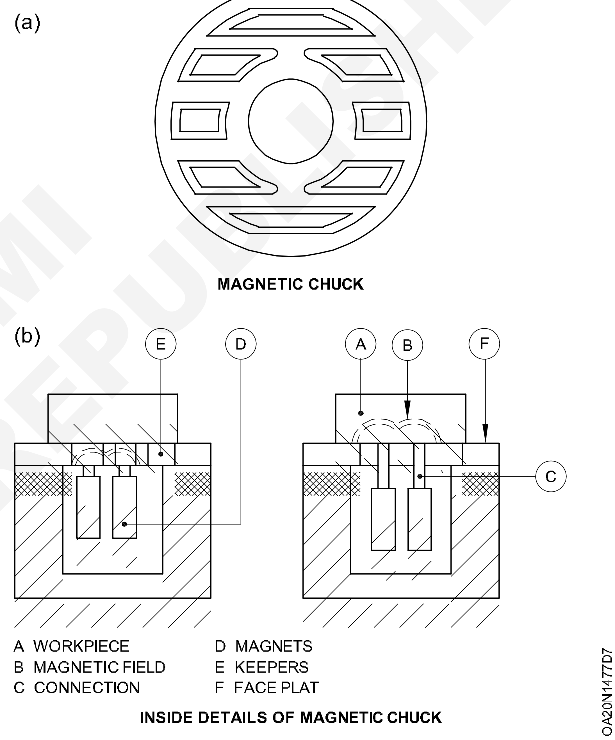


SPRING COLLET USED IN DEAD LENGTH BAR CHUCK

Magnetic chuck (Figs 7a & 7b)

This chuck is designed to hold the job by means of magnetic force. The face of the chuck may be magnetized by inserting a key in the chuck and turning it to 180°. The amount of magnetic force may be controlled by reducing the angle of the key. The truing is done with a light magnetic force, and then the job is held firmly by using the full magnetic force.

Fig 7



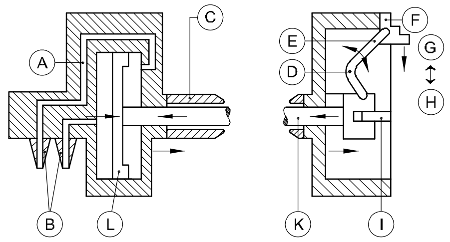
Hydraulic chuck or air-operated chuck (Fig 8)

These chucks are mainly used for getting a very effective grip over the job. This mechanism consists of a hydraulic or an air cylinder which is mounted at the rear end of the headstock spindle, rotating along with it. In the case of a hydraulically operated chuck the fluid pressure is transmitted to the cylinder by operating the valves. This mechanism may be operated manually or by power. The movement of the piston is transmitted to the jaws by means of connecting rods and links which enable them to provide a grip on the job.

Uses of a two jaw concentric chuck

It is mainly employed to hold an irregularly shaped job. As the chuck is designed with two jaws, it can be used as a turning fixture.

Fig 8



Uses of a combination chuck : This chuck may be used both as a universal three jaw chuck and as a four jaw independent chuck. This chuck is very useful where duplicate workpieces are involved in the turning.

Uses of a collet chuck

It is mainly used for holding jobs within a comparatively small diameter. The main advantage of collets lies in their ability to centre work automatically and maintain accuracy for long periods. It also facilitates to hold the bar work.

Uses of a magnetic chuck

This type of a chuck is mainly used for holding thin jobs which cannot be held in an ordinary chuck. These are suitable for works where a light cut can be taken on the job.

Uses of hydraulic or air-operated chuck

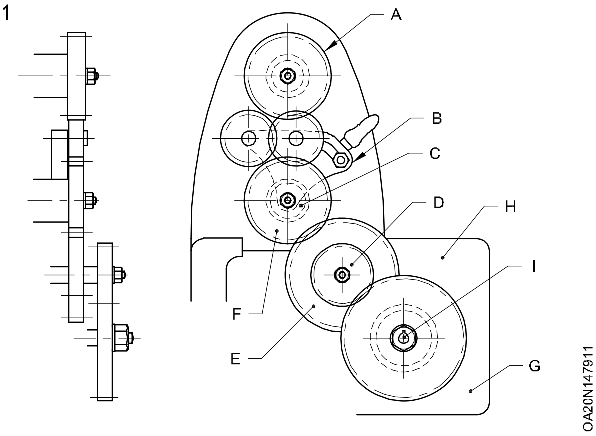
These chucks are mainly used in mass production because of their speedy and effective gripping capacity.

Feed mechanism of lathe

Objectives : At the end of this lesson you shall be able to
- **identify the parts of the feeding mechanism**
- **state the functional features of the feeding mechanism.**

Feed mechanism (Fig 1)

Fig 1



The feed mechanism of a lathe enables automatic feeding longitudinally and transversely as needed. By automatic feeding the finish on the work will be better, the feeding of the tool will be uniform by a continuous rate and it takes less time to finish the operation while manual labour is avoided.

The feed mechanism comprises the following.

Spindle gear	(A)
Tumbler gear unit	(B)
Fixed stud gear	(C)
Change gear unit	(DEFG)
Quick change gearbox	(H)
Feed shaft/lead screw	(I)
Apron mechanism	(not in figure)

The proportionate tool movement for each revolution of work is achieved through all the above units of the feed mechanism.

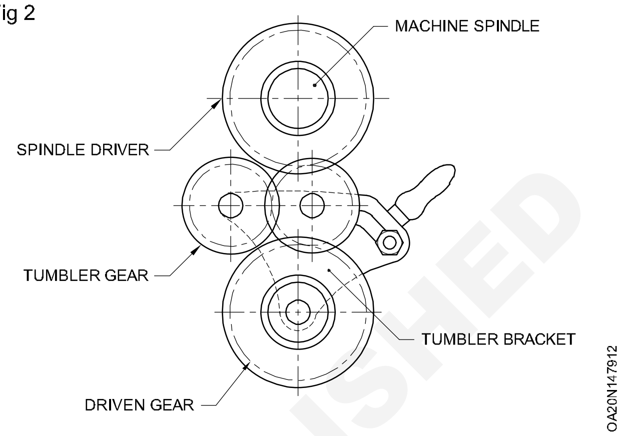
Spindle gear

The spindle gear is fitted to the main spindle, and it is outside the headstock casting. It revolves along with the main spindle.

Tumbler gear unit

The tumbler gear unit itself consists of three gears, each having the same number of teeth and it connects the spindle gear to the fixed gear. It is also called the reversing gear unit as it is used to change the direction of feed of the tool for the same direction of rotation of the spindle. It can be engaged and disengaged with the fixed spindle gear by the operation of the hand lever provided in the unit. (Fig 2)

Fig 2



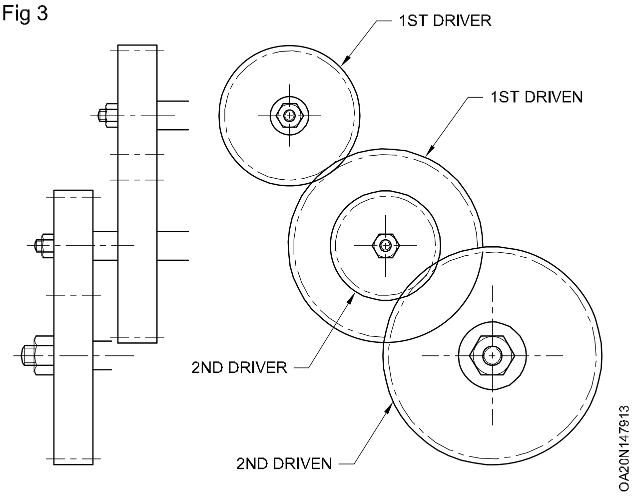
The fixed stud gear

The fixed stud gear gets the drive from the main spindle gear through the tumbler gear unit and runs at the same number of revolutions per minute as the spindle gear on most lathes.

Change gear unit

The fixed stud gear transmits its drive through a change gear unit to the quick change gearbox. The change gear unit has provision for changing the driver, the driven and the idler gears from the set of change gears available for the purpose of feed changing as an additional unit. (Fig 3)

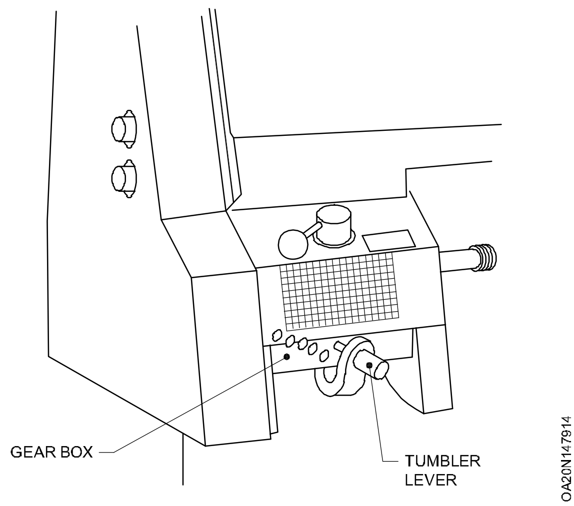
Fig 3



Quick change gearbox

The quick change gearbox is provided with levers outside the box casting, and by shifting the levers, different gears are brought in mesh so that different feed rates can be given to the tool. A chart listing the different feed rates for the different positions of the levers is fixed to the casting, and by referring to the table, the levers may be engaged in position for the required feed rate. (Fig 4)

Fig 4



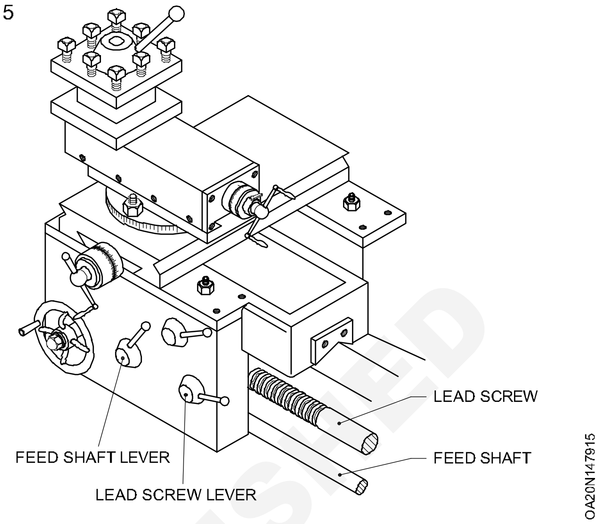
The feed shaft

The feed shaft gets its drive from the quick change gearbox, and through the apron mechanism, the rotary movement of the feed shaft is converted into the linear movement of the tool.

The apron mechanism

The apron mechanism has an arrangement for transmitting the drive from the feed shaft to the saddle for longitudinal movement of the tool or to the cross-slide for the transverse movement of the tool. (Fig 5)

Fig 5



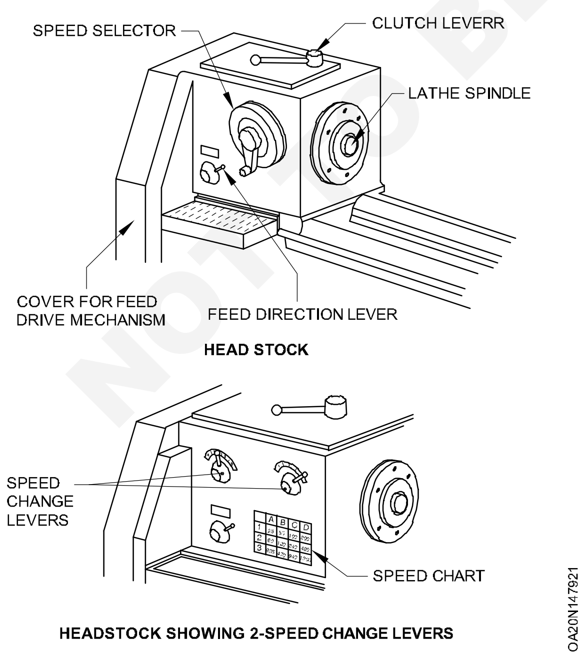
Type of Lathe drive - Merits and de-merits, cone pulley/gear type

Objectives: At the end of this lesson you shall be able to
- **state the functions of the headstock**
- **differentiate between cone pulley headstock and all geared headstock.**

Headstock

It is a fixed unit of lathe on the left hand side. (Fig 1)

Fig 1

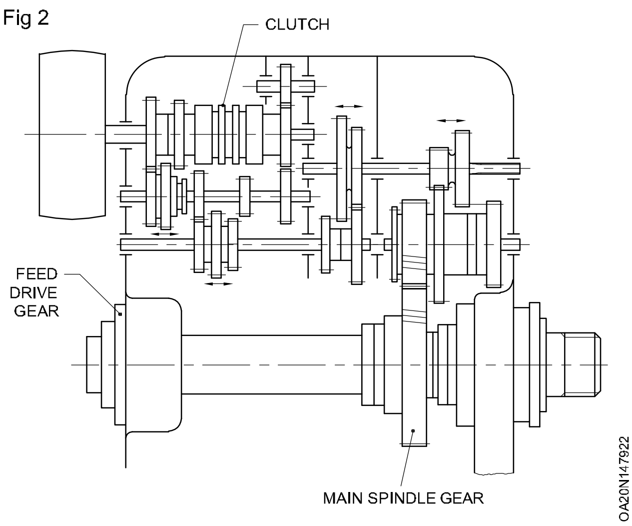


Its main functions are to :

- provide a means to assemble work-holding devices
- transmit the drive from the main motor to the work to make it revolve
- accommodate shafts with fixed and sliding gears for providing a wide range of work speeds
- have shift levers to slide gears to bring in mesh for different speeds
- have a means for lubricating the gears, shafts and bearings.

Constructional features of all-geared headstock (Fig 2)

Fig 2



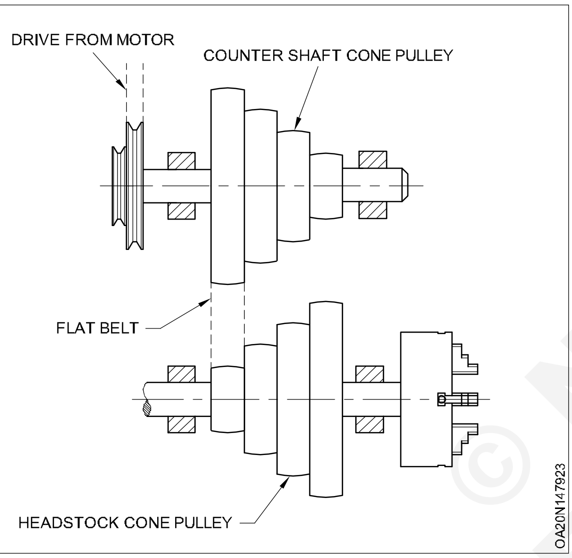
It is a box-section alloy iron casting having a top cover which can be removed, if needed. It has internal webs for stiffening and taking shaft bearings. It has an input shaft which is connected by means of 'V' belts to the main motor, and runs at constant speed. It is equipped with clutches and a brake.

There may be two or more intermediate shafts on which sliding gears are mounted. The main spindle is the last driven shaft in the headstock assembly. The nose of the spindle is outside the headstock casting and is designed to accommodate the work-holding devices.

The levers operating the forks of the sliding gears are situated outside in the front of the headstock casting. A sight glass is provided on the top to indicate the functioning of the automatic lubricating system and side of sight glass is provided oil length of the machine.

Cone pulley headstock (Fig 3)

Fig 3



It has a stepped cone pulley mounted on the main spindle and is free to revolve. It is connected by means of a flat belt to a similar cone pulley, the steps arranged in a reversing order. This cone pulley gets the drive from the main motor.

The spindle is mounted on the bush bearings in the headstock casting and a gear wheel called 'bull gear' keyed to it. A pinion is coupled to the cone pulley. The back gear unit has a shaft which carries a gear and a pinion. The number of teeth of the gear and pinion on the back gear shaft corresponds to the number of teeth on the bull gear and the pinion on the cone pulley. The axis of the back gear shaft is parallel to the axis of the main spindle, and the back gear is brought in engagement or disengagement with the cone pulley system by means of a lever. The back gear unit is engaged to have reduced spindle speeds. (Fig 4 & 5)

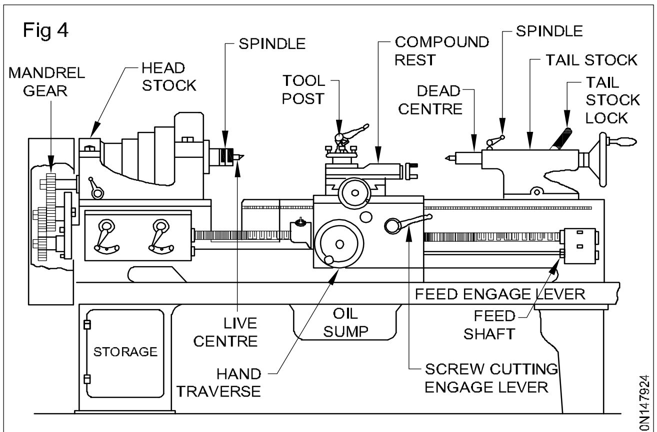
A three-stepped cone pulley headstock provides three direct ranges of speeds through the belt connection, and with the back gear in engagement, three further ranges of reduced speeds.

Advantages

Easy for maintenance.

Can take up heavy load.

Fig 4



CORE PULLEY HEAD STOCK

Less noise during functioning.

During overloads, the belt slips off, and hence, no major damage to the lathe is caused.

Positive drive when the back gear is in engagement.

Disadvantages

Number of spindle speeds limited to the number of steps in the cone pulley.

Takes time to change spindle speeds.

Needs adjustments of bush bearings.

Back gear unit has a shaft which carries a gear and a pinion. The number of teeth of the gear and pinion on the back gear shaft corresponds to the number of teeth on the pull gear and the pinion on the cone pulley. The axis of the back gear shaft is parallel to the axis of the main spindle, and the back gear is brought in engagement or disengagement with the cone pulley system by means of a ever. The back gear unit is engaged to have reduced spindle speeds. (Fig 6)

If three stepped cone pulley headstock provides three direct ranges of speeds through the belt connection and with the back gear in engagement, three further ranges of reduced speeds.

Advantages

Easy for maintenance.

Can take up heavy load.

Less noise during functioning.

During overloads, the belt slips off, and hence, no major damage to the lathe is caused.

Positive drive when the back gear is in engagement.

Disadvantages

Number of spindle speeds limited to the number of steps in the cone pulley.

Takes time to change spindle speeds.

Needs adjustments of bush bearings.

Difference between individual drive vs group drive (Fig 7)

Fig 5

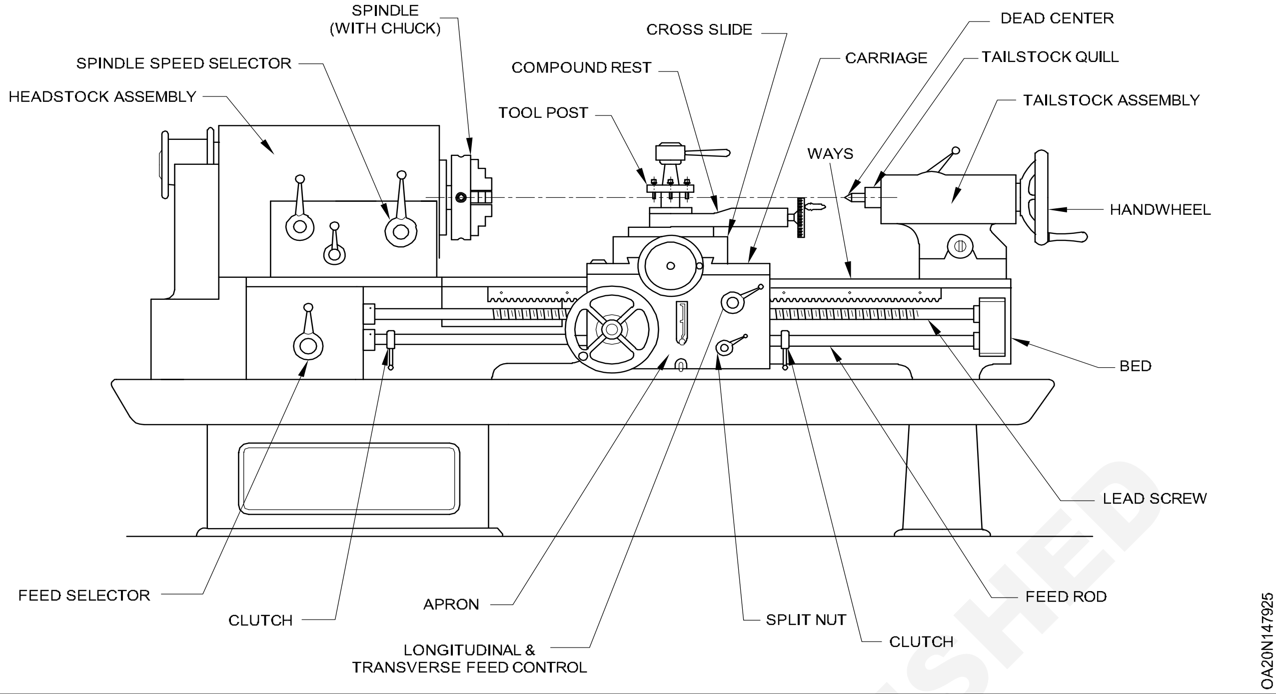
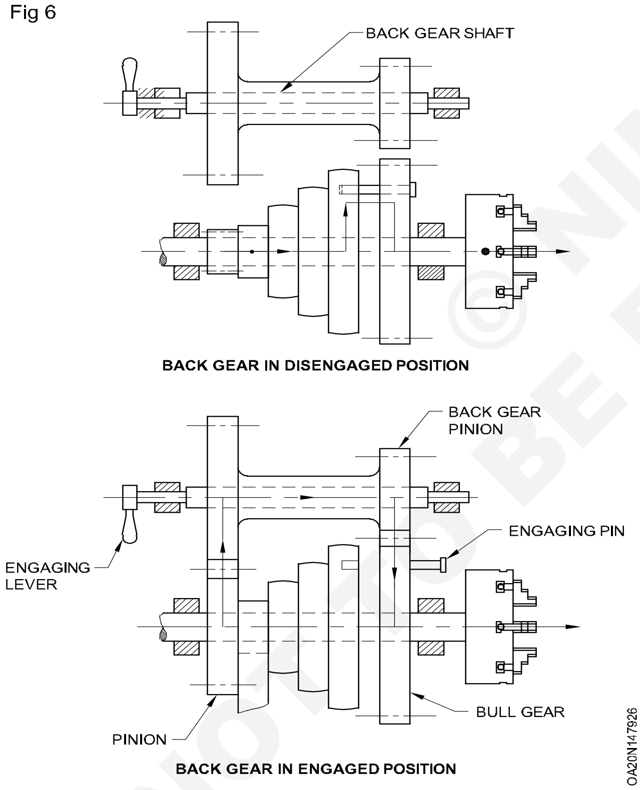
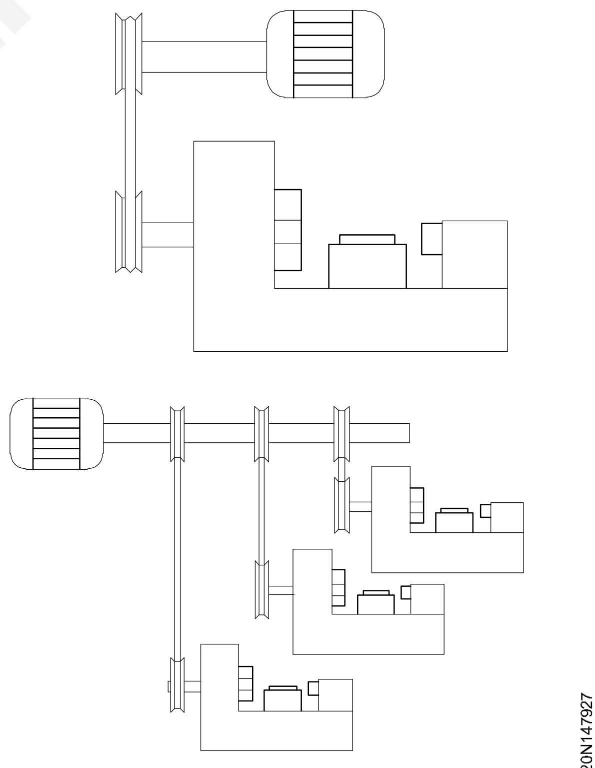


Fig 6



More likely used	For job production	For mass production
Efficiency	High	Less
Power required	Less	More

Fig 7



INDIVIDUAL DRIVE VS GROUP DRIVE

Difference between individual drive vs group drive

	Individual drive	Group drive
Initial cost	Low	High
Speed	More variation possible	Wider variation possible
Running cost	One	More than one
One time of breakdown	Only one machine get affected	All machine connected to group drive get affected

Lathe tools

Objectives : At the end of this lesson you shall be able to
- **distinguish between end-cutting and side-cutting tools**
- **state the features of each type**
- **identify the different shapes of cutting tools used for lathe operations**
- **distinguish the characteristics and uses of different shapes of lathe tools.**

Cutting tools - classification

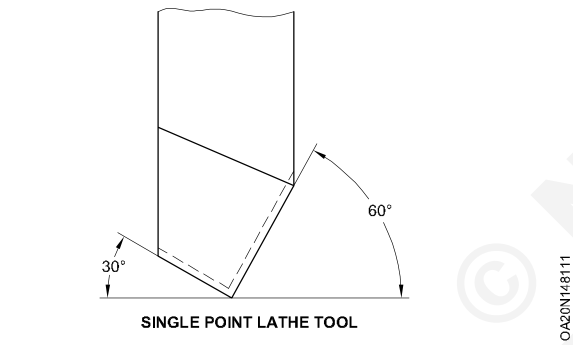
Cutting tools are classified as:

- single point cutting tools
- multi-point cutting tools
- form tools.

Single point cutting tools

The single point cutting tools have one cutting edge which performs the cutting action. Most of the lathe cutting tools are single point cutting tools. (Fig 1)

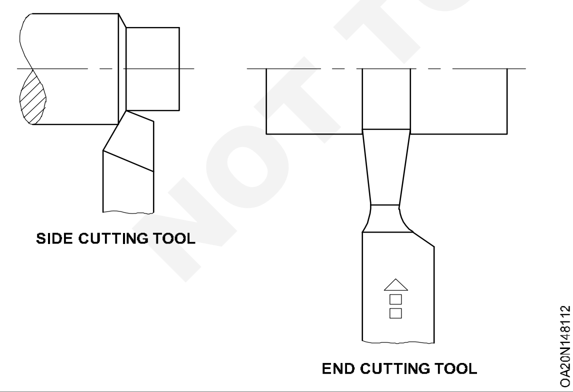
Fig 1



Single point cutting tools used on lathes may be grouped into:

- side-cutting tools
- end-cutting tools. (Fig 2)

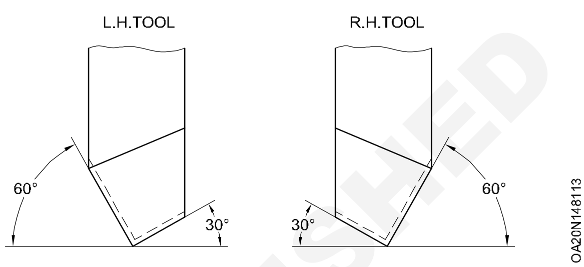
Fig 2



Side cutting edge tools have their cutting edges formed on the side of the cutting tool, and are used on lathes for most of the operations. They are again classified as right hand tools and left hand tools. (Fig 3) A right hand tool operates from the tailstock end towards the headstock, and a left hand tool operates from the headstock end towards the tailstock. The cutting edge is formed accordingly.

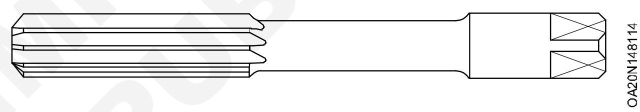
End-cutting tools have their cutting edge at the front end of the tools and are used on lathes for plunge-cut operations.

Fig 3



Multi-point cutting tools (Fig 4)

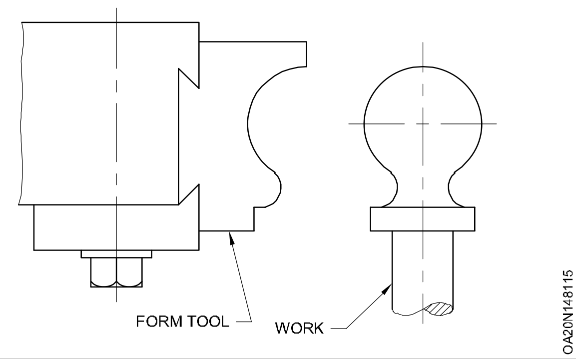
Fig 4



These tools have more than one cutting edge and remove metal from the work simultaneously by the action of all the cutting edges. The application of multi-point cutting tools on the lathe is mostly done by holding the tool in the tailstock and feeding it to the work.

Form tools (Fig 5)

Fig 5



These tools reproduce on the work the form and shape of the cutting edges to which they are ground. Form tools perform the operations on the work by the plunging action, and are fixed on the tool post, square to the axis of the work, and are fed by the cross-slide. They may have their cutting edges formed on square or rectangular section tool blanks acting radially. The form tools may be either circular form tools or tangential form tools. They may require special holders to which they are fixed, and the holders themselves are clamped on the tool posts for the operations.

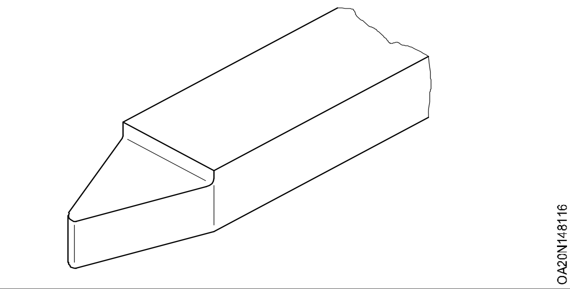
Lathe cutting tool- types

The tools used on lathes are:

- solid type tools
- brazed type tools
- inserted bits with holders
- throw-away type tools (carbide).

Solid tools (Fig 6)

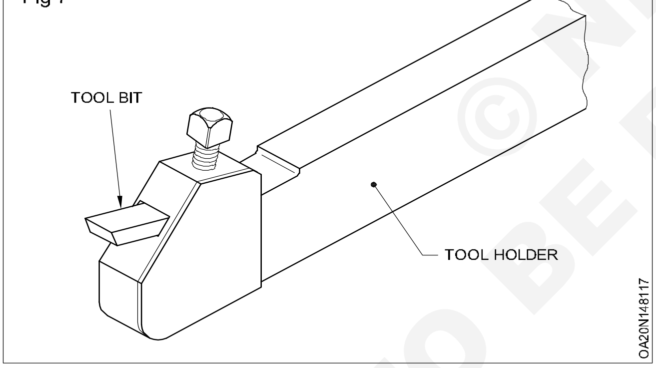
Fig 6



These are tools having their cutting edges ground on solid bits of square, rectangular and round cross-sections. Most of the lathe cutting tools are of the solid type, and high carbon steel and high speed steel tools are used. The length and cross-section of the tool depend upon the capacity of the machine, the type of tool post and the nature of the operation.

Inserted bits with holders (Fig 7)

Fig 7

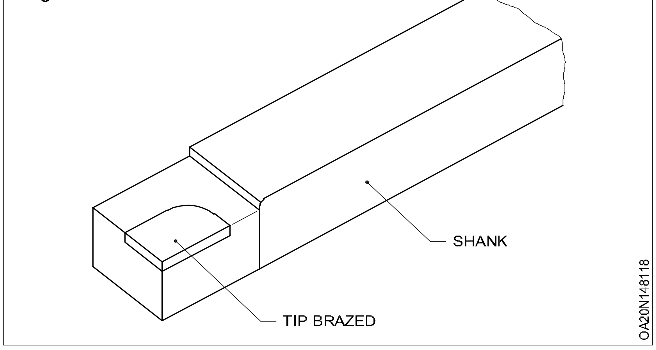


Solid high speed steel tools are costly, hence, sometimes inserted bits are used. These bits are small in size, and are inserted in the holes of the holder. These holders are held and clamped in the tool posts to carry out the operations. The disadvantage in this type of tools is that the rigidity of the tool is poor.

Brazed tools (Fig 8)

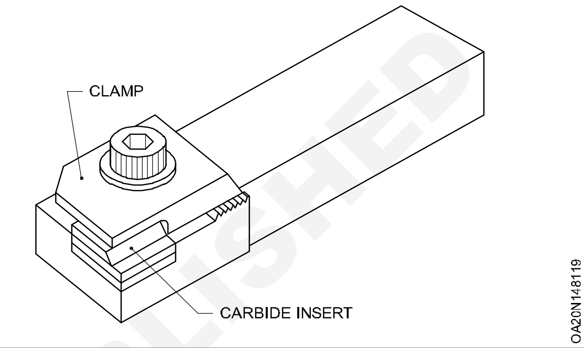
These tools are made of two different metals. The cutting portion of these tools is of cutting tool materials, and the body of the tools does not possess any cutting ability, and is tough. Tungsten carbide tools are mostly of the brazed type. Tungsten carbide bits of square, rectangular and triangular shape are brazed to the tips of the shank. The tips of the shank metal pieces are machined on the top surface according to the shape of the tips so as to accommodate the carbide bits. These tools are economical, and give better rigidity for the tools than the inserted bits clamped in the tool-holders. This is applicable to high speed steel brazed tools also.

Fig 8



Throw-away type tools (Fig 9)

Fig 9



Carbide brazed tools when blunt or broken need grinding which is time absorbing and expensive. Hence, they are used as throw-away inserts in mass production. Special tool-holders are needed and the carbide bits of rectangular, square or triangular shapes are clamped in the seating faces and machined on this type of special holders.

The seating faces are machined in such a way that the rake and clearance needed for the cutting bits are automatically achieved when the bits are clamped.

Lathe cutting tools shapes

Lathe cutting tools are available in a variety of shapes for performing different operations. Some of the lathe cutting tools generally used are shown in Figure 10 and 11.

Fig 10

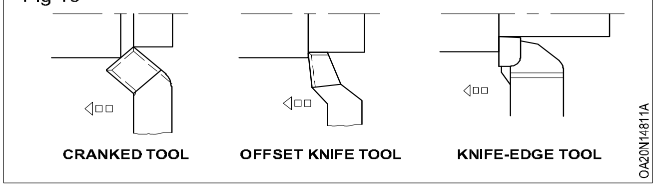
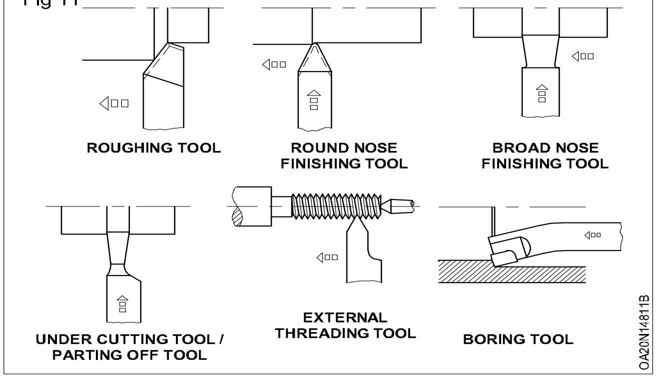


Fig 11



Lathe tools - angles and their functions

Objectives : At the end of this lesson you shall be able to
- **identify and name the angles of a lathe cutting tool**
- **state the characteristics of a rake angle**
- **state the characteristics of a clearance angle**
- **refer to a chart to determine the recommended rake and clearance angles for turning different metals**
- **state the characteristics of a relief angle.**

A lathe tool in action is shown in Fig 1. Notice that the section of the tool is basically a square or rectangle with a modified shape at the cutting end. If it is not modified and used, full face surface will make contact with the work and the tool can hardly penetrate into the work. (Fig 2) Otherwise the surface of the tool will only rub against the workpiece and hardly any cutting will take place. But by shaping the tool as shown in Fig 3, the full surface contact will be eliminated and a cutting edge will be created. The angle which is responsible for the creation of the cutting edge is called the clearance angle.

Fig 1

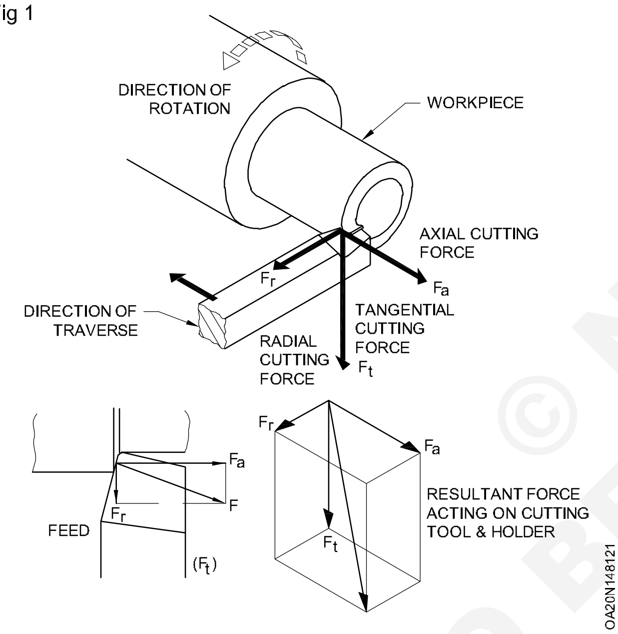
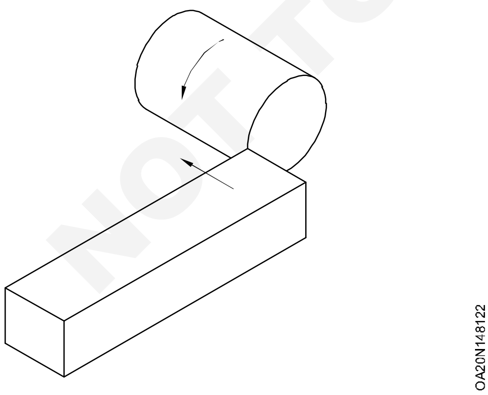


Fig 2



The tool in Fig 1 has some more angles ground in it to make the metal removal more efficient, and these angles are shown in respect of general roughing tool in Fig 4.

The angles are:

- side cutting edge angle
- end cutting edge angle
- top rake angle
- side rake angle
- front clearance angle
- side clearance angle.

Fig 3

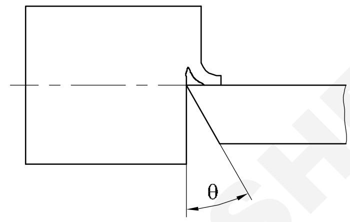
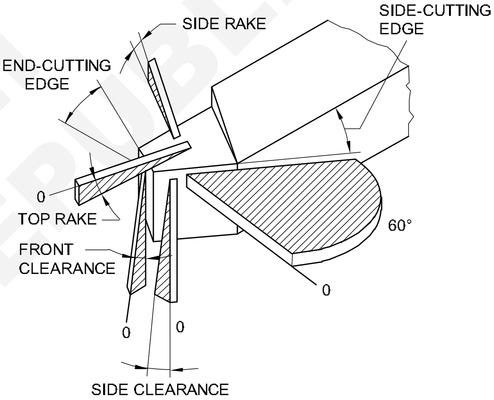
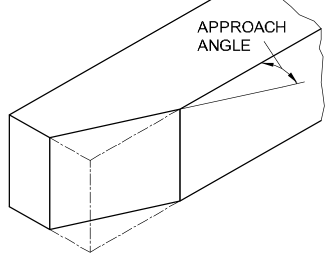


Fig 4



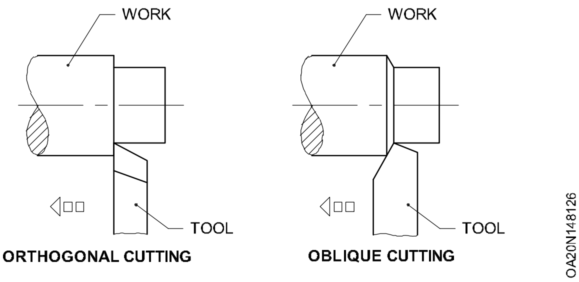
Side cutting edge angle (Approach angle) (Fig 5)

Fig 5



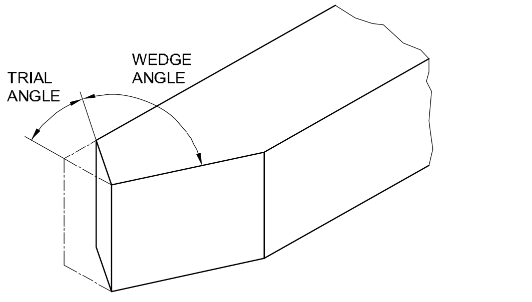
This is ground on the side of the cutting tool. The cutting will be oblique. The angle ground may range from 25° to 40° but as a standard a 30° angle is normally provided. The oblique cutting has certain advantages over an orthogonal cutting, in which the cutting edge is straight. More depth of cut is given in the case of oblique cutting since when the tool is fed to the work, the contact surface of the tool gradually increases as the tool advances, whereas, in the case of orthogonal cutting, the length of the cutting edge for the given depth fully contacts the work from the beginning itself, which gives a sudden maximum load on the tool face. The area, over which heat is distributed, is more in oblique cutting. (Fig 6)

Fig 6



End-cutting edge angle (Trial angle) (Fig 7)

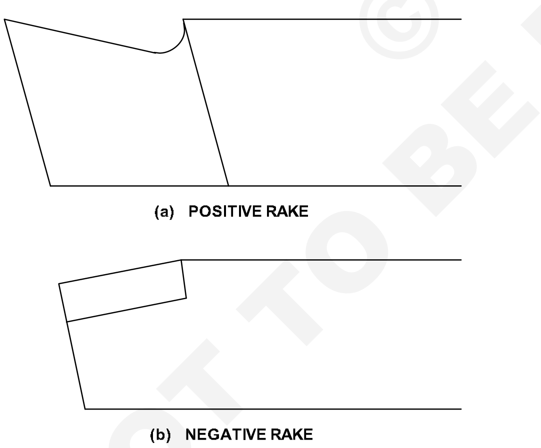
Fig 7



The end-cutting edge angle is ground at 30° to a line perpendicular to the axis of the tool, as illustrated in Fig 4. The side-cutting edge angle and the end-cutting edge angle, when ground, form a nose (wedge) angle of 90° for the tool.

Top or back rake angle (Fig 8)

Fig 8



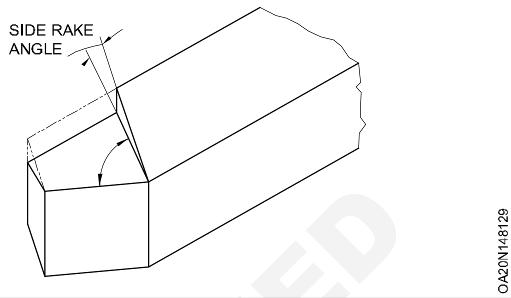
The rake angle ground on a tool controls the geometry of chip formation for any given material. It controls the mechanics of the cutting action of the tool. The top or back rake angle of the tool is ground on the top of the tool, and it is a slope formed between the front of the cutting edge and the top face. If the slope is from the front towards the back of the tool, it is known as a positive top rake angle,(Fig 8A) and, if the slope is from the back of the tool towards the front of the cutting edge, it is known as the negative back rake angle. (Fig 8B)

The top rake angle may be ground positive, negative or zero according to the material to be machined. When turning soft, ductile materials which form curly chips, the positive top rake angle ground will be comparatively more than for turning the hard brittle metals.

When turning hard metals with a carbide tool it is the usual practice to give a negative top rake. Negative top rake angle tools have more strength than the positive top rake angle tools.

Side rake angle (Fig 9)

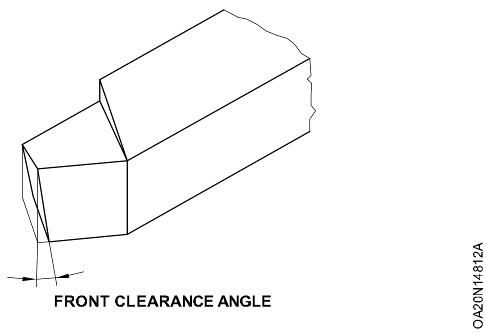
Fig 9



The side rake angle is the slope between the side of the cutting edge to the top face of the tool widthwise. The slope is from the cutting edge to the rear side of the tool. It varies from 0° to 20° according to the material to be machined. The top and side rakes, ground on a tool, control the chip flow and this results in a true rake angle which is the direction in which the chip that shears from the work passes.

Front clearance angle (Fig 10)

Fig 10



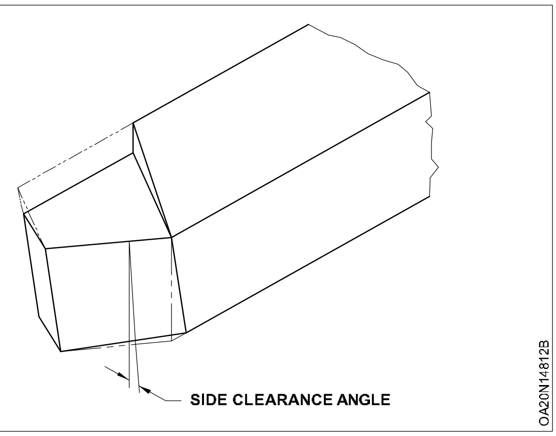
This angle is the slope between the front of the cutting edge to a line perpendicular to the axis of the tool drawn downwards. The slope is from the top to the bottom of the tool, and permits only the cutting edge to contact the work, and avoids any rubbing action. If the clearance ground is more, it will weaken the cutting edge.

Side clearance angle (Fig 11)

The side clearance angle is the slope formed between the side cutting edge of the tool with a line perpendicular to the tool axis drawn downwards at the side cutting edge of the tool. The slope is from the top of the side cutting edge to the bottom face. This is also ground to prevent the tool from rubbing with the work, and allows only the cutting edge to contact the work during turning. The side clearance angle needs to be increased when the feed rate is increased.

When grinding the rake and clearance angles, it is better to refer to the standard chart provided with the recommended values, and then grind. However, actual operation will

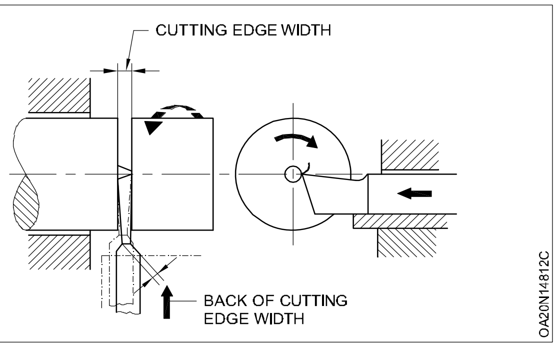
Fig 11



indicate the performance of the tool and if any modification is needed for the angles ground on the tool.

Side relief angle (Fig 12)

Fig 12



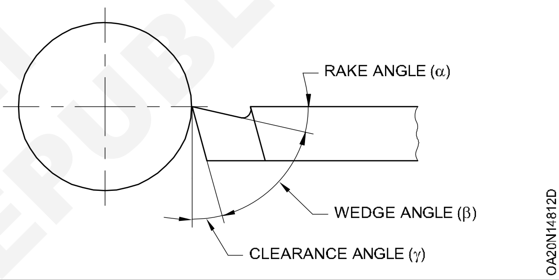
This angle is ground on the parting and the undercutting tools on both sides. This will provide the width of the cutting edge slightly broader than the back of the cutting edge.

This permits clearance between the sides of the tool and the groove walls formed by the plunging action of the tool, thereby, preventing the tool from getting jammed in the groove and causing breakage. The relief is kept as minimum as possible. Too much of relief will weaken the tool cutting edge, and also permit the chips to clog in the gap, causing the tool in both cases to break. Side relief is also provided sometimes to the main cutting edge of the facing tools, permitting only the cutting point performing the operation, when the tool axis is set perpendicular to the lathe axis. The side relief angle normally does not exceed 2°.

Relationship between rake, clearance and wedge angles (Fig 13)

The rake angle (μ), clearance angle (g) and the wedge angle (b) have close relationship for efficiency in cutting. Excessive rake angle reduces the wedge angle, which helps in good penetration and it is particularly useful for cutting soft metals. A decreased wedge angle weakens the tool strength. Therefore, for cutting hard metals, the rake angle is zero or negative. The clearance angle is generally fixed depending on the geometry of the surface being cut.

Fig 13



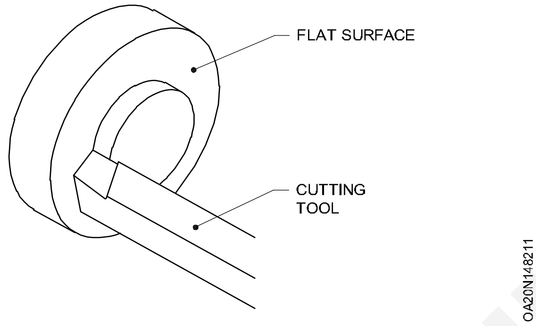
Lathe operations - facing

Objectives : At the end of this lesson you shall be able to
- **state the meaning of facing**
- **state the purpose of facing**
- **identify the defects in faced works**
- **state the reasons for the defects**
- **state the remedies to overcome the defects in facing.**

Facing

This is an operation of removing metal from the work-face by feeding the tool at right angles to the axis of the work. (Fig 1)

Fig 1



Purpose of facing

- To have a reference plane to mark and measure the step lengths of the work.
- To have a face at right angle to the axis of the work.
- To remove the rough surface on the faces of the work and have finished faces instead.
- To maintain the total length of the work.

Facing may be rough or finish facing. Rough facing is done to remove the excess metal on the face of the work by coarse feeding with more depth of cut, leaving sufficient metal for finishing.

Rough facing is done by feeding the tool from the periphery of the work towards the centre of the work. Finish facing is the operation to have a smooth face by removing the rough surface produced by the rough facing.

Finish facing is done by feeding the tool from the centre of the work towards the periphery. (Figs 2a and 2b)

Rough facing is done by choosing a spindle r.p.m. according to the average diameter of the work, with the recommended cutting speed, coarse feed and more depth of cut.

Finish facing is done by choosing a cutting speed about twice that of the cutting speed for roughing, with a fine feed rate of 0.05 mm approximately and with a depth of cut of not more than 0.1 mm.

The following are the defects found in facing a work. (Fig 3)

Fig 2

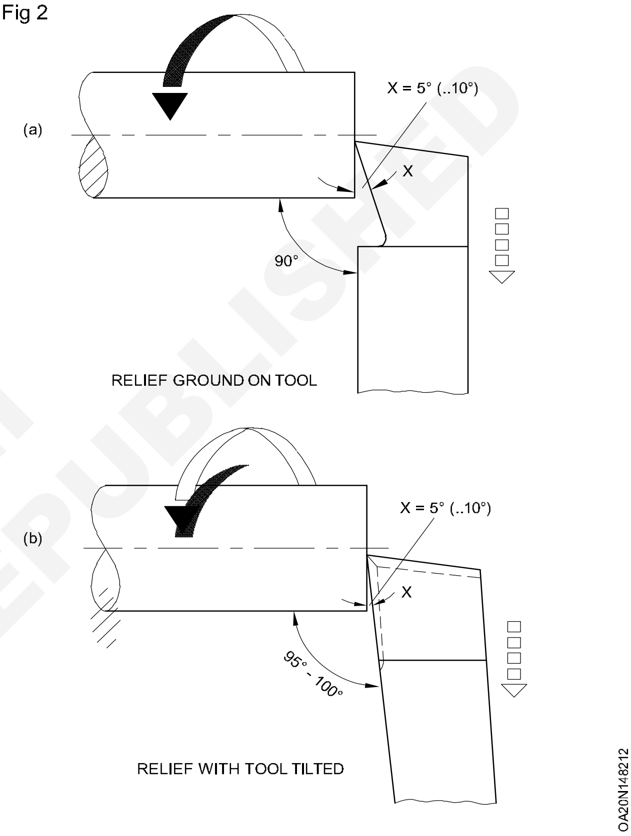
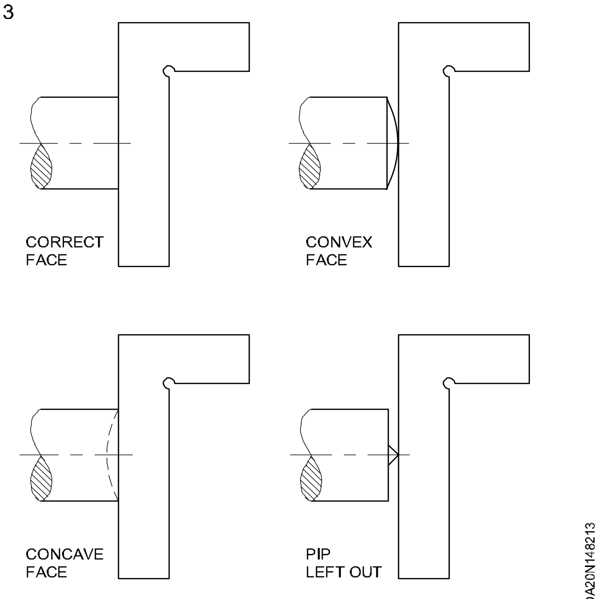


Fig 3



A concave face

This is caused by the tool digging into the work during the feeding as the tool is not clamped rigidly. By clamping the tool rigidly with minimum overhang, this defect can be avoided.

A convex face

This is caused by the blunt cutting edge of the tool and the carriage not being locked. To avoid this defect, re-sharpen the tool and use it; also lock the carriage to the bed of the lathe.

A pip left in the centre

This is due to the tool not being set to the correct centre height. By placing the tool to the correct centre height, this defect can be avoided.

Plain turning

Objectives : At the end of this lesson you shall be able to
- **state the meaning of plain turning**
- **distinguish between the two stages of plain turning.**

Plain turning (Parallel turning)

This operation involves removal of metal from the work and it has a cylinder for the full travel of the tool on the work, keeping the same diameter throughout the length.

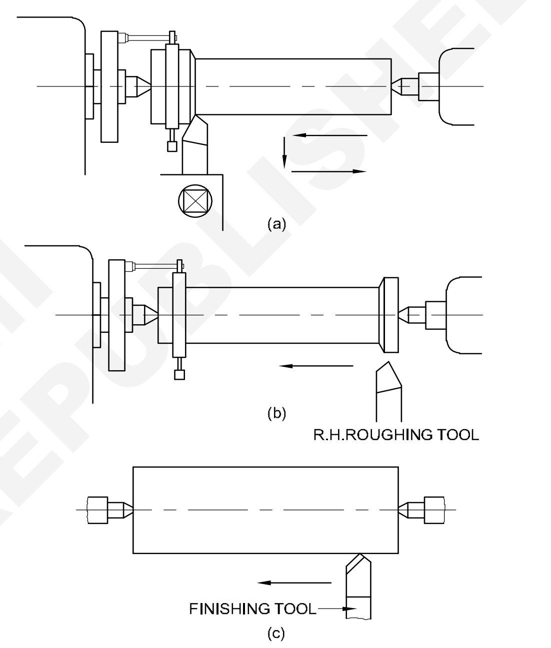
Plain turning is done in two stages.

- Rough turning, using roughing tool or knife tool. (Figs 1a and 1b)
- Finish turning using a finishing tool. (Fig 1c)

It is done after rough turning, and it aims to bring the size of the work within the specified accuracy and with better surface finish. The tool to be used in this case will be a finish turning tool. Finish turning is also carried out from the tailstock end towards the headstock end.

The spindle speed is calculated according to the material being turned, diameter of the work, the tool material and the recommended cutting speed diameter of the works.

Fig 1



Chamfering

Objectives : At the end of this lesson you shall be able to
- **state the meaning of chamfering**
- **state the purpose of chamfering**
- **name the methods of chamfering**
- **differentiate between the different methods of chamfering.**

Chamfering (Fig 1)

It is the operation of bevelling the edge of a cylinder or a bore to a definite length.

Purpose of chamfering

The following are the purposes of chamfering.

- To remove burrs and sharp edges from the turned components to make their handling safe.
- To permit for easy assembly of mating components (a shaft and a hole).
- To avoid the formation of feather edges on the threaded parts.
- To provide better appearance.

Methods of chamfering

Form tool method

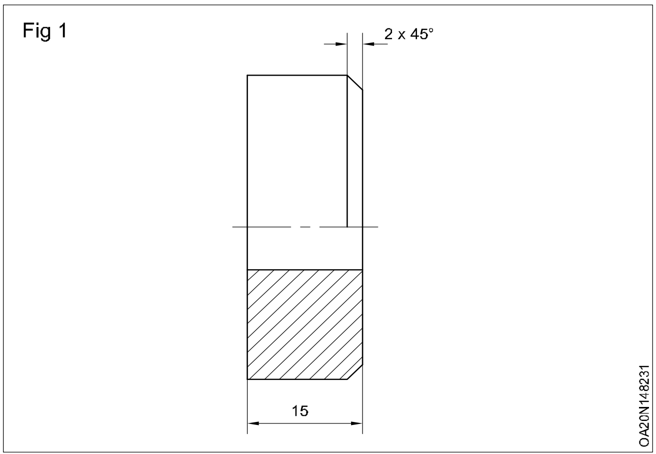
Chamfering can be done with the help of a cutting tool, having its edges ground to the angle of the chamfer and by directly applying the tool on to the edge of the work. (Fig 2)

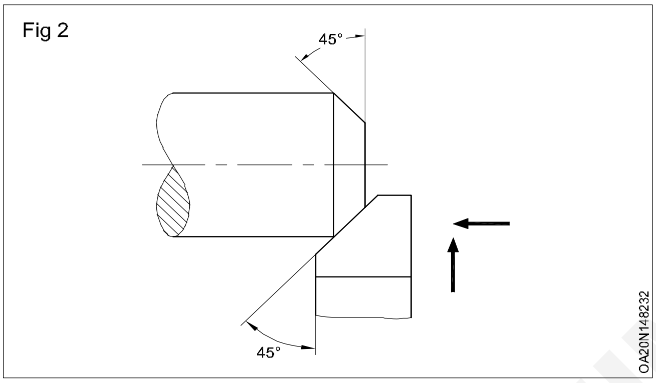
The tool is fed either longitudinally or crosswise. Depth is calculated by the graduated collars.

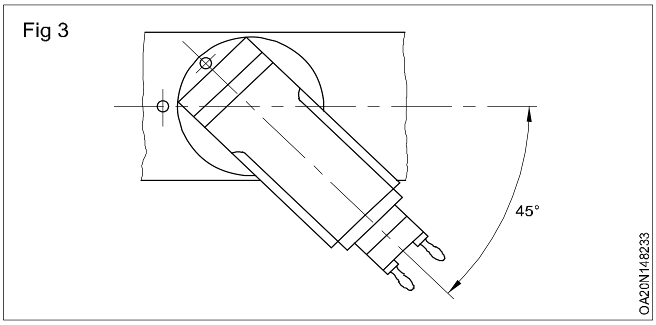
Compound slide method

Chamfering is also done by a tool fixed on the tool post, swivelling the compound slide to the angle of chamfer.

Then the carriage is locked and the tool is fed by the top slide. (Fig 3)



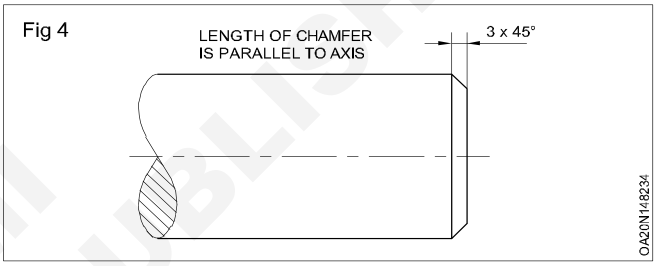




Filing method

This is a crude method, and is adopted only when the accuracy and finish are not a criterion. This is limited to external chamfer. The file is held on to the edge of the work to the angle of the chamfer and moved along the edge of the rotating work. A gentle pressure is applied until the required length of chamfer is achieved.

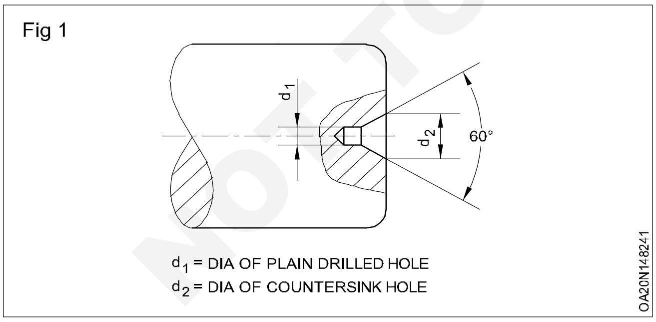
Length of chamfer is the distance measured parallel to the axis. (Fig 4)



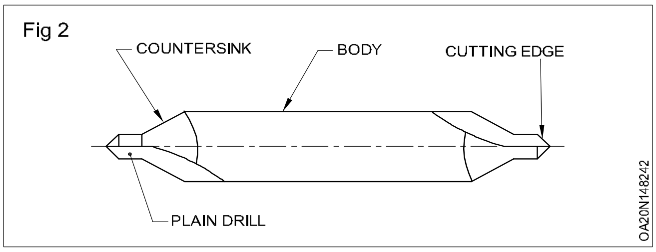
Centre drilling

Objectives : At the end of this lesson you shall be able to
- **state what is centre drilling**
- **identify the centre drills as per B.I.S.**
- **state the purpose of centre drilling**
- **state the defects in centre drilling**
- **indicate the causes for the defects**
- **state the remedies to avoid the defects.**

Centre drilling (Fig 1)



It is an operation of drilling and countersinking a hole on the face of the work, and on the axis of the work. It is done by a cutting tool known as centre or combination drill held in a drill chuck. The drill chuck is mounted in a tailstock spindle and the feeding of the drill to work is done by rotating the tailstock hand wheel. The spindle speed for the work rotation is calculated, taking into consideration the plain drilling diameter and the recommended cutting speed for the drilling. (Fig 2)



Defects in centre drilled holes

The two major defects in centre drilling are:

- insufficient depth of plain drilled portion (Fig 3)

- centre drilling done too deep. (Fig 4)

The first defect results in making the tip of the centre to contact the work surface, and the conical portion of the centre does not have any contact with the bearing surface of the centre drilled hole. Undue friction and overheating will be noticed which will damage the tip of the centre. Sometimes, breakage is also possible and the broken part of the centre may get welded to the centre hole. By feeding the centre drill up to 3/4th of the 60° countersink, this defect is avoided.

Fig 3

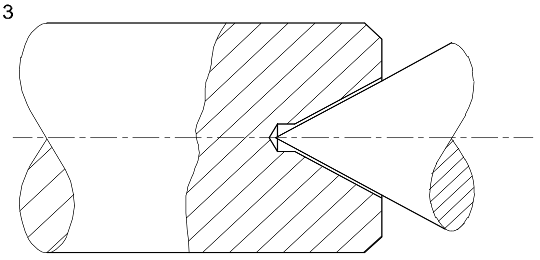
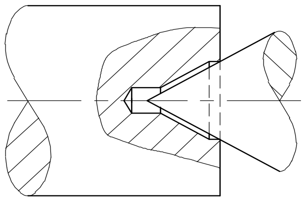


Fig 4



When the centre drill feeding is too much, a plain drilled portion by the body of the centre drill will be formed at the nose of the bearing surface of the centre hole, and the area of contact between the bearing surface and the work-supporting centre will be the only point of contact, as illustrated in Fig 4. This will not provide proper support to the work and any operation if carried out, may result in dimensional inaccuracy, chatter and poor surface finish.

To rectify this defect, face the work, if the length of the work permits, and feed the centre drill to the recommended length.

Centre drills

It is made of high speed steel and is cylindrical in shape. At both the ends, it has a plain drill and countersink as its integral part. It is hardened and ground. It is available in standard sizes.

Classification as per Indian Standard

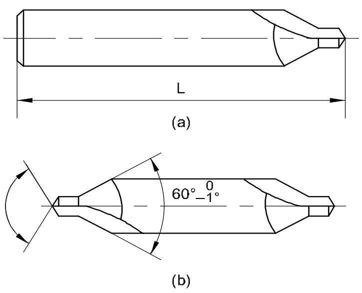
Indian Standard classifies centre drills into three types. They are Type A, Type B and Type R.

The difference lies in the formation of the countersink by each type.

Uses and specifications

Type 'A' centre drill is used to produce centre holes with plain drilled portion and countersink. It is designated as Centre Drill A. 1.6 x 4.0 IS: 6708 which means that the centre drill is of Type `A' with the plain drill portion having a diameter of 1.6 mm and a shank diameter 4 mm. (Figs 5a and b)

Fig 5



Type 'B' centre drill is used to produce a centre hole with a plain drilled portion and a countersink, and has a further conical portion to form additional countersinking to protect the centre hole. The countersinking for providing the bearing surface for centres has an angle of 60° and the countersinking surface has an angle of 120°. This type is designated as Centre Drill B1.6 x 6.3 IS: 6709 which means that the pilot diameter is 1.6 mm and shank diameter is 6.3 mm. (Fig 6)

The third type, 'R' is designated as Centre Drill R 1.6 x 4.0 IS: 6710. This also has provision to provide a protected centre hole. This has an enlarged radius, machined along with the countersinking portion. (IS: 6710) (Fig 7)

Fig 6

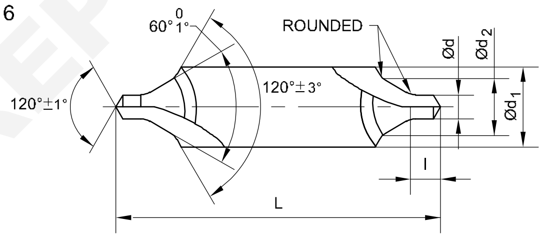
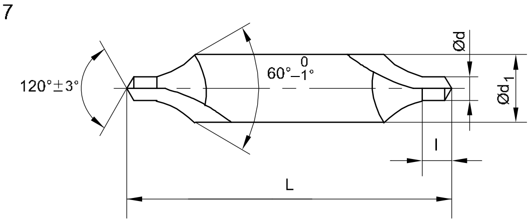


Fig 7



Boring tool and boring

Objectives : At the end of this lesson you shall be able to
- **identify and name the different types of boring tools**
- **list out the advantages of the different boring tools.**

Boring is the process of enlarging and truing an existing drilled or core hole with a single point cutting tool.

Necessity of boring a hole

- To enlarge a drilled hole larger than the drill size as drills are available in standard sizes only.
- To obtain concentricity of the hole.
- To maintain accuracy of the hole.
- To obtain better surface finish.
- To remove the error formed by drilling, and to facilitate the reaming operation.

Boring tools and holders

Boring is an internal operation performed on the drilled or cored holes. The cutting edge of a boring tool is ground similar to the left hand plain turning tool. But the operation being performed is from right to left. (Fig 1)

Parts of a rough boring tool (Figs 1,2 & 3)

Fig 1

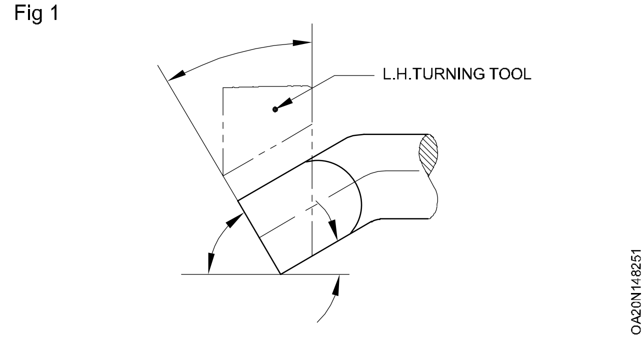


Fig 2

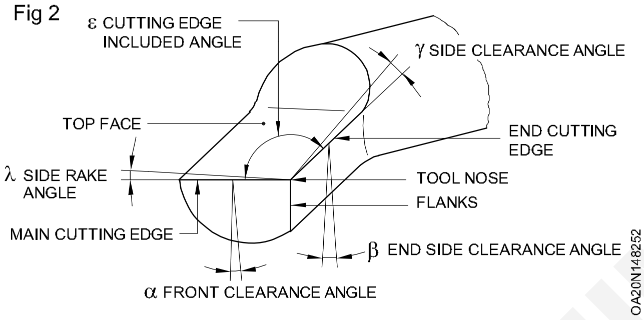
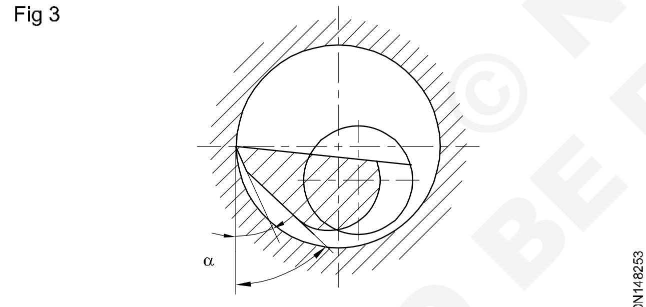


Fig 3



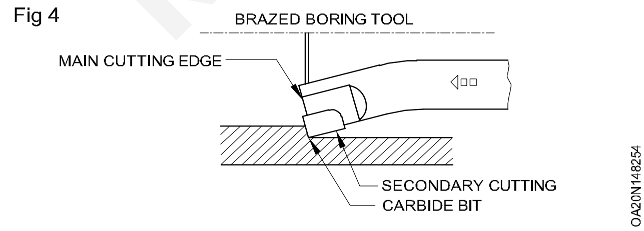
SECONDARY CLEARANCE

Types of boring tools

The following are the different types of boring tools.

- Solid forged tools
- Boring bars with bits
- Brazed tools (Fig 4)

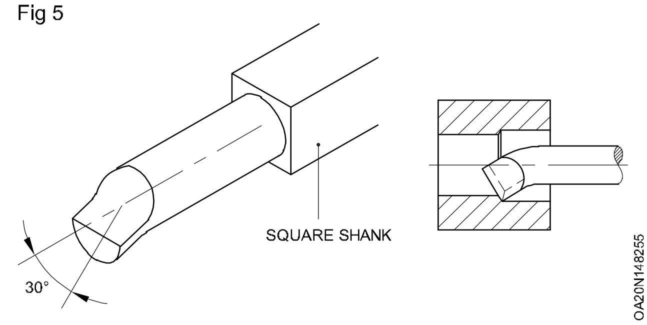
Fig 4



- Throw-away bits inserted in special holders.

Solid forged tools (Fig 5) : The solid forged boring tool is generally made of high speed steel, with the end forged and ground to resemble a left hand turning tool. They are light duty tools and are used on small diameter holes. They are held in special tool holders which are mounted in the tool post.

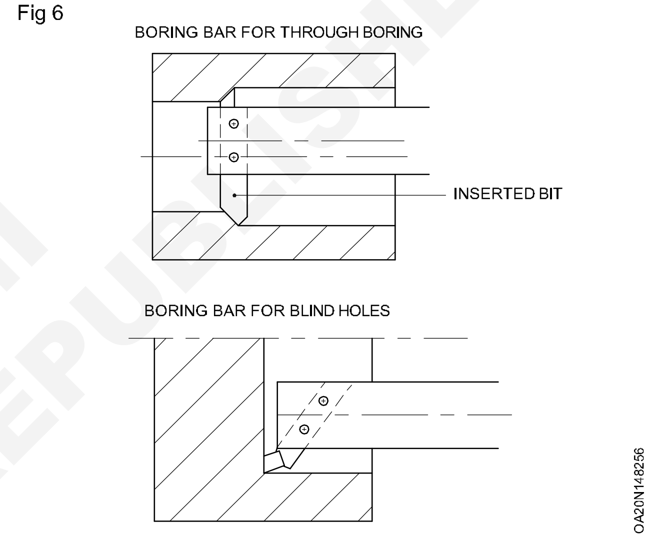
Fig 5



Occasionally tungsten carbide or high speed steel tips are brazed to low carbon bars, for economy.

Boring bars with inserted bit (Fig 6)

Fig 6



The boring bar tool-holder is mounted in the tool post and is used for heavier cuts than those for the forged boring tool.

The square tool bits are set at angles of 30°, 45° or 90° in the broached holes in the bar.

The boring bars may be plain type or end cap type. The cutting tool of the plain type is held in position by a set screw. The cutting tool of the end-cap type is held in position by the wedging action of a hardened plug.

The round or square section tool bits may be inserted in boring bars, the size depending on the diameter of the bar.

The tool bit may be square to the axis of the bar for plain boring or at an angle for facing shoulder, or threading up to a shoulder.

The bar is held in a split or ‘V’ block holder.

The advantages of Different boring tools

Solid boring tools

Available with square and round shank.

Enables to mount on the tool post easily.

Re-grinding is easy.

As the tool is integral, alignment is easy.

Can be easily forged to the required shape and angle.

Boring bars and inserted bits

Used for heavy duty boring operation.

Used for deep boring operation.

Tool changing is faster, thereby re-sharpening time is avoided.

Cost is less because the boring bar is made out of low carbon steel.

Boring tools can be set square to the axis of the boring bar or at an angle very quickly.

Grooving

Objectives: At the end of this lesson you shall be able to
- **state what is grooving**
- **identify and name the types of grooves**
- **state the specific uses of each type of groove.**

Grooving

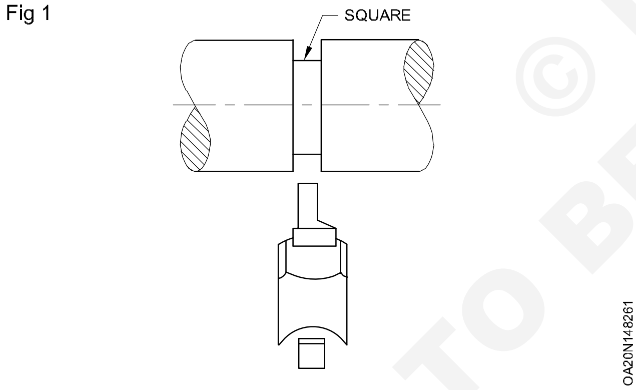
Grooving is the process of turning a grooved form or channel on a cylindrically turned workpiece. The shape of the cutting tool and the depth to which it is fed determine the shape of the groove.

Types of grooves

Square grooves

Square grooves are frequently cut at the end of a section to be threaded in order to provide a channel into which a threading tool may run. A square groove cut against a shoulder allows a matching part to fit squarely against the shoulder. (Fig 1)

Fig 1



When a diameter is to be finished to size by grinding, a groove is generally cut against the shoulder to provide clearance for the grinding wheel and to ensure a square corner.

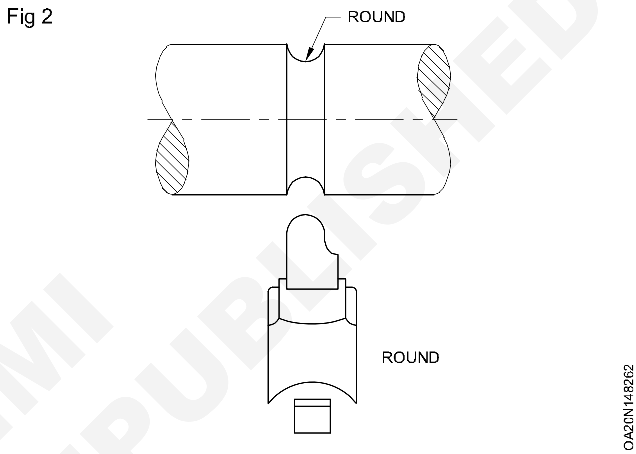
Square grooves are cut with a tool bit ground to the width of the square groove to be formed.

A square groove also serves the purpose of providing space for forks of shift levers in sliding gear assemblies.

Round groove

Round grooves serve the same purpose as square grooves. They are generally used on parts subjected to stress. The round groove eliminates the sharpness of the square corners and strengthens the part at the point where it tends to fracture. A tool bit with a round nose ground to the required radius is used to cut round grooves. (Fig 2)

Fig 2

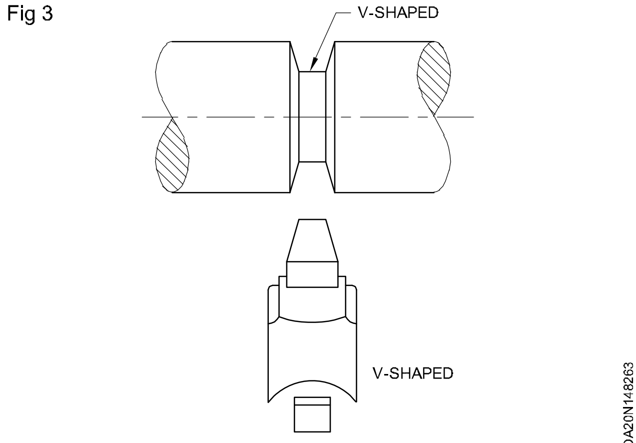


'V' Shaped groove

'V' shaped grooves are most commonly found on pulleys driven by `V' belts. The `V' shaped groove eliminates much of the slip which occurs in the other forms of the belt drive. A `V' groove may also be cut at the end of a thread to provide a channel into which the threading tool may run. (Fig 3)

A tool bit ground to the desired angle is used to cut a shallow `V' groove. Larger `V' grooves such as those found on pulleys should be cut with the lathe compound rest set to form each face of the groove individually.

Fig 3

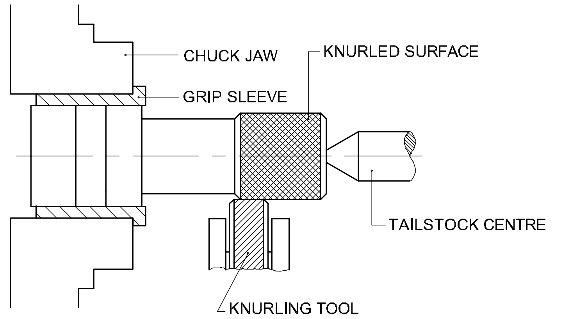


Knurling

Objectives : At the end of this lesson you shall be able to
- **define knurling operation**
- **state the purpose of knurling**
- **identify the different types of knurls and knurling patterns**
- **identify the grades of knurls**
- **distinguish between the various types of knurling tool-holders.**

Knurling (Fig 1)

Fig 1



It is the operation of producing straight lined, diamond shaped pattern or cross lined pattern on a cylindrical external surface by pressing a tool called knurling tool. Knurling is not a cutting operation but it is a forming operation. Knurling is done at a slow spindle speed (1/3 the turning speed). Soluble oil is to be used as coolant mostly and, sometimes straight cutting oil may be used to get better finish.

Purpose of knurling

The purpose of knurling is to provide:

- a good grip and make for positive handling.
- good appearance
- for raising the diameter to a small range for assembly to get a press fit.

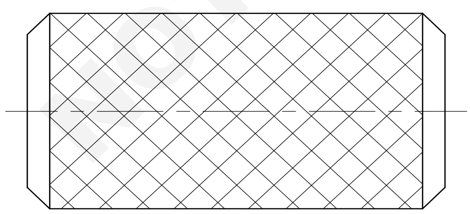
Types of knurls and knurling patterns

The following are the different types of knurling patterns.

- Diamond knurling, Straight Knurling, Cross knurling, Concave knurling and Convex knurling.

Diamond knurling (Fig 2)

Fig 2

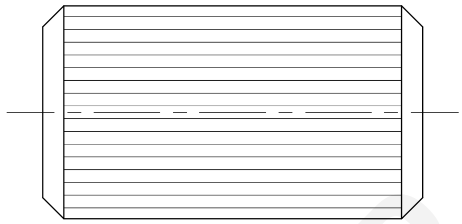


It is a knurling of diamond shaped pattern. It is done by using a set of rolls. One roller has got right hand helical teeth and the other has left hand helical teeth.

Straight knurling (Fig 3)

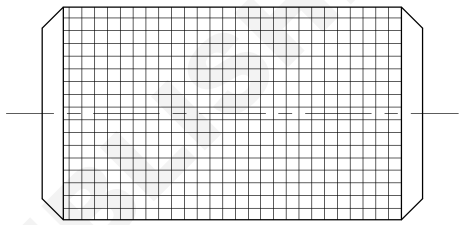
It is a knurling of straight lined pattern. This is done by using either a single roller or a double roller with straight teeth.

Fig 3



Cross knurling (Fig 4)

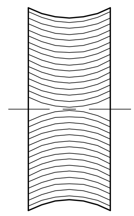
Fig 4



It is a knurling having a square shaped pattern. It is done by a set of rollers, one having straight teeth the other having teeth at right angles to the axis of knurl.

Concave knurling (Fig 5)

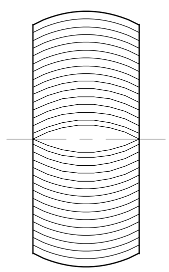
Fig 5



This is done by a convex knurl on a concave surface. This is done only by plunging the tool. The tool should not be moved longitudinally. The length of the knurling is limited to the width of the roller.

Convex knurling (Fig 6)

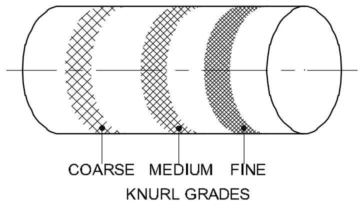
Fig 6



This is done by using a concave knurl on a convex surface. This is also done by plunging the tool.

Grades of knurling (Fig 7)

Fig 7



Knurling can be done in three grades.

Coarse knurling, Medium knurling and Fine knurling

Coarse knurling is done by using coarse pitched knurls of 1.75 mm pitch. (14 TPI)

Medium knurling is done by using medium pitched knurls of 1.25 mm pitch. (21 TPI)

Fine knurling is done by using fine pitched knurls of 0.75 mm pitch. (33 TPI)

Types of knurling tool-holders

The different types of knurling tool-holders are:

- single roller knurling tool-holders (parallel knurling tool-holders)
- knuckle joint type knurling tool-holders
- revolving type knurling tool-holders (universal knurling tool-holders).

A knurling tool-holder has a heat-treated steel shank and hardened tool steel knurls. The knurls rotate freely on hardened steel pins.

Single roller knurling tool-holder (Fig 8)

It has only one single roller which produces a straight lined pattern.

Knuckle joint type knurling tool-holders (Fig 9)

This tool holder has a set of two rollers of the same knurling pitch. The rollers may be of straight teeth or helical teeth. It is self-centering.

Fig 8

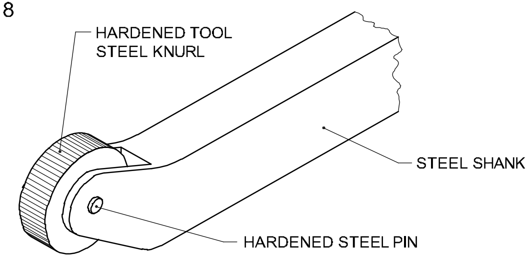
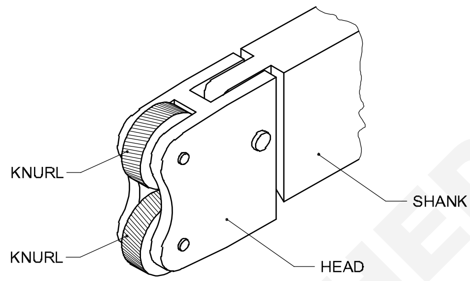


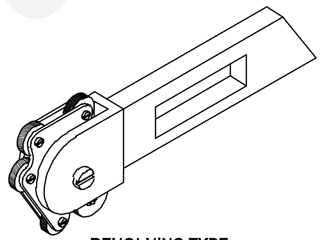
Fig 9



Revolving head knurling tool (Fig 10)

This tool-holder is also called a universal knurling tool-holder. It is fitted with 3 pairs of rollers having coarse, medium and fine pitches. These are mounted on a revolving head which pivots on a hardened steel pin. It is also self-centering.

Fig 10



REVOLVING TYPE

Differences between different types of knurling tool - holders

Single roller	Knuckle joint	Revolving type
Only one roller is used. Only one pattern of knurling can be produced with this type of knurling tool- holder.	A pair of rollers are used. Cross or diamond knurling pattern can be produced.	Three pairs of rollers are used. Knurling patterns of different pitches can be produced.
It is not self-centering.	It is self-centering.	It is self-centering.

Form turning

Objectives : At the end of this lesson you shall be able to
- **distinguish between plain turning and form turning**
- **state the necessity of form turning**
- **identify the methods of form turning.**

Form turning : The plain turning process is capable of generating cylin-drical, conical and flat surfaces whereas the form turning process is intended for generating concave and convex profiles on the workpiece. The figure shows the different types of forming obtained on the workpiece with the help of the form tools.

Purpose of form turning

Form turning is mainly used on the handles to provide better grip for handling purposes.

It provides additional decoration on the product.

Concave forming is mainly used in ball bearing races.

Form turning is largely employed in the manufacture of automobile engineering components.

Methods of turning formed surfaces

Formed surfaces can be turned by:

- using form tools
- using templates
- free hand form turning.

Form turning using form tools (Figs 1 & 2)

Fig 1

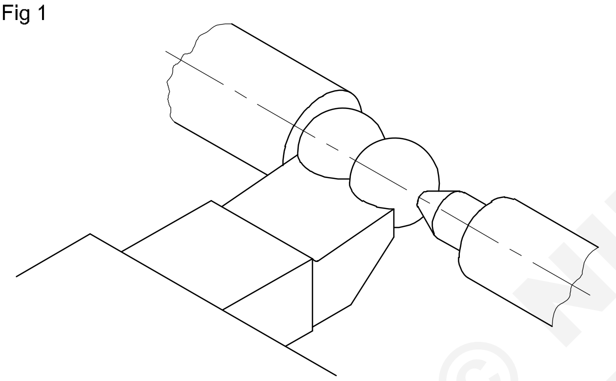
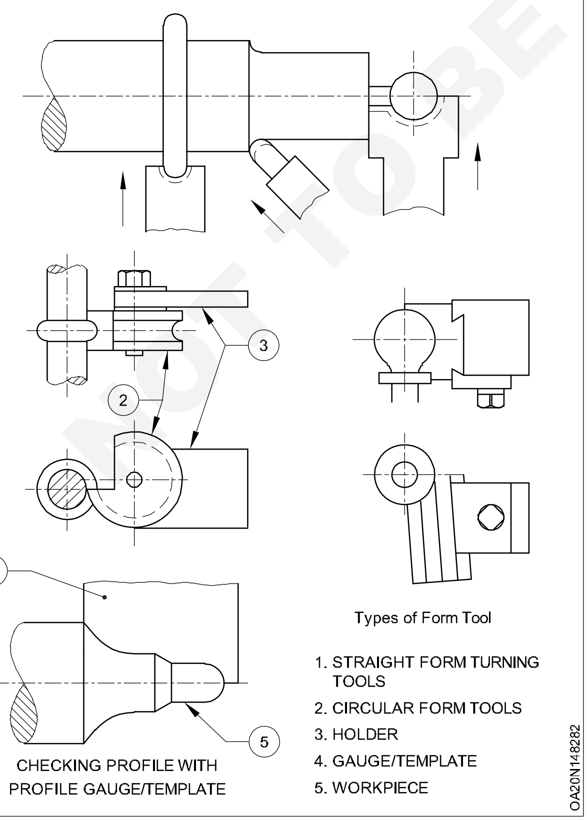


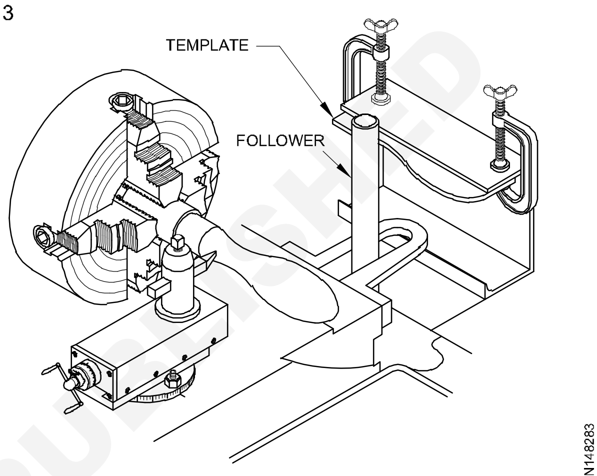
Fig 2



Form tools are ground so that the profile or contour of the cutting edge corresponds to the desired shape. If the tool bit is ground accurately, an accurate form is reproduced on the workpiece. If the form must be held to fine tolerances, it is wise to check the accuracy of the cutting edge on an optical projector. For mass production purposes, carbide tipped form tools are used. When a form tool requires sharpening, it is important that the grinding occurs only on the top of the cutting edge. Otherwise, the shape and accuracy of the form will be altered. When forms are produced manually, constant checking of parts against the master template is necessary.

Form turning using a template (Fig 3)

Fig 3



SETUP FOR PRODUCING A SPECIAL FORM

Very accurate profiles or contours may be produced by using templates. The main parts involved in this method are the:

- cutting tool
- template
- follower.

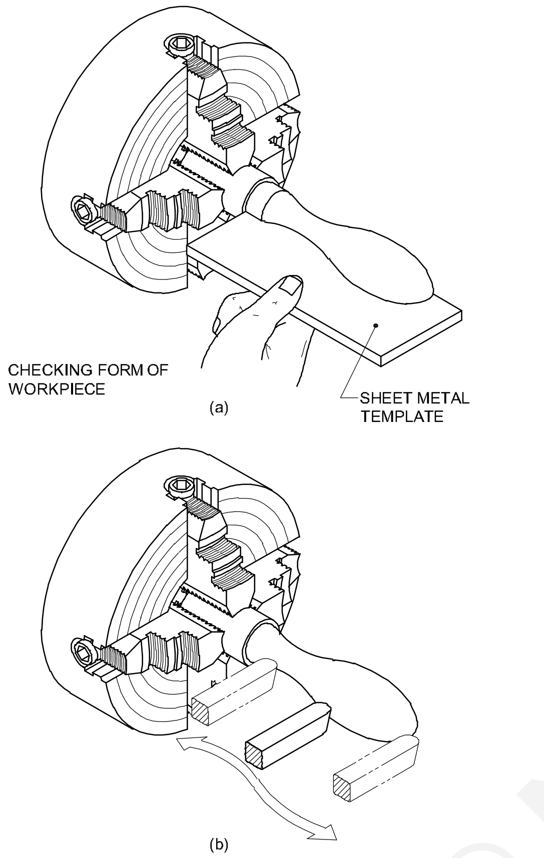
A follower is fastened to the cross-slide to follow the contour of the template. The accuracy of the template determines the accuracy of the form produced. The template is mounted on the back of the lathe. With these arrangements, the tool has to be moved by hand using cross and longitudinal feeds.

Free hand form turning (Figs 4a & 4b)

Free hand turning is generally used when only a few parts are required and when it would be uneconomical to provide templates and follower. A very high skill is needed to produce accurate forms on the workpiece. This method involves simultaneous control over the carriage and the cross-slide. Also it involves coordination of both the hands of the operator.

A work can be mounted on a face-plate while the face-plate is on the lathe spindle or on the workbench. If the workpiece is heavy or awkward to hold, the workpiece is mounted while the face-plate is on the workbench. Before mounting the face-plate and it is set up to the spindle, it is advantageous to locate the workpiece on the face-plate and centre the workpiece. Centre a punch mark or hole approximately on the face of the workpiece. This makes it easier to true the work after the face-plate is mounted on to the spindle.

Fig 4

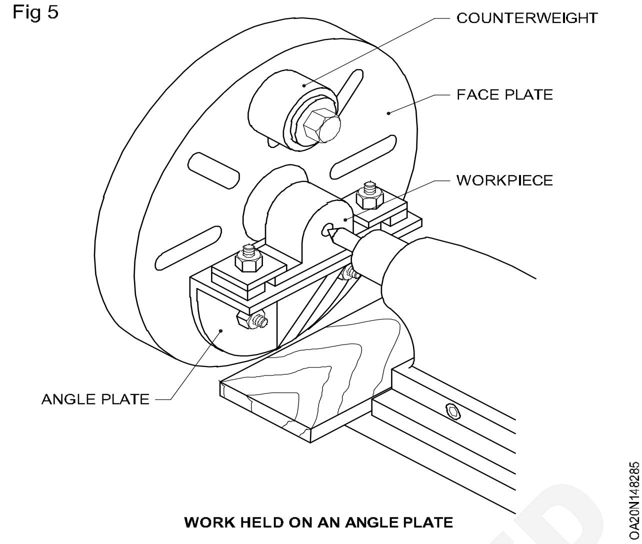


The position of the bolts and clamps is very important, if a workpiece is to be clamped effectively.

If a number of duplicate pieces are to be machined, the face-plate itself can be set up as a fixture, using parallel strips and stop blocks.

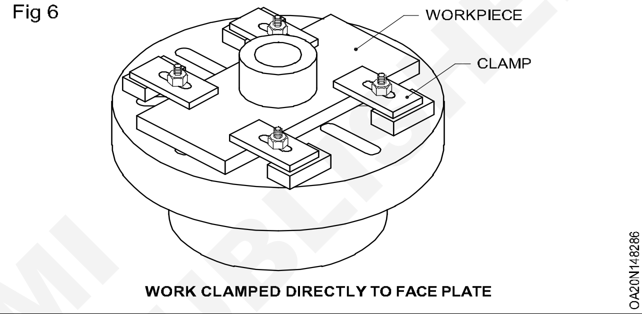
The application of the face-plate with the accessories in different set ups is shown in the sketches below. (Figs 5,6 and 7)

Fig 5



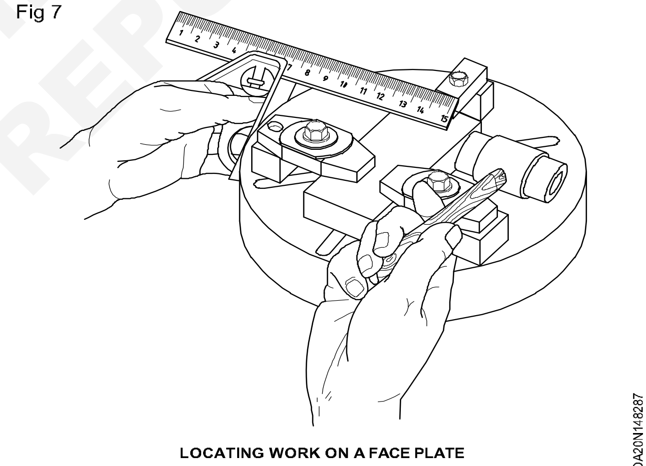
WORK HELD ON AN ANGLE PLATE

Fig 6



WORK CLAMPED DIRECTLY TO FACE PLATE

Fig 7



LOCATING WORK ON A FACE PLATE

Parting off operation

Objectives : At the end of this lesson you shall be able to
- **explain the parting off tool in the machine to the correct centre height**
- **state precaution while parting off**
- **state the meaning of plain turning**
- **explain the two stages of plain turning.**

Parting off operation : Parting off or cutting off is the operation of severing a finished part from the rough or finished stock.

Setting of parting tool : Set the parting tool exactly on the centre with as little back-rake as possible. (Fig 1)

Adjust the parting off tool so that it extends one half of the diameter of the work plus about 3mm for clearance from the tool-holder (Fig 2)

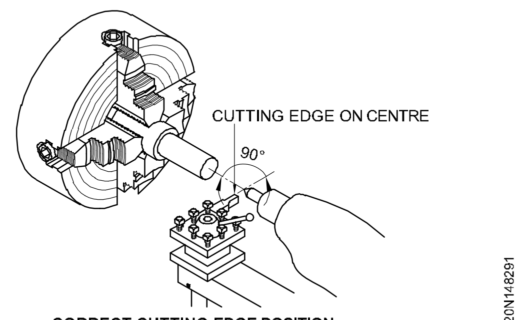
If the cutting tool is too high, it will not cut through the workpiece. If it is too low, the work may be bent and the cutting tool damaged.

Procedure

Select the correct type of tool for a specified job.

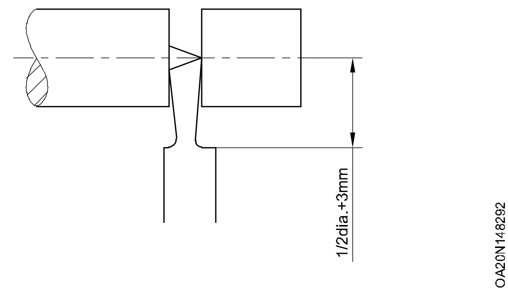
Hold the work with the minimum overhang in a chuck.

Fig 1



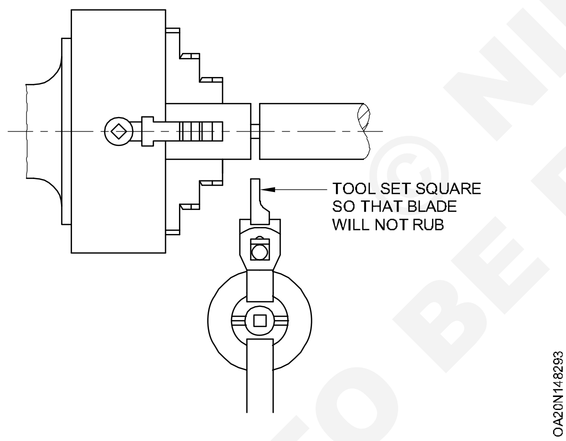
CORRECT CUTTING EDGE POSITION

Fig 2



Set the tool square with the work so that it does not rub against the sides of the groove, as it is fed into the work. (Fig 3)

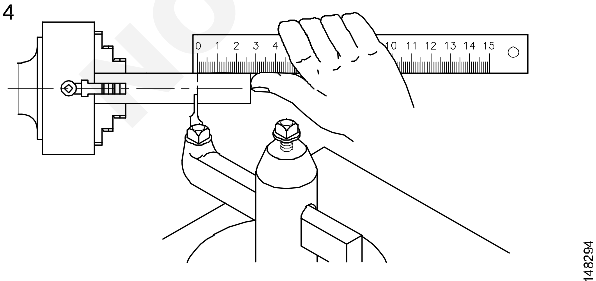
Fig 3



Set the spindle speed to half the speed for turning.

Move the carriage so that the right hand side of the blade is at the point where the work is to be cut off. (Fig 4)

Fig 4



PARTING TOOL POSITIONED TO CUT OFF A DEFINITE LENGTH OF WORKPIECE

Start the lathe and feed the tool steadily into the work using the cross-slide handle.

Continue to feed the tool into the work until the part is severed.

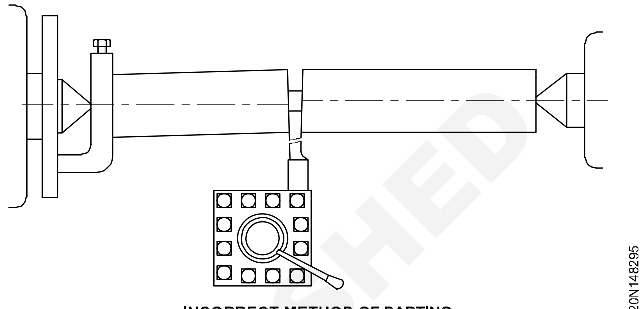
Precautions

The work should protrude from the chuck jaws, sufficiently enough to permit the cut to be made as close as possible to the chuck jaws.

The work must always be held securely in a chuck or a collet.

If the workpiece is held between centres, it may bend or break and fly aut of the lathe during parting off. (Fig 5)

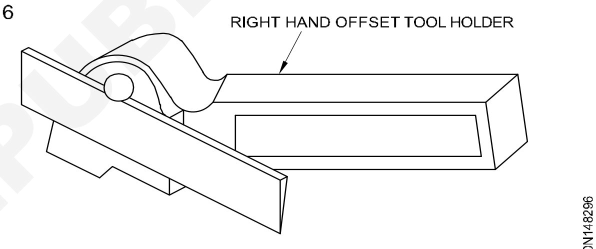
Fig 5



INCORRECT METHOD OF PARTING

Use a right hand offset tool-holder. (Fig 6)

Fig 6



INSERTED-BLADE TYPE PARTING TOOL

A work having more than one diameter should be gripped on the larger diameter while parting.

Intermittent feed tends to dull the tool's cutting edge.

Heavy feed causes jamming and tool breakage.

Use sufficient coolant on steel. Brass and cast iron should be cut off dry.

Make sure the saddle is locked during the entire operation.

Reduce the rate of feed, when the work is almost cut off.

While parting off long work, it should be supported with the tailstock centre.

If the machine is in good condition, the automatic cross feed may be used.

When the tool has penetrated to about the depth of its width, withdraw it and move it sideways with the compound slide and feed again.

The above operation should be repeated frequently to minimise the tendency of the tool to dig in and cause trouble.

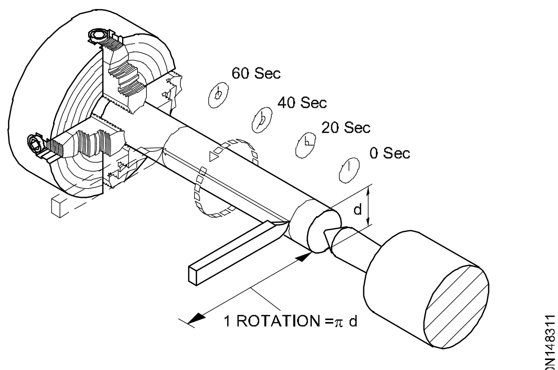
When the parting off operation is almost completed, hold the workpiece by hand to prevent it from falling, so that damage can be avoided.

Cutting speed and feed & depth of cut, recommended speed

Objectives : At the end of this lesson you shall be able to
- **distinguish between cutting speed and feed**
- **read and select the recommended cutting speed for different materials from the chart**
- **point out the factors governing the cutting speed**
- **state the factors governing feed.**

Cutting speed (Fig 1)

Fig 1



CUTTING SPEED FOR TURNING OPERATION

The speed at which the cutting edge passes over the material, which is expressed in metres per minute is called the cutting speed. When a work of a diameter 'D' is turned in one revolution the length of portion of the work in contact with the tool is π x D. When the work is making 'n' rev/min, the length of the work in contact with the tool is π x D x n. This is converted into metres and is expressed in a formula form as

$$V = \frac{\pi DN}{1000}$$

Where V = cutting speed in metre/min

π = 3.14

D = diameter of the work in mm.

N = r.p.m.

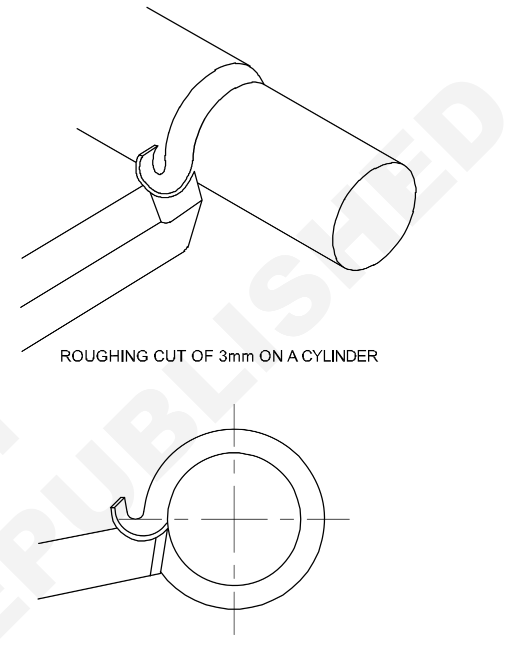
When more material is to be removed in lesser time, a higher cutting speed is needed. This makes the spindle to run faster but the life of the tool will be reduced due to more heat being developed. Recommended cutting speeds are given in a chart form which provides normal tool life under normal working conditions. As far as possible the recommended cutting speeds are to be chosen and the spindle speed calculated before performing the operation. (Fig 2)

Example

Find out the rpm of the spindle for a 50 mm bar to cut at 25 m/min.

$$V = \frac{\pi DN}{1000} \quad N = \frac{1000V}{\pi D}$$

Fig 2



DEPTH OF CUT

$$\frac{1000 \times 25}{3.14 \times 50} = \frac{500}{3.14} = 159 \text{ r.p.m}$$

Factors governing the cutting speed

Finish required

Depth of cut

Tool geometry

Properties and rigidity of the cutting tool and its mounting

Properties of the workpiece material

Rigidity of the workpiece

Type of cutting fluid used & Rigidity of machine tool

Feed (Fig 3) : The feed of the tool is the distance it moves along the work for each revolution of the work, and it is expressed in mm/rev.

Factors governing feed

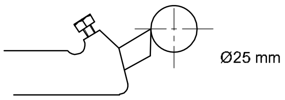
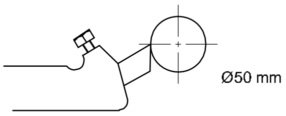
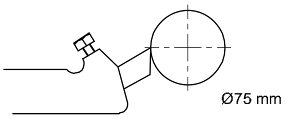
Tool geometry

Surface finish required on the work

Rigidity of the tool

Coolant used.

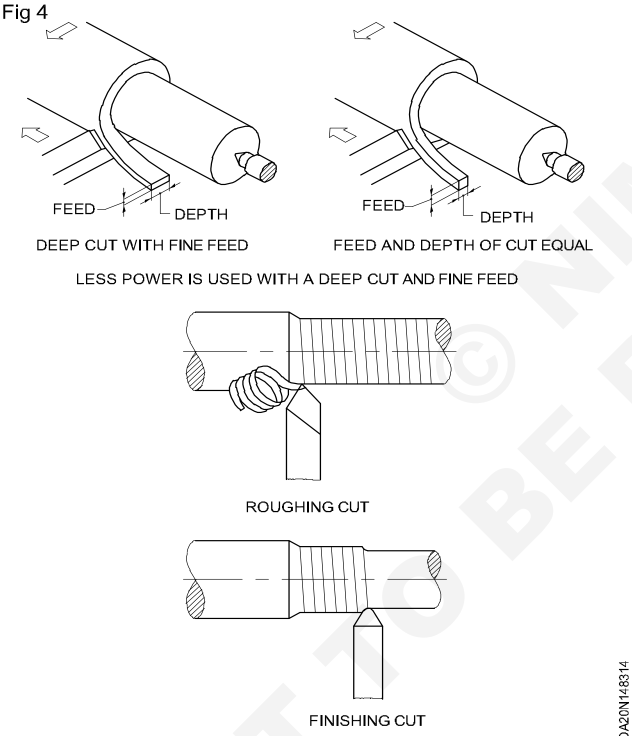
Relationship of r.p.m to the cutting speed on different diameter

Cutting speed 120m/min	Length of metal passing cutting tool in one revolution	Calculated r.p.m of spindle
	.... 78.5 mm	1528
	.... 157.0 mm	764
	.... 235.5 mm	509.5

Depth of cut (Fig 4)

It is defined as the perpendicular distance measured between the machined surface (d) and the unmachined surface (D) expressed in mm.

Fig 4



$$\text{Depth of cut} = \frac{D - d}{2}$$

Rate of metal removal

The volume of metal removal is the volume of chip that is removed from the work in one minute, and is found by multiplying the cutting speed, feed rate and the depth of cut.

The recommended cutting speed and feed for different metals are given in the table. It can be observed that soft materials has a very high cutting speed and hard metal has a lesser cutting speed. The feed for hard material is general. It very low compare to the feed given for soft material.

Cutting speeds and feeds for H.S.S. tools are given in Table 1

Table 1

Material being turned	Feed	Cutting speed
Aluminium	0.2 - 1.00	70 - 100
Brass (alpha) - ductile	0.2 - 1.00	50 - 80
Brass (free cutting)	0.2 - 1.5	70 - 100
Bronze (phosphor)	0.2 - 1.00	35 - 70
Cast iron (grey)	0.15 - 0.7	25 - 40
Copper	0.2 - 1.00	35 - 70
Steel (mild)	0.2 - 1.00	35 - 50
Steel (medium-carbon)	0.15 - 0.7	30 - 35
Steel (alloy high tensile)	0.08 - 0.3	5 - 10
Thermosetting plastics	0.2 - 1.00	35 - 50

Note

For super HSS tools the feeds would remain the same, but cutting speeds could be increased by 15% to 20%

A lower speed range is suitable for heavy, rough cuts.

A higher speed range is suitable for light, finishing cuts.

The feed is selected to suit the finish required and the rate of metal removal.

When carbide tools are used, 3 to 4 times higher cutting speed than that of the H.S.S. tools may be chosen.

Calculation involving cutting speed, feeds

Objectives : At the end of this lesson you shall be able to
- **determine the spindle speed for turning jobs of different materials of different diameters with different tool materials**
- **determine the turning time with the given data.**

The selection of the spindle speed is one of the factors which decides the efficiency of cutting. It depends on the size of the job, material of the job and material of the cutting tool. The formula to determine cutting speed is.

$$= \frac{\pi \times D \times N}{1000} \text{ metre/min. where D is in mm.}$$

$$N = \frac{CS \times 1000}{\pi \times D}$$

To determine the spindle speed (N)

Example 1

Calculate the spindle speed to turn a MS rod of ø40 mm. Using HSS tool data in the above problem, since the material is mild steel and tool is HSS, the recommended cutting speed from the chart is 30m/min.

ø = 40 mm

$$N = \frac{CS \times 1000}{\pi \times D}$$

$$= \frac{30 \times 1000}{\frac{22}{7} \times 40}$$

$$= \frac{30 \times 1000 \times 7}{22 \times 40}$$

$$= \frac{30 \times 25 \times 7}{22}$$

= 238.6 r.p.m.

The spindle speed should be set nearest to the calculated r.p.m., on the lower side.

Example 2

Determine the spindle speed to be set for a hard cast iron round rod of ø 40 mm using a HSS tool.

Data: The cutting speed for hard cast iron from the chart is 15 m/min.

ø = 40 mm

$$N = \frac{CS \times 1000}{\pi \times D}$$

$$= \frac{15 \times 1000}{\frac{22}{7} \times 40}$$

$$= \frac{15 \times 1000 \times 7}{22 \times 40}$$

$$= \frac{15 \times 25 \times 7}{22}$$

= 119.3 r.p.m.

The spindle speed should be set nearest to the calculated r.p.m., on the lower side.

Example 3

Calculate the spindle speed to turn a ø40 mm MS rod using a cemented carbide tool.

Data: The cutting speed recommended for-turning mild steel using a carbide tool is 92 mtr/minute.

ø of job = 40 mm

$$N = \frac{CS \times 1000}{\pi \times D}$$

$$= \frac{92 \times 1000}{\frac{22}{7} \times 40}$$

$$= \frac{92 \times 1000 \times 7}{22 \times 40}$$

$$= \frac{92 \times 25 \times 7}{22}$$

= 731.8 r.p.m.

The spindle speed should be set to the nearest calculate r.p.m.

Turning time calculation

The time factor is very important to decide the manufac turing of the component as well as to fix the incentives to the operator. If the spindle speed, feed and length of the cut are known, the time can be determined for a given cut.If the feed is ‘f’ and length of cut is ‘l’, then the total number if revolutions the job has to make for a cut is l/f. If N is the rpm, the time required for a cut is found by

$$\text{Time to turn} = \frac{\text{Length of cut} \times \text{No.of cuts}}{\text{Feed} \times \text{r.p.m}}$$

$$T = \frac{l \times n}{f \times N}$$

where 'n' is the number of cuts and 'N' is the r.p.m.

Example 1

A mild steel of ø 40 mm and 100 mm length has to be turned to ø 30 mm in one cut for full length using a HSS tool with a feed rate of 0.2 mm/rev. Determine the turning time.

$$\text{Turning time} = \frac{l \times n}{f \times N}$$

The r.p.m. for the above is calculated Hand found out as 238.6 r.p.m.

l = 100mm

f = 0.2 mm

n = 1

N = 238.6 r.p.m.

$$\text{Time} = \frac{100 \times 1}{0.2 \times 238.6}$$

$$= \frac{100 \times 10}{2 \times 238.6}$$

$$= \frac{500}{238.6}$$

= 2.09 minutes

2 minute 5.4 seconds.

Lubricant and coolant - types its necessity, system of lubrication, selection of coolant, handling & care

Objectives : At the end of this lesson you shall be able to
- **state what is cutting fluid**
- **state the function of cutting fluids & their advantages**
- **state the properties of a good cutting fluid**
- **list the different types of cutting fluids**
- **select appropriate cutting fluids for different materials.**

Cutting fluids and compounds are the substances used for efficient cutting while cutting operations take place.

Functions : The functions of cutting fluids are:

- to cool the tool as well as the workpiece
- to reduce the friction between the chip and the tool face by lubricating
- to prevent the chip from getting welded to the tool cutting edge
- to flush away the chips
- to prevent corrosion of the work and the machine.

Advantages : As the cutting fluid cools the tool, the tool will retain its hardness for a longer period; so the tool life is more.

Because of the lubricating function, the friction is reduced and the heat generated is less. A higher cutting speed can be selected.

As the coolant avoids the welding action of the chip to the tool-cutting edge, the built up edge is not formed. The tool is kept sharp and a good surface finish is obtained.

As the chips ar flushed away the cutting zone will be neat.

The machine or job will not get rusted because the coolant prevents corrosion.

Properties of a good cutting fluid : A good cutting fluid should be sufficiently viscous.

At cutting temperature, the coolant should not catch fire.

It should have a low evaporation rate.

It should not corrode the workpiece or machine.

It must be stable and should not foam or fume.

It should not create any skin problems to the operator.

Should not give off bad smell or cause itching etc. which are likely to irritate the operator, thus reducing his efficiency.

Should be transparent.

Types of cutting fluids

The following are the common cutting fluids.

- Straight mineral oil
- Chemical solution (synthetic fluids)
- Compounded or blended oil
- Fatty oils
- Soluble oil (Emulsified oil-suds)

Straight mineral oil

Straight mineral oils are the coolants which can be used undiluted. Use of straight mineral oil as a coolants has the following disadvantages.

It gives off a cloud of smoke.

It has little effect as a cutting fluid.

Hence straight mineral oils are poor coolants. But kerosene which is a straight mineral oil is widely used as a coolant for machining aluminium and its alloys.

Chemical solution (Synthetic oil)

These consist of carefully chosen chemicals in dilute solution with water. They possess a good flushing and a good cooling action, and are non-corrosive and non-clogging. Hence they are widely used for grinding and sawing. They do not cause infection and skin trouble. They are artificially coloured.

Compounded or blended oil

These oils are used in automatic lathes. These oils are much cheaper and have more fluidity than fatty oil.

Fatty oil

Lard oil and vegetable oil are fatty oils. They are used on heavy duty machines with less cutting speed. They are also used on bench-works for cutting threads by taps and dies.

Soluble oil (Emulsified oil)

Water is the cheapest coolant but it is not suitable because it causes rust to ferrous metals. An oil called soluble oil is added to water which gets a non-corrosive effect with water in the ratio of about 1:20. It dissolves in water giving a white milky solution. Soluble oil is an oil blend mixed with an emulsifier.

Other ingredients are mixed with the oil to give better protection against corrosion, and help in the prevention of skin irritations.

Soluble oil is generally used as a cutting fluid for centre lathes, drilling, milling and sawing.

Soft soap and caustic soda serve as emulsifying agents.

A chart showing coolants for different metals is given below.

Recommended Cutting Fluids for Various Metals and Different Operations

Material	Drilling	Reaming	Threading	Turning	Milling
Aluminium	Soluble oil Kerosene Kerosene and lard oil	Soluble oil Kerosene Mineral oil	Soluble oil Kerosene Lard oil	Soluble oil	Soluble oil Lard oil Mineral oil Dry
Brass	Dry Soluble oil Mineral oil Lard oil	Dry Soluble oil	Soluble oil Lard oil	Soluble oil	Dry Soluble oil Mineral oil Lard oil
Bronze	Dry Soluble oil Mineral oil Lard oil	Dry Soluble oil	Soluble oil Lard oil	Soluble oil	Dry Soluble oil Mineral oil Lard oil
Cast Iron	Dry Air jet	Dry Soluble oil	Dry Sulphurized oil	Dry Soluble oil	Dry Soluble oil
Copper	Dry Soluble oil	Soluble oil Lard oil	Soluble oil Lard oil	Soluble oil	Dry Soluble oil
Steel alloys	Soluble oil Sulphurized oil Mineral lard oil	Soluble oil Sulphurized oil Mineral lard oil	Sulphurized oil Lard oil	Soluble oil	Soluble oil Mineral
General purpose steel	Soluble oil Sulphurized oil Lard oil Mineral lard oil	soluble oil Sulphurized oil Lard oil	Sulphurized oil Lard oil	Soluble oil	Soluble oil Lard oil

Methods of applying lubricant

Objectives : At the end of this lesson you shall be able to
- **name the different methods of lubrication**
- **state the gravity feed methods of applying lubrication**
- **state the splash methods of applying lubrication**
- **name the different types of lubricators**
- **distinguish between the different methods of lubrication.**

The following methods are used for efficient lubrication

- Gravity feed method
- Force feed method
- Splash method

Gravity feed method

There are numerous ways of employing this principle, varying from the simple oil hole to the more elaborate wick and glass-sided drip feed lubricators in which the flow of the oil may be controlled and observed through the glass. A selection of these lubricators is shown in Fig 1.

Force (Pressure) feed method

There are various systems of lubrication employing a pressure feed to the lubricant, and the most important of such systems may be classified roughly into the following.

- Continuous feed of oil under pressure to each bearing concerned. In this method an oil pump driven by the machine delivers oil to the bearings and back to a sump from which it is drawn by the pump.
- Pressure feed by hand pump in which a charge of oil is delivered to each bearing at intervals (once or twice a day) by the machine operator. (Fig 2)
- Oil or grease gun method. The oil hole leading to each bearing is fitted with a nipple and by pressing the nose of the gun against this the lubricant is forced into the bearing. (Figs 3a, b, c & d)

Splash method : In this method the shaft, or something attached to it, actually dips into the oil and a stream of lubricant is continually splashed round the parts requiring lubrication. This method is employed for the gears and bearings inside all gear drives, the lower parts of the gears actually dipping in the oil. (Figs 4a, b and c)

Fig 1

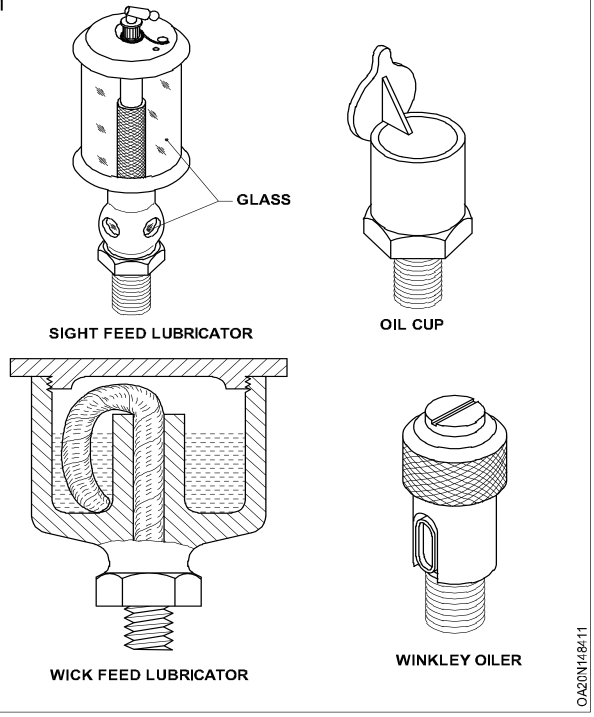
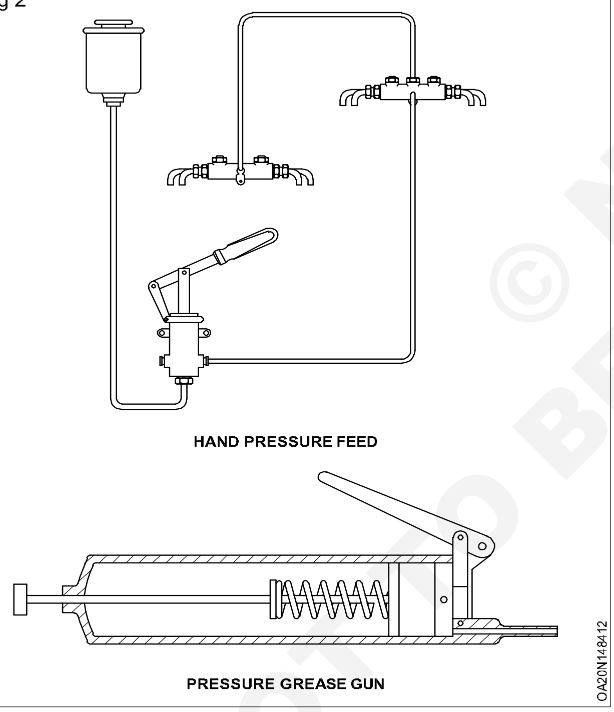


Fig 2



A common method of employing splash lubrication is known as 'ring oiling.'

Handling and Care:-

1 Stored in clean and dry location

2 Storage temperature should remain moderate at all times.

3 Lubricants in storage should be located away from all types of Industrial contamination including dust and humidity.

4 Brings must be kept tight at all times and drum covers should be used when ever drums are stored in the up right position.

5 Lubricants are stored in the horizontal position on proper storage racks allowing the containers to be rotate and used on as first - in first out basis.

6 Eliminate confusion with proper labeling.

7 Be sure that the proper transfer equipment and procedure are employed for that specific lubricants.

Fig 3

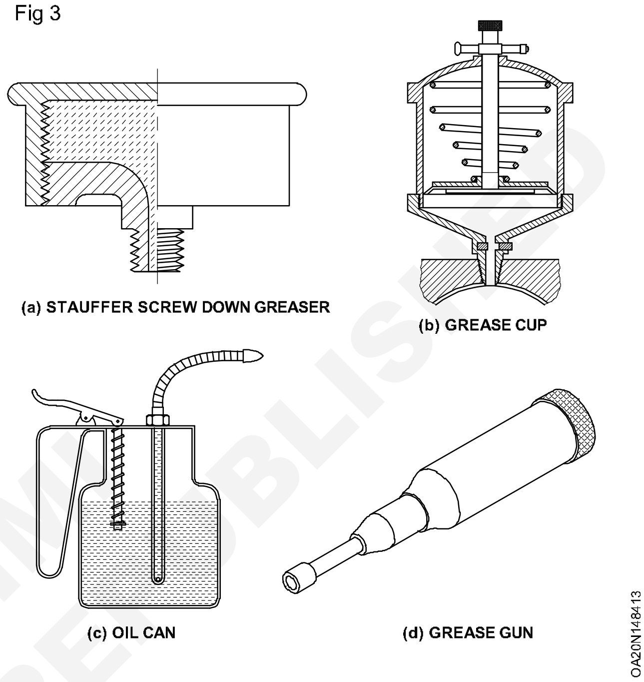
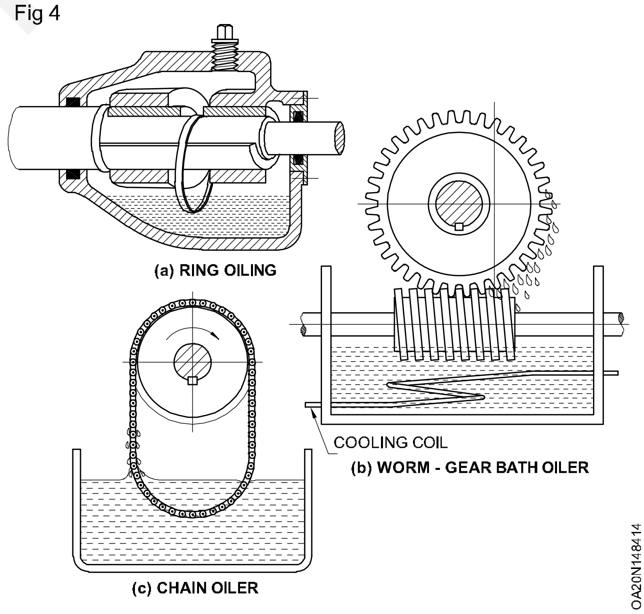


Fig 4



Types of milling machine

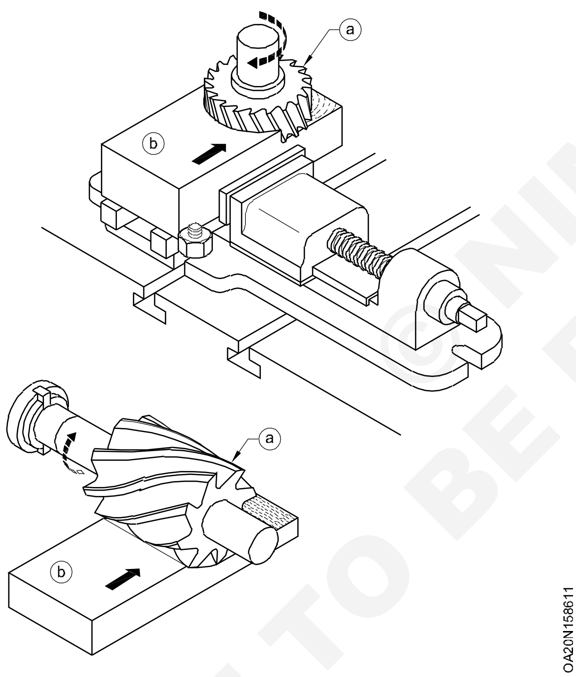
Objectives : At the end of this lesson you shall be able to
- **state the principle of milling**
- **classify the types of milling machines**
- **state the application of milling machines**
- **specify a milling machine.**

Principle of milling

In milling, the cutter has a rotary movement, the speed of which depends upon the cutting speed required. Driving the milling arbor at various rotational speeds makes it possible to achieve approximately the same cutting speeds [peripheral speed] with cutters of different diameters.

While the milling cutter (a) rotates at a high speed, and because of the multiple points, it removes metal at a very fast rate, in comparison with other machine tools. (Fig 1)

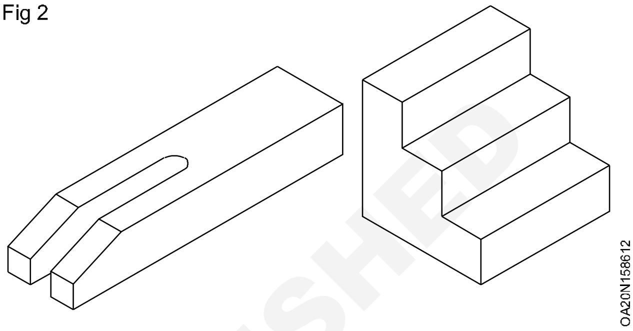
Fig 1



Job (b) can be fed manually or automatically.

By milling we can produce flat (horizontal, vertical, angular) and formed surfaces. (Fig 2)

Fig 2



A milling machine finds wide application in production work as the machine can hold one or more number of cutters at a time, and is good in accuracy, surface finish etc.

Classification

The classification according to the general design of the milling machine is:

- column and knee type
- fixed bed type
- planer type
- special type.

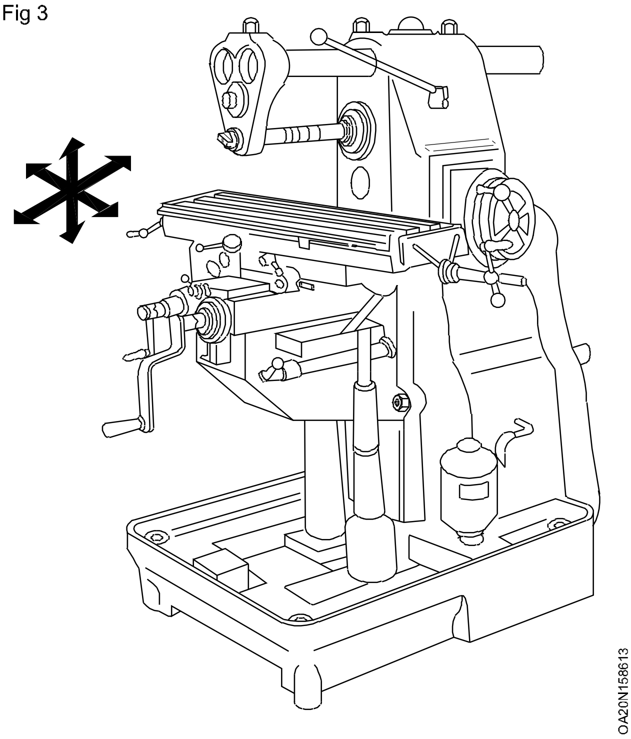
But out of these types the one that is used most in general workshop is the column and knee type machine.

In the column and knee type category the following machines are covered.

- Plain/horizontal milling machine
- Vertical milling machine
- Universal milling machine

Plain/horizontal milling machine (Fig 3)

Fig 3



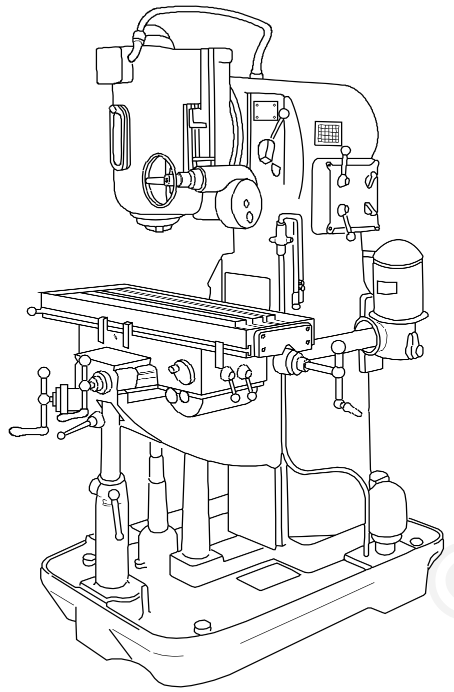
The plain milling machines are much more rigid and sturdy than many others and accommodate heavy work.

The milling machine table may be fed either by hand or by power against a rotating cutter. A milling machine having a horizontal spindle is also called horizontal spindle milling machine. Milling cutters are mounted on the horizontal arbor. In this machine the table may be fed in three directions - namely, longitudinal, vertical and crosswise.

The feed is longitudinal when the table is moved at right angles to the spindle axis, the feed is vertical when the table is moved in the upward/downward directions, and the feed is crosswise when the table is moved parallel to the spindle axis.

Vertical milling machine (Fig 4)

Fig 4



The vertical milling machine can be distinguished from the horizontal milling machine by the position of the spindle which is vertical or perpendicular to the work table. The spindle rotates about the vertical axis. The spindle can be moved up and down by a spindle feed, and on some machines it may be tilted/swivelled.

The vertical milling machine is ideally suitable for boring and for pocket milling, profile milling, and for keyways occuring in the middle of shafts etc.

The operator gets a better view of the milling cutter in a vertical milling machine than in a horizontal milling machine.

Universal milling machine (Fig 5)

The universal milling machine is similar in construction to the plain machine. But its table, apart from having movements in 3 directions, can also be swivelled about the horizontal axis. The maximum swivelling is 45° both in clockwise and anticlockwise directions. (Fig 6)

Fig 5

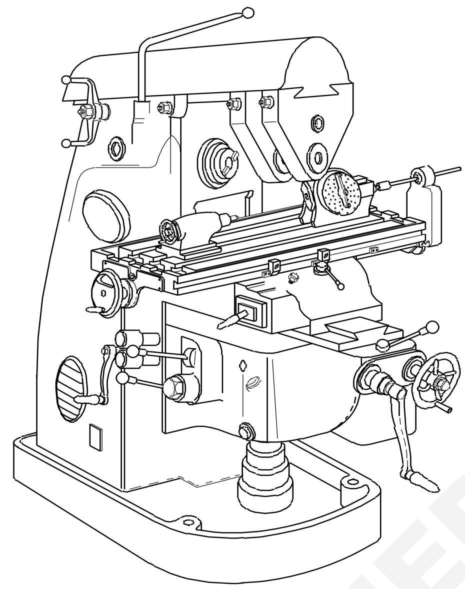
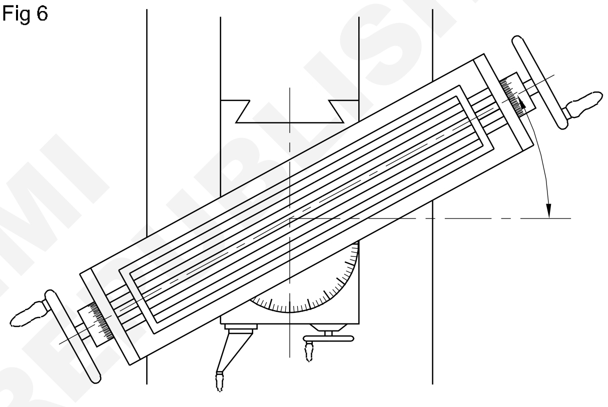


Fig 6



This swivelling of the table permits angular feeding. Because of this, the universal milling machine is suitable for milling helical gears, helical grooves, etc.

This machine is supported with different attachments like vertical head, slotting head, rack-milling attachment, etc.

Specification of a milling machine

The milling machine is normally specified by the

- dimension of the working surface of the table
- longitudinal travel of the table
- cross travel of the table
- vertical travel of the table
- number of spindle speeds
- spindle nose taper
- number of feeds
- floor space area, etc.

Arbor

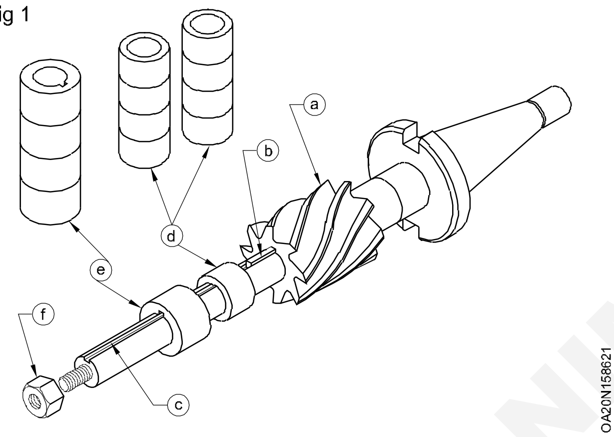
Objectives : At the end of this lesson you shall be able to
- **state the different types of arbors**
- **state the uses of arbors**
- **name the parts of an arbor**
- **specify the arbor.**

Types of arbors and their uses

An arbor is considered as an extension of the machine spindle on which milling cutters are mounted. Arbors are provided with quick-release taper shanks for proper alignment with the spindle. There are two types of arbors, normally used for holding the cutters. They are (1) long arbor and (2) short or stub arbor.

Long arbor (Fig 1)

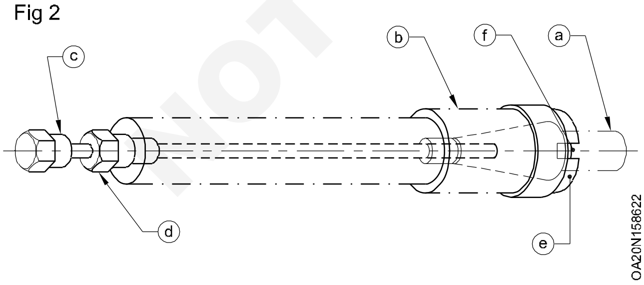
Fig 1



Long arbors are used for holding cutters in both horizontal and universal milling machines. The milling cutter (a) is driven by a key (b) which fits into the keyway (c) on the arbor and cutter. This prevents the cutter from turning on the arbor. The spacer (d) and bearing bushings (e) hold the cutter in position on the arbor after the nut (f) has been tightened.

The tapered end of the arbor (a) is held securely with the machine spindle (b) by a draw-in bar (c) and lock-nut (d). (Fig 2) The flange (e) has two notches (f) to engage with the spindle tennon for transmitting the power.

Fig 2



The outer end of the arbor assembly is supported by the bushing and the arbor support.

Long arbors with I.S.O.taper shanks are available in different diameters. The normal diameters used commonly are Ø16, Ø22,Ø27, Ø32, Ø40 and the taper is ISO40/50.

The arbor is designated by the taper number, diameter and length.

Example ISO40 x Ø 22 x 500 mm.

ISO40 = Type of taper

Ø 22 = diameter of the arbor in 'mm'

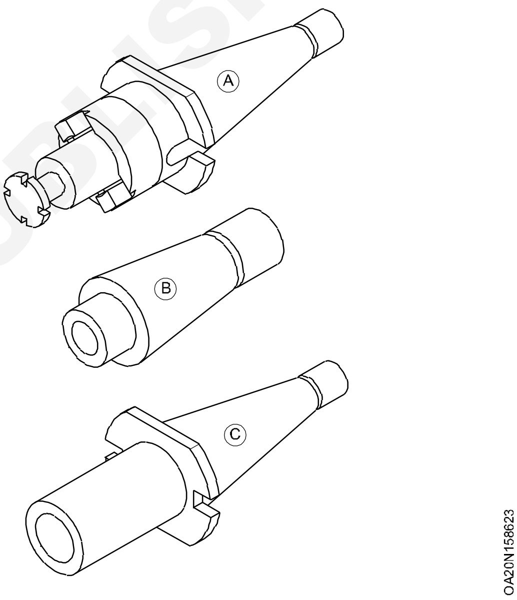
500mm = length of the arbor

Stub arbor

Stub arbors are used to mount various tapers of cutters in the spindle of horizontal and vertical milling machines.

The arbors are held with the machine spindle by a taper and a draw-in bar. The arbors are of three types (A), (B) & (C) as shown in Fig 3.

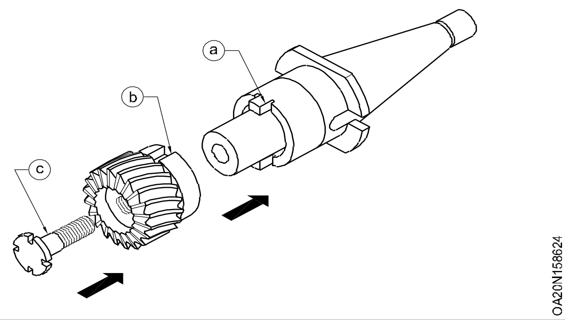
Fig 3



Types

Type A (Fig 4) is used to mount the shell end mills and similar cutters.

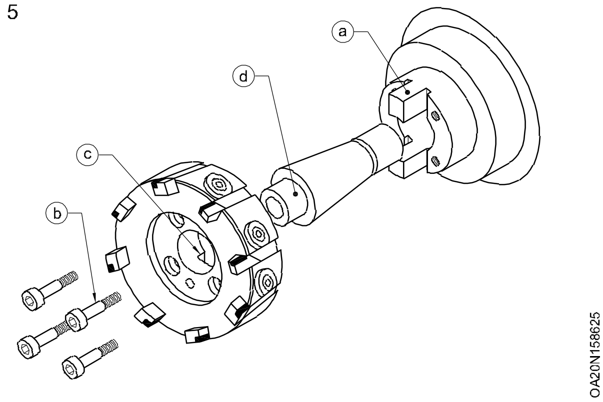
Fig 4



The cutter is pushed on the arbor so that the arbor key (a) fits with the slot (b) on the cutter. The cutter is tightened on the arbor using the screw (c).

Type B (Fig 5) is used to mount large face milling cutters. It is made with a centralizing spigot (a) to ensure that the cutter is centralized with the cutter spindle.

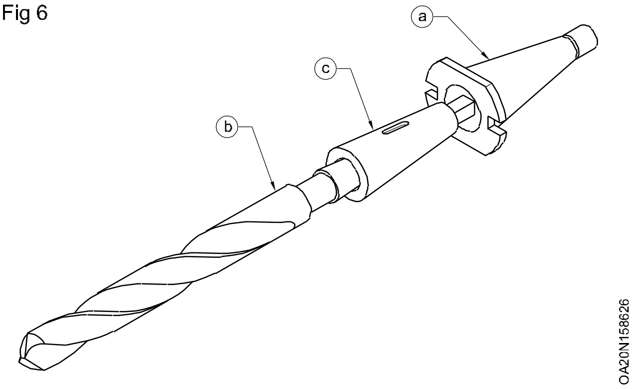
Fig 5



The cutter is held on the arbor by four screws (b). It has a slot (c) which fits over the spindle (d) to provide the drive.

Type C (Fig 6) is a Morse taper adapter arbor (a). It is used to hold drills, reamers, chucks (b), etc. which have taper shanks and also Morse taper sleeves (c) which are used to adapt a Morse taper to a larger taper.

Fig 6



According to B.I.S. specifications stub arbors with Morse taper shanks are available from 13 to 27 mm in diameters.

The stub arbor is designated by the taper number, diameter and length.

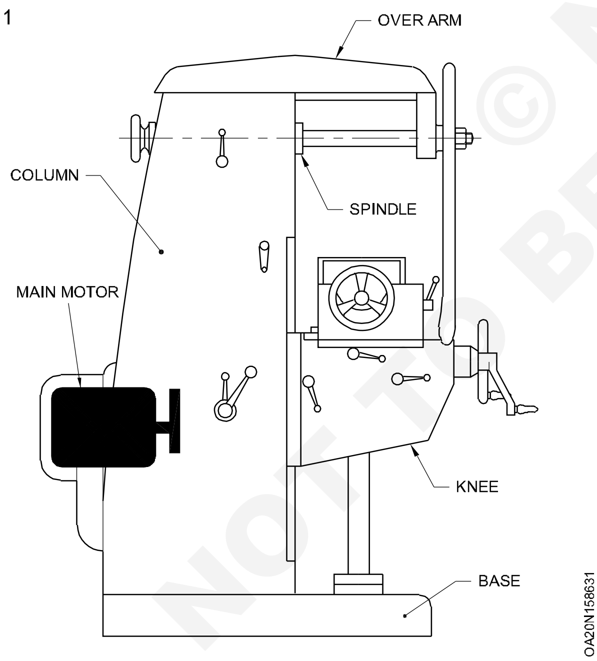
Parts of a milling machine

Objective : At the end of this lesson you shall be able to
- **state the main parts of a milling machine and its functions.**

Parts of a milling machine

The principal parts of a milling machine (Fig 1) are as follows.

Fig 1



Base

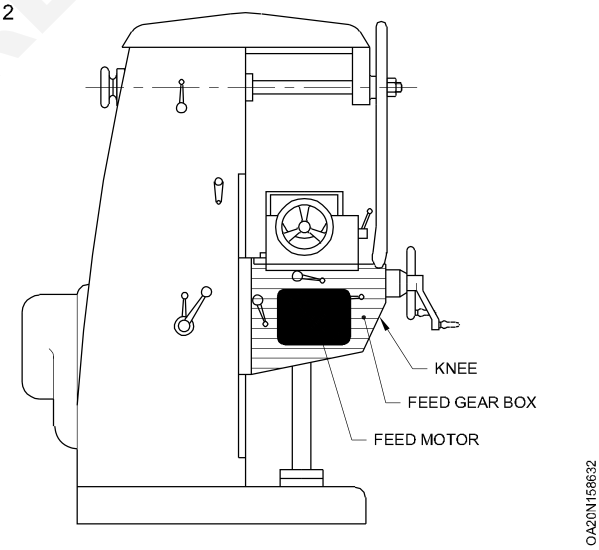
The base of the machine serves as a foundation member for all the other parts which rest upon it. It is made of cast iron. It carries a column.

Column

The column is the main supporting frame mounted vertically on the base. The column houses all the driving mechanism for the spindle and table feed. The main motor is usually incorporated in the column. The top of the column is finished to hold an overarm that extends outward at the front of the machine. The lower part of the column is a sturdy box base, which incorporates the cutting fluid tank.

Knee (Fig 2)

Fig 2

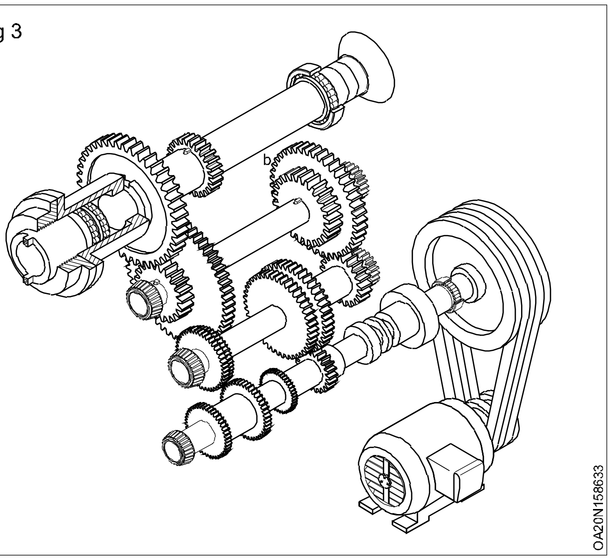


The knee is of rigid casting that slides up and down along a precision-machined guideway. The knee houses the speed mechanism of the table and the different controls to operate it. The feed motor and gearbox are usually incorporated in the knee.

Gearbox (Fig 3)

The gearbox for the spindle drive comprises shafts with bearings and gears, and controls for the setting of the spindle speed.

Fig 3

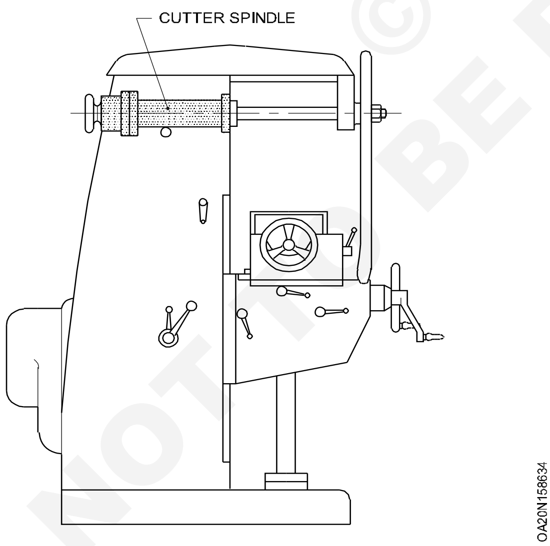


Spindle

The spindle is housed in the upper part of the column and receives power form the motor and transmits it to the arbor. The front end of the spindle projects from the column face and is provided with a tapered hole into which various cutting tools and arbors may be mounted. The accuracy in machining depends primarily on the rigidity of the spindle. The speed of the spindle can be selected by the speed gearbox, and the feeds can be selected through the feed gearbox.

The spindle is arranged horizontally in the horizontal milling machine and vertically in the vertical milling machine. (Figs 4 & 5)

Fig 4



Saddle (Fig 6)

The saddle is placed on the top of the knee which slides on the guideway, set exactly at 90° to the column face. A cross-feed screw near the top of the knee engages a nut on the bottom of the saddle to move it horizontally for applying the cross-feed.

Table (Fig 7)

The table rests on the guideway on the saddle and travels longitudinally. 'T' slots are provided on the table to mount the workpieces directly or to mount the work-holding devices. The longitudinal feed-stops are located on the front of the table. These disengage the machine feed at a set position. The table is also fitted with a hand wheel for hand feed in the longitudinal direction, and a lever for locking the table. There is a gutter around the edges of the table to collect the cutting fluid.

Fig 5

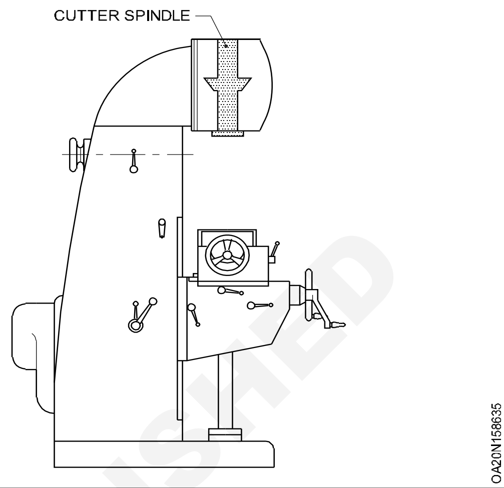


Fig 6

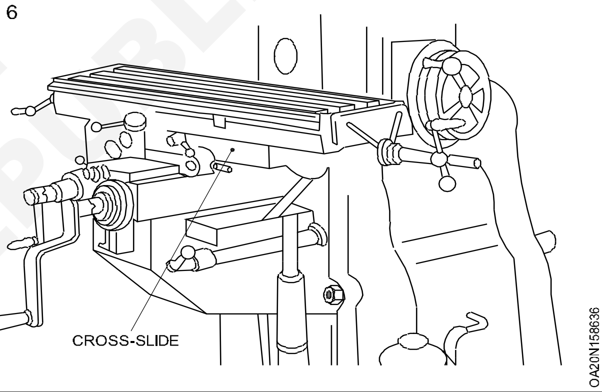
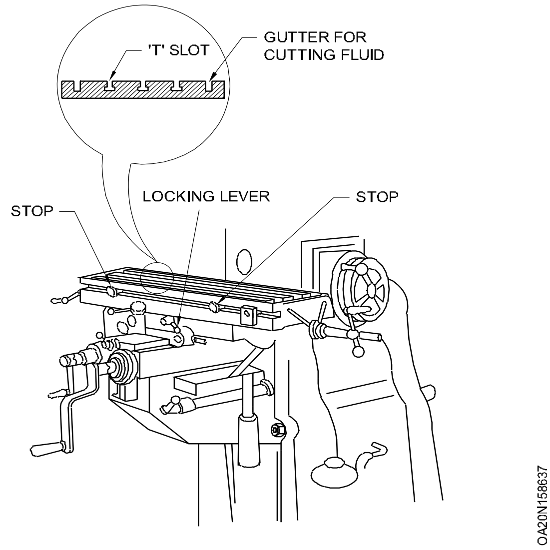


Fig 7



Overarm and brace (Fig 8)

The overarm is mounted on the top of the column above the spindle, and is intended as a support when milling with an arbor. The arm is adjustable so that the bearing support may be provided nearest to the cutter.

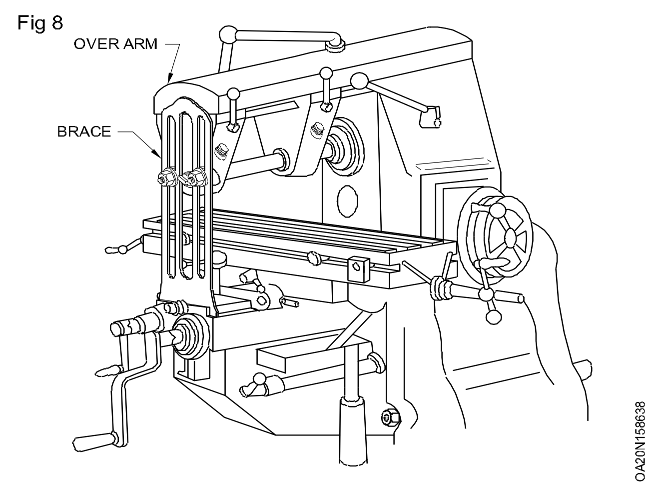


Fig 8

The brace provides extra stability to the machine. It must be loosened before the table elevation setting is altered.

Electrical equipment (Fig 9)

The electrical equipment for the different controls of the machine is usually grouped in the column. The equipment consists mainly of fuses, motor breakers and contactors. Motor breakers switch off the power in the event of an overload.

Cutting fluid equipment (Fig 10)

The cutting fluid equipment consists of a pump, piping and hoses, a nozzle and shut-off valve, and a tank in the machine base.

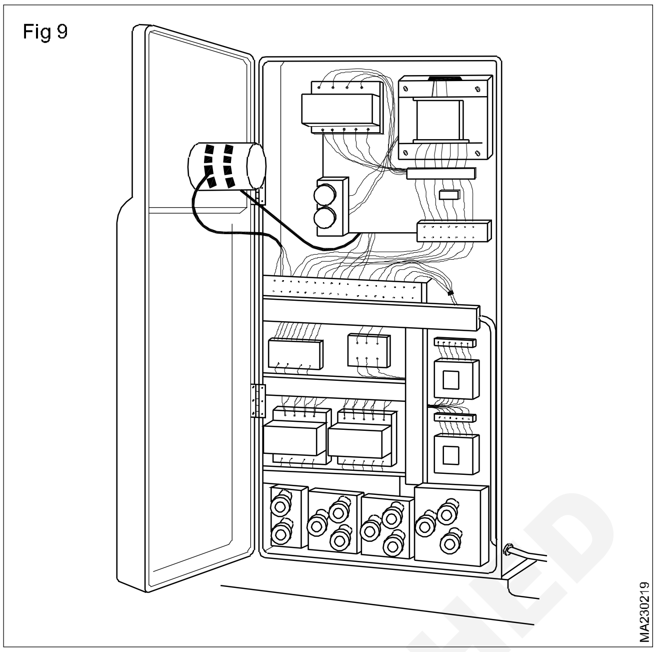


Fig 9

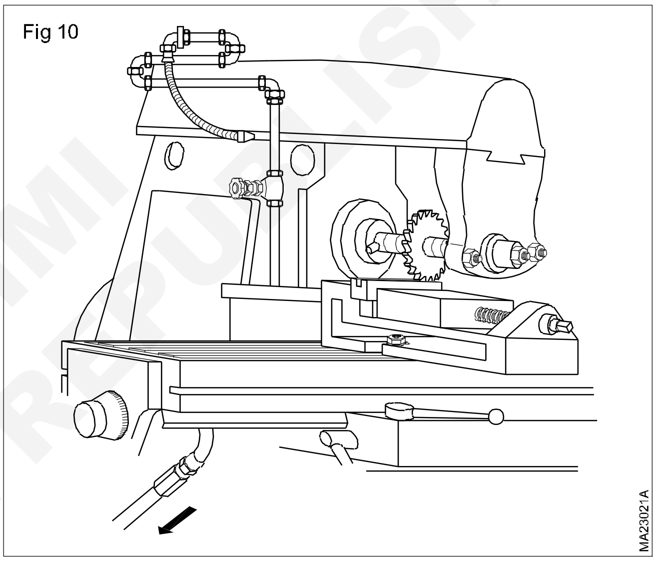


Fig 10

Driving and feed mechanism of milling machine

Objectives: At the end of this lesson you shall be able to
- **state type of mechanism**
- **explain the automatic feed**
- **describe the manual feed.**

Milling machine mechanism is divided into two types:

Spindle drive mechanism

Table feed mechanism

The spindle drive mechanism is incorporated in the column. All modern machines are driven by individual motors housed with in the column. The spindle receives power from a combination of gears and clutch assembly. By altering gears spindle receives multiple speed.

Table feed mechanism contained with in the knee of the machine table. It has three different feed movements.

Longitudinal feed movement

Cross feed movement

Vertical feed movement

These three movements can get manual feed or automatic feed. By swiveling the three handle wheels we can give manual feed. By engaging the clutch operating levers we can get the automatic feed as follows:

Fig 1 illustrates the power feed mechanism contained within the knee A of the machine to enable the table C to have three different feed movements, i.e longitudinal, cross and vertical. The power is transmitted from the feed gearbox H consisting of change gears to shaft 23 in the knee A of the machine by a telescopic - shaft 11. Both ends of the shaft 11 are provided with universal joint 10 and 12. Telescopic shaft and universal joints are necessary to allow vertical movement of the knee A, gear 14 attached to the jaw clutch 20, is keyed to the shaft 23 and receivers gear

13 which is free to rotate on the extreme end of the cross feed screw 7. Bevel gear 22 is free to rotate on shaft 23 and is in mesh with gear 19 fastened to the evaluating screw 15,16 serves as a nut for 15, and as a screw in nut 17,15 and 16 therefore, serve as a telescopic screw combination and a vertical movement of the knee is thus possible. As soon as the clutch 20 is engaged with the clutch attached to the bevel gear 22 by means of a lever 4,22 rotates and this being in mesh with gear 19 causes the elevating screw 15 to rotate in 16 giving a vertical movement of the knee. like-wise, when the clutch21, which is a keyed to the cross feed screw 7, is engaged with the clutch attached to gear 13, power comes to the screw 7 through gears 4 and 13. This causes the screw 7 to rotate in nut 6 of the clamp bed giving a cross feed movement of the clamp bed D and saddle B.

Gear 18 is fastened to shaft 23, and meshes with gear 25 which is fastened to the bevel gear 24. Again 24 meshes with gear 5 attached to a vertical shaft which carries at its upper end another bevel gear 3. Gear 3 meshes with gear 2 which is fastened to the table feed screw 1. Therefore, longitudinal feed movement of the table is possible through gears 18,25,24,5,3, and 2.

A Knee

B Saddle

C Table

D Clamp bed

E Feed hand wheel

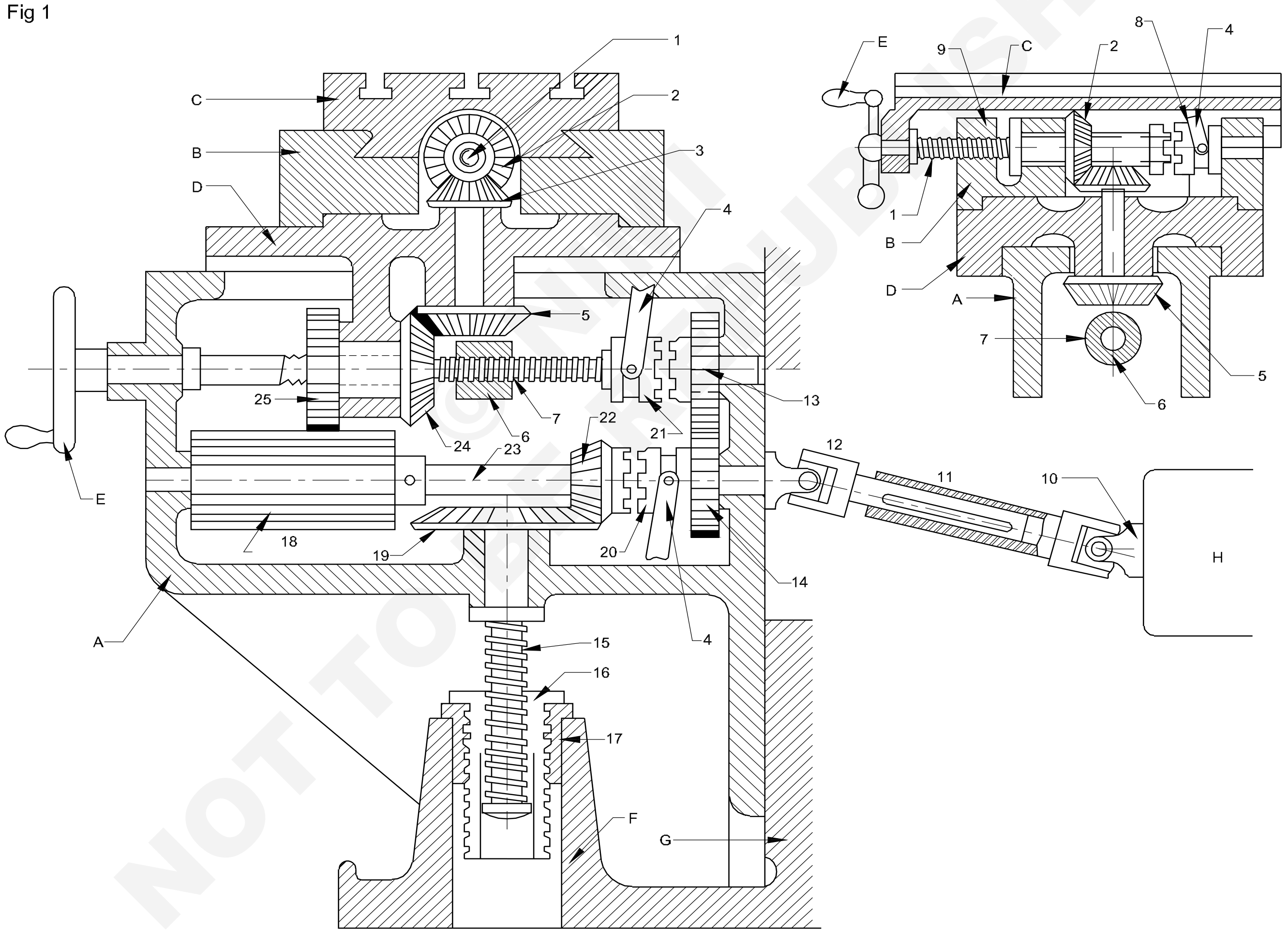
F Bed

G Column

H Feed gear box

1.Longitudinal feed screw, 2, 3, 5, 19, 22, 24. Bevel gears, 4.Clutch operating lever, 6 Nut, 7. Cross feed screw, 8,20,21. Power feed clutch, 9.Saddle nut, 10,12. Universal joint, 11.Telescopic feed shaft, 13, 14, 18.. 25 Gears 15, Elevating screw, 23 Feed shaft.

Fig 1



A. KNEE
B. SADDLE
C. TABLE
D. CLAMP BED
E. FEED HAND WHEEL
F. BED
G. COLUMN
H. FEED GEAR BOX

1. LONGITUDIONAL FEED SCREW
2,3,5,19,22,24. BEVEL GEARS
4.CLUTCH OPERATING LEVER
6. NUT
7. CROSS FEED SCREW
8,20,21. POWERFEED CLUTCH
9. SADDLE NUT
10,12. UNIVERSAL JOINT
11. TELESCOPIC FEED SHAFT
13,14,18,25. GEARS
15,16,17. ELEVATING SCREW
23. FEED SHAFT

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MILLING MACHINE POWER FEED MECHANISM

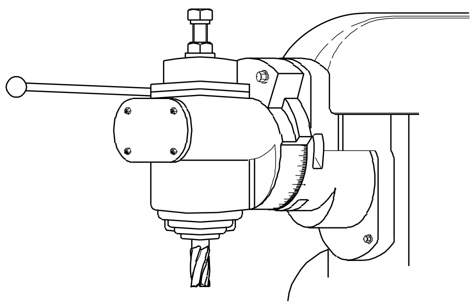
Milling attachments

Objective : At the end of this lesson you shall be able to
- **state the different types of milling machine attachments and their application.**

The application of a milling machine to various machining operations can be enhanced by the use of different types of attachments used in conjunction with the fundamental features of the machine.

Vertical milling attachment (Fig 1)

Fig 1



HEAVY DUTY VERTICAL ATTACHMENT

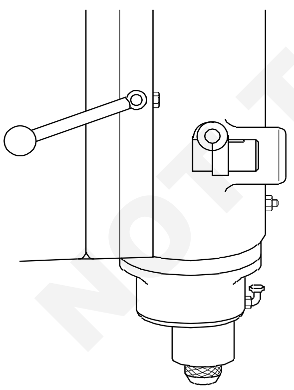
This attachment is mounted on the front of the column and can be driven by the spindle of plain and universal milling machines. The attachment consists of a housing, a spindle head and bevel drive gears with a 1:1 ratio. The spindle has a standard taper and drive lugs for the cutters.

The spindle housing has a swivel mechanism to permit the spindle to be angled with respect to the table of the milling machine. A graduated scale is fitted to the housing to permit setting of a selected angle. A lock is provided to hold the attachment at the selected angle.

It is used to perform milling operations which would otherwise need to be performed on a vertical milling machine.

High speed attachment (Fig 2)

Fig 2



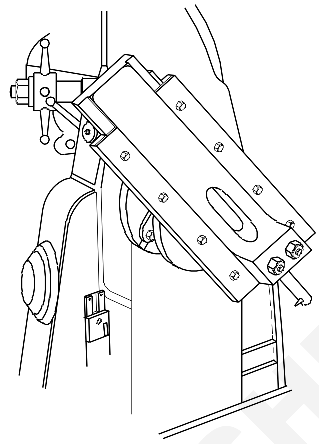
HIGH SPEED ATTACHMENT

The high speed attachment is used to drive small milling cutters at high speeds. The attachment consists of a housing containing a step-up gearing and a small spindle by means of which the spindle speed can be increased by four or six times.

It may be fitted to the vertical or horizontal machine as required.

Slotting attachment (Fig 3)

Fig 3

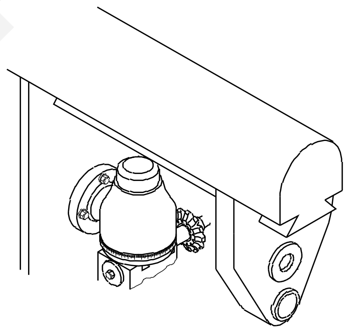


SLOTTING ATTACHMENT

The slotting attachment is used to provide a reciprocating drive for a single point cutting tool. It may be used for cutting at any angle in the vertical plane to produce keyways, slots and corners.

Universal spiral attachment (Fig 4)

Fig 4



UNIVERSAL SPIRAL ATTACHMENT

This attachment is used when it is required to mill spirals with a plain milling machine.

It consists of a housing fitted with a swivel plate for mounting on the face of the milling machine column. The body may then be swivelled about the axis of the machine spindle.

The attachment is fitted with a small spindle rotated by the machine spindle through the gearing in the housing.

The small spindle is also capable of swivelling with respect to the housing.

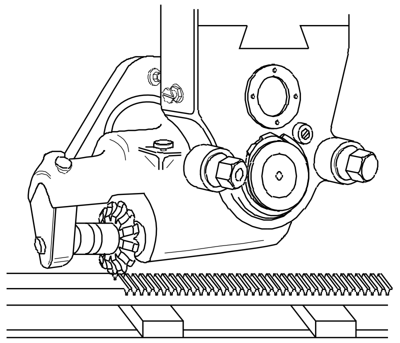
The combination of the two swivelling actions permits the small spindle to be set at any compound angle with respect to the column of the milling machine.

This attachment is particularly useful for cutting helical threads, gears, worms and racks.

Rack milling attachment

The rack milling attachment is mounted between the face of the column and the outer support on a plain or universal milling machine. It consists of a fixed housing fitted with an angle drive and a spindle. The spindle axis is fixed parallel to the table. (Fig 5)

Fig 5



RACK MILLING ATTACHMENT

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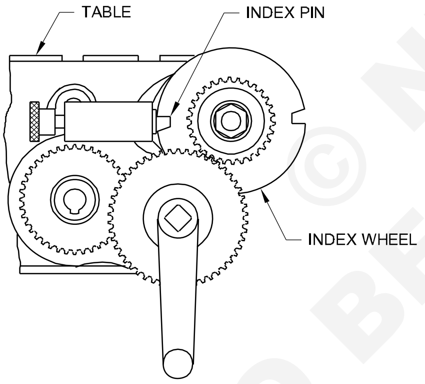
In rack milling, the cross-feed is used to move the cutter into the workpiece, and the longitudinal feed is used to index the cutter to produce the rack teeth.

A special rack indexing attachment (Fig 6) is used to move the work longitudinally, the exact amount needed for accurate spacing of the teeth.

Fig 6



RACK INDEXING ATTACHMENT

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At one end of the table is fastened a bracket which carries a locking indexing wheel together with change gears for gearing to the table feed screw.

To index any required spacing, change gears are selected which will produce one or more complete turns of the indexing wheel. For each indexing operation, the index pin is withdrawn and the table advanced by turning the table feed screw until the pin drops into the slot again, and locks the wheel.

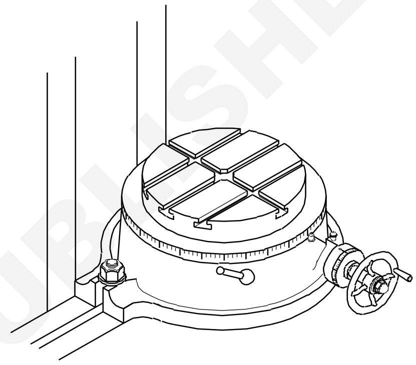
This method is positive and much more reliable than setting the table to a graduated dial directly fitted to the table feed screw.

Circular table attachment

This attachment is used for profile milling, surfacing quantities of small pieces in the one set up, and for many other circular operations in the horizontal plane such as slotting and dovetailing.

It consists of a base, a worm gear drive mechanism and a small circular work table. (Fig 7)

Fig 7



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The base is bolted to the table and the drive mechanism connected with the feed mechanism of the milling machine. A crank for manual feed is also provided.

The workpiece is secured to the circular table and the table is rotated by the feed mechanism for circular cuts.

By combining the rotary motion with one or more of the other feeds of the machine, profiles of almost any shape can be milled. The hand crank can be replaced by an indexing device for requiring accurately spaced slots, holes or grooves.

Different types of milling cutter and their uses - cutter nomenclature

Objectives: At the end of this lesson you shall be able to
- **state the two main categories of milling cutters**
- **state the different types of plain milling cutters**
- **state the uses of plain milling cutters.**

Milling cutters

Milling cutters generally fall into two categories, solid cutters and inserted tool cutters.

Solid cutters (Fig 1) : These cutters are those in which the teeth have been cut into the body of the cutter. The teeth may be straight (parallel) or helical (at an angle) to the axis of the cutter. Solid type cutters are generally made of high speed steel.

Inserted tool cutter (Fig 2)

These cutters have removable and replaceable teeth which are fastened or locked into the body of the cutter. The inserted tool construction is generally used on large cutters as the blades can be quickly replaced when they become dull.

Fig 1

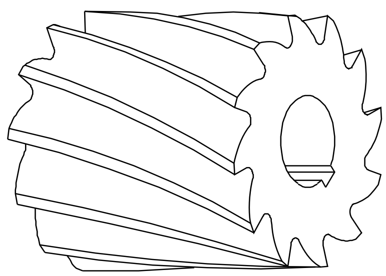
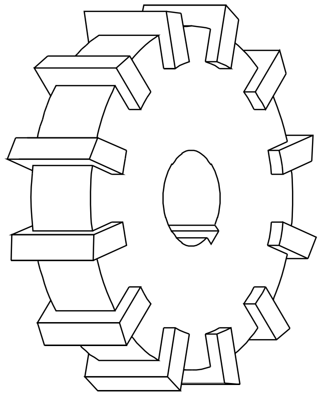


Fig 2



Plain milling cutters

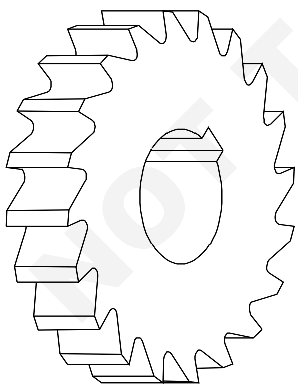
Plain milling cutters are cylindrical, having teeth on the periphery only. They are used to produce flat surfaces, by feeding the table longitudinally. The cutter teeth may be straight or helical according to the size of the cutter. Wider plain cutters are used for slab milling which are known as slab milling cutters.

Types of plain milling cutters

Light duty plain milling cutters

These are less than 19mm wide usually have straight teeth. (Fig 3) Those over 19mm wide have a helix angle of about 25°. (Fig 4)

Fig 3

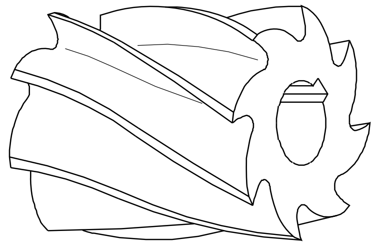


This type of cutter is used only for light milling operations since it has too many teeth to permit the chip clearance required for heavier cuts.

Heavy duty plain milling cutters (Fig 5)

These cutters have fewer teeth than the light duty ones, which provides for better chip clearance. The helix angle upto 45°.

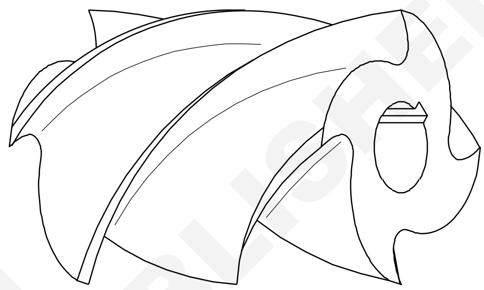
Fig 5



The greater helix angle on the teeth produces a smoother surface due to shearing action and reduces chatter. Less power is required for the cutter than what the straight tooth and small helix angle cutters require.

Helical plain milling cutters (Fig 6)

Fig 6



These cutters are high helix cutters with the helix angles from 45° to over 60°. They are particularly suited to this milling of wide and intermittent surfaces in contour and profile milling. These cutters are used for milling soft steels, brass, etc.

Plain milling cutters are also made in shank type. These are sometimes nicked on their periphery on a helical pattern for chip breaking and smooth operation.

Specification

The size of the plain milling cutter is specified by the outside diameter, length and the bore size.

Example

θ 50 x 100 x 27 bore, 45°

Direction of helix of the cutter

The teeth (cutting edge) of a cutter may be either straight or follow a helix.

If the cutter axis is hold vertically and the helix is towards the right side it is called a right hand helix cutter. (Fig 7) and if the helix is towards the left side, it is called a left hand helix cutter (Fig 8)

The helix angle generates a force directed along the cutter axis during cutting and a reaction to this force in the workpiece.

When a cutter has a helix and a cut of the same hand, this force will pull the cutter away from the spindle.(Fig9) when the helix and cut are of opposite hands, the force will press the cutter into the spindle. (Fig 10) As a consequence, cutters having a helix and a cut of the same hand can only be safely used when they are positively attached to the spindle. The frictional hold of a taper is inadequate in this situation.

When mounting a cutter on the arbor of a milling machine, it is particularly important that the hands of the cut and the helix are checked.

Fig 7

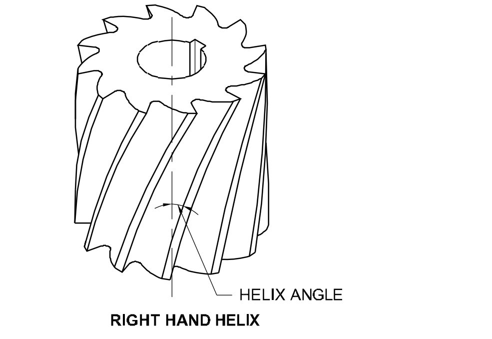
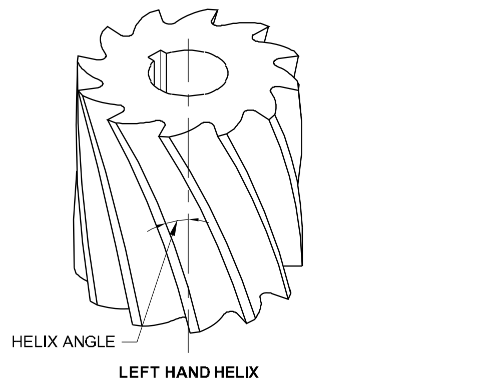


Fig 8



Side and face cutters

Objectives: At the end of this lesson you shall be able to
- **state the different types of side and face milling cutters and their uses.**

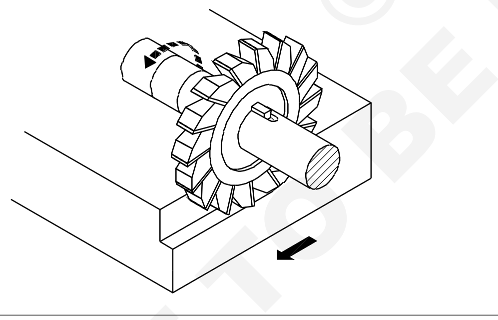
These cutters differ from plain milling cutters due to the fact that they have teeth on the periphery and face.

These cutters are mainly used for step milling, slot milling and straddle milling. These cutters are available from 50 to 100 mm in diameter and the width of the cutters ranges from 5 to 32 mm.

Types of side and face milling cutters

Half side milling cutter (Fig 1)

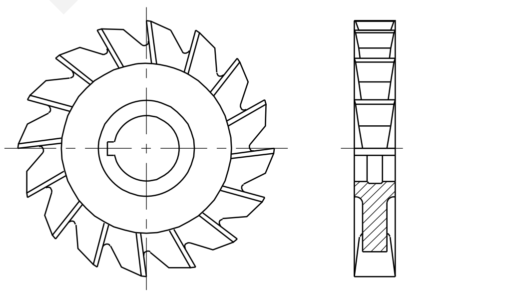
Fig 1



Cutters with teeth on one side only are called half side milling cutters and are used for heavy straddle milling, and for machining one side only.

Plain side and face milling cutter (Fig 2)

Fig 2



Inside and face milling cutters with teeth on both the sides are known as plain side and face milling cutters and are used for slot cutting (Fig 3) and face milling. These cutters are also used for straddle milling. (Fig 4).

Fig 3

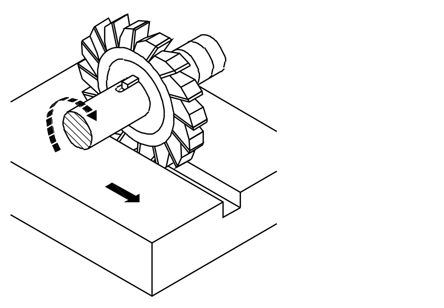
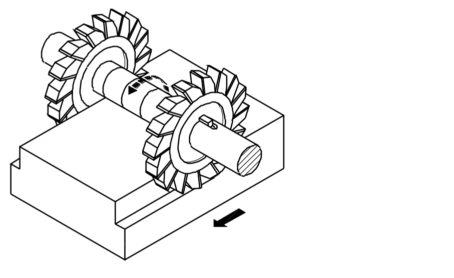


Fig 4



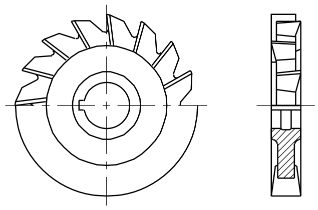
Staggered teeth side milling cutter (Fig 5)

These cutters have alternate teeth with opposite helix angles. Due to this design, the chip space increases to a great extent. These cutters are used for milling deep and narrow slots or keyways.

Interlocking side milling cutter (Fig 6)

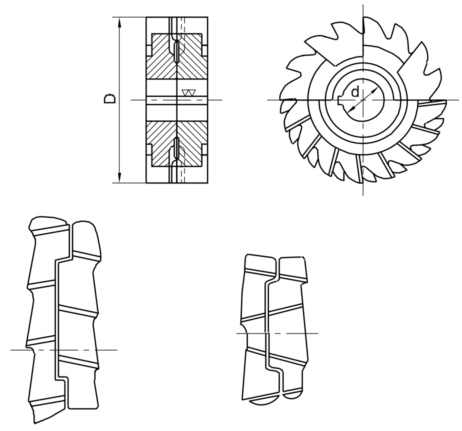
This cutter is formed out of two half side milling cutters or two staggered teeth side milling cutters. They are made to interlock to form one unit. The teeth of the two cutters may be plain or of alternate helix. The cutters are used for milling wider slots of accurate width. The width of the cutter can be varied by inserting spacers between the two halves of the cutter.

Fig 5



The width of the cutter ranges from 10 to 32 mm with the diameters ranging from 50 to 200 mm. The width of the cutter may be adjusted to the max/min of 4 mm. The interlocking cutters can be adjusted to compensate for thr wear, and get sharpened as well.

Fig 6



End mill cutters

Objectives: At the end of this lesson you shall be able to
- **list the different types of end mill cutters and their uses**
- **state the application of slot mill cutters**
- **state the different types of methods of holding end mill cutters**
- **explain the influence of down-milling and up-milling in end mill cutters.**

End mill cutters

End mill cutters have the cutting teeth on the end as well as on the periphery, and are fitted to the spindle by a suitable adapter.

The end mill is used for milling small faces, slots, (Fig 1) for milling profiles (Fig 2) and milling recesses. (Fig 3) Some end mills have indexable inserts which can be replaced when worn out. (Fig 4)

Fig 1

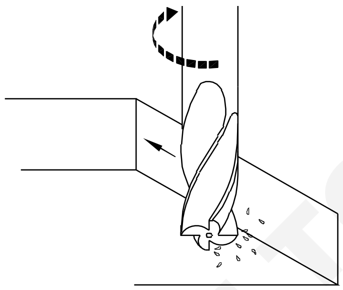


Fig 2

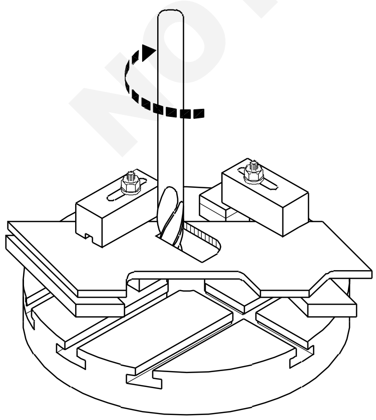


Fig 3

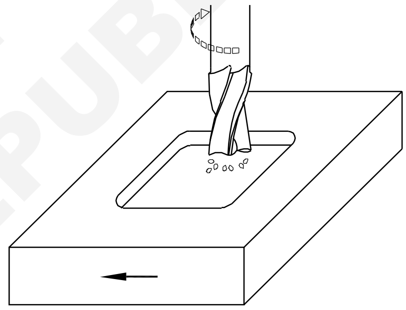
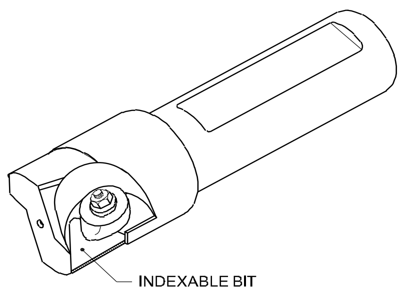


Fig 4



End mill cutters are solid type of cutters in which the shank and the cutters are integral. (Fig 5)

End mill cutters have straight shank (Fig 5) or taper shank (Fig 6).

Slot drills

The two-flute type (Fig 7) is called a slot drill. The slot drills have flutes which meet at the cutting end, forming two cutting tips across the bottom. These tips are of different lengths, one extending beyond the central axis of the cutter. This permits the slot drill to be used in a milling machine for drilling a hole to start a slot that does not extend to the edge of the metal. It is used for plunge milling like keyways etc.

Fig 5

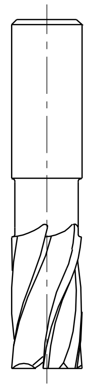


Fig 6

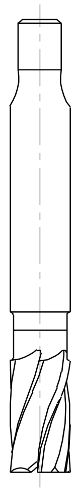
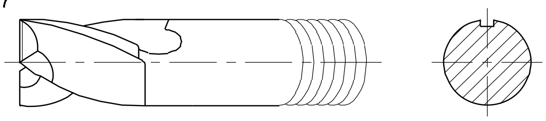


Fig 7



Angular and slitting saw milling cutter

Objectives : At the end of this lesson you shall be able to
- **state the different types of angular milling cutters and their uses**
- **state the specification of angular milling cutters**
- **explain slitting saw cutters and their uses**
- **state the specification of a slitting saw cutter.**

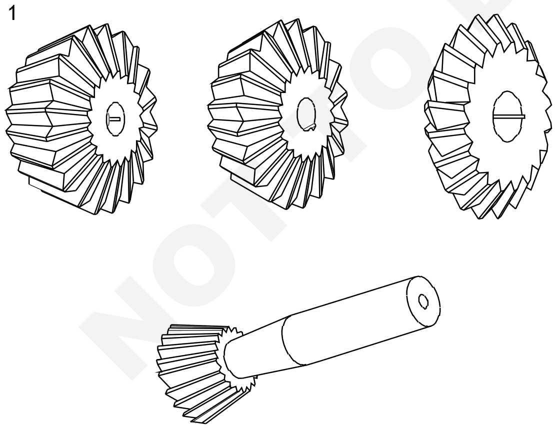
Angular milling cutters

These cutters have teeth on the periphery, and the cutting edges are placed on a conical surface.

Angular cutters have teeth that are neither parallel nor perpendicular to the cutting axis.

Angular milling cutters are made with a hole for use in horizontal milling, or with a shank for use in both horizontal and vertical milling. (Fig 1)

Fig 1

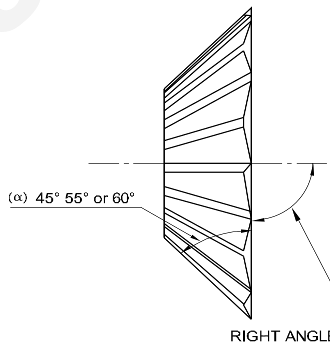


They may be divided into two groups.

Single angle milling cutters

These cutters have teeth on the angular surface, and may or may not have teeth on the flat side. The included angle between the flat face and the angular face designates the cutters, such as 45° or 60° angular cutter. (Fig 2) They may be of the shell or shank type.

Fig 2



Specification

A shell end single angle cutter of diameter D = 80, angle μ= 50° of 'tool type' H and for right hand cutting shall be specified and designated as

Shell end single angle milling cutter 80 x 50°H IS:6256.

A dovetail milling cutter type A having diameter D = 20 mm, angle μ = 60° of tool type 'N' for right hand cutting shall be specified as

Dovetail milling cutter A20 x 60°N BIS 6255.

In type 'A', the small end is having less diameter and in type 'B' the small end is having more diameter than in type A.

Single angle cutters are used to dovetail guideways etc. (Fig 3)

Equal angle milling cutters

These cutters have two intersecting angular surfaces with cutting teeth on both. When these cutters have equal angles on both sides of the line at right angle to the axis (symmetrical), they are designated as per the size of the included angle such as 45°, 60° or 90°. Double angle cutters have two cutting edges. (Fig 4a)

Fig 3

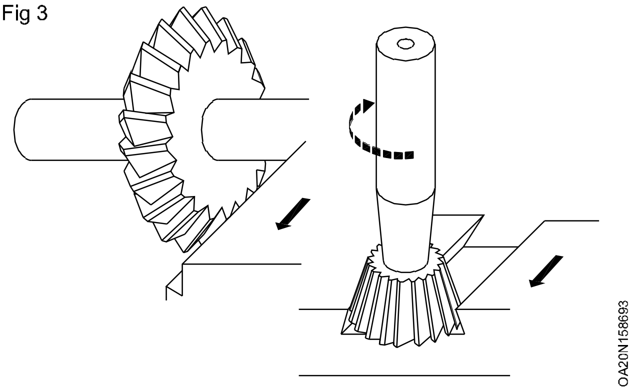
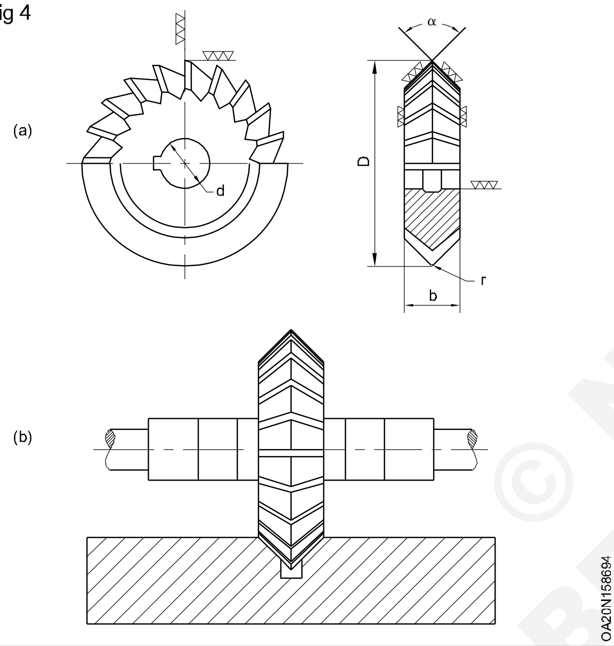


Fig 4



Specification

An equal angle milling cutter of diameter D = 56 mm for angle 60° of 'tool type' N shall be specified as Equal angle milling cutter 56 x 60° N IS 6326.

It is used to machine Vee slots. (Fig 4b)

Double unequal angle cutter

When the angles formed are not the same (unsymmetrical), the cutters are designated by specifying the angle on both sides of the plane or line. (Fig 5)

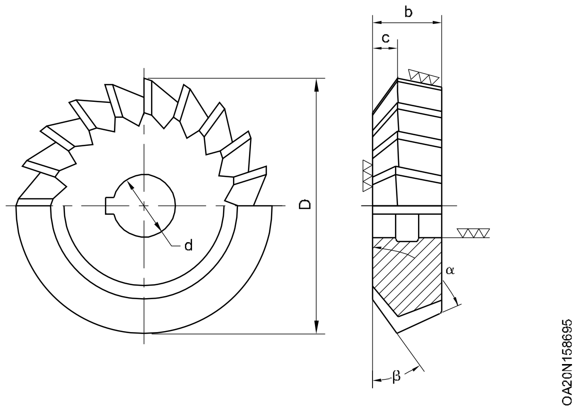
These cutters are generally used for milling the flutes on taps or reamers. The cutters are marked with the type of taps or reamers for which they should be used.

Specification

A double angle milling cutter of diameter D = 50 mm, b = 12 mm and angle 75° of 'tool type H and for right hand cutting shall be specification as

Double angle milling cutter 50 x 12 x 75°H IS 6325.

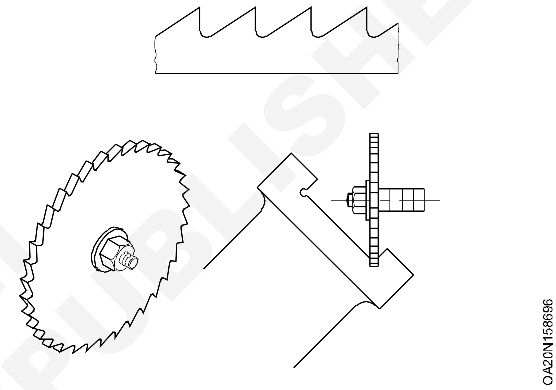
Fig 5



Slitting saw

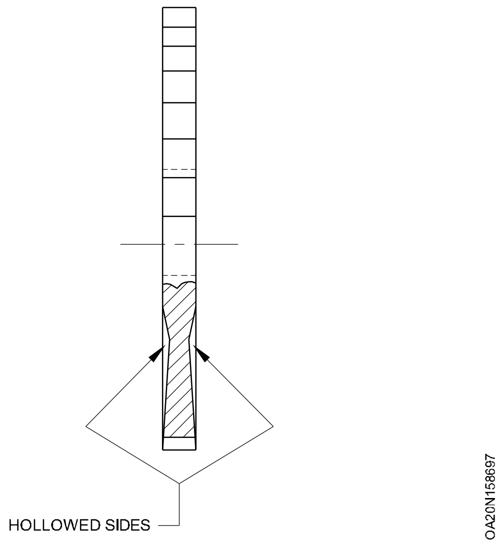
It is basically a thin plain milling cutter. It has a large number of teeth. (Fig 6)

Fig 6



In order to prevent the sides of the saw from rubbing or binding when in use, the sides are relieved or dished. (Fig 7)

Fig 7



Slitting saws are made in widths of 3 to 6 mm. Because of the thin cross-section, they should be operated at approximately one quarter to one eighth of the feed per tooth used for the other cutters. For non-ferrous metals, these speeds can be increased. Unless a special driving flange is used for slitting saws, it is not advisable to key the saw to the milling arbor.

The arbor nut should be pulled up as tightly as possible by hand only. Since slitting saws are so easily broken, some operators find it desirable to adopt climb or down-mill method when sawing. However to overcome the play between the lead screw and nut, the backlash eliminator should be engaged.

A slitting saw is specified by its outside diameter, bore diameter and thickness.

Example : 150 x 6 x 27 mm bore

Form milling cutters

Objectives : At the end of this lesson you shall be able to
- **state the name of different types form milling cutters and their uses**
- **state the specification of form milling cutters.**

Form milling cutters have irregular profile on the cutting edges in order to generate an irregular outline of the work. They are normally solid but, sometimes, may have inserted teeth. Different types of standard form cutters are described below.

Convex milling cutter : These cutters have their teeth curved outwards on the circumferential surface to form the contour of a semi circle. Concave semi-circular surfaces are produced with this cutter. (Fig 1) The diameter of the cutter ranges from 50 to 125 mm and the radius of the semi circle ranges from 1.6 to 20.0 mm. (Fig 2)

Fig 1

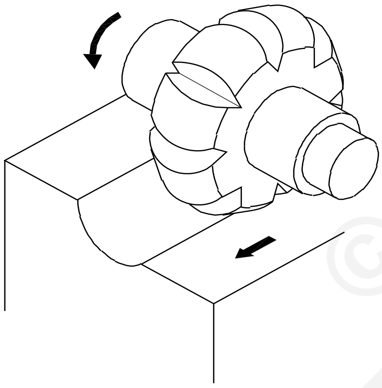
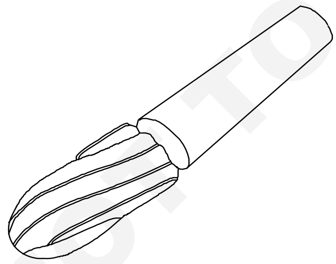
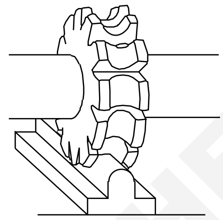


Fig 2



Concave milling cutter : These cutters have their teeth curved inwards on the circumferential surface to form the contour of a semi circle. Convex semicircular surfaces are produced with this cutter. (Fig 3).

Fig 3



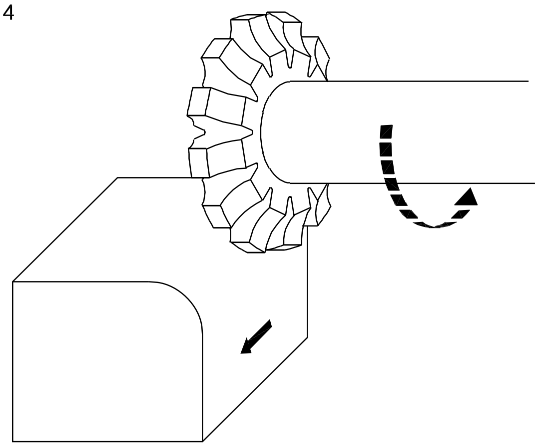
The diameter of the cutter ranges from 56 to 110 mm and the radius of the semi circle ranges from 1.5 to 20.0 mm.

Corner rounding milling cutter

The corner rounding milling cutters have their teeth curved inwards on the circumferential surface to form the contour of a quarter circle. A convex surface is produced with this cutter. This cutter is used for cutting a radius on the corner or edges. It may be of either the shank or arbor type.

Corner rounding cutters are available with their teeth having placed on one side or both the sides. (Fig 4)

Fig 4



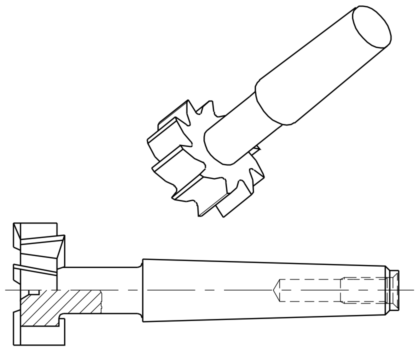
The cutters are specified by the type, diameter width, radius of the form and bore size.

'T' slots cutters

Objectives : At the end of this lesson you shall be able to
- **state the purpose of 'T' slot milling cutters**
- **state the specification of the 'T' slot milling cutters.**

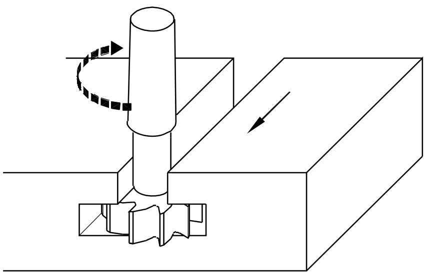
'T' slot cutters : These cutters are profile-sharpened side milling cutters with a straight or taper shank. (Fig 1) They have staggered teeth and are either solid or tipped in construction. Due to the staggered teeth the chips are cleared without clogging.

Fig 1



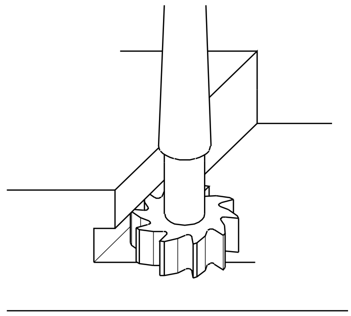
The ‘T’ slot cutter is used to cut ‘T’ shaped slots in machine tool work tables. (Fig 2) Before cutting the ‘T’ slot, a narrow vertical groove is machined with an end mill or a slot milling cutter.

Fig 2



This cutter can also be used to mill undercuts in wider milled channels. (Fig 3)

Fig 3



Specification : A ‘T’ slot milling cutter with plain parallel shank for milling a ‘T’ slot of nominal size 12, tool type N, for right hand cutting is designated as plain parallel shank ‘T’ slot cutter 12 BIS:2668. When the cutter is required with a tool type other than N, an appropriate tool type H or S shall be added to the designation after the size.

Tool type : N - for mild steel, soft cast iron and medium hard non-ferrous metals.

H - for specially hard and tough metals.

S - for soft and ductile material.

A ‘T’ slot milling cutter with Morse taper shank with tapped hole for milling a ‘T’ slot of nominal size 18, tool type N, for right hand cutting is designated as taper shank ‘T’ slot cutter 18 BIS:2668. When the cutter is required with a tool type other than N, an appropriate tool type H or S shall be added in the designation immediately after the size.

Example : 16 N BIS 2668

Special milling cutters

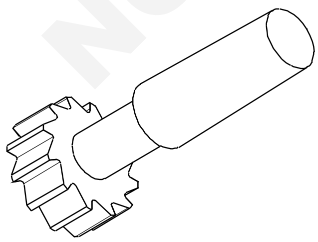
Objectives : At the end of this lesson you shall be able to
- **state the woodruff keyway cutter, thread cutter, gear cutter, tap and reamer cutter and state their uses**
- **state the sprocket cutter, spline cutter, fly cutter and bolted cutter and state their uses.**

Many types and sizes of cutters are available. The selection of an appropriate cutter for a particular type of operation is very important.

Woodruff key cutters

These are similar in appearance to ‘T’ slot cutters. These cutters have cutting edges on the periphery only. There are no side teeth. (Fig 1)

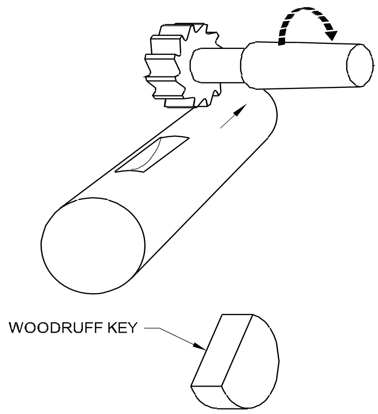
Fig 1



They are used for milling semi-cylindrical keyways in shafts for woodruff key seats. (Fig 2)

This cutter is provided with a shank which may be parallel or with Morse taper. These cutters are either solid or tapered in construction. They can either be of the arbor or shank type.

Fig 2



This cutter may have straight or staggered teeth.

Specification : A woodruff key slot milling cutter, type A of diameter d = 16.5 mm and width b = 5 mm and tool type ‘N’ for right hand cutting shall be specified as woodruff slot milling cutter A 16.5 x 5 N BIS2669.

When the cutter is required for left hand cutting, the letter 'L' shall be added before the size in the designation.

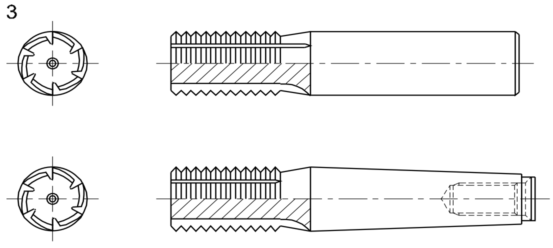
Type 'A' is for straight teeth and type B for staggered teeth.

Thread milling cutter

For milling the threads of specific form and size, thread milling cutters are used. Generally acme and worm-threads are produced on the workpiece by thread milling cutters.

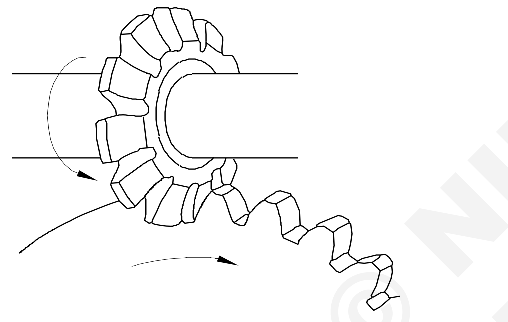
Both parallel shank and taper shank thread milling cutters are available. (Fig 3)

Fig 3



Gear cutter (Fig 4)

Fig 4



These cutters are used to machine gear teeth by milling.

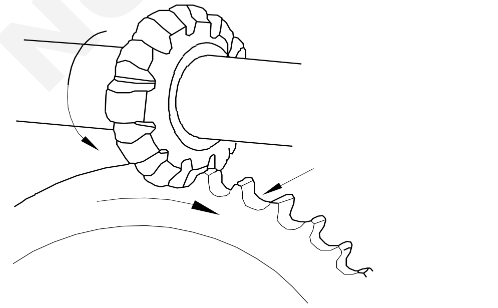
These cutters having formed cutting edges reproduce the shape of the cutter teeth on the gear blank. According to the gear teeth profile the shape of the cutter teeth may be involute or cycloid. These cutters are available in a very wide range of sizes covering the various sizes of gear tooth.

Example :

Involute cutter, 3mm module, 27 mm bore, cutter No.5

Sprocket cutters (Fig 5)

Fig 5

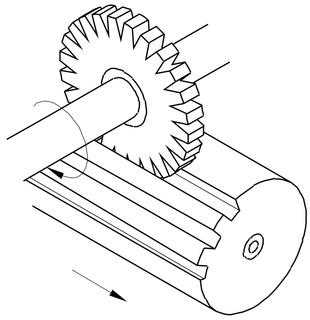


These cutters are designed to cut the teeth of sprocket wheels which are used in chain drives, such as those found on bicycles and on machinery in general.

Spline cutters (Fig 6)

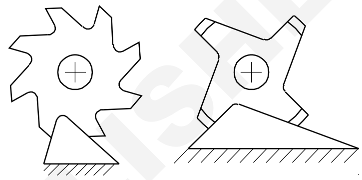
These cutters are used to cut splines. They are marked with the type and size of the spline that they should be used for.

Fig 6



Tap and reamer cutter (Fig 7)

Fig 7

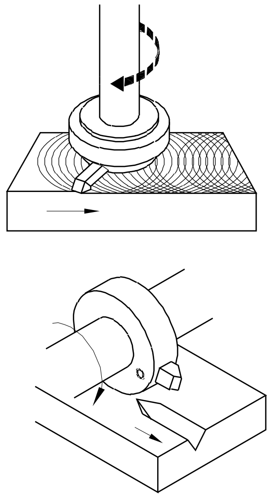


These cutters are used for producing grooves or flutes in taps and reamers. These are the special type of double angle cutters.

The point end of the tool is rounded and the tooth profile corresponds to the type of groove that it is to produce.

Fly cutters (Fig 8)

Fig 8



Fly cutters are single point tools having only one cutting edge. These tools are held in various types of holders.

These cutters are used to machine shapes which cannot be produced using standard milling cutters.

These are also used to mill flat surfaces which are truly flat to a very high standard of accuracy.

This cutter is used in tool room and in emergency when standard cutters are not available.

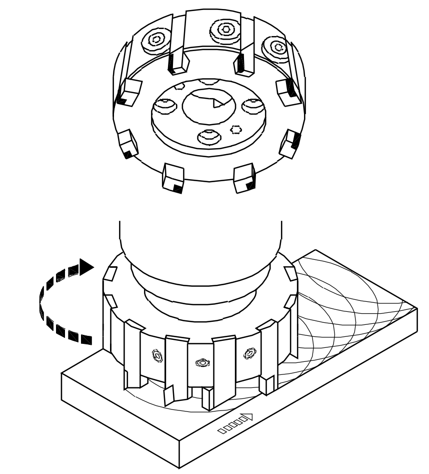
Bolted cutters (Fig 9)

The face milling cutters having no shank but one of a larger diameter and they are bolted directly on to the nose of the spindle.

This cutter is used for face milling on large areas of the workpiece. For utmost rigidity, this system is used.

The cutter has a body with slots and fixing devices for the cutting teeth which are fixed into the body. The cutting teeth, which may be made of high speed steel or carbide, can easily be replaced when worn out.

Fig 9

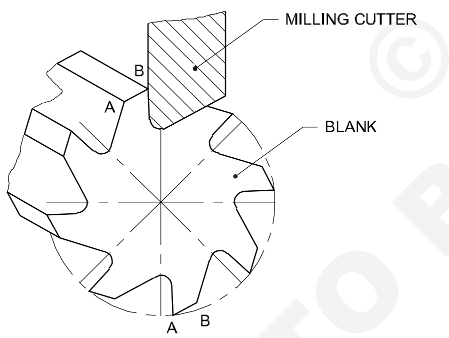


Cutter nomenclature

Objectives: At the end of this lesson you shall be able to
- **state the elements of a milling cutter**
- **state the influence of rake angles in machining.**

Milling cutter are multiple point cutting tools. They are made from cylindrical blanks with the teeth formed by milling the chip space. (Fig 1) The number of teeth so milled depends on the diameter of the cutter as well as on the type of operation, namely roughing and finishing. A roughing cutter will have less number of teeth as compared to a finishing cutter of the same diameter.

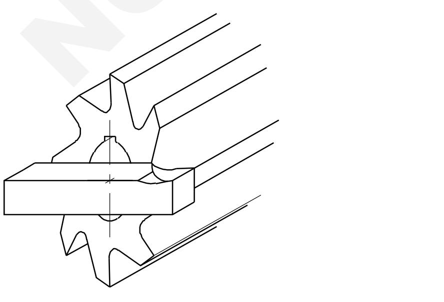
Fig 1



Angle of a milling cutter

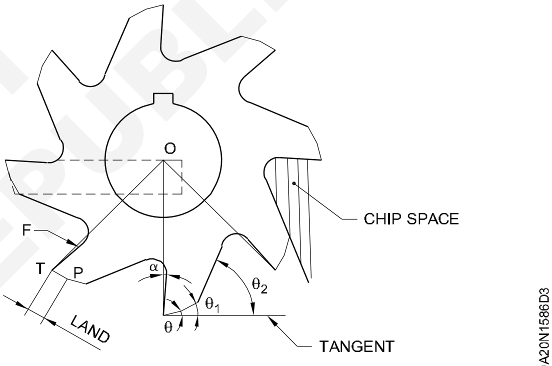
A milling cutter tooth is more or less identical to that of a single point tool. (Fig 2)

Fig 2



The rake angle (a) of a milling cutter is the inclination of the tooth face F, and it is measured from a line joining the centre of the cutter 'O' and the tip of the tooth 'T'. (Fig 3)

Fig 3



The **clearance angle** of a milling cutter is the relief given to the portion AB of the cutter. (Fig 1) This clearance relief is given to form the cutting edge, and it avoids rubbing the work piece while machining. It is given in two stages. First it is ground to a small angle θ. (Fig 3) and this angle is called relief angle. This angle should be very small (about 6°) as any increase in this angle would reduce the strength of the tooth. The portion TP of the tooth up to which the relief angle extends is called the land.

After the land, the tooth is further relieved to an angle θ1 (Fig 3) and this angle is called the **primary clearance** angle which is about 15°. The angle θ2 (Fig 3) is called the **secondary clearance** angle and this defines the shape of the chip space which is also called gash. The tooth of the chip space is reduced to help curling of the chips. (Fig 4) This round portion of the chip space is called **fillet**.

It may be noted that the relief angle θ, primary clearance angle θ1 and secondary clearance θ2 are all measured from a tangent drawn at the tool tip T. (Fig 3)

Positive, zero and negative rake

The rake angle may be positive, zero or negative as shown in fig 5.

Fig 4

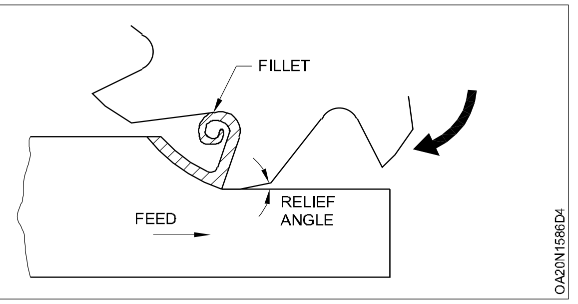
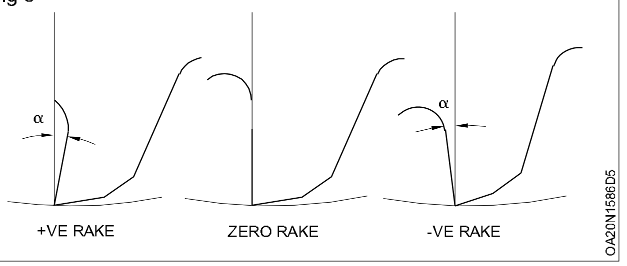
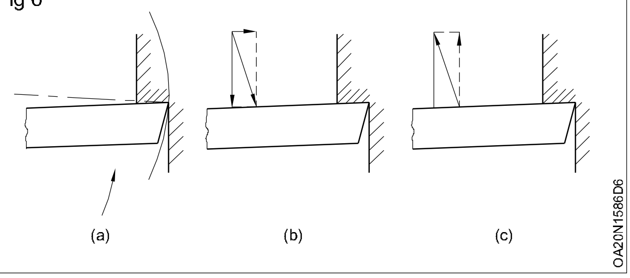


Fig 5



The positive rake is used for general purpose, and is used specially for milling materials which produce continuous chips. In the positive rake, the weakest point is presented to cut first. (Fig 6a) The reaction forces tend to pull the cutter into the work (Fig 6b) and the cutter forces tend to lift the workpiece. (Fig 6c) The positive rake cutting edges peal the chip away from the work, and hence, there is a likelihood of breakage of cast iron parts, especially those having thin and fragile sections.

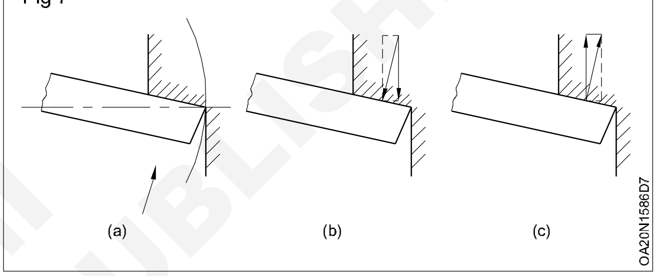
Fig 6



A negative rake makes the tooth stronger and is suitable for roughing cuts. In the negative rake, the strong area is presented to cut first. (Fig 7a) The reaction forces tend to push the cutter away from the work (Fig 7b), and the cutter forces tend to push the work against the fixture. (Fig 7c)

The zero rake is ideal for milling material like cast iron, brass etc. which produce broken chips.

Fig 7



Different method of work holding and cutters

Objectives: At the end of this lesson you shall be able to
- **state the different method of work holding and cutters.**

Milling Machine - Work Holding Devices

It is necessary that the work should be properly and securely held on the milling machine table for effective machining operations. The cutting pressure exhorted by milling cutter is quite high comparing the single point tool of a lathe machine. Therefore the workpiece has to be secured rigidly to avoid any vibration. The following are the usual methods of holding work on the milling machine.

In the milling machines, fixtures are still required to locate and hold the workpieces while machining.

Features of Work Holding Devices:

The work holding devices should have the following uniqueness:

a Work holding devices must have required accuracy and must have matching reference surfaces with the reference system.

b Work holding devices are allowed to perform a number of operations on different faces in a single setting.

c Work holding devices must enable quick loading and unloading.

d Work holding devices must be fool-proofing to avoid incorrect loading of the job.

e Work holding devices must be sufficient rigidity to fully withstand the cutting forces.

f Work holding devices must be safe in use and loading and unloading.

g Work holding devices must have a sufficient clamping force for the use of full roughing cuts.

h Work holding devices must be simple in construction maximum as possible.

Work holding devices used on milling machine

Various types of work holding decives are used for milling machine operations they are explained as follows:

- T-bolts and clamps
- Angle plates
- V-block
- Machine vices
- Dividing head
- Special fixture
- Circular table or Indexing table
- Parallels
- Magnetic chuch/ Vacuum chuck/ Collect chuck

T-Bolts and clamps

Bulky workpiece of irregular shapes are clamped directly on the milling machine table by using T-bolts and clamps. Different type of clamps are used for different patterns of work. The common types of clamps are shown in Fig 10 of Chapter 5. All these clamps carry a long hole, through which clamping bolt passes. This hole permits the bolt for adjustment according to the size and shape of the job.

Angle Plates

- When work surfaces are to be milled at right angles to another face, angle plates are used for supporting the work.
- The angle plate is made from high- quality material (generally spheroidal cast iron) that has been stabilized to prevent further movement or distortion.
- Slotted holes or "T" bolt slots are machined into the surfaces to enable the secure attachment or clamping of workpieces to the plate, and also of the plate to the worktable.
- Angle plates also may be used to hold the workpiece square to the table during marking-out operations.
- Adjustable angle plates are also available for workpieces that need to be inclined, usually towards a milling cutter.

V Block

The V blocks are used for holding shafts on a milling machine table in which keyways and slots are to be milled.

Vices

Vices are the most common appliance for holding work on milling machine tables. According to its quick loading and unloading arrangement. Vices are of three types,

a **Plain Vice** : The plain vice is directly bolted on the milling machine table is the most common type of vice used on plain milling operations, which involves heavy cuts, such as in slab milling. Its especially low construction enables the work to remain quite close to the table. This reduces the chance of vibration to a minimum. The base carries accommodate 'T' bolts to fix the vice on the table. Work is clamped between the fixed and movable jaw and for holding workpieces of irregular shape special jaws are sometimes used.

b **Swivel Vices :** The swivel vice is used to mill an angular surface in relation to a straight surface without removing the work from the vice. It has got a circular base graduated in degrees. The base is clamped on the table by means of T-bolts.

c Universal Vices : It can be swiveled in a horizontal plane similar to a swivel vice and can also be titled in any vertical position for an angular cut. The vice is not rigid in construction and is used mainly in tool room work. It enables the milling of various surfaces, at an inclination to one another, without removing the workpiece.

Dividing Head

Dividing head or indexing head used to hold the workpiece and divide the periphery into the divisions required. These are three types:

a Plain dividing head

b Universal dividing head

c Optical dividing head

Special Fixture

Work directly Mounted on table or special fixtures

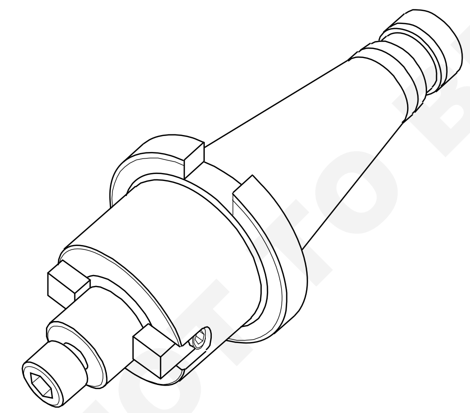
Work directly mounted on the table for heavy nature of jobs or odd-shaped jobs which is not possible to hold by other holding devices, with the help of slots, T-bolts, and nuts. The fixtures are special devices designed to hold work for specific operations more efficiently than standard work holding devices. The fixtures are especially useful when large numbers of identical parts are to be manufactured.

Cutter holding and driving devices for milling machines

The following holding and driving devices are used to hold and drive the milling cutters.

1 The Arbor (Fig 1)

Fig 1



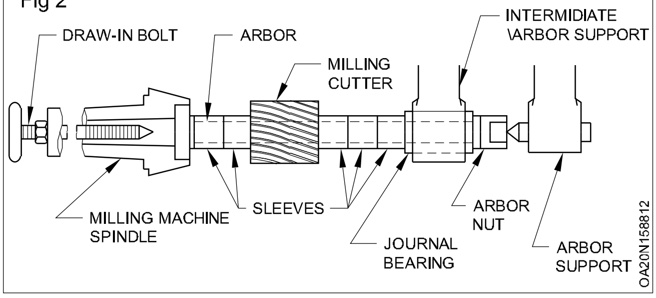
THE ARBOR

An arbor is a cutter holding device with a taper shank to fit the spindle taper hole of the machine; the short or long shaft end is used to mount and drive one or more cutters. having holes that fit on to the arbor. Standard milling arbors are made in three styles: A, B, and C.

2 A Draw - In Bar (Fig 2)

It is fitted through the spindle, screw into the arbor and holds it too firmly in the spindle. Drive Keys on the spindle nose fit into the slots on the arbor flange provide positive (no slip) drive.

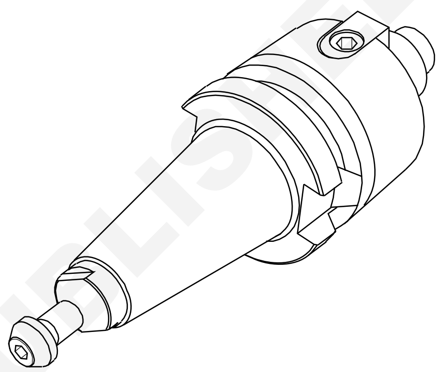
Fig 2



3 The Adapter (Fig 3)

An adapter also has a taper shank to fit the spindle hole, but the opposite end has either a straight or taper hole for holding end mills, taper collets, spring collects, and small arbors.

Fig 3

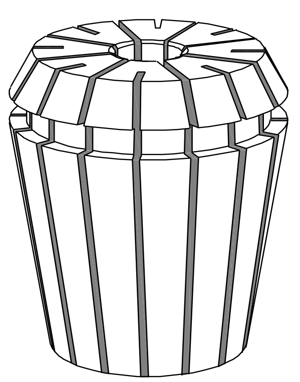


THE ADAPTER

4 Spring Chuck (Fig 4)

A spring chuck is an adapter that can be mounted in the spindle for holding and driving spring collets. A typical set of collets includes sizes from 3.18 to 25.4 mm (1/8 to in.) diameter for holding drills, straight shank cutters, and end mills. The collets holder has a ground taper shank to fit the spindle taper. Collets are held and located accurately in the holder by a cap nut, which forces the collets taper against the inside taper of the holder, clamping the collets tightly to the shank of the tool being held. Some other types of collets/devices are also used for holding cutters and tools, depending upon the nature of the work.

Fig 4

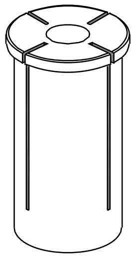


SPRING CHUCK

5 Sleeves (Fig 5)

These are used to reduce the spindle or adapter internal taper to receive a smaller tapered shank tools.

Fig 5



MILLING SLEEVES

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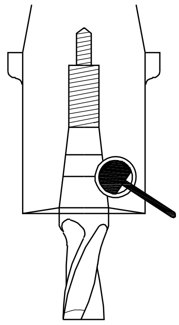
6 Cam Lock (Fig 6)

Cam lock is a device in cutter adapters; it is designed to give positive locking, drive, and quick release to end mills and to other adapters held in them.

7 The Quick Change Spindle Nose (Fig 7)

It is a specially designed attachment that can be clamped to the spindle nose for holding arbors and adapters. Various cutting tools needed to machine a job can be mounted in adapters or on an arbor and each used in sequence without changing the set up of the job. A special clamping ring, threaded on the outside, is bolted to the spindle nose. The adapters and arbors are placed in this clamping ring and held in a place by a ring nut. Because a draw-in bolt is not necessary much time can be saved when changing cutters.

Fig 6



CAM LOCK

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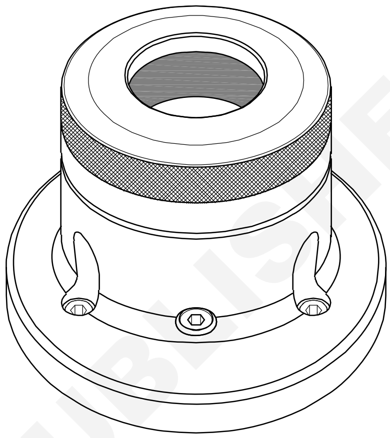
Fig 7



THE QUICK CHANGE SPINDLE NOSE

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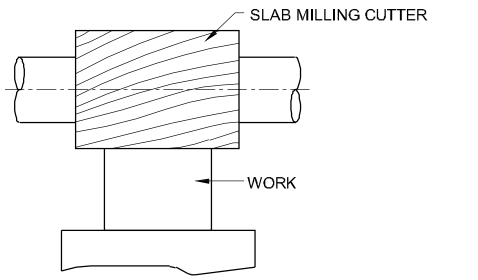
Different milling operation

Objectives: At the end of this lesson you shall be able to
- **explain the plain, face, angular and form milling**
- **describe slot, gang and straddle milling**
- **explain up and down milling.**

Plain milling

It is the operation of production of a flat surface parallel to the axis of rotation of the cutter. It is also called as slab milling. Plain milling cutters and slab milling cutters are used to perform this operation. Fig 1 shows plain milling operation.

Fig 1

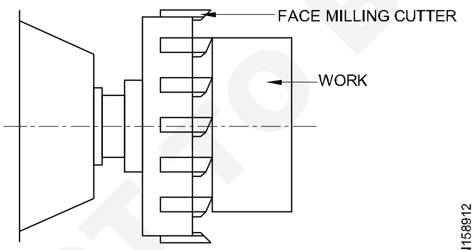


PLAIN MILLING OPERATION

Face milling

The face milling is the operation performed by the face milling cutter rotated about an axis at right angles to the work surface. End mills and side & face milling cutter are also used at times to perform this operation. The depth of cut is provided to the table. Fig 2 shows face milling operation.

Fig 2



FACE MILLING OPERATION

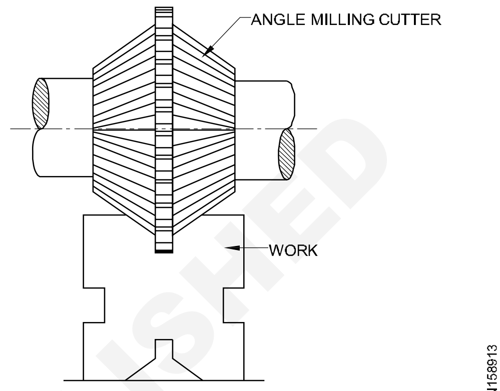
Angular milling

Production of an angular surface on a work piece other than at right angles to the axis of the milling machine spindle is known as angular milling. Example of angular milling is the production of the "V" blocks. Fig 3 shows angular milling operation.

Form milling

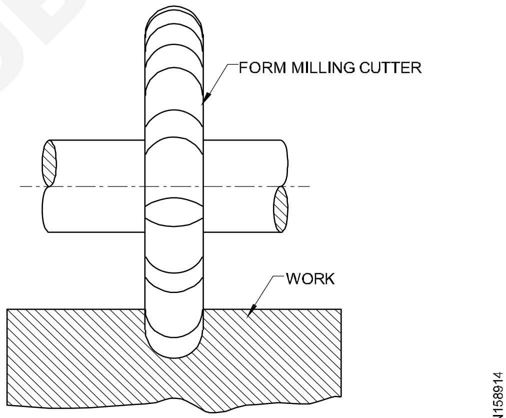
The form milling is the operation of production of irregular contours by using form cutters. Machining convex and concave surfaces and gear cutting are some examples of form milling. Fig 4 shows form milling operation.

Fig 3



ANGULAR MILLING OPERATION

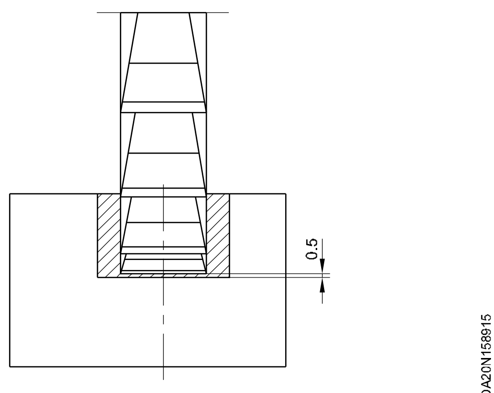
Fig 4



FORM MILLING OPERATION

Slot milling (Fig 5)

Fig 5

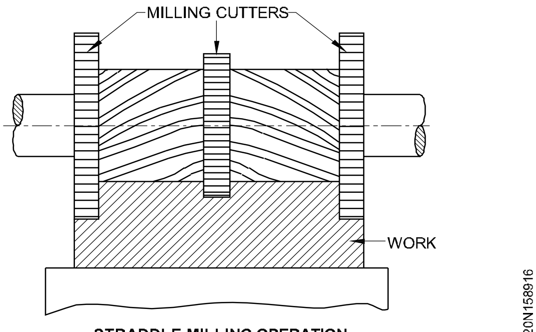


The operation of production of slot of different sizes can be produced in a milling machine by using a plain milling cutter and by an end mill or side milling cutter.

Gang milling

It is the operation of machining several surfaces of work simultanously by feeding the table against a number of cutters (either of same type of different type) mounted on the arbor of the machine. This method saves much of machining time and mostly used in production work. Fig 6 shows gang milling operation.

Fig 6

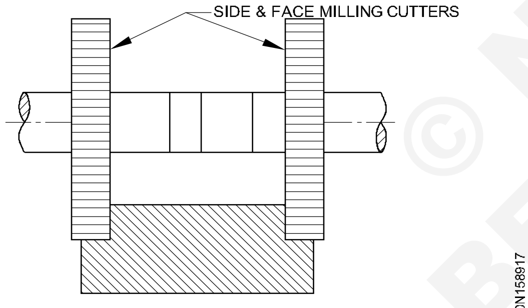


STRADDLE MILLING OPERATION

Straddle milling

It is the operation of production of two vertical surfaces on both sides of the work by two side milling cutters mounted on the same arbor. By using suitable spacing collars, the distance between the two cutters is adjusted correctly. The straddle milling is commonly used to produce square or hexagonal surfaces. (Fig 7)

Fig 7

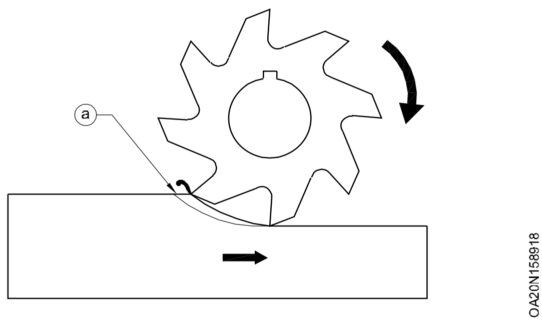


STRADDLE MILLING OPERATION

Up-cut milling

The most commonly used method of feeding is to bring the work against the direction of rotation of the cutter. (Fig 8) This is otherwise known as convention milling. This is the most commonly used method.

Fig 8



In up-milling the removal of chip by each cutting edge starts at the thinnest part of the chip (a) and progresses to the thickest part. The cutting edge slides in the material before it starts to cut. This scraping causes a good deal of heat and wear on the cutter. As the cutter teeth emerge from the material, the accumulated cutting forces are suddenly released.

The cutter and workipiece suddenly spring apart, the machine chatters, and the material surface is flawed by ripples. The spindle for the milling is tensioned in the direction of the feed. The forces involved are taken up by the flank of the thread in contact.

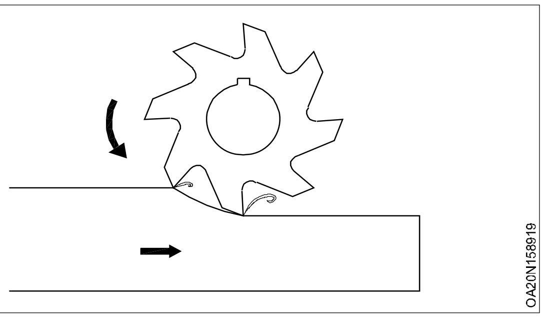
Down-cut milling

In down-milling or clamp-milling the feed moves in the same direction as the rotation of the cutter. (FIg 9)

In this method, chip removal starts at the thickest part. The cutter cuts into the material straight way and does not slide. As a result less heat is developed and there is less wear on the cutter.

In this method, the work piece is pressed down on the work table by the cutting pressure and thus prevents the work piece from lifting. This is an advantage, especially when milling long workpieces.

Fig 9



Gears - types and uses

Objectives : At the end of this lesson you shall be to
- **name the different types of gears**
- **state the broad area of application of the different types of gears**
- **state the merits and demerits of each gears.**

A gear is a machine element. It is used to transmit power and motion between rotating parts.

Positive transmission of power is accomplished by providing projections called teeth on the circumference of the gear.

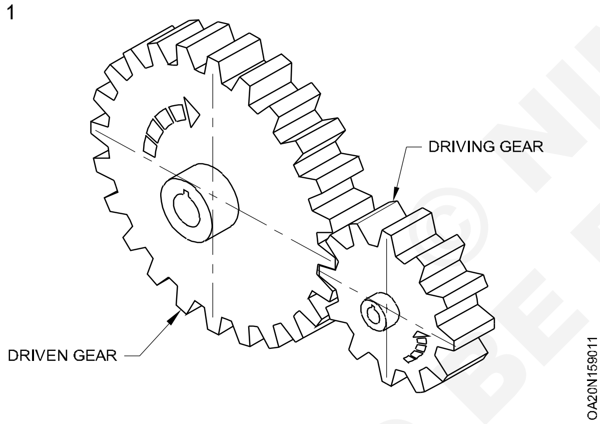
There will be no slippage in gear drives as it is found in friction and belt drives.

General classification of gears

Depending upon the axes, the shape of the solid on which the teeth are developed, the curvature of the tooth-trace and any other special features, gears are categorized into the following types.

Spur gear (Fig 1)

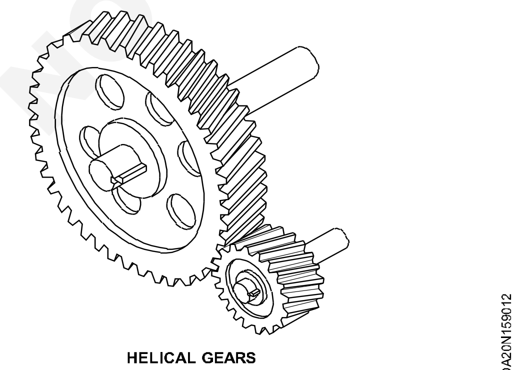
Fig 1



Such gears as are having their teeth element parallel to the rotating shafts are known as spur gears. (Fig 1) These gears are most commonly used to transmit power and motion through parallel shafts.

Helical gear (Fig 2)

Fig 2

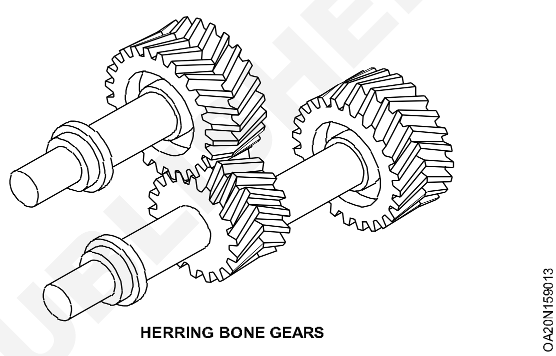


HELICAL GEARS

If the elements of the teeth are twisted or helical as shown in Fig 2, they are known as helical gears. These gears may be used for connecting shafts that are at an angle in the same plane or in different planes. Helical gears are smooth acting because there will always be more than one tooth in contact. The only disadvantage of using this gear is that there will be an axial thrust tending the shaft to move axially.

Herringbone gear (Fig 3)

Fig 3



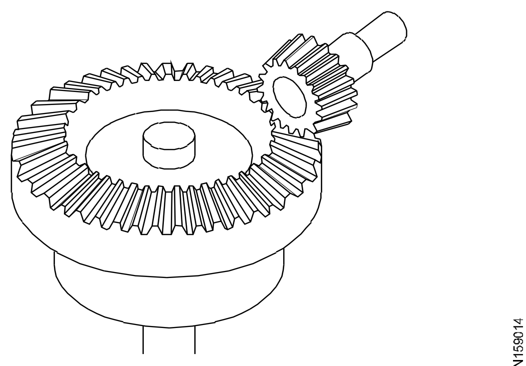
HERRING BONE GEARS

A herringbone gear is equivalent to two helical gears, one having a right hand and the other a left hand helix as shown in Fig 3. This type of gears does not produce axial thrust, and being strong are used in heavy duty machines like steel roll mills.

Bevel gear (Fig 4)

Such a gear is similar in appearance to the frustum of a cone having all the elements of the teeth intersecting at a point. (Fig 4)

Fig 4



BEVEL GEAR

When two shafts are in the same plane but at an angle with one another, bevel gears are used.

When the shafts are at right angles and two bevel gears are of the same size, they are known as ;Mitre gears' (Fig 5)

Hypoid gears (Fig 6)

It is the modification of a bevel gear where the shafts are at right angle but they do not intersect as do the shafts for bevel gears. The other type of bevel gears is the spiral bevel gears is the spiral bevel gear which has helical teeth used in automobile transmissions.

Fig 5

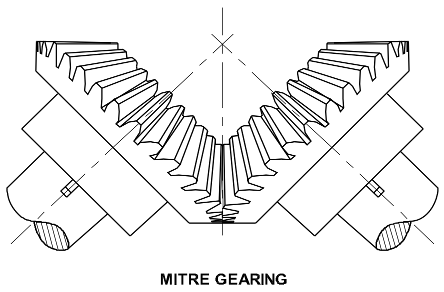
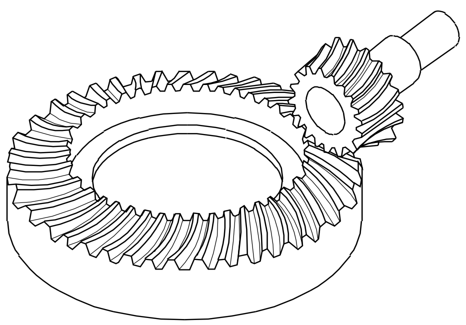
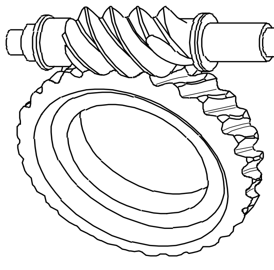


Fig 6



Worm gear (Fig 7)

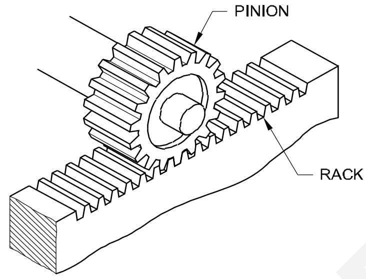
Fig 7



Worm gears are used where a large speed reduction is desired. The small driving gear is called a worm and the driven gear is called a wheel as shown in Fig 7.Shafts for such gears are at right angles but not in the same plane. In worm and worm wheel gearing, the worm will always be the driver. On machine tools these gears are used in the feed mechanism.

Rack gears (Fig 8)

Fig 8

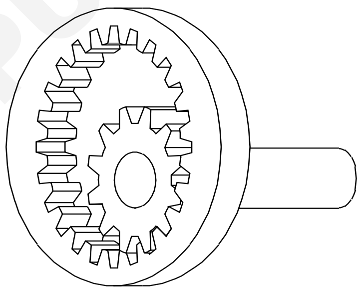


Rack gears are straight and have no curvature. They represent a gear of infinite radius and are used in feeding mechanisms and for reciprocating drives. They may have straight or helical teeth.

Annular gear (Fig 9)

A gear with internal teeth is known as annular gear. Annular gears are used in automobiles.

Fig 9



Gears - types - care & maintenance

Objectives : At the end of this lesson you shall be able to
- **determine the velocity ratio of a gear train**
- **state the care and maintenance of gears**
- **state the merits and demerits of various gears.**

Velocity ratio of gear train

The gear train transmits motion without slip.

Different speeds can be obtained by shifting gear position in the gear- box. Fig 1 shows the feed change by swivelling and sliding the swivel arm in the Norton gearbox of lathes.

Formula for velocity ratio of gear train

$N_1 T_1 = N_2 T_2$

where

N_1 = RPM of driver gear

T_1 = number of teeth in the driver gear

N_2 = rpm of the follower/driven gear

T_2 = number of teeth in the driven gear.

Care and maintenance of gears

The low speed gears which are visible may be lubricated with an oilcan or brush. (Fig 2) The drop oil method of lubrication is shown in Fig 3.

The enclosed gear trains should be packed in grease or run in an oil bath. (Fig 4)

In the case of big gearboxes mounted with different levels of gear sets, they are provided with oil pumps for In the lubrication purposes. (Fig 5)

To ensure proper and long life of gears they should never run dry.

Fig 1

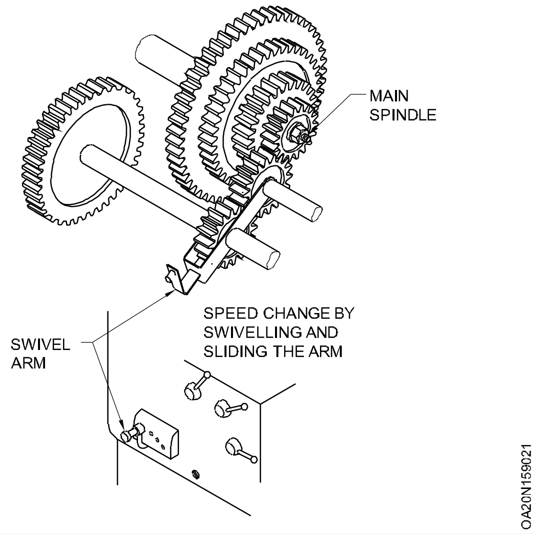


Fig 2

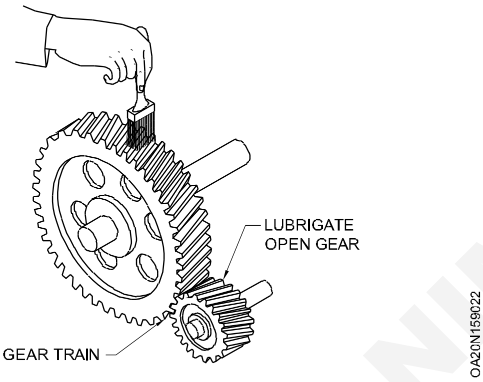


Fig 3

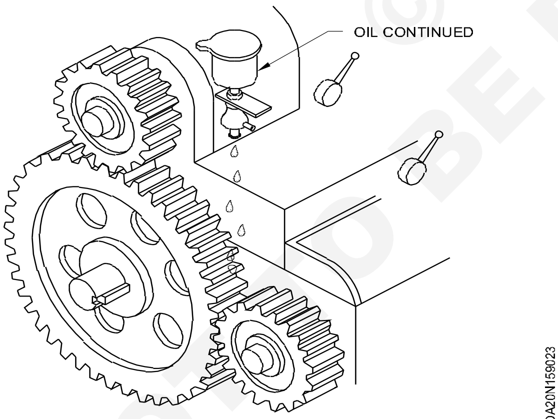
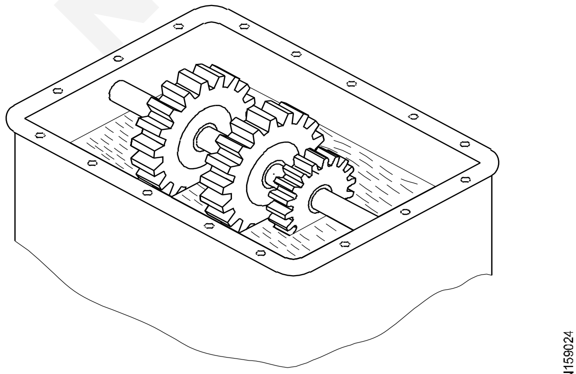
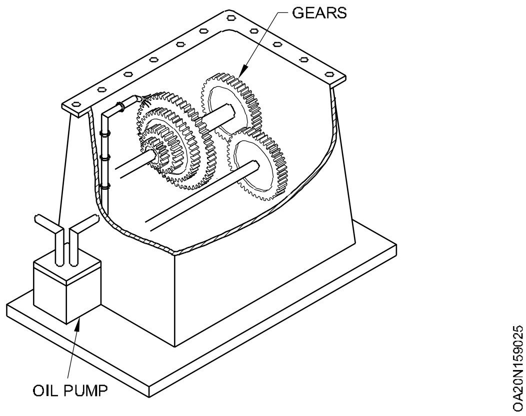


Fig 4



OIL IN GEAR BOX

Fig 5



Merits and demerits of each gears

1 Spur gear

Advantages

- They offer constant velocity ratio.
- Spur gears are highly reliable.
- Spur gears are simplest, hence easiest to design and manufacture.
- Spur gear teeth are parallel to its axis. Hence, spur gear train does not produce axial thrust. So the gear shafts can be mounted easily using ball bearings.

Disadvantages

- Spur gear are slow-speed gears
- Gear teeth experience a large amount of stress
- They cannot transfer power between non-parallel shafts.
- They cannot be used for long distance power transmission.
- Spur gears produce a lot of noise when operating at high speeds.
- When compared with other types of gears, they are not as strong as them.

2 Helical gear

Advantages

- They angled teeth engage more gradually so as to than do spur gear teeth causing to run more smoothly and quietly
- Helical gears are highly durable and are ideal for high load applications.
- At any given time their load is distributed over several teeth, resulting in less wear.
- Can transmit motion and power between either parallel or right angle shafts.

Disadvantages

- An obvious disadvantage of the helical gears is a resultant thrust along the axis of the gear, which needs to be accommodated by appropriate thrust bearings, and a greater degree of sliding friction between the meshing teeth, often addressed with additives in the lubricant.

- Efficiency of helical gear is less because helical gear trains have sliding contacts between the teeth which in turns produce axial thrust of gear shafts and generate more heat. So, more power loss and less efficiency.

3 Bevel Gear

Advantages

- This gear makes it possible to change the operating angle.
- Differing of the number of teeth (effectively diameter) on each wheel allows mechanical advantage to be changed. By increasing or decreasing the ratio of teeth between the drive and driven wheels one may change the ratio of rotations between the two, meaning that the rotational drive and torque of the second wheel can be changed in relation to the first, with speed increasing and torque decreasing, or speed decreasing and torque increasing.

Disadvantages

- One wheel of such gear is designed to work with its complementary wheel and no other.
- Must be precisely mounted.
- The shafts' bearings must be capable of supporting significant forces.

4 Worm wheel

Advantages

- Worm gear drives operate silently and smoothly.
- They are self-locking.
- They occupy less space.
- They have good meshing effectiveness.
- They can be used for reducing speed and increasing torque.

Disadvantages

- Worm gear materials are expensive.
- Worm drives have high power losses.
- A disadvantage is the potential for considerable sliding action, leading to low efficiency.
- They produce a lot of heat.

5 Rack and pinion

Advantages

- Cheap
- Compact
- Robust
- Easiest way to convert rotation motion into linear motion.
- Rack and pinion gives easier and more compact control over the vehicle.

Disadvantages

- The rack and pinion can only work with certain levels of friction. Too high a friction and the mechanism will be subject to wear more than usual and will require more force to operate.
- The most adverse disadvantage of rack and pinion would also be due to the inherent friction, the same force that actually makes things work in the mechanism. Due to the friction, it is under a constant wear, possibly needing replacement after a certain time.

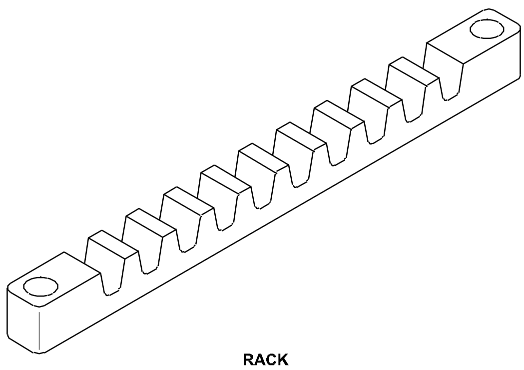
Rack - types, uses and calculations

Objectives : At the end of this lesson you shall be able to
- **define rack**
- **explain the purpose of the rack**
- **list the types of rack**
- **describe the parts and functions of rack cutting attachments.**

Rack

A rack or a gear rack is having teeth cut on a flat surface. (Fig 1). A rectangular stock is commonly used. At times square or round stock may also be used for cutting a rack.

Fig 1



RACK

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Purpose

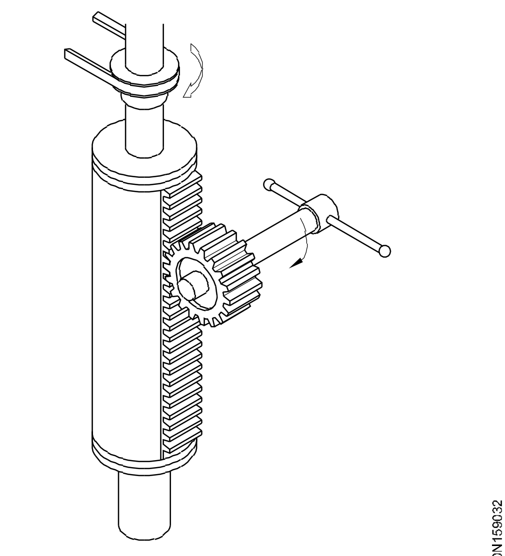
A gear rack when meshed with a gear, is used for converting rotary motion into reciprocating motion. Eg: drilling machine spindle - quill. (Fig 2)

The definition of the terms like, module, addendum, addendum, whole depth, clearance and pressure angle are same as spur gears.

Types

Racks may be of two types.

Fig 2



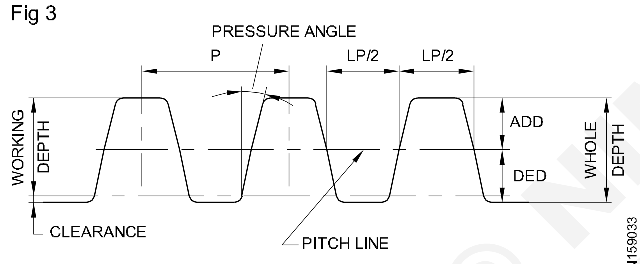
RACK & PINION

– Straight toothed rack

– Helical toothed rack

Terms used in connection with racks (Fig 3)

Fig 3



TERMS USED WITH GEAR RACKS

Pitch line, addendum, addedendum, whole depth clearance and pressure angle.

A rack, in conjunction with a gear (pinion), is used to convert rotary motion into longitudinal motion.

Racks are found on lathes, drill presses and many other machines in a workshop.

A rack may be considered as a spur gear which has been straightened out so that the teeth are all in one plane. The circumference of the pitch circle of this gear would now become a straight line which would just touch the pitch circle of a gear, meshing with the rack.

The pitch of a rack is measured in linear pitch, which is obtained by the formula.

Pitch = p m where 'm' is the module.

The method used to cut a rack will depend generally on the length of the rack.

For short lengths the work piece may be clamped in a vice such that the tooth will be parallel to the side of the cutter and the teeth may be cut accurately by moving the cross -slide of the machine.

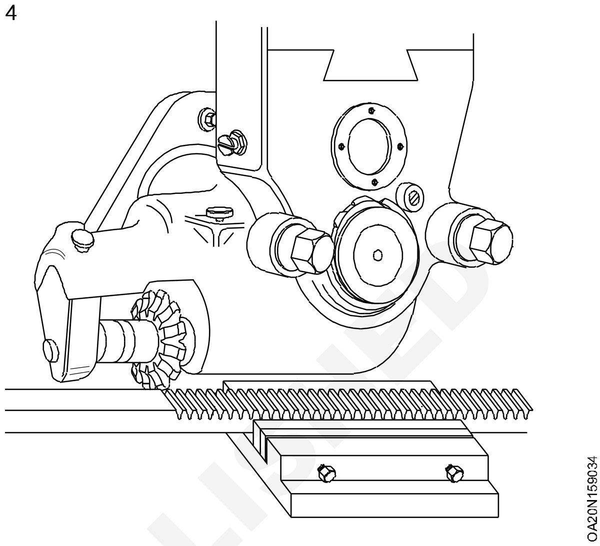
If the rack is longer than the maximum cross travel of the milling machine table, it must be held longitudinally on the table and should be generally held in a special fixture.

The milling cutter is held in a rack milling attachment. (Fig 4)

Rack milling attachment

The rack milling attachment is designed to mount between the face of the column and the arbor support on a plain or universal milling machine. (Fig 4)

Fig 4

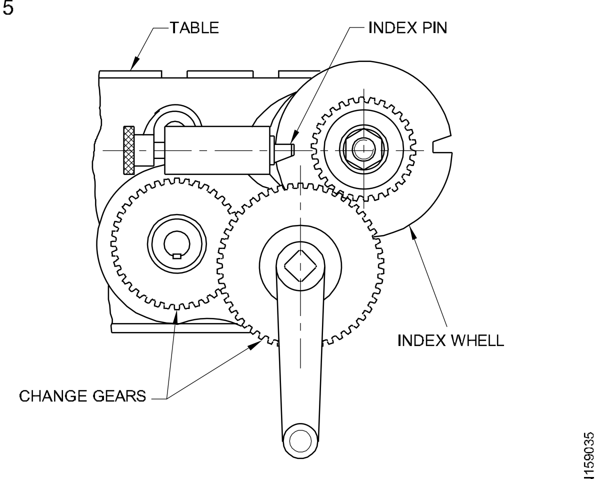


It consists of a fixed housing fitted with an angle drive and a spindle. The spindle axis is fixed parallel to the table.

In rack milling, the cross-slide is used to feed the job against the cutter and the longitudinal table is used to index the job to produce the rack teeth.

In order that the work may be moved longitudinally, and to ensure the exact amount needed for accurate spacing of the teeth, a special rack indexing attachment Fig 5 is used.

Fig 5



RACK INDEXING ATTACHMENT

On left end of the table is fastened a bracket which carries a locking indexing wheel together with change gears for gearing to the table feed screw.

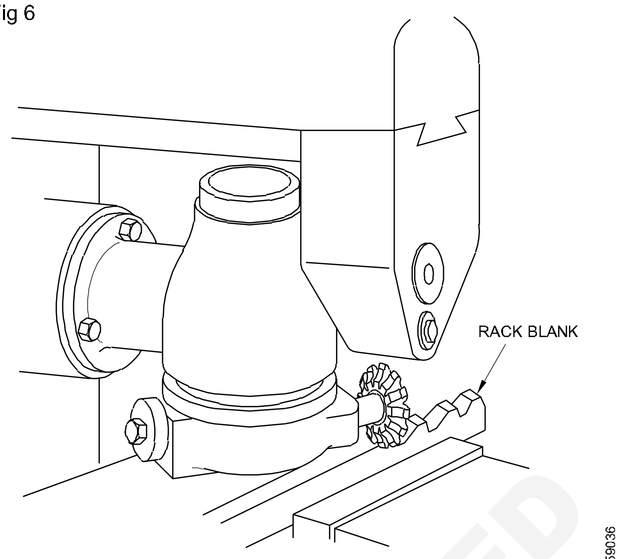
To index any required spacing, change gears are selected which will produce one or more complete turns of the indexing wheel.

This method is positive and much more reliable than setting the table to a graduated dial directly fitted to the table feed screw.

A universal or spiral attachment (Fig 6) can also be used to widen the scope of the rack indexing attachment to include operations such as milling the undercut teeth of a broach.

Special vices with long jaws and bases are available for use in rack cutting operations.

Fig 6



RACK MILLING WITH UNIVERSAL SPIRAL ATTACHMENT

Rack calculation

Objective : At the end of this lesson you shall be able to
- **calculate the proportions of elements of a rack.**

A rack and a gear have the following common terms.

- Addendum
- Dedendum
- Whole depth
- Clearance
- Pressure angle

A rack may be a straight-toothed or a helical-toothed one. Calculation

Straight teeth rack

Addendum = m.

Dedundum = 1.25 m.

Whole depth = 2.25 m.

Linear pitch = πm

Tooth thickness = πm/2 = 1.5708 m.

Example

Data given

Module = 3

Number of teeth = 20

Addendum = m = 3 mm.

Dedendum = 1.25 m = 1.25 x 3 = 3.75 mm.

Whole depth = 2.25 m = 2.25 x 3 = 6.75 mm.

Linear pitch = πm = 3.14 x 3 = 9.42 mm.

Tooth thickness = πm/2 = 3.14 x 3/2 = 4.71 mm.

Length of rack = Linear pitch x Number of teeth = 9.42 x 20 = 188.4 mm.

The tooth thickness in a rack need not be corrected by calculating the chordal thickness. It can be measured directly using a gear tooth vernier caliper.

The depth setting is equal to Addendum.

Helical rack

Data given

Module = 2.5

Helix angle β = 15°

Addendum = m = 2.5x1 = 2.5 mm

dedendum = 1.25 m = 1.25 x 2.5 = 3.12 mm.

Whole depth = 2.25 m = 2.25 x 2.5 = 5.62 mm.

Normal linear pitch = πm = 3.14 x 2.5 = 7.86 mm.

$$\text{Normal tooth thickness} = \frac{\pi m}{2} = \frac{7.86}{2} = 3.93\,\text{mm}$$

Linear pitch

$$= \frac{\pi m}{\text{Cos}\beta} = \frac{7.86}{\text{Cos}15^\circ} = \frac{7.86}{0.9659} = 8.137\text{mm}/ \cong 8.14\text{mm}$$

Spur gear calculations, curves and their uses

Objectives : At the end of this lesson you shall be to
- **state the basic elements of a spur gear**
- **calculate spur gear tooth proportions with the given data.**

Elements of Spur Gear

Spur gear elements

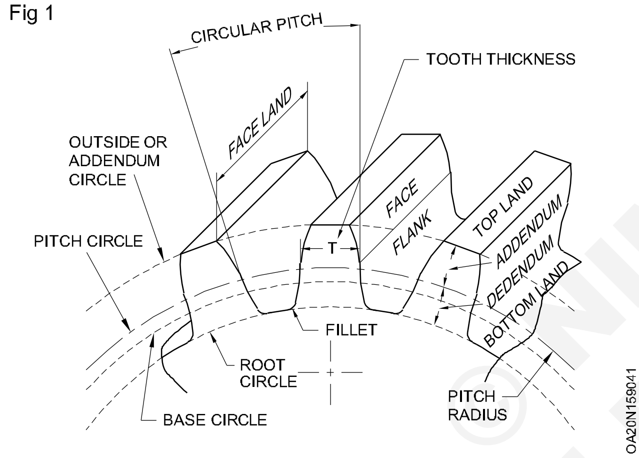
A spur gear is the simplest form of gears. The tooth proportions of the spur gears are expressed in terms of modules.

Module

It is defined as the ratio of the pitch diameter to the number of teeth of a gear. The module is denoted by the letter 'm' and is expressed in millimeters. The module is one of the major determining parameters of a gear.

Basic Elements (Fig 1)

Fig 1



Pitch circle

It is the imaginary circle on which two mating gears seems to be rolling.

The gear calculations are based on this circle.

Circular pitch: 'CP or 'P'

It is the distance from the point of one tooth to the corresponding point of the adjacent tooth measured on pitch circle.

Pitch circle diameter (PCD)

The diameter is called pitch circle diameter (PCD) or simply pitch diameter.

It is denoted by the letter 'd' with proper subscripts eg. d1 for pinion and d2 for the matting gear.

Addendum circle

Addendum circle or outside circle bounds the outer edges of the teeth of a gear and its diameter is denoted by 'da'.

Root circle

The root circle or addendum circle bounds the bottom of the teeth and its diameter is denoted by 'df'.

Base circle ('db')

This is the circle from which the in volute tooth profile is developed. Its diameter is denoted by db.

Addendum (ha) (Fig 2)

It is the radial distance between the pitch circle and the addendum circle and is denoted by ha.

Dedendum (hf) (Fig 2)

It is the radial distance between the pitch circle and the root circle, and is denoted by hf.

Land (Fig 2)

The land and the bottom land are surfaces at the top of the tooth and the bottom of the tooth space respectively.

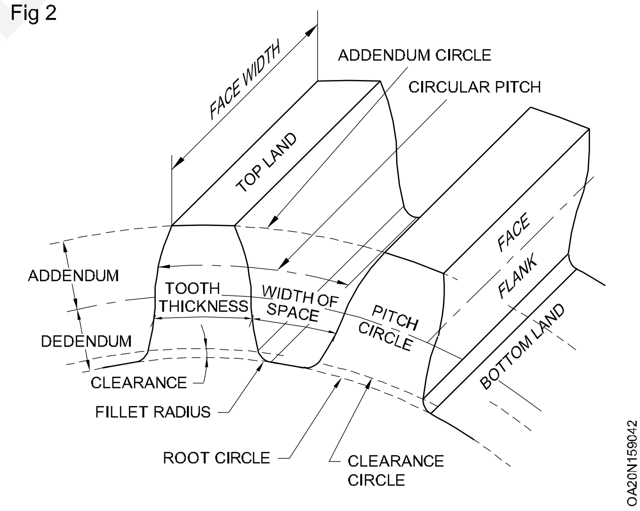
Working depth (Fig 2)

This is the distance of engagement of two mating teeth and is equal to the sum of addendums of the mating teeth of the two gears in the case of standard systems and is expressed as '2ha'.

Whole depth (Fig 2)

This is the height of a tooth and is equal to the addendum plus addendum and is expressed as (ha+hf).

Fig 2



Clearance (Fig 3)

This is the radial distance between the top land of a tooth and the bottom land of the mating tooth.

Face width (Fig 2)

This the width of the gear and it is the distance from one end of a tooth to the other end.

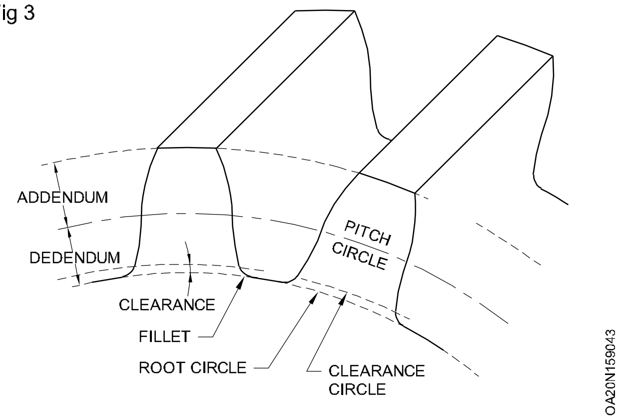
Face of a tooth (Fig 2)

This is the surface of the tooth between the pitch circle and the outside circle.

Flank of tooth (Fig 3)

This is the surface of the tooth between the pitch circle and the root circle.

Fig 3



Chordal tooth thickness (Fig 4)

This is the chord referred to above. chordal addendum (or) chordal height, as it is sometimes called) as well as the chordal tooth thickness are important in the checking of gears.

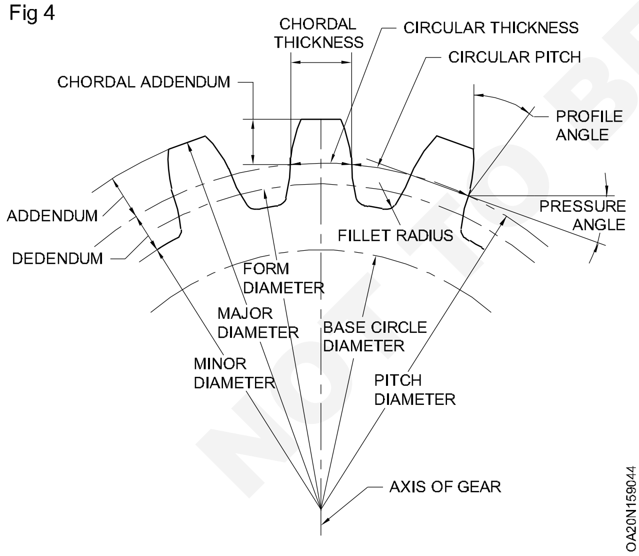
Chordal addendum (Fig 4)

This is the height bound by the top of the tooth and the chordal corresponding to the arc of the pitch circle representing the circular tooth thickness.

Diametric pitch (DP) (Fig 4)

This is a term used in gear technology in the F.P.S. system. It is defined as the ratio of the number of teeth to the pitch diameter in inches.

Fig 4



It is usually denoted as 'DP'. It is equal to the number of gear teeth per inch of the pitch diameter. The unit of DP is the reverse of inch.

The following relation exists between DP and module.

Module (mm)

25.4

Line of action

This is the line along which the point of contact of the two mating teeth profiles moves.

Pitch line

It is the line of contact of two pitch surfaces.

Pressure angle

The angle which the common normal to the two teeth at the point of contact makes with the common tangent to the two pitch circles at the pitch point is known as the pressure angle.

Spur gear tooth proportions

Symbols

Pd	=	Pitch diameter
da	=	Outside diameter
df	=	Root diameter
P	=	Circular pitch
Z	=	Number of teeth
m	=	Module
h	=	Height of tooth (ha + hf)
ha	=	Tooth addendum
hf	=	Tooth addendum

Tooth proportions for 14 1/2° pressure angle

Pitch diameter (Pd) = Zm

Outside diameter (da) = m(Z + 2)

Root diameter (df) $= m\left(Z - \frac{7}{3}\right)$

Circular pitch (p) $= \frac{\pi}{Z} X pd$

Module (m) $= \frac{pd}{Z}$

Height of tooth (h) = ha + hf = m(1 + 7/6)

Tooth addendum (ha)= m

Tooth addendum (hf) = $\frac{7}{6}$ m

Example

Determine P, ha, hf, h, Pd, da and df for a gear wheel with a module of 3 mm 20 teeth.

Given m = 3 mm

Z = 20.

Pd (Pitch diameter) = Zm

= 20 x 3 = 60mm.

da (Outside diameter) = m (Z+2)

= 3 (20 + 2)

= 3 x 22 = 66mm.

(or)

da = Pd + 2 addendum

da = 60 + 2 x ha

da = 60 + 2 x 3 (because ha = m)

60 + 6 = 66mm.

$$df\ (\text{Root diameter}) = m\left(Z - \frac{7}{3}\right)$$

$$df = 3\left(20 - \frac{7}{3}\right) = 3\,\frac{60-7}{3} = 3\,\frac{53}{3}$$

$$= 3 \times \frac{53}{3} = 53\,mm$$

ha (Tooth addendum) ha = m, ha = 3mm.

$$hf\ (\text{Tooth dedendum}) = \frac{7}{6}m$$

$$\frac{7}{6} \times 3 = \frac{7}{2} = 3.5\,mm$$

h = (height of tooth) = (ha + hf) = 3 + 3.5 = 6.5mm.

$$P = (\text{Circular pitch}) = \frac{\pi \times pd}{Z} = \frac{22}{7} \times \frac{66}{7}$$

= 9.43mm.

Ans. P = 9.43mm. ha = 3mm. hf = 3.5mm.

h = 6.5mm. Pd = 60mm. da = 66mm.

df = 53mm.

Cutting speed, feed and depth of cut

Objectives: At the end of this lesson you shall be able to
- **select cutting speeds and calculate the revolution per minute for various cutters and materials**
- **select and calculate proper feeds for various cutters and materials**
- **follow the correct procedure for taking roughing and finishing cuts.**

Cutting speeds, feeds and depth of cut

Cutting speeds, feeds and depth of cut

The efficiency of a milling operation depends upon the cutting speed, feed, and depth of cut.

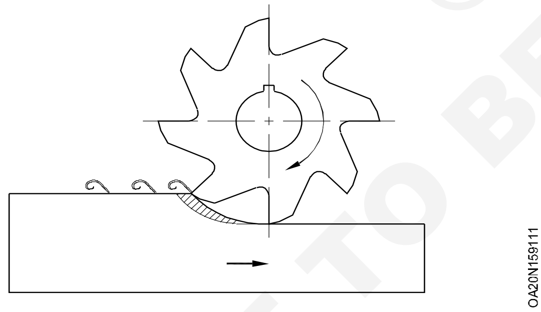
If the cutter is run too slowly valuable time will be wasted, while excessive speed results in loss of time in replacing and regrinding cutters. Somewhere between these two extremes is the efficient cutting speed for the material being machined.

The rate at which the work is fed into the revolving cutters is important. If the work is fed too slowly time will be wasted and chatter may occur which shortens the tool life of the cutter. If the work is fed too fast, the cutter teeth can be broken. Much time will be wasted if several shallow cuts are taken instead of one deep or roughing cut. Therefore speed, feed and depth of cut are the three important factors in any milling operation.

Cutting speed

The cutting speed for a milling cutter is the speed at which the cutting edge or tooth cuts into the workpiece. (Fig 1)

Fig 1



It is expressed in metres per minute.

The following important factors must be considered when determining the proper revolutions per minute at which to machine a metal.

- Type of work material
- Cutter material
- Diameter of the cutter
- Surface finish required
- Depth of cut being taken
- Rigidity of the machine and work set up

Since different types of metals vary in hardness, structure and machineability, different cutting speeds must be used for each type of metal and for various cutter materials.

The cutting speeds for the more common metals for HSS milling cutters are shown in Table 1.

Chart showing r.p.m. values corresponding to the cutter diameter and the cutting speed are shown in Table 2.

Calculation

$$\text{Cutting speed (V)} = \frac{\pi DN}{1000} \text{ m/min.}$$

$$N(\text{r.p.m.}) = \frac{V \times 1000}{3.1416 \times D}$$

Since only a few machines are equipped with a variable speed drive which allows them to be set to the exact calculated speed, a simplified formula can be used to calculate the revolution per minute.

The (3.1416) on the bottom line of the formula will divide the 1000 of the top line approximately 320 times. This results in a simplified formula which is close enough for most milling operations.

$$N(\text{r.p.m.}) = \frac{V(m) \times 320}{D(mm)}$$

where 'D' is diameter of the cutter.

Example

Calculate the revolution per minute required for 75 mm high speed steel cutter when cutting machine steel. (V = 30 m/min.)

$$\text{r.p.m.} = \frac{30 \times 320}{75} = \frac{9600}{75} = 128$$

From the Table 2 the intersection of 75 mm and cutter speed of 30 m/min. is in between 115 and 140 r.p.m. This can be taken as 128 r.p.m. as calculated.

Too fast a speed will shorten the cutter tool life; too slow a speed will waste time.

Milling feeds and depth of cut

The two other factors which affect the efficiency of a milling operation are the milling FEED or the rate at which the work is fed into the milling cutter and the DEPTH of CUT taken at each pass.

Feed

Feed is the rate at which the work moves into the revolving cutter. It is measured in millimetres per minute (m/min.)

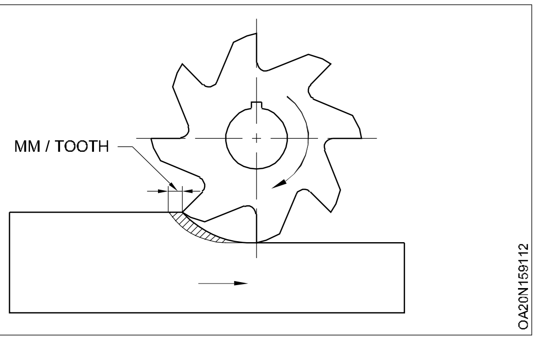
> **Feed rate is specified in mm/min.**

The feed is expressed in milling machines by following three different methods.

Feed per tooth

Feed per tooth is defined by the distance the work advances and the time between engagement by two successive teeth. It is expressed in mm/tooth of the cutter.(Fig 2)

Fig 2



Feed per cutter revolution

Feed per cutter revolution is the distance the work advances in the time when the cutter runs through one complete revolution. It is expressed in mm/revolution of the cutter.

Feed per minute

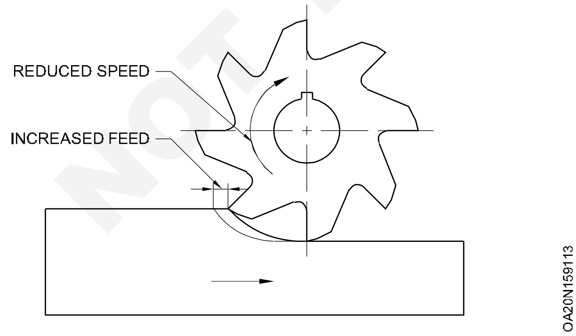
Feed per minute is defined by the distance the work advances in one minute. It is expressed in mm/ minute.

The rate of feed has an effect on the life of the cutter. An increase in feed, using the same cutting speed and depth of cut will reduce the amount of wear of the cutter.

In general we can say that the

- cutting speed should be be reduced when feed is increased (Fig 3)

Fig 3

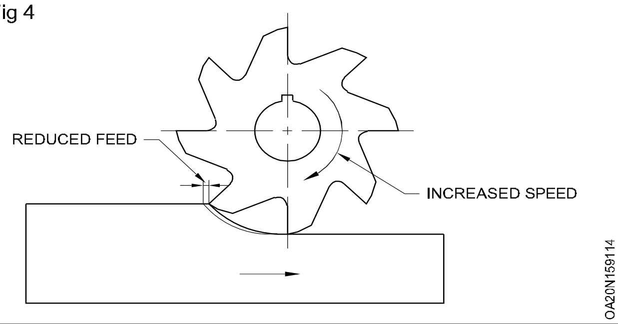


- cutting speed should be increaed when feed is reduced. (Fig 4)

The feed rate on a milling machine depends on a variety of factors such as:

- width and depth of cut
- type of cutter

Fig 4



- sharpness of the cutter
- workpiece material
- strength and uniformity of the workpiece
- type of finish and accuracy required
- power and rigidity of the machine.

Calculation

The formula used to find the work feed is

feed mm/min.(S) = N x Cpt x r.p.m.

where N = number of teeth in milling cutter

Cpt = chip per tooth for a particular cutter

r.p.m. = revolution per minute of the milling cutter.

Example 1

Calculate the feed in mm/min. for a 75, six-teeth helical carbide milling cutter when machining a cast iron workpiece (V = 60 and Cpt = 0.18).

First calculate the r.p.m. of the cutter

$$\text{r/min.} = \frac{60 \text{X} \ 320}{75} = 256.$$

Feed (mm/min.) = N x C.p.t x r.p.m.

= 6 x 0.18 x 256

= 276.4

= 276 mm/min.

> **The spindle speed (revolution per minute) must always be calculated before the feed rate can be calculated.**

Example 2 (Fig 5)

A cutter having 8 teeth is to have a feed of 0.04 mm/tooth. The spindle speed is to be 200 r.p.m. What feed, in mm/ min. should be set on the machine?

While rough milling, where the purpose is to remove surplus metal as quickly as possible and finish is not important, a heavy feed and low cutting speed are used. (Fig 6) However, the cutting speed should not be reduced too much as the cutter would then be operating under very heavy cutting forces.

For finish milling, the quality of the surface finish is, of course, important. Therefore, a light feed and a high cutting speed are used. (Fig 7)

Cutting speed should be reduced when the feed is increased.

Cutting speed should be increased when the feed is reduced.

Fig 5

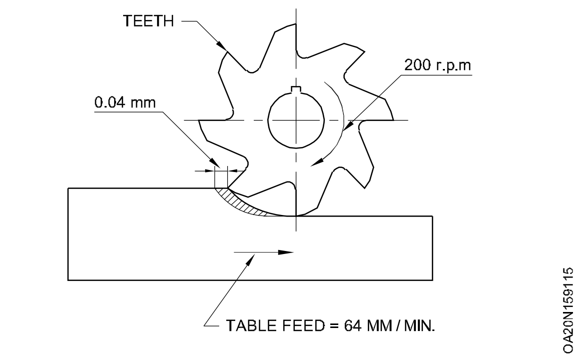


Fig 6

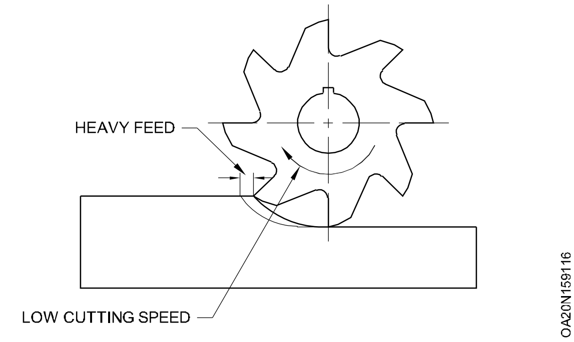
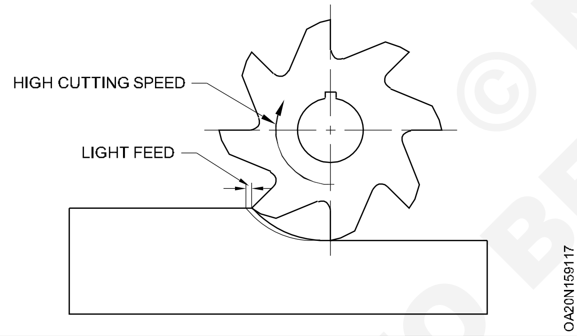


Fig 7



Depth of cut

The depth of cut is the depth to which the cutter penetrates the workpiece surface during a given cut. It is the perpendicular distance (Fig 8) measured between the original and the final surface of the workpiece.

Where a smooth and accurate finish is needed, it is a good practice to take roughing and finishing cuts. Roughing cuts should be deep with a feed as heavy as the work and machine will permit with low cutting speed. (Fig 9) Heavier cuts may be taken with helical cutters having fewer teeth than with those having many teeth. Cutters with fewer teeth are stronger and have greater chip clearance than cutters with more teeth.

Fig 8

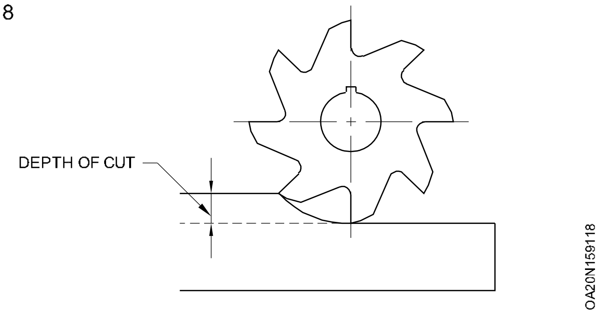
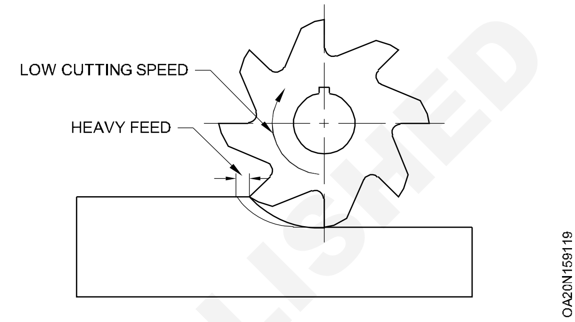
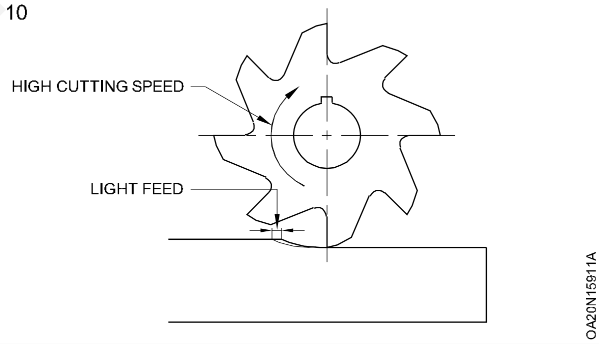


Fig 9



Finishing cuts should be light with a fewer and finer feed than is used in roughing cuts. (Fig 10) The depth of cut should be atleast 0.4 mm. Light cuts and extremely fine feeds are not advisable, since the chip taken by each tooth will be thin and the cutter will often rub the surface of the work. When a fine finish is required, the feed should be reduced rather than the cutter speed; more cutters are dulled by high speeds than by high feeds.

Fig 10



The table below shows the cutting speed (V) in metres per minute (m/min) for various materials, using high speed steel (HSS) milling cutters of various types. They must be considered as average values which may vary according to actual working conditions.

TABLE 1

Table for selecting cutting speeds)for high speed steel milling cutters

Materials to be machined	BHN used	Shell end hardness	End mill	S &F cutter	Cylin. cutter	Slot'g cutter	Form cutter	In.tooth face mill
Mild steel	150	20-30	20-30	15-25	15-25	15-25	30-45	20-30
Medium carbon steel	200	15-25	15-20	15-20	20-30	15-20	15-25	15-25
High carbon steel	300	10-15	10-15	10-15	12-20	10-15	13-20	13-20
Stainless steel	200	22-30	22-30	15-25	15-25	20-30	15-25	20-30
Malleable iron	160	15-22	15-22	15-20	15-20	20-30	15-20	18-25
Soft cast iron	180 max	15-20	15-25	15-20	15-20	20-30	15-20	18-25
Hard cast iron Over	180	13-17	10-15	10-15	10-15	10-25	10-15	13-17
Hard brass& hard bronze	-	40-60	40-60	30-45	30-45	70-90	30-45	50-60
Soft brass & soft bronze	-	40-60	40-60	25-35	25-35	70-90	25-35	40-50
Copper	-	30-45	30-45	30-45	30-45	70-90	25-35	50-60
Aluminium alloy	-	200-300	200-300	150-300	150-300	200-300	150-250	200-400

Note :Carbide cutters are able to cut at a much higher speed than HSS cutters and they are made in a variety of grades. If you are going to use a carbide cutter, ask your instructor what cutting speed you should select, as he will have the values for the particular grade of carbide used in the cutter in your workshop.

TABLE 2

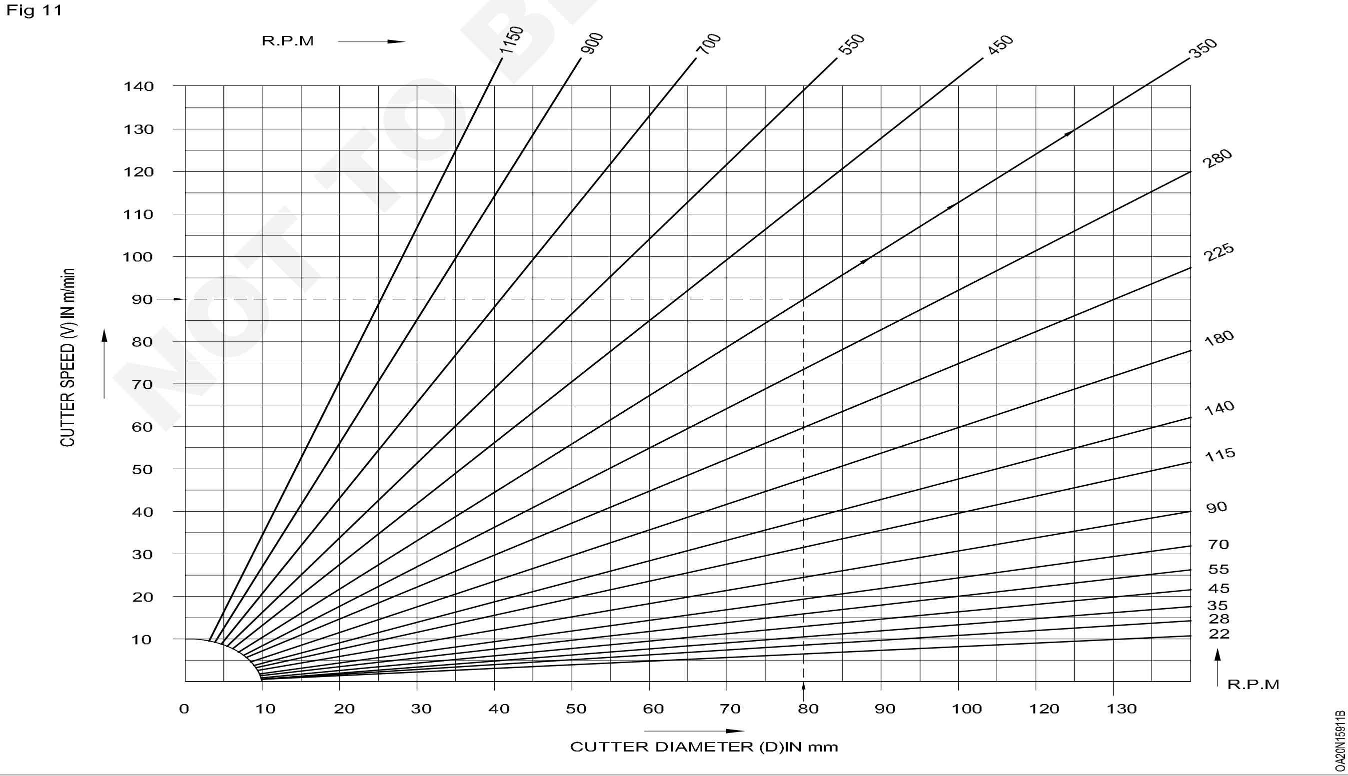
Having selected a suitable cutting speed from the tables, this must be converted into revolutions per minute (r.p.m.) of the machine spindle. This can be done using the chart shown here.

(The chart has r.p.m values corresponding to the speeds available on a typical milling machine.)

Example : A cutter of 80mm diameter is to cut at 90 m/min. What spindle speed should be selected?

The two broken lines - - - - - on the chart show that the spindle speed should be 355 r.p.m.

Fig 11



Lubrication methods

Objective: At the end of this lesson you shall be able to
- **state the systems of lubrication and their application.**

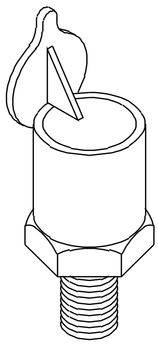
There are 3 systems of lubrication.

- Gravity feed system
- Force feed system
- Splash feed system

Gravity feed

The gravity feed principle is employed in oil holes, oil cups and wick feed lubricators provided on the machines. (Figs 1 & 2)

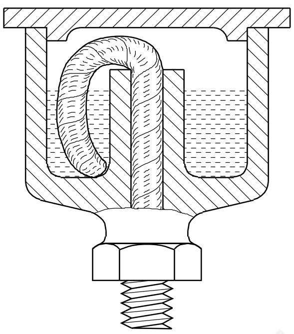
Fig 1



OIL CUP

OA20N159121

Fig 2



WICK FEED

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Force feed/Pressure feed

Oil, grease gun and grease cups

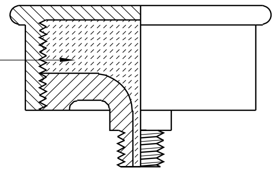
The oil hole or grease point leading to each bearing is fitted with a nipple, and by pressing the nose of the gun against this, the lubricant is forced to the bearing. Greases are also force fed using grease cup. (Fig 3)

Oil is also pressure fed by hand pump and a charge of oil is delivered to each bearing at intervals once or twice a day by operating a lever provided with some machines. (Fig 4) This is also known as shot lubricator.

Oil pump method

In this method an oil pump driven by the machine delivers oil to the bearings continuously, and the oil afterwards drains from the bearings to a sump from which it is drawn by the pump again for lubrication.

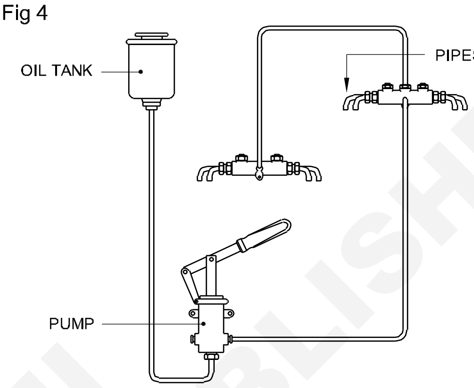
Fig 3



MANUAL SCREW DOWN GREASER

OA20N159123

Fig 4



HAND PRESSURE FEED (SHOT LUBRICATED)

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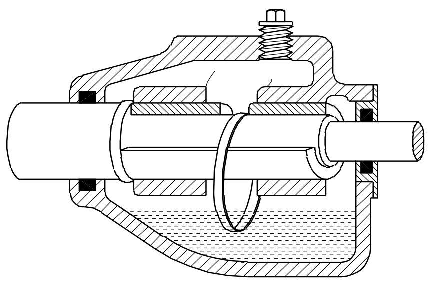
Splash lubrication

In this method a ring oiler is attached to the shaft and it dips into the oil and a stream of lubricant continuously splashes around the parts, as the shaft rotates. The rotation of the shaft causes the ring to turn and the oil adhering to it is brought up and fed into the bearing, and the oil is then led back into the reservoir. (Fig 5) This is also known as ring oiling.

Fig 5



RING OILING

OA20N159125

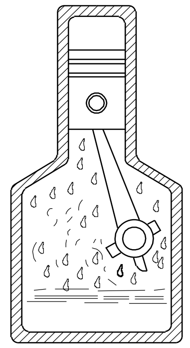
In other systems one of the rotating elements comes in contact with that of the oil level and splash the whole system with lubricating oil while working. (Fig 6) Such systems can be found in the headstock of a lathe machine and oil engine cylinder.

Types of grease guns

The following types of grease guns are used for lubricating machines.

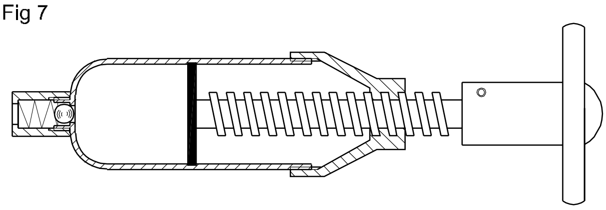
- ‘T’ handle pressure gun (Fig 7)
- Automatic and hydraulic type pressure gun (Fig 8)

Fig 6



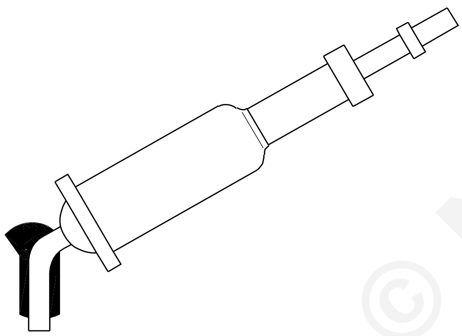
SPLASH-LUBRICATING SYSTEM

Fig 7



T-HANDLE PRESSURE GUN

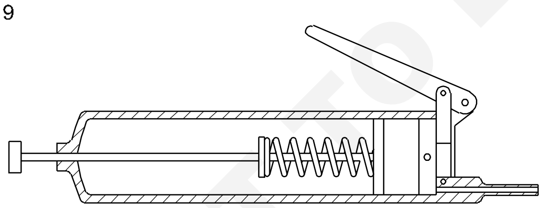
Fig 8



AUTOMATIC HYDRAULIC-TYPE PRESSURE GUN

- Lever-type pressure gun (Fig 9)

Fig 9



PRESSURE GREASE GUN

Lubrication to exposed slideways

The moving parts experience some kind of resistance even when the surface of the parts seems to be very smooth.

The resistance is caused by irregularities which cannot be detected by the naked eyes.

Without a lubricant the irregularities grip each other as shown in the diagram. (Fig 10)

With a lubricant the gap between the irregularities fills up and a film of lubricant is formed in between the mating components which eases the movement. (Fig 11)

Fig 10

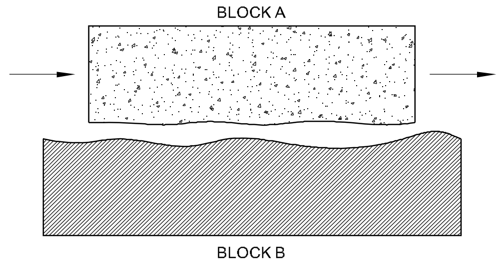
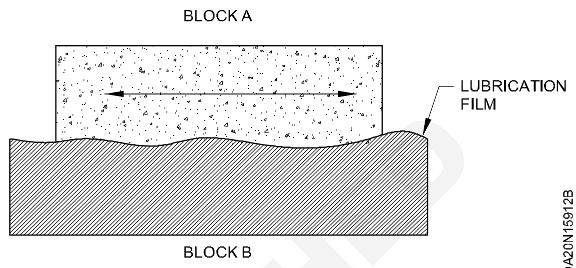
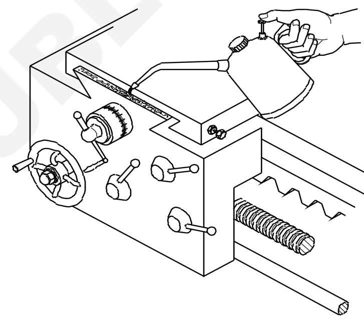


Fig 11



The slideways are lubricated frequently by an oilcan. (Fig 12)

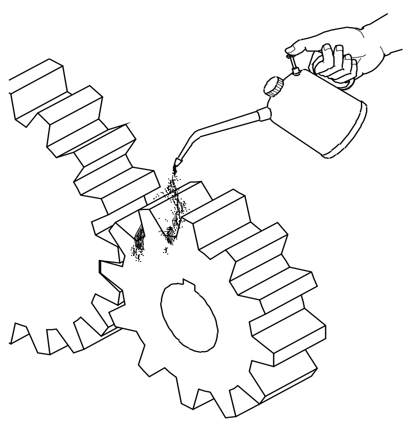
Fig 12



OIL THE SLIDES FREQUENTLY

After cleaning the open gears, oil them and repeat lubrication regularly. (Fig 13)

Fig 13

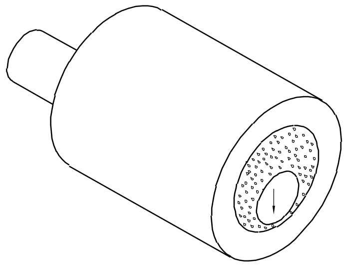


Lubricate bearings

A shaft moving in a bearing is also subjected to frictional resistance. The shaft rotates in a bush bearing or in ball/ roller bearing, experiencing friction.

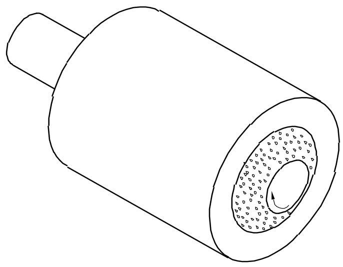
When the shaft is at rest on the bottom of the bush bearing, there is hardly any lubricant between the shaft and the bush. (Fig 14)

Fig 14



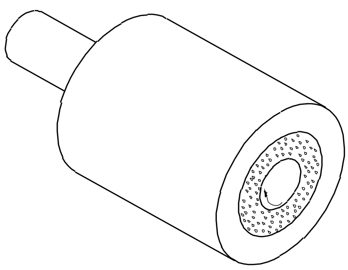
When the shaft starts rotating the lubricant maintains a film between the shaft and the bush and an uneven ring of lubricant builds up. (Fig 15)

Fig 15



When the shaft is rotating at full speed a full ring of lubricating film surrounds the shaft (Fig 16) which is known as hydro dynamic lubrication.

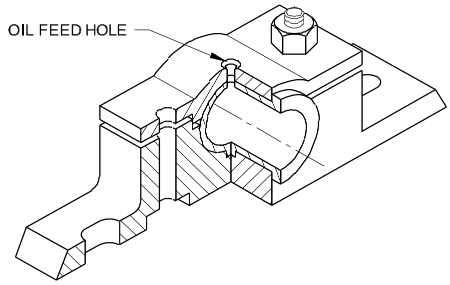
Fig 16



This lubrication ring decreases the frictional resistance very much and at the same time protects the mating members against wear and changes.

Some bush bearings have oil feeding holes over which the oil or grease cup is mounted and the lubricant is fed through the holes into the bearing by gravity feed system.(Fig 17)

Fig 17



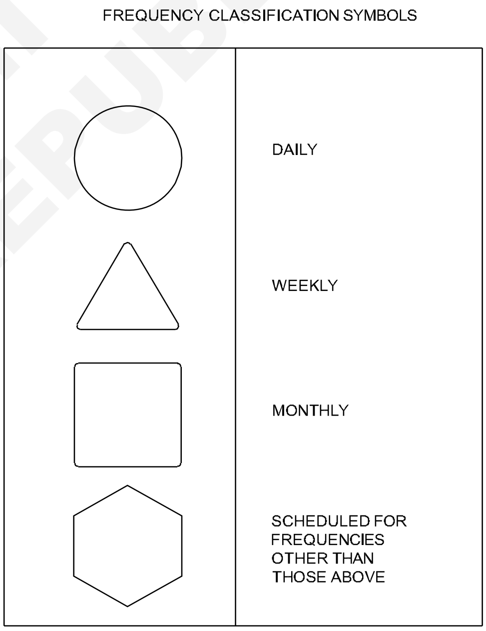
Hints for lubricating machines:

- identify the oiling and greasing points
- select the right lubricants and lubricating devices
- apply the lubricants.

The manufacturer's manual contains all the necessary details for lubrication of parts in machine tools. Lubricants are to be applied daily, weekly, monthly or at regular intervals at different points or parts as stipulated in the manufacturer's manual.

These places are indicated in the maintenance manuals with symbols as shown in Fig 18.

Fig 18



Cutting fluids

Objectives: At the end of this lesson you shall be able to
- **state what is cutting fluid**
- **state the function of cutting fluids & their advantages**
- **state the properties of a good cutting fluid**
- **identify different types of cutting fluids**
- **select appropriate cutting fluids for different materials.**

Cutting fluids and compounds are the substances used for efficient cutting while cutting operations take place.

Functions

The functions of cutting fluids are:

- to cool the tool as well as the workpiece
- to reduce the friction between the chip and the tool face by lubricating
- to prevent the chip from getting welded to the tool cutting edge

- to flush away the chips
- to prevent corrosion of the work and the machine.

Advantages

As the cutting fluid cools the tool, the tool will retain its hardness for a longer period; so the tool life is more.

Because of the lubricating function, the friction is reduced and the heat generated is less. A higher cutting speed can be selected.

As the coolant avoids the welding action of the chip to the tool-cutting edge, the built up edge is not formed. The tool is kept sharp and a good surface finish is obtained.

As the chips are flushed away, the cutting zone will be neat.

The machine or job will not get rusted because the coolant prevents corrosion.

Properties of a good cutting fluid

A good cutting fluid should be sufficiently viscous.

At cutting temperature, the coolant should not catch fire.

It should have a low evaporation rate.

It should not corrode the workpiece or machine.

It must be stable and should not foam or fume.

It should not create any skin problems to the operator.

Should not give off bad smell or cause itching etc. which are likely to irritate the operator, thus reducing his efficiency.

Should be transparent.

Types of cutting fluids

The following are the common cutting fluids.

- Straight mineral oil
- Chemical solution (synthetic fluids)
- Compounded or blended oil
- Fatty oils
- Soluble oil (Emulsified oil-suds)

Straight mineral oil : Straight mineral oils are the coolants which can be used undiluted. Use of straight mineral oil as a coolant has the following disadvantages.

It gives off a cloud of smoke.

It has little effect as a cutting fluid.

Hence straight mineral oils are poor coolants. But kerosene which is a straight mineral oil is widely used as a coolant for machining aluminium and its alloys.

Chemical solution (Synthetic oil)

These consist of carefully chosen chemicals in dilute solution with water. They possess a good flushing and a good cooling action, and are non-corrosive and non-clogging. Hence they are widely used for grinding and sawing. They do not cause infection and skin trouble. They are artificially coloured.

Compounded or blended oil

These oils are used in automatic lathes. These oils are much cheaper and have more fluidity than fatty oil.

Fatty oil

Lard oil and vegetable oil are fatty oils. They are used on heavy duty machines with less cutting speed. They are also used on bench-works for cutting threads by taps and dies.

Soluble oil (Emulsified oil)

Water is the cheapest coolant but it is not suitable because it causes rust to ferrous metals. An oil called soluble oil is added to water which gets a non-corrosive effect with water in the ratio of about 1: 20. It dissolves in water giving a white milky solution. Soluble oil is an oil blend mixed with an emulsifier.

Other ingredients are mixed with the oil to give better protection against corrosion, and help in the prevention of skin irritations.

Soluble oil is generally used as a cutting fluid for centre lathes, drilling, milling and sawing.

Soft soap and caustic soda serve as emulsifying agents.

Surface grinder

Objectives: At the end of this lesson you shall be able to
- **state the types and parts of surface grinding**
- **describe the construction of surface grinder**
- **state the methods of surface grinding.**

Surface grinding machine

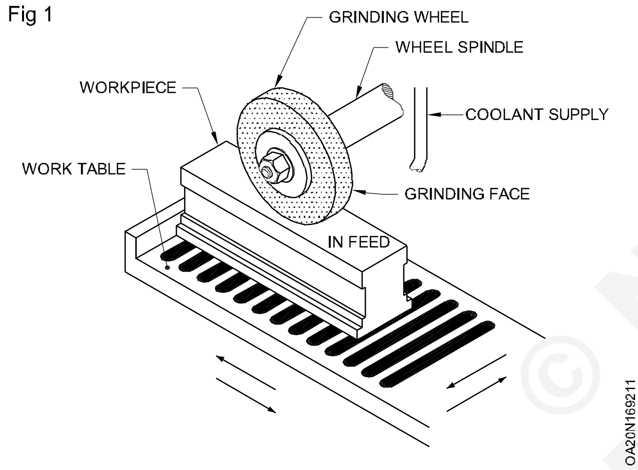
It is a precision grinding machine to produce flat surfaces on a workpiece. It is a more economical and more practical method of accurately finishing flat surfaces than filing and scraping.

Types of surface grinders

There are four types of surface grinders.

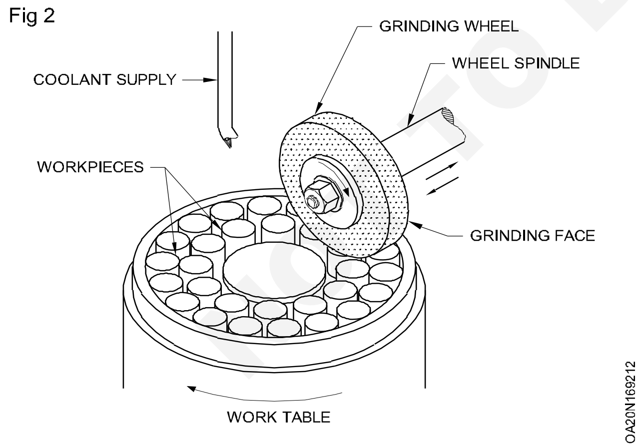
- Horizontal spindle reciprocating table (Fig 1)

Fig 1



- Horizontal spindle rotary table (Fig 2)

Fig 2



- Vertical spindle reciprocating table (Fig 3)
- Vertical spindle rotary table (Fig 4)

Parts

Horizontal spindle reciprocating table surface grinder main parts (Fig 5).

- Base

Fig 3

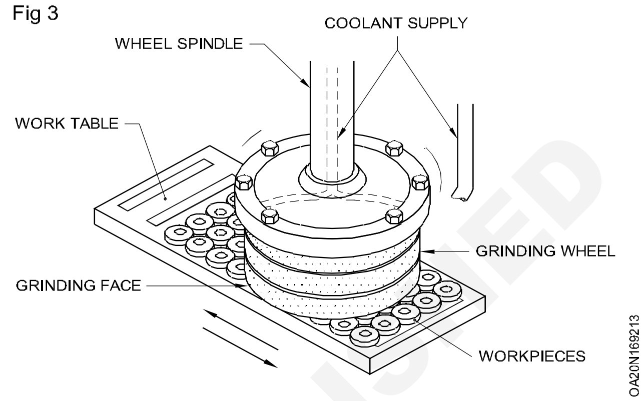


Fig 4

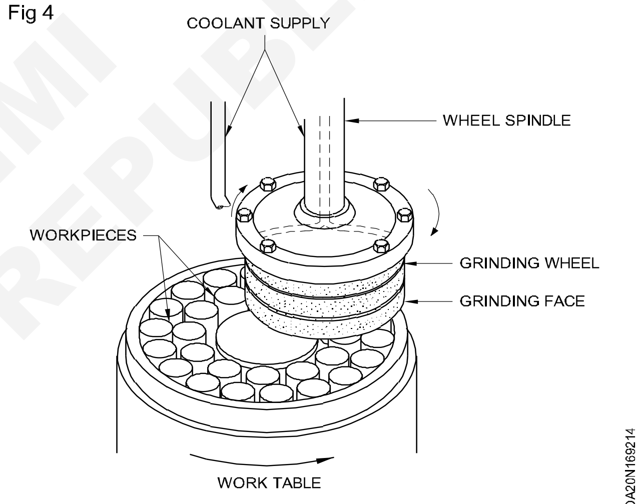
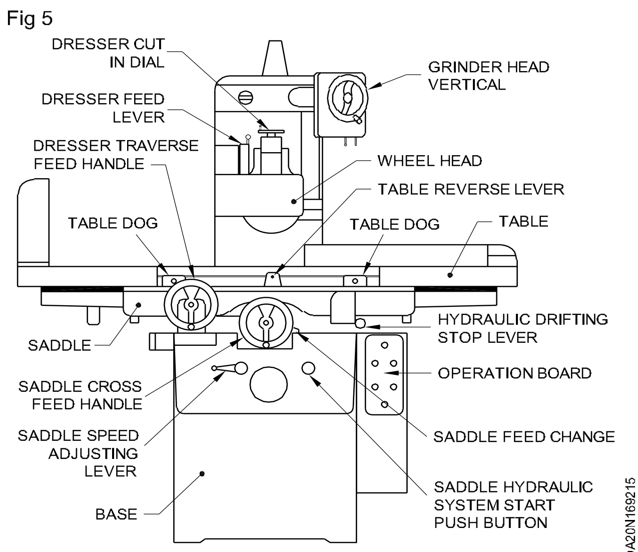


Fig 5



- Saddle
- Table
- Wheel head

Base : It is a rigid rectangular box contains the driving mechanism (hydraulic device tank and motor). It has a column at the back for supporting the wheel head on the top of the base provide precision guide ways for moving saddle.

Saddle : It is a frame. It contains the table in its cross wise movement. It is used to give cross feed to the work. It can be removed by hand or auto feed.

Table : It is fitted on the saddle. It is reciprocating along the guide ways to provide the longitudinal feed to the work. The surface is accurately machined and T-slots are provided for clamping of workpieces directly on the table or for clamping magnetic chuck and grinding fixtures. It is moved by hand or auto feed.

Wheel head

It is mounted on the column secured to the base. It can be moved vertically up and down to by rotating a hand wheel accommodate work piece of different height and set the wheel for depth of cut. The wheel rotates at a constant wheel speed. (1500 rpm)

Some surface grinding machines the dressing unit mounted on the top of the wheel head and slide for dressing the wheel with help of rotating micrometer collar handle. Dress the wheel 0.015 mm to 0.025 mm giving feed.

Surface grinding methods and operation

Objectives: At the end of this lesson you shall be able to
- **list the general hints on grinding operation**
- **brief the method of grinding parallel surfaces**
- **brief the method of grinding stepped surfaces.**

Surface grinding operations

General hints on surface grinding

As the limits of accuracy are very close in this case, it is absolutely important that all possible precaution are taken to obtain accurate settings. Even the most accurate machine if carelessly set up will give in accurate results. All chucks vice or fixtures etc. should be thoroughly wiped clean. When using a magnetic chuck, desirable practice is to fasten a dial indicator to a rigid part of the wheel-head and run the pointer over the surface to make sure that it is absolutely level. If a knee plate is used, the pointer is brought in contact with the vertical face and the machine table raised or lowered. This indicator will show whether the knee-plate is absolutely square or not.

After setting the work correctly, longitudinal traverse stops are set to approximately the correct position while making sure that the wheel will not foul the work of fixture. The machine is then started. If the stops are not correctly set, re-setting is done only after stopping the machine.

Raising the table for bringing the workpiece in contact with the wheel should be done very carefully to avoid hitting of the work with a heavy blow. The winding of table across while it is moving backwards and forward may cause mishaps due to irregularities on the surface.

Grinding a flat face

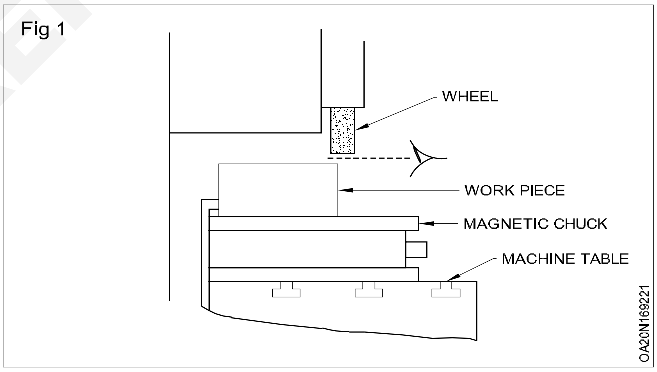
The following factors determine whether grinding can be done by single dressing of wheel or whether roughing out and then finish grinding is required.

- Surface area of the face to be ground
- Amount of material to be removed by grinding
- Surface texture of the workpiece

Steps involved are:

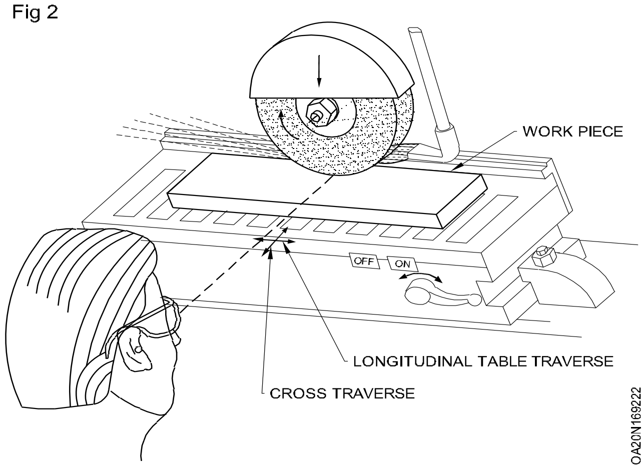
- Measure the workpiece check the flatness of its face as also parallelism and note high spots.
- Dress the wheel as required as stated above.
- Mount the workpiece on the magnetic check. Set table traverse stops.
- Start the wheel and align it over the highest spot. Feed the wheel-head down by hand till it is only about 0.25 mm above the workpiece. (Fig 1)

Fig 1



- Engage longitudinal traverse using fine feed being the wheel head until it just comes in contact with the workpiece.
- Move the workpiece clear from the wheel. Start supply of coolant. Apply 0.05 mm downfeed. Using cross traverse bring the side of the workpiece in line with the front side of the wheel. Let the wheel pass over whole face of workpiece. (Fig 2)
- Stop cross traverse of wheel-head. Apply further drawn feed and reset reverse traverse. Repeat the process until the face is fully cleaned up. Remove the workpiece from the chuck.
- Dress wheel for finish grinding.
- Set the workpiece again on the chuck
- Engage longitudinal table traverse. With the help of cross traverse, bring the edge of the workpiece under the wheel.

Fig 2

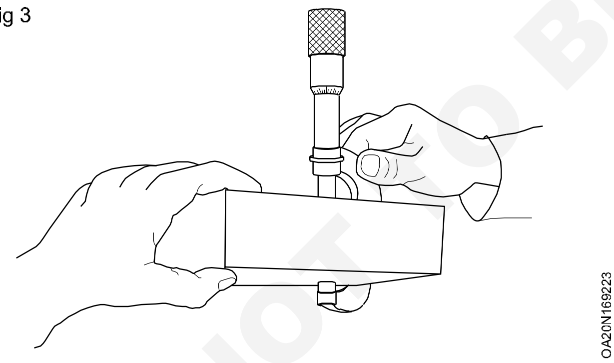


- Feed the wheel-head down until the wheel is lightly in contact with the workpiece.
- Move the workpiece away from the wheel. Apply downfeed approximately 0.0125mm.
- Engage cross traverse, turn the coolant pump on and grind the face
- Repeat the process of applying downfeed and cross traverse until the face is completely ground.
- Remove the workpiece from the chuck. Check its flatness and surface texture. Remove sharp edges using a fine abrasive stone. Demagnetise the workpiece.

Grinding two opposite flat and parallel

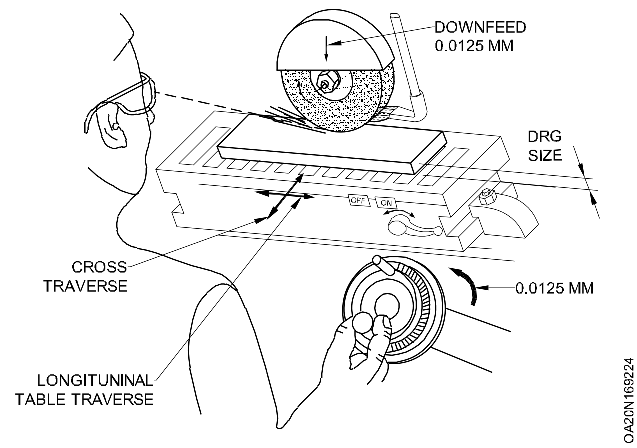
- The procedure for grinding a flat has been described above. Steps given below are involved in grinding a workpiece flat and parallel.
- Measure the workpiece. Check its parallelism.(Fig 3)

Fig 3



- Dress the wheel for taking rough cuts.
- Mount the workpiece on the magnetic chuck. Adjust the position of traverse stops. Clean the face of the workpiece by removing minimum amount of material.
- Remove the workpiece from chuck. Measure it again to determine the remaining grinding allowance. Check also parallelism.
- Mount the workpiece for grinding the opposite side. Carry out rough grinding by removing 1/2 remaining grinding allowance minus 0.05 mm.
- Remove workpiece. Check its size and parallelism. Mount it on the reverse side for rough grinding the first face. Rough grind within 0.05 mm of finished size.
- Remove workpiece. Determine remaining grinding allowance. Dress the wheel for finish grinding.
- Mount the workpiece again making sure that the workpiece and chuck are perfectly clean.
- For finish grinding engage longitudinal table traverse when wheel is clear of the workpiece. Then position the edge of the workpiece under the wheel with the help of cross traverse.
- Feed the wheel-head down very slowly for bringing the wheel in very light contact with the workpiece. Not wheel-head index reading.
- Move the workpiece away from the wheel. Use 0.0125 mm down feed. Engage cross traverse turn the coolant on and let the wheel pass over the whole surface of the workpiece.
- Again apply 0.005 mm downfeed and engage reverse cross traverse.
- After the workpiece has cleaned the wheel, reverse the direction of cross traverse and like this let the wheel pass over the face once or twice without applying any cut.
- Stop all traverses. Set the workpiece on the reverse side without altering the wheel-head setting.
- Finish grind the reverse side by applying downfeed and traversing until the remaining grinding allowance is removed. After that let the wheel pass over the face once or twice to spark out.
- Remove the workpiece. Check its thickness, flatness, parallelism and surface texture.
- Remove sharp edges and de-magnetise the workpiece. (Fig 4)

Fig 4

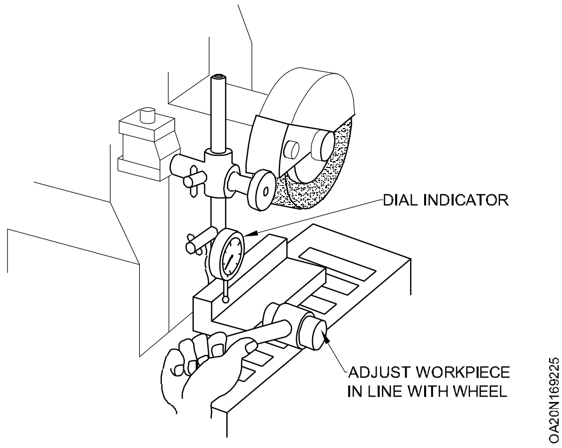


Grinding a flat face and shoulder

- Dress the face of the wheel. Relieve its rear.
- Mount the workpiece on magnetic chuck, first visually align workpiece shoulder face in line with wheel and

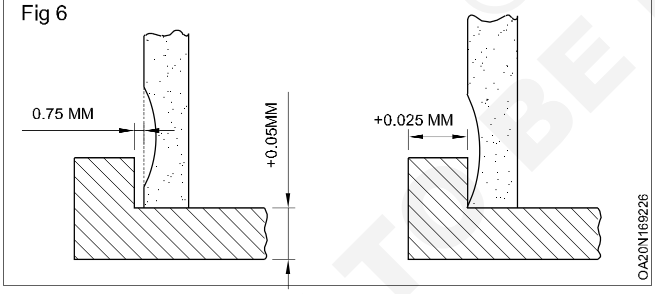
then click and adjust alignment with a dial indicator. (Fig 5) If the chuck has a back plate, it can be used as a datum surface for correctly setting the workpiece. More over it can be helpful in re-setting the workpiece accurately after removal.

Fig 5



- Set longitudinal stops. Engage longitudinal traverse. Supply downfeed until wheel just starts grinding. Note zero graduated scale on hand wheel of wheel-head. Start supply of coolant.
- For rough grinding of horizontal face, apply 0.05 mm downfeed. With hand feed cross traverse, grind the surface to within 0.75 mm of vertical face. Apply further cuts until 0.05 mm is left for finish grinding. (Fig 6)
- For rough grinding of vertical face, cross traverse table until wheel lightly contacts vertical face. Use cross traverse cuts of 0.0125 mm to leave 0.025 mm for finish grinding. (Fig 6) Remove the workpiece.

Fig 6



- Dress the wheel face and side again for finish grinding.
- Re-set the stopper to engage longitudinal traverse and carefully bring down the wheel just touches the horizontal face. Note give final cuts to grind the workpiece to size.
- For finish grinding of vertical face, bring it lightly in contact with the wheel by cross traverse. Apply cuts of upto 0.0125 mm to bring workpiece to size.
- Remove workpiece from table. Clean and check workpiece.

Grinding two vertical faces parallel and central : In this operation grinding of two vertical faces parallel, square and central to a base are involved, the face and sides of base having been previously finish machined.

Dress the face of the wheel, relieve and dress the sides of the wheel.

Measure the workpiece to know the grinding allowance. Measure the width of tenon. Inspect the position of tenon so as to determine the direction of error.

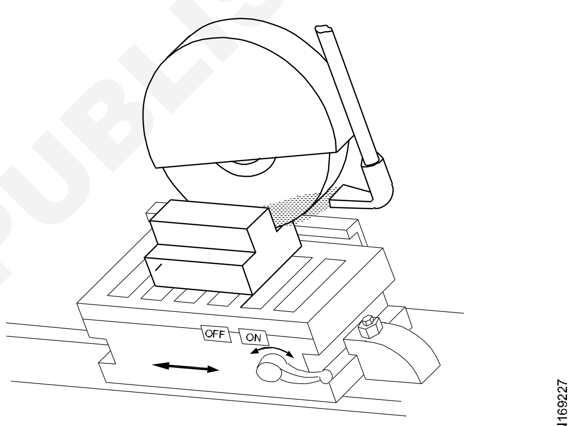
Mount the workpiece on the chuck and set table traverse stops so that wheel will clear fully the vertical face of the workpiece.

For cleaning up back vertical face, bring the wheel approximately 0.375 mm above horizontal face and 0.375 mm from vertical face. Feed the wheel-head down carefully until the wheel makes a light contact with the horizontal face. Then feed cross traverse until the wheel makes a light contact with vertical face. Apply 0.0125 mm cuts until face is cleaned up.

Remove and measure the workpiece. Check the distance from side of base to vertical face. Check parallelism of face to side of base, width of tenon and the amount of material to be removed.

Set the wheel again and rough grind the back vertical face by applying cuts until the face is within 0.05 mm of the finished size. (Fig 7)

Fig 7



GRINDING BACK VERTICAL FACE

Now clean up front vertical face of the workpiece. Remove it from the chuck and measure the amount of material to be removed from front face.

Re-set the workpiece and rough grind front vertical face by applying cuts until the face is within 0.05 mm of the finished size.

Dress the wheel again for finish grinding.

Set the workpiece and finish grind back vertical face.

Remove and re-set the workpiece for finish grinding front vertical face. (Fig 8)

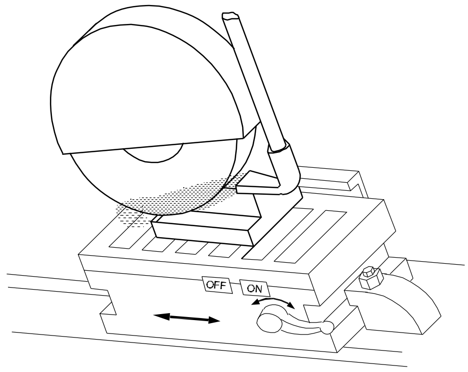
Check the workpiece to determine the position of the tenon relative to the base and its parallelism, squareness, width and surface texture.

Remove sharp edges and demagnetise workpiece.

Grinding angular faces

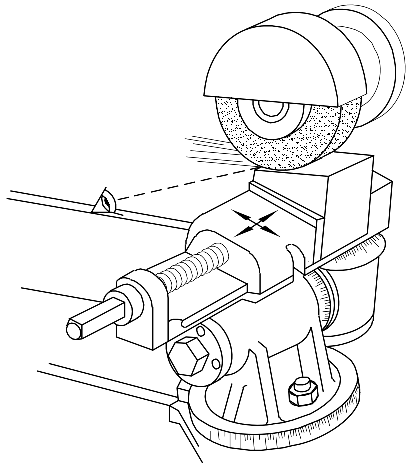
Faces having angular relationship are ground as shown in fig 9. The method used for holding and setting the workpiece depends upon the angular accuracy required. Steps involved in grinding are the same as for grinding of flat surfaces.

Fig 8



GRINDING FRONT VERTICAL FACE

Fig 9

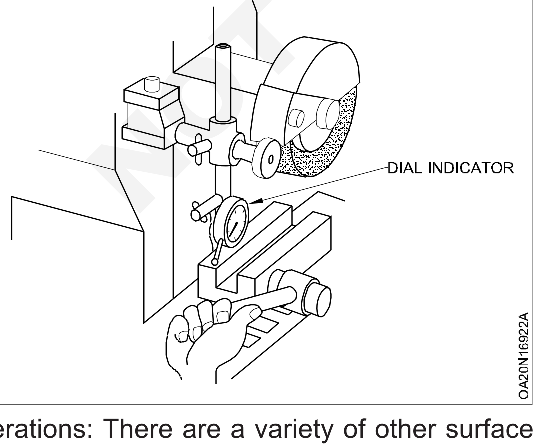


Grinding slots

This involves grinding of two vertical faces and one horizontal face which must be parallel and square to the previously machined datum surfaces. Steps involved are similar to those described in other cases earlier. After mounted and setting the workpiece using a dial indicator, horizontal face is cleaned and rough ground within 0.05 mm of the second vertical face is cleaned and rough ground within 0.025 mm of the finished size.

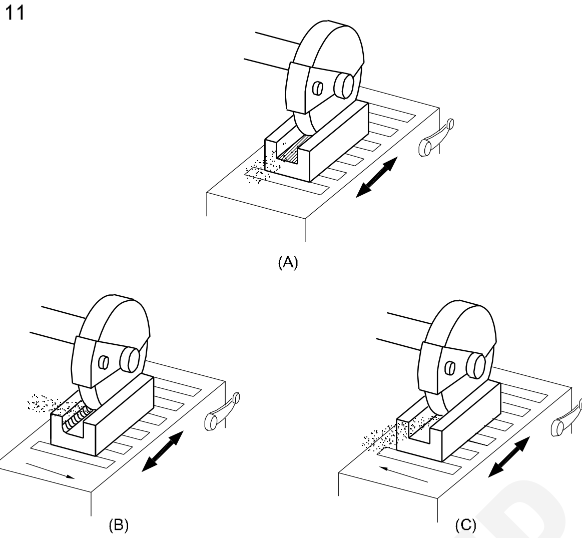
After dressing the wheel for finish grinding, the slot is finish ground. (Fig 10)

Fig 10



Other operations: There are a variety of other surface grinding operations which are done. Fig 11 indicates set-ups for:

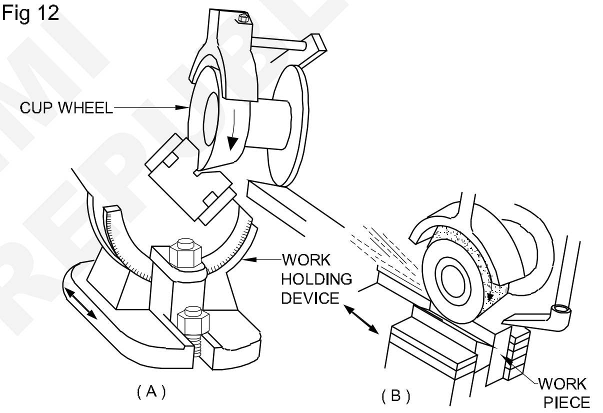
Fig 11



Grinding operations

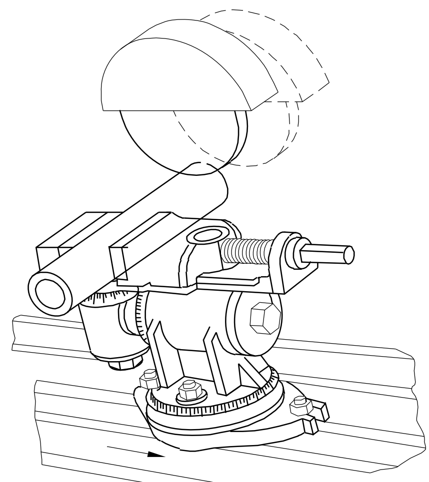
- Grinding vee using cup wheel. (Fig 12)
- Grinding dovetail using formed wheel
- Plunge grinding (Fig 13)

Fig 12



(A) GRINDING VEE USING CUP WHEEL.
(B) GRINDING DOVETAIL USING FORMED WHEEL.

Fig 13



PLUNGE GRINDING

Safety to be observed while working on grinding machine

Objective: At the end of this lesson you shall be able to
- **state the precautions to be observed while working on grinding.**

Safety precautions

All grinding machines have parts that move at high speed.

The machines are fitted with guards to protect the operator from injury and to make operation of the machine as safe as possible

Despite this, accidents still happens.

These accidents are usually caused by :

- Ignorance
- Thoughtlessness
- Carelessness

Lack of consideration for the safety of others.

These accidents can be prevented by thinking before doing.

Various unsafe conditions and procedure are mentioned throughout this manual. Learn to recognize them and gain a clear understanding of what should be done in each case.

The safety precautions to be taken when using grinding machines may be divided into four areas.

- General
- Machine
- Personal

General safety precautions

- Key the work area around machines free of obstacles and waste a material.
- Immediately clean up any oil, grease or coolant spilled on the floor.
- Place cleaning cloths and waste materials in the proper containers after use
- Store hand tools and accessories away from machines after use.
- Do not handle workpieces which may be hot as a result of grinding operations.
- Use the correct hand tool for the job in hand.
- Seek assistance when handling heavy machine accessories, grinding wheels or workpieces.
- Learn the location of the nearest fire alarm.
- Learn where fire extinguishers are located and how to use them,
- Stop, look and think before starting any new operation.
- Ensure lighting is adequate.
- Always be courteous, considerate an obliging to others.

Machine safety precautions

- Operation machines only when you are authorized by your instructor to do so.
- Follow your instructor's directions carefully.
- Keep your fingers away from the moving parts of the machine
- Do not start a machine unless all machine guards are correctly fitted.
- Make sure the workpiece is securely fitted to the work table before starting a grinding operation.
- Do not handle the surface of the workpiece while the machine is operating.
- Do not use your hand to stop movement of any part of the machine.
- Use a brush, not your hand, to clean ground material from the workpiece and machine.
- Keep the machine free of tools, accessories and parts not being used at the time.
- When setting the work table for automatic traverse, allow the wheel to over travel the workpiece in each direction.
- Do not clamp hardened workpiece too tightly in the jaws of a vice.
- Whenever possible, use a coolant during a grinding operation.
- If a grit exhaust system is fitted to the machine, use it all times during grinding.
- Stop the machine before cleaning or oiling it or before making any adjustments to the accessories or to the workpiece.
- Dot not leave a machine while it is still running.
- Do not touch or lean on a machine someone else is using.
- Do not divert the attention of someone else using a machine.

Personal safety precautions

- Wear goggles at all times when using a grinding machine.
- Report any injuries, however slight, to your instructor or supervisor
- Wear close - fitting clothes.
- Avoid wearing a tie and long sleeves. If necessary, tuck your tie carefully inside your shirt or keep in inside of outer clothing, buttoned or zipped up high and roll up your sleeves.

- If your hair is long, wear a protective head covering and make sure your hair is completely enclosed in side it.
- Do not wear a watch, rings or other loose ornaments.
- Do not wear gloves.
- Wipe your hands clean before operating a machine, adjusting accessories or handling a workpiece.

Specification

- Size of the table i.e 600 x 300 mm
- Longitudinal traverse of table i.e 650 mm
- Cross traverse of the table
- Vertical traverse of wheel least count of hand wheel for vertical and cross traverse
- Number of speeds and feeds available
- Power input.

Cylindrical grinders

Objectives: At the end of this lesson you shall be able to
- **state the purpose of a cylindrical grinder**
- **state the types of cylindrical grinders**
- **list the parts and functions of a plain centre type cylindrical grinder**
- **state the specification of a cylindrical grinder.**

Cylindrical grinders are used to grind the external or internal surfaces of a cylindrical workpiece.

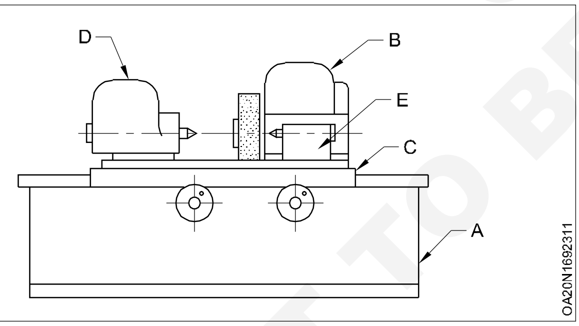
By cylindrical grinding the diameter of a workpiece can be maintained to a close tolerance (upto 0.0025 mm), and high quality surface finish can be obtained (upto N4).

The four types of cylindrical grinders are:

- external cylindrical grinders
- Internal cylindrical grinders
- universal cylindrical grinders
- centreless grinders

Plain centre type cylindrical grinder (Fig 1)

Fig 1



It is mainly intended to produce plain, stepped or tapered

Parts

The main parts of this type of a cylindrical grinder are the:

base

wheel head

table

headstock

foot-stock

Functions

Base (A) is made out of cast iron. It is heavy and provides rigidity to the machine. The top surface is machined to form guideway to the table.

The wheel head (B) is mounted on the cross-slide. It moves perpendicular to give depth of cut.

The table (C) is mounted on the bed-ways. It reciprocates past the wheel. It can be swivelled to grind taper. Trip dogs are provided to control reciprocation.

The headstock (D) is mounted on the table at the left end. It has a motor with 2 or 4 speed steps to drive the work. A dead centre is mounted in the spindle of this head to support the workpiece between centres.

The foot-stock (E) is mounted on the table at the right hand side. It can be moved and locked at any place along the table is spring-loaded and carries a dead centre to support the work.

The spring tension provides even, stiff support

Specification of cylindrical grinder

maximum diameter of workpiece which can be held

the breadth of the table

maximum table traverse movement

maximum diameters of the grinding wheel

H.P of the spindle motor

weight of the machine

Safety

Always wear safety goggles

Ensure the safety guards properly placed

Before starting the machine the wheel must be inspected

Ensure the holding devices are sufficiently tightened

Be sure to allowable clearance between hand and grinding wheel

Before starting of hydraulic system do not hold the job in between centre.

If the work is heavy shut the machine down when placing the work between centres.

Different methods of cylindrical grinding

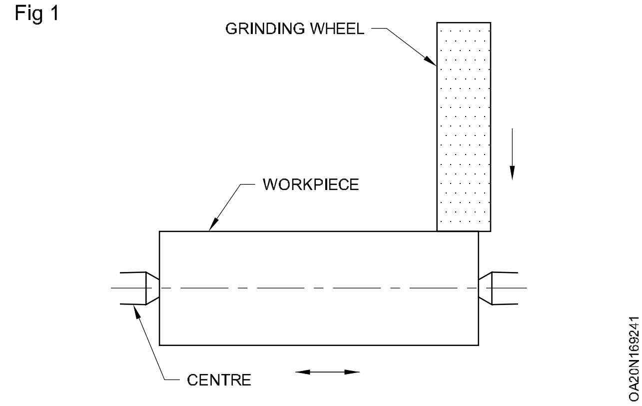
Objectives: At the end of this lesson you shall be able to
- **state the various cylindrical grinding operations**
- **list the various cylindrical operations.**

Cylindrical grinding operations

The figures given here show the various types of cylindrical grinding operations.

Grinding plain cylindrical (Fig 1)

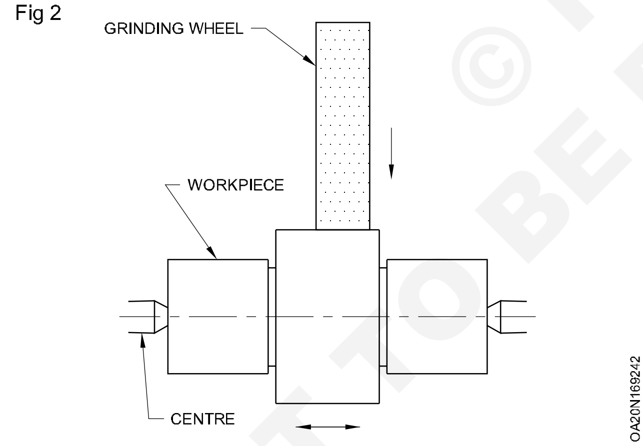
Fig 1



This operations involves removal of metal from the grinding wheel and it has a cylindrical form for the full travel of the work on the wheel keeping same diameter throughout the length.

Grinding stepped cylindrical (Fig 2)

Fig 2



Stepped cylindrical grinding is the process of grinding a different diameters in stepped form on a cylindrical grinding workpiece.

Grinding taper cylindrical (Fig 3) : Methods of taper cylindrical grinding

The table work head and wheel head may be swivelled

The grinding wheel may be dressed at an angle

Grinding slight tapers (Fig 4) : The table is set by using the swivel adjustment located on the right hand side of the table.

Grinding steep tapers : Sharp external tapers either the wheel head or work head is set to taper angle

Fig 3

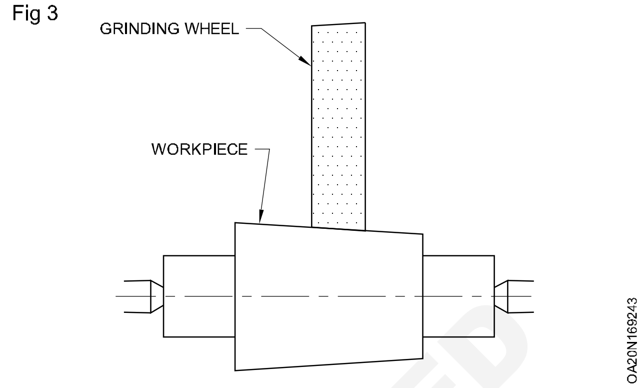
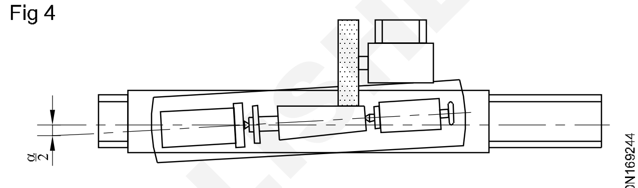


Fig 4



GRINDING SLIGHT TAPERS BY SWIVELLING THE TABLE

Wheel dressing at an angle for taper cylindrical : Dressing taper parts can be checked with taper ring gauge.

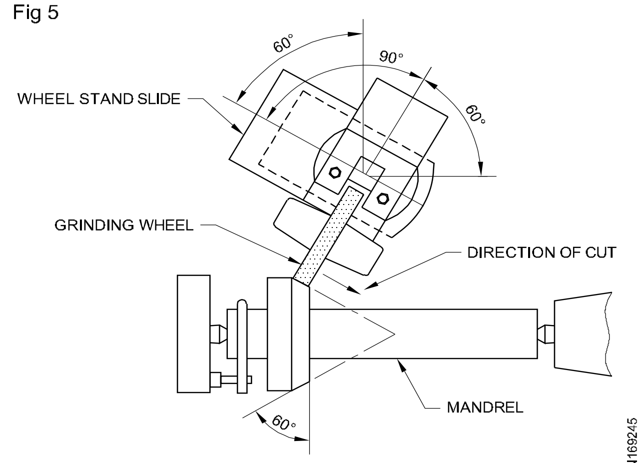
Taper parts can also be checked using sine bar, slip gauge and dial test indicator set up.

- Swivelling of table and grind upto 10°
- Swivelling workhead
- Swivelling wheel head
- Swivelling both workhead & wheel head
- Dressing grinding wheel to the required angle

Grinding slight tapers: Grinding of tapers upto 12° is usually done by swivelling the swivel table. (Fig 4)

Grinding steep or sharp exterior tapers (Fig 5) : This is done by swivelling the wheel head on its base or incases by swivelling the headstock.

Fig 5

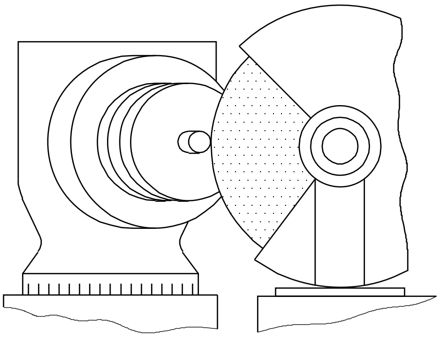


GRINDING A STEEP TAPER

Say the angle of the taper is 30°. Swivel and set there at 60° (90°-30°). Fig 5 Shows the wheel set in position for 30° taper. Turn the plate to bring the spindle parallel to the slide.

Fig 6 shows the setting for 60° grinding and Fig 7 is the flat centre gauge.

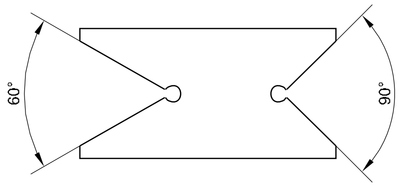
Fig 6



GRINDING A 60° MACHINE CENTRE

OA20N169246

Fig 7



FLAT CENTRE GAUGE

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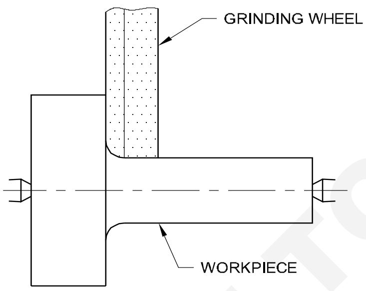
Shoulder grinding (Fig 8) : The wheel axis is parallel to that of the work and the squareness of the shoulder, depends on the accuracy of the dressing of the side of the wheel.

Fig 8



SHOULDER GRINDING

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If the side of the shoulder is wider than that of the side of the wheel the wheel is moved forward and back-while grinding.

When work has to be ground upto a shoulder it should be undercut so that the wheel may grind the diameter without touching the shoulder. (Fig 9)

Do not operate a wheel above its recommented speed.

Internal cylindrical (Fig 10 & 11)

Internal grinding is used to grind plain or parallel bore, step bore and taper bore in workpieces.

The wheel rotates in a fixed position. The work is rotated and reciprocated that it moves backwards and forwards to obtain traverse.

Fig 9

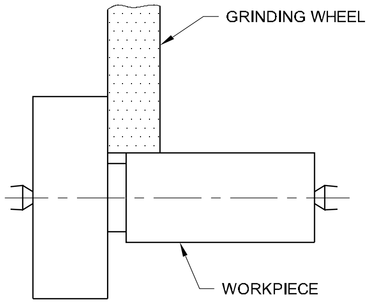

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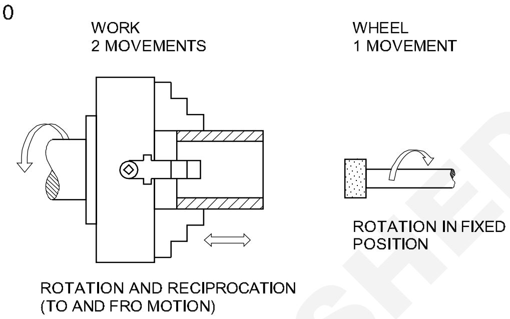
Fig 10



THE MOVEMENTS IN INTERNAL GRINDING

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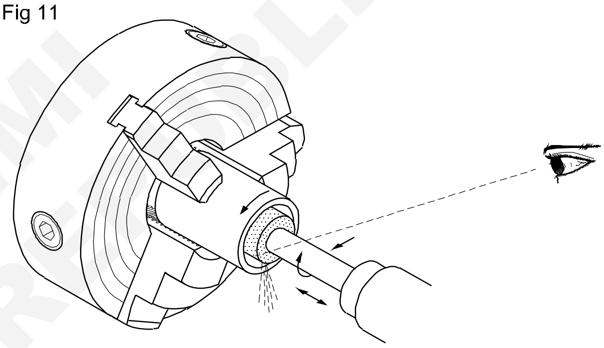
Fig 11

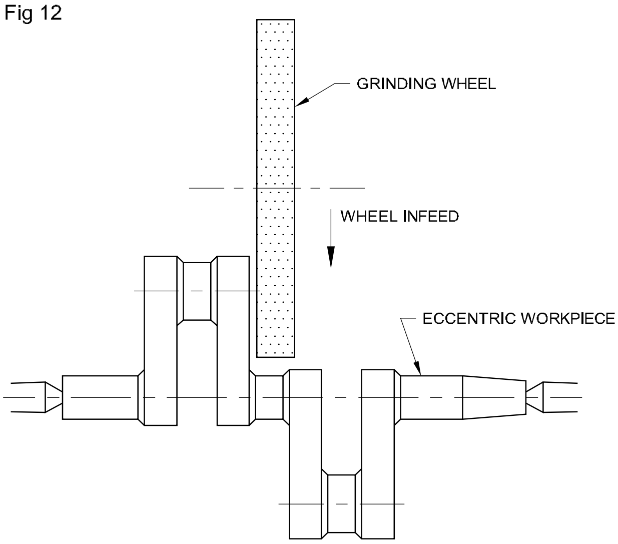


OA20N16924B

The work is held on three jaw chuck, four jaw chuck, face plate, spring collect chuck and fixture.

Eccentric cylindrical (Fig 12)

Fig 12



ECCENTRIC CYLINDRICAL GRINDING

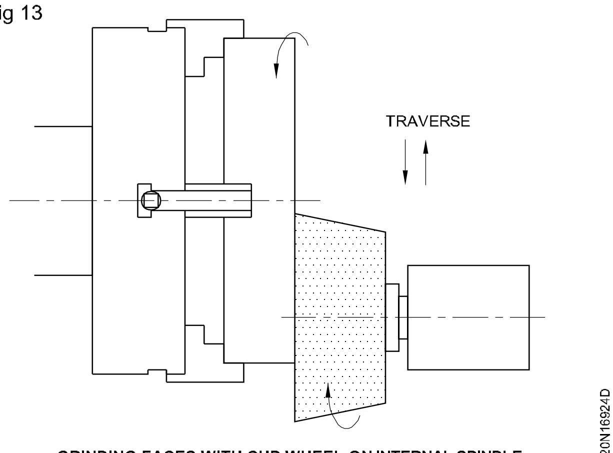
OA20N16924C

Fig 12 illustrates the principle of crank shaft grinding and it is an example of the work by such a grinder. In grinding the main journals the width of the wheel is limited by the bogges and cranks on each side of the main bearings. Cross feed of the wheel is used without traverse feed of the work.

In order to minimise wheel marks on the finished journals the wheel is given a slight longitudinal reciprocating motion.

Face grinding (Fig 13)

Fig 13



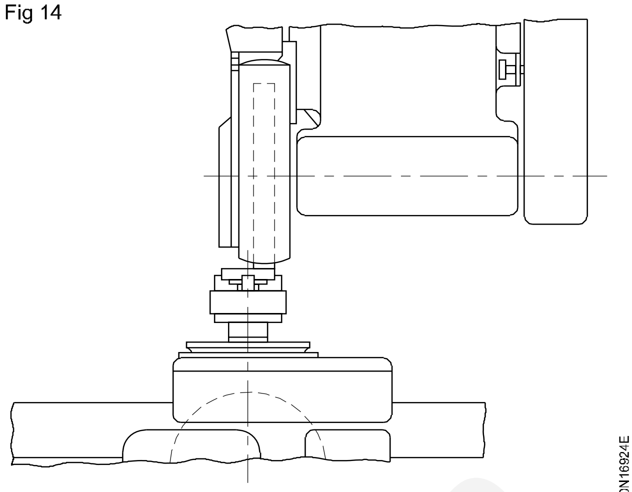
GRINDING FACES WITH CUP WHEEL ON INTERNAL SPINDLE

When the side of the wheel is used for facing ends and shoulders the face should be brought upto the wheel by hand. The machine table carefully moved until the wheel touches the work. The cut is given by gently tapping the traverse wheel by hand.

Facing operation is done by universal cylindrical grinding machine, holding work in chuck or face plate. The grinding wheel used is flaring cup wheel.

Another facing method is shown at Fig 14. Where the workhead is swiveled through 90° and the grinding is performed by the face of the wheel. Face is flat. Face flatness checked by straight edge.

Fig 14



CIRCULAR FACE GRINDING

Checked the work piece for truness

Before starting a precision grinding operation it is essential to check that the workpiece running true in the machine.

Errors may be caused by any one of the following

Inaccurate mounting of the workpiece device

One or both ends of the workpiece being out of square and causing a centre to be wrongly placed.

Faulty alignment of the work holding devices on the worktable

Tapering or other irregularities of the surfaces of the workpiece.

Inaccurate functioning of the workpiece holding devices or the machine.

Inaccurate centering of the workpiece, (use a dial indicator or gauge to check that the workpiece is running true).

Grinding wheel

Objectives: At the end of this lesson you shall be able to
- **explain grinding wheel**
- **state the types of abrasives**
- **explain grain and grade**
- **state the types of bonds.**

Grinding wheel

A grinding wheel is multipoint cutting tool made up of many hard particles known as abrasive. The abrasive grains are held together with adhesive substance known as bond.

The wheel may consist of one piece or segments of abrasive blocks built up to a solid wheel.

Abrasives

An abrasives are hard, tough, sharp edge and resistance to fracture used for cutting other materials.

There are two types of abrasives

Natural abrasive

Artificial abrasive

Natural abrasives

The natural abrasives are emery, corundum, sandstone or solid quartz and diamond.

Emery is a natural aluminium oxide. It contains aluminium iron oxide and other impurities.

Corundum also natural aluminium oxide it contains upto 95% and remainder is impurities.

Sand stone or quartz is one of the natural abrasive stones from which grind stones are shaped.

Diamond is less than quality of gem are crushed to produce abrasive grains for making grinding wheels and lapping compound.

Artificial abrasive

The artificial abrasive are silicon carbide and aluminium oxide.

Silicon carbide (SiC)

Silicon carbide abrasives are manufactured from silica sand. Silicon carbide is hard and brittle. It is used for grinding low tensile material like brass, copper, grey cast iron, aluminium. Silicon carbide is represented by letter 'S'.

Aluminium oxide (Al_2O_3)

This is manufactured from mineral bauxite. Aluminium oxide is tough and less brittle. It is used for grinding high tensile strength material like steels. Carbon steels, malleable iron, high speed steel and wrought iron. Aluminium oxide is represented letter 'A'.

The abrasives are selected depending upon the material being ground.

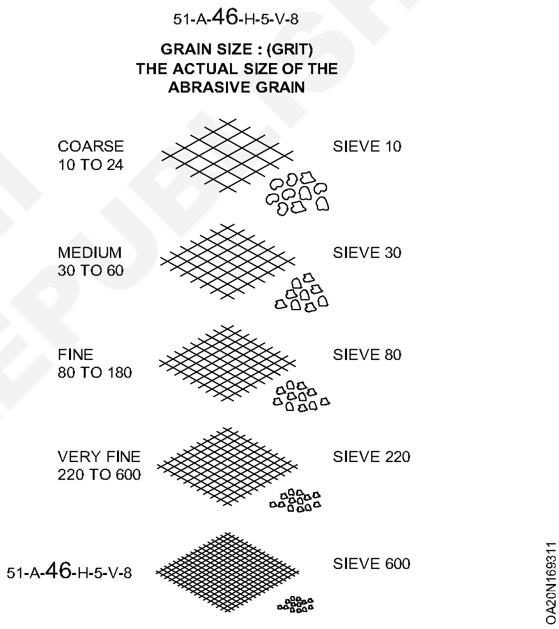
'Green' silicon carbide is used for very hard materials with low tensile strength such as cemented carbides.

'Brown' aluminium oxide is used for general purpose grinding of tough materials.

Aluminium oxide is used for grinding die steels.

Grain size (Grit size) (Fig 1)

Fig 1



The grit or grain size refer to the actual size of the abrasive particles. The grains size is denoted by a number. The sieve used to size the grain.

The larger the grit size number the finer the grit and the smaller the grit size number the large the grit.

Grade (Fig 2)

Grade indicates the strength of the bond and, therefore, the 'hardness' of the wheel. In a hard wheel the bond is strong and it securely anothers the grit in place, and therefore, reduce the rate of wear. In a soft wheel, the bond is weak and the grit is easily detached resulting in a high rate of wear.

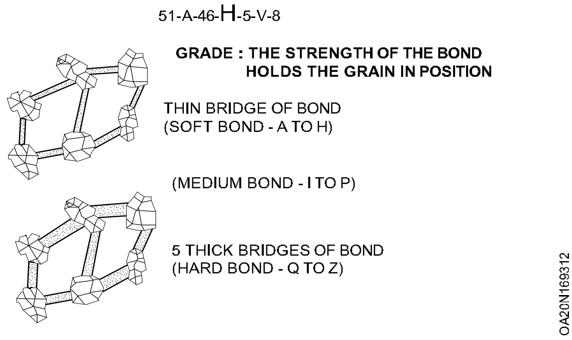
Alphate letters are used to indicate the grade of wheel

A to H - Soft

I to P - Medium

Q to Z - Hard

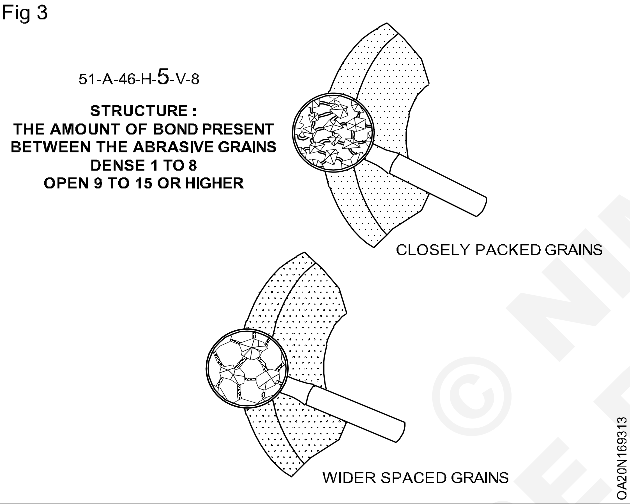
Fig 2



Structure (Fig 3)

This indicates the amount of bond present between the individual abrasive grains, and the closeness of the individual grains to each other. An open structured wheel will cut more freely. That is, it will remove more metal in a given time and produce less heat. It will not produce such a good finish as a close structured wheel.

Fig 3



The structure is specified by number from 1 to 15.1 is indicating dense structure 15 indicates most wider structure. 1 to 8 dense and 9 to 15 and above indicates open structure.

Open structure wheel is used for grinding soft tough and ductile metal and used rough grinding.

A closed structure wheel is used for finish grinding of hard and brittle metal.

Bond

The bond is the substance which, when mixed with abrasive grains, holds them together, enabling the mixture to be shaped to the form of the wheel, and after suitable treatment to take on the form of the wheel and the necessary mechanical strength for its work. The degree of hardness possessed by the bond is called the 'grade' of the wheel, and this indicates the ability of the bond to hold of bonding materials used for making wheels.

Types of bonds and their uses

Vetrified bond (V)

This is the most widely used bond. It has high porosity and strength which makes this type of wheel suitable for high rate of stock removal. It is not adversely affected by water, acid, oils at ordinary temperature conditions.

Silicate bond (S)

Silicate wheels have a milder action and cut with less harshness than vitrified wheels. For this reason they are suitable for grinding fine edge tools, cutlery etc. This bond is used for making large dia grinding wheels.

Shellac bond (E)

This is used for heavy duty, large diameter wheels where a fine finish is required. For example, the grinding of mill rolls.

Rubber bond (R)

This is used where a small degree of flexibility is required on the wheel as in the cutting of the cutting off wheels.

Resinoid bond (B)

This is used for high speed wheels. Such wheels are used in foundries for dressing castings. Resinoid bond wheels are also used for cutting off parts. They are strong enough to withstand considerable abuse.

Oxychloride bond (O)

The abrasive grains are mixed with magnesium chloride and magnesium oxide. This bond is used for making disc shaped wheels.

The bond ensures a cool cutting action so best for dry grinding operation. This bond is used for making segmented wheels.

Bonding materials, brief about ISO - 9000

Objectives: At the end of this lesson you shall be able to
- **name the different types of banding material and their uses and drawbacks**
- **state the advantages and disadvantages of bending materials**
- **state what is the quality control**
- **state the advantages of ISO 9000**
- **state the different series of ISO 9000.**

Bonding material: The bond chosen to act as the matrix for the abrasive particles depends upon;

- the proposed shape of the wheel
- the grain size
- the reaction of the bonding material when in contact with the coolant and
- the service requirements

Vitrified bond: Wheels containing either aluminium oxide or silicon carbide abrasive are made with the vitrified bond. The maximum safe linear speed for this class of bond is around 6,500 f.p.m. But, in the interests of safety, a speed of 5,000 f.p.m, is the general recommendation.

Wheels having the vitrified bond are suitable for both rough and finish grinding and, under suitable conditions, they will produce a finish having a low micro inch value.

The precise properties of the vitrified bond are adjusted to suit the service needs and this may be traced in Table 1. But the strength also varies with different grain sizes. (Table 2)

Manufacturing problems associated with high kiln temperatures restrict the size of a wheel having the vitrified bond to around 30 in diameter maximum, and an analysis of the advantages and drawbacks of this class of bonding material is listed in Table 3.

Table 1

Strength of the vitrified bonds

Grade	**H**	**I**	**J**	**K**	**L**	**M**	**N**
Strength p.s.i	600	800	1,200	1,350	1,500	1,750	2,000

Table 2

Grade M having	60	46	36 grain	**Bond Q having**	8	12	14	20	24 grain
strength p.s.i. :	1750	1550	1450	**strength p.s.i. :**	1150	1400	1450	1750	2000

Table 3

Advantages and drawbacks of the vitrified bond

Advantages	**Drawbacks**
It is porous and free cutting.	The process is slow.
The bond is unaffected by water, oil, acids, temperature, or climatic conditions.	Large wheels are likely to crack whilst being fused in the kiln.
The bond is hard and itself is practically an abrasive.	The maximum wheel diameter is say 30 in.
Wet mixing tends to ensure uniformity of the wheel structure.	The burning or fusing process is difficult to control, hence production troubles can arise.
The high kiln temperature tends to burn out any impurities leaving behind only the abrasive and the bond.	The high kiln temperature tends to weaken the abrasive particles.

Silicate bond: The softer and weaker silicate bond is used as the matrix for both the aluminium oxide and the silicon carbide abrasives. One advantage of this bond is that large wheels, as are used in the cutlery, also the stove and grate trades can readily be produced. Practical considerations connected with hardening the bond control the size of any wheel, the grey silicate bond lends itself to the production of larger wheels than is feasible with the vitreous bond. The combined effects of the weaker bonding material, drying at a lower temperature, are such that the abrasive particles are more readily dislodged. The net result is that the silicate bonded wheels have a free and cooler cutting action than the vitreous type. By judicious adjustment of the wheel and workpiece speeds, excessive wear can be avoided. Due to their cool cutting action, silicate bonded wheels are normally preferred when grinding fully heat-treated steel components. The advantages and drawbacks of the silicate bond are listed in Table 4.

Table 4

Advantages and drawbacks of the silicate bond

Advantages	**Drawbacks**
The process is rapid; special wheels can be produced within a few days.	The harder grades do not cut freely
The bond is dependable; baking is more readily controlled.	The bond is unsuitable for extra hard & durable wheels.
With a moderate kiln or furnace temperature there is no tendency to soften the abrasive.	
With wet grinding the soda in the bond acts as a lubricant.	
The wheels cut smoothly.	
Wheels upto 60 in. dia. are made.	
Silicate bonded wheels cut cool.	
Silicate bonded wheels can be moulded on to iron backs or centres. This is impossible with the vitreous bond owing to the high firing temperature of say 1250° C.	

Shellac bond: When thin wheels are needed for cutting off operations of bar or tube, the more flexible bonding material, shellac, is chosen as neither the vitreous nor silicate bonds will safely resist the applied bending stresses. As the shellac bond has a greater strength and retentively than the vitrified or silicate bonds, it follows that

1 Abrasive particles are not so readily dislodged.

2 the wheels may be operated at a much higher, safe linear speed.

Its characteristics are such that the bond is only used for wheels that do not remove much metal; typical operations are grinding slots, sharpening knives and saws, thread grinding and finish grinding hardened steel rolls.

Rubber bond: Rubber bonded wheels are chiefly used when a first-class surface is demanded with close dimensional accuracy. This class of bond is also chosen, (1) When making thin cutting off wheels, (2) for regulating wheels such as those used on centreless grinding machines.

Resinoid bonds: Resinoid bonds are used for much the same purposes as the shellac and rubber types, that is, for cutting off operations, thread grinding, and for cylindrical grinding if a low micro inch value is desired.

Metallic bond: The metallic bond, as produced by the powder metal technique, is only used at the present time for the diamond wheels.

Quality control: The process of delegating responsibility# and authority for a management activity, thus freeing# management of unnecessary detail while retaining for it the means of assuring that results will be satisfactory, is labelled as control. The procedure for meeting the industrial quality goal is, therefore, termed quality control.

The quality control, is in the nature of a feedback loop and involves:

Setting standards- determining the cost-quality, performance quality, and reliability quality standards for the product/service.

Appraising conformance - Comparing the conformance# of the manufactured product/service to these standards.

Acting when necessary - taking corrective action when the standards are exceeded, and Planning for improvements - developing a continuing

effort to improve the cost, performance and reliability standards.

Quality control function is actually a collection of activities within the production system. Sales, purchasing product design, process development, manufacturing, inspection and so forth, are all different functions within the production function. Yet each of these activities includes a sub-activity devoted to quality. Each production function includes quality as one of its considerations.

The advantages of the ISO 9000 quality system for the company, its customers and its employees.

For the company

- Its products will be of a more consistent quality, and it will produce fewer rejects.
- The company will make greater savings in costs, because production will be more efficient. It will achieve economies in production (because company systems will be controlled from start to finish) and economics in time (because less effort will need to be expanded on re-doing work).
- The company can improve the quality of its raw materials and components be, requiring its suppliers to install an ISO 9000 system.
- Export marketing will be easier, because some foreign buyers place a premium on the ISO 9000 system.
- The company can expect preferential treatment from potential customers who have ISO 9000 certification system. This will mean an increase in new business.
- the company will secure greater customer loyalty, because it will continuously satisfy its customers needs and give them no cause to seek another supplier. This means that the company will suffer fewer customer losses.
- The company can use ISO 9000 in its publicity to win more sales.

For the company's customers

- The company's customers will receive products or services of a known level of quality that is independently audited.
- Customers are presented with a means of choosing between competing suppliers.
- Customers will have more confidence in the company's goods.

For the company's employees

- Staff will obtain a better understanding of their role and objectives from the documented management system.
- They will benefit from reduced stress levels, because they will be using an efficient management system, and because they know what is expected of them.
- Their morale and sense of pride will rise when they achieve the goals of registration and customer satisfaction.
- New staff can immediately learn their jobs, because the details are in writing.

Grinding wheel balancing

Objectives: At the end of this lesson you shall be able to
- **state what is a wheel balancing**
- **name the method of balancing**
- **state the procedure of balancing**
- **state the causes of breakage of the grinding wheel**
- **state the method of storage of grinding wheels.**

Wheel balancing: Wheel balancing is an action of bringing the grinding wheel to rotate concentric to its axis and the weight and density of wheel are uniform throughout its circumference. Before testing the balance of the wheel it is true.

Necessary of wheel balancing

- A god surface finish is possible to the work surface.
- Prevents wheel vibration and breakage.
- Prevents chatter marks on the work surface.
- Improves the dimensional accuracy of the work.
- Considerably increases the life of grinding wheel.
- Prevents the damage of the spindle /bearings.

Small wheel normally do not require any balancing, but larger diameters of the wheel important is the balancing. Similar equipment used to balance the wheels of motor cars.

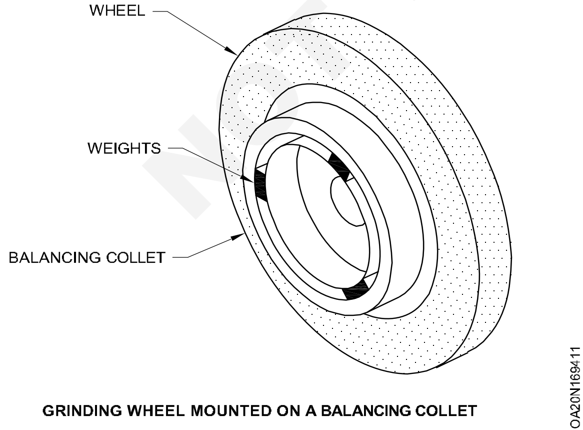
Method of balancing

1 Static balancing 2 Dynamic balancing

Static balancing means that when the wheel is cantered in balancing mandrel and placed on a balancing stand. Dynamic balancing means that when the wheel can be balanced while it is running on the machine, for getting still better result.

Wheel mounted on a balancing collet (Figs 1&2)

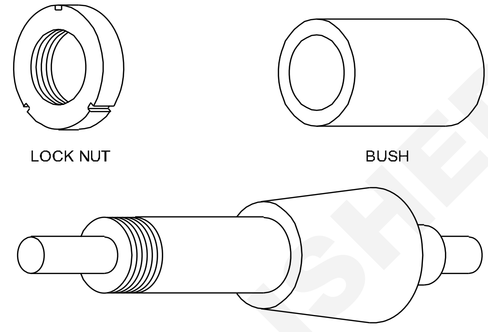
Fig 1



GRINDING WHEEL MOUNTED ON A BALANCING COLLET

Large grinding wheels must be mounted on a balancing collet and balanced before being fitted to the grinding machine. The collect remains fitted to the wheel during use.

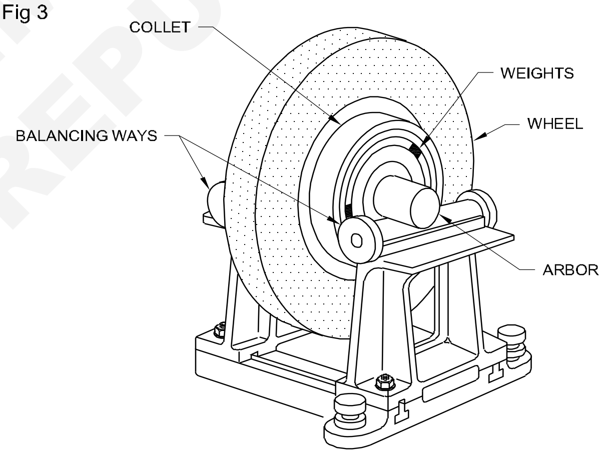
Fig 2



BALANCING ARBOR COMPONENTS

To balance a wheel proceed as follows (Fig 3)

Fig 3



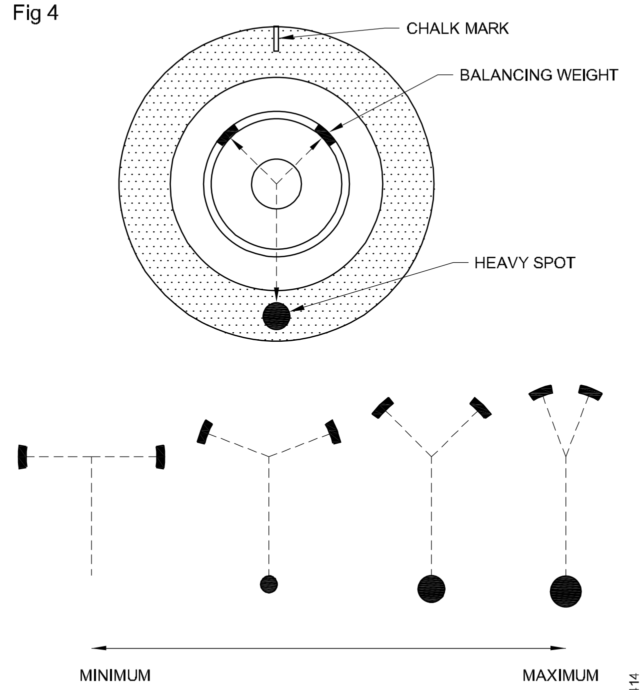
GRINDING WHEEL MOUNTED ON BALANCING COLLET AND ARBOR PLACED ON BALANCING WAYS

- Mount the wheel on a balancing collect.
- Fit a balancing arbour to the collet.
- Remove the adjustable weight from the collet.
- Place the arbour collet and wheel assembly on a pair of balancing ways in a position near the centre of the ways.
- Ensure that the ways are perfectly horizontal.
  - Use are accurate spirit level for this if none is mounted on the ways.
- Allow the wheel to roll slowly on the ways by a very gentle push until it comes to rest. In this rest position the heavy spot of the wheel will be on the lower part of the wheel.

- Do not push so hard that the wheel rolls off the ways.

- Make a chalk mark on the wheel at the point opposite to the heavy spot. This will be the uppermost position of the wheel when it is at rest. (Fig 4)

Fig 4



ADJUSTING BALANCING WEIGHTS TO OBTAIN MAXIMUM AND MINIMUM COUNTERBALANCE

- Mount the balancing weights on either side of the chalk mark.
- Test as before by allowing the wheel to rotate slowly on the balancing ways, each time moving the weights a little further back from the chalk mark after the wheel comes to rest until a perfect balance is obtained.
  - The wheel is balanced when it gently comes to a stop with no tendency to roll back regardless of which portion of the wheel was the lowest at the start of the roll.
- Fix the weights in the balance position by tightening the weight set screws.
- Remove the arbor from the collect.
  - The balanced wheel with its collet assembly is now ready for mounting on the grinding machine spindle.

Wheels in use should be re-balanced at intervals since the balance may change with wear of the wheel.

Caution: If a wheel is re-dressed during service, it must be re-balanced after the dressing operation.

Reasons for wheel breakage

- Increased wheel speed.
- In correct size of bolts, nut.
- More depth of cut.
- Insufficient coolent.
- Wheel getting jammed on work.
- Wheel force fitted on spindle.
- Wheels are not checked for crack by light tapping before fitting.
- Workpiece is not hold proporely (rigidly).

9 Unbalanced grinding wheel is used for grinding.

Wheel storage: Grinding wheel is properly stored on edge or piled flat as per recommendations of the manufacture.

- They should be kept in dry place.
- Racks in which wheels are stored have no tendency to roll off.

Advantage of balancing, inspection, care and storage of grinding wheel

Objectives: At the end of this lesson you shall be able to
- **state the advantages of balancing**
- **brief the method of wheel inspection, storage and care of grinding wheel**
- **state the safety point while handling the grinding wheel.**

Advantages of balancing

- Power consumption of the machine is not excessive.
- Wear on bearing is minimum.
- Tendency to produce defective work is reduced.
- Chances of wheel breaking is reduced.
- Better accuracy & surface finish of workpiece is obtained.
- Sources of danger to the operator is minimised.
- Vibration of machine spindle is reduced.

Wheel breakage

- Before putting to use, wheel should be examined by tapping to make sure that it is sound. Following main points should be considered to prevent breakage of wheels.
- Use correct wheel speed. Do not over speed it.
- While mounting, make sure that correct blotters are used and flanges provide even pressure.
- Use appropriate coolant in sufficient quantity to prevent overheating.
- Do not use excessive pressure on work.
- Avoid wheel getting jammed on work.
- Prevent blows on wheel.
- Do not force wheel on arbor.
- Take necessary safety precautions governing use of grinding wheels.

Wheel storage: Grinding wheels should be properly stored on edge or piled flat as per recommendations of the manufacturers, they should be kept in a dry place and should not be subjected to extreme temperature.

Racks in which wheels are stored should be such that once the wheels are placed there, they have no tendency to roll off say as a result of a sudden shock.

Saucer and cup wheels which are less than 150 mm in diameter may be stored on edge or flatwise cup wheels more than 150 mm in diameter and all cylindrical wheels are stacked flatwise. Tapered cup wheels are stacked with the backside up. All rubber and elastic wheels more than 6 mm thick are stacked on their edges. Rubber and elastic wheels which are 6 mm or less in thickness are stacked flat and on a plane surface that will not warp.

The best way to store wheels 50 mm or less in diameter is in properly labelled boxes or drawers.

Safety: The operation of all high speed machinery is hazardous. It applies to grinding machine as the grinding wheel rotates at a high peripheral speed (upto 50 metres/ sec and even higher).

Causes of accidents in the operation of grinding machines can be traced to one of the following four sources:

- the wheel
- the machine
- the mounting
- the method of protection.

The chief hazard is the breakage of grinding wheels. In addition to what has been stated earlier regarding prevention of wheel breakage, following measures are important for safety:

- Balance the wheel properly and also test it for its strength.
- Adjust the bearings of the spindle properly.
- Use the proper wheel guards of the required strength.
- Wear safety goggles even if wheel has a glass shield.
- See that clothing doesn't come in contact with the moving wheel or work.
- Run the new wheel at full operating speed at least for one minute before applying work.
- Do not force the work against a cold wheel, but apply gradually.
- True the wheels properly which have become out of round.

Guidelines to avoid heat generated in grinding

Objectives: At the end of this lesson you shall be able to
- **select the grinding wheels depending upon the arc of contact**
- **state what is wet and dry grinding**
- **list the use of grinding coolant/grinding fluids**
- **state types of grinding fluids.**

In grinding operation the heat is generated due to rubbing action between grinding wheel and the work material.

This can be avoided considering the following point.

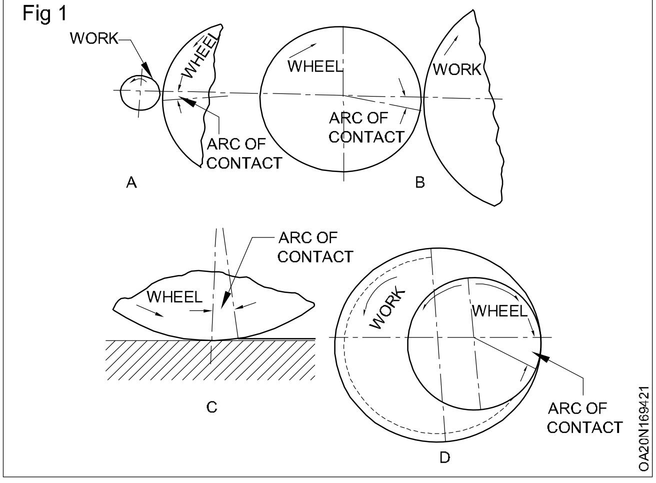
- Arc of contact
- Wet grinding
- Dry grinding
- Volume of grinding fluid use
- Method of applying grinding fluid
- Types of grinding fluid used.

Arc of contact (Fig 1): If the arc of contact is small (like in most cylindrical grinding) a few grits carry the entire penetration pressure between the wheel and the work. Increase in stress renders a wheel softer than what it would have been with a larger arc of contact. It is, therefore, better to use harder wheels if the arc of contact is small and softer wheels if the arc of contact is large.

This consideration is, however, modified by the structure of the wheel. If the packing of grains is closer, more number of grits share the load and, therefore wheel appears harder than one with a more open spacing.

As with the larger arcs of contact, more number of grains support the pressure between the wheel and the work, a more open structure and coarser grits can be used without concentrating too much pressure on individual grits.

Fig 1



Wet and dry grinding: A considerable amount of grinding eg. tool grinding is done dry mainly to avoid the additional expense of providing a pump and other accessories required for supplying adequate quantity of coolant. But wet grinding has the advantage that it provides better finish and avoids the chances of overheating. A small water tank provided for periodic quenching of tool during dry grinding is not satisfactory as it is likely to cause small cracks in the tool material. It is better to do dry grinding by applying the tool with very little pressure so that the end is not “blued”.

The grinding machines which are equipped for wet grinding should be able to supply coolant in adequate quantity without undue pressure, splash or spray and be adequately drained so that the wheels are not left standing in the coolant, as this is likely to result in the wheel absorbing some liquid and atleast being out of balance.

Use of grinding fluids

Reasons for using grinding fluids(lubricants or coolants)

- To carry off the heat generated by the friction of the wheel on the work.
- To maintain uniform temperature of work as far as possible.
- To wash away dust, dirt, chips, abrasives, etc. and thus protect the finished surface of the workpiece.
- To prevent loading of wheels.
- To help obtain the desired finish of the work.
- To increase the cutting efficiency of the abrasive wheel.

Amount of grinding fluid used: Following factors govern the amount of grinding fluid used :

- The larger the work, the greater the wheel surface in contact, which means more coolant should be supplied.
- The wider the wheel face the more the surface contact which means extra coolant should be supplied.
- The higher the work speed the more the coolant required.

Work holding devices

Objectives : At the end of this lesson you shall be able to
- **list the name of the work-holding devices used in grinding**
- **brief the uses of each work-holding device**
- **state the purpose of a de-magnetizer.**

In grinding, different work-holding devices are used to keep the workpiece in position.

The work-holding devices used in grinding are:

- magnetic chuck
- vice
- angle plates
- 'V' blocks
- clamps.

Magnetic chuck

Magnetic chucks are of two types.

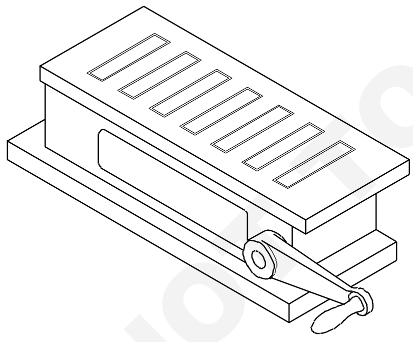
- Electromagnetic chuck
- Permanent magnetic chuck

The magnetic power of the electro- magnetic chuck can be varied according to the size of the work. But not so in the case of a permanent magnetic chuck.

Uses

The magnetic chuck (Fig 1) is the most commonly used work-holding device. It holds ferrous workpieces. A ferrous work-holding device also can be mounted on it.

Fig 1



MAGNETIC CHUCK

OA20N169511

Vices

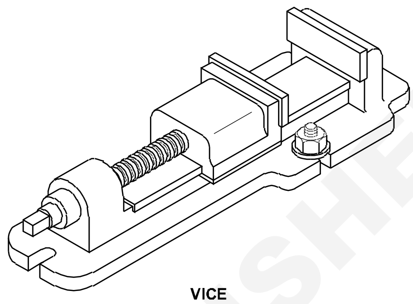
Vices are used to hold jobs with narrow surface or non-ferrous workpieces (which cannot be conveniently held on magnetic chucks).

A vice may be set on the grinder table directly or on the magnetic chuck.

A plain vice (Fig 2) is used to hold workpieces for plain or step grinding.

A tilting type vice (Fig 3) is used to hold the workpiece while grinding angular surfaces. If required the tilting base can be removed and it can be mounted on the magnetic chuck as a plain vice.

Fig 2



VICE

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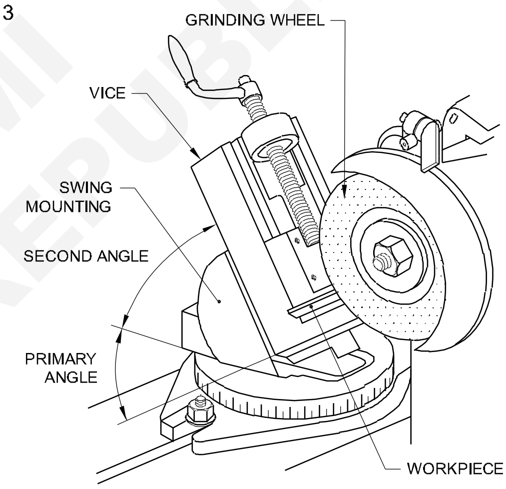
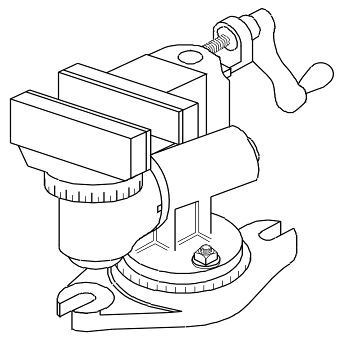
Fig 3



TILTING VICE

OA20N169513

Fig 4



UNIVERSAL VICE

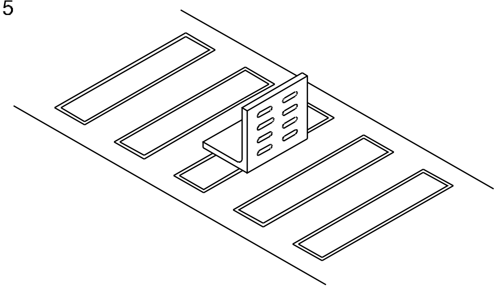
OA20N169514

A universal vice (Fig 4) is used to hold the workpiece while grinding the angular surface in two different planes. This is small in size. So it is mainly used in tool grinding.

Angle plate

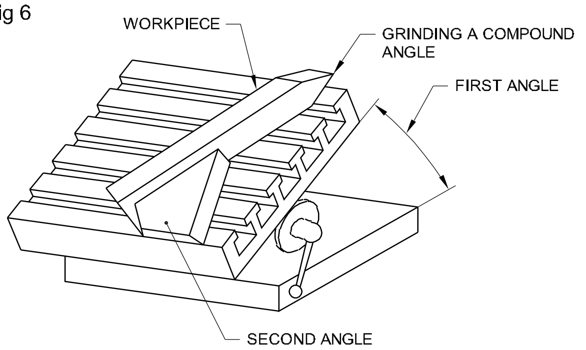
Angle plates are used to hold the workpiece while grinding, one surface perpendicular to another surface (plain type, Fig 5) or while grinding one surface at an angle to another surface (adjustable type, Fig 6).

Fig 5



ANGLE PLATE MOUNTED ON MAGNETIC CHUCK

Fig 6



WORKPIECE SUPPORTED ON ADJUSTABLE ANGLE PLATE

'V' block

'V' blocks are used to hold the round workpieces while grinding a flat on the workpiece.

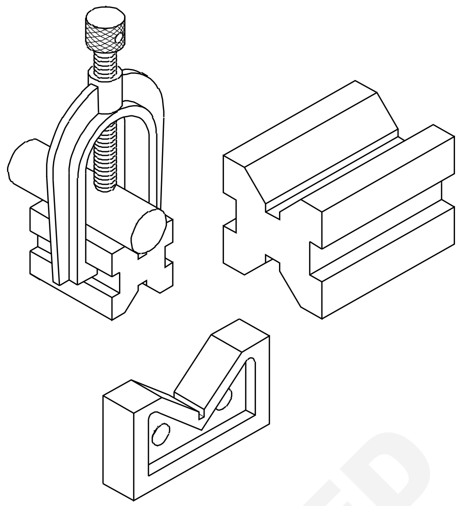
These are used for holding tube or bar workpieces for grinding flat surfaces on the exterior. Square workpieces may also be supported in Vee blocks for grinding the external corners of the work.

Vee blocks may be attached to the work table by clamps or be set on a magnetic chuck.

Magnetic Vee blocks can be used also in combination with other mounting devices, such as angle plates which themselves can be clamped to the work table or held in position on a magnetic chuck.

'V' block (Fig 7)

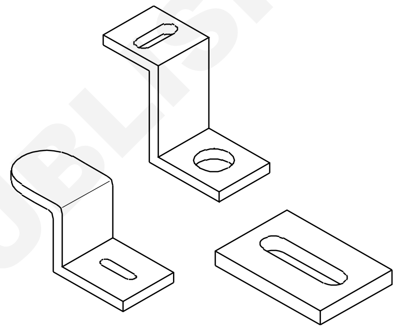
Fig 7



'V' BLOCKS

Clamps (Fig 8)

Fig 8



CLAMPS

Clamps are used to hold any workpiece or a work-holding device on the table. Alternatively they may be held on a magnetic chuck.

De-magnetizer : It is a special device used to remove the magnetic power from an object. In grinding whenever a job is ground by holding it on the magnetic chuck, the job will also get some magnetic power. A de-magnetizer is, therefore, used to remove this.

Cutting speed, feed and depth of cut

Objectives: At the end of this lesson you shall be able to
- **state the is wheel speed, work speed, table traverse, and depth of cut**
- **explain machining time**
- **state grinding allowance.**

Cutting speeds and feeds

Wheel speed, work speed and table traverse required consideration when setting up a grinding machine.

Wheel speed

The faster a wheel is run, the more efficient it cuts but if it runs too fast, it will fly apart. Other adverse effects of using higher speeds are - clogging of wheels, smoothing of wheels (they will, then, not grind any more), overheating of workpiece, inaccuracy of surface and danger of accidents. On the other hand, if the speed is low, the abrasive is wasted without much work being done. It is best to run the wheel at the speed recommended by the manufacturer.

Recommended circumferential speed (cutting speed) of the grinding wheel (metres / second) is given in the table below.

Grinding method	Material			
	Steel	cast iron	cemented carbide	zinc alloys light metals
Internal grinding	25 m/s	20 m/s	8 m/s	25 m/s
External grinding	30 m/s	25 m/s	8 m/s	35 m/s
Surface grinding	25 m/s	25 m/s	8 m/s	20 m/s

R.P.M of the grinding wheel is calculated by the following formula:

Where,

V3 = Circumferential speed of the grinding wheel in m/s

D = Diameter of the grinding wheel in mm

n = R.P.M of the grinding wheel.

Work speed

Work speed is chosen based on the surface finished desired and to obtain highest rate of production. Table below gives the normal work speeds in m/min. For grinding of work that is out of balance, lower surface speeds are used. Rough grinding of automatic cams is done at about 5-10 m/min and finish grinding is done at half of that speed.

Grinding of non-ferrous and light metals is done at higher work speeds. Plunge grinding requires very low speed. For thread grinding extremely low work speed is used.

The slower the workpiece revolves the harder will be the wheel action. The work speed should not be lower than the minimum or above the maximum speed recommended. Too high speed may cause accidents and is also likely to damage the machine.

Method of Grinding	Materials to be ground			
	Soft steel	Hardened steel	Cast iron	Light metals
Internal grinding	18-20 m/min	20-24 m/min	20-24 m/min	28-32 m/min
External grinding rough	12-18 m/min	14-18 m/min	12-15 m/min	25-40 m/min
Finish	10-15 m/min	10-12 m/min	10-12 m/min	20-30 m/min
Surface grinding	8-14 m/min	8-14 m/min	8-14 m/min	8-14 m/min

R.P.M of the workpiece,

Where,

$$\eta w = \frac{V_w \times 1000}{\pi d}$$

V_W = Circumferential speed of the workpiece in m/min

d = diameter of workpiece in mm

Table traverse

It depends upon the width of the wheel and the accuracy of finish required. For rough grinding, table travel should be about 2/3 of the width of the wheel per revolution of the workpiece. For finish grinding it should be 1/3 or even less of the width of the wheel face. For very smooth finish, very low table travel say 1/8 of the width of the wheel face may be used.

Traverse should not be such as may allow the wheel to extend fully beyond the work. The wheel should over run the end of the work about $1/4^{th}$ to $1/3^{rd}$ the width of the wheel face. This is done so that wheel may finish the cut. If there is no over-run of the wheel at all, the work will be over size at the end. Momentary stoppage of the wheel at the end of each traverse is important as it permits the wheel to grind the work to size.

Depth of cut

Infeed or depth of the cut depends upon the following factors:

Amount of metal to be removed.

Type of finish required.

Power and rigidity of the machine.

Coolant used.

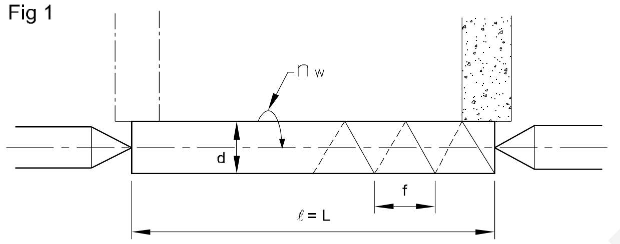
Provision of work support (Steady rest)

Depth of cut used for roughing is 0.01-0.03 mm, and for finishing 0.0025-0.005 mm. The shower of sparks thrown off by grinding wheel is a convenient and sensitive indication of the depth of cut being taken. An experienced operator can judge the depth of the cut within close limits by seeing the shower of sparks.

Feeding of the grinding to the work may be by hand or automatic. But it is advisable to use automatic feed except for bringing the wheel upto the work and to remove it away or when taking very fine cuts. The automatic feed takes 0.006 to 0.10 mm for each traverse of the machine table.

Machining time for cylindrical grinding (Fig 1)

Fig 1



MACHINING TIME FOR CYLINDRICAL GRINDING

Where

l = Length of the workpiece in mm ; L = Grinding length in mm ; f = Feed in mm/revolution of workpiece ; n_W = R.P.M of workpiece ; i = no.of cuts ; = f x n_W

Machining time:

i With feed adjustment at every stroke of the table

ii With feed adjustment at every cycle

$$(i) = \frac{L x i}{f x n_w} \quad (ii) = \frac{2 x L x i}{f x n_w}$$

Example:

A steels shaft q 50.3 mm, 500 mm long is to be ground to q 50 mm, width of grinding wheel = 40 mm, feed adjustment per stroke = .005 mm circumferential work speed = 12 m/min feed = 1/2 width of grinding wheel per revolution of workpiece.

Then, grinding allowance= 50.3 - 50 = 0.3 mm

Grinding allowance applied to radius   0.3/2 = 0.15 mm

Feed, f = 40 mm x 1/2= 20 mm per revolution of work

R.P.M of workpiece,

Grinding allowances

The amount of stock to be left on the work for removal by grinding in case of cylindrical work depend upon:

Diameter of work

Length of work

The usual practice is to leave from 0.25 mm to 0.75 mm for grinding. The allowance on short, thick pieces of work is 0.25m. For larger and thinner pieces of work, the grinding allowance is correspondingly increased. For example for a 12 mm diameter shaft of 150 mm length, grinding allowance will be about 0.25 mm, while for a 900 mm long shaft, it will be 0.50 mm. Grinding allowance for a 300 mm long shaft of different diameters will be as follows:

Diameter	Grinding allowance
12 mm	0.25 mm
25-50 mm	0.375 mm
75-100 mm	0.50 mm
125-200 mm	0.625 mm
250-300 mm	0.75 mm

Other factors which need to be considered in deciding the allowance to be left for grinding are:

The finish of the work before grinding

The condition of the work when being ground, whether hardened or not.

If the work has been case hardened, the depth of penetration of case.

Grinding wheels, types, application, defects and remedies

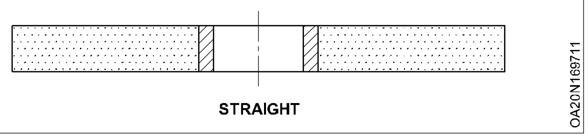
Objectives: At the end of this exercise you shall be able to
- **explain the type and names of different shapes of grinding wheels**
- **state the application of each type of grinding wheel.**

Grinding wheels are made in different shapes and sizes for grinding different jobs and for use in different machines. The size may differ in diameter, face width and bore dia.

The following are the standard shapes of grinding wheels.

Straight wheel: Type 1 (Fig 1)

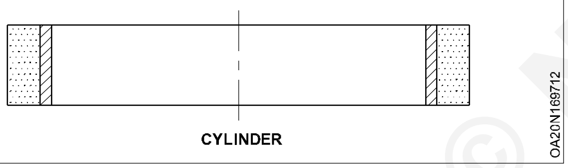
Fig 1



This type of wheels is used on cylindrical, surface and centreless grinders for grinding cylindrical and flat surfaces. Sometimes this type of wheel is used on rough grinders for off hand grinding.

Cylinder: Type 2 (Fig 2)

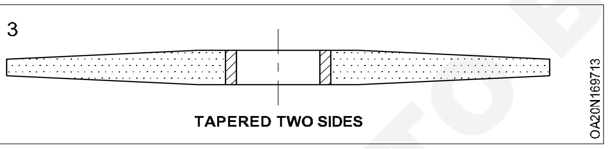
Fig 2



This type of wheel is used on both horizontal and vertical spindle surface grinders for the surface grinding operations.

Tapered (both sides) Type 4 (Fig 3)

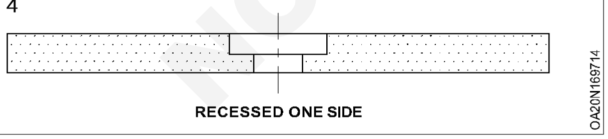
Fig 3



It is mainly used for rough grinding. The tapered sides reduce the chance of breaking.

Recessed one side: Type 5 (Fig 4)

Fig 4



It is used for cylindrical, surface and centreless grinding. The recess provides clearance for the flange.

Straight cup: Type 6 (Fig 5)

It is used on surface grinders and on tool and cutter grinders to grind flat surfaces.

Recessed both sides: Type 7 (Fig 6)

Used on cylindrical, surface and centreless grinders. The recesses provide clearance for both flanges.

Fig 5

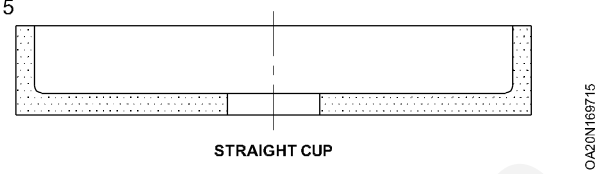
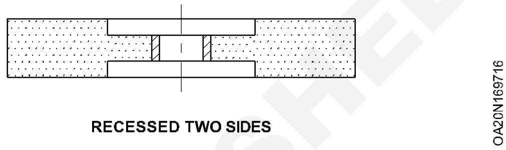
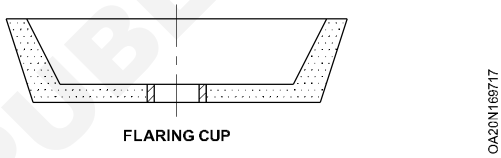


Fig 6



Flaring cup: Type 11 (Fig 7)

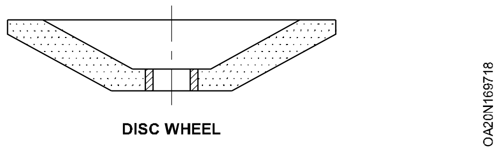
Fig 7



It is used on tool and cutter grinders mainly to sharpen milling cutters and reamers.

Dish: Type 12 (Fig 8)

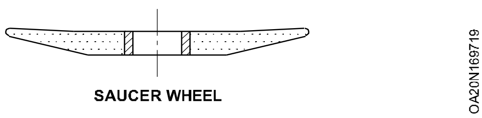
Fig 8



Used on tool and cutter grinders to sharpen milling cutters with narrow slots like formed relieved cutters, hobs etc.

Saucer: Type 13 (Fig 9)

Fig 9



It is used for sharpening circular and handsaws. It is also used for gashing milling cutter teeth.

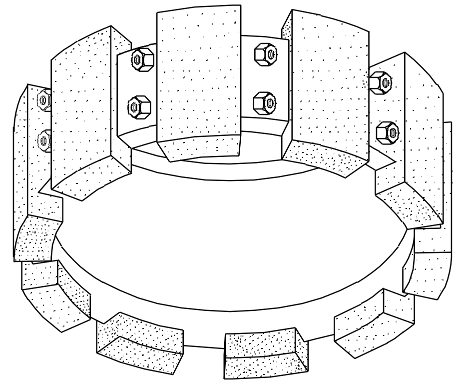
Segmented wheels (Fig 10)

This type of wheels is formed by holding segments of abrasives using a metal holder. This is mainly used on a vertical spindle surface grinder.

Mounted wheels (Fig 11)

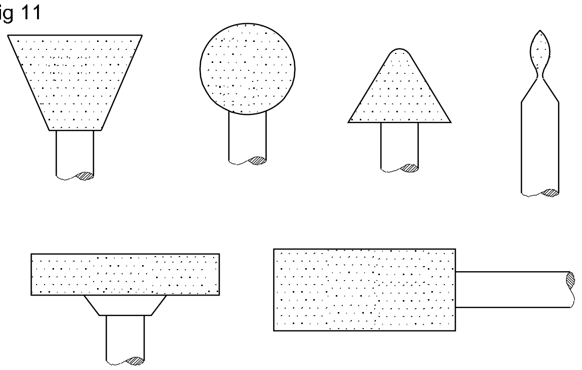
These are wheels with less than 50 mm dia. formed on a steel shank to various shapes. Mounted wheels are mainly used for die grinding, deburring and for finishing operations.

Fig 10



SEGMENTED WHEEL

Fig 11



Used on pneumatic or electric grinders.

Types of wheel faces

To do different operations different types of wheel faces are produced by manufacturers. (Fig 12)

Grinding wheel specification

A grinding wheel is specified by its marking, shape, outside dia. bore dia. thickness etc. (Fig 13a)

A recessed wheel is specified with all the above given particulars plus the dia. of the recess and the depth of the recess. (Fig 13b)

Grinding wheel marking system

eg. A 56 K 5 V 75

Fig 12

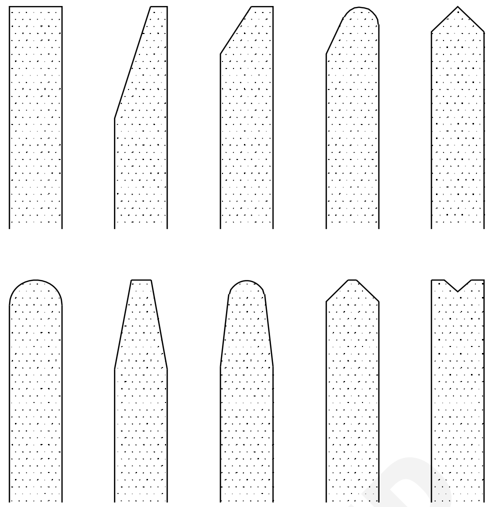
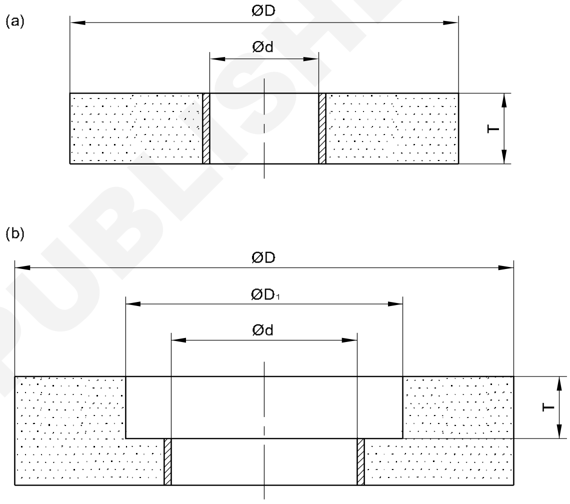


Fig 13



1st Position ‘A’ denotes ‘ Abrasives’ ie., Aluminium Oxide

2nd Position ‘56’ denotes ‘Grit size’ ie., Medium

3rd Position ‘K’ denotes ‘Grade’ ie., Medium

4th Position ‘5’ denotes ‘ Structure’ ie., Dense

5th Position ‘V’ denotes ‘Bond’ ie., Vitrified

6th Position ‘75’ denotes manufacturer’s Code if any

Wet and dry grinding

Objectives: At the end of this exercise you shall be able to
- **state the wet and dry grinding**
- **state difference between wet and dry grinding.**

Wet grinding

This grinding process heat is generated by the friction between the wheel and work. To maintain uniform temperature of work the supply of cutting fluid is made continuously, and this grinding method is called wet grinding. Precision grinders like cylindrical, surface, centreless and internal grinders are adopted by wet grinding method.

Dry grinding

A considerable amount of metal removing by grinding without cutting fluid is called dry grinding.

Dry grinding method involves rough (Bench, pedestal, flexible) tool and cutter grinders.

Differentiate between wet and dry grinding

Wet grinding	Dry grinding
Coolant used	Coolant not used
Increase the depth of cut	Minimise the depth of cut
Suitable for precision grinders	Suitable for tool and cutter grinder
Good surface finish be possible	Rough surface possible
Closed dimensional accuracy possible	Wider dimensional accuracy possible
Chances of burning effect is less	Chances of burning effect is more
Not possible for any changes in structure	Possible for changes of structure of the job.

Common defects (faults) in grinding and their remedies

Objectives : At the end of this lesson you shall be able to
- **list out the common faults and their causes in grinding**
- **state the remedies for the faults.**

Fault	Symptom	Caused by	Remedies
Chatter marks	Intermittent sparking. Uneven sound.	Wheel out of balance.	Re-balance the wheel.
	Glazing of wheel.	Incorrect grade of wheel.	Change the wheel.
		Workpiece (or) workhold device loose.	Secure both properly.
		Wheel incorrectly dressed.	Re-dress the wheel.
		Loose pulley on spindle.	Tighten the pulley.
	Uneven cutting and irregular sparking.	Feed too coarse.	Decrease the feed rate.
	Machine vibration.	Improper bedding down.	Report to your supervisor.
Poor surface finish	Scratched surface.	Incorrect grain size of wheel	Change to correct grain size.
		Dirty coolant.	Clean the tank and replace.
	Surface burnished.	Incorrect wheel grade.	Fit a correct wheel.
		Feed too coarse.	Reduce the feed.
		Cut too deep.	Decrease the depth of cut.
		Insufficient coolant.	Increase the supply of the coolant.
	Ridges	Wheel damaged/not properly dressed.	Change the wheel if necessary or dress the wheel.
Wheel wearing out too fast	Wheel size reduced.	Wheel is too soft.	Use harder wheel.
		Grinding wheel speed lower than that recommended.	Increase the wheel speed to the recommended . speed.
		Wrong rate of traverse or work speed. and decrease slightly	Reduce the rate of traverse and work speed depth of cut.

Coolants

Objectives: At the end of this lesson you shall be able to
- **state the purpose of using coolant**
- **state the properties of coolant**
- **list the type of coolant.**

Coolant : It is matter/substance used to reduce the heat produced by tool and work. The heat affects the life and accuracy of machine, tool and job becomes hardened.

Purpose of coolant

To cool the job to avoid expansion by heat

To cool the cutting points of the tool and save temper and cutting efficiency.

To wash away the chip

To obtain a smooth finishing

To reduce friction between the tool and work

To prevent the machine from corrosion

Properties of coolant

Higher the viscosity

Good oiliness

Should have high fire point

Should be chemically stable

Low sulphur content (less than 3%)

Should be harmless to skin of operator

Odorless - Should not have bad smell.

Types of coolant

The most common machine coolants used today belong to one of two categories based on their oil content.

Oil based machine coolants - Including straight oils and soluble oils

Chemical machine coolants - Including synthetics and semi synthetics

Fluids vary in suitability for metal working operations due to their excellent lubricity while water miscible fluids provide the cooling properties required for most turning and grinding operations.

Oil based machine coolants

Straight oils - 100% petroleum oil

Soluble oils - 60% to 90% petroleum oil

Chemical machine coolants

Synthetics - No petroleum oils

Semi synthetics - 2% to 30% petroleum oil

Lubricants

Objectives: At the end of this lesson you shall be able to
- **state the purpose of using lubricants**
- **state the properties of lubricants**
- **state the qualities of a good lubricant.**

With the movement of two mating parts of the machine, heat is generated. If it is controlled the temperature may rise resulting in total damage of the mating parts. Therefore a film of cooling medium with high viscosity is applied between the mating parts which is known as a 'lubricant'.

A 'lubricant' is a substance having an oily property available in the form of fluid, semi-fluid, or solid state . It is the lifeblood of the machine, keeping the vital parts in perfect condition and prolonging the life of the machine. It saves the machine and its parts from corrosion, wear and tear, and it minimise friction.

Purposes of using lubricants

- Reduces friction.
- Prevents wear.
- Prevents adhesion.
- Aids in distributing the load.
- Cools the moving elements.
- Prevents corrosion.
- Improves machine efficiency.

Properties of lubricants

Viscosity

It is the fluidity of an oil by which it can withstand high pressure or load without squeezing out from the bearing surface.

Oiliness

Oiliness refers to a combination of wettability, surface tension and slipperiness. (The capacity of the oil to leave an oily skin on the metal.)

Flash point

It is the temperature at which the vapour is given off from the oil (it decomposes under pressure soon).

Fire point

It is the temperature at which the oil catches fire and continues to be in flame.

Pour point

The temperature at which the lubricant is able to flow when poured.

Emulsification and de-emulsibility

Emulsification indicates the tendency of an oil to mix intimately with water to form a more or less stable emulsion. De-emulsibility indicates the readiness with which subsequent separation will occur.

Methods of applying lubricant

Objectives: At the end of this lesson you shall be able to
- **state the different methods of lubrication**
- **state the gravity feed methods of applying lubrication**
- **state the splash methods of applying lubrication**
- **state the different types of lubricators**
- **explain the different methods of lubrication.**

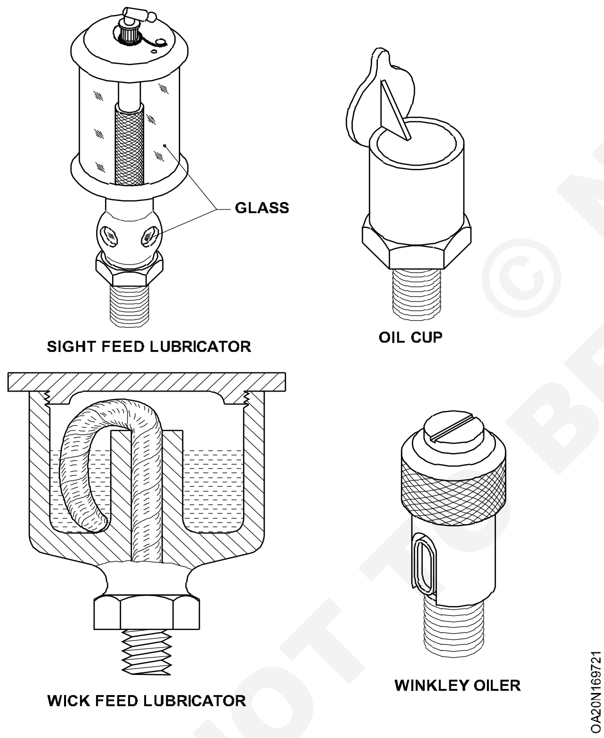
The following methods are used for efficient lubrication

- Gravity feed method
- Force feed method
- Splash method

Gravity feed method

There are numerous ways of employing this principle, varying from the simple oil hole to the more elaborate wick and glass-sided drip feed lubricators in which the flow of the oil may be controlled and observed through the glass. A selection of these lubricators is shown in Fig 1.

Fig 1

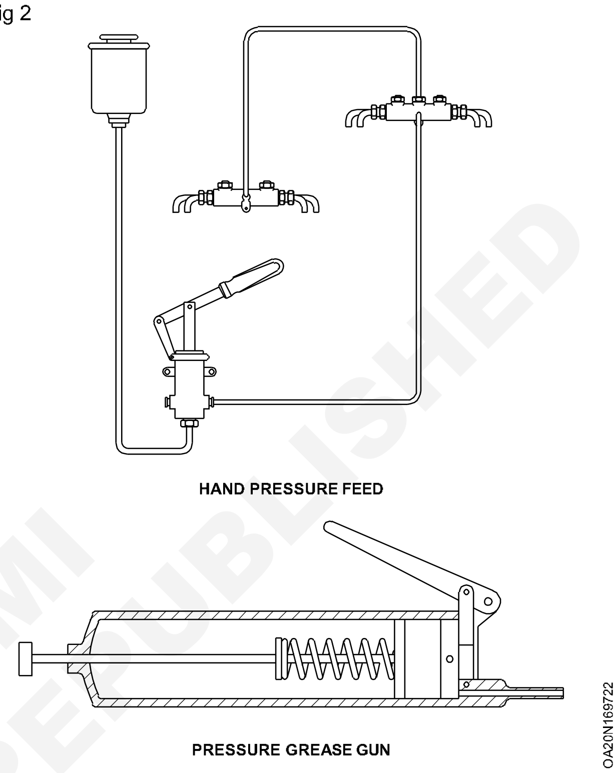


Force (Pressure) feed method

There are various systems of lubrication employing a pressure feed to the lubricant, and the most important of such systems may be classified roughly into the following.

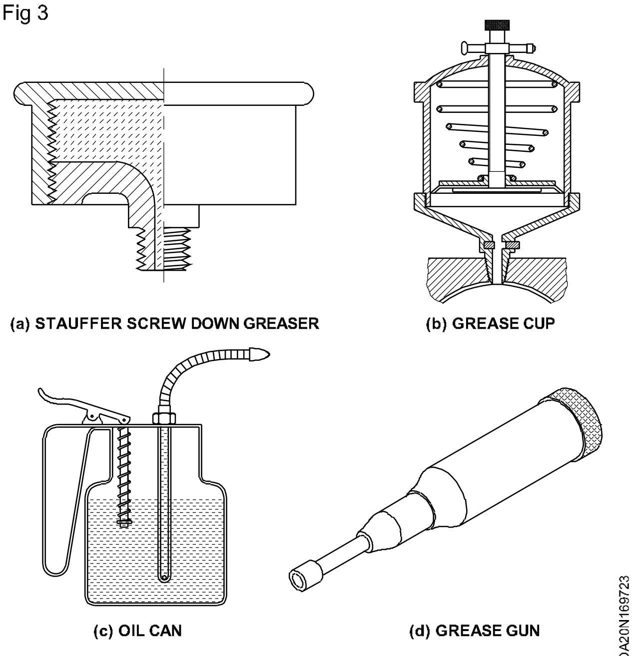
- Continuous feed of oil under pressure to each bearing concerned. In this method an oil pump driven by the machine delivers oil to the bearings and back to a sump from which it is drawn by the pump.
- Pressure feed by hand pump in which change of oil is delivered to each bearing at intervals (once or twice a day) by the machine operator. (Fig 2)

Fig 2



- Oil or grease gun method. The oil hole leading to each bearing is fitted with a nipple and by pressing the nose of the gun against this and the lubricant is forced into the bearing. (Figs 3 a, b, c & d)

Fig 3

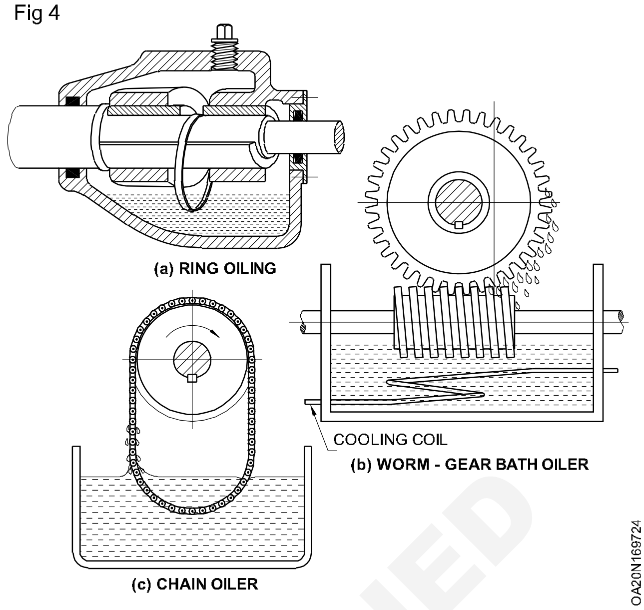


Splash method

In this method the shaft, or something attached to it, actually dips into the oil and a stream of lubricant is continually splashed round the parts requiring lubrication. This method is employed for the gears and bearings inside all gear drives, the lower parts of the gears actually dipping in the oil. (Figs 4a, b and c)

A common method of employing splash lubrication is known as 'ring oiling.'

Fig 4



Classification of lubricants

Objectives: At the end of this lesson you shall be able to
- **state solid lubricants and their application**
- **state liquid and semi-liquid lubricants and their application**
- **state the classification of lubricants as per Indian Oil Corporation.**

Lubricants are classified in many ways. According to their state, lubricants are classified as:

- solid lubricants
- semi-solid or semi-liquid lubricants
- liquid lubricants.

Solid lubricants

These are useful in reducing friction where an oil film cannot be maintained because of pressure and temperature. Graphite, molybdenum disulphide, talc, wax, soap- stone, mica and french chalk are solid lubricants.

Semi-liquid or semi-solid lubricants

Greases are semi-liquid lubricants of higher viscosity than oil. Greases are employed where slow speed of heavy pressure exists. Another type of application is for high temperature components, which would not retain liquid lubricants.

Liquid lubricants

According to the nature of their origin, liquid lubricants are classified into:

- mineral oil
- animal oil
- synthetic oil.

According to the product line of Indian Oil Corporation the lubricants are classified as:

- automotive lubricating oils
- automotive special oils
- rail-road oils
- industrial lubricating oils
- metal working oils
- industrial special oils
- industrial greases
- mineral oils.

For industrial purposes the commonly used lubricants for machine tools are:

- turbine oils
- circulating and hydraulic oils (R & O Type)
- circulating and hydraulic oils (anti-wear type)
- circulating oil (anti-wear type)
- special purpose hydraulic oil (anti-wear type)
- fire-resistant hydraulic fluid
- spindle oil
- machinery oils
- textile oils
- gear oils
- straight mineral oils
- morgan bearing oils
- compressor oils.

In each type, there are different grades of viscosity and flash point. According to the suitability, lubricants are selected using the catalogue.

Example 1

Spindle oils are graded according to their viscosity and flash point.

Servospin - 2

Servospin - 5

Servospin - 12

Servospin - 22

Servospin oils are low viscosity lubricants containing anti-wear, anti-oxidant, anti-rust and anti-foam additives. These oils are recommended for lubrication of textile and machine tool spindle bearings, timing gears, positive displacement blowers, and for tracer mechanism and hydraulic systems of certain high precision machine tools.

Example 2

Gear oils are graded according to their viscosity and flash point.

Servomesh - 68

Servomesh - 150

Servomesh - 257

Servomesh - 320

Servomesh - 460

Servomesh - 680

Servomesh oils are industrial gear oils blended with lead and sulphur compounds. These oils provide resistance to deposit formation, protect metal components against rust and corrosion, separate easily from water and are non-corrosive to ferrous and non-ferrous metals.

These oils are used for plain and anti-friction bearings subjected to shock and heavy loads, and should be used in systems where the operating temperature does not exceed 90° C. These oils are not recommended for use in food processing units.

Servomesh A-90 is a litumenous product which contains sulphur-lead type and anti-wear additive. It is specially suitable for lubrication of heavily loaded low-speed open gears.

Servomesh SP 68

Servomesh SP 150

Servomesh SP 220

Servomesh SP 257

Servomesh SP 320

Servomesh SP 460

Servomesh SP 680

Servomesh SP oils are extreme pressure type industrial gear oils, which contain sulphur-phosphorous compounds and have better thermal stability and higher oxidation resistance compared to conventional lead-napthenate gear oils.

These oils have good de-emulsibility, low foaming tendency and provide rust and corrosion protection to metal surfaces. These oils are recommended for all heavy duty enclosed gear drives with circulation or splash lubrication system operating under heavy or shock load conditions up to a temperature of 110° C.

Hydraulic systems in machine tool

Objectives: At the end of this lesson you shall be able to
- **state the application of Hydraulic power in machine tools**
- **state the advantages of Hydraulic power**
- **explain the transmission forces in Hydraulic system.**

Basics of hydraulics and their applications

Basic Hydraulics

The term Hydraulics is based on the Greek word for water. It was concerned only with the Physical behaviour of water at rest and in motion. It has since been broadened to include the study of all liquids.

Application

Hydraulic power is applied to all types of machine tools to control and guide them through machining operations. Its simplicity and smoothness of operation, flexibility and ease of control, makes hydraulic power transmission ideal for machine tool operations.

Advantages of Hydraulic power

Ease of control

Simple valving permits accurate control of fluid pressure and flow to make possible on infinite number of machine speeds and feeds. Large forces can be controlled by small forces.

Mechanical parts

There is no need for a complicated system of belting, gearing, cams and levers. Lubrication is inherent in the unit.

Simple installation

Installations are simple and power can be transmitted up, down, around corners and over relatively long distances with little loss of efficiency.

Separate controls

Speed and feed units are separate and can be controlled independently.

Smooth application of power

Transmitted motion is remarkably smooth and constant. Maximum pressures are generated almost instantly at the start of the cut and remain constant during the entire cutting stroke.

Rapid directional changes : Rapid reversals at the end of the cutting stroke are cushioned and shock-free because there is no metal control. The cushioning action (known as DWELL) can be increased or decreased as needed.

Flexibility : A great number of motions - locating, clamping, feeding, driving etc., are possible and can be built into a single machine.

Contour machining possible

Precision contour machining is possible through the application of special hydraulic valving system. Tool feed is controlled automatically by a stylus (mounted to a hydraulic piston) as it traces over a master template or pattern.

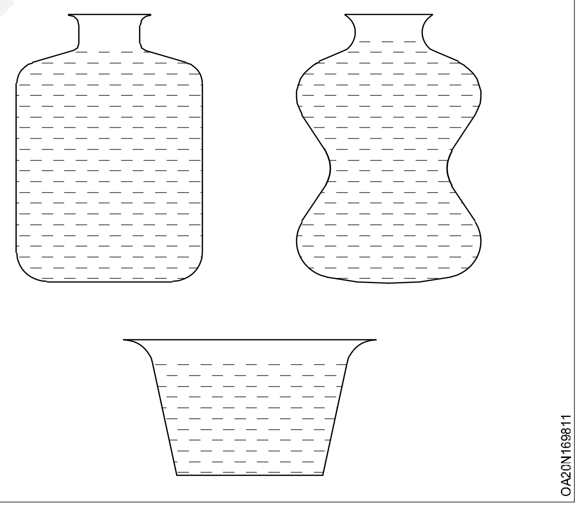
Physical properties of fluids

For better understanding the operation of hydraulically actuated units, it is necessary to learn about the physical properties of liquids.

Shapeless of fluids

Fluids have no outer shape of their own as do solids. They quickly can form to the shape of their container. (Fig 1) This makes it possible to transmit fluids easily through pipes, tubing and hoses. This can be done by gravity or by applying pressure.

Fig 1



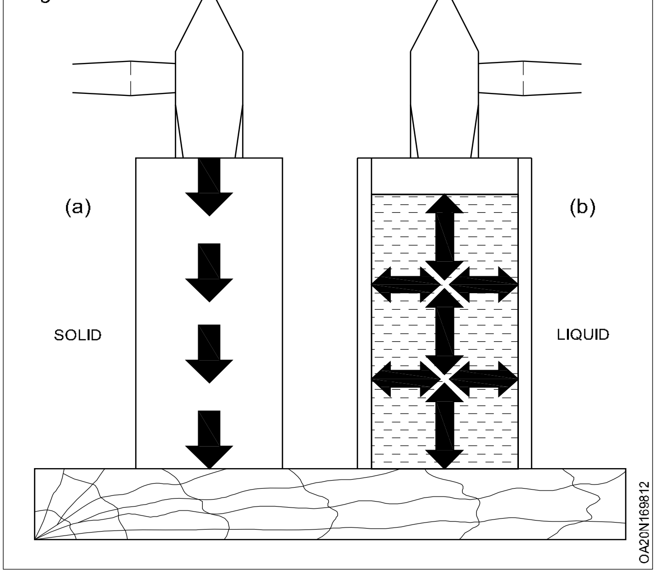
Relative incompressibility of liquids

The relatively slight decrease in volume when liquids are compressed acts like a “shock absorber” and cushions machine movement. Also, when force is applied to a confined liquid, it quickly exhibits the same characteristics of a solid.

- Transmission of forces through liquids

The direction of a blow on a solid almost entirely determines the direction of the transmitted force. (Fig 2a) When force is applied to a column of liquid, the face is not only transmitted straight through to the other end, but also equally in every direction throughout the column. (Fig 2b)

Fig 2



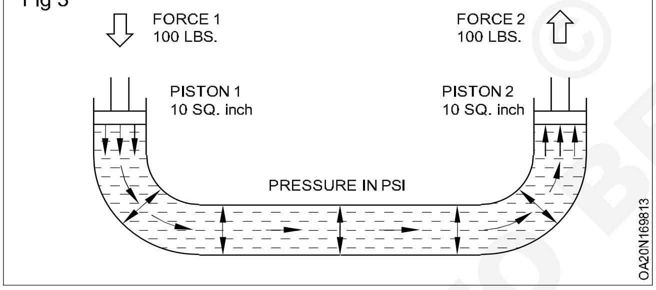
- Pascal's law

Pressure set up in a liquid acts equally in all directions. The shape of the container in no way alters this pressure relation. Pascal's law is the foundation of modern hydraulics.

Transmission of forces in Hydraulic system

Force applied to a confined liquid transmitted equally throughout the liquid regardless of the shape of the container - Force applied to PISTON No.1 will be transitted to PISTON No.2. (Fig 3)

Fig 3



Pressure is defined as the force divided by the area over which it is distributed - a force of 100 N applied to a piston 10 sq. mm will create a pressure in the liquid of 10 N/sq.mm.

As the shape of the container has no bearing on the degree of pressure (providing an unobstructed passage way is available) a relatively small pipe can be used to connect the two cylinders and work well. (Fig 4)

Multiplication of forces

The output force was equal the input force on the previous examples. By using pistons of different sizes, forces can be multiplied. (Fig 5) However, note that piston travel is no longer equal.

The general rule is, because of Pascal's law, if the pistons are used in a hydraulic system, "The force acting on each will be directly proportional to its area, and the magnitude of the pressure and its area. The distance moved are inversely proportional to their areas.

Fig 4

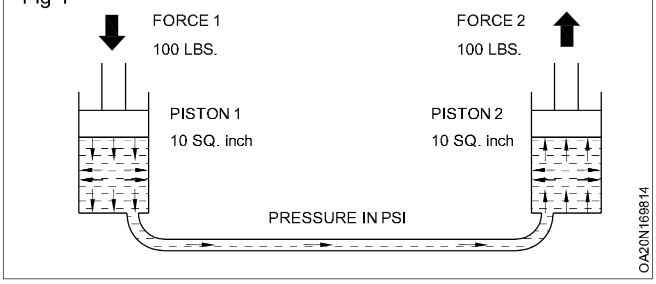
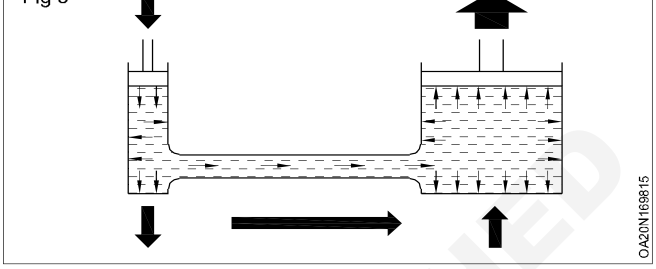


Fig 5



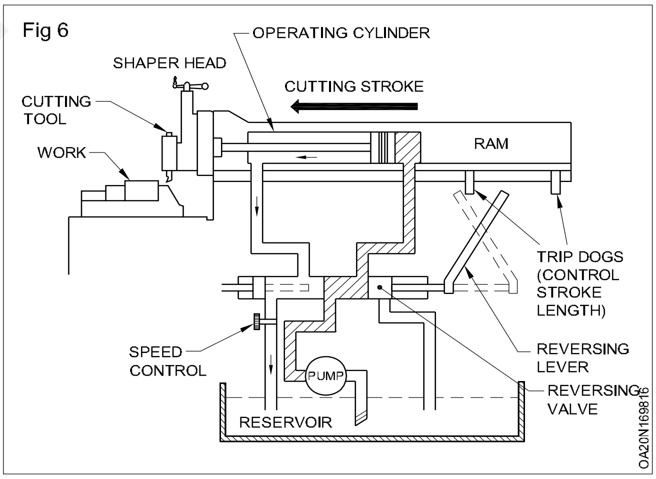
Machine tool application

Hydraulic units are used widely on machine tools because of their simplicity and dependability and the ease by which speeds and feeds can be controlled through an almost infinite range of operations.

A great number of motions - locating, clamping, feeding, driving etc are possible and can be built into a single machine.

Hydraulic actuated shaper is shown in Fig 6. It uses hydraulic pressure to impart movement to ram. Because of hydraulic system flexibility, ram speed can be changed and stroke length varied while the machine is in operation. Power on the cutting stroke is uniform through the entire stroke.

Fig 6



A schematic drawing of the hydraulic system of a surface grinder is shown in Fig 7. A scheme drawing makes use of simple symbols for the complicated drawing.

1 Relief valve

2 Filter assembly

3 Constant flow rotary gear pump

4 Electric motor

5 Special Elbow

6 Oil filter and check valve

7 Pressure relief - oilways

8 4 - way valve

9 Table control

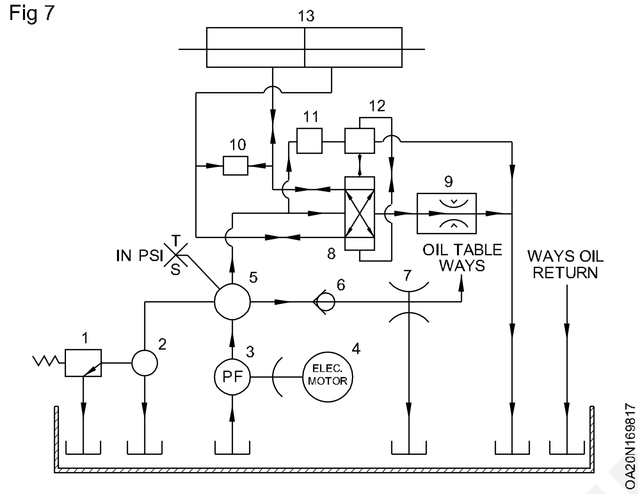
10 Table stop

11 Dwell

12 Directional valve

13 Table drive cylinder

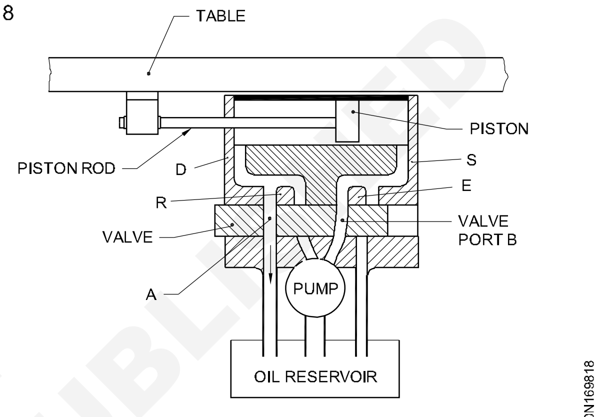
Fig 7



Hydraulic drive (Fig 8) : In this system the table of a planing machine gets its reciprocating motion from a piston which moves to and fro with hydraulic power. Oil is used as a working fluid and the hydraulic pressure is generated by a variable, delivery electrical pump. The speed of the piston is changed by adjusting the amount of oil delivered by the pump.

As shown in the figure, oil from the pump flows through port 'B' in the valve through the discharge line 'E' to the cylinder. Hence the piston is moved to the left. When the table reaches the end of its stroke, a dog or trip moves the valve to the right so that valve ports 'A' and 'B' come in alignment with the lines 'D' and 'S'. In this position the piston moves to the right. The oil in the head end of the cylinder returns through line 'S' and valve port 'B' to the oil reservoir.

Fig 8



SCHEMATIC DIAGRAM OF THE HYDRAULIC DRIVE

Types of taper

Objectives : At the end of this lesson you shall be able to
- **state the uses of tapers**
- **identify the elements of a taper**
- **classify tapers**
- **state the different standard tapers and their uses.**

A taper is uniform increase or decrease in diameter along the length of a cylinder.

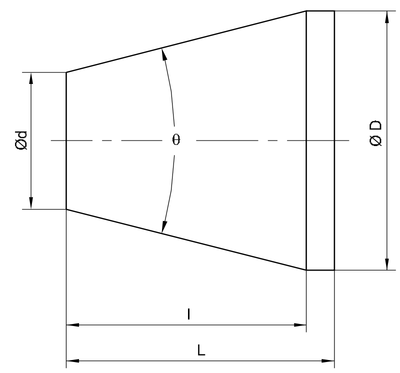
Uses of taper

Tapers are used for the following.

- Assist to transmit drive in the assembled parts.
- Used for easy assembly and disassembly of parts.
- Gives self-alignment in the assembled parts.

Elements of taper (Fig 1)

Fig 1



Big diameter in mm	D
Small diameter in mm	d
Length of the taper in mm	ℓ
Included taper angle in degrees	θ
Total length of job in mm	L

Expression of taper and its conversion

The methods by which tapers can be expressed are:

- giving the big dia. small dia. and the length of taper (Fig 2)
- giving the included angle of the taper in degrees. (Fig 3)
- giving Taper per foot (TPF)

Example

5/8" taper per foot means in a length of 12" taper (1 foot) the difference in diameter is 5/8" or mm per metre (Fig 4)

- giving taper in ratio - Ratio 1:20 means, for a taper length of 20 units the difference in diameter is 1 unit (Fig 5)

Fig 2

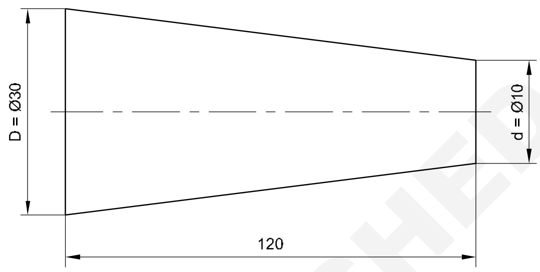


Fig 3

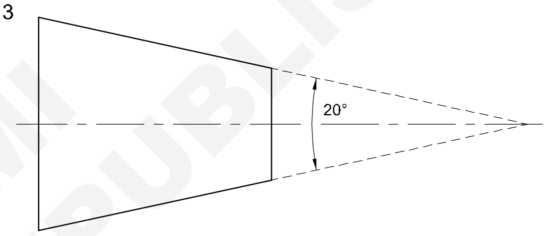


Fig 4

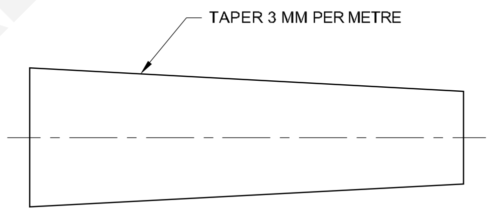
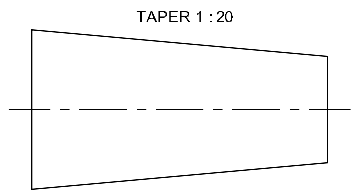


Fig 5



- mentioning by standard taper.

Example

MT3 (Morse taper number 3)

The relationship between the elements of a taper-

φ = included angle of a taper

α = Half included angle of a taper

Tan α =

$$\tan \alpha = \frac{TPF}{24} \text{ or } \frac{TPM}{2000}$$

$$\tan \alpha = \frac{Ratio}{2}$$

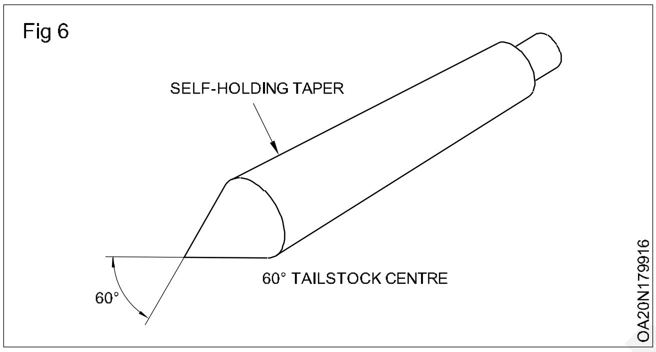
Classification of tapers

Tapers are classified as

- self-holding tapers
- quick releasing tapers.

Self-holding taper (Fig 6)

Fig 6



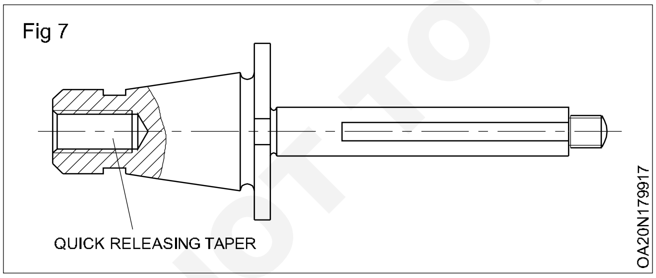
A self-holding taper has the property of holding the two parts together and be able to assemble together without any additional locking device such as keys. Just insert the internal taper into the external taper with a slight 'bang' and they get locked together. These tapers have a smaller taper angle that is limited to a maximum of 3°.

Example

Taper shank of drills, reamers and sleeves.

Quick releasing taper (Fig 7)

Fig 7



Quick releasing tapers in contrast to the self-holding tapers do not hold the parts together by themselves. They require additional locking devices for holding. (They have a larger included angle the value of which is not less than 18°. The purpose of quick releasing tapers is only to provide perfect alignment of the tool mating parts.)

Example

Arbor of milling machines.

Different standard tapers and their uses

The common standard tapers in use are:

- Morse taper (MT)
- Brown and Sharpe taper (BS)
- Jarno taper (JT)
- metric taper
- pin taper.

Morse taper

The Morse taper is the most commonly used standard taper in the industry. It is a self-holding taper. This taper is usually used in spindles of lathes and drilling machines, shanks of drills, reamers, centres, etc. The Morse taper is denoted by the letters MT. It is available from MT0 to MT7. The numbers MT0 to MT5 are commonly used on taper shanks of twists of drills, reamers and lathe centres. The included angle of the Morse taper is approximately 3° and the taper per foot is 5/8".

Brown and Sharpe taper

Both quick releasing and self-holding tapers are available in Brown and Sharpe tapers. The taper used in the arbors of a milling machine is a quick-releasing Brown and Sharpe taper, having a taper of 3 1/2" T.P.F.

Brown and Sharpe self-holding tapers are available from BSI to BS18. The taper per foot is 1/2" except BS10 which has a taper of 0.5161" taper per foot.

Jarno taper

Jarno tapers are self-holding and are used on external tapers of the lathe spindle nose where the chuck or face plate is mounted. It is available from Nos. 1 to 20. The amount of taper per foot is 0.6". The dimensions of this taper will be as follows.

$$\text{Big diameter of taper} = \frac{\text{Number}}{8}$$

$$\text{Small diameter of taper} = \frac{\text{Number}}{10}$$

$$\text{Length of taper} = \frac{\text{Number}}{2}$$

Jarno taper is mostly used in die-making machines.

Metric taper

Metric taper is available as both self-holding and quick-releasing tapers. A self-holding metric taper has an included angle of 2° 51' 51".

Quick releasing metric tapers are used as the external tapers of lathe spindle noses. Metric tapers are expressed by numbers which represent the big diameter of the taper in millimetres.

Standard pin taper

Standard pin tapers are used in taper pins. It is a self-holding taper. It is available both in Metric and British systems. The amount of taper is 1:50 in the metric system and 1:48 (1/4" TPF) in the British system.

Taper turning methods

Objectives : At the end of this lesson you shall be able to
- **name the methods of turning tapers on lathes**
- **state how each method is performed**
- **state the advantages and disadvantages of each method.**

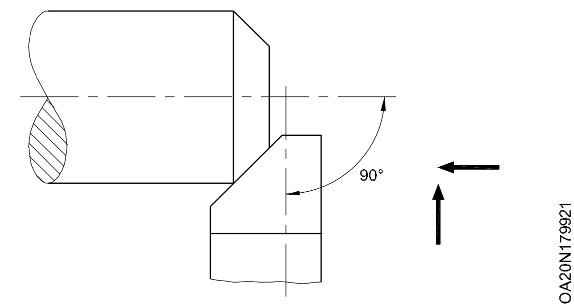
Methods of turning taper on a lathe

The different methods of taper turning on a lathe are:

- form tool method
- compound slide method
- tailstock offset method
- taper turning attachment method
- taper turning by combining feeds.

Form tool method (Fig 1)

Fig 1

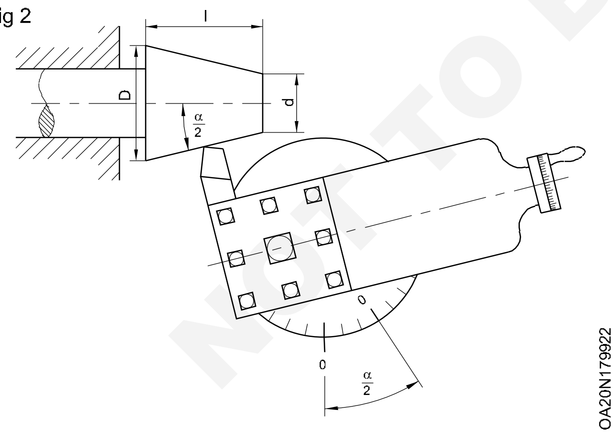


This method is used in mass production for producing small lengths of taper. The form tool should be set at right angles to the axis of the work and feed.

The carriage should be locked while turning taper by this method.

Compound rest method (Fig 2)

Fig 2



In this method, the compound rest is swivelled to half the included angle of the taper, and the taper is turned by feeding the top slide.

The angle '$\frac{\alpha}{2}$' to which the compound rest is set is found by the formula

$$\tan\frac{\alpha}{2} = \frac{D-d}{2\ell}$$

where

D = big dia of taper

d = small dia of taper

ℓ = length of taper

$\frac{\alpha}{2}$ = 1/2 included angle in degrees.

Advantages

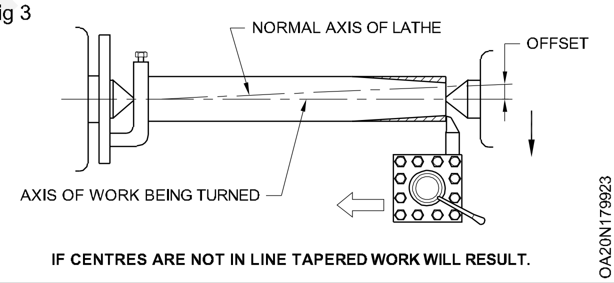
- Both internal and external tapers can be produced.
- Steep tapers can be produced.
- Easy setting of the compound rest.

Disadvantages

- Only hand feed can be given.
- Threads on the taper portion cannot be produced.
- The taper length is limited to the movement of the top slide.

Tailstock offset method (Fig 3)

Fig 3



In this method the job is held at an angle, and the tool moves parallel to the lathe axis. The body of the tailstock is shifted on its base to an amount corresponding to the angle of the taper.

These tapers can be turned between centres only, and this method is not suitable for producing steep tapers. The amount of offset is found by the formula

$$\text{offset} = \frac{(D-d)L}{2\ell}$$

where

D = big dia. of taper

d = small dia. of taper

ℓ = taper length

L = total length of the job.

Advantages

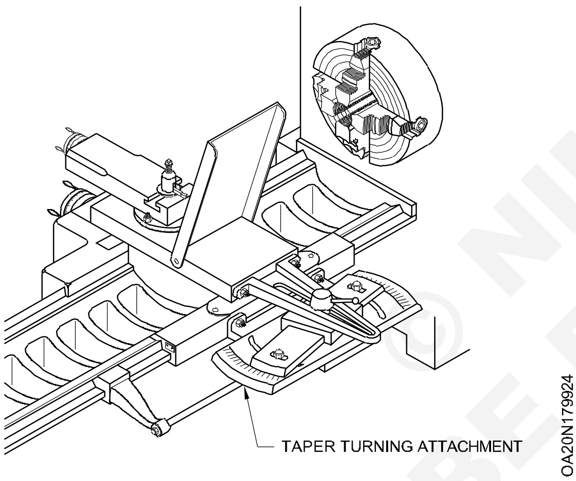
- Power feed can be given.
- Good surface finish can be obtained.
- Maximum length of taper can be produced.
- External thread on taper portion can be produced.
- Duplicate tapers can be produced.

Disadvantages

- Only external taper can be turned.
- Accurate setting of the offset is difficult.
- Taper turning is possible when the work is held between centres only.
- Damages the centre drilled holes of the work.
- The alignment of the lathe centres will be disturbed.

Taper turning attachment method (Fig 4)

Fig 4



A special attachment is provided on a few modern lathes. Here the job is held parallel to the axis and the tool moves at an angle. The movement of the tool is guided to the required angle by the attachment.

Advantages

- Both internal and external tapers can be produced.
- Threads on both internal and external taper portions can be cut.
- Power feed can be given.
- Lengthy taper can be produced.
- Good surface finish is obtained.
- The alignment of lathe centres is not disturbed.
- It is most suitable for producing duplicate tapers because the change in length of the job does not affect the taper.
- The job can be held either in chuck or in between centres.

Disadvantage

- Use is limited to turning of slow taper angles only.

Measuring angle of tapered (external) components

Objectives : At the end of this lesson you shall be able to
- **name the features of a taper which can be measured using a precision roller and slip gauges**
- **state the formula for measuring the angle of a taper**
- **calculate the angle of taper.**

A method used for measuring tapered components is by using precision rollers or balls along with the slip gauges. Using this method, the following (elements) measurements of tapers can be taken.

– Angle of taper (Fig 1)
– Small end diameter (Fig 2)
– Large end diameter (Fig 2)

Measuring the angle of taper : For determining the angle two measurements are needed, i.e. X and Y. (Figs 3 and 4)

The measurement Y is taken by placing the component against a datum surface like a surface plate or marking table. Two precision rollers are then placed at the smaller end resting on the datum surface. (Fig 3)

Fig 1

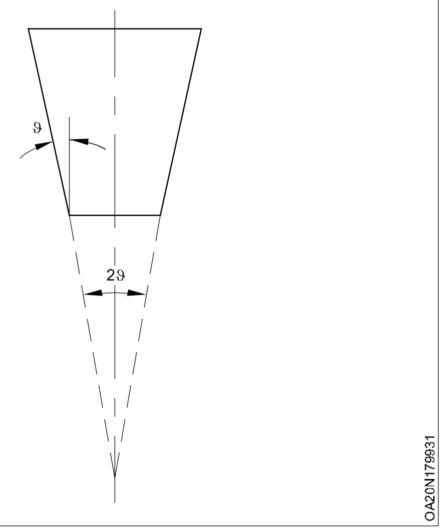


Fig 2

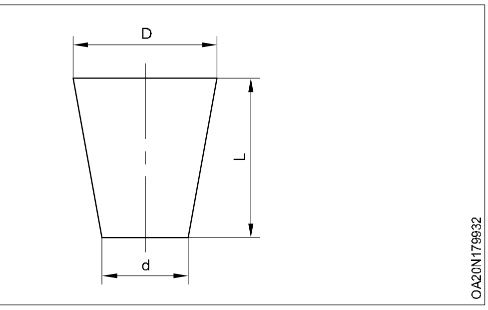
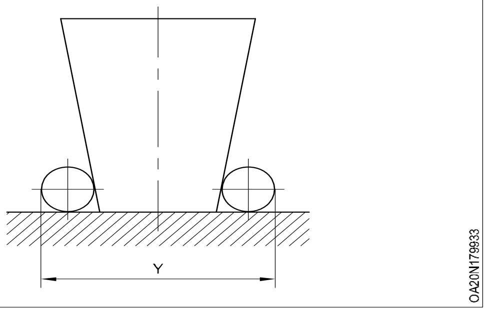
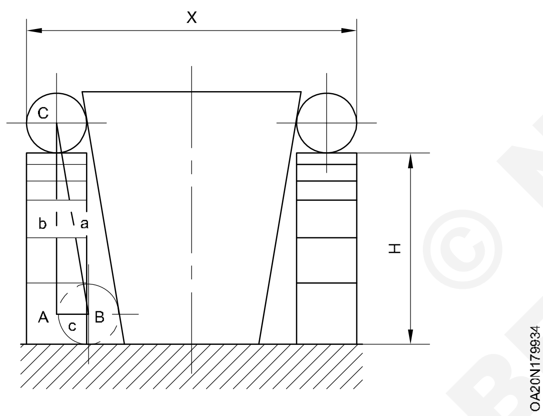


Fig 3



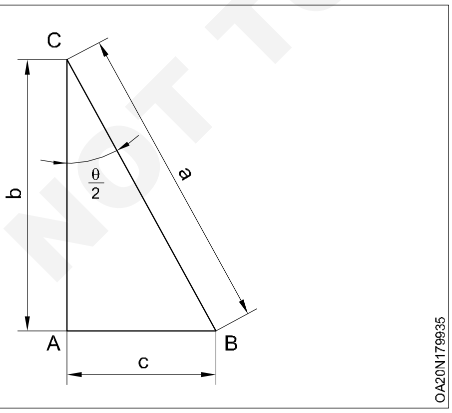
Measurement 'X' is taken by lifting and placing the rollers on both sides with the help of two sets of slip packs having the same size. The measurement is then taken with a micrometer over the rollers. (Fig 4)

Fig 4



For computing the taper angle the following trigonometrical ratio is applied. (Fig 5)

Fig 5



$$\text{Tan}\,\theta = \frac{\text{Opposite side}}{\text{Adjacent side}} = \frac{AB}{AC}$$

From the two measurements taken and the height of the slip packs the ratio is established by subtracting the measurements Y from X and dividing it by 2 (two).

This corresponds to the distance AB. (Fig 5)

$$AB = \frac{X-Y}{2}$$

The length AC corresponds to the size of the slip pack used on one side. (Fig 5) Then the taper angle is

$$\text{Tan}\frac{\theta}{2} = \frac{X-Y}{2} \div H$$

$$= \frac{X-Y}{2} \times \frac{1}{H} = \frac{X-Y}{2H}$$

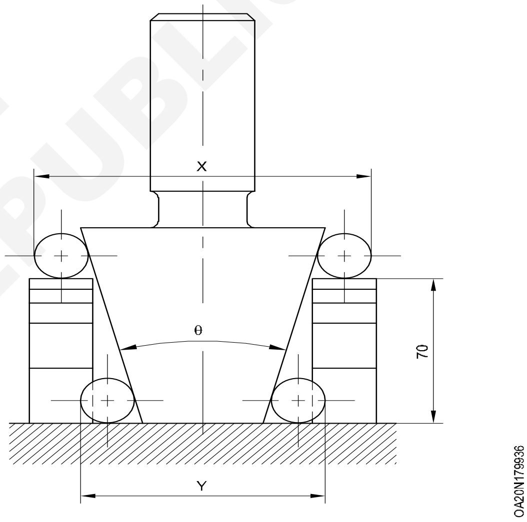
where X is the measurement over the rollers placed on the slip gauge height, Y is the measurement over the rollers at the smaller end and H is the slip gauge height.

The included angle of the taper will be double the above angle.

Example

Calculate the included angle of the tapered component as shown in Figure 6.

Fig 6



The measurement

$X = 69.3$

$Y = 61.5$

Height $= 70\,mm$

$$\text{Tan}\frac{\theta}{2} = \frac{69.3 - 6.15}{2 \times 70}$$

$$\text{Tan}\frac{\theta}{2} = \frac{7.8}{2} \times 70$$

$$= \frac{3.9}{7.0} = 0.05571$$

Referring to the table under natural tangent, we get

$\frac{\theta}{2} = 3° 11'$

Hence included angle of the taper

θ = 3° 11' x 2

= 6° 22'

Taper turning attachment

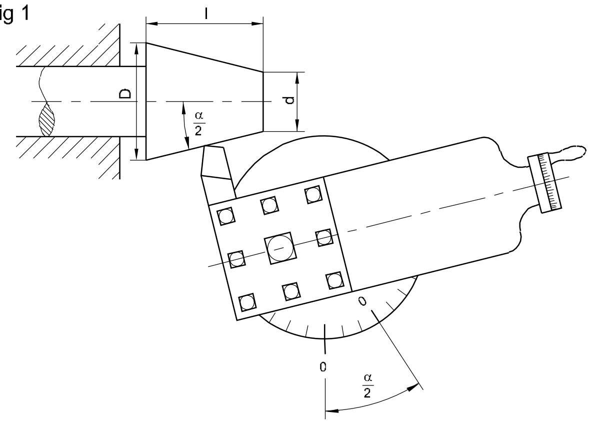
Objective : At the end of this lesson you shall be able to
- **state the taper turning method with taper turning attachment.**

Calculation (Fig 1)

The angle at which the compound rest is to set is found by the formula

$$\text{Tan } \theta = \frac{D-d}{2\ell}$$

Fig 1



D = big diameter

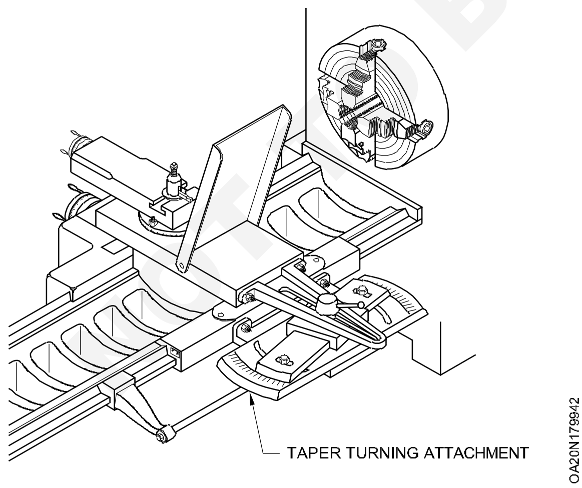
d = small diameter

ℓ = length of taper

$$\text{Tan } \theta = \frac{1}{2} \text{ included angle in degree}$$

Taper turning by attachment (Fig 2)

Fig 2



A special attachment is provided on a few modern lathes. Here the job is held parallel to the axis and the tool moves at an angle. The movement of the tool is guided to the required angle by the attachment.

Advantages

- Both internal and external tapers can be produced.
- Threads on both internal and external taper portions can be cut.
- Power feed can be given.
- Lengthy taper can be produced.
- Good surface finish is obtained.
- The alignment of lathe centres is not disturbed.
- It is most suitable for producing duplicate tapers because the change in length of the job does not affect the taper.
- The job can be held either in chuck or in between centres.

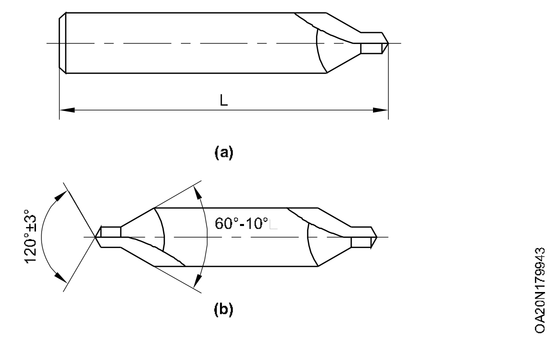
Disadvantages

- Use is limited to turning of slow taper angles only.
- Initial cost is slightly high

Uses and specifications

Type 'A' centre drill is used to produce centre holes with plain drilled portion and countersink. It is designated as Centre Drill A. 1.6 x 4.0 IS: 6708 which means that the centre drill is of Type `A' with the plain drill portion having a diameter of 1.6 mm and a shank diameter 4 mm. (Figs 3a and b)

Fig 3



Type 'B' centre drill is used to produce a centre hole with a plain drilled portion and a countersink, and has a further conical portion to form additional countersinking to protect the centre hole. The countersinking for providing the bearing surface for centres has an angle of 60° and the countersinking surface has an angle of 120°. This type is designated as Centre Drill B1.6 x 6.3 IS: 6709 which means that the pilot diameter is 1.6 mm and shank diameter is 6.3 mm. (Fig 4)

The third type, 'R' is designated as Centre Drill R 1.6 x 4.0 IS: 6710. This also has provision to provide a protected centre hole. This has an enlarged radius, machined along with the countersinking portion. (IS: 6710) (Fig 5)

Fig 4

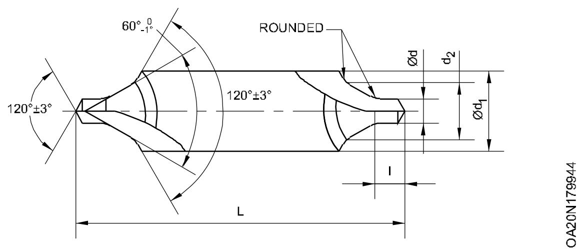
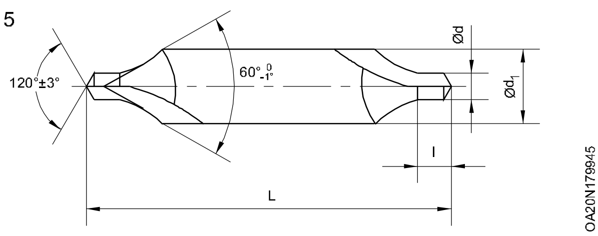


Fig 5



Boring tool and boring

Objectives : At the end of this lesson you shall be able to
• identify and name the different types of boring tools
• list out the advantages of the different boring tools.

Boring is the process of enlarging and truing an existing drilled or core hole with a single point cutting tool.

Necessity of boring a hole

- To enlarge a drilled hole larger than the drill size as drills are available in standard sizes only.
- To obtain concentricity of the hole.
- To maintain accuracy of the hole.
- To obtain better surface finish.
- To remove the error formed by drilling, and to facilitate the reaming operation.

Boring tools and holders

Boring is an internal operation performed on the drilled or cored holes. The cutting edge of a boring tool is ground similar to the left hand plain turning tool. But the operation being performed is from right to left. (Fig 1)

Parts of a rough boring tool (Figs 1,2 & 3)

Types of boring tools

Fig 1

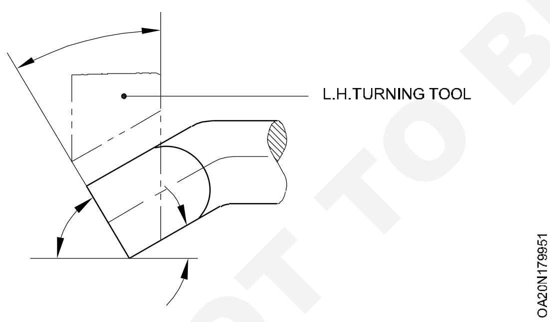
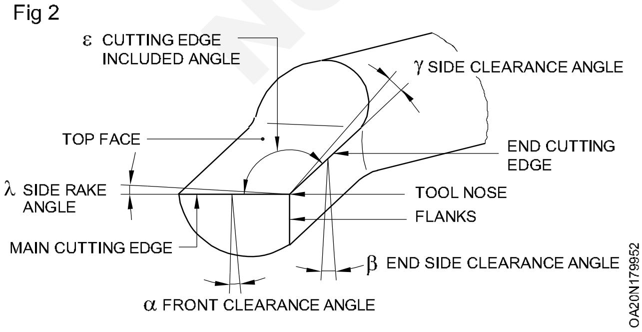


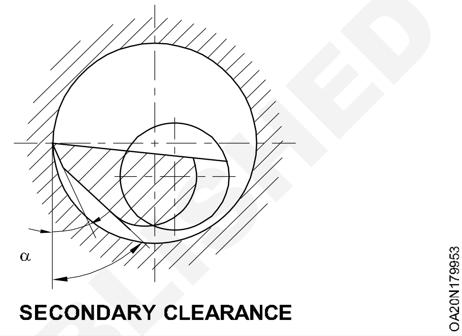
Fig 2



The following are the different types of boring tools.

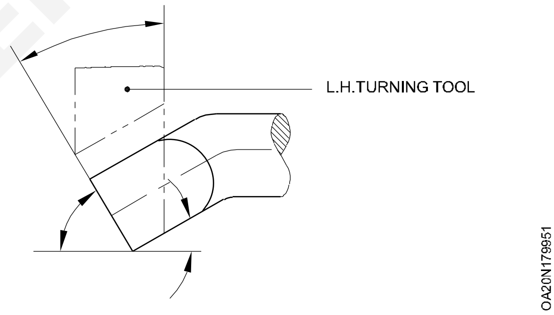
- Solid forged tools

Fig 3



- Boring bars with bits
- Brazed tools (Fig 4)

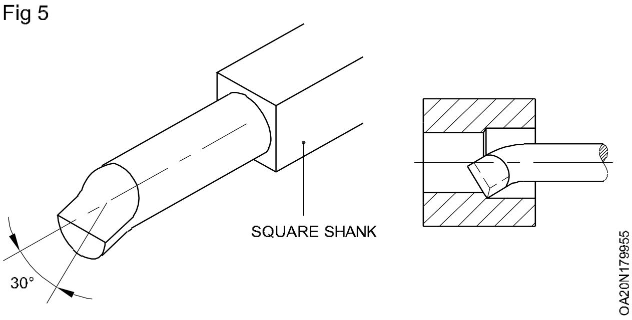
Fig 1



- Throw-away bits inserted in special holders.

Solid forged tools (Fig 5)

Fig 5

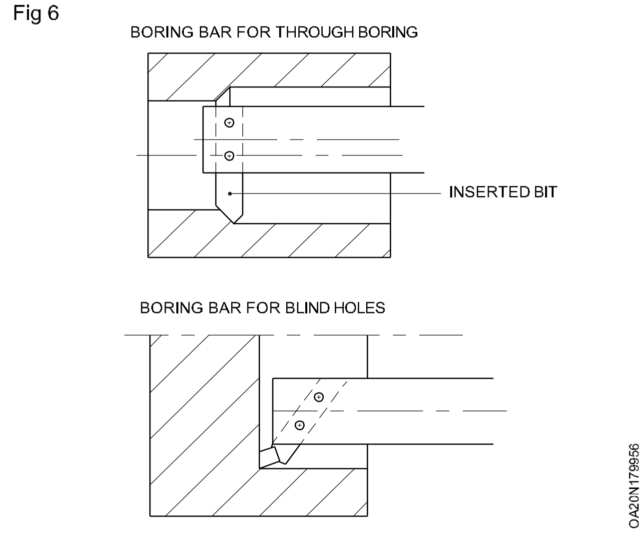


The solid forged boring tool is generally made of high speed steel, with the end forged and ground to resemble a left hand turning tool. They are light duty tools and are used on small diameter holes. They are held in special tool holders which are mounted in the tool post.

Occasionally tungsten carbide or high speed steel tips are brazed to low carbon bars, for economy.

Boring bars with inserted bit (Fig 6)

Fig 6



The boring bar tool-holder is mounted in the tool post and is used for heavier cuts than those for the forged boring tool.

The square tool bits are set at angles of 30°, 45° or 90° in the broached holes in the bar.

The boring bars may be plain type or end cap type. The cutting tool of the plain type is held in position by a set screw. The cutting tool of the end-cap type is held in position by the wedging action of a hardened plug.

The round or square section tool bits may be inserted in boring bars, the size depending on the diameter of the bar.

The tool bit may be square to the axis of the bar for plain boring or at an angle for facing shoulder, or threading up to a shoulder.

The bar is held in a split or 'V' block holder.

The advantages of Different boring tools

Solid boring tools

Available with square and round shank.

Enables to mount on the tool post easily.

Re-grinding is easy.

As the tool is integral, alignment is easy.

Can be easily forged to the required shape and angle.

Boring bars and inserted bits

Used for heavy duty boring operation.

Used for deep boring operation.

Tool changing is faster, thereby re-sharpening time is avoided.

Cost is less because the boring bar is made out of low carbon steel.

Boring tools can be set square to the axis of the boring bar or at an angle very quickly.

Truing a job for eccentric turning

Objectives: At the end of this lesson you shall be able to
- **true the job for external eccentric turning**
- **true the job for internal eccentric boring.**

Truing the eccentric job in a four jaw chuck

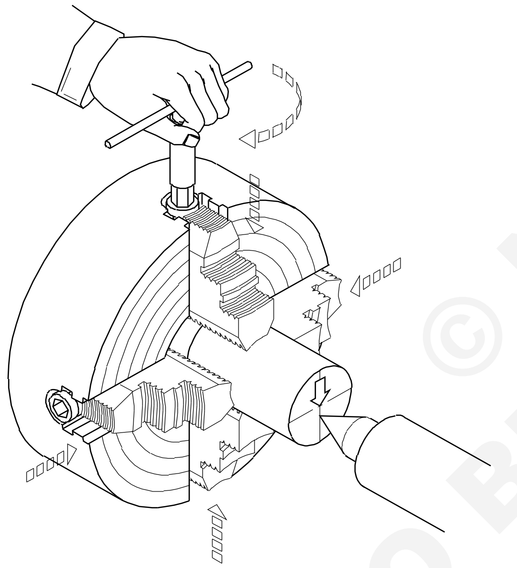
Open all the four jaws to give clearance to the workpiece.

Hold the workpiece up to the chuck face with the scribed lines towards the tailstock.

Insert the tailstock centre and slide the tailstock over the bed towards the headstock

Position the workpiece until the tailstock centre locates in the eccentric centre dot on the workpiece. (Fig 1)

Fig 1



Move the tailstock centre until the pressure applied holds the workpiece against the chuck face

Move the chuck iaws, tighten each jaw lightly in turn, taking care not to shift the workpiece.

Check and adjust the position of the workpiece so that it will protrude enough from the jaws to allow the total length of the eccentric portion to be machined.

Tighten the jaws.

Remove the tailstock.

Truing of eccentric job held in a four jaw chuck by using a surface gauge

Most of the eccentric truing is done with the help of guide circles scribed on the face of the chuck and the surface gauge. Since the guide circle has been scribed in concentric with the eccentric marking, truing the work to the guide circle gives the exact centre point of the eccentric turning.

Open all the four jaws to give clearance to the workpiece.

Hold the workpiece up to the chuck face.

Set the scriber of the surface gauge over the lathe bed.

Rotate the chuck by hand and check the running of the centre dot or guide circle with the surface gauge pointer.

Tighten each jaw slightly in turn, after necessary adjustments of the two sets of opposite jaws are made Recheck the centre dot or guide circle with the surface. gauge

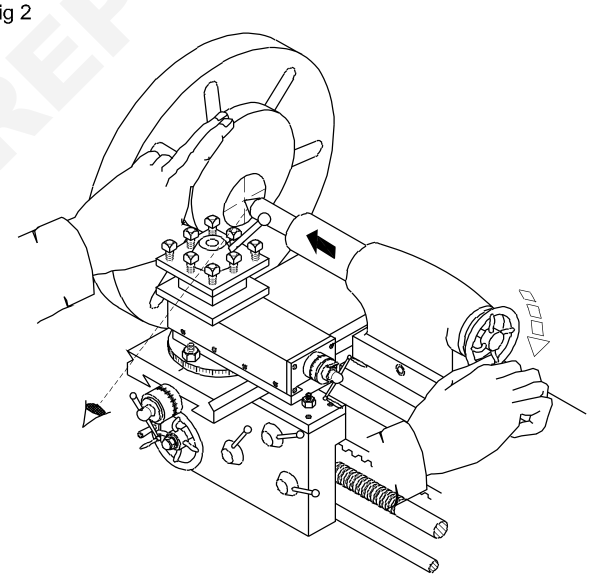
Realign the jaws, if required. Tighten the jaws fully.

Truing the eccentric job held on a face plate

Hold the workpiece on to the face plate.

Bring up the tailstock, locate the tailstock centre to the eccentric centre dot, apply pressure until the workpiece is held in position. (Fig 2)

Fig 2

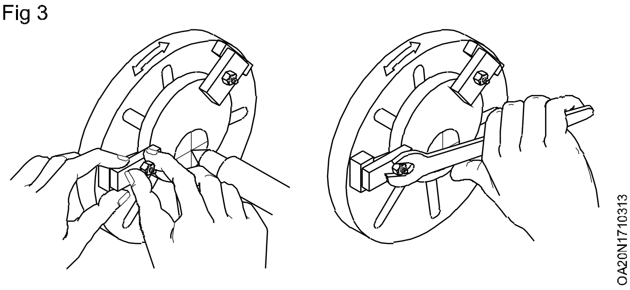


If the eccentric bore in the workpiece is to be through then the parallel bars must be placed behind the workpiece to Clear off the face plate during drilling and boring

Select suitable clamps, Tee bolts, nuts, washers and packings as required

Clamp the workpiece to the face plate, clamp in positions which will give supportie., as near to the holes as possible but diametrically opposite. (Fig 3)

Fig 3



Remove the tailstock.

Recheck the tightness of the clamps.

Rotate the face plate by hand and check the concentricity of the marked off bore with the help of the surface gauge.

Realign the job, if required.

Recheck the tightness of the clamps.

If the amount of eccentricity is great, then the counter-balance weights must be clamped or bolted to be face plate to give a balanced condition.

Eccentric turning and boring

Objectives: At the end of this lesson you shall be able to
- **turn external eccentric diameter**
- **bore internal eccentric diameter.**

Turning external eccentric diameter, work held in a 4 jaw chuck

The procedure of setting the work to turn the eccentric shaft has already been dealt with.

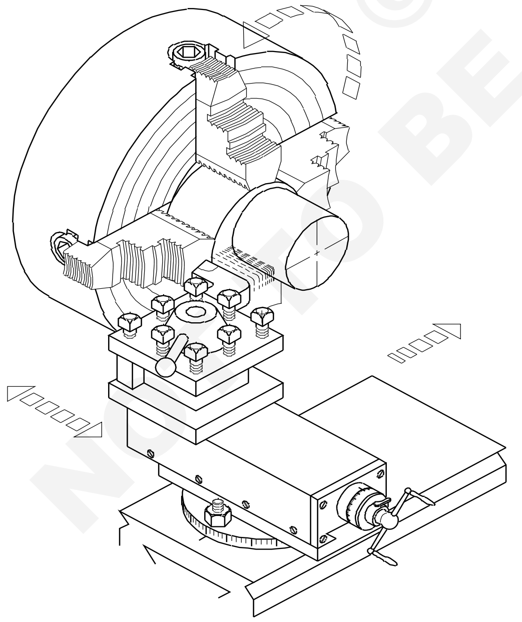
Further steps for turning are given below.

Set the tool to centre height with a minimum overhang.

Ensure that the tool tip is clear off the eccentric throw at the commencement Of the operation as shown in Fig 1.

Rough turn by successive cuts the eccentric diameter leaving approximately 0.8 mm in the diameter for finish turning. (Fig 1)

Fig 1

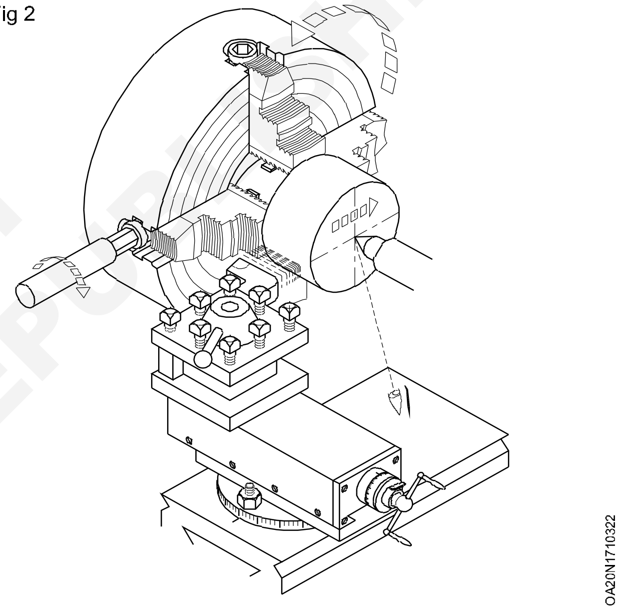


Set the finishing tool and finish turn to the diameter. Face to length.

Remove the workpiece from the chuck.

Reverse and reset the job for turning concentric diameter. Use packing strips to protect the furned diameter held In chuck. (Fig 2)

Fig 2



Bring up the tailstock centre to the workpiece,

Release the chuck jaws, rotate he workpiece until the centre dot of the concentric centre is in line with the tailstock centre. (Fig 2)

Check that all packing strips are in position. Tighten the jaws.

Remove the tailstock.

help of the surface gauge.

Realign the jaws, if required

Give each jaw a final tightening.

Make sure that the running of the concentric centre dot is in line with the lathe axis.

Set the tool for rough turn.

Rough turn the concentric diameter.

Set the tool for finish turn, and finish turn the concentric diameter.

Face to lenath.

Remove the eccentric turned job from the chuck.

Eccentric boring work held in a face plate

Truing has already been dealt with.

Rotate the face plate by hand to check that the clamps etc. are clear of the cross-slide and saddle.

Centre drill.

Drill a hole for boring. Use a suitable coolant, and drill the hole on slow r.p.m. Keep an even pressure on the tailstock hand wheel. Take care when the drill is breaking through.

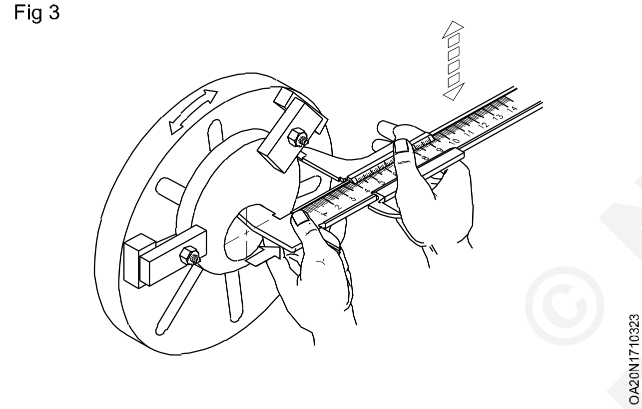
Set the boring bar/tool in he tool post.

Check and ensure that the length of the boring bar will clear the bore and clamping bore.

Rough cut bore.

Check the position of the hole from the outside diameter of the workpiece. Measurement should be taken on the line where maximum eccentricity occurs. (Fig 3)

Fig 3



Adjust the work position, if needed.

Finish bore to size. Check the diameter.

Unlock the tool post and swing the boring tool clear.

Bring up the tailstock to support the workpiece.

Remove the clamps, retract the tailstock and remove the workpiece from the machine. (Fig 4)

Return the tailstock to the extreme right hand end.

Remove all the counter-balance weights from the face plate.

Eccentric turning on work held between centres

Centre drill the marked dots at both ends. (Concentric and eccentric centres)

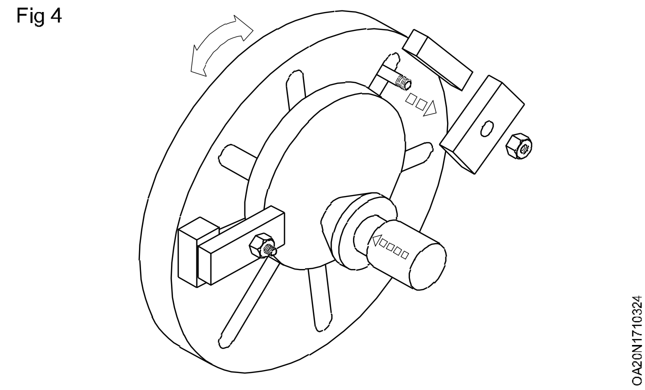
Mount the catch plate to the lathe spindle.

Clamp the earner to the workpiece.

Grease, the dead centre.

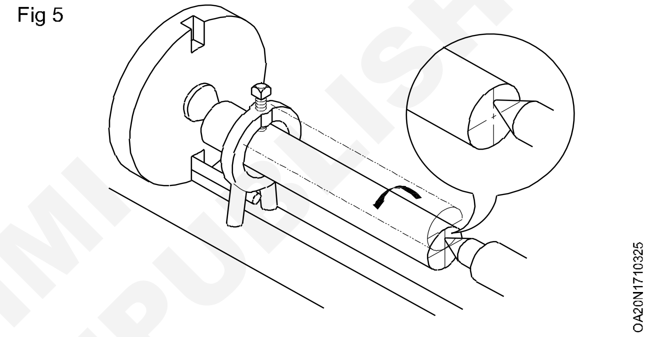
Support the workpiece between the eccentric centres for eccentric turning.

Fig 4



Ensure a positive drive from the catch plate to the carrier, and a minimum overhang of the tailstock barrel. Rotate the catch plate by hand to check that the workpiece is in the. correct plane. (Fig 5)

Fig 5



Clamp the tool in the tool post to correct centre height with a minimum overhang.

Rough turn eccentric diameter.

Take successive cuts until over half the diameter is machined.

Check and determine the amount of metal to be removed.

Rotate the workpiece by hand and touch the tool to the workoiece at the highest point of the throw and set the cross-slide graduated collar to zero.

Rough turn the eccentric diameter leaving 0.8 mm for finish turning. (Fig 6)

Remove the workpiece and reset the job for concentric turning

Turn length, leaving 0.4 mm for finish turning. (Fig 6)

Clamp a suitable carrier to the eccentric diameter. Use So packing strips between the finished diameter and the

carrier.

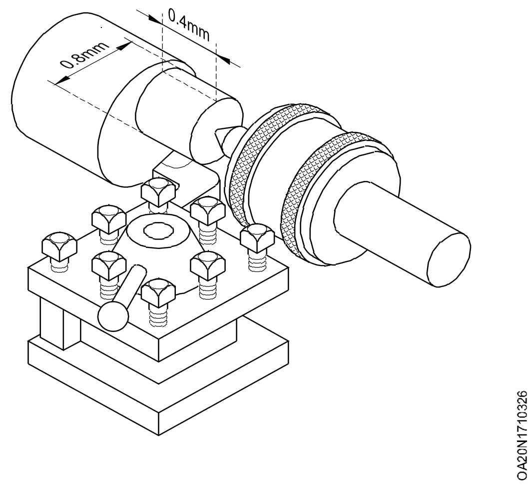
Hold the workpiece between the concentric centres, Check that the workpiece is located in the correct plane.

Rough turn the diameter.

Finish turn the diameter to size.

Remove the workpiece and reset the job for finish turning the eccentric diameter.

Fig 6



Clamp the carrier to the finished concentric diameter. Use soft packings to protect the finished diameter.

Finish turn the eccentric diameter to size.

Finish turn the length to size.

This procedure applies only to jobs which will have both the centre holes available for roughing and finishing operations.

Screw thread - Methods of producing threads

Objectives : At the end of this lesson you shall be able to
- **state the different methods of producing threads**
- **distinguish between the procedures of producing threads by different methods.**

Methods of producing threads

Production of threads depends on the following factors.

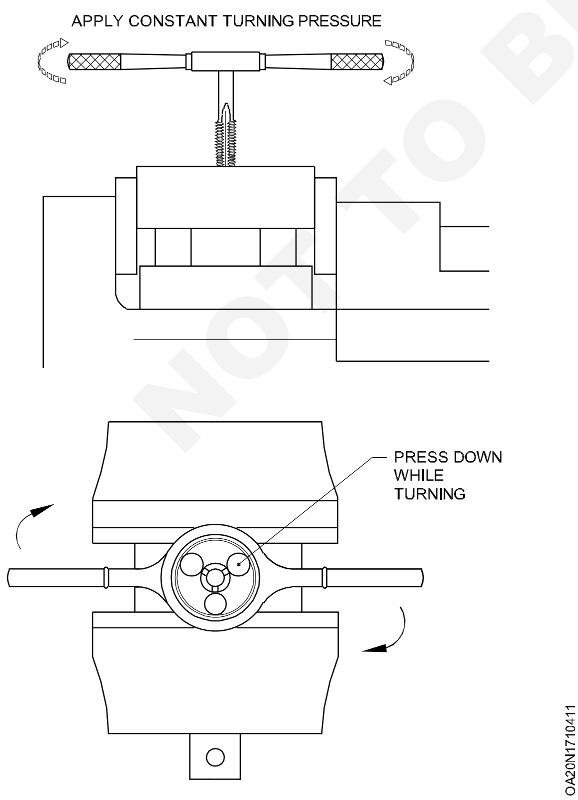
- Type and number of components required.
- The accuracy of the thread and its surface finish.
- Availability of machine tools.
- Skill of the operator, etc.

The different methods of producing threads are by:

- using hand tools like taps and dies
- using single point cutting tools on lathes
- using multi-point cutting tools called chasers
- using coventry die-head and collapsible taps in production lathes
- thread rolling
- thread milling
- thread grinding
- thread casting (**die casting or moulding).**

Using taps and dies (Fig 1)

Fig 1

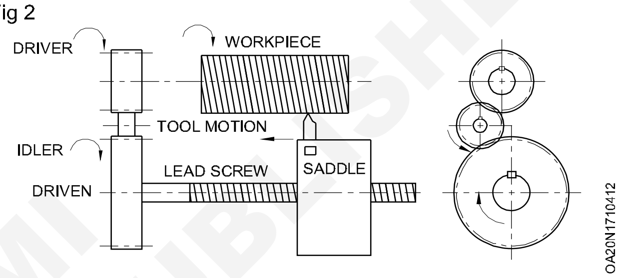


These are commonly used for general purpose bolts and nuts. Taps are used to produce internal threads. Dies are used to produce external threads.

Taps and dies can be used only for producing standard 'V' threads for both coarse and fine pitches. Machine taps are also available for cutting threads using machine tools.

Using single point cutting tools on lathe (Fig 2)

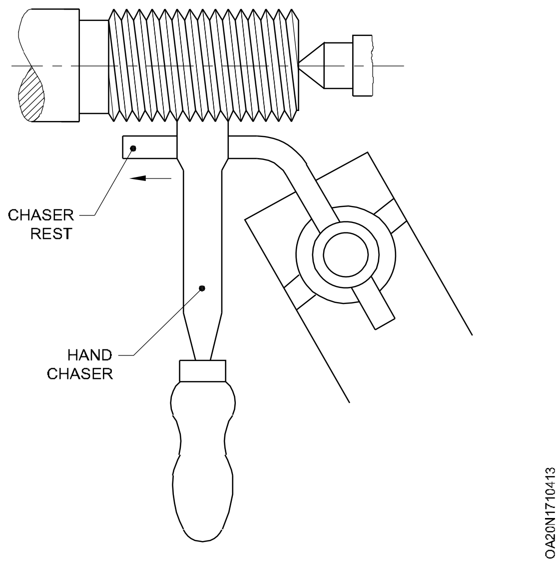
Fig 2



Both internal and external right hand and left hand threads can be cut by this method. Any form of thread to a required pitch can be cut or produced by using the corresponding tools. Accuracy of the thread depends on the skill of the operator.

Using chasers (Fig 3)

Fig 3

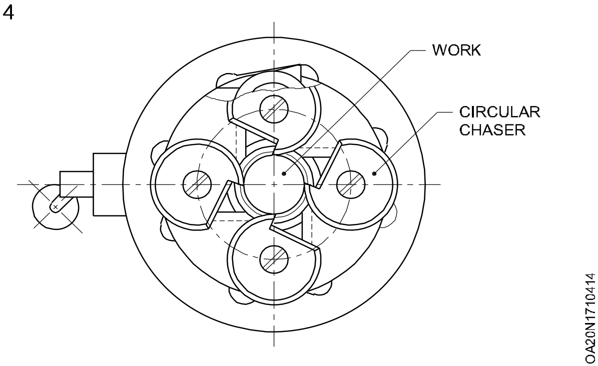


Chasers are multi-point cutting tools to produce external 'V' threads. There are different types of chasers, each one having its own special characteristics.

Usually hand chasers are used to finish the thread, and machine chasers are used for producing the threads. Machine chasers are used in conjunction with die heads.

Die head (Fig 4)

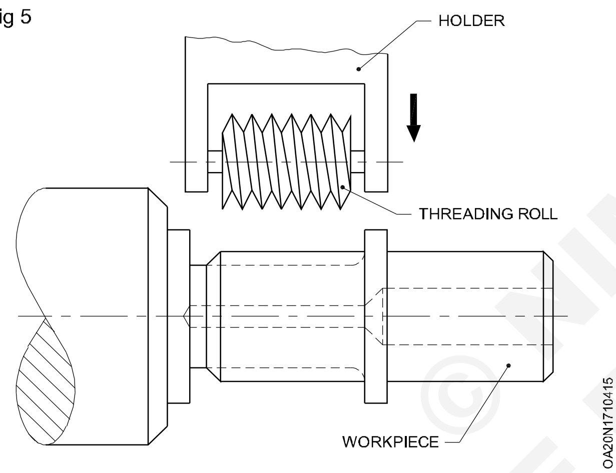
Fig 4



It is used in mass production to produce threads on capstan, turret lathes and automats. A highly skilled operator is not essential for cutting threads, but for setting skilled setters are required. This method is limited to producing 'V' threads.

Thread rolling (Fig 5)

Fig 5

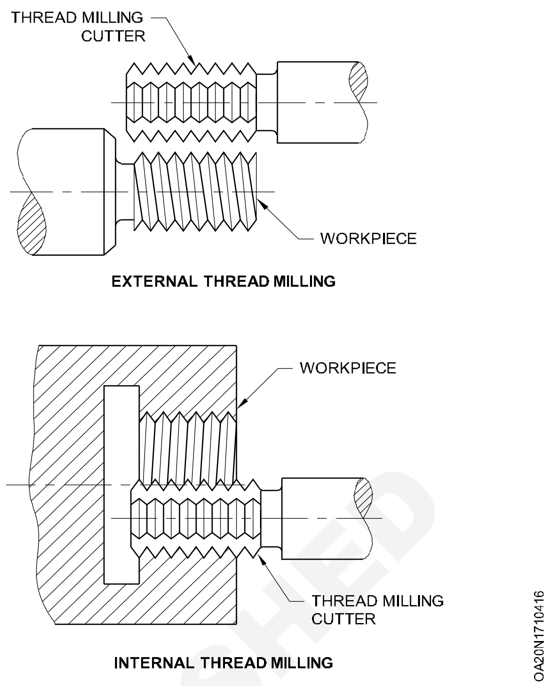


It is used in mass production. In this method, the thread is not cut and chips will not be produced. Thread is produced by rolling. Rolling is a process of cold forging, resulting in a plastic deformation. The job is turned to the pitch diameter before rolling. The rollers may be flat or of disc type. Threads produced by rolling have better strength, a good finish and closer tolerance.

Thread milling (Fig 6)

In this method, threads are produced by thread milling cutters. This operation is performed on special thread milling machines to produce accurate threads in small or large quantities. In this operation, there are three driving motions, that is, for cutter, work, and longitudinal movement of the cutter. The thread is completed in one cut by setting the cutter to the full depth of the thread, and then feeding it along the entire length of the workpiece. Internal thread milling can also be performed to produce accurate internal threads.

Fig 6



Thread grinding (Figs 7 and 8)

Special grinding machines are required for thread grinding. External and internal threads can be ground.

Fig 7

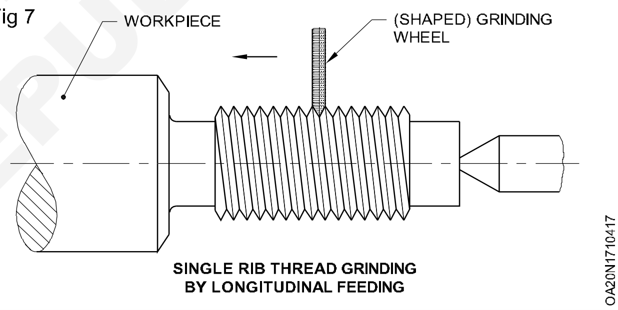
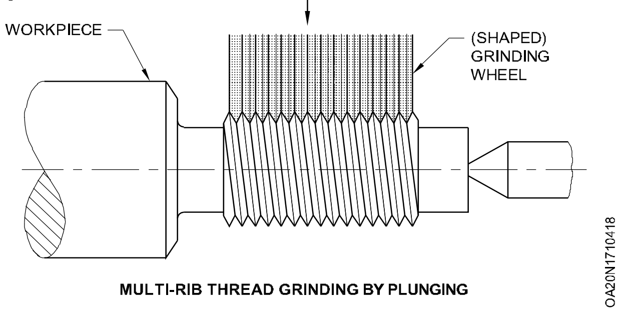


Fig 8



Thread casting : Die casting and plastic moulding can also be used to produce crude threads. Such threads are less accurate and can be made only on certain categories of metals and non-metals. These threads are produced either by die casting or mould for plastics. Usually threads on non-metals are produced by this method.

Thread cutting on lathe by single point cutting tools

Objectives : At the end of this lesson you shall be able to
- **state the principle of thread cutting by a single point cutting tool**
- **state the parts involved in the thread cutting mechanism and their functions**
- **derive formula for change gear calculation.**

Principle of thread cutting

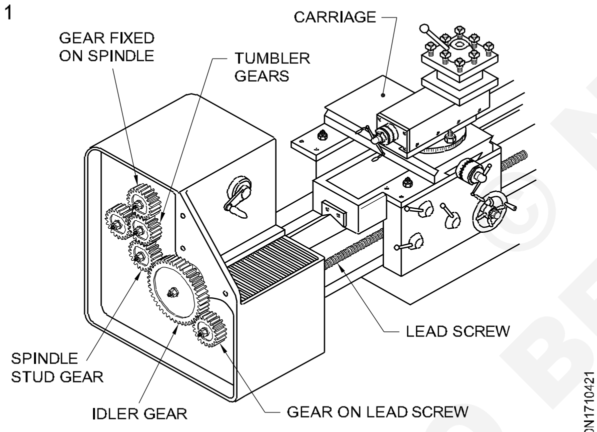
The principle of thread cutting involves producing a uniform helical groove on a cylindrical or conical surface by rotating the job at a constant speed, and moving the tool longitudinally at a rate equal to the pitch of the thread, per revolution of the job.

The cutting tool moves with the lathe carriage by the engagement of a half nut with the lead screw. The shape of the thread profile on the work is the same as that of the tool ground. The direction of rotation of the lead screw determines the hand of the thread being cut.

Parts involved in thread cutting

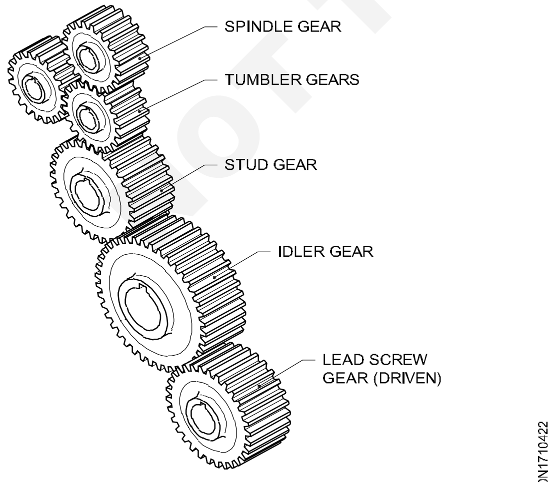
Figures 1 & 2 illustrate how the drive is transmitted from the spindle to the lead screw through a change gear arrangement. From the lead screw the motion is transmitted to the carriage by engaging the half nut with the lead screw.

Fig 1



TRANSMITTING MOTION FROM SPINDLE TO CARRIAGE

Fig 2



GEARING BETWEEN SPINDLE AND LEAD SCREW

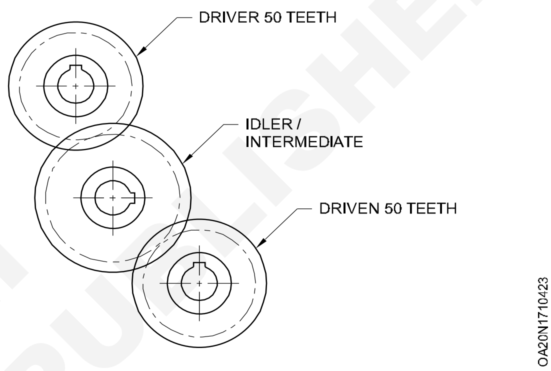
Derivation of the foumula for change gears

Example

Case 1: To cut a 4 mm pitch (lead) thread on the job in a lathe having a lead screw of 4 mm pitch.

When the job rotates once, the lead screw should make one revolution to move the tool by 4 mm. Hence, if the stud gear (driver) has a 50 tooth wheel, the lead screw should be fixed with a gear of 50 teeth (driven) to get the same number of revolutions as the spindle. (Fig 3)

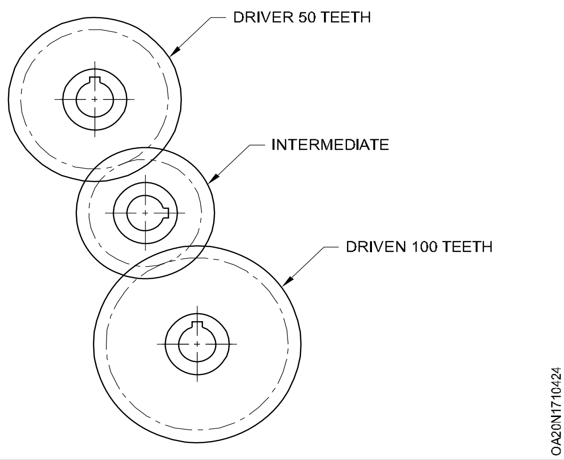
Fig 3



Case 2: To cut 2 mm pitch threads instead of 4 mm in the same lathe.

When the job makes one rotation, the lead screw should rotate 1/2 revolution so that the lead screw rotation is slower. Therefore, the driven wheel (lead screw gear) should be of 100 teeth if the driver (stud gear) is of 50 teeth. (Fig 4)

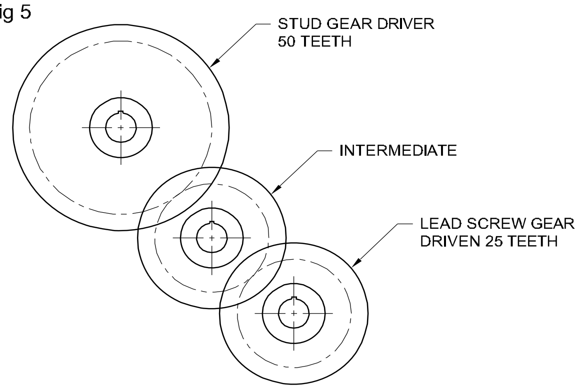
Fig 4



Case 3: If we have to cut a 8 mm pitch thread on a job, with a 4 mm lead screw pitch, the tool should move 8 mm per revolution of the job. The lead screw should rotate 2 revolutions when the job makes one rotation, making the L.S. to run twice as fast as the spindle. So the driven wheel (lead screw gear) should be of 25 teeth if the driver wheel is of 50 teeth. (Fig 5)

Let us compare the above three examples.

Fig 5



	I	II	III
Pitch(lead)of job	4	2	8
Pitch(lead) of L.S	4	4	4
Driver	50	50	50
Driven	50	100	25

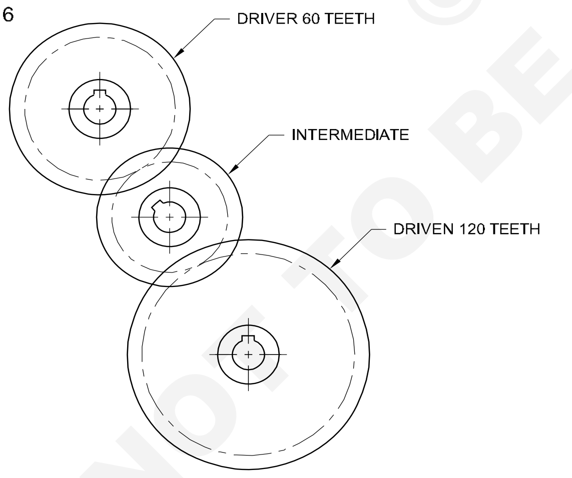
Stating the above in the form of a formula:

$$\text{The gear ratio} = \frac{\text{Driver}}{\text{Driven}} = \frac{\text{Pitch(lead)of work}}{\text{Pitch(lead)of leadscrew}}$$

Solved Examples

1 Find the change gears required to cut a 3 mm pitch on a job in a lathe having a lead screw of 6 mm pitch. (Fig 6)

Fig 6



$$\text{Ratio} = \frac{\text{Driver}}{\text{Driven}} = \frac{\text{Lead of work}}{\text{Lead of Lead Screw}}$$

$$= \frac{3}{6} \times \frac{20}{20} = \frac{60}{120}$$

Driver 60 teeth

Driven 120 teeth.

2 Find the change gears to cut a 2.5 mm pitch in a lathe having a lead screw of 5 mm pitch.

$$\text{Ratio} = \frac{\text{Driver}}{\text{Driven}} = \frac{\text{Lead of work}}{\text{Lead of Lead screw}}$$

$$= \frac{2.5}{5} \times \frac{2.5 \times 20}{5 \times 20} = \frac{50.0}{100} = \frac{50}{100}$$

Driver 50 teeth

Driven 100 teeth.

3 Calculate the gears required to cut a 1.5 mm pitch in a lathe having a lead screw of 5 mm pitch. (Fig 7)

$$\text{Ratio} = \frac{\text{Driver}}{\text{Driven}} = \frac{\text{Lead of work}}{\text{Lead of Lead screw}}$$

$$= \frac{1.5}{5} \times \frac{3}{10} = \frac{3 \times 10}{10 \times 20} = \frac{30 \text{ Driver}}{100 \text{ Driven}}$$

$$= \frac{3 \times 10}{10 \times 10}$$

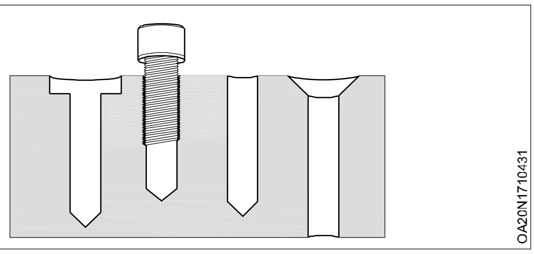
$$= \frac{30 \text{ Driver}}{100 \text{ Driven}}$$

Care to be taken during internal threading in a blind hole

Objectives: At the end of this lesson you shall be able to
- **describe the facts for making a successful threaded hole.**

Considerations for Making a successful threaded hole making a threading hole on a metal cast (Fig 1)

Fig 1



Making a successfully threaded hole depends on the properties of the material you are working on, hole characteristics, and several other parameters explained below:

Hardness Of The Material

The harder a workpiece, the greater the force you need to drill and tap the hole. For example, to thread a hole in hardened steel, you can use a tap made of carbide due to its high heat and wear resistance. To thread a hole in a hard material, you can imbibe the following:

- Reduce the cutting speed
- Cut slowly under pressure
- Apply a lubricant to the tap tool to ease Threading and prevent tool and material damage

Keep With Standard Thread Size

The thread size you use may affect the entire threading process. These standard sizes make it easy for the thread to fit in the part accurately.

You can use the British standard, the National (American) Standard, or Metric Thread (ISO) standard. The metric thread standard is the most common, with thread sizes coming in a corresponding pitch and diameter. For example, M6×1.00 has a bolt diameter of 6mm and a diameter of 1.00 between the threads. Other common metric sizes include M10×1.50 and M12×1.75.

Ensure Optimal Depth Of The Hole

Achieving the desired hole depth can be difficult, especially for threaded blind holes (a through hole is easier due to the lower restriction). As a result, you need to reduce the cutting speed or feed rate to avoid going too deep or not going deep enough.

Choose Suitable Machinery

Using the right tool can determine the success of any manufacturing process.

You can use a cutting or forming tap to make a threaded hole. Though both can create internal threads, their mechanism is different, and your choice depends on the material texture and bolt diameter factors.

Cutting Tap: These tools cut away the materials to create the internal thread leaving a space where the screw thread would fit in.

Forming Tap: Unlike cutting taps, they roll the material to create threads. As a result, there is no chip formation, and the process is highly efficient. Furthermore, it is applicable for threading parts made from soft materials like aluminum and brass.

Angled Surfaces

When working with an angled surface, the tapping tool can slide down the surface or break as it cannot withstand bending stress. As a result, working with angled surfaces should be done with care. For example, when working with an angled surface, you should mill a pocket to provide the needed flat surface for the tool.

Correct Positioning

Threading should occur in the correct position for an efficient and effective process. Threading position can be anywhere, e.g., middle and close to the edge. However, it would be best to be careful during Threading close to the edge, as mistakes during Threading can ruin the part surface finish and break the tapping tool.

Milling operations

Objectives : At the end of this lesson you shall be able to
- **state various types of milling operation**
- **state various types of cutter used.**

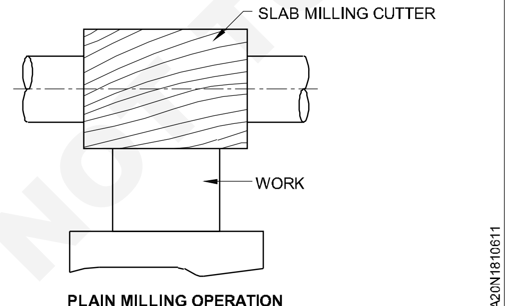
Milling Machine Operations

- Plain milling
- Face milling
- Side milling
- Straddle milling
- Angular milling
- Gang milling
- Form milling
- End milling
- Flute milling
- Keyway milling
- Drilling & reaming
- Boring
- Gear cutting
- Thread milling
- Cam milling

Plain Milling

It is the operation of production of a flat surface parallel to the axis of rotation of the cutter. It is also called as slab milling. Plain milling cutters and slab milling cutters are used to perform this operation. Fig 1 Shows Plain Milling Operation.

Fig 1

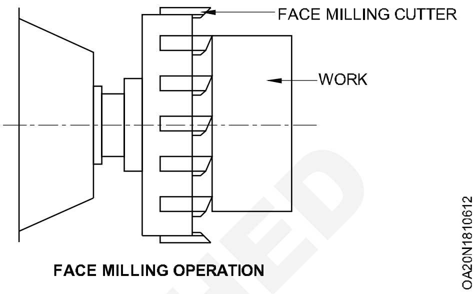


PLAIN MILLING OPERATION

Face Milling

The face milling is the operation performed by the face milling cutter rotated about an axis at right angles to the work surface. End mills and side & face milling cutter are also used at times to perform this operation . The depth of cut is provided to the table . Fig 2 Shows face milling operation.

Fig 2



FACE MILLING OPERATION

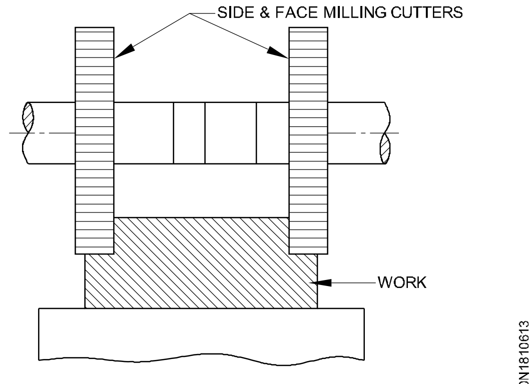
Side Milling

Side milling is the operation of machining a vertical surface on the side of a workpiece by using a side milling cutter.

Straddle Milling

It is the operation of production of two vertical surfaces on both sides of the work by two side milling cutters mounted on the same arbor. By using suitable spacing collars, the distance between the two cutters is adjusted correctly. The straddle milling is commonly used to produce square or hexagonal surfaces. (Fig 3)

Fig 3



STRADDLE MILLING OPERATION

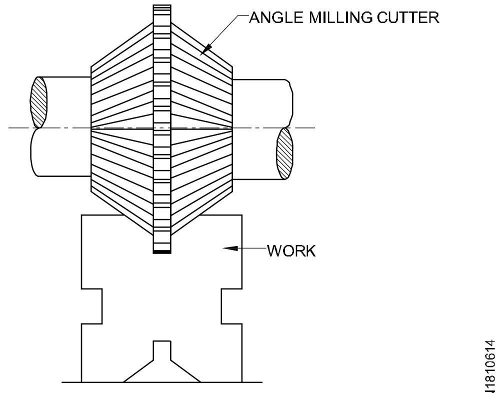
Angular Milling

Production of an angular surface on a workpiece other than at right angles to the axis of the milling machine spindle is known as angular milling. Example of angular milling is the production of the 'V' blocks. Fig 4 Shows angular Milling operation .

Gang Milling

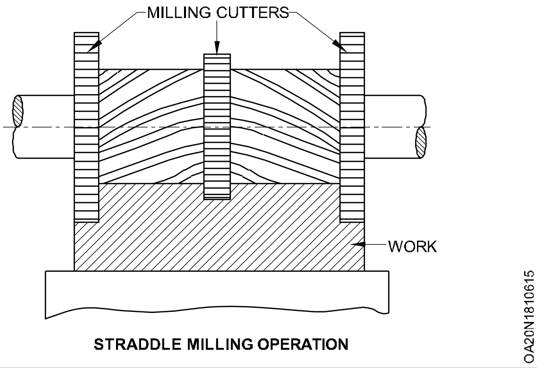
It is the operation of machining several surfaces of work simultaneously by feeding the table against a number of cutters (either of same type or of different type) mounted on the arbor of the machine. This method saves much of machining time and mostly used in production work. Fig 5 Shows gang milling operation.

Fig 4



ANGULAR MILLING OPERATION

Fig 5

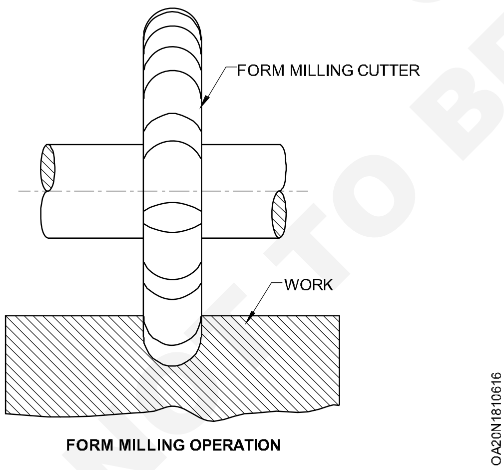


STRADDLE MILLING OPERATION

Form Milling

The form milling is the operation of production of irregular contours by using form cutters. Machining convex and concave surfaces and gear cutting are some examples of form milling. Fig 6 Shows form milling Operation.

Fig 6

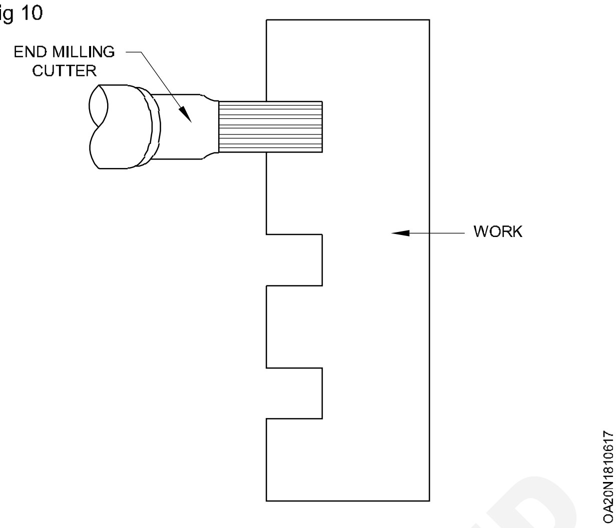


FORM MILLING OPERATION

End Milling

It is the operation of producing a flat surface which may be vertical, horizontal or at an angle to the table surfaces. The end milling is performed by a cutter known as an end mill. End milling is mostly performed in a vertical milling machine. (Fig 7)

Fig 10



Flute Milling

Flute milling is performed by selecting a suitable cutter in a milling machine. The flutes fond on the drills, reamers and taps are machined by this method.

Keyway milling

The operation of production of keyways, grooves and slots of different shapes and sizes can be performed in a milling machine by using a plain milling cutter, a metal slitting saw, an end mill or by a side milling cutter.

Drilling and reaming

The operation of drilling and reaming are performed in a milling machine by mounting drills and reamers into the spindle of the machine.

Boring

A single point cutting tool is mounted on the arbor to perform boring. By adjusting the single point cutting tool radially, different diameters of bores are machined.

Gear Cutting

Gear cutting operation is performed in a milling machine by using a form cutter. The work is held between centers on a universal dividing head. A proper gear cutter is selected and the teeth are cut by DP, module method.

Thread milling

This operation is performed in a special thread milling machine by rotating both the work and the cutter. Several cuts are made to cut the threads to their depth.

Cam Milling

Cam milling is the operation of producing cams in a milling machine with the use of a universal dividing head and a vertical milling attachment. It is performed by end mills on the cam blank.

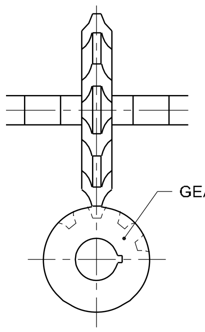
Indexing

Objectives : At the end of this lesson you shall be able to
- **state what is indexing**
- **list the types of indexing heads**
- **state the principle of direct indexing**
- **calculate the indexing movement required for direct indexing.**

What is indexing?

It is an operation of dividing the circumference of a workpiece into equally spaced divisions (Fig 1) for milling gears, splines, squares, cutting of flutes in reamers, etc.

Fig 1



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Indexing is also used to rotate the workpiece at a predetermined ratio to the table feed rate to produce cams, helical grooves etc.

This operation is performed on a milling machine by means of an indexing attachment which is called as indexing head or the dividing head.

Types of indexing heads

The most common types of indexing heads are

- direct indexing head (Fig 2)
- simple indexing head (Fig 3)
- universal indexing head. (Fig 4)

Fig 2

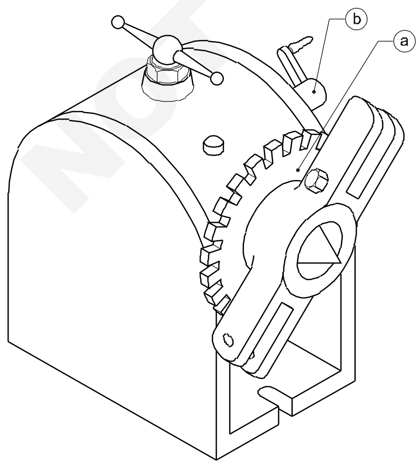

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Fig 3

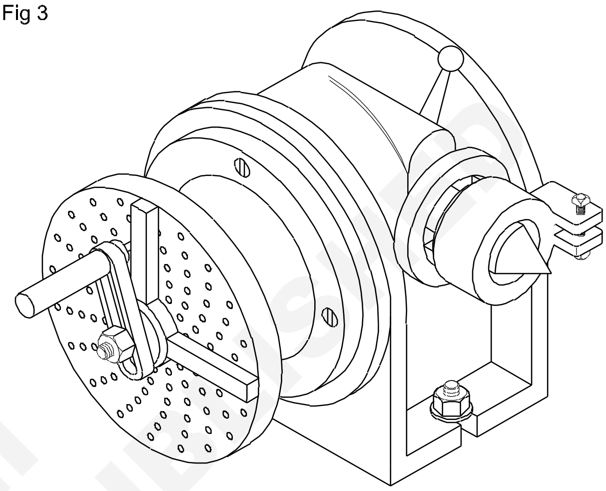

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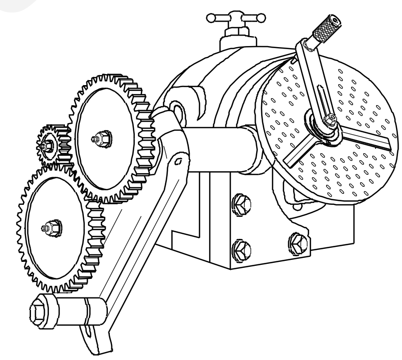
Fig 4



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Direct indexing

Purpose of direct indexing

Direct indexing is a rapid method of indexing. It is used where a large number of identical pieces are indexed by very small number of divisions. Usually, this type of indexing can be performed on a direct indexing head.

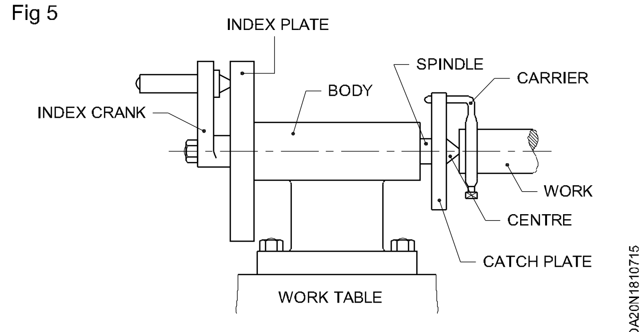
Principle of direct indexing

Direct indexing may be employed whenever the number of divisions required can be divisible without remainder into the number of holes or slots in the direct index plate.

Direct indexing mechanism (Fig 5)

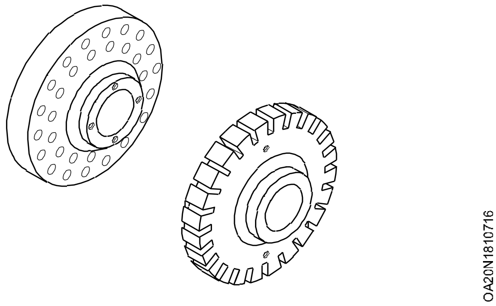
It consists of a housing, a spindle with a driving lug and an indexing crank. The rear of the housing is fitted with a flat index plate which has a number of holes spaced around the circumference of the circles of different radii. The number of holes varies from circle to circle. The index plate usually has three circles of holes with 24, 30, 36 holes respectively.

Fig 5



Another type of index plate (Fig 6) which is having a number of slots (ie.24 or 30 or 36 slots) on the periphery of the index plate, is fitted to the front end of the spindle nose. (Fig 2) The spindle is rotated by hand and locked by a pin.

Fig 6

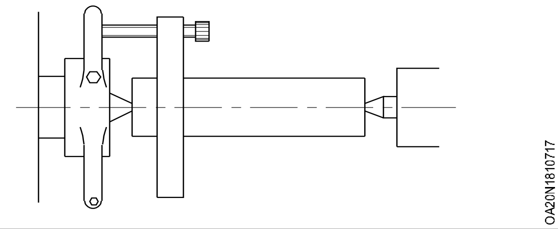


The handle of the indexing crank, which can be moved radially, is fitted with a spring-loaded index pin. The index pin engages with the holes in the indexing plate.

While indexing, the pin is taken out from the index plate hole. The spindle is rotated by the crank and after the required position is reached, it is again locked by the pin.

The workpiece can be set up in a chuck on the indexing head spindle or between centres using the indexing head and a matching tailstock. For centre work, any suitable carrier may be used to engage the workpieces with the driving lug on the indexing head spindle. (Fig 7)

Fig 7



Formula

The formula for indexing is given below.

$$\text{Index crank movement} = \frac{\text{No. of holes in the index plate}}{\text{No. of divisions required}}$$

Example

If six slots are to be machined and the 30 circles located.

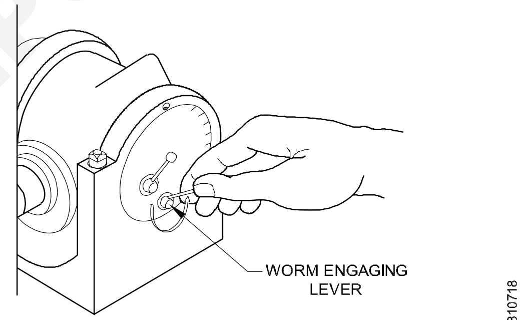
No.of index crank movement

$$= \frac{\text{No. of holes in the index plate}}{\text{No. of divisions required}} = \frac{30}{6} = 5$$

The pin is inserted in every fifth hole of the 30 hole circle.

All divisions that are exactly divisible by 360° can also be obtained - 180°, 120°, 90°, 60°, 45°, 30° and 15°. This indexing can also be performed by simple indexing head by disengaging worm from worm wheel. (Fig 8)

Fig 8



DISENGAGING WORM FROM WORM WHEEL

Plain or simple indexing

Objectives : At the end of this lesson you shall be able to
- **state the purpose of simple indexing**
- **explain the simple indexing mechanism**
- **calculate the indexing movement required for simple indexing.**

Purpose of simple indexing

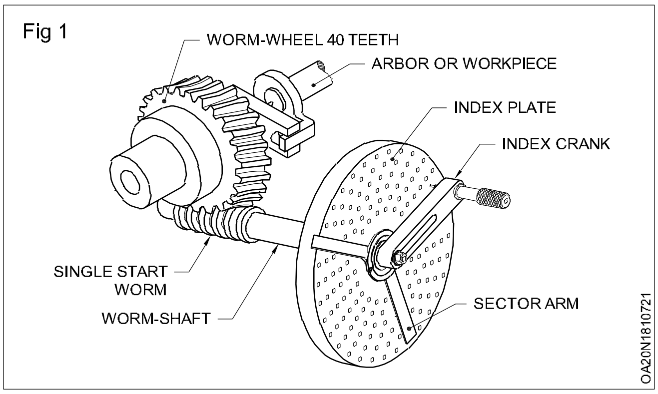
Simple indexing is used to obtain a greater number of divisions that cannot be obtained by direct indexing. This operation may be performed in both simple and universal dividing heads.

Principle of simple indexing : It is carried out using 40:1 ratio of the worm and worm- wheel mechanism. One rotation of the worm, rotates the worm-wheel spindle 1/40 of a complete turn. A fractional part of 1/40 of the revolution of the worm-wheel can be performed by using the index plate.

Simple indexing mechanism (Fig 1)

The simple indexing mechanism consists of a 40 tooth worm-wheel fastened to the spindle, a single start worm, a crank for turning the work shaft and an index plate and sector.

The worm-wheel is keyed to the spindle shaft, and meshes with the warm shaft. When the worm is given one complete turn, the worm-wheel advances one tooth or, as it has 40 teeth it will revolve 1/40 of a revolution. In other words, 40 turns of the index crank will make the spindle revolve one complete revolution.



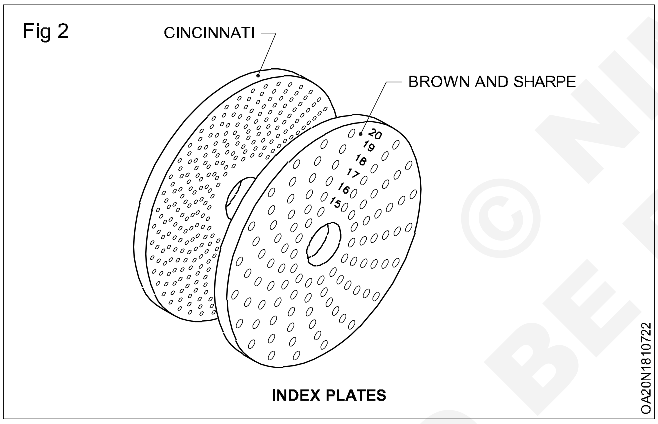
To facilitate indexing to fraction of a turn, index plates are used to cover practically all the numbers.

Index plate

The index plate is mounted behind the index crank. It is a circular plate provided with a circle of holes representing different divisions of the circle. The object of these plates is to allow the worm to be moved a fractional part of a turn.

The two systems in common use are the Brown and Sharpe index system and the Cincinnati index plate system.

Brown and Sharpe index plate system (Fig 2)



The Brown and Sharpe system has three index plates and each plate has six circles of holes.

Plate No.1 - 15, 16, 17, 18, 19, 20

Plate No.2 - 21, 23, 27, 29, 31, 33

Plate No.3 - 37, 39, 41, 43, 47, 49

With the three index plates, simple indexing can be used for all divisions up to 50, even numbers up to 100, except 96.

Cincinnati and parkinison index plate system

The Cincinnati and parkinison system uses one index plate with eleven circles of holes on each side. The plate is reversible and this gives twenty two cycle of holes.

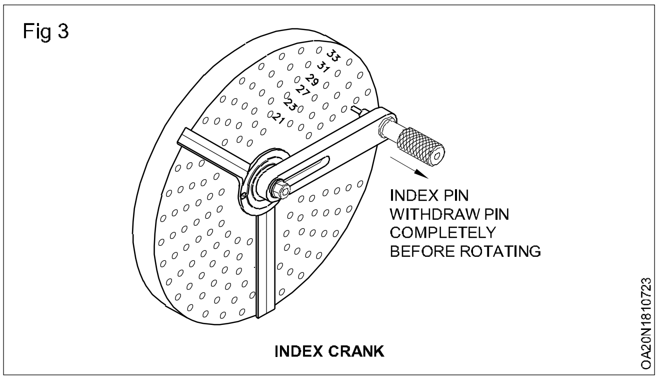
First side

24, 25, 28, 30, 34, 37, 38, 39, 41, 42, 43

Second side

46, 47, 49, 51, 53, 54, 57, 58, 59, 62, 66

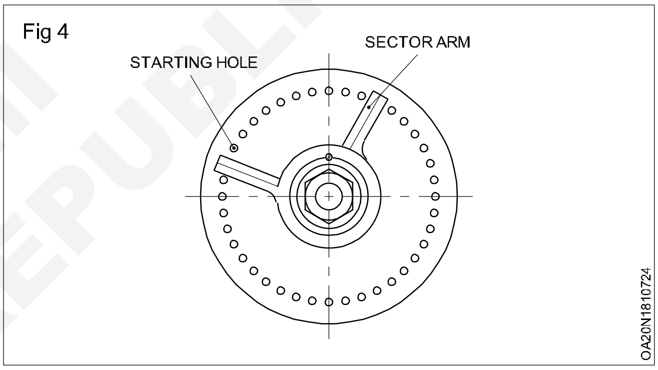
Index crank (Fig 3)



The index crank is fitted to the end of the worm-shaft. The crank carries a spring-loaded index pin to engage the hole in the plate.

The crank is rotated by withdrawing the knob, turning the crank around a selected circle of holes and releasing the knob to engage the pin in the required hole.

Sector arms (Fig 4)



There are two sector arms which fit on the face of the index plate. The arms can be set apart to cover a required number of holes between them.

Adjustment is made by slackening the lock screws, moving the arms to the desired setting and re-tightening the screws to lock the arm in position.

The arms eliminate the need for counting the number of holes each time the crank has to be turned by a set number of divisions.

Formula for simple indexing

$$\text{Index crank movement} = \frac{40}{N}$$

'N' is the number of turns of the crank required.

Example

Find the number of turns of the crank required to index 12 divisions.

$$\text{Index crank movement} = \frac{40}{N} = \frac{40}{12} = 3\frac{1}{3}$$

3 complete turns and 1/3 of a turn for each division.

To index the fractional part of a turn, select an index plate which has a circle of holes exactly divisible by the denominator of the fraction. In this case 3.

Assuming that a plate is chosen having a circle of holes equal to 24, then the number of holes that the index pin would have to move for 1/3 of a turn would be

$$\frac{24}{1} \times \frac{1}{3} = 8 \text{ holes}$$

Each division would require three complete turns of the index crank and 8 holes on the 24 hole circle.

Example

Find the number of turns of the index crank for indexing 43 holes.

$$\text{Index crank movement} = \frac{40}{N} = \frac{40}{43}$$

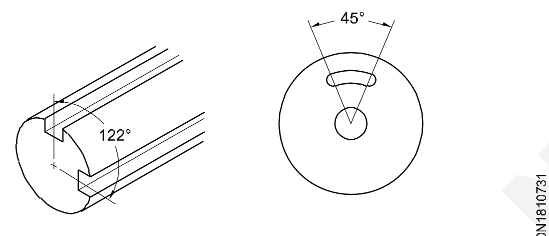
In this case a partial turn of the crank for each division is only required. A circle having 43 holes is available, so that for each division, the index crank is turned 40 holes in the 43 hole circle.

Angular indexing

Objectives : At the end of this lesson you shall be able to
- **state the need for angular indexing**
- **state the principle of angular indexing**
- **calculate the indexing movement for angular indexing.**

It is often necessary to index for a certain number of degrees as when machining, keyways, grooves, flats or other features located at angles to each other. (Fig 1)

Fig 1



EXAMPLES OF ANGULAR INDEXING

Angular indexing can be carried out using a simple indexing head equipment.

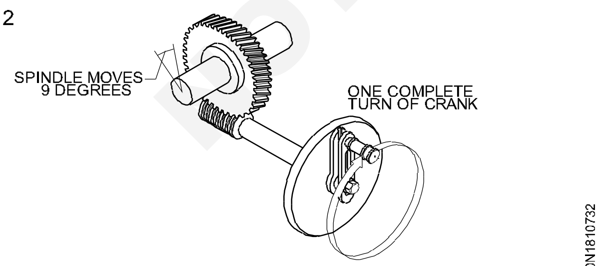
Principle

Most indexing heads require 40 turns of the crank to rotate the spindle once.

One revolution of the spindle = 360 degrees or 40 turns of the crank.

If the crank is turned once, the spindle rotates 1/40 of a turn and 1/40 of 360° is 360/40 = 9 degrees. (Fig 2)

Fig 2



PRINCIPLE OF ANGULAR INDEXING

It follows that 1/9 turn of the crank will give a spindle movement of 1 degree.

$$\text{Turn of crank (T)} = \frac{\text{Degress to be indexed (D)}}{9}$$

Example

Index for 45°

$$T = \frac{D}{9}$$

$$= \frac{45}{9} = 5 \text{ complete turns}$$

Index for 122°

$$T = \frac{D}{9}$$

$$= \frac{122}{9} = 13\frac{5}{9} \text{ turns}$$

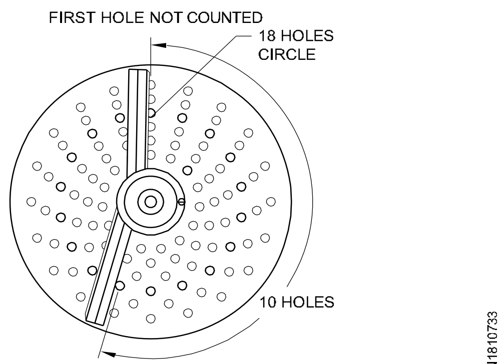
That is 13 complete turns and 5/9 of a turn. This is obtained by setting an index plate with a circle of holes divisible by 9 and setting the sector arms of 5/9 of a turn.

If a 18 hole circle is used

$$\frac{5}{9} \times 18 = 10 \text{ holes}$$

Then T = 13 turns + 10 holes of the 18 holes in the circle. (Fig 3) using brown and sharp company index plate No.1

Fig 3



SECTOR ARMS SET FOR 5/9 TURN

Indexing in minutes

One revolution of the crank gives a spindle movement of 9° and to convert the degrees into minutes multiply by 60.

9° = 9 x 60 = 540 minutes.

The number of turns of crank is found by dividing the angle to be indexed in minutes by 540.

$$\text{No.of turns} = \frac{\text{Angles to be indexed in minutes (M)}}{540}$$

Example (Figs 4 to 6)

Fig 4

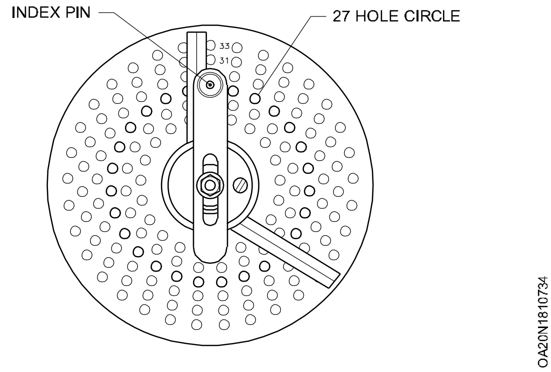


Fig 5

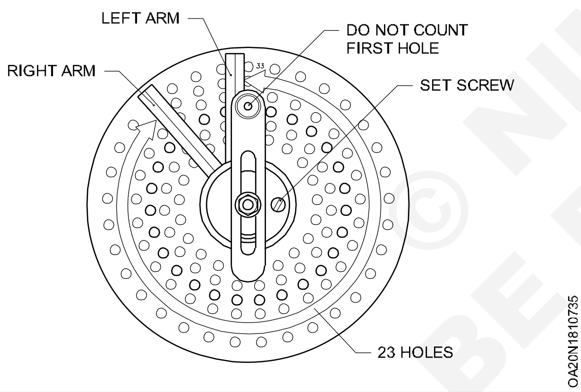
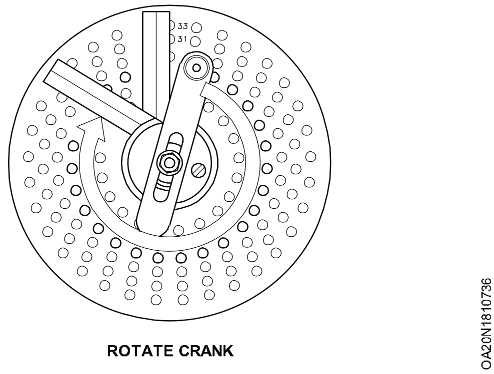


Fig 6



To index an angle of 34°40'

Angle in minutes = 34 x 60 + 40 = 2080

$$T = \frac{M}{540} = \frac{2080}{540} = \frac{208}{54} = \frac{104}{27} = 3\frac{23}{27}$$

3 complete turns plus 23 holes spaces in the 27 hole circle will give an index angle of 34° 40' by using brown and sharp company plate No.2

Indexing in seconds

One revolution of the crank gives a spindle movement of 9° and to convert the degrees into seconds multiply by 60 x 60.

9° = 9 x 60 x 60 = 32400 seconds

Index crank movement =

$$\frac{\text{Angular displacement of work in seconds}}{32400}$$

Types of gear

Objectives : At the end of this lesson you shall be able to
- **state the name of different types of gear**
- **explain the broad area of application of the different types of gear**
- **compare between involute and cycloidal gears.**

A gear is a machine element. It is used to transmit power and motion between rotating parts.

Positive transmission of power is accomplished by providing projections called teeth on the circumference of the gear.

There will be no slippage in gear drives as it is found in friction and belt drives.

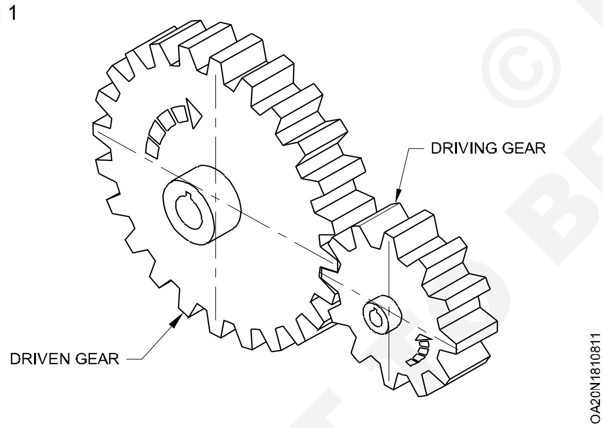
General classification of gears

Depending upon the axes, the shape of the solid on which the teeth are developed, the curvature of the tooth-trace and any other special features, gears are categorised into the following types.

Spur gear

Such gears as are having their teeth element parallel to the rotating shafts are known as spur gears. (Fig 1) These gears are most commonly used to transmit power and motion through parallel shafts.

Fig 1



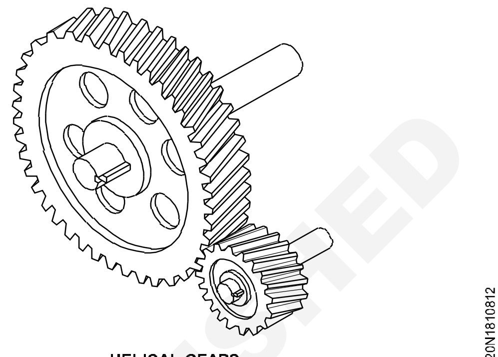
Helical gear

If the elements of the teeth are twisted or helical as shown in Fig 2, they are known as helical gears. These gears may be used for connecting shafts that are at an angle in the same plane or in different planes. Helical gears are smooth acting because there will always be more than one tooth in contact. The only disadvantage of using this gear is that there will be an axial thrust tending the shaft to move axially.

Herringbone gear

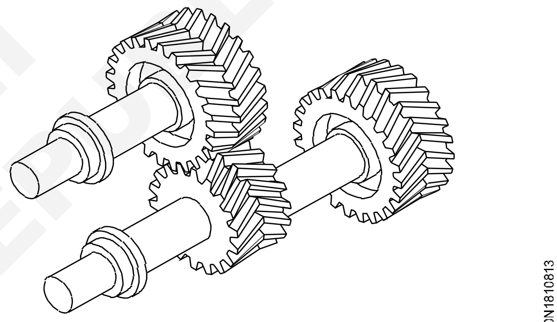
A herring bone gear is equivalent to two helical gears, one having a right hand and the other a left hand helix as shown in Fig 3. This type of gears does not produce axial thrust, and being strong are used in heavy duty machines like steel roll mills.

Fig 2



HELICAL GEARS

Fig 3

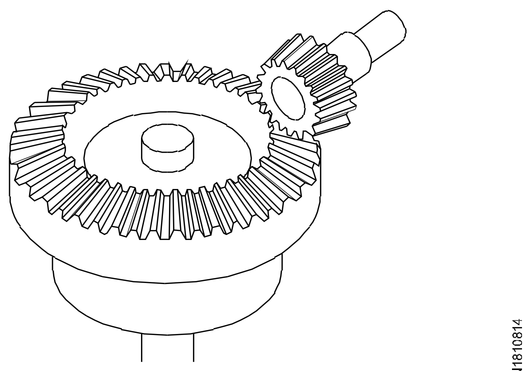


HERRING BONE GEARS

Bevel gear

Such a gear is similar in appearance to the frustum of a cone having all the elements of the teeth intersecting at a point. (Fig 4)

Fig 4

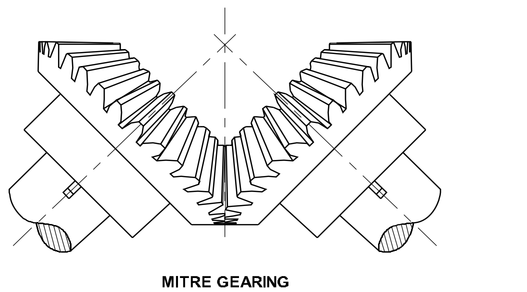


BEVEL GEAR

When two shafts are in the same plane but at an angle with one another, bevel gears are used.

When the shafts are at right angles and two bevel gears are of the same size, they are known as 'Mitre gears'. (Fig 5)

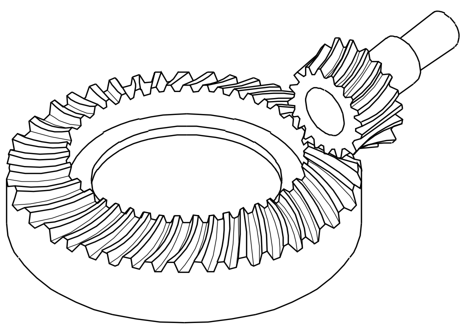
Fig 5



Hypoid gears (Fig 6)

It is the modification of a bevel gear where the shafts are at right angle but they do not intersect as do the shafts for bevel gears. The other type of bevel gears is the spiral bevel gear which has helical teeth used in automobile transmissions.

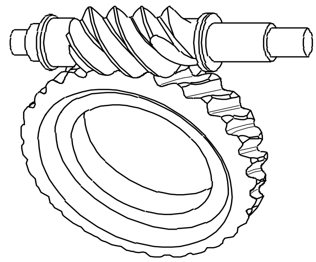
Fig 6



Worm gear

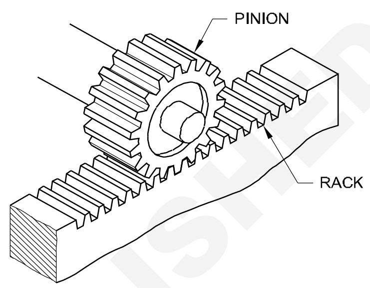
Worm gears are used where a large speed reduction is desired. The small driving gear is called a worm and the driven gear is called a wheel as shown in Fig 7. Shafts for such gears are at right angles but not in the same plane. In worm and worm wheel gearing, the worm will always be the driver. On machine tools these gears are used in the feed mechanism.

Fig 7



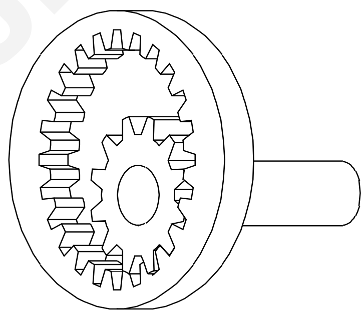
Rack gears (Fig 8) : Rack gears are straight and have no curvature. They represent a gear of infinite radius and are used in feeding mechanisms and for reciprocating drives. They may have straight or helical teeth.

Fig 8



Annular gear (Fig 9) : A gear with internal teeth is known as annular gear. Annular gears are used in automobiles.

Fig 9



Gear cutting on a Milling Machine

Objectives: At the end of this lesson you shall be able to
- **describe the gear cutting process in milling machine.**

Spur gear can be easily manufactured on a universal milling machine. In this principle of gear cutting, the solid blank wheel is mounted on the mandrel connected to the dividing head. The cutter is mounted on the arbor.

The axis of the cutter is always perpendicular to the axis of the gear blank the vertical axis of the blank wheel is properly matched with the horizontal axis of the cutter.

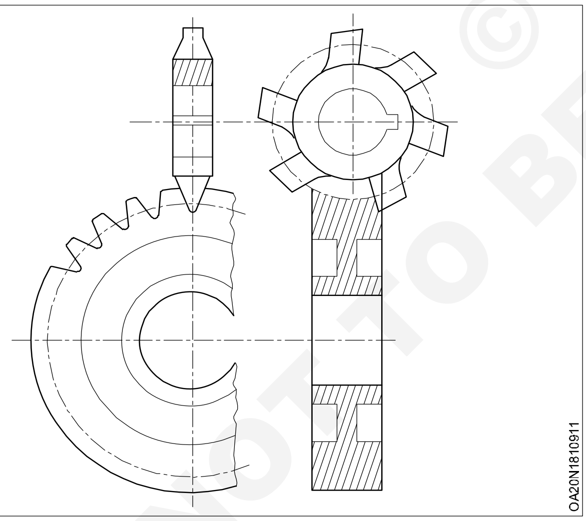
The table is then moved upward using a vertical movement crank until the nose of the cutter just touches the periphery of the gear blank wheel. The indexing movements are pre-calculated and are determined accordingly.

Then the knee is raised with the required height i.e., equal to the depth of teeth, and the vertical zero is set. Simultaneously the power is given to the cutter.

In a single pass, one tooth is finished, and the table is brought back to its starting position. This vertical movement may be less if the gear is to be cut in two or more passes. The gear blank is then indexed for the next tooth.

The same cycle of operations is repeated till the required number of teeth are cut along the periphery of the gear blank wheel. (Fig 1)

Fig 1



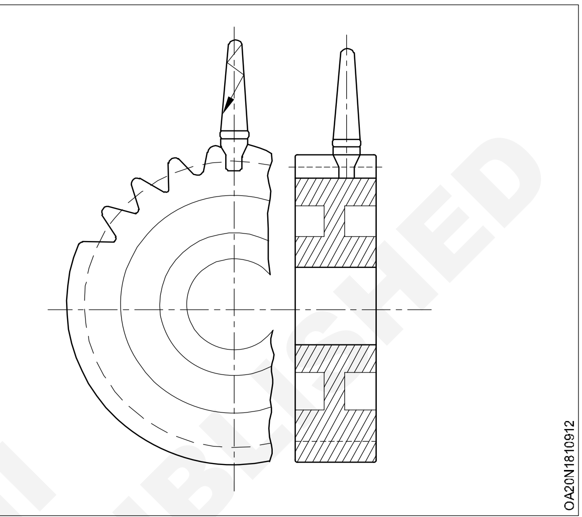
For the making of helical gears or worms on a universal milling machine, a spiral milling attachment is used.

The helix angle is obtained by the use of the attachment in order to set the cutter and the gear blank wheel at an inclination to one another. In cutting of helical gears, a set of two cutters are used.

One for roughing and the other for finishing. These gears are also cut by the same sequence of operations discussed above.

To manufacture pinion of large pitch, the end mill cutters are employed at the place of disc type cutter. The end mill cutter is mounted on the milling machine spindle through a chuck. (Fig 2)

Fig 2



Producing gears on a milling machine is one of the simplest and most economical methods. The gears of type spur, bevel and helical, and also racks can be made by the gear milling method.

The quality of gear produced cannot be considered accurate since the motion of indexing is not precise.

Following safety precautions points must be followed by operators

1 Learn to operate controls before operating the machine.

2 The work piece must be rigidly held on the worktable.

3 Keep hands and body away from the revolving cutter.

4 Do not change spindle speed when machine is running.

5 Do not remove or tighten the milling machine arbour nut while power is on.

6 Do not measure work while continuous operations.

7 Do not remove guards while machining.

8 Do not remove chips when the machining is running

9 Wear snugly fitting clothing.

10 Do not lean on the machine when it is running.

Vertical milling machine - Helical groove

Objectives : At the end of this lesson you shall be able to
- **list the parts of a vertical milling machine**
- **describe the construction of a vertical milling machine**
- **state the uses of a vertical milling machine**
- **difference between horizontal and vertical milling machines.**

Parts, construction and functions

A vertical milling machine is similar to a horizontal milling machine in all aspects except the spindle position. The spindle is supported by a vertical head in the vertical plane. The vertical head is attached to the column. The spindle rotates about the vertical axis perpendicular to the table surface.

Parts

The parts of a vertical milling machine are shown in Fig 1.

1 Base	2 Column
3 Vertical head	4 Spindle
5 Table	6 Saddle
7 Knee	

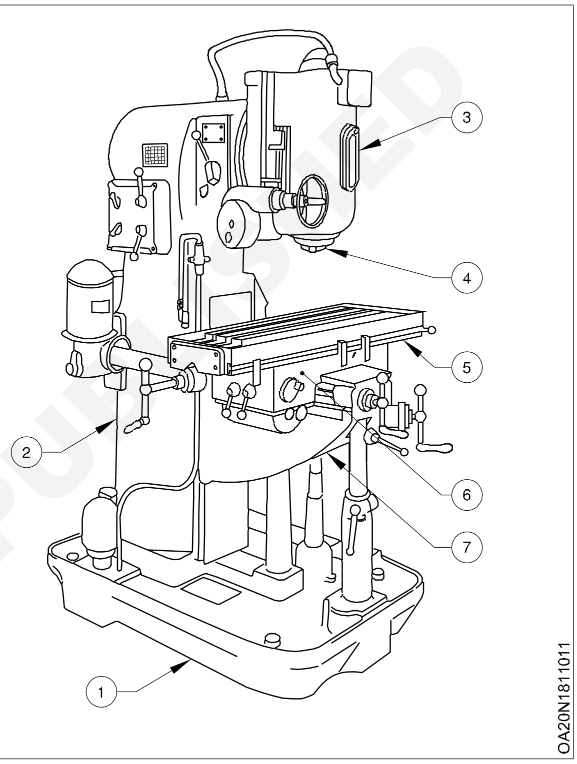
The construction and function of all parts except the vertical head (3) and the spindle (4) are the same as plain or horizontal milling machines.

The vertical head (3) is attached to the column (2), it can be swivelled up to 45° in both left/right hand directions.

The spindle (4) is mounted in the vertical head (3) and rotates about a vertical axis. The spindle can be moved up and down even when the spindle is rotating. This arrangement is useful to give feed while boring.

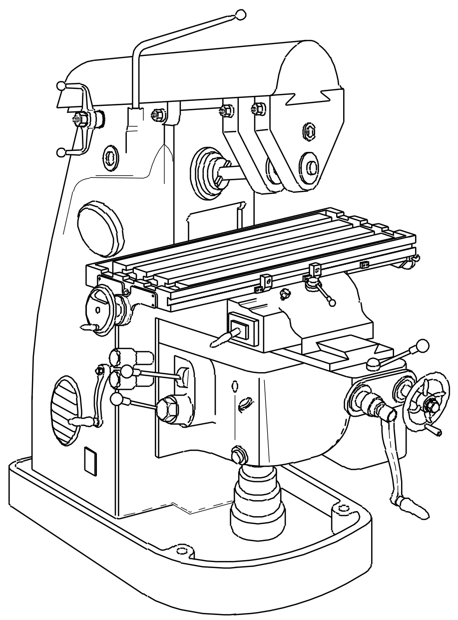
A vertical milling machine is used for face milling, 'T' slot milling, angular milling, end milling, keyway milling etc.

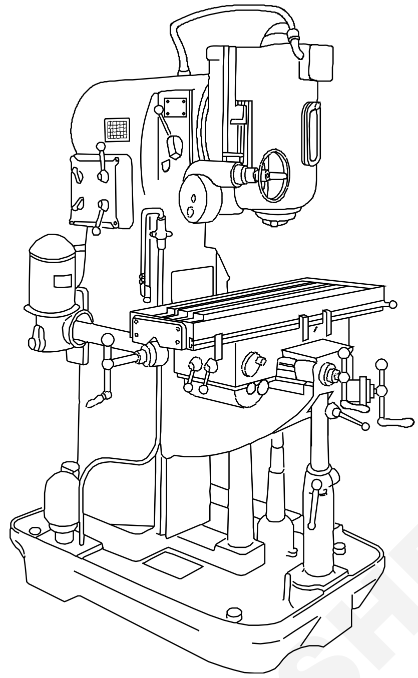
Fig 1



Differences between horizontal and vertical milling machines

Horizontal milling machine	Vertical milling machine
The spindle axis is in horizontal plane axis parallel to the table surface.	The spindle is in the vertical plane and rotates about a vertical axis perpendicular to the table surface.
The position of the spindle cannot be changed.	The spindle can be moved up and down.
Mainly, peripheral milling operation is done on this machine, using bore type cutters.	Face milling and end milling operations are done on this machine using end mills and face mills.
Angular milling cutters and swivelling vices are required to do angular milling.	Angular milling can be done just by swivelling the spindle head.
The operator will not have a good view of the milling cutter and the cutting zone.	The operator will have a better view of cutter and cutting zone.
Normally, long arbors are used to mount the cutters. The tendency to chatter is more.	The cutters are mounted on stub arbors or directly on to the spindle. So the tendency to chatter is less.





Boring heads and methods of boring in vertical milling machine

Objectives : At the end of this lesson you shall be able to
- **name the different boring bars**
- **identify each type of boring bars**
- **state the uses of each type.**

Boring is done on the vertical milling machine by using boring bars with single point tool.

The different boring bars are:

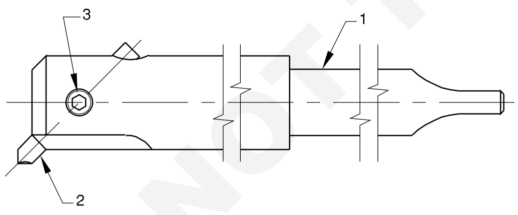
– Solid boring bar

– Adjustable boring bar or micro boring bar

– Boring heads.

Solid boring bar (Fig 1)

Fig 1

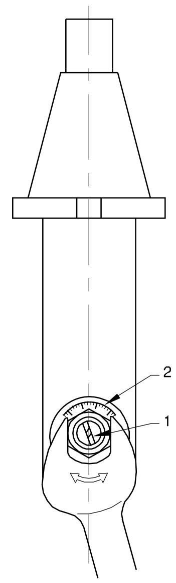


It is the simplest form of a solid bar with an angular or straight hole at one end to mount the tool, a standard shank (1) (ISO or Morse taper) at the other end. The tool (2) is held in position by a locking screw(3). The tool is adjusted further at the end of every cut.

Adjustable boring bar (Fig 2)

This type of boring bar is capable of some fine adjustment of the tool within short ranges. The tool bits are generally of a throw away type. The tools bits are mounted on the cartridges (1) with micrometer collars (2) called micro cartridges for accurate adjustments. It is useful to maintain sizes of bores within close tolerances.

Fig 2

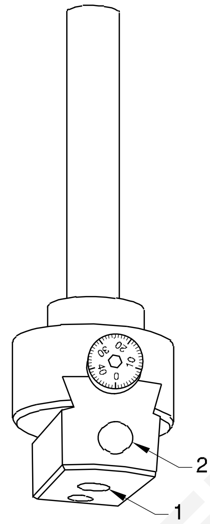


Boring heads (Fig 3)

A boring head is a rigid tool holder used to hold boring tools or boring bars. The boring heads are used to bore large holes. The range of adjustment varies from 100 to

500 mm. The boring tools can be mounted axially(1) or radically (2) in the boring head according to the size of the bore to be machined.

Fig 3



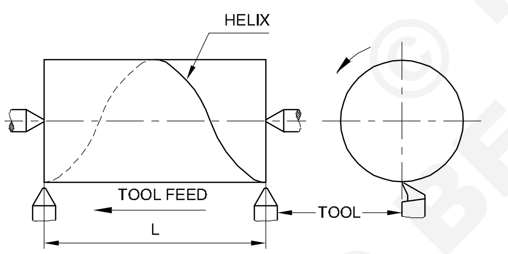
Helix and spiral introduction

Objectives : At the end of this lesson you shall be to
- **define helix and spiral**
- **state the elements of a helix**
- **difference between a helix and a spiral.**

Helix

A helix is the line generated by the progressive rotation of a point around a cylinder. (Fig 1)

Fig 1



The flutes on a drill or the threads on a bolt are examples of helices.

Spiral

A spiral is the path generated by the progressive rotation of a point moving along the surface of a cone is called conical spiral. (Fig 2)

Threads on a wood screw and pipe threads are examples of conical spirals. While watch springs and scroll threads on a self centering lathe chuck are examples of plane or flat spirals.

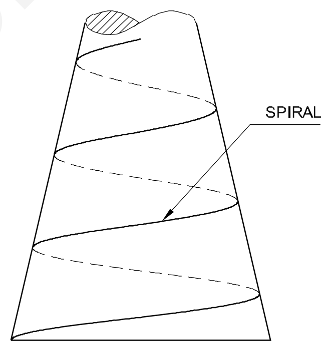
In order to cut a helix or a spiral, any two of the following elements must be known.

1 The lead of the helix

2 The angle of the helix

3 The diameter (or circumference) of the work piece.

Fig 2



1 The lead of a helix is the longitudinal distance, the helix advances axially in one complete revolution of the work.

2 The angle of helix is formed by the intersection of the helix with the axis of the work piece.

The relationship of lead circumference and helix angle is shown in the Fig 3.

The lead of a helix varies with

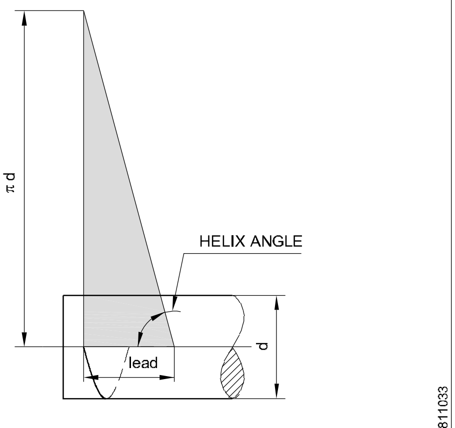
- The diameter of the work
- The angle of the helix

Differentiate between helix and spiral

Helix

A line traced on a cylindrical surface where all points of the surface area cut at the same angle.

Fig 3



RELATIONSHIP OF LEAD, CIRCUMFERENCE AND HELIX ANGLE

Spiral

A simple curve in the plane which continuously winds about itself either into some point or out from some point.

Spiral milling calculations

Objectives : At the end of this lesson you shall be able to
- **state the applications of the helix**
- **calculate the angle of helix for both metric and the British systems of dimensions**
- **determine the direction of swivel of the table with reference to the hand of helix**
- **calculate change gears for the required lead.**

Applications of helix

Helical grooves are used as flutes on cutting tools like reamers, milling cutters etc.

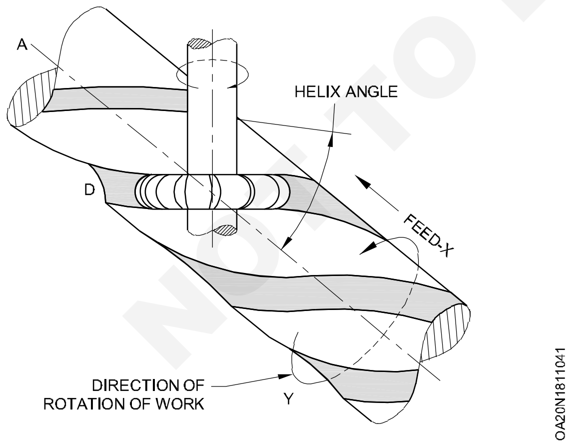
Helical grooves cut on shafts to lubricate its bush bearings.

Flat spirals known as across are used on a lathe's self-centering chucks to move the jaws for champing the work.

Determining the helix angle

To ensure that a groove of the same contour as the cutter is produced, the table must be swung to the angle of the helix. (Fig 1)

Fig 1



Note that when the table is not swung (Fig 2), a helix having the proper lead but an improper contour will be generated.

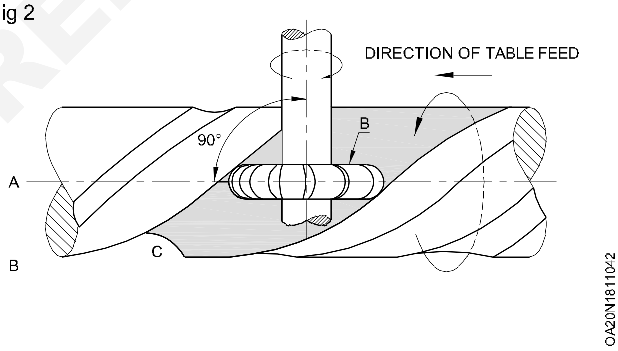
To determine the angle of swivel of the table, it is necessary to calculate the tangent of the helix angle.

Tangent of helix angle

$$= \frac{\text{Circumference of work}}{\text{lead of helix}}$$

$$= \frac{\pi \times D}{\text{lead of helix}}$$

Fig 2



Example (British system)

To what angle must the milling machine table be swivelled to cut a helix having a lead of 10.882 in a piece of work of diameter 2 inches.

Solution

Tangent of helix angle

$$= \frac{\pi \times D}{\text{lead of helix}}$$

$$= \frac{3.1416 \times 2}{10.8882}$$

$$= 0.57739$$

Helix angle $= 30^{o}$.

Example (Metric)

To what angle must a milling machine table be swivelled to cut a helix having a lead of 450 mm on a workpiece of diameter 40 mm.

Tangent of helix angle

$$= \frac{3.1416 \times D(mm)}{\text{lead of helix}(mm)}$$

$$= \frac{3.1416 \times 40}{450}$$

= 0.2792

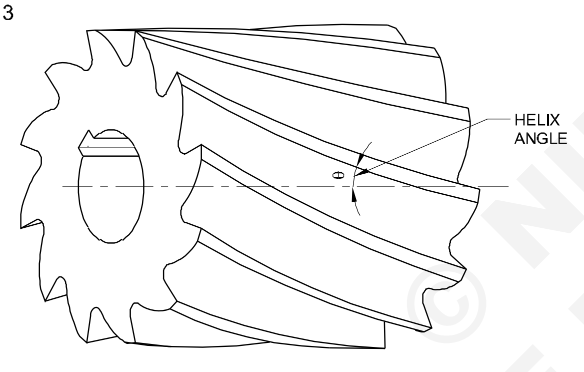
= 15°- 36'.

Determining the direction to swing the table

In order to determine the hand of a helix, hold the cylinder on which the helix is cut in a horizontal plane with its axis running in a right-left direction.

If the helix slopes down to the right, it is a right hand helix (Fig 3). A left hand helix slopes down to the left.

Fig 3



RIGHT HAND HELIX

Milling machine safety precautions

Milling machine operators must be extremely careful in running this machine tool, therefore, some of the safety points should be required to know milling operators. Following safety points must be followed by operators:

1 Learn to operate controls before operating the machine.

2 The work piece must be rigidly held on the worktable.

3 Keep hands and body away from the revolving cutter.

4 Do not change spindle speed when machine is running.

5 Do not remove or tighten the milling machine arbour nut while power is on.

6 Do not measure work while continuous operations.

7 Do not remove guards while machining.

8 Do not remove chips when the machining is running

9 Wear snugly fitting clothing.

10 Do not lean on the machine when it is running.

Procedure for milling helical gears, bend gears, rack, worm and worm wheel

Objectives: At the end of this lesson you shall be able to
- **mill the helical teeth to the desired depth.**

Procedure for helical gear

- Turn the given C-1 blank to required diameter in lathe
- Drill a hole in the blank diameter equal to mandrel size
- Fix the blank between two centres of the dividing head using mandrel.
- Set the milling cutter on the machine spindle and select the suitable speed.
- The cutter is centred accurately with the gear blank.
- Revise the table vertically up until blank touches the cutter.
- Then table is raised further to give the required depth of cut.
- According to index calculation set the dividing head and also set the compound gear train as per gear ratio.
- Move the index arm on the index plate according to the calculated number of holes.
- Switch on the spindle and feed the blank against the rotating cutter by reciprocating the table.
- Swivel the table to 20' for right hand helix.
- Then gear blank is induced for next tooths space.
- This is continued till all the gear teeth are cut.

Bevel gear

Objectives: At the end of this lesson you shall be able to
- **calculate the essential data for milling teeths on bend gear**
- **state the bend gear teeths cutting step by step.**

Procedure for bend gear

- Turn the given C-1 blank to the required size in lathe.
- Fix the blank in a M.T Shank mandrel and the mandrel into the spindle of the index head.
- Tilt the spindle of the dividing head to 41" 38' root angle of bend gear.
- Select and set the bend gear cutter 3, module 3 and mount it on the arbor.
- Centralise the job with respect to the cutter lock the cress feed and set graduated collar at '0' when the cutter toucher the layer end of bend gear.
- Apply a depth of cut 4mm and roughout all the teeths.
- Set the depth of cut at the large end to 6.75 mm back the vertical feed.
- According to the index calculate and set the dividing head.
- Move the index arm on the index plate according to the calculated number of holes.
- Mill the 1st tooth space.
- Mill the second tooth space after rotation on crank pin 1 1/3
- Check the form and measure thickness at the ends of the tooths by gear tooths Vernier caliper.
- Determine the excess material at layer end to be trimmed of by offset method.
- Repeat the steps and mill all the teeths.
- Correct and mill all the 30 teeths.

Rack gear

Objectives: At the end of this lesson you shall be able to
- **describe the procedure for racking milling cutting.**

Procedure for Rack milling

- Mill the rack blank to the given dimension as per the drawing.
- Clean the machine table and mount the machine vice keeping jaws perpendicular to the machine.
- Align it with dial test indicator.
- Mount 2 module rack cutter at the middle of the arbor
- Bring the job under the cutter such that centre of the cutter form is aligned to the edge of the job.
- Eliminate the backlash, adjust the graduated collar of the cress slde and the elevating screw to zero.

- Start the machine and mill the initial portion of the rack to a depth in two steps, 3 mm for the roughing cut and 1.5 mm for the finishing cut.
- Slide the job using a cross slide to a pitch distance of 6.28 mm and reset the collar again to zero.
- Start the machine and mill the rest two.
- Repeat the above sequence and mill the remaining rack teeth over the entire length of the job.

Worm wheel gear

Objectives: At the end of this lesson you shall be able to
- **describe the procedure for worm wheel gear teeth cutting.**

Procedure for cutting worm wheel teeth on milling

- Check the size of the blank, outside dia throat area and throat radius
- Fix the blank between two centres of the dividing head using mandrel.
- Mount a job between centres using a mandrel
- Check run out
- Mount cutter no.6 of 2 module on the arbor.
- The cutter is centred accurately with the gear blank.
- Raise the table up until blank touched the cutter.
- Swine the table to 3"16' for right band
- According to index calculation, set the dividing head.
- Set the indexing head for indexing.
- Switch on the spindle and feed the blank against the rotating cutter without moving the table.
- Only drum movement not for table movement.
- Drill one tooth space to a depth by plugging the job gradually by using vertical feed.
- The gear blank is indexed next to its space.
- This is continued till all the gear teeth are cut deburr and finish the job

Worm gear

Objectives: At the end of this lesson you shall be able to
- **describe the cutting of worm.**

Procedure for cutting worm

- Check the dia of worm blank
- Mount the job in between centres and align it.
- Centralise the job with respect to cutter,
- Mount the unused milling attachment into the spindle of a universal milling machine.
- Set the universal index.
- Disengage the shaft from wheel of the index head by shifting the eccentric bush.
- This is essential to mill work thread with short lead.
- Set driver gear are 40,64 and driver gear are 100,32 in the gear train.
- Select and mount a gear cutter 2 module on the spindle attachment.
- Swivel the table or attachment of the machine to 3"15' for right hand helix.
- Give a depth of cut 4.5 mm by vertical feed.
- Feed the job longitudinally slowly, gentle and mill he worm thread.
- Check the thickness of the teeth by Vernier caliper from tooth caliper

Gauges different types and uses

Objectives : At the end of this lesson you shall be to
- **list the various types of gauges**
- **explain the care and maintenance of gauges.**

Materials for gauges

The material used for manufacturing the gauge must fulfil the following requirements, either by virtue of its own properties, or by a heat treatment process.

- Hardness to resist wear.
- Stability to ensure that its size and shape will not change over a period of time.
- Corrosion resistance
- Machinability to enable it to be machined easily into the required shape and to the required degree of accuracy.
- Low coefficient of linear expansion to avoid effect of temperature.
- The parts of the gauge which are to be held in the hand should have low thermal conductivity.

A good quality high carbon steel is usually used for gauge manufacture. Suitable heat treatment can produce a high degree of hardness coupled with stability. High carbon steel is relatively inexpensive, it can be readily machined and brought to a high degree of accuracy and surface finish.

Gauges can also be made from steels, special wear resisting materials, like hard chrome plated surfaces and tungsten carbide, Invar etc. Glass gauges were used during World War. Chromium plating makes the gauge corrosion and wear resistant. Also, the size of worn gauging surface can be increased by this method. The gauge surfaces can also be plated to provide hardness, toughness and stainless properties.

Care of Gauges

While using the gauges proper care should be taken to prolong their maximum useful life. Some suggestions for their use and care are:

- Master, inspection and working gauge should be employed only to the uses for which they are intended, as follows:

Type of gauge	intended use
Master gauge	To check inspection and working gauges
Inspection gauge	To check the finished product
Working gauge	To check the product as it is being manufactured.

Care and maintenance of gauges

- A plain cylindrical gauge should be cleaned properly, and a thin film of light oil should be applied to the gauging surfaces before it is used.
- The work should also be cleaned before checking with the gauges. Then the gauge should be aligned with the hole to be measured and given a forward motion combined with a slight rotation. To Go plug gauge will enter the hole if the hole is of correct size otherwise, it will not enter it. The same procedure may be applied while using plane cylindrical gauges.
- Force should not be applied in gauging operation as it tends to harm the gauge, the work or both. Therefore, the snap gauge should not be forced over the work because it will cause the gauge to pass on oversized parts and it may also spring the frame of the gauge.
- A gauge should be properly cleaned after use and prepared for storage. It should be coated with a rust preventive oil, if it is to be stored for a short time only. However, if it is to be stored for a longer period, it should be dipped in a molten plastic material designed as a protective coating for tools, and gauges.

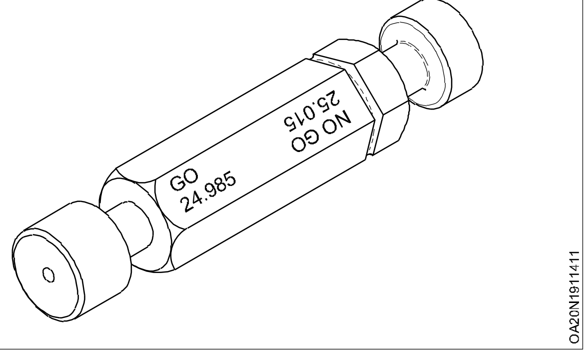
Limit gauges

Objectives: At the end of this lesson you shall be able to
- **state the features of the 'Go' and 'No-Go' limit gauges**
- **Identify the common types of limit gauges and state their uses.**

When a number of components have to be checked, it is not necessary to measure the size exactly but only to check whether the components' size lies within the limits. The most economical method of checking a component is with a limit gauge. These gauges are used in inspection because they provide a quick means of checking a specific dimension.

'Go' and 'No-Go' limit gauges (Fig 1) : The dimensions of the 'Go' and 'No-Go' ends of gauges are determined from the limits stated on the dimension to be gauged.

Fig 1



In the ‘Go’ and ‘No-Go’ method of gauging, the ‘Go’ end of the gauge must go into the feature being checked and the ‘No-Go” end must not go into the same feature.

The dimension of the ‘Go’ end is equal to the maximum permissible dimension and that of the ‘No - Go’ end is equal to the minimum permissible dimension of the component being checked.

Essential features

These gauges must be easy to handle and accurately finished. They are generally finished to one-tenth the tolerance it is designed to control.

For example, if the tolerance is to be maintained to 0.02 mm, then the gauge must be finished to one-tenth the tolerance it is designed to control.

For example, if the tolerance is to be maintained to 0.02 mm, then the gauge must be finished to within 0.002 mm of the required size.

They must be resistant to wear, corrosion and expansion due to temperature.

Their production cost must be low.

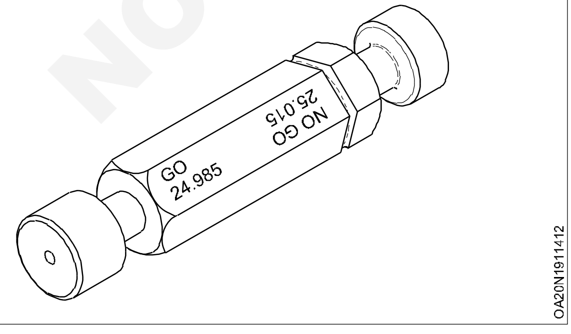
The ‘Go’ end is made longer than the ‘No-Go’ end for easy identification. Sometimes a groove is cut on the handle near the ‘No - Go’ end to distinguish it from the ‘Go’ end.

Types

Cylindrical plug gauges

Double ended plug gauge (Fig 2)

Fig 2



Progressive plug gauge (Fig 3)

Plain cylindrical plug gauges are used for checking the inside diameter of the straight hole. the ‘Go’ gauge checks the lower limit of the hole and the ‘No-Go” gauge checks the upper limit. The plugs are ground and lapped. (Fig 4)

Fig 3

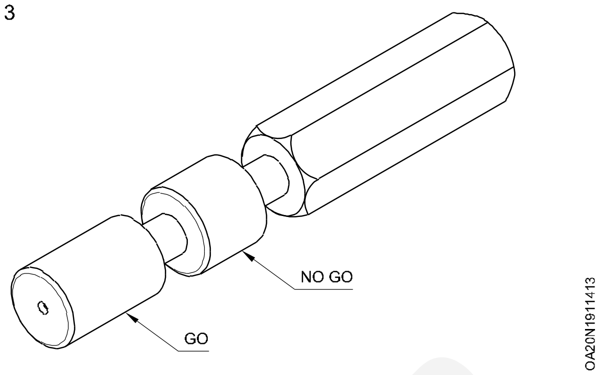
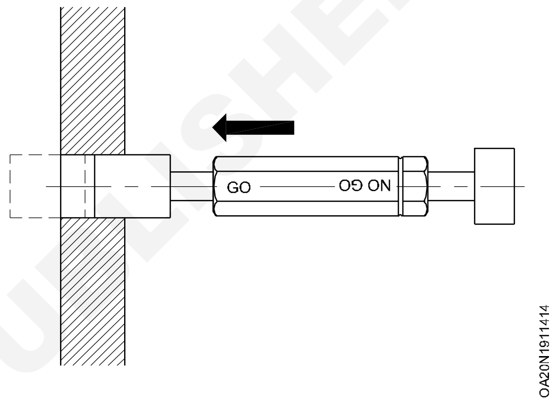


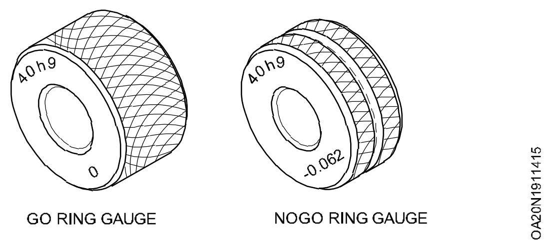
Fig 4



Plain ring gauges (Fig 5)

They are used to check the outside diameter of pieces. Separate gauges are used for checking ‘Go’ and ‘No-Go’ sizes. The ‘No-Go’ gauge is identified by an annular groove on the knurled surface.

Fig 5



Taper plug gauges (Fig 6)

These are made with standard or special tapers and are used to check the size of the hole and the accuracy of the taper. The gauge must slide into the hole for a prescribed depth and fit perfectly. An incorrect taper is evidenced by a wobble between the plug gauge and the hole.

Taper ring gauges (Fig 7)

They are used to check both the accuracy and the outside diameter of an external taper. Taper ring gauges often have scribed lines or a step ground on the small end to indicate the ‘Go’ and ‘No-Go’ dimensions.

Fig 6

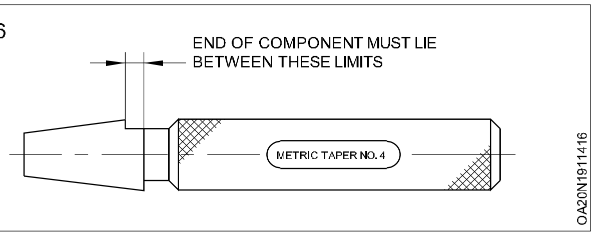
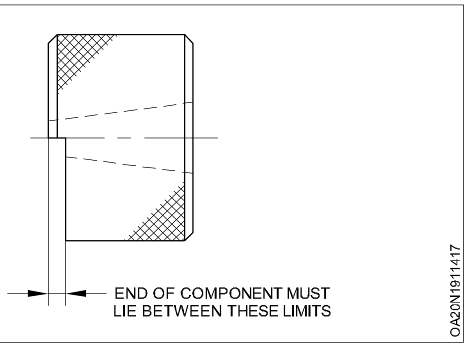


Fig 7



Thread plug gauges (Figs 8 & 9)

Internal threads are checked with thread plug gauges of 'Go' and 'No-Go' variety and employ the same principle as cylindrical plug gauges.

Fig 8

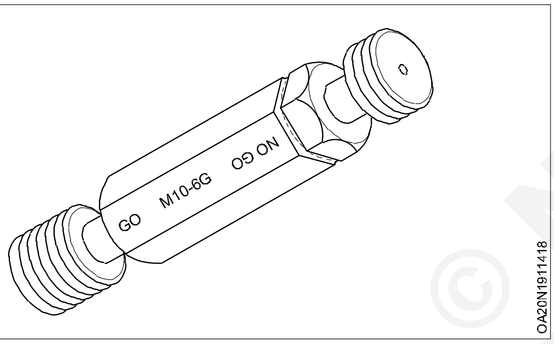
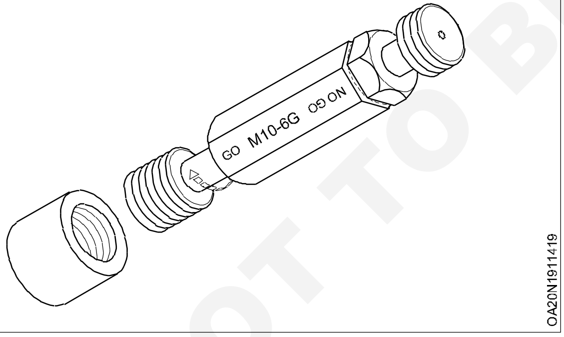


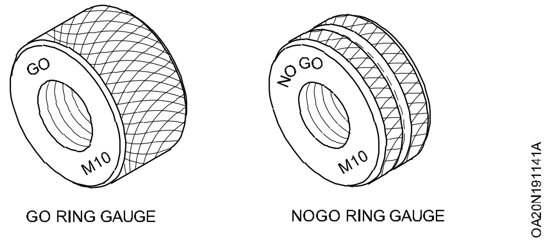
Fig 9



Thread ring gauges (Fig 10)

These gauges are used to check the accuracy of external threads and have a threaded hole in the centre.

Fig 10



Snap gauges (Figs 11 & 12)

Snap gauges are a quick means of checking diameters and thickness within certain limits by comparing the part size, to the dimension of the snap gauge.

Snap gauges are generally C-shaped and are adjustable to the maximum and minimum limits of the part being checked. When in use, the work should slide into the 'Go' gauge but not into the 'No-Go' gauge.

Fig 11

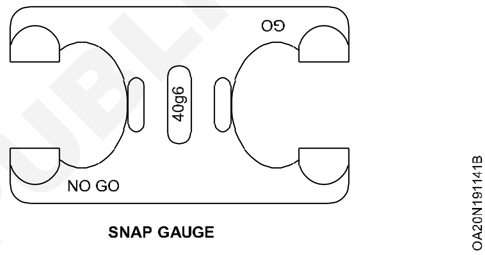
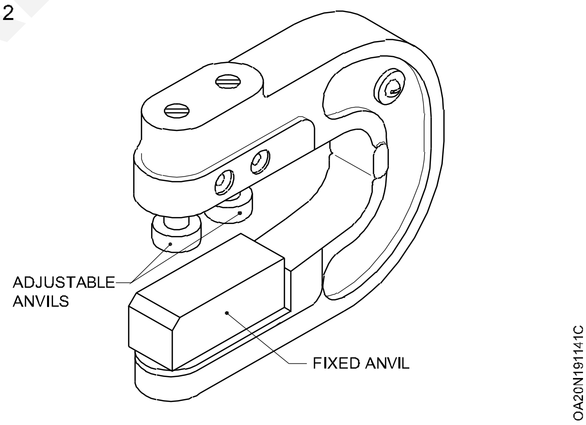


Fig 12



Comparator gauges

Objectives: At the end of this lesson you shall be able to
- **state the purpose of comparator gauges**
- **state the principle of working of comparator gauges**
- **state the essential features of a good comparator gauge**
- **state the purpose of a comparator gauge**
- **differentiate between gauges and measuring instruments.**

Purpose of a comparator gauge

The purpose of all comparator gauges is to indicate the difference in the size between the standard (slip gauge or ring gauge) and the work being measured by means of some form of pointer on a scale at a magnification which is sufficient to read to the accuracy required. Almost every possible principle known to the Science of Physics for providing magnification has been used for the construction of these comparator gauges.

Essential features of a good comparator gauge

– Should be compact.
– Maximum rigidity.
– Maximum compensation for temperature effects.
– No backlash in the movement of the plunger and recording mechanism.
– Straight line characteristics of the scale readings.
– Most suitable measuring pressure which remains uniform throughout the scale.
– Indicator should be consistent in its return to zero.
– Method of indication should be clear and the pointer 'dead beat' (ie. free from oscillations).
– Should be able to withstand reasonable wrong usage.
– Should have a wide range of operations.

Principles of working

The following principles are employed in the commonly used comparator gauges.

– Mechanical
– Electronics
– Pneumatic
– Optical

Difference between measuring instrument and gauges

Measuring instrument	Gauges
It is used to measure actual size of component.	It is used to check the dimensions within the specified limits.
These have an adjustable facility.	In most cases these have no adjustable facility.
Variable dimension instrument.	Fixed dimension instrument.
They have a graduations.	They have no graduation.
These are used to measure processing and finishing of the component.	Only for finished component.
Skill required.	Un skilled person may also used.
These are used in Tool room work.	Mainly used in mass production.

Gears - types and uses

Objectives : At the end of this lesson you shall be to
- **name the different types of gears**
- **state the broad area of application of the different types of gears**
- **state the merits and demerits of each gears.**

A gear is a machine element. It is used to transmit power and motion between rotating parts.

Positive transmission of power is accomplished by providing projections called teeth on the circumference of the gear.

There will be no slippage in gear drives as it is found in friction and belt drives.

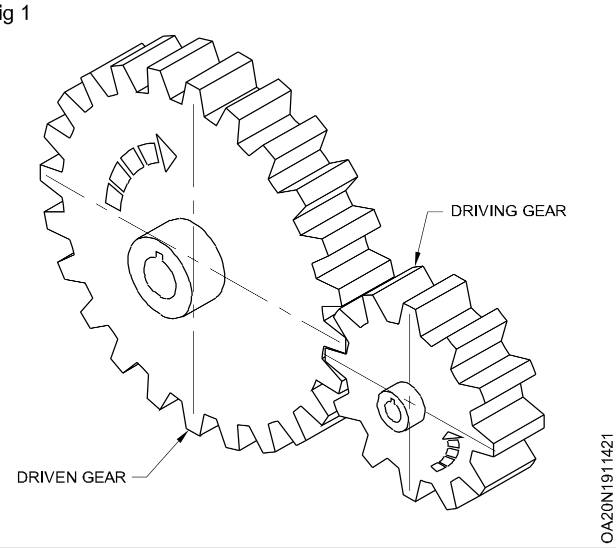
General classification of gears

Depending upon the axes, the shape of the solid on which the teeth are developed, the curvature of the tooth-trace and any other special features, gears are categorized into the following types.

Spur gear (Fig 1)

Such gears as are having their teeth element parallel to the rotating shafts are known as spur gears. (Fig 1) These gears are most commonly used to transmit power and motion through parallel shafts.

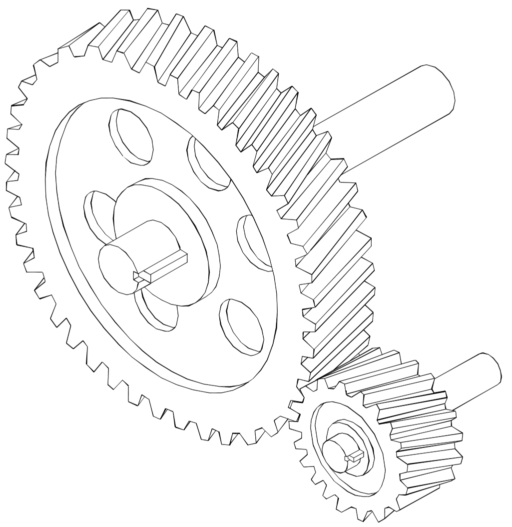
Fig 1



Helical gear (Fig 2)

If the elements of the teeth are twisted or helical as shown in Fig 2, they are known as helical gears. These gears may be used for connecting shafts that are at an angle in the same plane or in different planes. Helical gears are smooth acting because there will always be more than one tooth in contact. The only disadvantage of using this gear is that there will be an axial thrust tending the shaft to move axially.

Fig 2



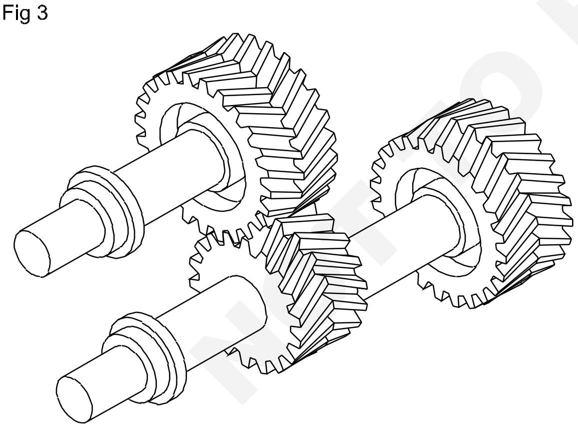
HELICAL GEARS

OA20N1911422

Herringbone gear (Fig 3)

A herringbone gear is equivalent to two helical gears, one having a right hand and the other a left hand helix as shown in Fig 3. This type of gears does not produce axial thrust, and being strong are used in heavy duty machines like steel roll mills.

Fig 3



HERRING BONE GEARS

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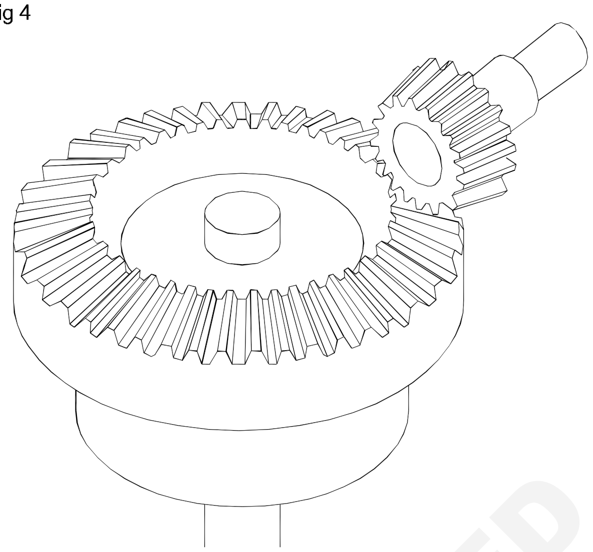
Bevel gear (Fig 4)

Such a gear is similar in appearance to the frustum of a cone having all the elements of the teeth intersecting at a point. (Fig 4)

When two shafts are in the same plane but at an angle with one another, bevel gears are used.

Fig 4



BEVEL GEAR

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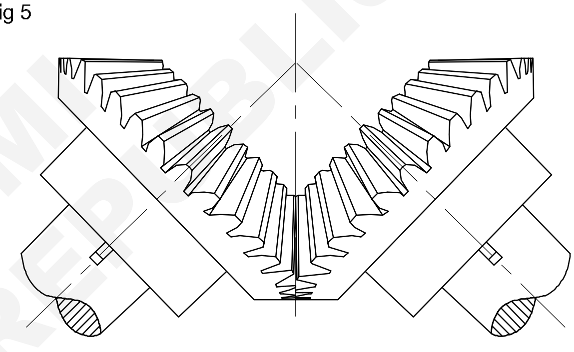
When the shafts are at right angles and two bevel gears are of the same size, they are known as ;Mitre gears' (Fig 5)

Fig 5



MITRE GEARING

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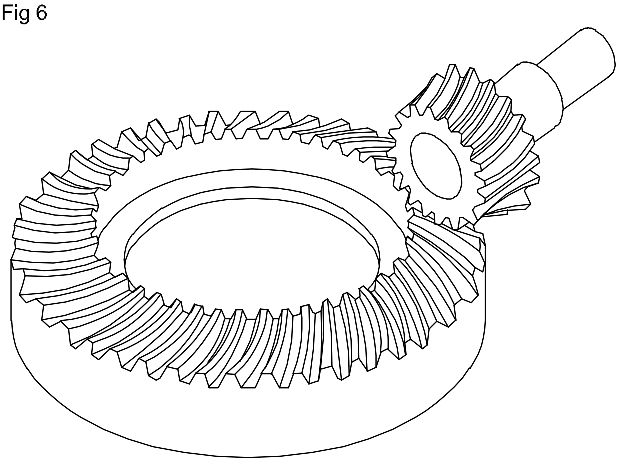
Hypoid gears (Fig 6)

It is the modification of a bevel gear where the shafts are at right angle but they do not intersect as do the shafts for bevel gears. The other type of bevel gears is the spiral bevel gears is the spiral bevel gear which has helical teeth used in automobile transmissions.

Fig 6



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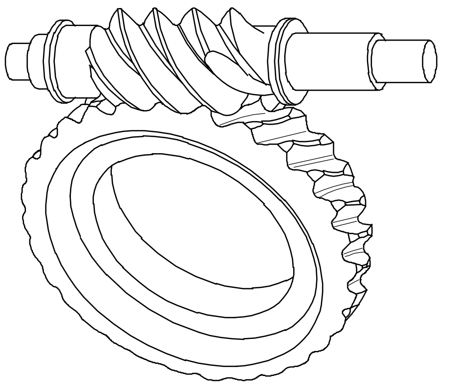
Worm gear (Fig 7)

Worm gears are used where a large speed reduction is desired. The small driving gear is called a worm and the driven gear is called a wheel as shown in Fig 7.Shafts for such gears are at right angles but not in the same plane. In worm and worm wheel gearing, the worm will always be the driver. On machine tools these gears are used in the feed mechanism.

Fig 7



Rack gears (Fig 8)

Rack gears are straight and have no curvature. They represent a gear of infinite radius and are used in feeding mechanisms and for reciprocating drives. They may have straight or helical teeth.

Annular gear (Fig 9)

A gear with internal teeth is known as annular gear. Annular gears are used in automobiles.

Fig 8

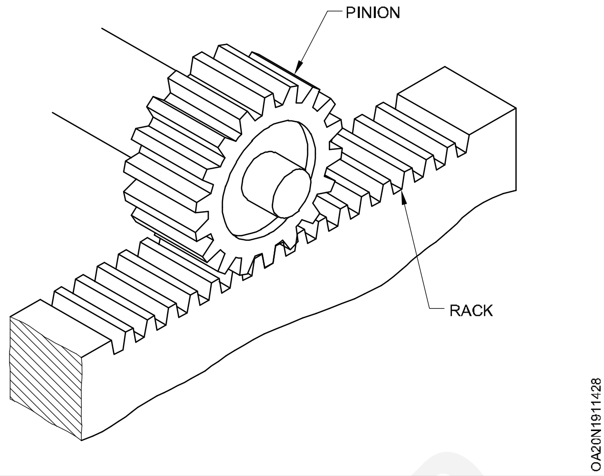
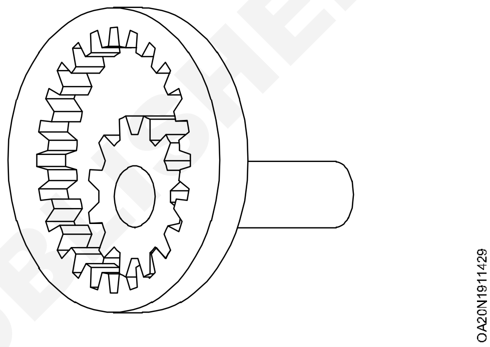


Fig 9

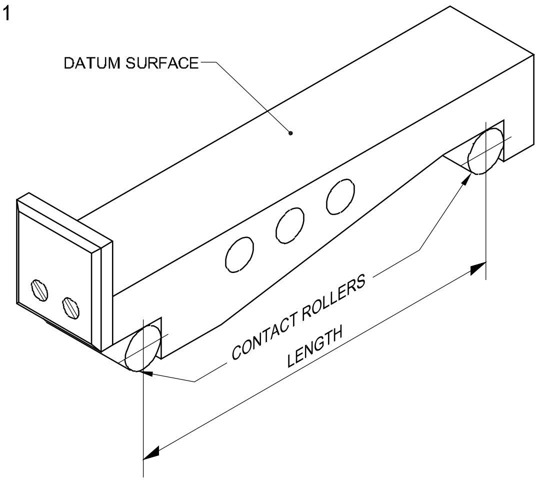


Use of sine bar and slip gauge

Objectives: At the end of this lesson you shall be able to
- **state the principle of a sine bar**
- **specify the sizes of sine bars**
- **state the features of sine bars**
- **state the different uses of sine bars.**

A sine bar is a precision measuring instrument for checking and setting of angles. (Fig 1)

Fig 1

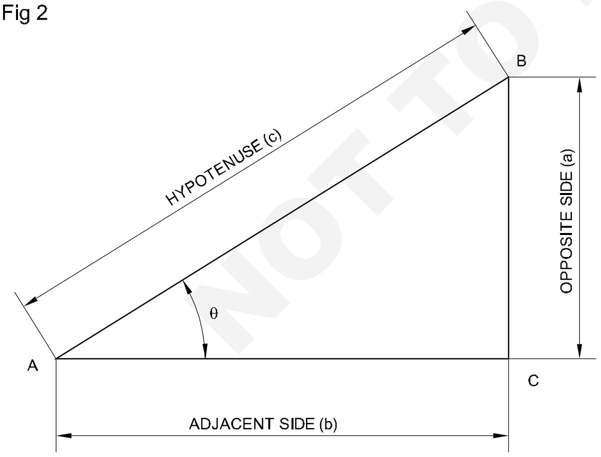


The principle of a sine bar

The principle of a sine bar is based on the trigonometrical function.

In a right angled triangle the function known as Sine of the angles is the relationship existing between the opposite side to the angle and the hypotenuse. (Fig 2)

Fig 2

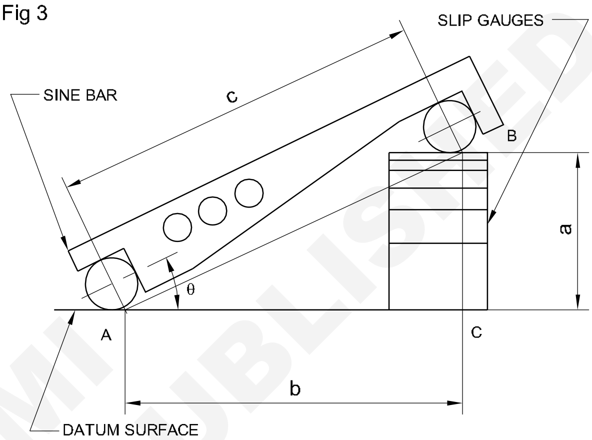


It may be noted that for setting the sine bar to different angles, slip gauges are used.

A surface plate or marking table provides the datum surface for the set up.

The sine bar, the slip gauges and the datum surface upon which they are set form a right angled triangle. (Fig 3)

Fig 3



The sine bar forms the hypotenuse (c) and the slip gauge stack forms the side opposite (a).

$$\text{Sine of the angle } \theta = \frac{\text{Opposite side}}{\text{hypotenuse}}$$

$$\text{Sine } \theta = \frac{a}{c}$$

Features

This is a rectangular bar made of stabilized chromium steel.

The surfaces are accurately finished by grinding and lapping.

Two precision rollers of the same diameter are mounted on either end of the bar. The centre line of the rollers is parallel to the top face of the sine bar.

There are holes drilled across the bar. This helps in reducing the weight, and also it facilitates clamping of sine bar on angle plate.

The length of the sine bar is the distance between the centres of the rollers. The commonly available sizes are 100 mm, 200 mm, 250 mm and 500 mm. The size of a sine bar is specified by its length.

Uses

Sine bars are used when a high degree of accuracy to less than one minute is needed for

Determining taper using sine bar and slip gauges

Objectives: At the end of this lesson you shall be able to
- **determine correctness of a known angle**
- **calculate the height of slip gauges to a known angle.**

Sine bars provide a simple means of checking angles to a high degree of accuracy of not less than one minute upto 45^0.

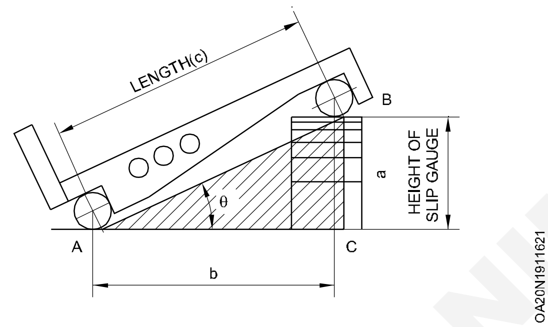
The use of a sine bar is based on trigonometric function. The sine bar forms the hypotenuse of the triangle and the slip gauges the opposite side. (Fig 1)

Checking the correctness of a known angle

For this purpose first choose the correct slip gauge combination for the angle to be checked.

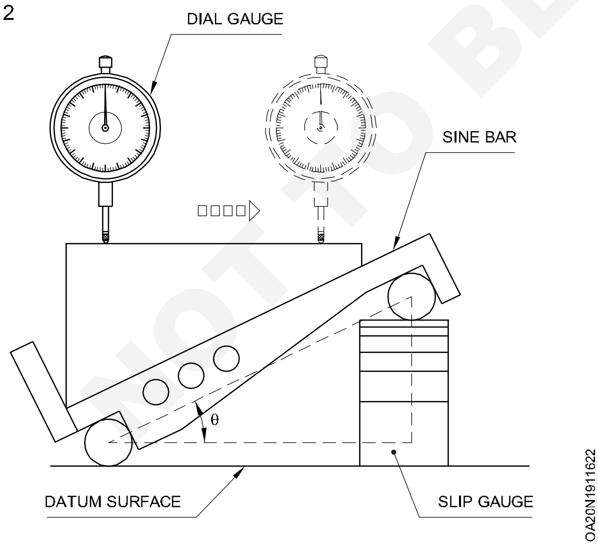
The component to be checked should be mounted on the sine bar after placing the selected slip gauges under the roller. (Fig 1)

Fig 1



A dial test indicator is mounted on a suitable stand or vernier height gauge. (Fig 2) The dial test indicator is then set in first position as in the figure and the dial is set to zero.

Fig 2

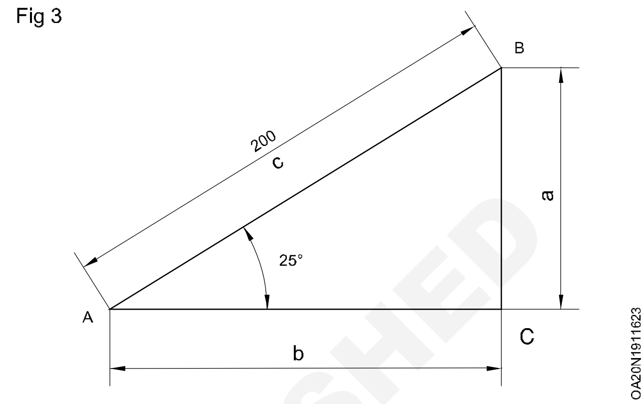


Move the dial to the other end of the component (second position). If there is any difference then the angle is incorrect. The height of the slip gauge pack can be adjusted until the dial test indicator reads zero on both ends. The actual angle can then be calculated and the deviation, if any, will be the error.

Method of calculating the slip gauge height

Example (Fig 3)

Fig 3



Exercise 1

To determine the height of slip gauges for an angle of 25^o using a sine bar of 200 mm long.

$$\text{Sine } \theta = \frac{a}{c}$$

$$\theta = 25^0$$

$$a = C \text{ Sine } \theta$$

$$= 200 \times 0.4226$$

$$a = 84.52 \text{ mm}$$

The height of the slip gauge required is 84.52 mm.

> **The value of sine θ can be obtained from mathematical tables. (Natural trigonometrical functions)**

Tables are also available with readily worked out sine bar constants for standard sine bar lengths.

Calculating the angle for tapered components

Example *2*

The height of the slip gauge used is 84.52 mm.The length of the sine bar used is 200 mm.

What will be the angle of the component? (Fig 4)

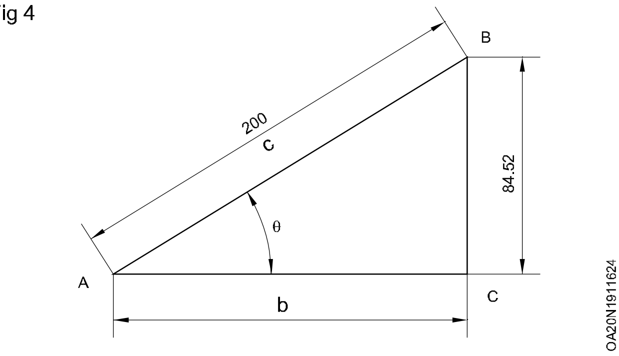
$$\text{Sine } \theta = \frac{a}{c}$$

$$= \frac{84.52}{200}$$

$$\text{Sine } \theta = 0.4226$$

The angle whose sine value is 0.4226 is 25^0. Hence the angle of tapered component is 25^0.

Fig 4



Classroom Assignment

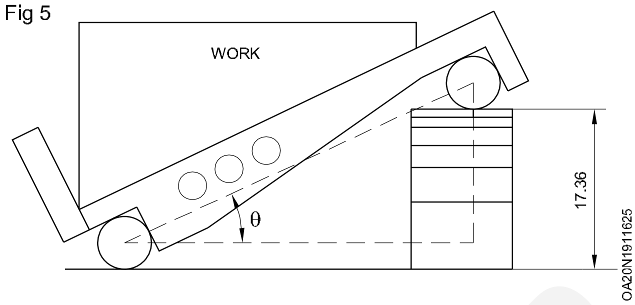
1 What will be the angle of the workpiece if the slip gauge pack height is 17.36 mm and the size of the sine bar used is 100 mm? (Fig 5)

Answer ________________________

2 Calculate the height of the slip gauge pack to raise a 100 mm sine bar to an angle of 3^0 35'.

Answer ________________________

Fig 5



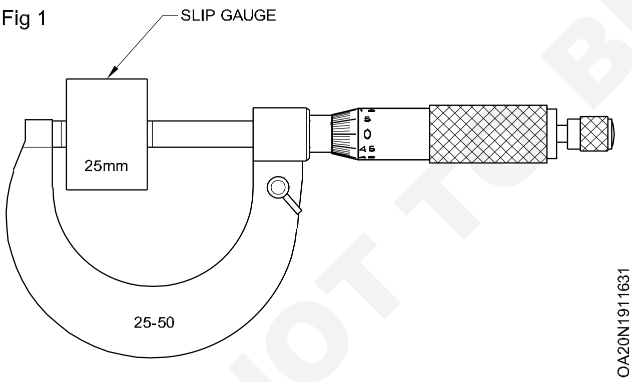
Slip gauges

Objectives: At the end of this lesson you shall be able to

- **state the features of slip gauges**
- **state the different grades of slip gauges and their uses**
- **state the number of slips in standard sets**
- **state the precautions to be followed while using slip gauges.**

Slip gauges or gauge blocks are used as standards for precision length measurement. (Fig 1) These are made in sets and consist of a number of hardened blocks, made of high grade steel with low thermal expansion. They are hardened throughout, and heat treated further for stabilization. The two opposite measuring faces of each block are lapped flat and parallel to a definite size within extremely close tolerances.

Fig 1



These slip gauges are available in various sets with different numbers. (Fig 2) (Ref.Table 1)

A particular size can be built up by wringing individual slip gauges together. (Figs 3 & 4)

Wringing is the act of joining the slip gauges together while building up to sizes.

steel or tungsten carbide. These are used for protecting the exposed faces of the slip gauge pack from damage while in use.

Fig 2

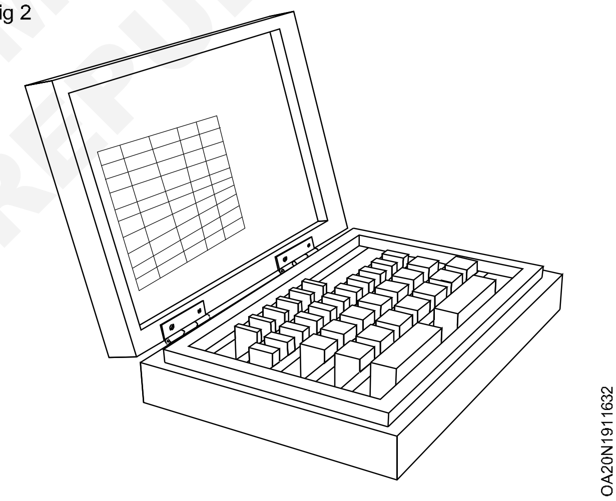
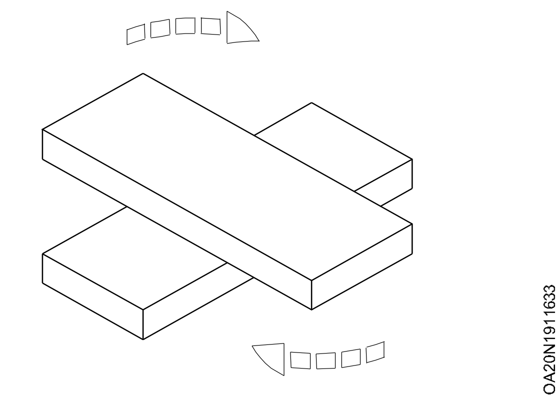


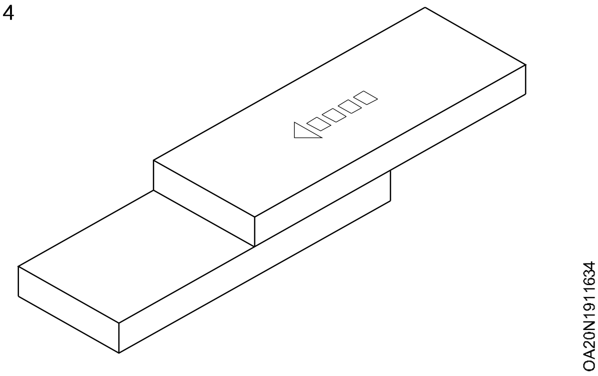
Fig 3



Grades

The following four grades of slip gauge are recommented as per IS 2984 -1981.

Fig 4



Grade ‘00’ , Grade ‘0’ Grade ‘1’ & Grade ‘2’

Grade ‘00’ shall normally be used for calibration purposes. It shall not be used in combination.

Grades 0,1 and 2 are intended for general use.

Grade ‘0’ is used only for calibration of Inspection Grade ‘1’, Grade ‘1’ is used in tool room and standards room. It is also used for calibration of Grade ‘2’.

Grade ‘2’ is used on machines for setting purposes and on surface plate for inspection purposes in shop floor. It is also used for zero setting of precision measuring instruments in shop floor. **For further details refer IS 2984 - 1981**

Some sets of slip gauges also contain protector slips of made to standard thickness from higher wear-resistant steel or tungsten carbide. These are used for protecting the exposed faces of the slip gauge pack from damage while in use.

Grades

The following four grades of slip gauge are recommented as per IS 2984 -1981.

Grade ‘00’ , Grade ‘0’ Grade ‘1’ & Grade ‘2’

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Grade ‘2’ is used on machines for setting purposes and on surface plate for inspection purposes in shop floor. It is also used for zero setting of precision measuring instruments in shop floor. **For further details refer IS 2984 - 1981**

B.I.S. recommendations

Three grades of slip gauges are recommended as per IS - 2984. They are:

Grade ‘00’

Grade ‘0’

Grade 1

Grade 2.

Care and maintenance points to be remembered while using slip gauges

(Avoid handling the slip gauges with bare hands since this affects the size of them due to heating).

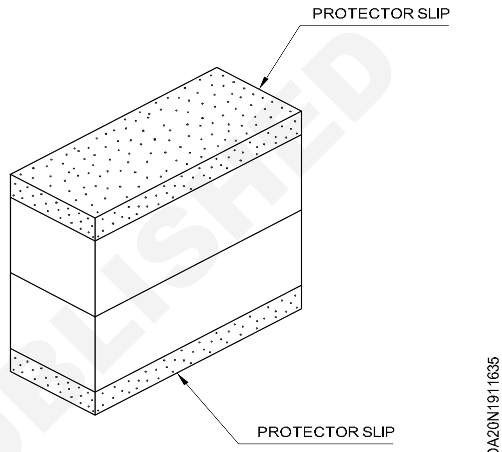
Use a minimum number of blocks as far as possible while building up a particular dimension.

While building the slip gauges, start wringing with the largest slip gauges and finish with the smallest.

While holding the slip gauges do not touch the lapped surfaces.

If available use protector slips on exposed faces.(Fig 5)

Fig 5



After use, clean the slips with carbon tetrachloride and apply petroleum jelly for protection against rust.

Before use, remove petroleum jelly with carbon tetrachloride. Use chamois leather to wipe the lapped surfaces.

Table 1

Set of 112 pieces (M 112)

Range (mm)	Steps (mm)	No.of pieces
Special piece 1.0005	-	1
1st series 1.001 to 1.009	0.001	9
2nd series 1.01 to 1.49	0.01	49
3rd series 0.5 to 24.5	0.5	49
4th series 25.0 to 100.0	25.0	4
Total pieces		**112**

Set of 103 pieces (M 103)

Range (mm)	Steps (mm)	No.of pieces
Special piece 1.005	-	1
1st series 1.01 to 1.49	0.01	49
2nd series 0.5 to 24.5	0.5	49
3rd series 25 to 100	25.0	4
Total pieces		**103**

Set of 78 pieces (M 78)

Range (mm)	Steps (mm)	No.of pieces
1.0025	-	1
1.005	-	1
1.0075	-	1
1.01 to 1.49	0.01	49
0.5 to 9.5	0.5	19
10.0 to 50.0	10.0	5
75.0 & 100.0	-	2
Total pieces		**78**

Set of 47 pieces (M 47)

Range (mm)	Steps (mm)	No.of pieces
1st series 1.005	-	1
2nd series 1.01 to 1.09	0.01	9
3rd series 1.1 to 1.9	0.1	9
4th series 1.0 to 24.0	1.0	24
5th series 25.0 to 100.0	25.0	4
Total pieces		**47**

Set of 87 pieces (M 87)

Range (mm)	Steps (mm)	No.of pieces
1st series 1.001 to 1.009	0.001	9
2nd series 1.01 to 1.49	0.01	49
3rd series 0.5 to 9.5	0.5	19
4th series 10.0 to 100.0	10.0	10
Total pieces		**87**

Set of 9 pieces (M 9)

Range (mm)	Steps (mm)	No.of pieces
1.001 to 1.009	0.001	9

Set of 46 pieces (M 46)

Range (mm)	Steps (mm)	No.of pieces
1st series 1.001 to 1.009	0.001	9
2nd series 1.01 to 1.09	0.01	9
3rd series 1.1 to 1.9	0.1	9
4th series 1.0 to 9.0	1.0	9
5th series 10.0 to 100	10.0	10
Total pieces		**46**

Even though there are a number of sets of slip gauges available, the popularly recommended are: M 112, M 87, M 46, M 38 and M 9

Set of 38 pieces (M 38)

Range (mm)	Steps (mm)	No.of pieces
1.005	-	1
1st series 1.01 to 1.09	0.01	9
2nd series 1.1 to 1.9	0.1	9
3rd series 1 to 9.0	1.0	9
4th series 10.0 to 100	10.0	10
Total pieces		**38**

Set of 86 pieces (M 86)

Range (mm)	Steps (mm)	No.of pieces
1st series 1.001 to 1.009	0.001	9
2nd series 1.01 to 1.49	0.01	49
3rd series 0.5 to 9.5	0.5	19
4th series 10.0 to 90.0	10.0	9
Total pieces		**86**

Selection and determination of slip gauges for different sizes

Objective: At the end of this lesson you shall be able to
- **state slip gauges for different sizes.**

For determining a particular size, in most cases a number of slip gauges are to be selected and stacked one over the other by wringing of the slip gauges.

While selecting slip gauges for a particular size using the available set of slip gauges, first consider the last digit of the size to be built up. Then consider the last or the last two digits of the subsequent value and continue to select the pieces until the required size is available.

Example

Building up a size of 44.8725 mm with the help of 112 piece set. (Table 1)

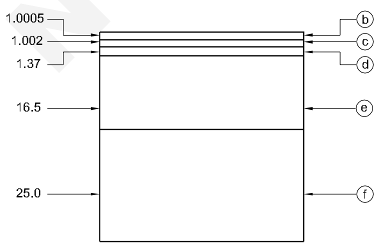
Set of 112 pieces

Range (mm)	Steps (mm)	No.of pieces
1.0005	-	1
1.001 to 1.009	0.001	9
1.01 to 1.49	0.01	49
0.5 to 24.5	0.5	49
25.0 to 100.0	25.0	4
Total pieces		**112**

Table 1

Procedure	Slip pack	Calculation
a First write the required dimension.		44.8725
b Select the slip gauge having the 4th decimal place.	1.0005 Substract	1.0005 43.872
c Select 1st series slip that has the same last figure.	1.002 Substract	1.002 42.87
d Select the 2nd series slip that has the same last figure and that will leave .0 or 0.5 as the last figure.	1.37 Substract	1.37 41.5
e Select a 3rd series slip that will leave the nearest 4th series slip (41.5-25=16.5).	16.5 Substract	16.5 25.00
f Select a slip that eliminates the final figure.	25.0 Substract	25.00
Add	44.8725	0

Fig 1



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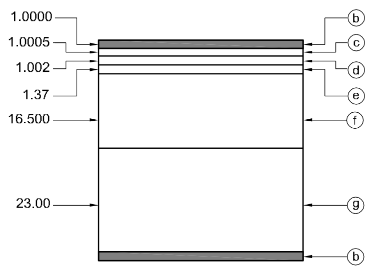
Procedure	Slip gauge pack	Calculation
a First write the . required dimension		44.8725
b Two numbers of protectorslips of 1mm each	2.000 Substract	2.0000 42.8725
c Select the slip gauge having the 4th decimal place	1.0005 Substract	1.0005 41.8720
d Select 1st series slip that has the same last figure	1.002 Substract	1.0020 40.8700
e Select the 2nd series slip that has the same last figure and that will leave .0 or 0.5as the last figure	1.3700 Substract	1.3700 39.5000
f Select a 3rd series slip that will leave the nearest 4th series slip	16.5000 Substract	16.5000 23.0000
g Select a slip that eliminates the final figure	23.0000 Substract	23.0000

Fig 2



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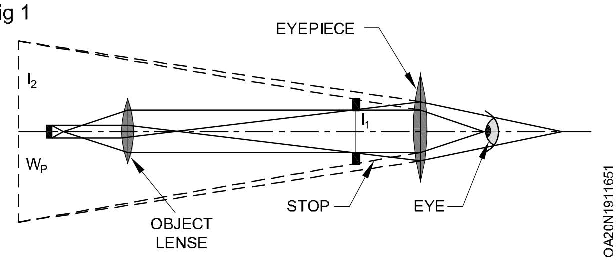
Tool maker's microscope

Objectives: At the end of this lesson you shall be able to
- **state the principle and working procedure of tool maker's microscope.**

Tool maker's microscope provides a high degree of magnification, and is also a simple and convenient means for taking readings. This enables the Tool Maker's Microscope both absolute and comparative measurements. First, we need to understand the basic principle of a Microscope.

The basic principle of Microscope (Fig 1)

Fig 1



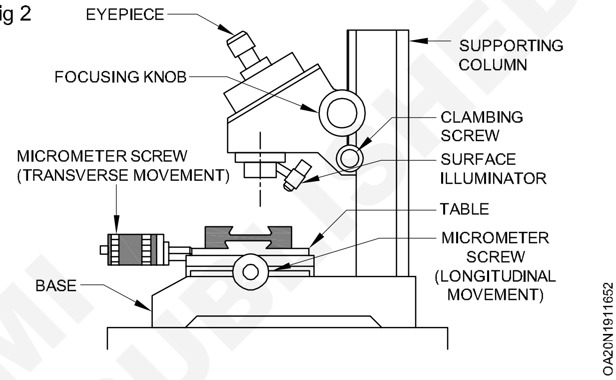
There will be two stages of magnification coupled in the microscope. The first magnification is at the Objective lens and the second magnification s at the eyepiece. The objective lens forms an image of the workpiece at I1 at the stop. The stop frames the image so that it can be enlarged by the eyepiece. Viewed through the eyepiece, an enlarged virtual image I2 is obtained. The magnification at each stage will be multiplied. Thus, a highly effective magnification can be achieved in the microscope with only moderate magnification at each stage.

In metrology we use many microscopes, Among them, the tool maker's microscope is the most familiar one. The tool maker's microscope is a multifunctional device that is primarily used for measurement on factory shop floors. Designed with the measurement of workpiece contours and inspection of surface features in mind, a tool maker's microscope supports a wide range of applications from shop-floor inspection, and measurement of tools and machined parts to precision measurement of test tools in a measuring room. The main use of a tool maker's microscope is to measure the shape, size, angle, and position of small components that fall under the microscope's measuring range.

Construction and Working of Tool Maker's Microscope

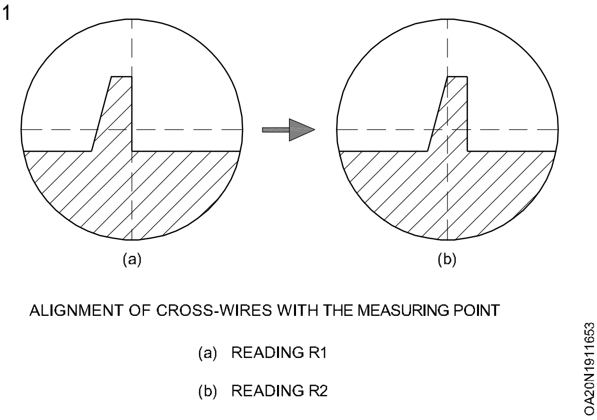
- It features a vertical supporting column, which is robust and carries the weight of all other parts of the microscope.
- It provides a long vertical working distance.
- The workpiece is loaded on an XY stage, which has a provision for translatory motion in two principal directions in the horizontal plane.
- Micrometres are provided for both X and Y axes to facilitate linear measurement to a high degree of accuracy.
- The entire optical system is housed in the measuring head.
- The measuring head can be moved up and down along the supporting column and the image can be focused using the focusing knob.
- The measuring head can be locked into position by operating the clamping screw.
- An angle dial built into the eyepiece portion of the optical tube allows easy angle measurement.
- A surface illuminator provides the required illumination of the object so that a sharp and clear image can be obtained. (Fig 2)

Fig 2



- The element that makes a microscope a measuring instrument is a reticle.
- When the image is viewed through the eyepiece, the reticle provides a reference or datum to facilitate measurement.
- Specialized reticles have been developed for precise settings.
- A typical reticle has two 'crosswires', which can be aligned with a reference line on the image of the workpiece.
- In fact, the term 'cross-wire is a misnomer, because modern microscopes have cross-wires etched on glass. (Fig 3)

Fig 1



- The above schematic diagram illustrates the procedure for linear measurement.
- A measuring point on the workpiece is aligned with one of the cross-wires and the reading R1 on the microscope is noted down.
- Now, the XY table is moved by turning the micrometre head, and another measuring point is aligned with the same cross-wire. The reading, R2 is noted down.
- The difference between the two readings represents the dimension between the two measuring points.
- Since the table can be moved in two mutually perpendicular directions (both in the longitudinal as well as transverse directions) using the micrometres, a precise measurement can be obtained.
- In some tool maker's microscopes, instead of a micrometre head, vernier scales are provided for taking readings.
- The reticle is also inserted into the eyepiece mount.
- A positioning pin is provided to position the reticle accurately.
- A dioptre adjustment ring is provided in the eyepiece mount to bring the cross-wires of the reticle into sharp focus.
- The measuring surface is brought into focus by moving the optical tube up and down, with the aid of a focusing knob.
- Looking into the eyepiece, the user should make sure that the cross-wires are kept in ocular focus during the focusing on the operation.
- The positioning of the workpiece on the table is extremely important to ensure accuracy in measurement.
- The measuring direction of the workpiece should be aligned with the traversing direction of the table.
- While looking into the eyepiece, the position of the eyepiece mount should be adjusted so that the horizontal cross-wire is oriented to coincide with the direction of the table movement.
- Now, the eyepiece mount is firmly secured by tightening the fixing screws.
- The workpiece is placed/clamped on the table and the micrometre head is turned to align an edge of the workpiece with the centre of the cross-wires.
- Then, the micrometre is operated and the moving image is observed to verify whether the workpiece pavement is parallel to the measuring direction.
- By trial and error, the user should ensure that the two match perfectly. Most tool makers microscopes are provided with a surface illuminator.
- This enables the creation of a clear and sharp image. Out of the following three types of illumination modes that are available, an appropriate model can be selected based on the application.

Contour illumination

This type of illumination generates the contour image of a workpiece and is suited for measurement and inspection of workpiece contours. The illuminator is equipped with a green filter.

Surface illumination

This type of illumination shows the surface of a workpiece and is used in the observation and inspection of workpiece surfaces. The angle and orientation of the illuminator should be adjusted so that the workpiece surface can be observed under optimum conditions.

Simultaneous contour and surface illuminations

Both contour and surface of a workpiece can be observed simultaneously. Some of the latest microscopes are also provided with angle dials to enable angle measurements. Measurement is done by aligning the same cross-wire with two edges of the workpiece, one after the other. An angular vernier scale, generally with a least count of 6, is used to take the readings.

Applications of Tool Maker's Microscope

1 It is used in shop floor inspection of screw threads, gears, and other small machine parts.

2 Its application includes precision measurement of test tools in tool rooms.

3 It helps determine the dimensions of small holes, which cannot be measured with micrometres and callipers.

4 It facilitates template matching inspection. Small screw threads and involute gear teeth can be inspected using the optional template reticles.

5 It enables inspection of tapers on small components up to an accuracy of 6.

Optical profile projector

Objectives: At the end of this lesson you shall be able to
- **describe the working of optical profile projector.**

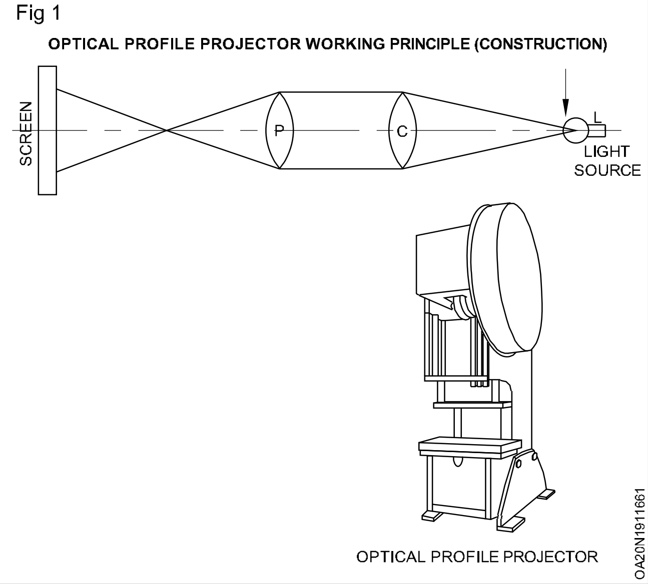
An Optical Profile Projector is a type of comparators

A projector is an optical device, which enlarges the image. This is the principle we are going to use it in the Optical projector comparator.

This Optical Profile of projectors is used to check relatively small engineering components with the working standard.

Optical profile Projector Working principle (Construction) (Fig 1)

Fig 1



List of components

- Light source
- Condenser Lens (C)
- Projection Lens (P)
- Screen

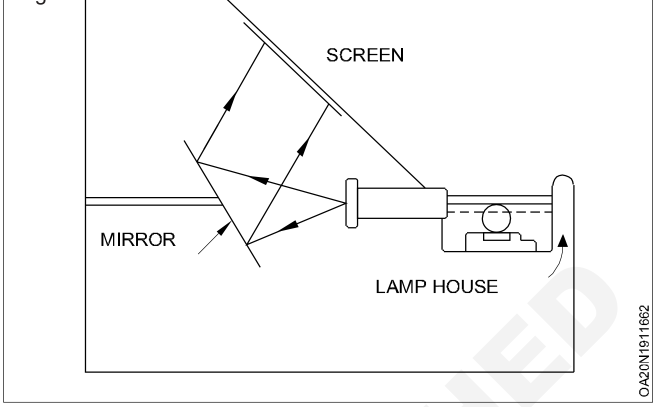
A beam of light from the light source is passed thru the condenser lens(C) and Projection lens(P) and fall on the Screen. the workpiece will be placed in between the light source and condenser lens. A shadow image of the workpiece will be created. while we placed the workpiece.

The magnified image will be shown on the screen. This magnification is up to 5 to 100.

Working with Optical profile Projector (Fig 2)

There is a lamp source, it can be a tungsten lamp or a filament lamp or a mercury lamp. Coming to workpiece holding table it will be stationary or it can be movable with an angular adjustment. There are two lenses, one is condenser lens (Collecting and directing the light) Projecting Lens. A mirror is placed to reflect the image on to the screen. This is how a commercial profile projector is constructed.

Fig 2



When an object is placed in between condenser lens and the light source, a shadow of the profile is projected at some enlarged scale on the screen. this enlarged profile will be used to compare with the working standard.

Here, Lenses plays a significant role in the magnification of the profile(Image).

Optical Profile Projector Applications

Optical profile projectors have a wide range of applications.

- Used in the automotive industry to inspecting surface deformities.
- In glass Producing industries to inspecting minute flaws in glassware.
- Used to inspect the components with irregular shapes and sizes.

Defects and remedies of turning, milling and grinding

Objectives: At the end of this lesson you shall be able to
- **tabulte the fault, cause and remedies of turning, milling and grinding.**

Fault	Indication	Causes	Remedies
Chatter	Excessive tool wear	Increased cutting force can lead to chatter during the cut	Replace tool, reduce the depth of cut feed ratio or spindle speed
Resonate chattered surface finish	Chipload too light	When cutting sped in two high or the fed rate in too low, the cut can become unstable and begin to resonate, learning charttered surface finish	Reduce the cutting speed or increase the feed rate make sure that the stick tools are correct size for tool holder
Chatter low tool life, poor surface finish	Improper tool insert	Improper insert can cause problem with surface finish, tool life and chatter	Select the proper insert geometry , radius size, coating
Chatter into the cut	Insufficient support on the work piece	Begin to vibrate and introduce chatter into the cut	Follow diameter-to-length ratio, need to use additional support of a steady rest
Poor surface finish	Centred drilled hole is incorrect	Center drilled hole was wrong angle, too small, too shalow, too deep (or) damaged the line center will not have sufficient contact	Use 60° center drill tool

Recommended cutting fluids for various metals and different operations

Material	Drilling	Reaming	Threading	Turning	Milling
Aluminum	Soluble oil Kerosene and lard oil	Soluble oil Kerosene	Soluble oil	Soluble oil	Soluble oil lard oil
Brass	Dry soluble oil Mineral oil Lard oil	Dry soluble oil	Soluble oil lard oil	Soluble oil	Dry soluble oil
Bronze	Dry soluble oil Mineral oil Lard oil	Dry soluble oil Mineral oil Lard oil	Soluble oil lard oil	Soluble oil	Dry soluble oil Mineral oil Lard oil
Cast iron	Dry air jet Soluble oil	Dry soluble oil Mineral Lard oil	Dry sulphurized Mineral Lard oil	Dry soluble oil	Dry soluble oil
Copper	Dry soluble oil Mineral Lard oil Kerosene	Soluble oil Lard oil	Soluble oil Lard oil	Soluble oil	Dry soluble oil
Steel alloys	Soluble oil Sulphurized oil Mineral Lard oil	Soluble oil Sulphurized oil Mineral Lard oil	Sulphurized oil Lard oil	Soluble oil	Soluble oil Mineral
General pur - pose steel	Soluble oil Sulphurized oil Lard oil Mineral Lard oil	Soluble oil Sulphurized oil Lard oil	Sulphurized oil Lard oil	Soluble oil	Soluble oil Lard oil

Cutter breakage: Causes and remedies

Fault	Indication	Causes	Remedies
Cutter breaks		Backlash on the table not not taken into account.	Check the direction of backlash and accommodate it while moving the table.
	Cutter running in wrong direction	Insufficient care taken while setting.	Correct the direction of rotation of the cutter.
	Ragged or black coloured chips/ swarf	Incorrect speed, feed and depth of cut.	Use correct speed and depth of cut as recommended.
	Cutter drags	Backlash in table.	Adopt conventional up milling process.
	Work fed violent against the cutter	Improper approach of work piece.	Provide proper approach clearance.
		Rapid traverse of work/table correctly.	Adjust the rapid traverse is improperly set.
		Sudden release od deflecting pressure on cutters (end mills) at the end of cut.	Reduce the feed rate at the end of the cut.
		Less lip angle on the cutter due to excessive rake and clearance angles	Use the recommended cutter with proper rake and clearance angles
		Non rigid set up of workpiece.	Clamp the workpiece rigidly.
			Use the largest possible diameter and the shortest length of cutter.

Errors, inaccuracies and chatters in milling

Fault	Indication	Causes	Remedies
Flatness error		Excessive tilt in the axis of the cutter spindle	Minimise the tilit (0.01m/ 100mm)
		Work is distorted through clamping pressure for fine cut.	Use shim under the work. Release and reset the clamp with less
		Internal Stresses of workpiece released by machining.	If possible, rough out the part on the opposite sides before taking the finish cut.
			Release and reset the clamp with less pressure for the finish cut.
Chatter	Unusual cutting sound/ noise	Load exceed beyond the capacity of the machine	Reduce the load by depth of cut and speed and feed combination.
		Excessive speed.	Reduce the spindle speed.
		Feed is very slow.	Increase the rate of feed.
		Damaged or worn out cutter.	Use a good cutter.
		Improper rake and clearance angle on cutter tooth.	Use a cutter with proper rake and clearance angle.
	Intermittent rotation of cutter.(Cutter stalling)	Cutter is loose on the arbor. Arbor loose in spindle.	Tighten the arbor nut. Tighten the draw bar lock nut.
	Slack between table and slide.	Table too loose.	Tighten the table locks and adjust the gibs.
	Slack between work-holder and table	Clamps loose.	Tighten the draw bar lock nut.
	Slack between fixed and movable parts of the work holder.	Work holder locks are loosened.	Tighten the locking devices.

	Slack between work piece and work holder.	Workpiece not clamped in work holder	Tighten the work holder.
	Workpiece vibrates.	Excessive overhang of workpiece.	Reduce overhang and add support.
	Slack between vertical head or vertical attachment and machine column.	Clamping devices not tightened.	Tighten the clamping devices
Inaccuracy in size of job, faces, not parallel (Taper)	Cutter removes uneven metal from the face of the workpieces	Workpiece shifted while being clamped.	Correct and re clamp the workpiece.
		Table set at an angle. (Universal machines)	Check and correct.
		Swarf or burrs on the face of the table	Check the face of the table in clean & free from burrs. Check for rocks when locating work holding device or workpieces.
		Swarf or burrs on locating face of work holding devices.	It is high for work holding devices.
		Swarf or burrs on parallels.(if used)	Clean the face of the parallels.
		Swarf or burrs on faces of workpiece.	Clean the burrs on the job before locating.
		Workpiece not correctly seated.	Check the seating with the use of the feller gauge.
		Parallels with taper or parallels of different heights.	Check, clean or replace.
		Machine spindle is not vertical.	Check and reset.
		Cutter springs away from the work.	Use short length cutters.
		Periphery of cutter is not parallel.	Check and re grind or replace.
Dimensional inaccuracy		Cutter wrong size.	Replace with proper sized cutter.
		Cutter not running true.	Reset the cutter on the arbor.
		Movement of cutter or workpiece while machining.	Ensure the cutter and workpiece are secured properly.
		Setting bar or cutter running out of true.	Check and correct.
		Inaccurate spacing of cutters.	Check and set space between cutters if more than one cutter is used.
		Inaccurate setting of zero or datum.	Check and correct the zero or datum references.
		Backlash on the table not taken into account.	Check the direction of backlash and accommodate it while moving the table.