MACHINIST

NSQF LEVEL - 4

1st Year

TRADE THEORY

SECTOR : CAPITAL GOODS AND MANUFACTURING

(As per revised syllabus July 2022 - 1200 hrs)

Directorate General of Training

DIRECTORATE GENERAL OF TRAINING
MINISTRY OF SKILL DEVELOPMENT AND 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 : **Machinist 1st Year - Trade Theory - NSQF Level - 4 (Revised 2022)**

Developed & Published by

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First Edition : October 2022 Copies : 1000

Rs.325/-

FOREWORD

The Government of India has set an ambitious target of imparting skills to 30 crores people, one out of every four Indians, by 2022 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 committe 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 **Machinist 1st Year - Trade Theory - NSQF level - 4 (Revised 2022) in Capital Goods & Manufacturing Sector under Annual Pattern.** 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

Addl.Secretary / Director General (Training)
Ministry of Skill Development & Entrepreneurship,
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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 the 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 organisations to bring out this Instructional Material **(Trade Theory)** for the trade of **Machinist - NSQF Level - 4 (Revised 2022)** under **CG & M** Sector for ITIs.

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NIMI records its appreciation for 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 NIMI staff who have contributed towards the development of this Instructional material.

NIMI is also grateful to everyone who has directly or indirectly helped in developing this Instructional Material.

INTRODUCTION

TRADE PRACTICAL

The trade practical manual is intented to be used in practical workshop . It consists of a series of practical exercises to be completed by the trainees during the Course of the **Machinist under NSQF Level - 4** 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) syllabus are covered.

The manual is divided into Seven modules.

Module 1	-	**Safety**
Module 2	-	**Basic fitting**
Module 3	-	**Turning**
Module 4	-	**Slotting**
Module 5	-	**Milling**
Module 6	-	**Advanced Turning**
Module 7	-	**Grinding**

The skill training in the shop floor is planned through a series of practical exercises centred around some practical object. 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

This manual consists of theoretical information for the course of the **Machinist under NSQF Level-4** (Revised 2022). The contents are sequenced according to the practical exercise contained in the manual on Trade practical. Attempt has been made to relate the theortical 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 indicating about the corresponding practical exercise are given in every sheet of this manual.

It will be preferable to teach/learn the trade theory connected to each exercise atleast 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.

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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	Ref.Ex.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, Chiselling, Filing, Drilling, Taping and Grinding etc. Accuracy: ± 0.25mm]	1.1.01 -1.2.24
2	Produce components by different operations and check accuracy using appropriate measuring instruments. [Different Operations - Drilling, Reaming, Tapping, Dieing; Appropriate Measuring Instrument - Vernier, Screw Gauge, Micrometre] (NOS not available)	1.2.25 - 1.2.35
3	Make different fit of components for assembling as per required tolerance observing principle of interchangeability and check for functionality. [Different Fit - Sliding, 'T' fitand Square fit; Required tolerance: ±0.2 mm, angular tolerance: 1 degree. (NOS not available)	1.2.36 - 1.2.38
4	Set different shaped jobs on different chuck and demonstrate conventional lathe machine operation observing standard operation practice. [Different chucks: 3 jaws & 4 jaws, different shaped jobs: round, square, hexagonal] (NOS not available)	1.3.39 - 1.3-41
5	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.] (NOS not available)	1.3.42 - 1.3.50
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.] (NOS not available)	1.3.51- 1.3.54
7	Set the different machining parameters to produce metric-v threaded components applying method/ technique and test for proper assembly of the components.(NOS not available)	1.3.55 1.3.57
8	Set the different machining parameters and cutting tool to prepare job by performing different slotting operation. [Different machining parameters - feed, speed and depth of cut. Different slotting operations -concave & convex surface, internal key ways, profiling, making internal sprocket with an accuracy of +/- 0.04 mm] (NOS not available)	1.4.58 -1.4.61
9	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] (NOS not available)	1.4.62 -1.5.83
10	Set the different machining parameters to produce square & "V" threaded components applying method/ technique and test for proper assembly of the components. (NOS not available)	1.6.84 -1.6.92
11	Produce components of high accuracy by different operations using grinding. [Different operations - surface grinding, cylindrical grinding with an accuracy of+/- 0.01 mm} (NOS not available)	1.7.93 -1.7.110

SYLLABUS FOR MACHINIST

Duration	Reference Learning Outcome	Professional Skills (Trade Practical) with Indicative hours	Professional Knowledge (Trade Theory)
Professional Skill 100 Hrs.; Professional Knowledge 20Hrs.	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, Chiselling, Filing, Drilling, Taping and Grinding etc. Accuracy: ± 0.25mm] (NOS not available)	1 Importance of trade training, List of tools & Machinery used in the trade.(02hr.) 2 Safety attitude development of the trainee by educating them to use Personal Protective Equipment (PPE). (05hrs.) 3 First Aid Method and basic training.(03hrs.) 4 Safe disposal of waste materials like cotton waste, metal chips/burrs etc. (02hrs.) 5 Hazard identification and avoidance. (02hrs.) 6 Identification of safety signs for Danger, Warning, caution & personal safety message.(02 hrs.) 7 Preventive measures for electrical accidents & steps to be taken in such accidents.(03hrs.) 8 Use of fire extinguishers.(04hrs.) 9 Practice and understand precautions to be followed while working in fitting jobs. (02hrs.) 10 Safe use of tools and equipments used in the trade. (02 hr)	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 precautions 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 application. Occupational Safety & Health: Health, Safety and Environment guidelines, legislations & regulations as applicable. Basic understanding on Hot work, confined space work and material handling equipment. (04 hrs.)
		11 Study the drawing to plan the job/ work. Identification of tools &equipments as per desired specifications for marking, filing& sawing. (03hrs.) 12 Familiarisation of bench vice. (02 hr) 13 Filing- Flat and square (Rough finish). (06 hrs.) 14 Marking with scriber and steel rule.(03hrs.) 15 Filing practice, surface filing, marking of straight and parallel lines with odd leg calipers and steel rule. (06hrs.)	Linear measurements- its units, steel rule dividers, callipers - types and uses, Punch - types and uses. Uses of different types of hammers. Description, use and care of marking off table. (03hrs.)
		16 Marking out lines, gripping suitably in vice jaws, hack sawing to given dimensions. (05hrs.) 17 Sawing different types of metals of different sections. (06hrs.)	Bench vice construction, types, uses, care & maintenance, vice clamps, hacksaw frames and blades, specification, description, types and their uses, method of using hacksaws.

		18 Marking practice with dividers, odd leg callipers, scriber and steel rule (circles, arc, parallel lines). (06hrs.)	Files- elements, types, specification and their uses. Methods of filing. Care and maintenance of files. Measuring standards (English, Metric Units) (04 hrs.)
		19 Grinding, centre punch, dot punch, chisel and scriber.(07hrs.) 20 Marking, filing, filing square and check using try-square. (10 hrs.)1.	Pedestal grinding machine: Use, care and safety aspect. Marking off and layout tools, scribing block, care & maintenance. Try square, ordinary depth gauge, Care & maintenance of cold chisels- materials, types, cutting angles. Combination set- its components, uses and cares. (05 hrs)
		21 Marking according to drawing for locating, position of holes, scribing lines on chalked surfaces with marking tools. (04hrs.) 22 Finding centre of round bar with the help of 'V' block and marking block. (04hrs.) 23 Prepare mushroom head and round bar and bending metal plate by hammering. (05hrs.) 24 Marking using scale, surface gauge and angle plate. (06 hrs.)	Marking media, Prussian blue, red lead, chalk and their special application, description. Surface plate and auxiliary marking equipment, 'V' block, angle plates, parallel block, description, types, uses, accuracy, care and maintenance. (04 hrs.)
Professional Skill 39 Hrs; Professional Knowledge 08 Hrs.	Produce components by different operations and check accuracy using appropriate measuring instruments. [Different Operations - Drilling, Reaming, Tapping, Dieing; Appropriate Measuring Instrument - Vernier, Screw Gauge, Micrometre] (NOS not available)	25 Chipping flat surfaces along a marked line. (07hrs.) 26 Make a square from a round job by chipping upto 20mm length. (3 hrs) 27 Slot straight and angular chipping. (2 hrs) 28 Mark off and drill through holes. (03hrs.) 29 Drill and tap on M.S. flat. (02hrs.) 30 Cutting external thread on M.S. rod using Die.(03hrs.) 31 Punch letter and number (letter punch and number punch). (03hrs.) 32 Counter sinking, counter boring and reaming with accuracy +/- 0.04 mm.(05 hrs.) 33 Drill blind holes with an accuracy 0.04 mm.(02 hrs.) 34 Form internal threads with taps to standard size (blind holes).(03 hrs.) 35 Prepare studs and bolt.(06hrs.)	Drill, Tap,Die-types & application. Determination of tap drill size. Basic terminology related to screw thread. Reamer- material, types (Hand and machine reamer), parts and their uses, determining hole size for reaming, Reaming procedure. Vernier height gauge: construction, graduations, vernier setting & reading. Care and maintenance of Vernier height Gauge. (04 hrs.) Drilling machines-types &their application, construction of Pillar & Radial drilling machine. Countersunk, counter bore and spot facing-tools and nomenclature. Cutting Speed, feed, depth of cut and Drilling time calculations. (04 hrs.)
Professional Skill 90 Hrs.; Professional Knowledge 12 Hrs.	Make different fit of components for assembling as per required tolerance observing principle of interchangeability and	36 Make Male & Female 'T' fitting with an accuracy +/- 0.2 mm and 1 degree. (25hrs.) 37 Make male female square fit with accuracy +/- 0.1 mm. (25hrs.)	Interchangeability: Necessity in Engg., field, Limit- Definition, types, terminology of limits and fits-basic size, actual size, deviation, high and low limit, zero-line, tolerance zone, allowances. Different standard

	check for functionality. [Different Fit - Sliding, 'T' fitand Square fit; Required tolerance: ±0.2 mm, angular tolerance: 1 degree.] (NOS not available)	38 Make Male & Female Hexagon fitting with accuracy +/- 0.06 mm. (40 hrs.)	systems of fits and limits. (British standard system & BIS system) (06 hrs) Vernier calliper-its parts, principle, reading, uses & care. Outside micrometre- its parts, principle, reading, uses, Reading of Vernier Micrometre), care & maintenance. Dial test indicator-its parts, types, construction and uses. (06 hrs.)
Professional Skill 20 Hrs.; Professional Knowledge 05 Hrs.	Set different shaped jobs on different chuck and demonstrate conventional lathe machine operation observing standard operation practice. [Different chucks: 3 jaws & 4 jaws, different shaped jobs: round, square, hexagonal] (NOS not available)	39 Identify & function of different parts of lathe. Practice on operation of lathe (dry/idle run). (07 hrs.) 40 Setting lathe on different speed and feed.(04 hrs.) 41 Dismantling, assembling & truing of 3-jaw & 4-jaw chucks. (09hrs.)	Getting to know the lathe with its main components, lever positions and various lubrication points as well. Definition of machine & machine tool and its classification. History and gradual development of lathe. Introduction to lathe- its types. Centre lathe construction, detail function of parts, specification. Safety points to be observed while working on a lathe. (05 hrs.)
Professional Skill 112 Hrs.; Professional Knowledge 16 Hrs.	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.] (NOS not available)	42 Grinding of R.H. and L.H. tools, V- tool, parting tool, Round nose tool. (15 hrs.) 43 Checking of angles with angle gauge/ bevel protractor. (02 hrs.) 44 Grinding of "V" tools for threading of Metric 60-degree threads. (08 hrs.)	Lathe cutting tool-different types, material, shapes and different angles (clearance, rake etc.) and their effects, specification of lathe tools, grinding process of tools. Types of chips, chip breaker. Tool life, factors affecting tool life. (04 hrs.)
		45 Perform facing operation to correct length. (05 hrs.) 46 Centre drilling and drilling operation to required size. (05 hrs.) 47 Perform parallel turning and step turning operation. (12 hrs.)	Driving mechanism, speed and feed mechanism of Lathe. (03 hrs)
		48 Perform drilling, boring and undercut operation, parting, grooving, chamfering practice, Blinding hole Boring. (55 hrs.) 49 Measurement with steel rule and outside calliper with an accuracy of ± 0.5 mm. (02 hrs.)	Concept of Orthogonal and Oblique Cutting. Chucks & different types of job holding devices on lathe and advantages of each type. Mounting and dismounting of chucks. Vernier Bevel Protractor - parts, reading and uses. (06hrs)
		50 Perform different Knurling operation in lathe with accuracy of ± 0.5 mm (8 hrs.)	Lathe operations-facing, turning, parting-off, grooving, chamfering, boring etc. Knurling-types, grade & its necessity. (03 hrs)

Professional Skill 45 Hrs.; Professional Knowledge 06 Hrs.	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.] (NOS not available)	51 Make taper turning by form tool with an accuracy of 1 degree. (05 hrs.) 52 Make taper turning by compound slide swivelling with an accuracy of ± 30 minute (15 hrs.)	Taper - different methods of expressing tapers, different standard tapers. Method of taper turning, important dimensions of taper. Taper turning by swiveling compound slide, its calculation. (03 hrs.)
		53 Make taper by off-setting tailstock with an accuracy of ± 30 minute. (20hrs.) 54 Checking taper by Vernier Bevel Protractor and sine bar & slip gauge. (05 hrs.)	Calculations of taper turning by off-setting tail stock. Sine Bar - description & uses. Slip gauge -description and uses. (03 hrs.)
Professional Skill 40 Hrs.; Professional Knowledge 07 Hrs.	Set the different machining parameters to produce metric-v threaded components applying method/ technique and test for proper assembly of the components. (NOS not available)	55. Cutting V thread (external) in a lathe and check with Screw Pitch Gauge. (18 hrs.) 56. Cutting V thread (internal) in a lathe and check with Screw Pith Gauge. (19 hrs.) 57. Fitting of male & female threaded components. (03 hrs.)	Different thread forms, their related dimensions and calculations of screw cutting in a lathe (Metric thread on English lathe and English thread on Metric lathe). Measurement of threads by three wire methods. Use of Screw Pitch Gauge. (07hrs.)
Professional Skill 71 Hrs.; Professional Knowledge 15 Hrs.	Set the different machining parameters and cutting tool to prepare job by performing different slotting operation. [Different machining parameters - feed, speed and depth of cut. Different slotting operations -concave & convex surface, internal key ways, profiling, making internal sprocket with an accuracy of +/- 0.04 mm] (NOS not available)	58. Identification of slotting machine parts & its construction, use of rotary table. (10 hrs.) 59. Practice on slotting key ways on pulley with accuracy +/- 0.04 mm (15 hrs.)	Slotter- Classification, principle, construction, Safety precaution. Introduction and their indexing process on a Slotter by its Rotary table graduations. Driving mechanisms, quick return motion and speed ratio. Safety points to be observed while working on a Slotter. (06 hrs.)
		60. Slotting a double ended spanner with accuracy +/- 0.1 mm. (25 hrs.)	Job holding devices-vice, clamps, V-block, parallel block etc. Slotting tools- types, tool angles. (04 hrs)
		61. Cutting internal spline on slotting machine with accuracy +/-0.04 mm. (21 hrs.)	Spline - types and uses. Coolant & lubricant - Introduction, types, properties, application & applying methods. (05hrs)
Professional Skill 138 Hrs.; Professional Knowledge 25 Hrs.	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]	62. Identification of milling machine. (02 hrs.) 63. Demonstrate working principle of Milling Machine. (04hrs.) 64. Set vice & job on the table of Milling Machine. (04 hrs.) 65. Set arbor on the spindle of milling machine. (06hrs.) 66. Set the cutter on arbour. (04 hrs.) 67. Safety points to be observed while working on a milling machine. (02 hrs.)	Milling Machine: Introduction, types, parts, construction and specification. Driving and feed mechanism of Milling Machine. (04 hrs)

	(NOS not available	68. Demonstrate Up Milling and Down Milling Process. (05hrs.) 69. Sequence of milling six faces of a solid block. (08 hrs.) 70. Check the accuracy with the help of try-square and vernier height gauge. (02hrs.) 71. Perform Step milling using side and face cutter checking with depth micrometer. (05hrs.) 72. Perform slot milling using side and face cutter. (05hrs.)	Different types of milling cutters & their use. Cutter nomenclature. (03 hrs)
		73. Make "V" Block using Horizontal Milling Machine with accuracy +/-0.02 mm. (20hrs.)	Different milling operations - plain, face, angular, form, slot, gang and straddle milling etc. Up and down milling. (03 hrs)
		74. Make concave surfaces with an accuracy +/-0.02 mm. (03 hrs.) 75. Make convex surfaces with an accuracy +/-0.02 mm. (03 hrs.) 76. Straddle milling operation with an accuracy +/-0.02 mm. (07 hrs.) 77. Gang milling operation with an accuracy +/-0.02 mm. (07hrs.)	Different types of milling attachments and their uses. (03 hrs)
		78. Make Dovetail fitting (male & female) on Milling Machine with an accuracy +/-0.02 mm. (12hrs.)	**Jigs and Fixtures-** Introduction, principle, types, use, advantages & disadvantages. (03 hrs)
		79. Make T-Slot fitting (male & female) on Milling Machine with an accuracy +/-0.02 mm. (18hrs.)	Properties of metals general idea of physical, mechanical properties of metals, colour, weight, hardness toughness, malleability, ductility their effect on machinability. Heat Treatment - Introduction, necessity, types, Purposes, different methods of Heat Treatment. Heat Treatment of Plain Carbon Steel. (05 hrs)
		80. Demonstrate indexing head. (04hrs.) 81. Set and align indexing head with reference to job on milling machine.(04hrs.) 82. Make square job by direct/ simple indexing method with an accuracy +/-0.02 mm. (05hrs.) 83. Make hexagonal job by simple indexing method with an accuracy +/-0.02 mm. (08hrs.)	Indexing-introduction & types. Indexing head-types &constructional details, function of indexing plates and the sector arms. Calculation for direct and simple indexing. (04 hrs)
Professional Skill 60 Hrs.; Professional Knowledge 13 Hrs.	Set the different machining parameters to produce square & "V" threaded components applying method/ technique and test for	84. Checking of alignment of lathe centres and their adjustments. (03 hrs.) 85. Turning practice-between centres on mandrel (gear blank) with an accuracy +/-30 minute. (07hrs.)	Turning of taper by taper turning attachment - advantages and dis-advantages, taper calculations. Mandrel, Lathe centres, Lathe dog, catch plate/Driving plate, Face plate, Rests, their types & uses. (04 hrs)

	proper assembly of the components. (NOS not available)	86. Taper turning by swivelling the cross slide. (03 hrs.)	
		87. Make square thread (external) on a lathe with an accuracy +/-0.02 mm. (10hrs.) 88. Make square thread (internal) on a lathe with an accuracy +/-0.02 mm. (14hrs.) 89. Check with thread gauge - grinding of tool & setting in correct position. (04hrs.) 90. Fitting of male & Female Square threaded components. (02hrs.) 91. Make multi-start V thread on lathe with Screw Pitch gauge.(10 hrs.) 92. Perform eccentric turning with an accuracy +/-0.02mm. (07hrs..)	Terms relating screw thread major/ minor diameter, pitch and lead of the screw, depth of thread. Simple gear train and compound gear train change gears for fractional pitches. Square thread and its form and calculation of depth, core dia, pitch dia. Difference between single and multi-start threads- their uses, merits and demerits. (9 hrs.)
Professional Skill 125 Hrs.; Professional Knowledge 35 Hrs.	Produce components of high accuracy by different operations using grinding. [Different operations - surface grinding, cylindrical grinding with an accuracy of+/- 0.01 mm] (NOS not available)	93. Identification of different types of grinding machine. (02 hrs.) 94. Wheel balancing & truing. (06 hrs.) 95. Dressing of grinding wheel. (02 hrs.) 96. Grinding of block (six sides) by surface grinding machine with an accuracy of +/- 0.01 mm. (15 hrs.)	**Grinding -** Introduction, grinding wheel- abrasive, types, bond, grade, grid, structure, standard marking system of grinding wheel, selection of the grinding wheel. (06 hrs.)
		97. Grinding of step block by surface grinding machine with an accuracy of +/- 0.01 mm. (10hrs.) 98. Grinding of slot block by surface grinding machine with an accuracy of +/- 0.01 mm. (08hrs.)	Dressing, types of dresser. Glazing and Loading of wheels - its causes and remedies. Roughness values and their symbols. Explain the importance and necessity of quality. (06 hrs.)
		99. Set and perform angular grinding using universal vice/ sign vice to standard angle. (05 hrs.) 100. Make slide fit with an accuracy ± 0.01mm (male female) (05hrs.) 101. Perform form grinding (05 hrs.) 102. Make dovetail fitting with an accuracy ± 0.01mm (male & female) (08 hrs.)	**Surface Grinder -** Types, Parts, construction, use, methods of surface grinding, specification & safety. (06 hrs.)
		Cylindrical grinding: 103. External parallel cylindrical grinding (Both holding in chuck/ collet and in between centers. (10 hrs.) 104. Plunge grinding (08hrs.)	**Cylindrical grinder:** Introduction, parts, construction, types, specification, safety, different methods of cylindrical grinding. (06 hrs.)

		105. Perform straight bore grinding (05hrs.) 106. Perform step bore grinding (05hrs.) 107. Internal taper bore grinding (05hrs.) 108. Make male female fitting with an accuracy of +/- 0.01 mm (08hrs.)	Cutting speed, feed, depth of cut, machining time calculation. (06 hrs.)
		109. External step cylindrical grinding with an accuracy of +/- 0.01 mm (10hrs.) 110. External taper Cylindrical grinding with an accuracy of +/- 0.01 mm. (08hrs.)	Wet grinding and dry grinding, various types of grinding wheels and their application, grinding defects and remedies. (05 hrs.)

Familiarisation industrial training institute in India

Objectives: At the end of this lesson you shall be able to
- **state what is ITI and brief the objectives of ITI**
- **describe the organizational chart**
- **list out the infrastructure available in ITI**
- **explain the job opportunities and carrier development after completion of courses**
- **brief the examination pattern and soft skills.**

Introduction to ITI

Industrial Training Institutes (ITI) and Industrial Training Centers (ITC) comes under Craftsman training Scheme (CTS) to provide Vocational Training in various trades functioning under Directorate General of Training (DGT), Ministry of Skill Development and Entrepreneurship, Government of India.

ITIs and ITCs are one and the same; ITIs are governed by the state/union government, whereas, the ITCs are self-financing institutions to provide same training courses as ITI's. Trade test for ITI and ITC trainees are common and the National Trade Certificate issued by the National Council for Vocational Training (NCVT) is of the same standard.

The objectives of an ITI

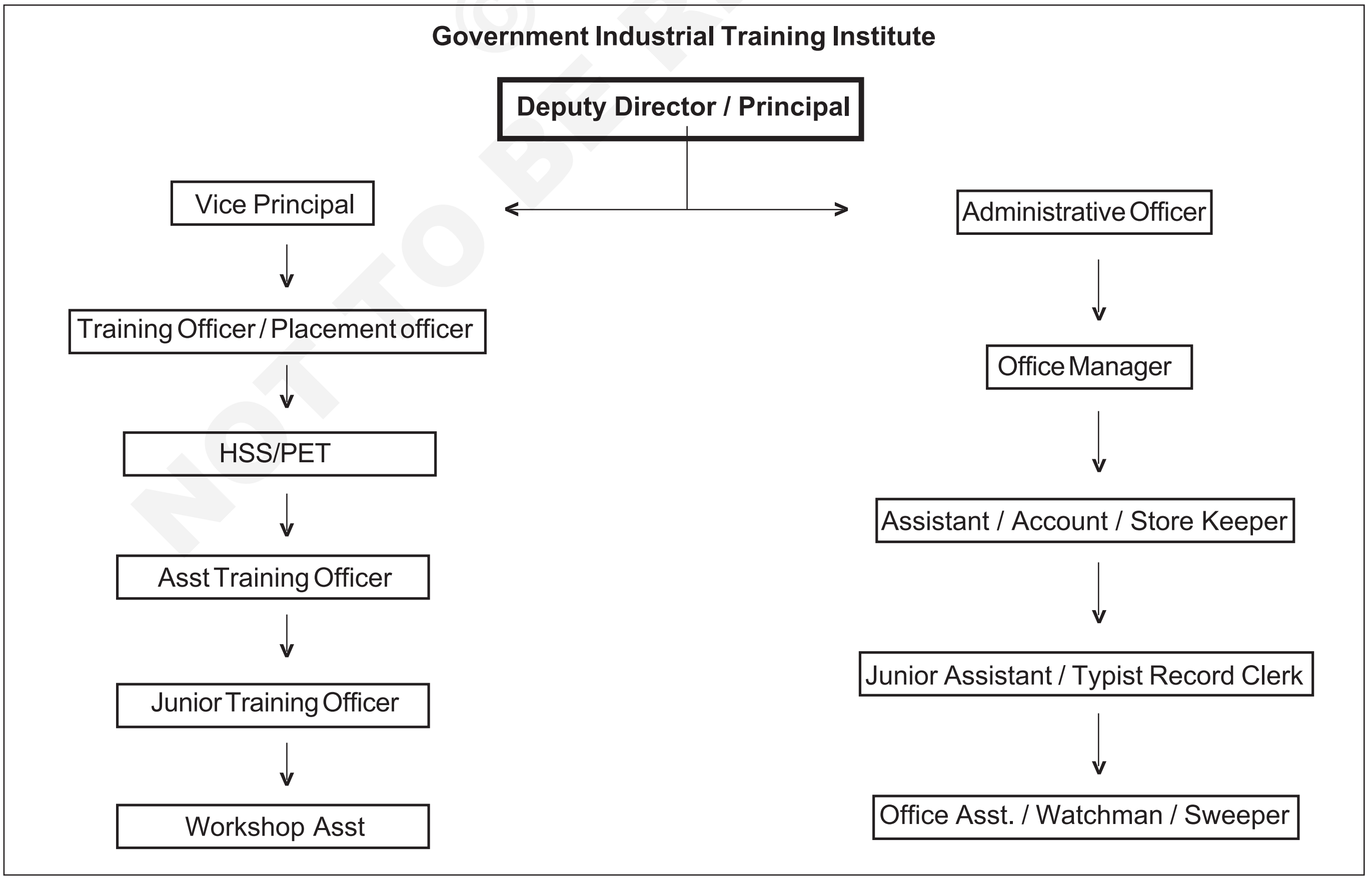
The objective of an ITI is to ensuring a steady flow of skilled workers and to reduce unemployment among the educated youth by training & equipping for suitable industrial employment and as well as for self employment.

The institute imparts training in engineering and non engineering two years/ one year trade courses approved by the Government of India in consultation with the National Council for Vocational Training, New Delhi.

Structure of ITI

The structure of industrial training institute is shown in the following chart 1. It may vary state to state It explain the information /order flow from higher superior officials to the ground level officials. The working hours may differ state to state. The trade master is the overall in-charge for the particular trade .the trainee has to report to trade master.

In every ITI there is a store and the incharge of the store is storekeeper for inward and outward movement of tools, equipment and consumables. The instructor will indent the training requirement for the training purposes.



Infrastructure available in ITI's

To provide 100% practical training to the trainees, tools, equipments, machineries and classroom facilities are available in ITI's. Continuous learning process/ programs are conducted in regular intervals as per the instructions given by the DGT.

The following facilities are available in ITI's

- Hostel facilities
- Libraries
- Soft skills lab/ computer labs
- High end classrooms /smart class.
- Stores
- Sports
- Wi-Fi enabled campus.
- Industrial visit's/ Industrialist guest lecture
- Internship training on the job training
- Apprentice programs
- Campus interview etc.,

CTS Admission Process

Online counseling is conducted Statewide selection is made on merit basis duly following rules of reservation. The candidates exercise the option of choosing the ITI and trade of their choice.

Students between the age of 14 - 40 are admitted in Industrial Training Institutes. Admission is made during the month of August every year.

Craftsman Training Scheme Exam System

Final Trade Test is conducted on All India basis and the question papers are issued to all Trade Testing Centres on the same day by the NCVT. Passed-out candidates are issued with National Trade Certificate (NTC) under the seal and authority of NCVT by DGT, New Delhi

Job area after completion of training

This highlights the employability aspect on 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 jobs available in different industries in INDIA and abroad.

After successful completion of training in any one of the engineering trade one can seek 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 is own factory / ancillary unit or design products manufacture and become an entrepreneur.

Further learning scope

- Apprentice training in designated trade.
- Craft Instructor certificate course.
- Diploma in relevant Engineering.

Skill competition

All India Skill Competition for Craftsmen scheme at national level was introduced to foster a healthy competition among the trainees of ITIs / ITCs

India skill competition is organized by National Skill Development Corporation., India skill competition the country's biggest skill competition is designed to demonstrate the highest standards of skilling and offers a platform to young people to show their talent at national level and international levels.

The competition is now held every year in 15 trades viz. Instrument Mechanic, Electronic Mechanic, Welder, Machinist, Turner, Machinist, Mechanic Motor Vehicle, Foundry man, Electrician, Cutting & Sewing, Computer Operator & Programming Assistant, Draughtsman (Civil), Draughtsman (Mechanical), Mechanic Diesel and Mechanic Refrigeration & Air- Conditioning.

The best trainee of each of the above trades at the State level competition competes at the All India Skill Competition.

Awards

The best Craftsmen in each of the above 15 trades at the All India level are awarded merit certificates and a cash prize of Rs. 50,000/- each. ITIs whose trainee stands first in the competition at the All India Skill Competition is awarded a merit certificate and is declared as the best ITI.

Approach on soft skills

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

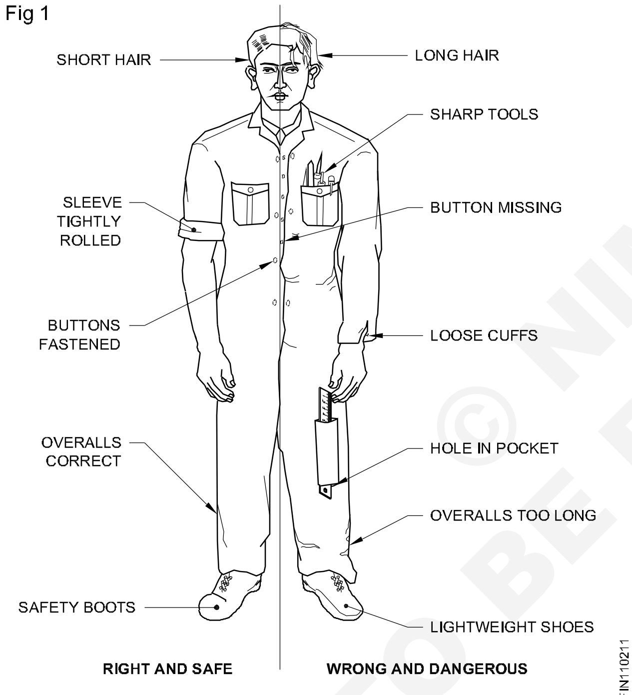
More and more business is considering soft skills as an important job criteria. Soft skills are used in personal and professional life. Hard skills / technical skills do not matter without soft skills.

Safety and general precautions in 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 crack practical jokes while on work.

Use the appropriate 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 of machinery is in the neutral
- the work area is clear & neat.

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 methodological 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 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 make people to varying degrees. The same can also be defined as an ability to interact communicate positively & productively with others. Sometimes called "character skills".

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 do not matter 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 area completion of training: This highlights the employability aspect on 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 trade 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 is own factory/ancillary unit or design products manufacture and became an entrepreneur.

Further learning scope

- Apprentice training in designated trade.
- Craft Instructor certificate course.
- Diploma in relevant Engineering.

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

Personal protective equipment, commonly referred to as "PPE", is equipment worn to minimize exposure to hazards that cause serious workplace injuries and illnesses. These injuries and illnesses may result from contact with chemical, radiological, physical, electrical, mechanical, or other workplace hazards. Personal protective equipment may include items such as gloves, safety glasses and shoes, earplugs or muffs, hard hats, respirators, or coveralls, vests and full body suits.

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.

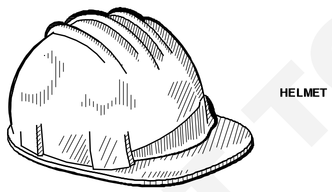
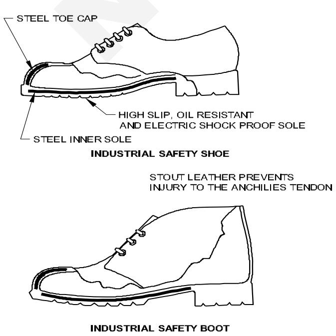
They are to meet the applicable BIS (Bureau of Indian Standards) standards for different types of PPE.

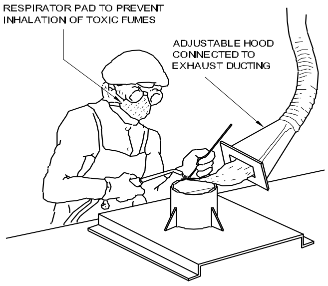
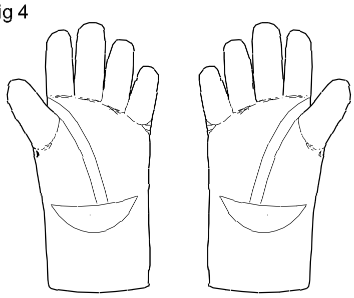
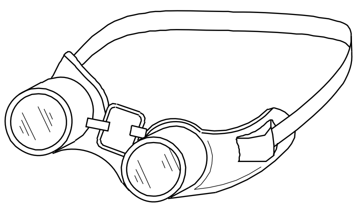
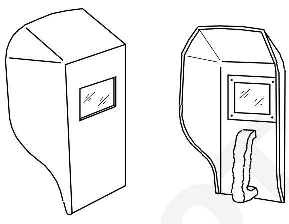
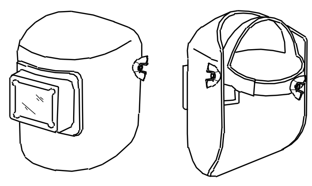
The guidelines on 'Personal Protective Equipment' is issued to facilitate the plant management in maintaining an effective programmer with respect to protection of persons against hazards, which cannot be eliminated or controlled by engineering methods listed in table 1.

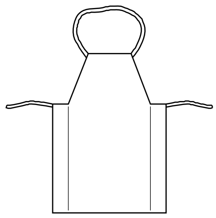
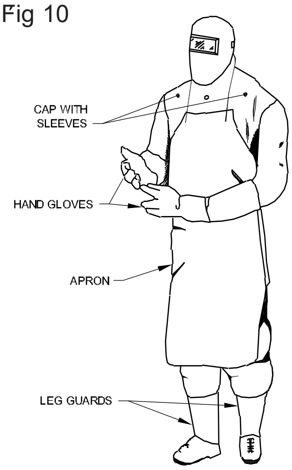
Table 1

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

Personal protective equipment's and their uses and hazards are listed in Table 2

Types of protection	Hazards	PPE to be used
Head protection (Fig 1) Fig 1 	1. Falling objects 2. Striking against objects 3. Spatter	Helmets
Foot protection (Fig 2) 	1. Hot spatter	Leather leg guards

Types of protection	Hazards	PPE to be used
Nose (Fig 3) Fig 3 	1. Dust particles 2. Fumes/gases/ vapors	Nose mask
Hand Protection (Fig 4) Fig 4  GLOVES	1. Heat burn due to direct contact 2. Blows spark moderate heat 3. Electric shock	Hand gloves
Eye protection (Fig 5 & Fig6) Fig 5  Fig 6  HAND SCREEN	1. Flying dust particles 2. UV rays, IR rays heat and High amount of visible	Goggles Face shield radiation Hand shield Head shield
Face protection (Fig 7) Fig 7  WELDING HELMET	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

Types of protection	Hazards	PPE to be used
Ear protection (Fig 8)   Ear muffs Ear plug	1. High noise level	Ear plug Ear muff
Body protection (Fig 9, & Fig 10) Fig 9  APRON Fig 10  LEG GUARDS	1. Hot particles	Leather aprons

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.

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 reparable air
- Expected activity of workman and duration of work, comfort of workman when using PPE
- Operating characteristics and limitation of PPE
- Ease of maintenance and cleaning
- Conformity to Indian / International standards and availability of test certificate.

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.

First-aid

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

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.

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.

Important guideline for first aiders

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.

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)

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.

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.

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

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.

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.- If you are trained.

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.

- Shock (Cardiogenic, Neurogenic)
- Head injury (Concussion, Compression)
- Asphyxia (obstruction to air passage)
- Extreme of body temperature (Heat, Cold)
- Cardiac arrest (Heart attack)
- Stroke (Cerebro-vascular accident)
- Blood loss (Hemorrhage)
- Dehydration (Diarrhea & vomiting)
- Diabetes (Low or high sugar)
- Blood pressure (Very low or very high)
- Over dose of alcohol, drugs
- Poisoning (Gas, Pesticides, Bites)
- Epileptic fits (Fits)
- Hysteria (Emotional, Psychological)

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

First aid

- 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.
- 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.

DO NOT

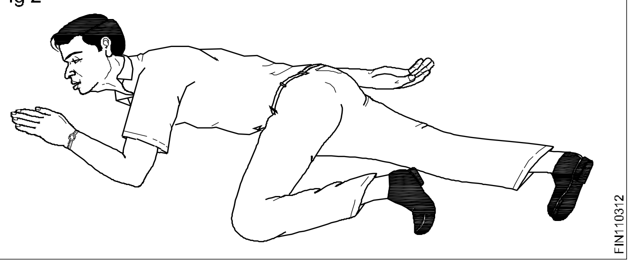
- Do not give an unconscious person any food or drink.
- Do not leave the person alone.
- Do not place a pillow under the head of an unconscious person.
- Do not slap an unconscious person's face or splash water on the face to try to revive him.

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 disheveled scene?
- **Think insulin:** might the person be suffering from insulin shock (see 'How to diagnose and treat insulin shock")?

Fig 2



- **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.

Shock: 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.

Operation of electrical mains

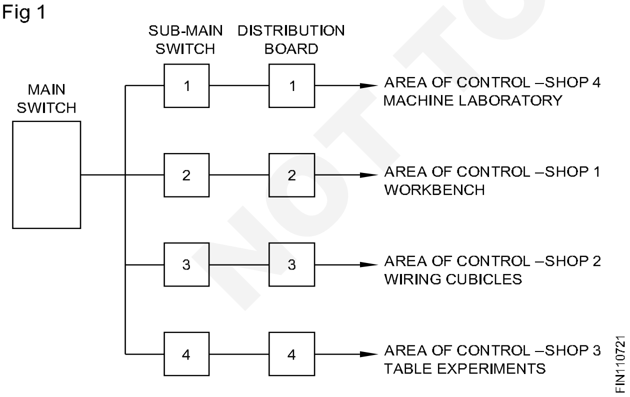
Objectives : At the end of this lesson you shall be able to
- **explain the term 'emergency'**
- **explain the need to switch off the circuit during emergency**
- **explain the method of locating the area sub-main and switches in the shop floor**
- **explain the position of handle with respect to ON & OFF in case of iron clad switches, MCB and ordinary house hold stitches.**

An emergency is an unexpected occurrence and requires immediate action. In a place like a workshop such a situation can arise when a person gets a shock due to electrical current or a person gets injured by the rotating part of a machine.

In such situations, switching off the supply will be the first and best solution to avoid further damage to the victim. For this, every person involved in the workshop should know which switch controls the area where the victim of shock remains.

Normally the total wiring in a workshop is controlled by a main switch and the different areas within the workshop may have two or more sub-main switches as shown in Fig 1.

Fig 1



To ascertain the area of the sub-main control, switch off one of the sub-main switches and try to switch 'on' the lights, fans and power points in that suspected area. If they do not work, then the area covered by the fan, light and power points are controlled by the sub-main switch. One after another, switch off the sub-main switches and locate their area of control. Mark the area of control of the switch in the plan of the wireman's section.

In a well organised workshop, the main switch, the sub main switches and distribution ways will have clear marking to show their area of control. (Fig 1) If this is not found, do this now. However, If you are not sure about the area of control the sub-main of the switches it is always better to switch 'off' the main switch itself.

Fig 2

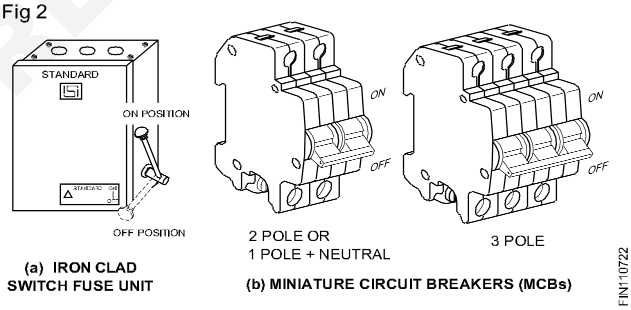
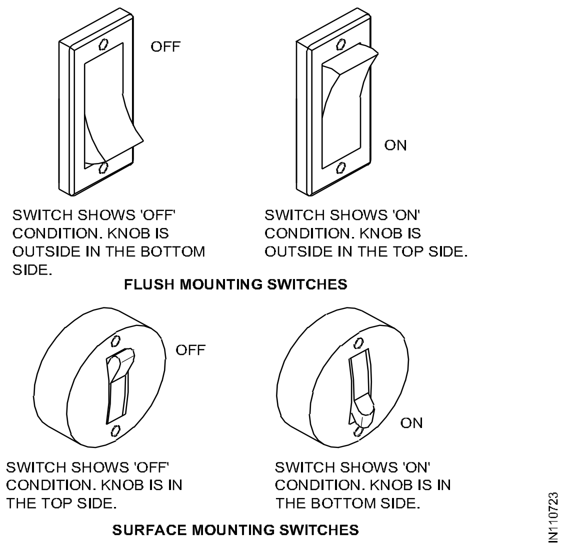


Fig 3



The handle of iron clad switches and the knob of MCB should be pushed down to switch 'off ' the circuits as shown in Fig 2. whereas in the ordinary switches, the switch off the circuit should be done by pushing the switch to upward position. (Fig 3)

The emergency situations could happen even at home Hence, identify the area of control of the switch and mark them in the main/sub-main/ distribution bound of your house switch board as a safety measure. Educate the intimates of the house how to switch off the circuit in case of any emergency.

Electrical safety

Objectives : At the end of this lesson you shall be able to
- **explain the necessary of adopting the safety rules**
- **list the safety rules and follow them.**

Safety rules

Necessity of safety rules: Safety consciousness is one of the essential attitudes required for any job. A skilled electrician always should strive to form safe working habits. Safe working habits always save men, money and material. Unsafeworking habits always end up in loss of production and profits, personal injury and even death. The safety hints given below should be followed by Electrician to avoid accidents and electrical shocks as his job involves a lot of occupational hazards.

The listed safety rules should be learnt, remembered and practiced by every electrician. Here a electrician should remember the famous proverb, "Electricity is a good servant but a bad master".

Safety rules

- Only qualified persons should do electrical work
- Keep the workshop floor clean, and tools in good condition.
- Do not work on live circuits, if unavoidable, use rubber gloves rubber mats, etc.
- Use wooden or PVC insulated handle screwdrivers when working on electrical circuits.
- Do not touch bare conductors.
- When soldering, place the hot soldering irons in their stand. Never lay switched 'ON' or heated soldering iron on a bench or table as it may cause a fire to break out.
- Use only correct capacity fuses in the circuit. If the capacity is less it will blow out when the load is connected. If the capacity is large, it gives no protection and allows excess current to flow and endangers men and machines, resulting in loss of money.
- Replace or remove fuses only after switching off the circuit switches.
- Use extension cords with lamp guards to protect lamps against breakage and to avoid combustible material coming in contact with hot bulbs.
- Use accessories like sockets, plugs and switches and appliances only when they are in good condition and be sure they have the mark of BIS (ISI). (Necessity using BIS (ISI) marked accessories is explained under standardisation.
- Never extend electrical circuits by using temporary wiring.
- Stand on a wooden stool, or an insulated ladder while repairing live electrical circuits/appliances or replacing fused bulbs. In all the cases, it is always good to open the main switch and make the circuit dead.
- Stand on rubber mats while working/ operating switch panels, control gears etc.
- Position the ladder, on film ground.
- While using a ladder, ask the helper to hold the ladder against any possible slipping.
- Always use safety belts while working on poles or high rise points.
- Never place your hands on any moving part of rotating machine and never work around moving shafts or pulleys of motor or generator with loose shirt sleeves or dangling neck ties.
- Only after identifying the procedure of operation, operate any machine or apparatus.
- Run cables or cords through wooden partitions or floor after inserting insulating porcelain tubes.
- Connections in the electrical apparatus should be tight. Loosely connected cables will heat up and end in fire hazards.
- Use always earth connection for all electrical appliances along with 3-pin sockets and plugs.
- While working on dead circuits remove the fuse grips; keep them under safe custody and also display 'Men on line' board on the switchboard.
- Do not meddle with inter locks of machines/switch gears
- Do not connect earthling to the water pipe lines.
- Do not use water on electrical equipment.
- Discharge static voltage in HV lines/equipment and capacitors before working on them.

Disposal of waste material

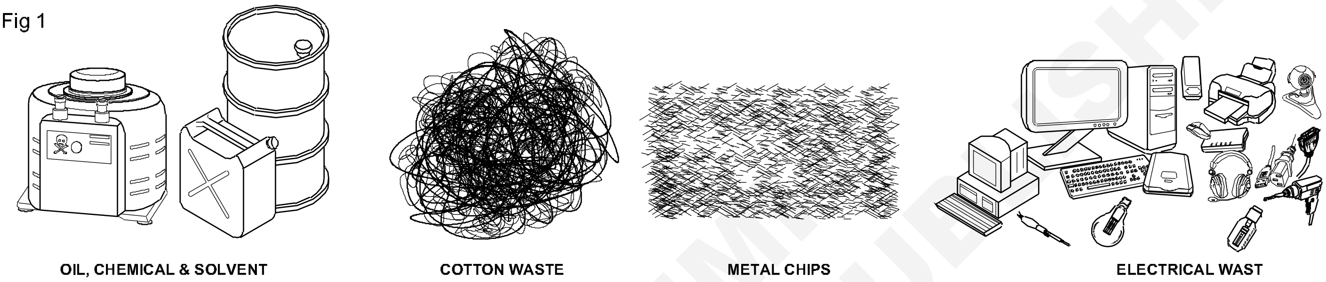
Objectives: At the end of this lesson you shall be able to
- **state what is waste material**
- **list the waste materials in a work shop**
- **explain the methods of disposal of waste material.**
- **state advantage of disposal of waste material.**
- **state colour code for bins for waste segregation.**

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)

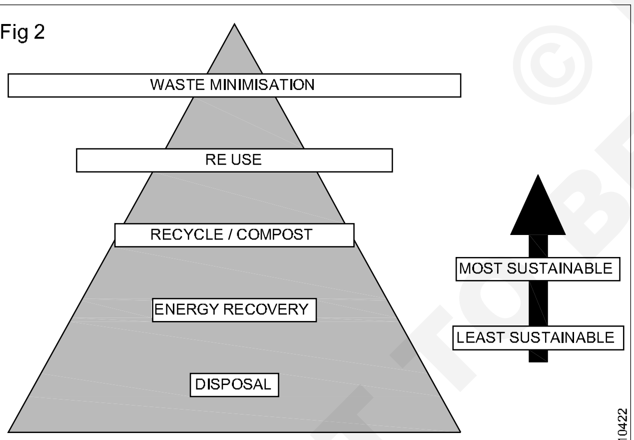
- Cotton waste
- Metal chips of different material.
- Oily waste such as lubricating oil, coolant etc.
- Other waste such electrical, glass etc.

Fig 1



Methods of waste disposal (Fig 2)

Fig 2



METHOD OF WASTE DISPOSAL

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.

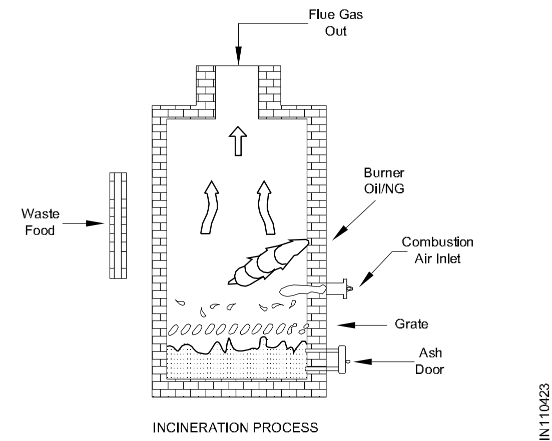
Burning the waste material: If you cannot recycle or if there are no proper places for setting up landfills, you can burn the waste matter generated in your household. Controlled burning of waste at high temperatures to produce steam and ash is a preferred waste disposal techique.

Advantage of waste disposal:

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

Incineration (Fig 3)

Fig 3



INCINERATION PROCESS

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 reduced 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 space need, thus making transportation and positioning easy.

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
- **describe occupational safety and its importance at work place to prevent unsafe act and conditions in work-related activities**
- **brief the Environmental guidelines, legislations & regulations in India, framed to protect workplace health and safety.**
- **list the Occupational safety and health Tips.**

Occupational safety, and health

Occupational safety, and health means actions or working conditions which are safe from any cause resulting in danger to life, physique, mentality or health arising out of or related to working environment. OSH includes the laws, standards and programs that are aimed at making the workplace better for workers, along with co-workers, family members, customers, and other stakeholders.

The goal of Occupational safety and health

The goal of Occupational safety and health program is to foster a safe and healthy occupational environment. OSH also protects all the general public who may be affected by the occupational environment.

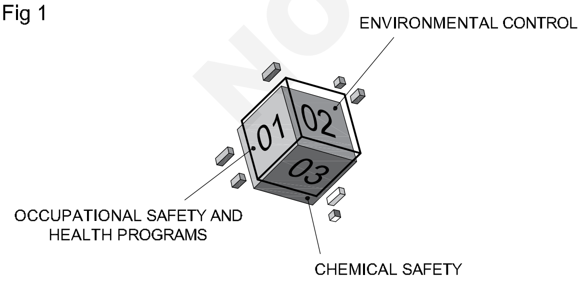
Environmental safety

Environmental safety is defined by the guidance, policies, and practices enforced in order to ensure that the surrounding environment is free from hazards that will warrant the safety and well-being of workers and employees, residents near industrial operations, as well as the prevention of accidental environmental damage

The surrounding areas include industrial facilities, work areas, and laboratories. Environmental safety is a crucial issue for any industrial activity as negligence and non-compliance heighten the risk resulting in injuries, illnesses, and accidental environmental releases.

Environmental safety is usually divided into three subcategories: (fig1) Occupational safety and Health Programs, Environmental Control, and Chemical Safety. (Fig 1)

Fig 1



ENVIRONMENTAL SAFETY SEGMENTS

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In order to protect the workers against work related sickness, disease and injury. The International labour organization(ILO) came up with an official order on OSH.

Similarly government of India is enacted the following acts

- The legislation for labour welfare, known as the Factories Act 1948, was enacted with the prime objective of protecting workmen employed in factories against industrial and occupational hazards. There are number of Acts enacted by the government of India and amended from time to time; among them the following are the most important ones in this regard:
- Factories Act, 1948,
- Mines Act, 1952,
- Dock workers (Safety, Health and welfare) Act, 1986,
- Building and other Construction workers (Regulation of Employment and conditions of service) Act, 1996,
- Plantation Labour Act, 1951,
- Contract Labour (Regulation and Abolition) Act, 1970
- The Child labour (Prohibition and Regulation) Act, 1986, etc.

Constitutional provisions form the basis of workplace safety and health laws in India by imposing a duty on the State governments to implement policies that promote the safety and health of workers at workplaces. In addition, safety and health statutes for regulating occupational safety and health (OSH) of persons at work exist in different sectors, namely manufacturing, mining, ports, and construction sector.

The health and safety at work Act,1974 states employers are responsible for protecting the safety of their employees at work by preventing potential dangers in the workplace. It places general duties on employers to ensure the health, safety and welfare of all persons while at work.

Legislation is a directive proposed by a legislative body while a regulation is a specific requirement within legislation. Legislation is broader and more general while regulation is specific and details how legislation is enforced.

The difference between legislation and regulation is that legislation is the act of process of making certain laws while regulation is maintaining the law or set of rules that govern the people. It is a government-driven or ministerial order having the force of law.

The ILO's primary goal is to promote opportunities for women and men to obtain decent and productive work in conditions of freedom, equity, security and human dignity. In 2003 the ILO adopted a global strategy to improve preventive standards on occupational safety and health to provide essential tools for governments, employers, and workers to establish safe practices and health culture for providing maximum safety at work.

The four important aims of health and safety legislation is to

i secure the safety, health and welfare of employees and other people at work;

ii protect the public from the safety and health risks of business activities;

iii amend statutes relating to safety aspects of substances, equipment and environment;

iv eliminate workplace risks at the source.

Occupational safety and health Tips:

- Be aware of your surroundings.
- Maintain a correct posture.
- Take break regularly.
- Use Equipment properly.
- Locate Emergency Exits.
- Report Unsafe conditions.
- Practice Effective Housekeeping.
- Make use of mechanical aids.
- Wear the correct Safety equipment.
- Reduce workplace stress.

Safety signs

Objective : At the end of this lesson you shall be to
- **state the safety attitude and list the four basic categories of safety signs.**

Safety signs: As you go about your work on a construction site you will see a variety of signs and notices. Some of these will be familiar to you - a 'no smoking' sign for example; others you may not have seen before. It is up to you to learn what they mean - and to take notice of them. They warn of the possible danger, and must not be ignored.

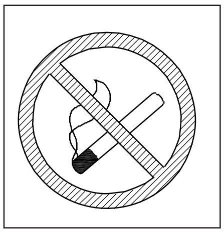
Safety signs fall into four separate categories. These can be recognised by their shape and colour. Sometimes they may be just a symbol; other signs may include letters or figures and provide extra information such as the clearance height of an obstacle or the safe working load of a crane.

The four basic categories of signs are as follows:

- prohibition signs (Fig 1 & Fig 5)
- mandatory signs (Fig 2 & Fig 6)
- warning signs (Fig 3 & Fig 7)
- information signs (Fig 4)

Prohibition signs

Fig 1



SHAPE	**Circular.**
COLOUR	**Red border and cross bar. Black symbol on white background**
MEANING	**Shows it must not be done.**
Example	**No smoking**

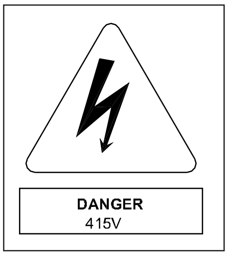
Mandatory signs

Fig 2

SHAPE	**Circular.**
COLOUR	**White symbol on blue background**
MEANING	**Shows what must be done**
Example	**Wear hand protection**

Warning signs

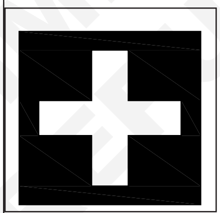
Fig 3



SHAPE	**Triangular**
COLOUR	**Yellow background with black border and symbol.**
MEANING	**Warns of hazard or danger.**
Example	**Caution, risk of electric shock.**

Information signs

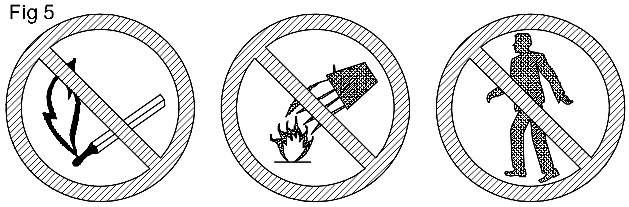
Fig 4



SHAPE	**Square of oblong.**
COLOUR	**White symbols on green background.**
MEANING	**Indicates or gives information of safety provision.**
Example	**First aid point.**

Prohibition signs

Fig 5



SMOKING AND NAKED FLAMES PROHIBITED — DO NOT EXTINGUISH WITH WATER — PEDESTRIANS PROHIBITED

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Mandatory signs

Fig 6

MANDATORY SIGNS

Warning signs

Fig 7

WARNING SIGNS

Question about your safety

Do you know the general safety rules that cover your place of work?

Are you familiar with the safety laws that govern you particular job?

Do you know how to do your work without causing danger to yourself, your workmates and the general public?

Are the plant, machinery and tools that you use really safe? Do you know how to use them safely and keep them in a safe condition?

Do you wear all the right protective clothing, and have you been provided with all the necessary safety equipment?

Have you been given all the necessary safety information about the materials used?

Have you been given training and instruction to enable you to do your job safely?

Do you know who is responsible for safety at your place of work?

Do you know who are the appointed 'Safety Representatives'?

Response to emergencies

Objectives: At the end of this lesson you shall be able to
- **respond incase of power failure, system failure and fire**
- **report an emergency.**

Power failure, System failure & Fire

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 Assassin bug

2 Lightening bug

3 Brain bug

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

3 Fire

When fire alarm sounds in your buildings

- Evacuate to outside immediately.
- Never go back
- Make way for fire fighters and their trucks to come
- Never use an elevator
- Do not panic

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 prevail 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 passer by would like to get involved to assist the victims. Hence first aid man-agreements is often very difficult to attend to the injured persons. 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 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 occurred 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 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.

Importance of housekeeping

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

Housekeeping

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

- **Cleaning of shop floor:** Keep clean and free from accumulation of dirt and scrap daily
- **Cleaning of Machines :** Reduce accidents to keep machines cleaned well
- **Prevention of Leakage and spillage:** Use splash guards in machines and collecting tray
- **Disposal of Scrap-** Empty scrap, wastage, staffroom respective containers regularly
- **Tools Storage-** Use special racks, holders for respective tools
- **Storage Spaces: I**dentify storage areas for respective items. Do not leave any material in gangway
- **Piling 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 improvement of the manufacturing process.

- All workers are communicated with daily target on manufacturing, activities.
- Informative charts are used to post production, quality and safety results 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"

Introduction to 5S concept and its application

Objectives: - At the end of this lesson you shall be able to
- **stat what is 5S**
- **state the general benefits of implementing 5S**
- **explain the terms in 5S and its concept of implementation.**

Introduction

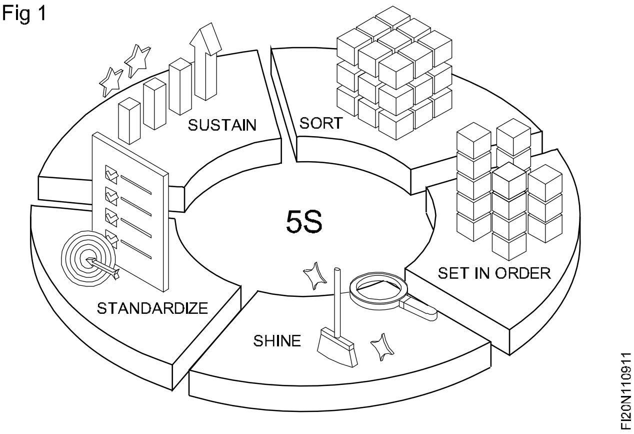
5S is a philosophy and a way of organizing and managing the workspace and work flow with the intent to improve efficiency by eliminating waste, improving flow and reducing process unreasonableness. There are five steps in the system, each starting with the letter S:

1 Sort 2 Set in order 3 Shine
4 Standardize 5 Sustain

The Steps of 5S (Fig 1)

5S was created in Japan, and the original "S" terms were in Japanese, so English translations for each of the five steps may vary. The basic ideas and the connections between them are easy to understand, though.

Fig 1

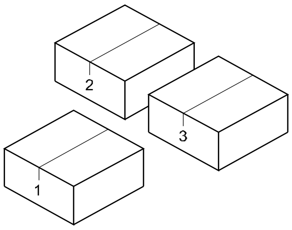


Step Name	Japanese term	Explanation
1	Sort Seiri (tidiness)	Remove unnecessary items from each area
2	Set In Order	Seiton (orderliness) Organize and identify storage for efficient use
3	Shine Seiso (cleanliness)	Clean and inspect each area regularly
4	Standardize	Seiketsu (standardization) Incorporate 5S into standard operating procedures
5	Sustain Shitsuke (discipline)	Assign responsibility, track progress, and continue the cycle

Step 1 Sort

The first step in the 5S process is Sort, or "seiri," which translates to "tidiness." The goal of the Sort step is to eliminate clutter and clear up space by removing things that don't belong in the area. (Fig 2)

Fig 2



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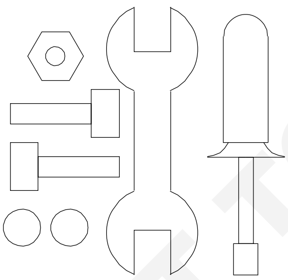
Step 2: Set In Order

The second step, set in Order, was originally called "seiton," which translates to "orderliness." A variety of names have been used in English: "Systematic Organization," "Straightening Out," and "Simplify," for example. No matter what it's called, the goal of this step is to organize the work area. Each item should be easy to find, use, and return: a place for everything, and everything in its place. (Fig 3)

Fig 3



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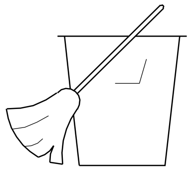
Implementation steps of Set in order

- Draw up a map, and then implement it
- Physically arrange the workplace first, and then map it out
- Map as you go, testing ideas and writing down what works well

Step 3: Shine

The third step of 5S is Shine, or "seiso," which means "cleanliness." While the first and second steps cleared up space and arranged the area for efficiency, this step attacks the dirt and grime that inevitably builds up underneath the clutter, and works to keep it from coming back. (Fig 4)

Fig 4



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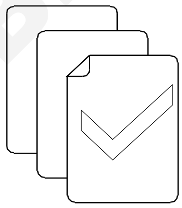
Step 4: Standardize

The fourth step is Standardize, or "seiketsu," which simply means standardization. By writing down what is being done, where, and by whom, you can incorporate the new practices into normal work procedure. This paves the way for long-term change. (Fig 5)

Fig 5



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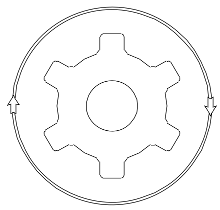
Tools for Standardizing

- 5S checklists
- Job cycle charts
- Procedure labels and signs

Step 5: Sustain

The fifth step of a 5S program is Sustain, or "shitsuke," which literally means "discipline." The idea here is continuing commitment. It's important to follow through on the decisions that you've made and continually return to the earlier steps of 5S, in an ongoing cycle. (Fig 6)

Fig 6



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Sustaining a 5S program can mean different things in different work places, but there are some elements that are common in successful programs.

- Management support
- Department tours
- Updated training
- Progress audits
- Performance evaluations

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**
- **use of 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. 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.

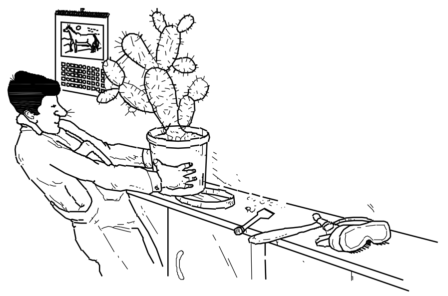
Type of injury and how to prevent them?

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 sufficient for protection, but the load should be checked to make sure of this, since large or heavy loads may involve body contact as well.

Fig 1



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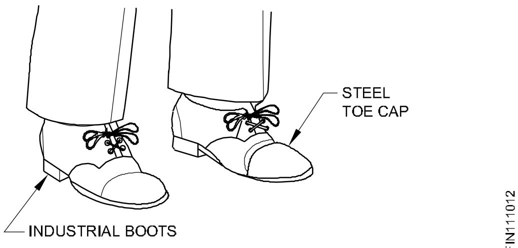
Crushing of feet or hands

Feet or hands should be so positioned that they will not be trapped by the load. Timber wedges can use 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)

Fig 2



Strain to muscles and joints

Strain to muscles and joints may be result of:

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

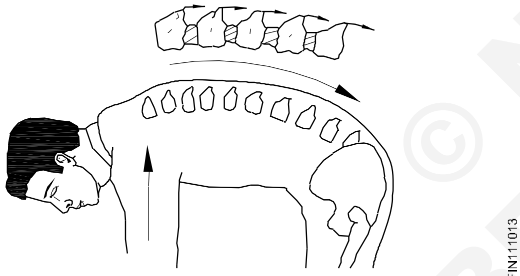
Sudden and awkward movements such as twisting or jerking during a lift can put severe strain on muscles.

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 farther 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 to lifting and handling heavy loads.

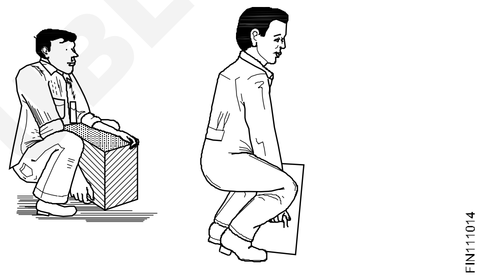
What makes an object difficult to lift and carry?

- Weight is not the only factor which makes it difficult to lift and carry.
- The size and shape can make an object awkward to handle.
- Loads high require the arms to be extended in front of the body, place more strain on the back and stomach.
- The absence of hand holds or natural handling points can make it difficult to raise and carry the object.

Correct manual lifting techniques

- Approach the load squarely, facing the direction of travel
- 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.
- Ensure that a safe firm hand grip is obtained. Before the weight is taken, the back should be straight ended and held as near the vertical position as possible. (Fig4)

Fig 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.
- 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

- To complete the lift, raise the upper part of the body to the vertical position. When a load is near 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)

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)

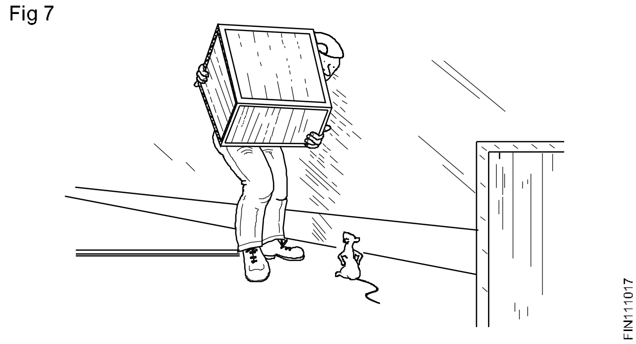


Fig 7

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.

Moving heavy equipment

Objectives: At the end of this lesson you shall be able to
- **name 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 equipment's are moved in industry using any of the following methods.

Crane and slings

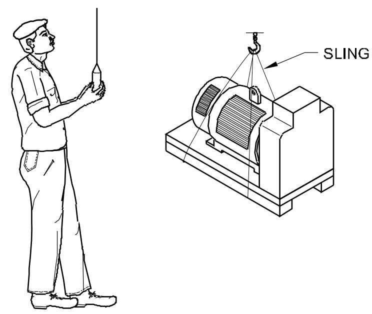
Winches

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.

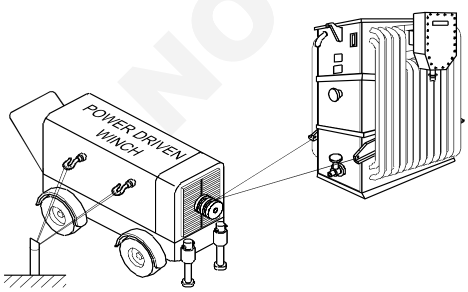
Distribute the weight as evenly as possible between the slings when using more than one sling. (Fig 1)

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. (Fig3)

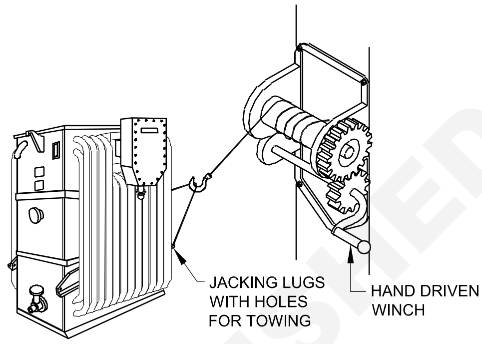
Fig 2



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 3



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 lugs 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. Practice how to use the brakes.

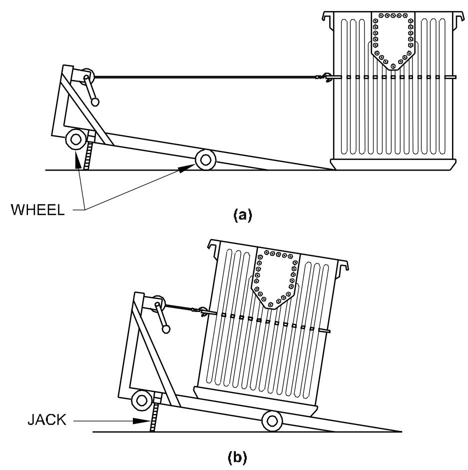
Keep hands and fingers well away from the gear wheels.

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.

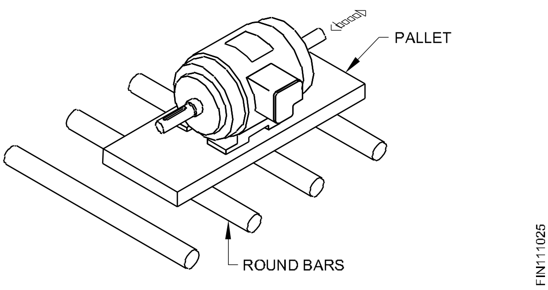
For unloading follow the procedure in the reverse order.

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



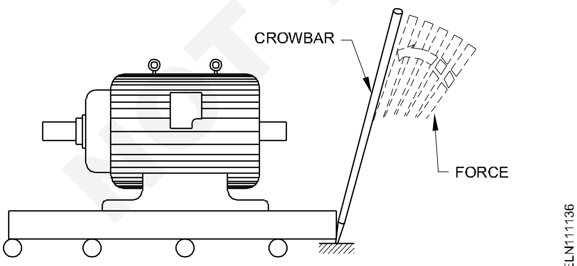
Ensure the bars (rollers) are long enough to project at each side of the load, for ease of handling.

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

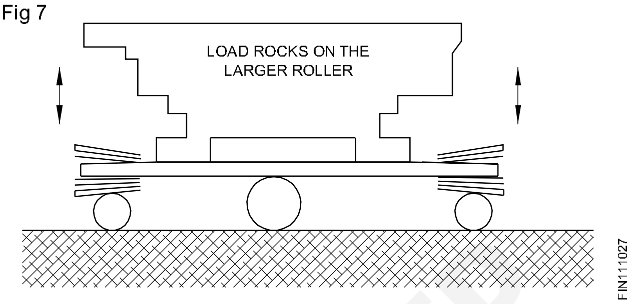
> **When a load is on rollers, only shallow slopes can be negotiated.**
>
> **Hold the load in check all the time if it is on the slope.**
>
> **Use a winch with an effective brake for this operation.**

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 swiveled around sideways. (Fig 7)

Fig 7

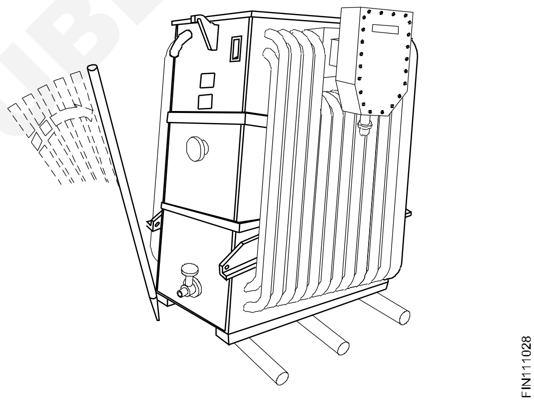


For heavier loads

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

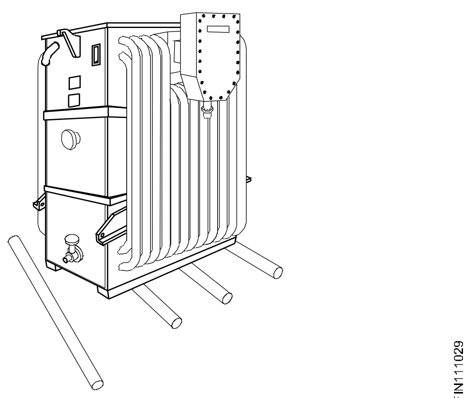
Twist the load round on the rollers by pushing the sides with crowbars until the load is just over the ends of the rollers. (Fig 8)

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

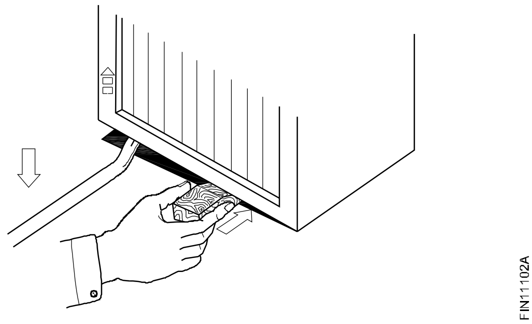
Make sure your hands are clear of the load before lowering it on to the packing or rollers.

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.

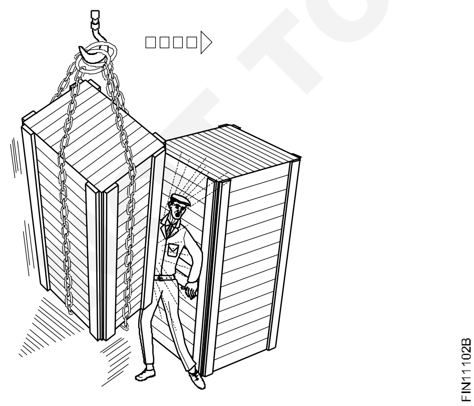
Before starting to lift a load, if you cannot see an assistant on the far side of the load, verify that he is ready to lift the load and ensure that his hands are clear of the slings.

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.

Fig 11



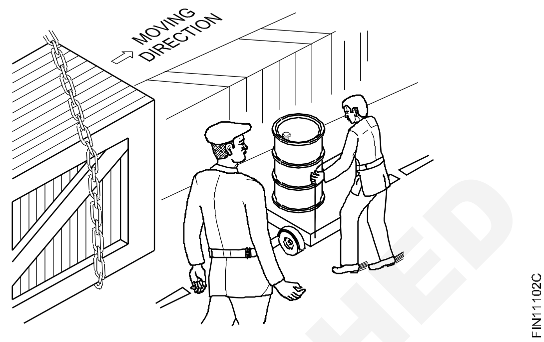
Minimise such movement by locating the hooks as accurately as possible above the centre of gravity of the load.

Keep the floor clear of unnecessary objects.

Moving a load

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

Fig 12



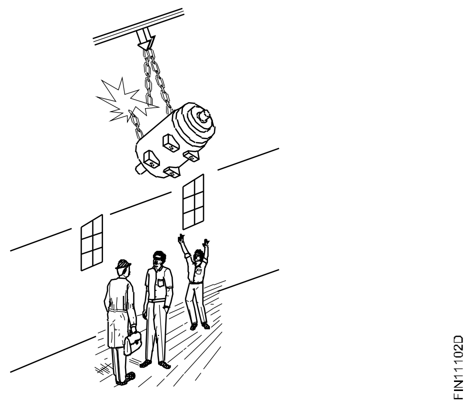
Stand clear off the load and move it steadily.

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)

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.

Linear measurement

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 (cm) = 10 mm

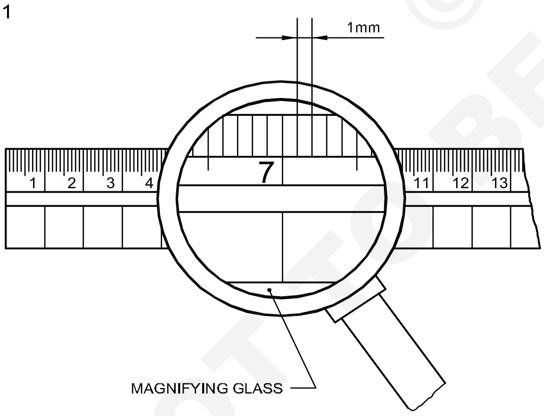
MILLIMETRE (mm) = 1000 µm

MICROMETRE (µm) = 0.001 mm

Measurement in engineering practice

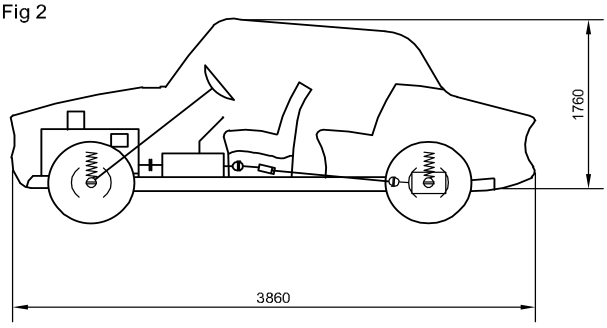
Usually, in engineering practice, the preferred unit of length measurement is millimetre. (Fig 1)

Fig 1



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

Fig 2

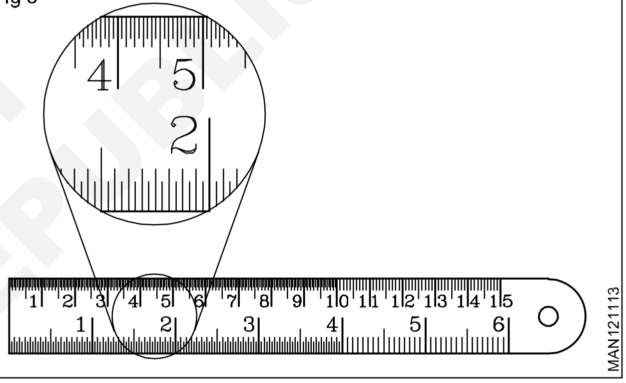


The British system of length measurement

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.

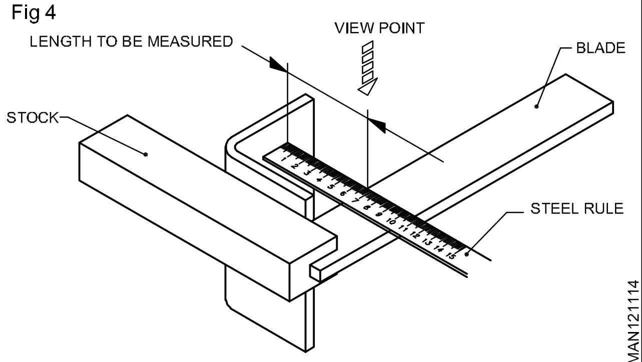
Fig 3



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)

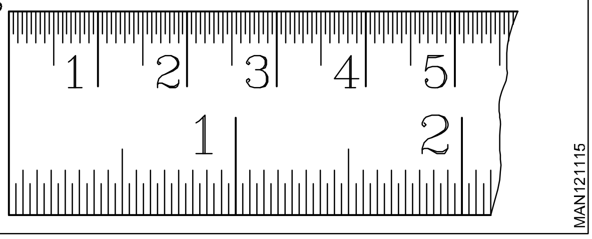


Fig 5

Other types of rule

- Narrow steel rules
- 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 cannot reach. Its width is approximately 5 mm and thickness 2 mm. (Fig 6)

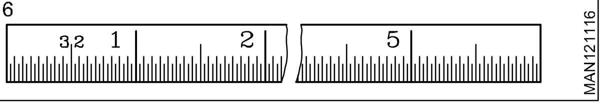


Fig 6

Short steel rule (Fig 7)

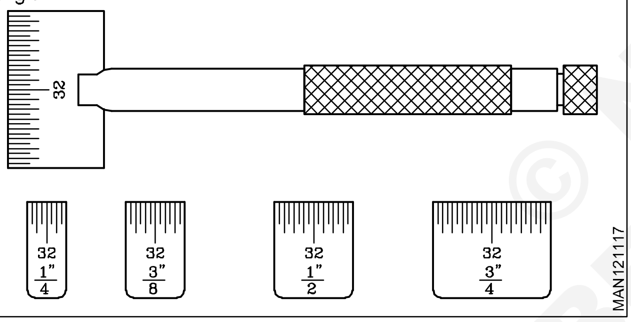


Fig 7

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.

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 favorite 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)

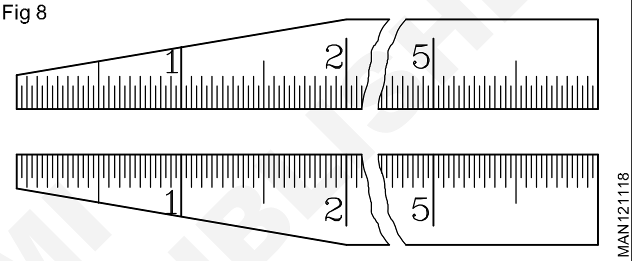


Fig 8

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

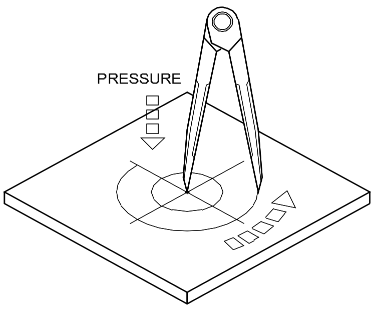
Metric	British
Micron 1μ = 0.001 mm	Thousandth of an inch = 0.001"
Millimetre 1 mm = 1000μ	Inch = 1"
Centimetre 1 cm = 10 mm	Foot 1 ft = 12"
Decimetre 1 dm = 10 cm	Yard 1 yd = 3 ft
Metre 1 m = 10 dm	1 furlong 1 fur = 220 yds
Decametre 1 dam = 10 metre	1 mile = 8 furlong

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

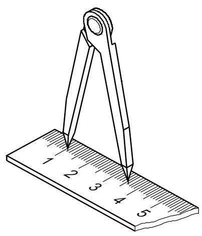


SCRIBING CIRCLES

MAN121121

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)

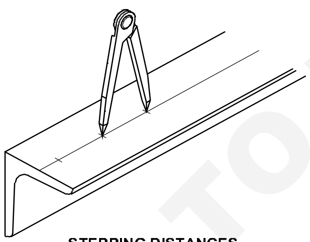
Fig 2



SETTING MEASUREMENT

MAN121122

Fig 3



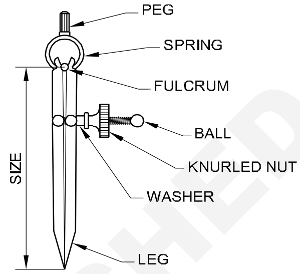
STEPPING DISTANCES

MAN121123

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

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

Fig 4



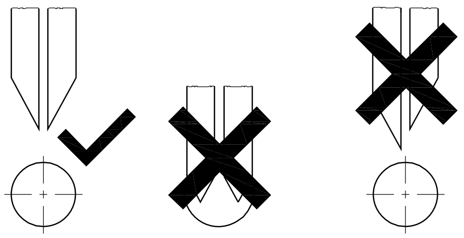
SPRING JOINT DIVIDER

MAN121124

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.

Fig 5



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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 by grinding will make the points soft.

Calipers

Objectives: At the end of this lesson you shall be able to
- **state the commonly used calipers**
- **state the advantages of spring joint calipers.**

Calipers are indirect measuring instruments used for transferring measurements from a steel rule to a job, and vice versa.

Calipers are classified according to their joints and their legs.

Joint

- Firm joint calipers (Fig 1a)
- Spring joint calipers (Fig 1b)

Legs

- Inside caliper for internal measurement. (Fig 2)
- Outside caliper for external measurement. (Fig 3)

Calipers are used along with steel rules, and the accuracy is limited to 0.5 mm. Parallelism of jobs etc. can be checked with higher accuracy by using calipers with sensitive feel.

Fig 1

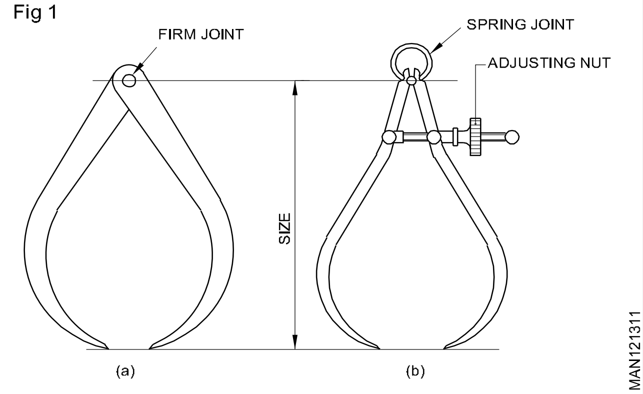
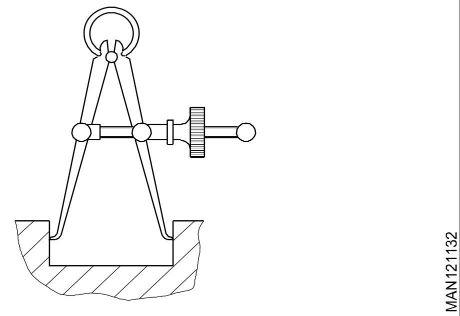
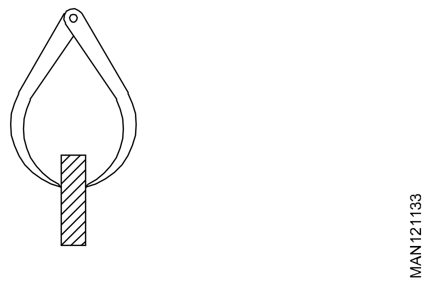


Fig 2



Spring joint calipers have the advantage of quick setting with the help of an adjusting nut. For setting a firm joint caliper, tap the leg lightly on a wooden surface.

Fig 3

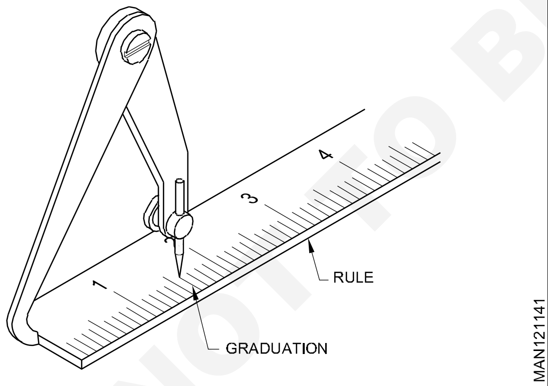


Jenny calipers

Objectives: At the end of this lesson you shall be able to
- **state the uses of a jenny caliper**
- **state the two types of legs of a jenny caliper.**

Jenny calipers have one leg with an adjustable divider point, while the other is a bent leg. (Fig 1) These are available in sizes of 150 mm, 200 mm, 250 mm and 300mm.

Fig 1



Jenny calipers are used

- for marking lines parallel to the inside and outside edges (Fig 2)
- for finding the centre of round bars (Fig 3)

These calipers are available with the usual bent leg or with heel.

Calipers with bent leg (Fig 2B) are used for drawing lines parallel along an inside edge. and the heel type (Fig 2A) is used for drawing parallel lines along the outer edges.

Fig 2

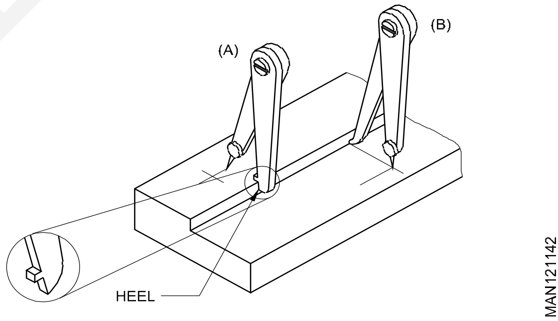
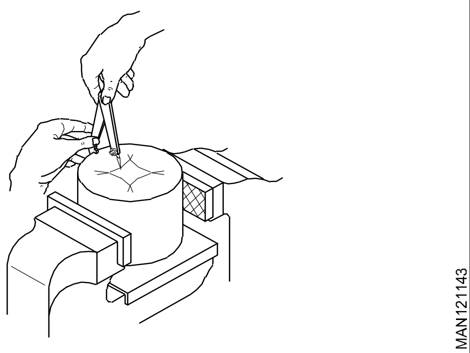


Fig 3



The other names for this caliper are:

- hermaphrodite calipers
- leg and point calipers
- odd leg caliper

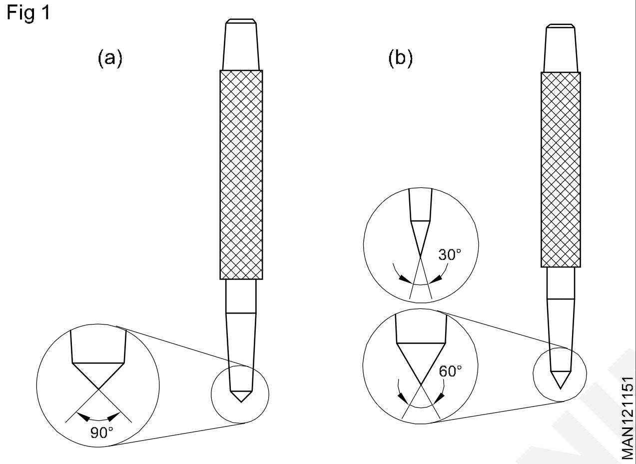
Types of marking punches

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)

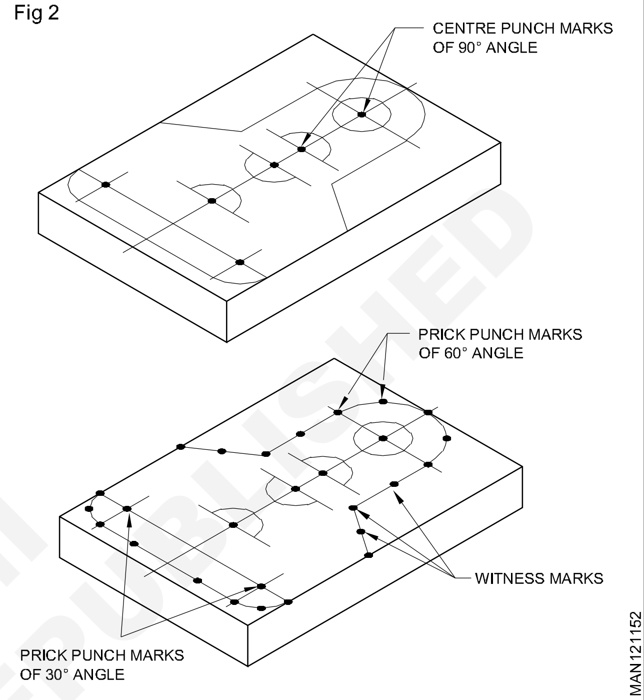
Fig 1



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



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 riveting.

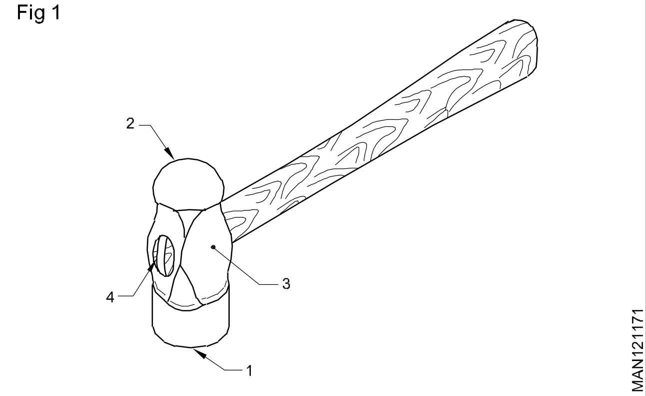
Major parts of a hammer: The major parts of a hammer are the head and the handle.

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).

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.

Fig 1

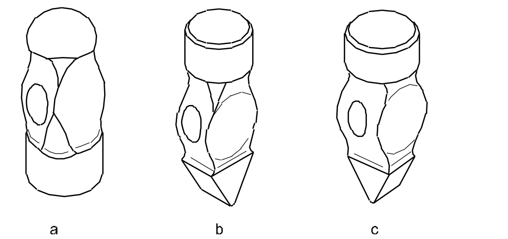


Pein: The pein is the other end of the head. It is used for shaping and forming work like riveting and bending The pein is of different shapes such as:

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

The face and the pein are case hardened.

Fig 2



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

This portion of the hammer 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

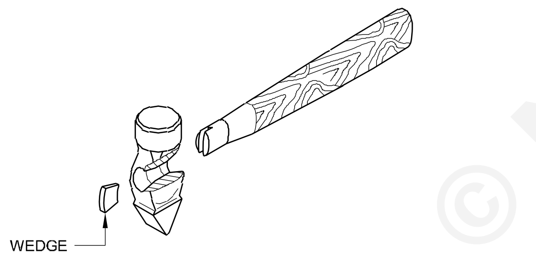
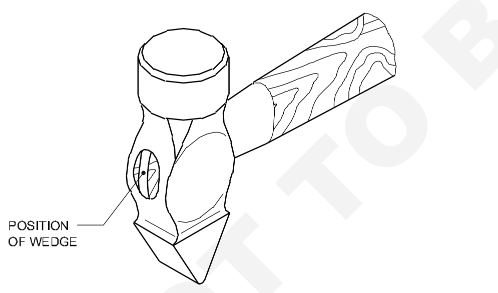
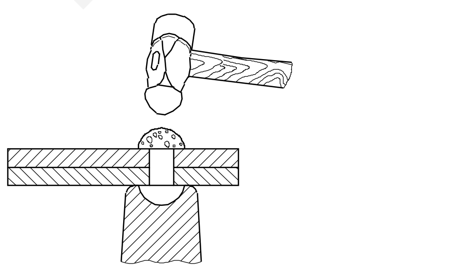


Fig 4



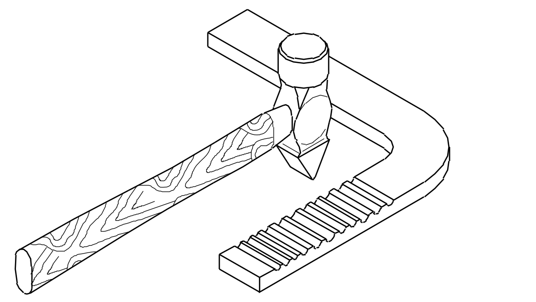
Application of hammer pein: The ball pein is used for riveting. (Fig 5)

Fig 5



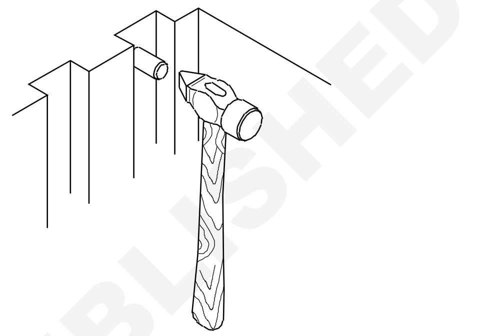
The cross- pein is used for spreading the metal in one direction. (Fig 6)

Fig 6



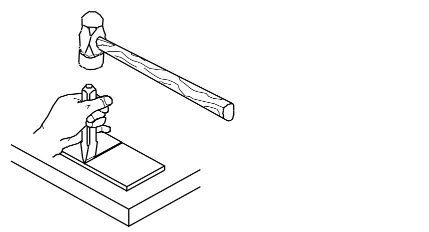
The straight pein is used at the corners. (Fig 7)

Fig 7



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

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.

The weight of an engineer's hammer, used for marking purpose is 250gms.

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.

Marking off and marking off table

Objectives : At the end of this lesson you shall be able to
- **state why marking off is necessary**
- **state the function of witness marks**
- **state the features of marking tables**
- **explain the uses of marking tables**
- **state the maintenan ce aspects concerning marking tables.**

Marking off

Marking off or layout is carried out to indicate the locations of operation to be done, and provide guidance during rough machining or filing.

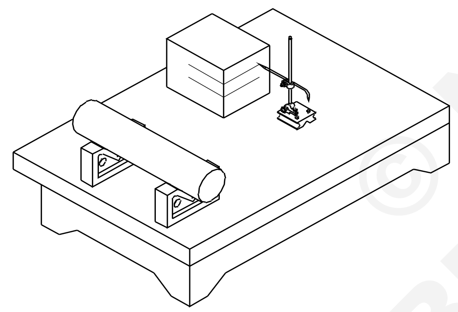
Witness marks

The line marked on metal surfaces is likely to be erased due to handling. To avoid this, permanent marks are made by placing punch marks at convenient mark intervals along the marked line. Punch marks act as a witness against inaccuracies in machining and hence, they are known as witness marks.

Marking off table (Figs 1 and 2)

A marking table (marking-off table) is used as a reference surface for marking on workpieces.

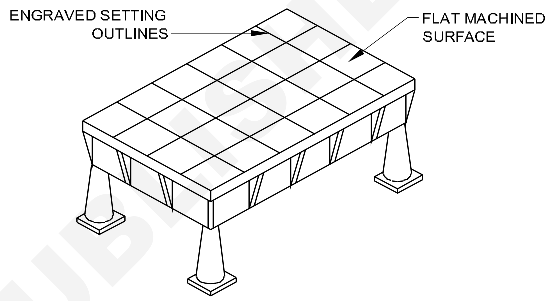
Fig 1



Marking tables are of rigid construction with accurately finished top surfaces. The edges are also finished at right angles to the top surface.

Marking tables are made of cast iron or granite, and are available in various sizes. These tables are also used for setting measuring instruments, and for checking sizes, parallelism and angles.

Fig 2



Care and maintenance

A marking table is very precise equipment, and should be protected from damage and rust.

After use, the marking table should be cleaned with a soft cloth.

The Surface of the marking table, made of cast iron, should be protected by applying a thin layer of oil.

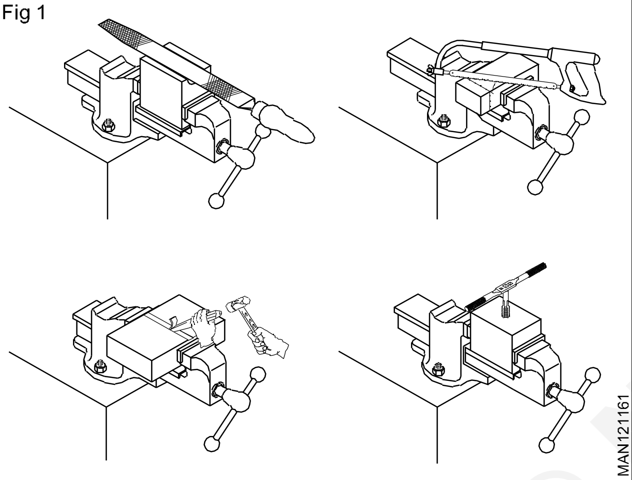
Bench vice

Objectives: At the end of this lesson you shall be able to
- **state the uses of bench vice**
- **describe the size of the bench vice**

Vices are used for holding the workpieces. They are available in different types. The vice used for bench work is the bench vice or called Engineer's vice.

A bench vice is made of cast iron or cast steel and it is used to hold the work for filing, sawing, threading and other hand operations. (Fig 1)

Fig 1



The size of the vice is stated by the width of the jaws.eg. 150mm parallel jaw bench vice.

Positioning of bench vice: Vices are mounted rigidly on a work bench with the fixed jaw in line with the bench edge to permit a long work to be clamped in a vertical position. (Fig 2)

For the convenience of working, the vice should be held at a correct height i.e. when the fist is pressed against the chin the elbow should touch the top of the vice. For further height adjustments, wooden platforms can be used.

For the convenience of working the vice should be held at a correct height i.e, when the fist is pressed against the chin, the elbow should touch the top of the vice. For further height adjustments wooden platforms can be used (Fig 3)

Precautions

Clamp the work as low as possible on the vice. Do not give extra leverage while tightening the work.

Lubricate the spindle and the box-nut periodically. Do not tighten the jaws of the vices without any work in between

Do not hammer on the vices for levelling metal

Fig 2

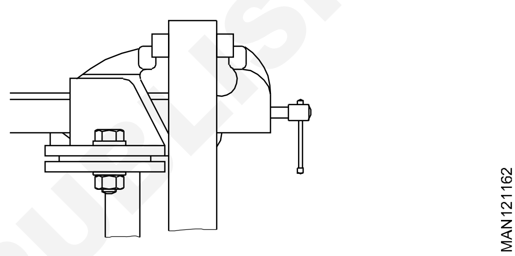
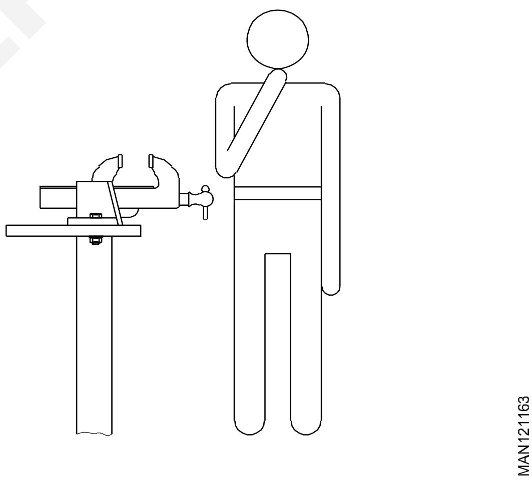


Fig 3



Parts of a bench vice

Objectives: At the end of this lesson you shall be able to
- **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)

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)

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.

Fig 1

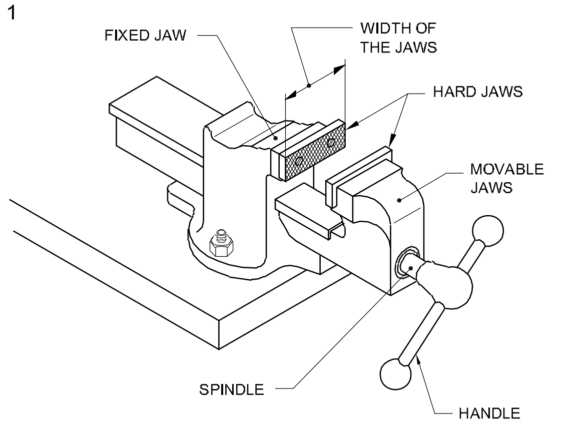
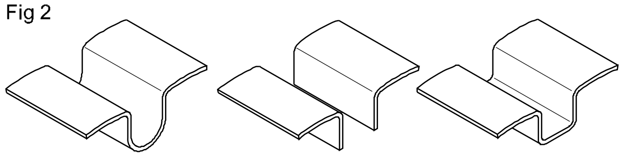


Fig 2



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.

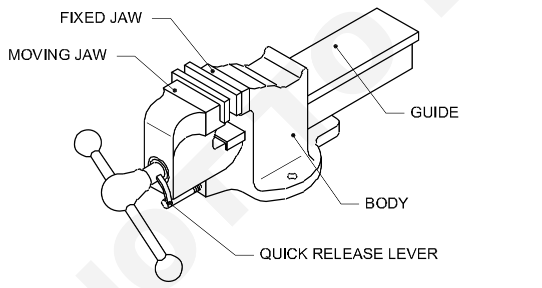
Types of vices

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.

Fig 1



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.

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

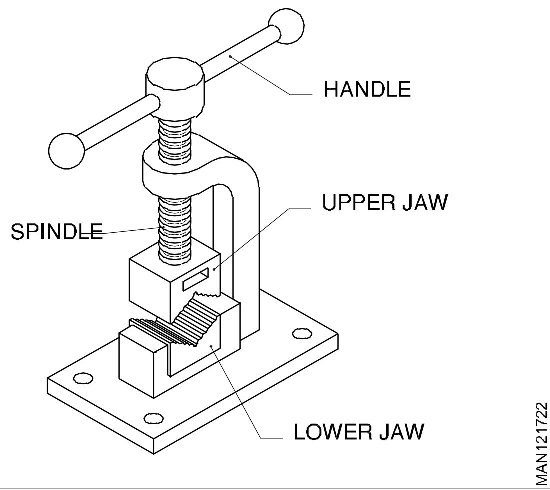
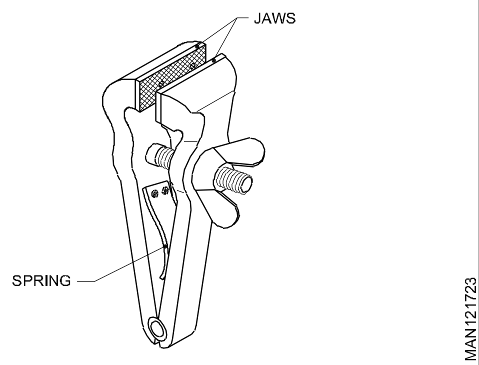
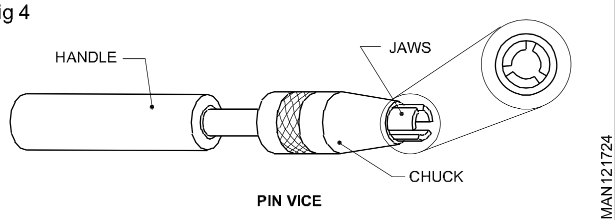


Fig 3



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.

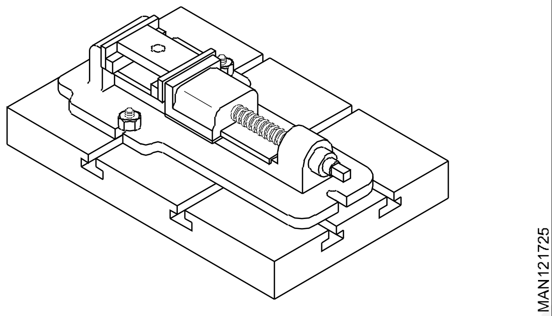
Fig 4



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.

Fig 5



Leg vice

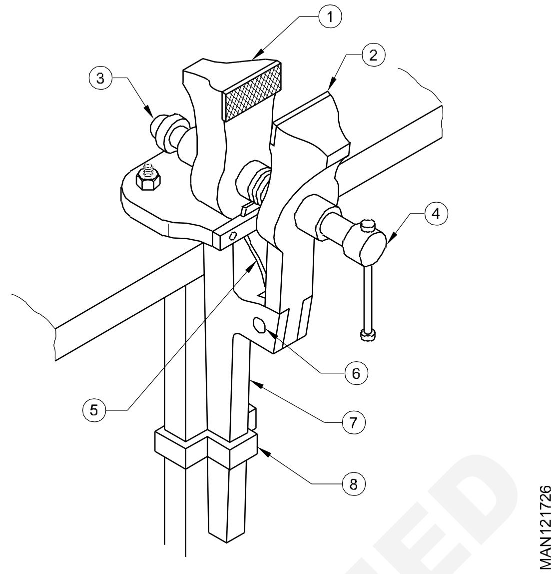
A leg vice is a holding device generally used in a forge shop for bending and forging work. It is made fo mild steel to avoid breakage while hammering.

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

The following are the main parts of a leg vice.

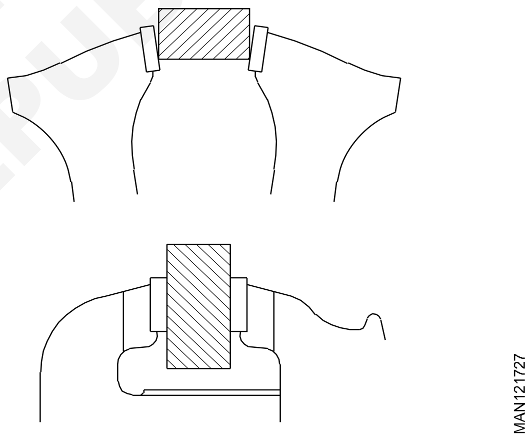
1 Solid jaw	5 Spring
2 Movable jaw	6 Pivot
3 Threaded jaw	7 Leg
4 Spindle	8 Clamp

Fig 6



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



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.

Parts of a hacksaw frame

1 Handle

2 Frame

3 Tubular frame with holes for length adjustment

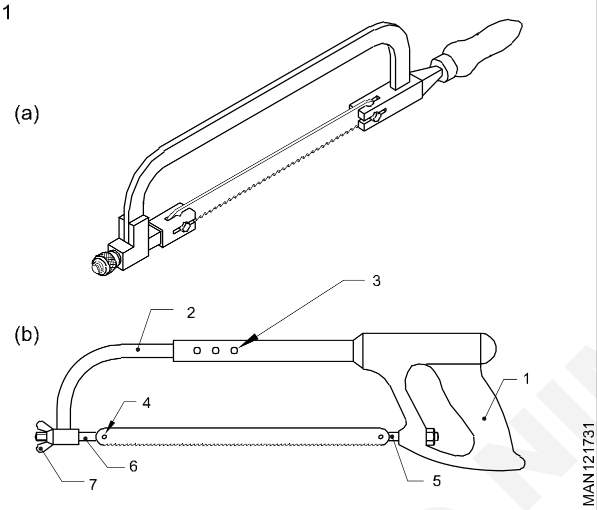
4 Retaining pins

5 Fixed blade-holder

6 Adjustable blade-holder

7 Wing-nut

Fig 1



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.

Parts of a hacksaw blade (Fig 2)

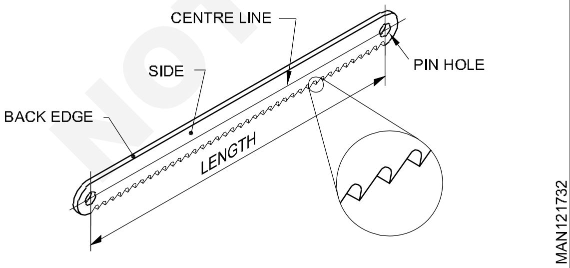
1 Back edge

2 Side

3 Centre line

4 Pin holes

Fig 2



Type of hacksaw blades

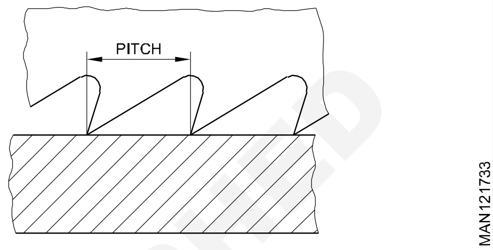
All-hard blade: The full length of the blade between the pins is hardened and it is used for harder metals such as tool steel, die steel and HCS.

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.

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

Fig 3



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

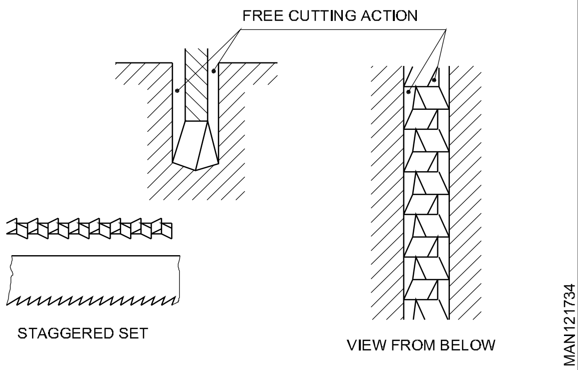
Example

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



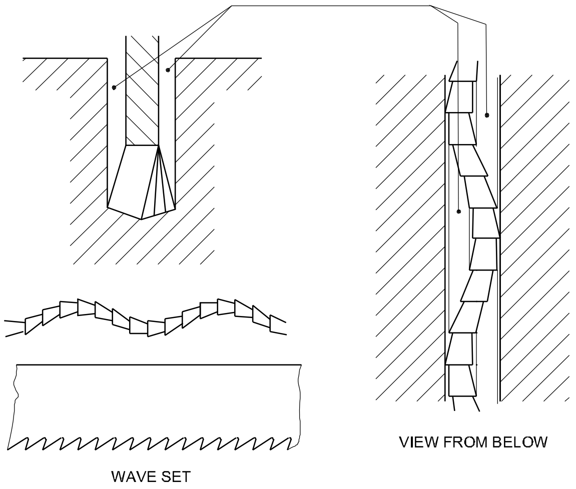
Wave set (Fig 5)**:** In this, the teeth of the blade are arranged in a wave-form. The types of sets for different pictures are as follows:

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.

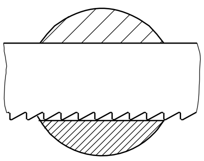
Selection of blade: The selection of the blade depends on the shape and hardness of the material to be cut.

Fig 5



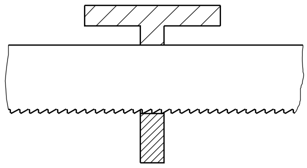
Pitch selection (Fig 6)**:** For soft materials such as bronze, brass, soft steel, cast iron, heavy angles etc. use a 1.8 mm pitch blade.

Fig 6



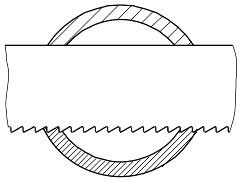
For tool steel, high carbon, high speed steel etc. use a 1.4 mm pitch. For angle iron, brass tubing, copper, iron pipe etc. use a 1 mm pitch blade. (Fig 7)

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.

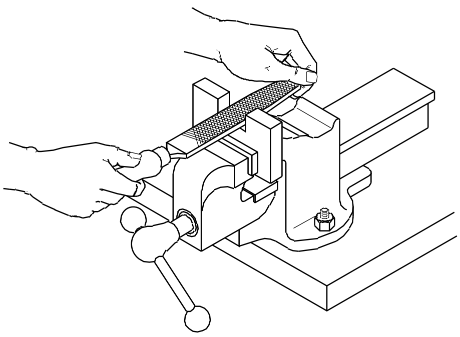
File

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

File

Filing is a method for removing excess material from a workpiece by using a file which acts as a cutting tool. (Fig 1) shows how to hold a file. Files are available in many shapes and sizes.

Fig 1



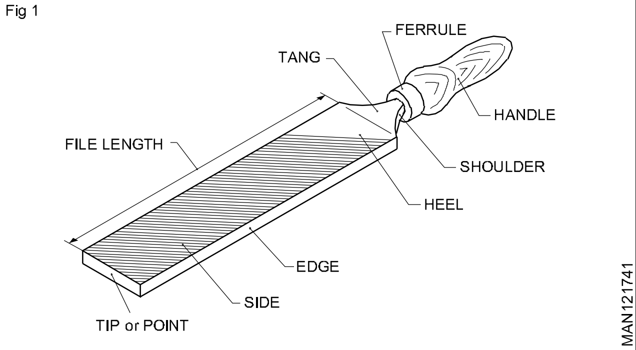
Elements of a file

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 1 they are

Fig 1



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

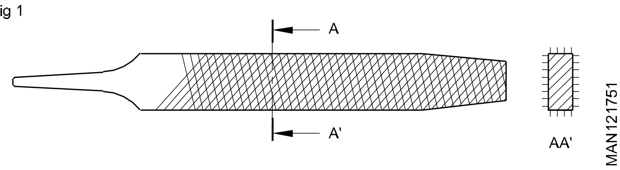
The shape of files is stated by its cross section.

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.

Fig 1

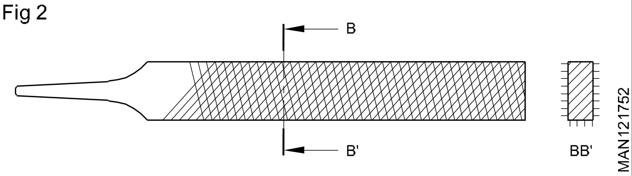


Hand file (Fig 2)

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.

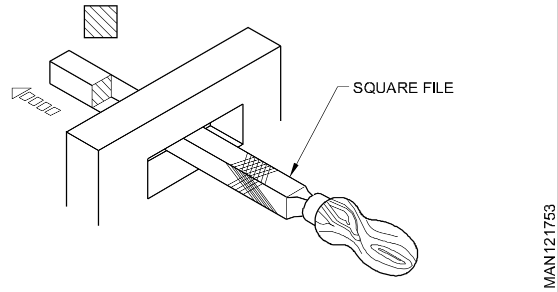
> **Flat files are general purpose files. They are available in all grades. Hand files are particularly useful for filing at right angles to the finished surface.**

Fig 2



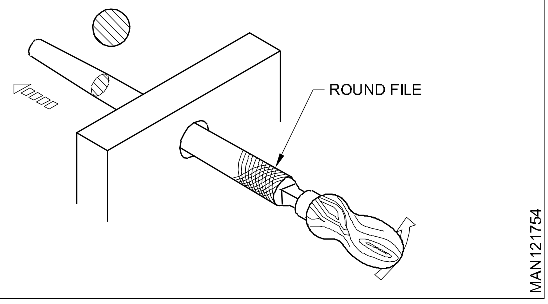
Square File: The square file is square in its cross section. It is used for filing square holes, internal square corners, rectangular openings, keyways and splines. (Fig 3)

Fig 3



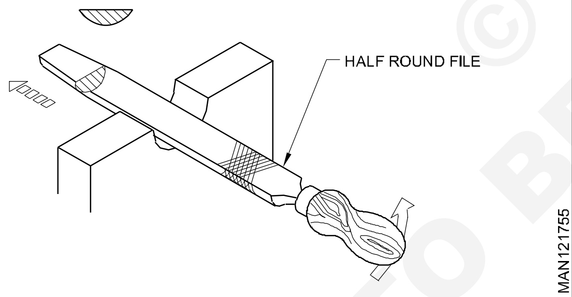
Round file: A round file is circular in its cross section. It is used for enlarging the circular holes and filing profiles with fillets. (Fig 4)

Fig 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)

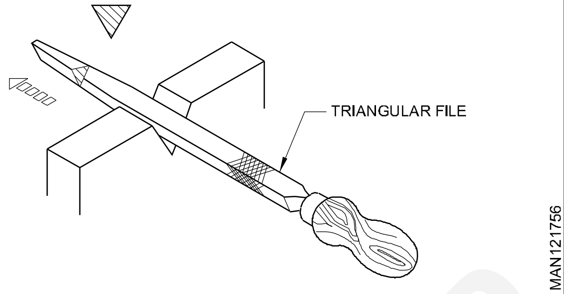
Fig 5



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)

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

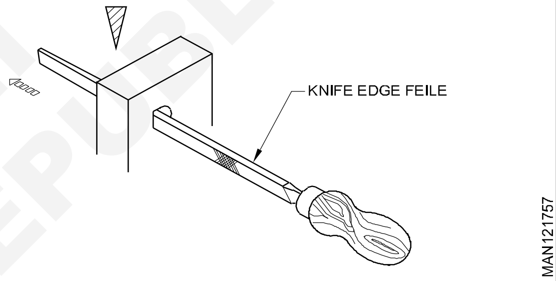
Fig 6



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)

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.

Fig 7



Needle files

Objectives: At the end of this lesson you shall be able to
- **explain the different shapes of needle files**
- **state the needle files as per BIS.**

Needle files are usually available in sets with assorted shapes. These types of files are used for delicate, light kinds of work. These files are available in bastard and smooth grade.

Shapes: The common shapes of needle files are shown in figure 1. The shapes are round edge, flat edge, flat taper, half round, triangular, square, round, knife, feather edge, crossing, Barret and marking. (Fig 1)

Nomenclature of needle files. (Fig 2)

Length: These files are available in a nominal length of 120mm to 180mm.

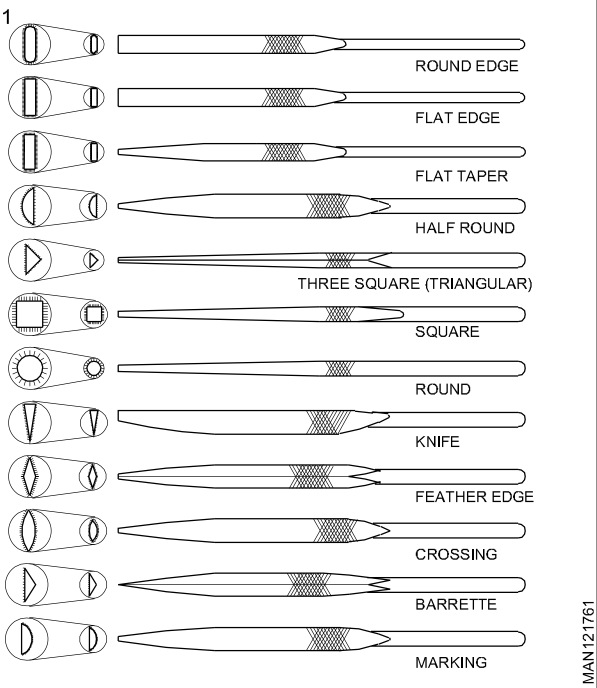
Grades: The grades of cut may be identified by the cut number as follows

- bastard - Cut 0.
- smooth - Cut 2.

Designation of needle files: The needle files are designated by their names

- grade of cut

Fig 1

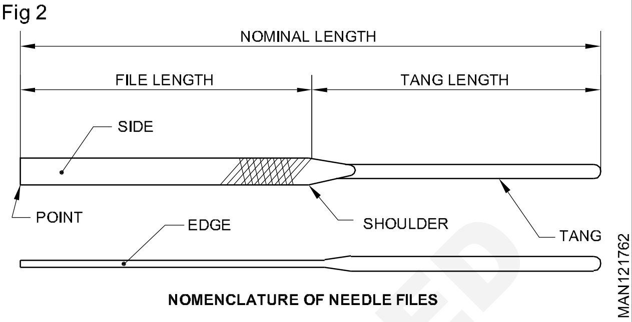


- nominal length
- BIS number

Example

A flat edge needle file with grade of cut bastard, having a nominal length of 160mm shall be designated as flat edge needle file bastard, 160 IS 3152

Fig 2



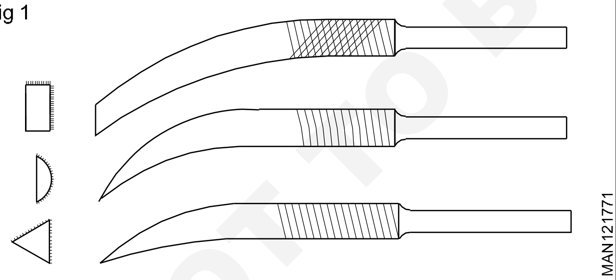
Special files

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

In addition to the common type of files, files are also available in a variety of shapes for 'special' applications. These are as follows.

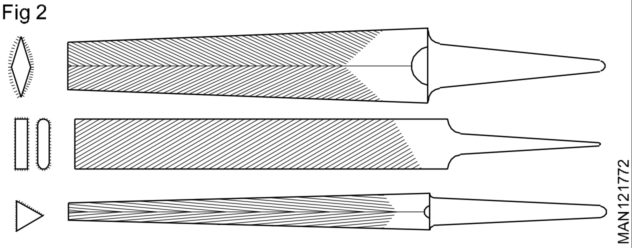
Riffle files (Fig 1): These files are used for die-sinking, engraving and in silversmith's work. They are made in different shapes and sizes and are made with standard cuts of teeth.

Fig 1



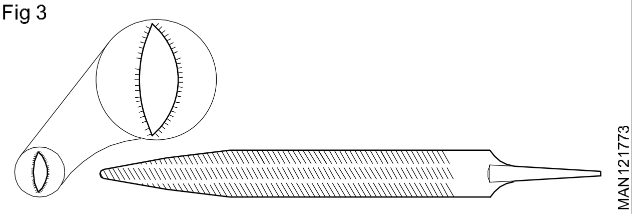
Mill saw files (Fig 2): Mill saw files are usually flat and have square or rounded edges. These are used for sharpening teeth of wood-working saws, and are available in single cut.

Fig 2



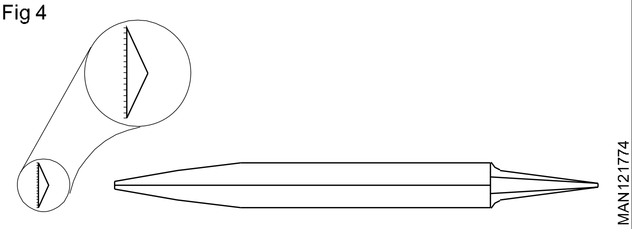
Crossing file (Fig 3): This file is used in the place of a half round file. Each side of the file has different curves. It is also known as 'fish back' file.

Fig 3



Barrette file (Fig 4): This file has a flat, triangular face with teeth on the wide face only. It is used for finishing sharp corners.

Fig 4



Tinker's file (Fig 5): This file has a rectangular shape with teeth only at the bottom face. A handle is provided on the top. This file is used for finishing automobile bodies after tinkering.

Rotary files (Fig 6): These files are available with a round shank. They are driven by a special machine with a portable motor and flexible shaft. These are used in die sinking and mould-making work.

Fig 5

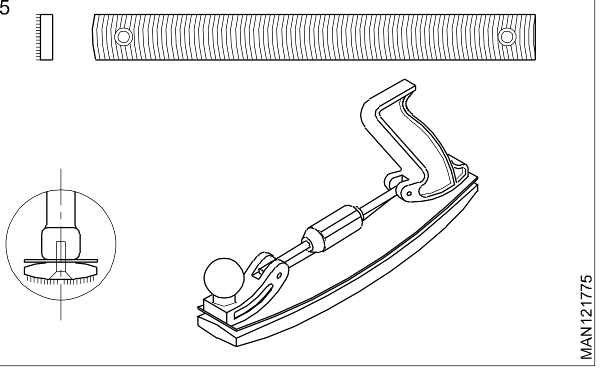
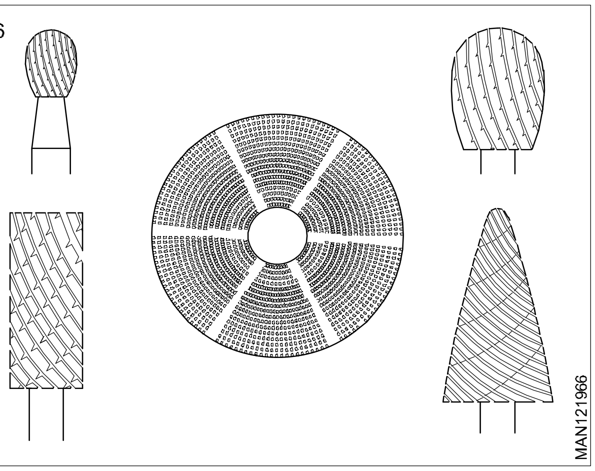
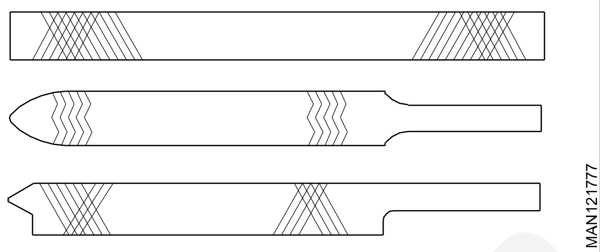


Fig 6



Machine files for hand filing machine (Fig 7)**:** Machine files are of double cut, having holes or projections to fix to the holder of the filing machine. The length and shape will vary according to the machine capacity. These files are suitable for filing the inner and outer surfaces, and are ideal for die sinking and other tool-room work.

Fig 7



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

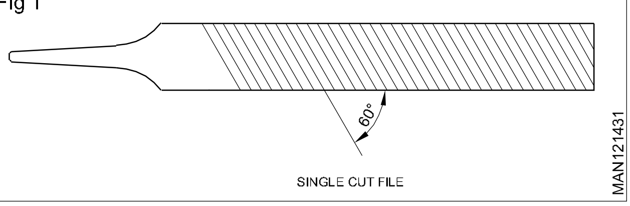
Basically there are four types.

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

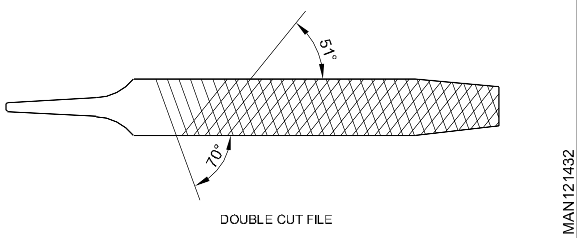


Single cut files do not remove stock as fast double cut files, but the surface finish obtained is much smoother.

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.

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.

Fig 3

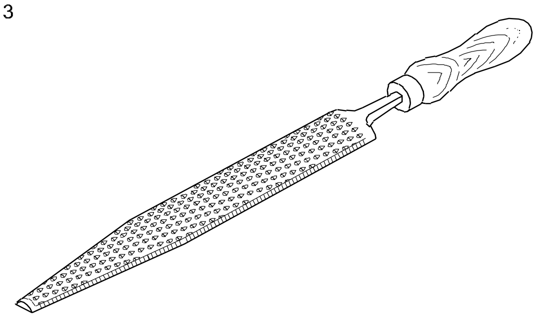
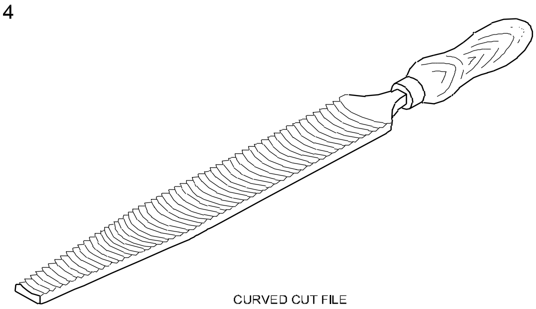


Fig 4



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.**

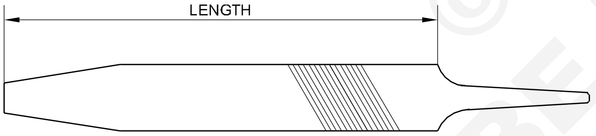
Files are manufactured in different types and grades to meet the various needs.

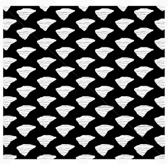
Files are specified according to their length, grade, cut and shape.

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

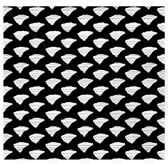
File grades are determined by the spacing of the teeth.

Fig 1

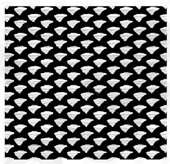




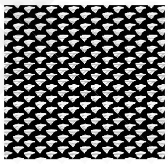
A **rough file** is used for removing rapidly a larger quantity of metal. It is mostly used for trimming the rough edges of soft metal castings.



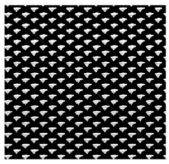
A **bastard file** is used in cases where there is a heavy reduction of material



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

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.

Measuring standards (English & Metric)

Objective: At the end of this lesson you shall be able to
- **describe the measuring standards of english and metric units.**

Necessity

All physical quantities are to be measured in terms of standard quantities.

Unit

A unit is defined as a standard or fixed quantity of one kind used to measure other quantities of the same kind.

Classification

Fundamental units and derived units are the two classifications.

Fundamental units

Units of basic quantities of length, mass and time.

Derived units

Units which are derived from basic units and bear a constant relationship with the fundamental units.

Ex : Area, Volume, Pressure, Force, etc.

System of units

F.P.S. system is the British system in which the basic units of length, mass and time are foot, pound and second respectively.

C.G.S. system is the metric system in which the basic units of length, mass and time are centimetre, gram and second respectively.

M.K.S system is another metric system in which the basic units of length, mass and time are metre, kilogram and second respectively.

S.I. units is referred to as Systems International units which is again of metric and the basic units, their names and symbols are Listed in table - 1

Fundamental units and derived units are the two classification of units.

Length, mass and time are the fundamental units in all the systems (ie) F.P.S, C.G.S, M.K.S and S.I systems.

Table 1

Basic Quantity	Metric Unit		British unit	
	Name	Symbol	Name	Symbol
Length	Metre	m	Foot	F
Mass	Kilogram	kg	Pound	P
Time	Second	S	Second	S
Current	Ampere	A	Ampere	A
Temperature	Kelvin	K	Fahrenheit	F°
Light intensity	Candela	Cd	Candela	Cd

Off-hand grinding with 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.**

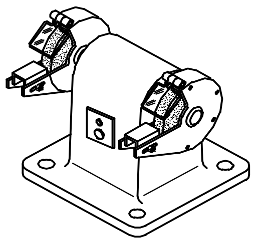
Off-hand grinding is the operation of removing material which does not require great accuracy in size or shape. This is carried out by pressing the workpiece by hand against a grinding wheel.

Off-hand grinding is performed for rough grinding of jobs and re-sharpening of

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

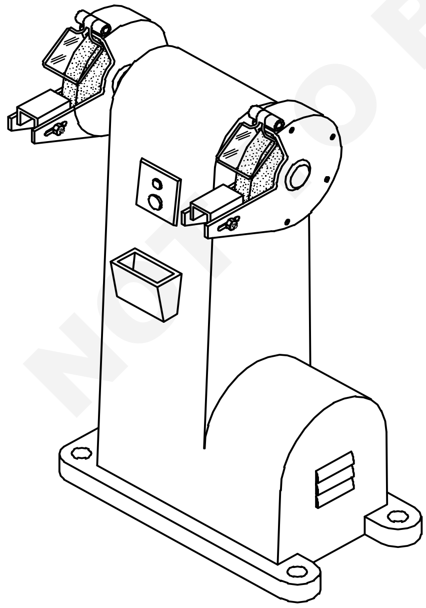
Off-hand grinding is performed with a bench or pedestal grinder. (Figs 1 and 2)

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

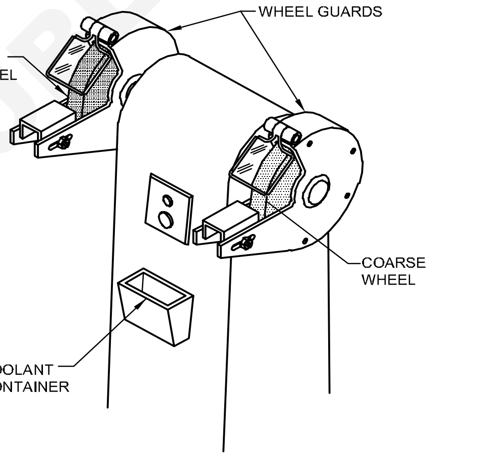
Pedestal grinders are mounted on a base (pedestal), which is fastened to the floor. They are used for heavy duty work.

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)

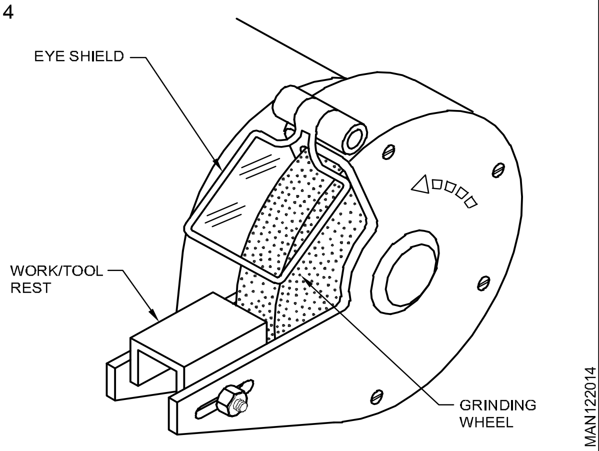
Adjustable work-rests are provided for both wheels to support the work while grinding. These work-rests must be set very close to the wheels. (Fig 4)

Fig 3



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)

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

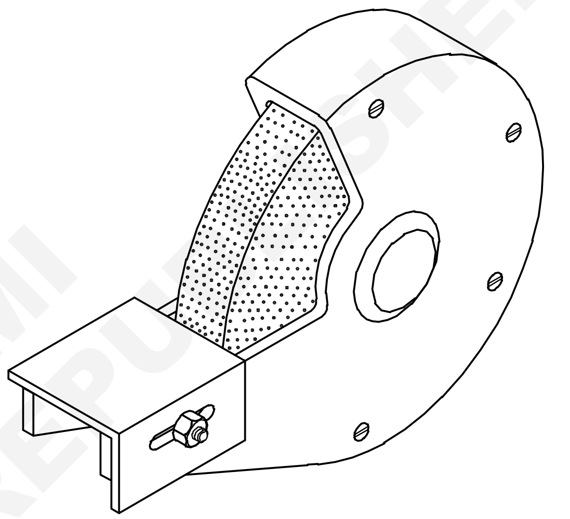
The purpose of dressing is to restore the correct cutting action of the wheel. Dressing removes the clogs on the surface of the wheel and the blunt grains of the abrasive, exposing the new sharp abrasive grains of the wheel which can be cut and brought to shape efficiently.

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.

Fig 1

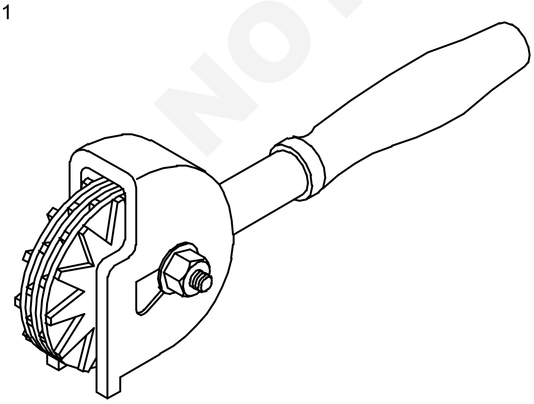


Grinding wheel dressers

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



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.

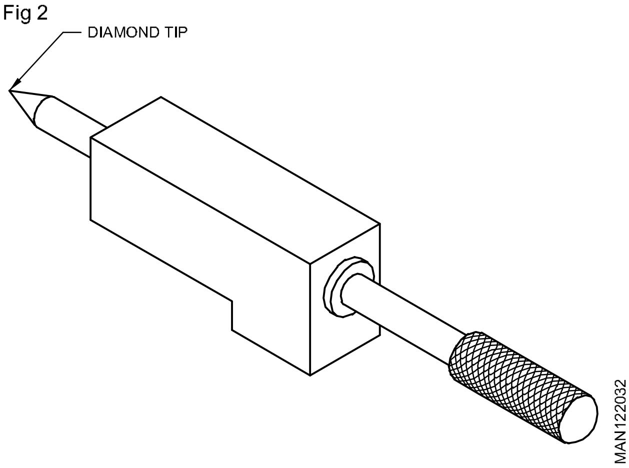
Star wheels are useful for pedestal grinders in which a precision finish is not expected.

> **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.

Fig 2



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)

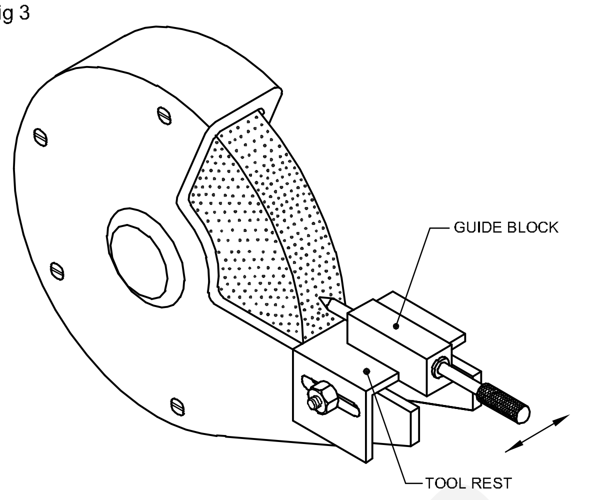
For dressing and truing, the dresser is slowly brought in contact with the wheel face and moved across.

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.

Fig 3



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.

Surface gauges

Objectives: At the end of this lesson you shall be able to
- **state the constructional features of surface gauges**
- **explain the types of surface gauges**
- **state the uses of surface gauges**
- **state the advantages of universal surface gauges.**

Types of surface gauges

Surface gauges/scribing blocks are of two types, fixed and universal.

Surface gauge - fixed type (Figs 1 & 2)

Fig 1

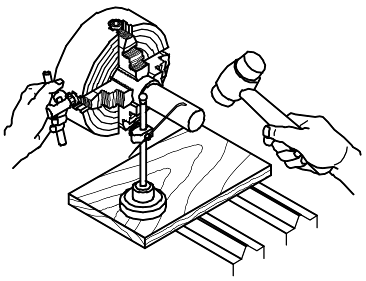
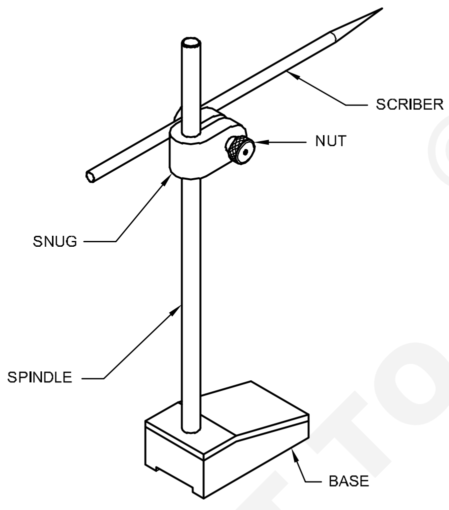


Fig 2



The fixed type of surface gauges consists of a heavy flat base and a spindle, fixed upright, to which a scriber is attached with a snug and a clamping nut.

Universal surface gauge (Fig 3)

This has the following additional features.

- The spindle can be set to any position.
- Fine adjustments can be made quickly.
- Can also be used on cylindrical surfaces.

Parallel lines can be scribed from any datum edge with the help of guide pins. (Fig 4)

Fig 3

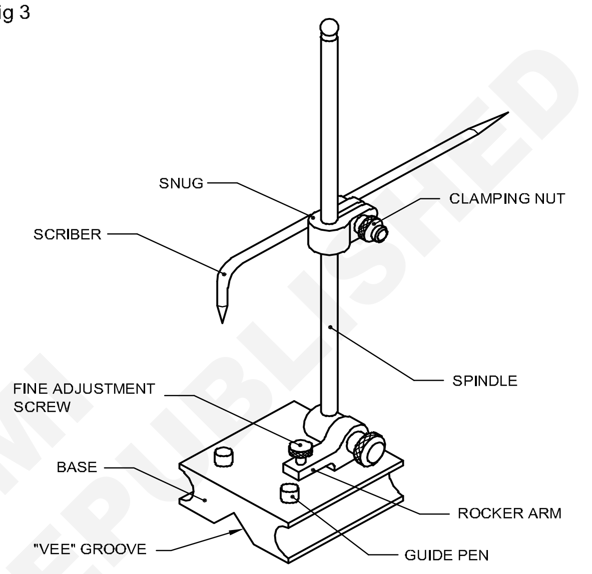
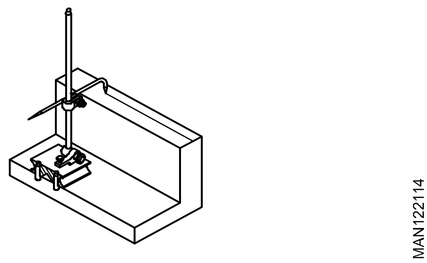


Fig 4



Parts and functions of a Universal Surface Gauge

Base

The base is made of steel or cast iron with a 'V' groove at the bottom. The 'V' groove helps to seat on circular work. The guide pins, fitted in the base, are helpful for scribing lines from any datum edge.

Rocker arm

The rocker arm is attached to the base along with a spring and a fine adjustment screw. This is used for fine adjustments.

Spindle

The spindle is attached to the rocker arm.

Scriber

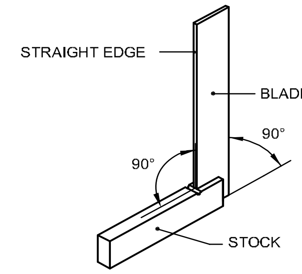
The scriber can be clamped in any position on the spindle with the help of a snug and a clamping nut.

Try-Square

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

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

Fig 1

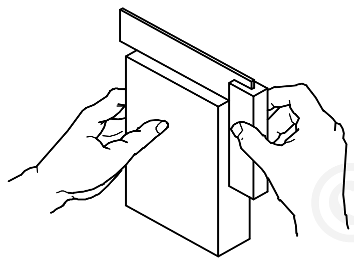


The accuracy of measurement by a try-square is about 0.002 mm per 10 mm length, which is accurate enough for most workshop purposes. The try-square has a blade with parallel surfaces. The blade is fixed to the stock at 90°.

Uses

To check the squareness of machined or filed surfaces the try-square is used (Fig 2)

Fig 2



Check the flatness of surfaces (Fig 3)

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

Set workpieces at right angles on work-holding devices. (Fig 5)

Fig 3

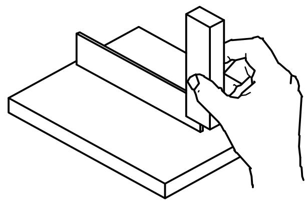
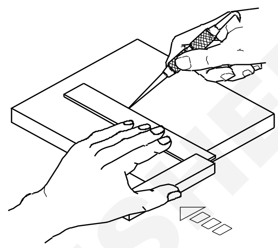


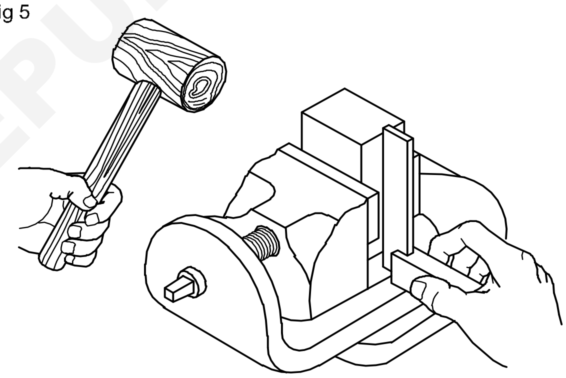
Fig 4



Try-squares are made of hardened steel.

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

Fig 5



Ordinary depth gauge

Objectives: At the end of this lesson you shall be able to
- **state the uses of ordinary depth gauge**
- **explain the parts of depth gauge.**

Ordinary depth gauge

Ordinary depth gauge is semi precision instrument used for measuring the depth of recesses, slots and steps.

Parts of ordinary depth gauge (Fig 1)

1 Graduated beam

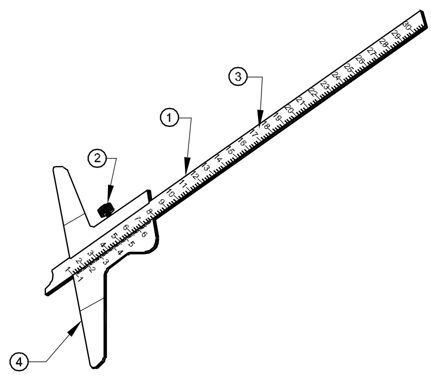
2 Clamping screw

3 Scale

4 Base

Available in the ranges of 0-200 mm. Ordinary depth gauge is used to measure an accuracy of 0.5 mm.

Fig 1

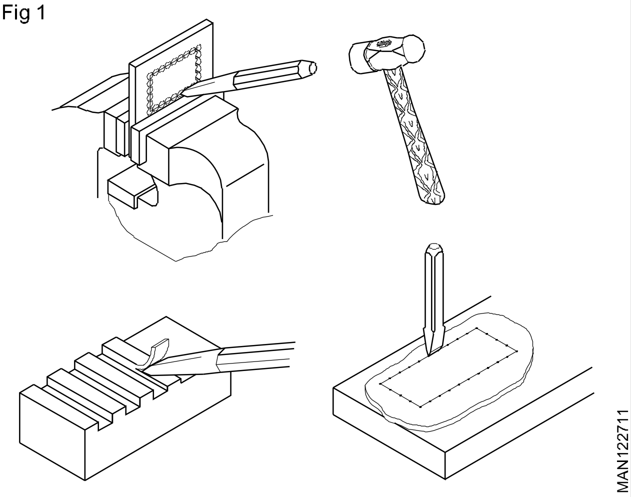


Cold Chisel

Objectives: At the end of this lesson you shall be able to
- **list the uses of a cold chisel**
- **explain the parts of a cold chisel**

The cold chisel is a hand cutting tool used by fitters for chipping and cutting off operations. (Fig 1)

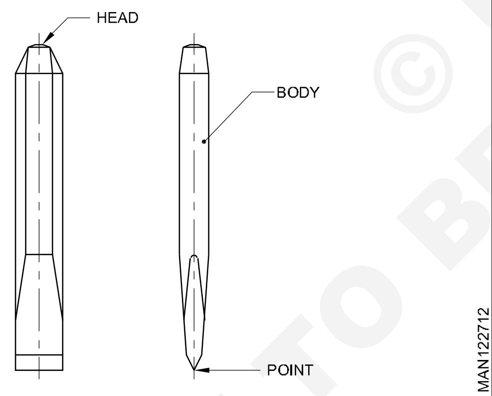
Fig 1



Chipping is an operation of removing excess metal with the help of a chisel and hammer. Chipped surfaces being rough, they should be finished by filing.

Parts of a Chisel (Fig 2)**:** A chisel has the following parts.

Fig 2



Head, body, point or cutting edge.

Chisels are made from high carbon steel or chrome vanadium steel. The cross-section of chisels is usually hexagonal or octagonal. The cutting edge is hardened and tempered.

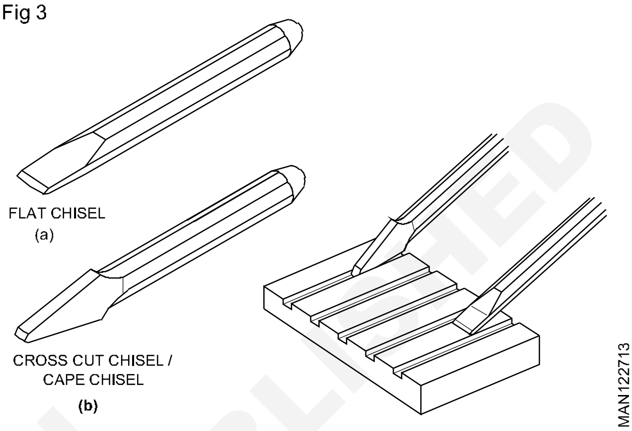
Common types of chisels: There are five common types of chisels.

- Flat chisel
- Cross-cut chisel
- Half-round nose chisel
- Diamond point chisel
- Web chisel

Flat chisels (Fig.3a)**:** They are used to remove metal from large flat surfaces and chip-off excess metal of welded joints and castings.

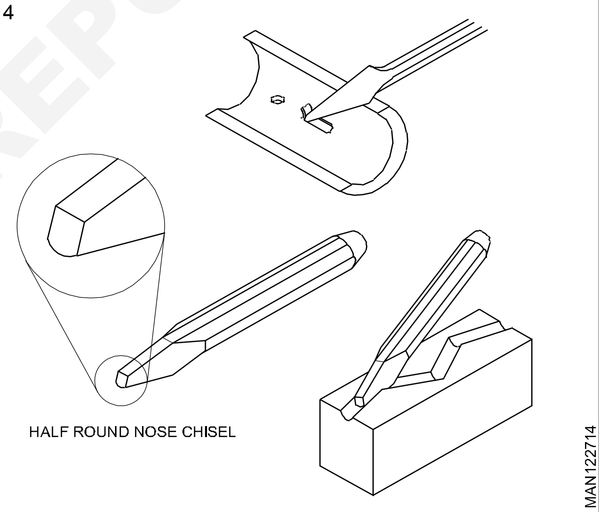
Cross-cut or cape chisels (Fig.3b)**:** These are used for cutting key ways, grooves and slots.

Fig 3



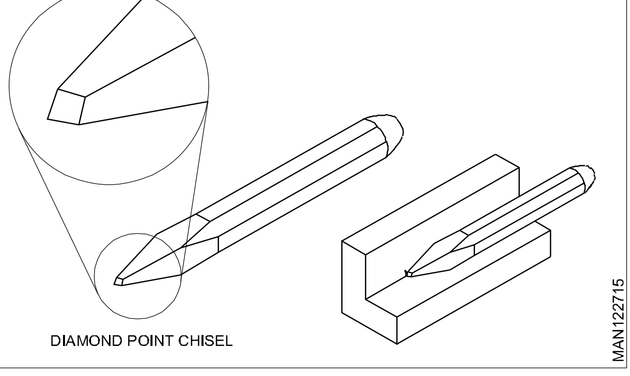
Half-round nose chisels (Fig 4)**:** They are used for cutting curved grooves (oil grooves).

Fig 4



Diamond point chisels (Fig 5)**:** These are used for squaring materials at the corners, joints.

Fig 5

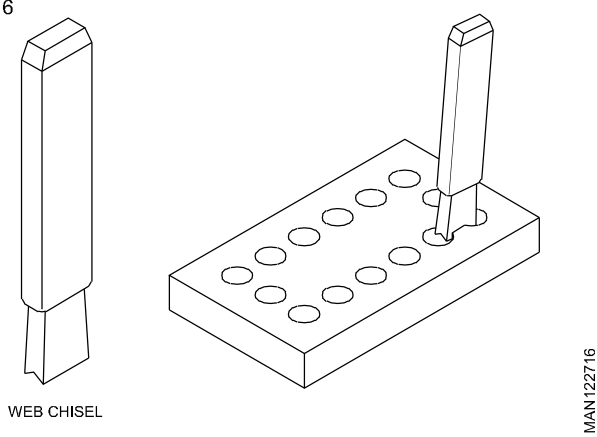


Web chisels/ punching chisels (Fig 6)**:** These chisels are used for separating metals after chain drilling.

Chisels are specified according to their

- length
- width of the cutting edge
- type
- cross-section of the body.

Fig 6



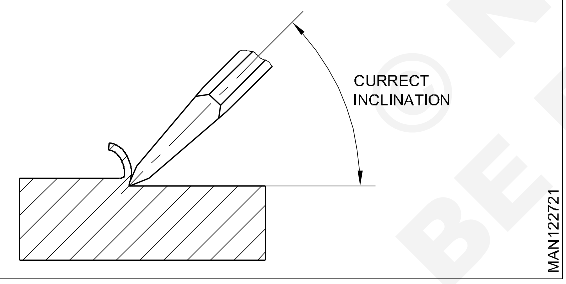
Angles of chisels

Objectives: At the end of this lesson you shall be able to
- **state the point angles of chisels for different materials**
- **state the effect of rake and clearance angles**
- **explain the care and maintenance of chisels.**

Point angles and materials: The correct point/cutting angle of the chisel depends on the material to be chipped. Sharp angles are given for soft materials, and wide angles for hard materials.

The correct point and angle of inclination generate the correct rake and clearance angles. (Fig 1)

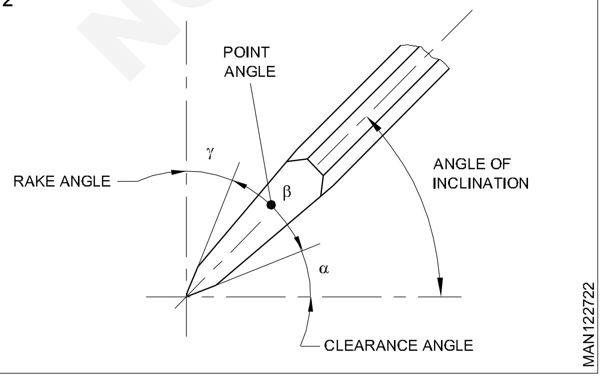
Fig 1



Rake angle: Rake angle is the angle between the top face of the cutting point, and normal (90°) to the work surface at the cutting edge. (Fig 2)

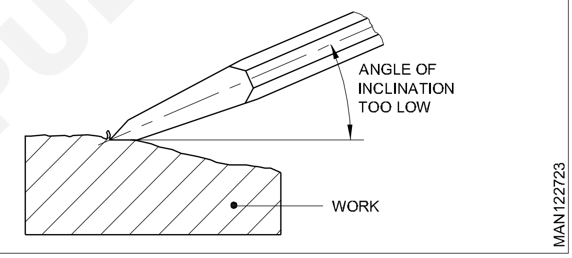
Clearance angle: Clearance angle is the angle between the bottom face of the point and the tangent to the work surface originating at the cutting edge. (Fig 2)

Fig 2



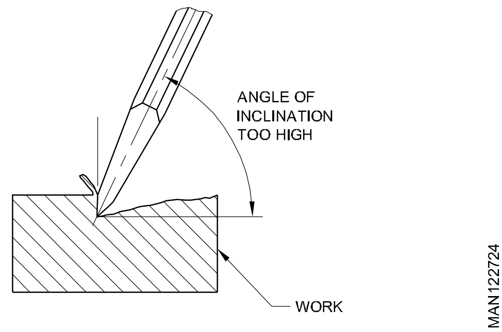
If the clearance angle is too low or zero, the rake angle increases. The cutting edge cannot penetrate into the work. The chisel will slip. (Fig 3)

Fig 3



If the clearance angle is too great, the rake angle reduces. The cutting edge digs in and the cut will become deeper and deeper. (Fig 4).

Fig 4



Combination set

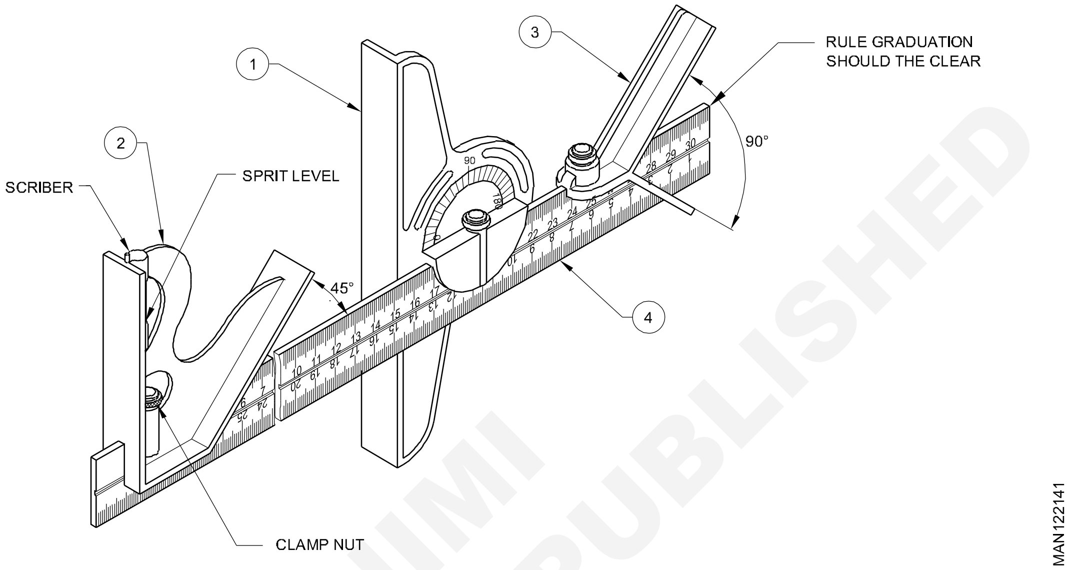
Objectives: At the end of this lesson you shall be able to
- **explain the parts of a combination set**
- **state the uses of each attachment in a combination set.**

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

The combination set has a following parts (Fig 1)

- protractor head
- square head
- centre head
- rule.

Fig 1



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° and 45° angles. It can also be used to set workpieces on the machines and measure the depth of slots. (Figs 2 and 3)

Fig 2

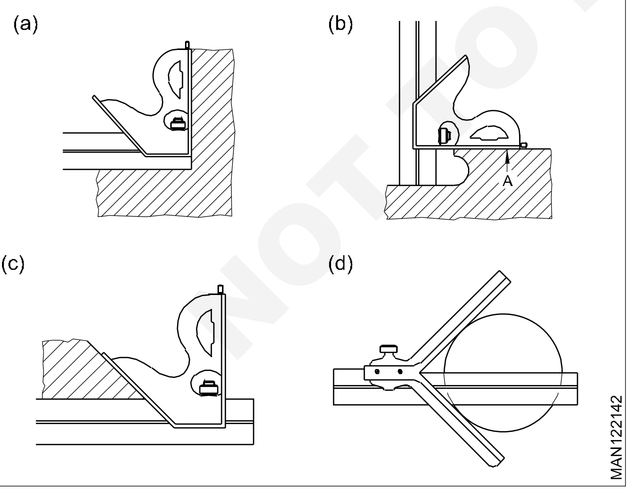
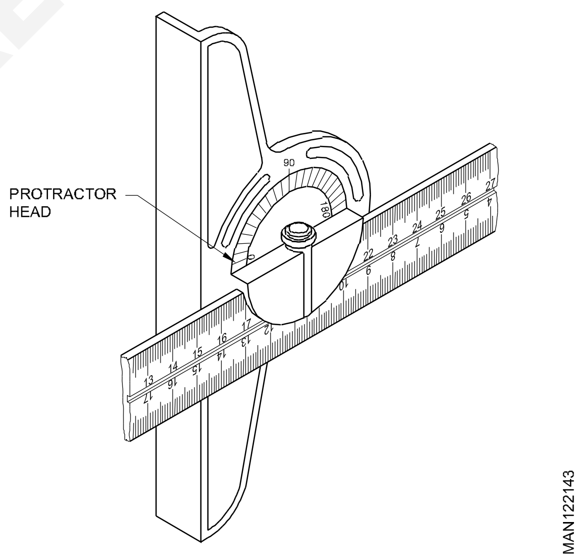


Fig 3



Centre head

This along with the rule is used for locating the centre of cylindrical jobs.

Marking media

Objectives: At the end of this lesson you shall be able to
- **state the purpose of marking media**
- **explain the common types of marking media**
- **state the correct marking medium for different applications.**

Purpose of marking media

In marking off/Layout, the surface of the job / workpiece is coated with a medium to show the marked lines clear and visible. To get clear and thin lines, the best layout medium is to be selected.

Different marking media

The different marking media are Whitewash, Marking blue, Prussian Blue, Copper Sulphate and Cellulose Lacquer.

Whitewash

Whitewash is prepared in many ways.

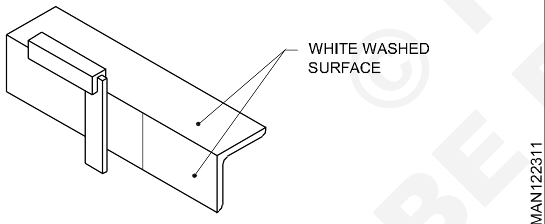
Chalk powder mixed with water

Chalk mixed with methylated spirit

White lead powder mixed with turpentine

Whitewash is applied to rough forgings andcastings with oxidised surface. (Fig 1)

Fig 1



Whitewash is not recommended for workpieces of high accuracy.

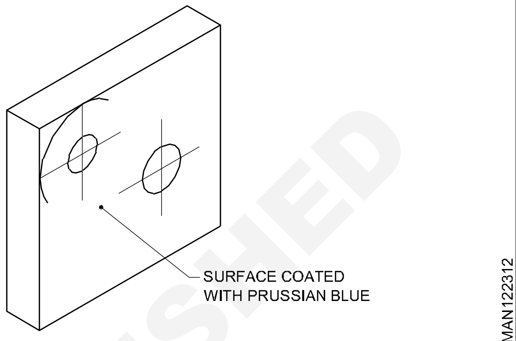
Marking blue

A Chemical dye, blue based colour mixed with methylated spirit used for marking on workpieces which are reasonably machined surface.

Prussian blue

This is used on filed or machine-finished surfaces. This will give very clear lines but takes more time for drying than the other marking media. (Fig 2)

Fig 2



Copper sulphated

The solution is prepared by mixing copper sulphate with water and a few drops of nitric acid. The copper sulphate is used on filed or machine-finished surfaces. Copper sulphate sticks to the finished surfaces well.

Copper sulphate needs to be handled carfully as it is poisonous. Copper sulphate coating should be dried before commencing marking, as otherwise, the solution may stick on the instruments used for marking.

Cellulose lacquer: This is a commercially available marking medium. It is made in different colours and dries very quickly.

The selection of marking medium for a particular job depends on the surface finish and the accuracy of the workpiece.

In present days, marking media used are readily available in aerosol container, which can be applied by spraying on to any surface, which needs marking.

Readymade solutions of marking dye/ink which are quick drying and thin layer to mark precise dimensions and clear visible lines. Also permanent marker pens are available in different. colours, which are quick drying and used for smaller workpieces of metal, wood and plastics.

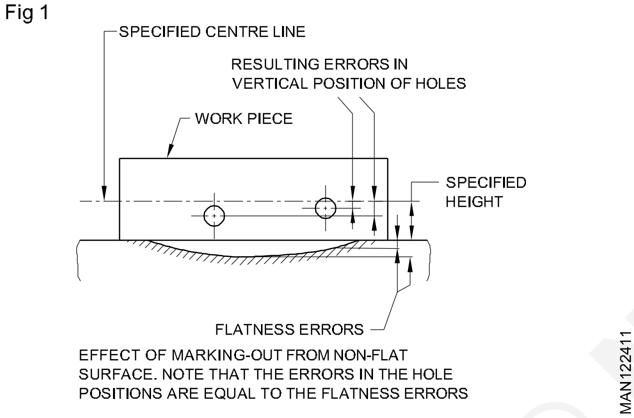
Surface plates

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

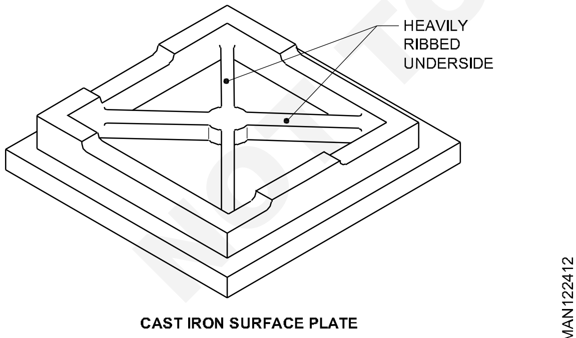


Materials and construction

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)

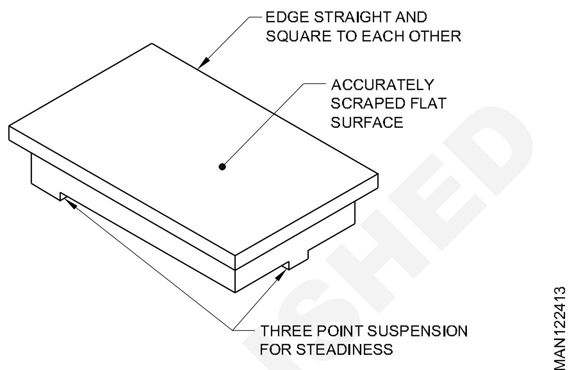
Fig 2



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.

'V' Blocks

Objectives: At the end of this lesson you shall be able to
- **state the constructional features of 'V' Blocks**
- **explain the types of 'V' Blocks and state their uses**
- **state 'V' Blocks as per B.I.S recommended practice.**

Constructional features

'V' Blocks are devices used for marking and setting up work on machines. The features of the common type of 'V' Blocks are as given in Figs 1 and 2.

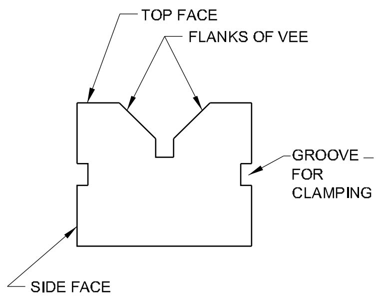
The included angle of the 'V' is 90° in all cases. 'V' Blocks are finished to a high accuracy in respect of dimension, flatness and squareness.

Types

Different types of 'V' blocks are available. As per BIS, there are four types, as listed below.

Single level single groove 'V' Block (Fig 1)

Fig 1



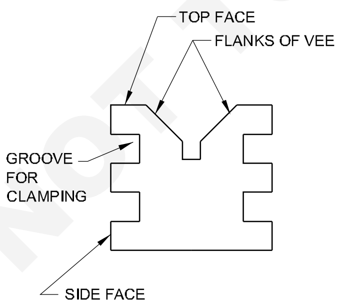
SINGLE LEVEL SINGLE GROOVE V-BLOCK

This type has only one 'V' groove, and has single groove (slots) on either side. These grooves are for accommodating the holding clamps.

Single level double groove 'V' Block (Fig 2)

This type will have one 'V' groove, and two grooves (slots) on either side for clamping in two positions.

Fig 2

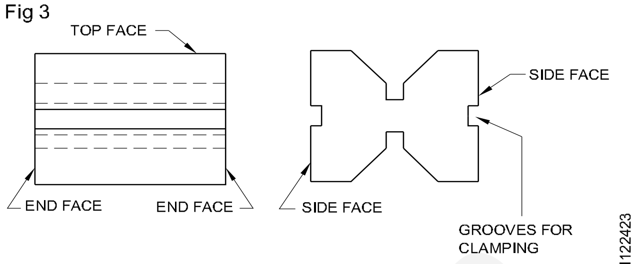


SINGLE LEVEL DOUBLE GROOVE V-BLOCK

Double level single groove 'V' Block (Fig 3)

In this case, the 'V' Block will have two 'V' grooves on the top and bottom, and a single groove for clamping on either side.

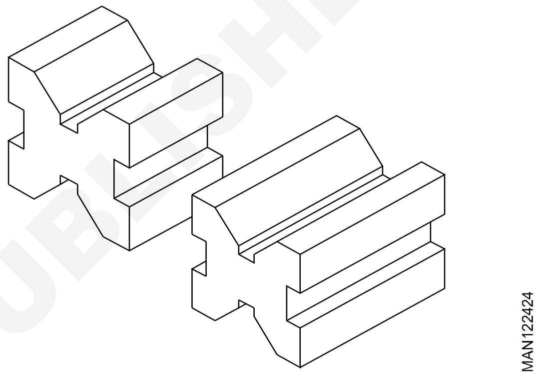
Fig 3



DOUBLE LEVEL SINGLE GROOVE V-BLOCK

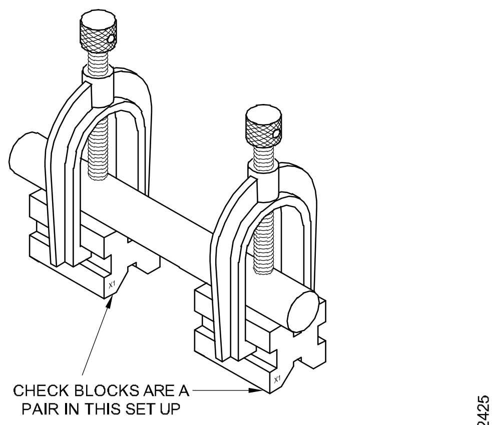
Matched pair 'V' Block (Figs 4 & 5)

Fig 4



These blocks are available in pairs which have the same size and the same grade of accuracy. They are identified by the number or letter given by the manufacturer. These sets of blocks are used for supporting long shafts, parallel on machine tables or marking off tables.

Fig 5



'V' BLOCKS SUPPORTING A SHAFT FOR MARKING OUT AND DRILLING

Grades and materials

'V' Blocks are available in Grade A and Grade B.

Grade A 'V' Blocks

There are more accurate, and are available only up to 100 mm length. They are made of high quality steel.

Grade B 'V' Blocks

These blocks are not as accurate as the ones in Grade A. These blocks are used for general machine shop work. These blocks are available up to 300 mm length. These 'V' Blocks are made of closely grained cast iron.

Clamping devices for `V'-Blocks

'U' clamps are provided for holding cylindrical jobs firmly on 'V' Blocks. (Fig 6)

Designation

'V' Blocks are designated by the nominal size (length) and the minimum and maximum diameter of the workpiece capable of being clamped, and the grade and the number of the corresponding B.I.S. standard.

In the case of matched pairs, it should be indicated by the letter M.

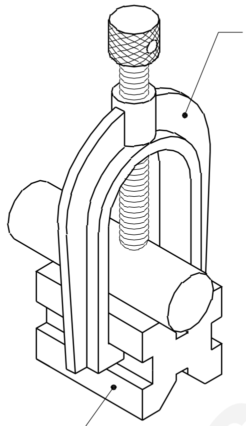
For 'V' Blocks with clamps it should be indicated as, 'WITH CLAMPS'.

Example

A 50 mm long (nominal size) 'V' Block capable of clamping workpieces between 5 to 40 mm in diameter and of Grade A will be designated as

- 'V' Block 50/5-40 A - I.S.2949.
- In the case of a matched pair, it will be designated as 'V' Block M 50/5-40 A I.S.2949.
- For 'V' Block supplied with clamps, the designation will be 'V' Block with clamp 50/5 40 A I.S. 2949.

Fig 6



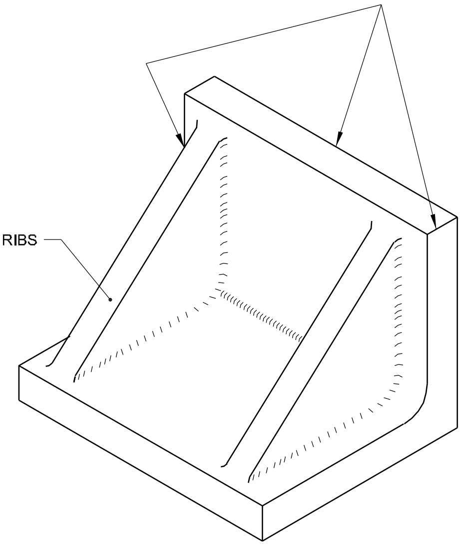
Angle plates

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

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 un-machined part for good rigidity and to prevent distortion.

Fig 1



ANGLE PLATE

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.

Slotted type angle plate (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 3 and 4)

Fig 2

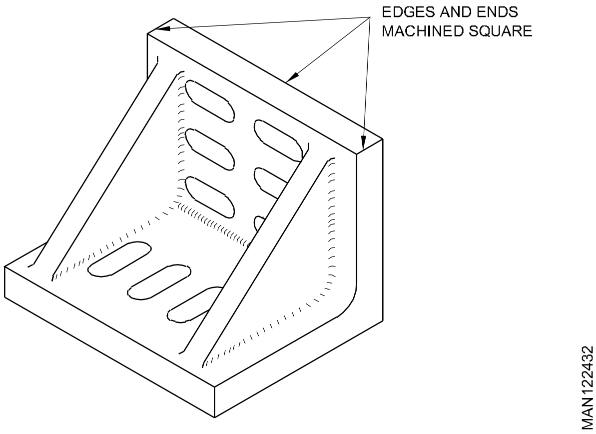


Fig 3

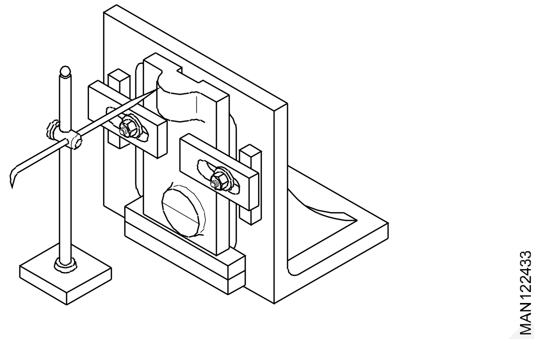
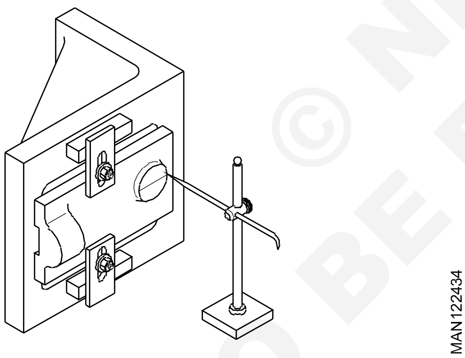


Fig 4



Swivel type angle plate (Fig 5)

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.

Box angle plate (Fig 6)

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.

Fig 5

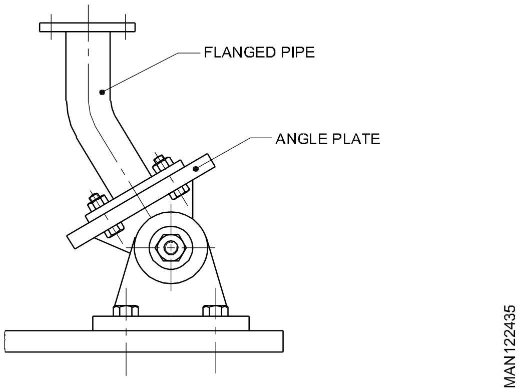
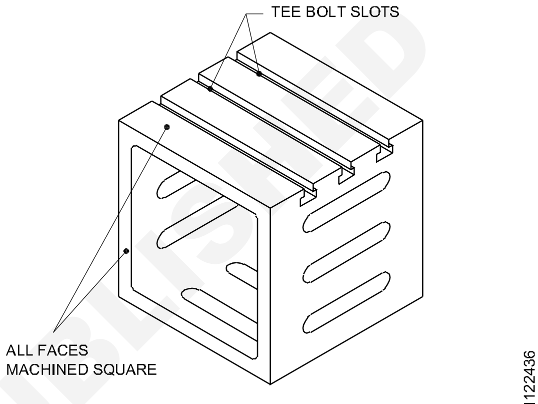


Fig 6



BOX ANGLE PLATE

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.

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.

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			

Care & Maintenance

- Clean before and after use.
- Apply oil after the use.

Parallel blocks

Objectives: At the end of this lesson you shall be able to
- **explain the types of parallel blocks**
- **state the constructional features of parallel blocks**
- **state parallel blocks as per BIS recommended**
- **state the uses of parallel blocks.**

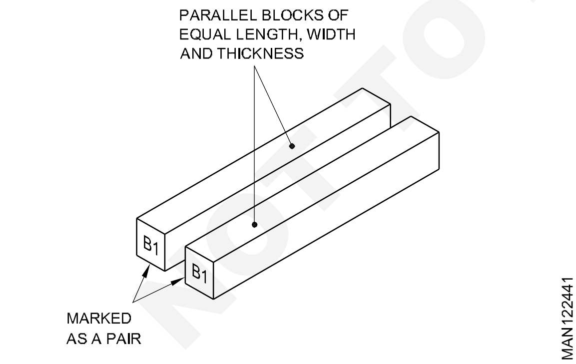
Parallel blocks of different types are used for setting workpieces for machining. The commonly used are of two types.

- Solid Parallels
- Adjustable Parallels

Solid parallels (Solid parallel blocks) (Fig 1)

This is the type of parallel which is very much used in machine shop work. They are made of steel pieces of rectangular cross section, and are available in different lengths and cross sectional sizes.

Fig 1



They are hardened and ground sometimes finished by lapping.

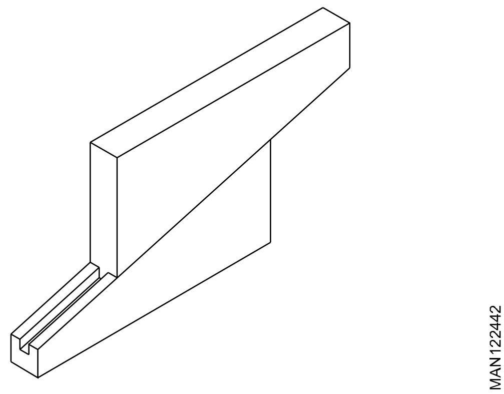
Parallels are machined to close limits, and are perfectly flat, square, and parallel throughout the length. These are made in pairs of identical dimensions.

Grades

Parallels are made in two grades - Grade A and Grade B. Grade A is meant for fine tool room type of work, and Grade B for general machine shop work.

Adjustable parallels (Fig 2)

Fig 2



These consist of two tapered blocks sliding one over the other in a tongue and groove assembly. These types of parallels can be adjusted and set to different heights.

Uses

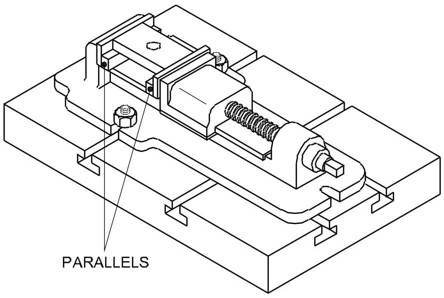
Solid and adjustable parallels are used for parallel setting of workpieces while machining. They are also useful for raising the workpieces held in vices or machine tables to provide better observation of the machining process. (Fig 3)

Parallels are made in pairs and should be used in matching pairs to ensure accuracy in set-up.

Care and maintenance

- Clean before and after the use.
- Apply oil after use
- Do not use as a hammer.

Fig 3



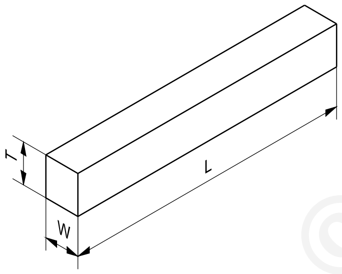
Sizes of parallels

These are given in TABLE 1 and TABLE 2.

Designation of parallels

Parallels are designated by the type, grade (for solid parallels only) size, and the number of the standard. (Fig 4)

Fig 4



Examples

Solid parallel A5 x 10 x 100 IS: 4241

Adjustable parallel 10 x 13 IS:4241

Fig 5

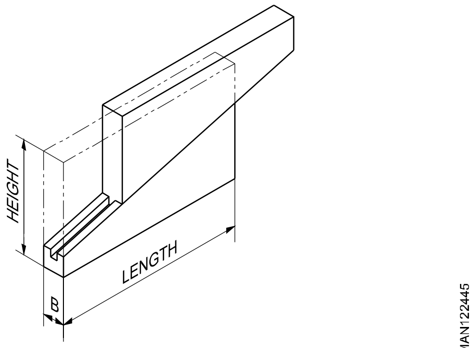


Table 1

Sizes of solid parallels

Grade	Size T.W.L.
A & B	5 x 10 x 100
A & B	10 x 20 x 150
A & B	15 x 25 x 150
A & B	20 x 35 x 200
A & B	25 x 45 x 250
A & B	30 x 60 x 250
A & B	35 x 70 x 300
B	40 x 80 x 350
B	50 x 100 x 400

Table 2

Range and size of Adjustable Parallels

Height Range	Length
10 - 13	40
13 - 16	50
16 - 20	60
20 - 25	65
25 - 30	70
30 - 40	85
40 - 50	100

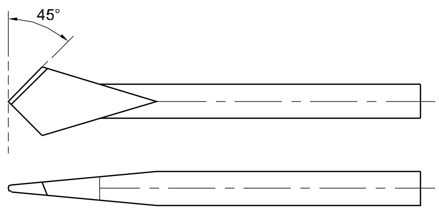
Drill & Tap

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

Drilling is a process of making holes on workpieces. The tool used for drilling is a drill and it is rotated with a downward pressure causing the tool to penetrate into the material.

Flat or spade drill (Fig 1)

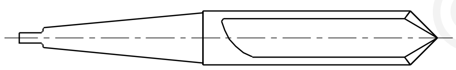
Fig 1



This type of drill is used where the required size of twist drill is not available. It is made from a round tool steel piece which is forged to shape and ground to size, and then hardened and tempered. This type of drill is used for hand drilling (without power) or with a ratchet brace.

Straight fluted drill (Fig 2)

Fig 2

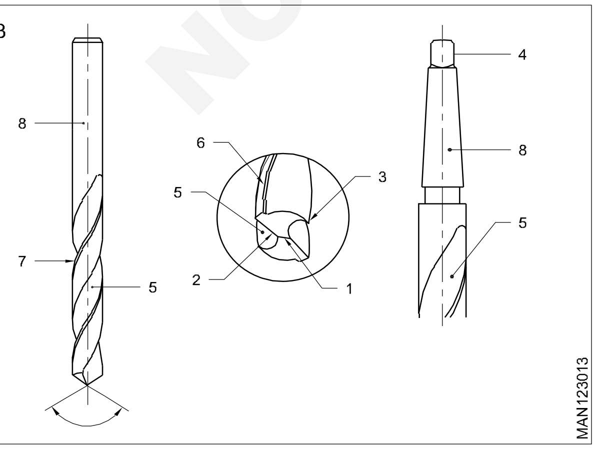


It has grooves or flutes running parallel to the drill axis. It is mainly used in drilling brass, copper or soft materials. This type of drill is inconvenient in standard practice as the chips do not come out from the hole automatically. It is used to drill sheet metals and cores in the castings.

Twist drills (Fig 3)

In this type, two spiral flutes or grooves run lengthwise around the body of the drill. It is the most common type of drill used for all purposes, and especially for faster drilling of accurate holes and for harder materials - in comparison with the other drills.

Fig 3



Parts of a twist drill (Fig 3)

Point (1, 2 & 3)

The cone shaped end which does the cutting is called the point. It consists of a dead centre (1), lips or cutting edge (2) and a heel (3).

Tang (4)

This is provided only on taper shank drills, for driving (giving torque to) the drill, which when overloaded, becomes twisted or gets sheared off.

Flutes (5)

Flutes are the spiral grooves which run to the length of the drill. The flutes help.

to form the cutting edge

to curl the chips and allow these to come out

the coolant to flow to the cutting edge.

Shank (8)

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

Taper shank, with Morse taper provided, is used for larger diameter drills, and the straight shank is used for smaller diameter drills.

Land/margin (6)

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.

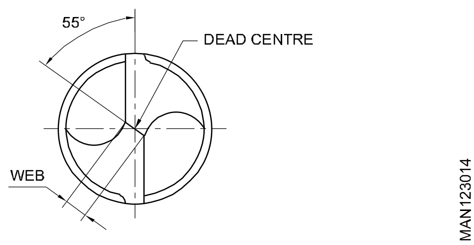
Body clearance (7)

Body clearance is that 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



Material for twist drills

Twist drills, used in a machine shop, are usually made out of high speed steel. For drilling hard materials at higher cutting speeds, there are drills with carbide tips, brazed at the lips of the drill.

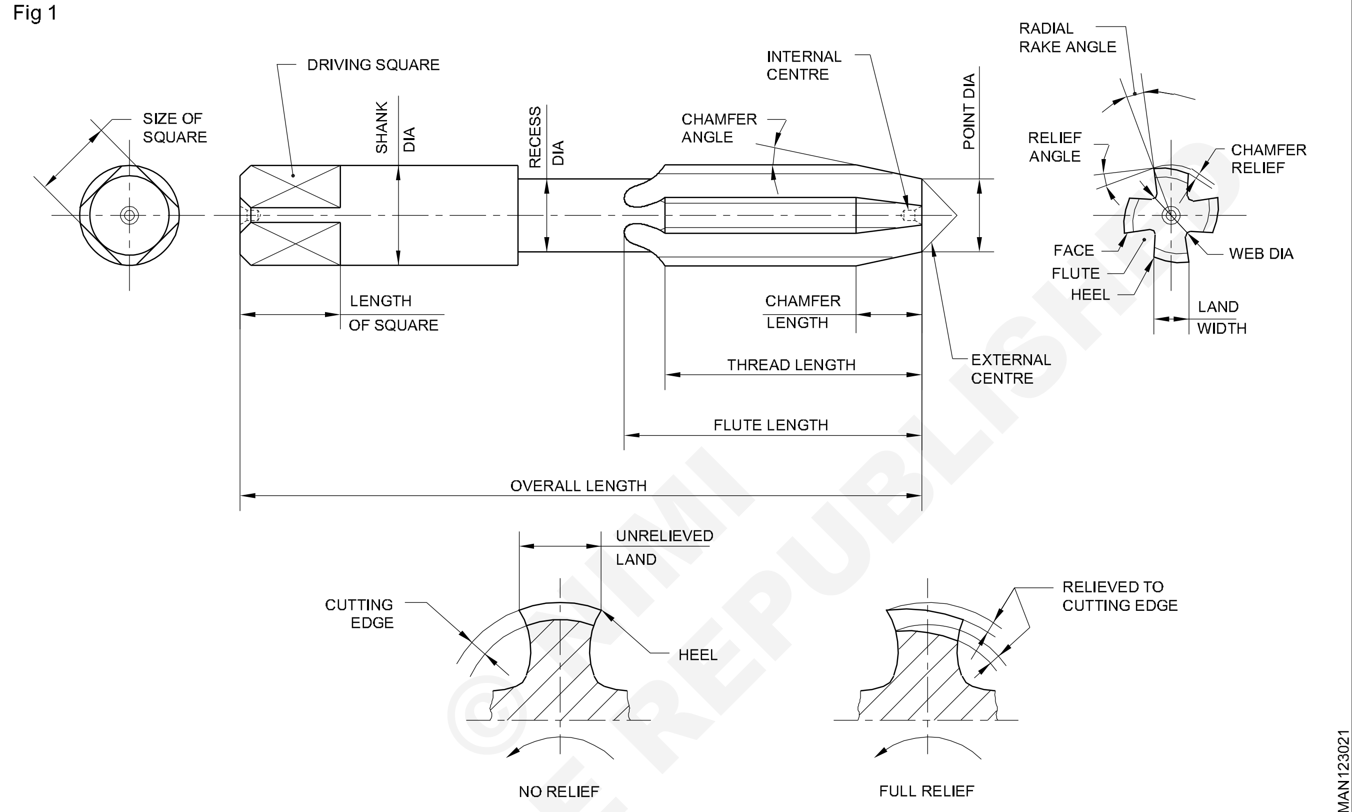
Hand taps and wrenches

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

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.

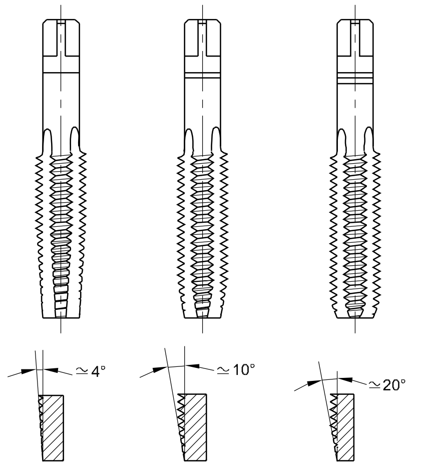
For identifying the type of taps quickly - the taps are either numbered 1,2 and 3 or rings are marked on the shank.

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.

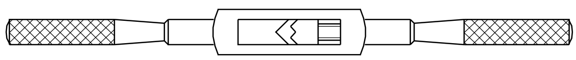
Fig 2



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.

It is important to select the correct size of wrench.

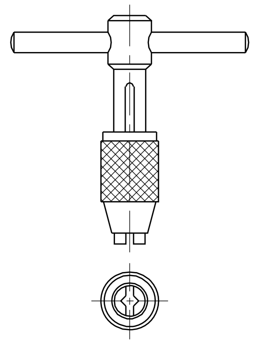
Fig 3



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.

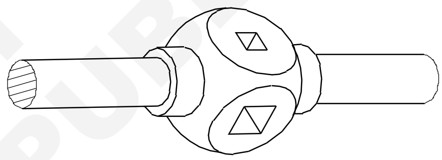
Fig 4



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



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 = Major diameter minus pitch

$$\text{Major diameter} - \frac{1 \text{ inch}}{\text{No.of threads per inch}}$$

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 dize

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

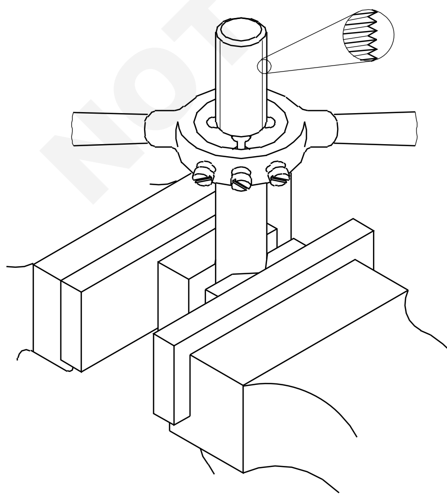
Die and die stock

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.

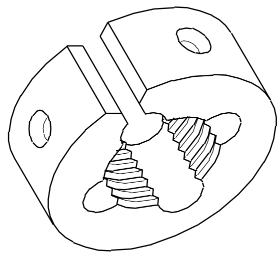
– Circular split die (Button die)

– Half die

– Adjustable screw plate die

Circular split die/button die (Fig 2)

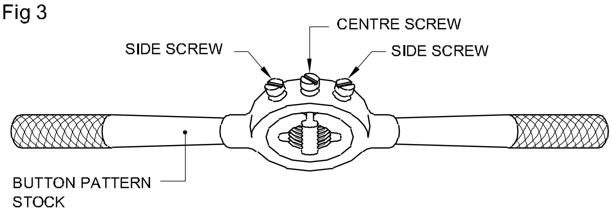
Fig 2



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



MAN123033

Half die (Fig 4)

Half dies are stronger in construction.

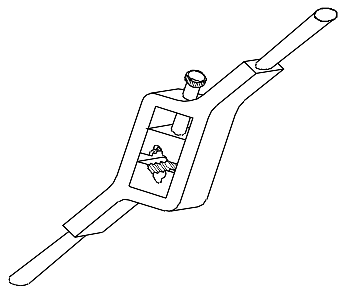
Adjustments can be made easily to increase or decrease the depth of cut.

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.

Fig 4



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Adjustable screw plate die (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)

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.

Fig 5

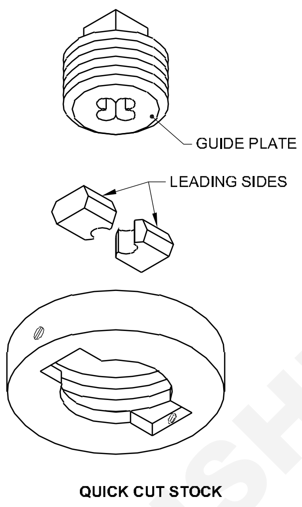

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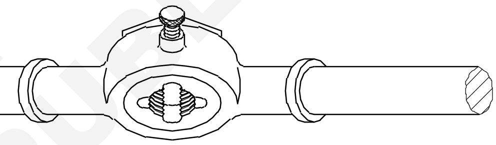
Fig 6



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Die nut (Solid die) (Fig 7)

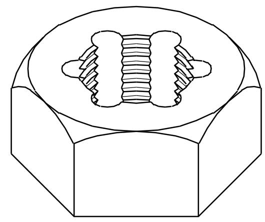
The die nut is used for chasing or reconditioning the damaged threads.

> **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.

Fig 7



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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, $D = d - p/10$

$= 12 \text{ mm} - 0.175 \text{ mm}$

$= 11.825$ 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

____

____

____

Screw thread and elements

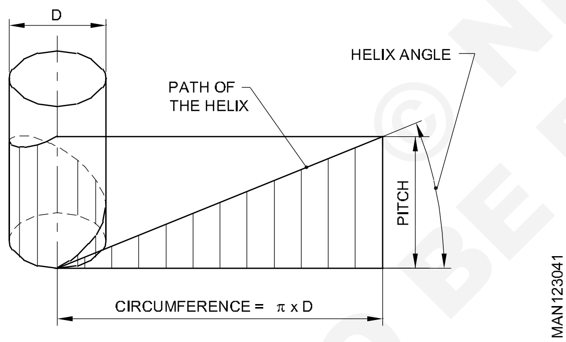
Objectives: At the end of this lesson you shall be able to
- **state the uses of screw threads**
- **explain the difference between external and internal threads**
- **state the elements of screw threads.**

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)

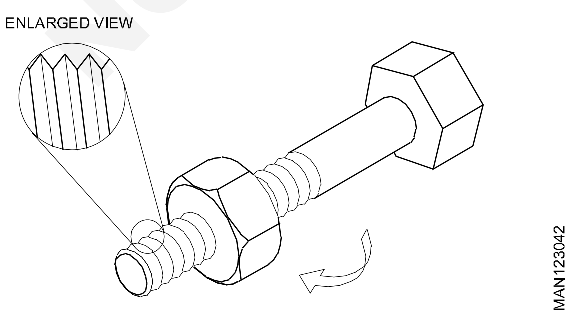
Fig 1



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

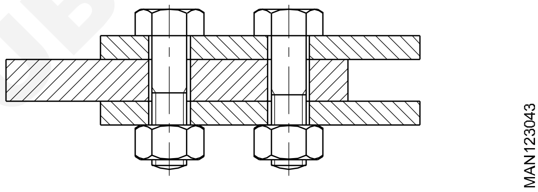


Uses of screw threads

Screw threads are used

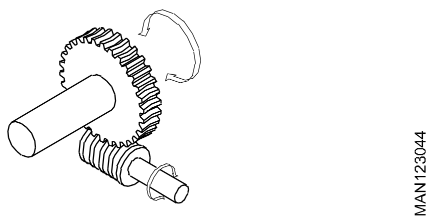
- as fasteners to hold together and dismantle components when needed (Fig 3)

Fig 3



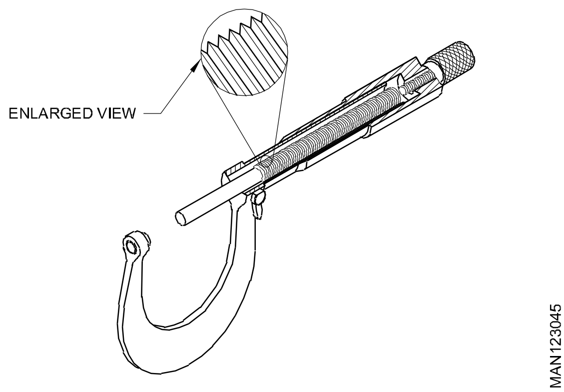
- to transmit motion on machines from one unit to another (Fig 4)

Fig 4



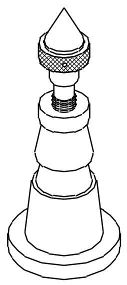
- to make accurate measurements (Fig 5)

Fig 5



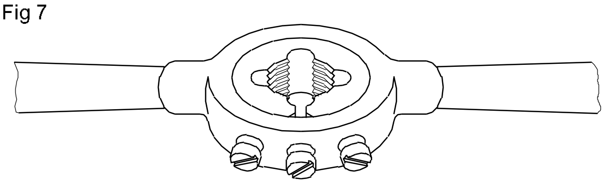
- to apply pressure (Fig 6)

Fig 6



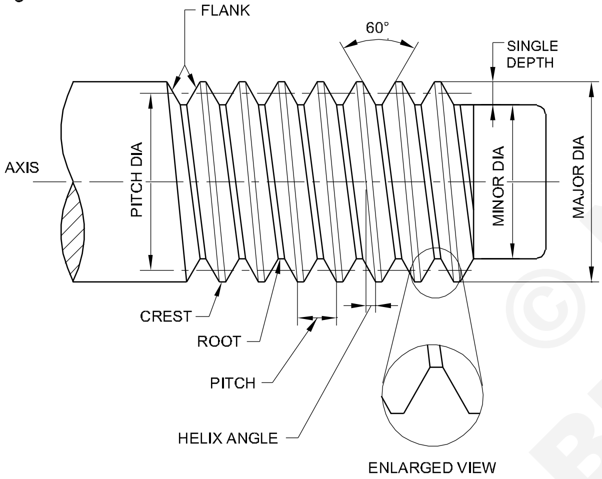
- to make adjustments. (Fig 7)

Fig 7



Parts of a screw thread (Fig 8)

Fig 8



Crest

The top surface joining the two sides of a thread.

Root

The bottom surface joining the two sides of adjacent threads.

Flank

The surface joining the crest and the root.

Thread angle

The included angle between the flanks of adjacent threads.

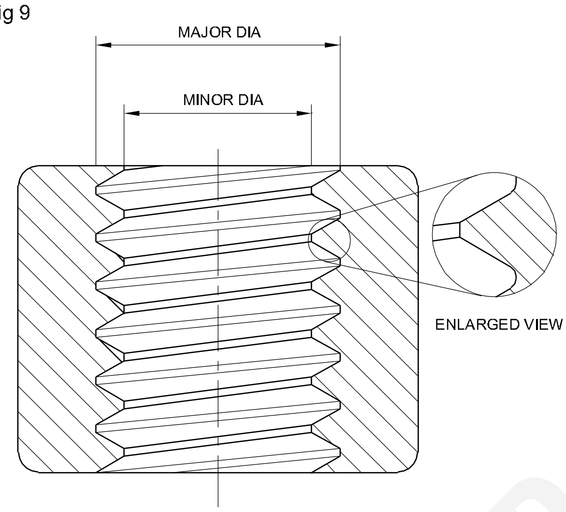
Depth

The perpendicular distance between the roots and crest of the thread.

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 are known as the major diameter. (Fig 9)

Fig 9



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 8)

It is the distance from a point on one thread to a 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.

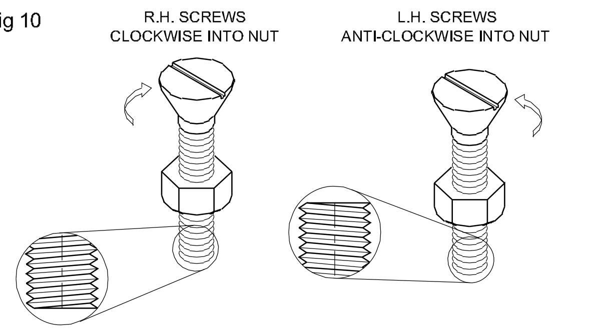
Helix angle

The angle of inclination of the thread to the imaginary perpendicular line.

Hand

The direction in which the thread is turned to advance. A right hand thread is turned clockwise to advance, while a left hand thread is turned anticlockwise. (Fig 10)

Fig 10



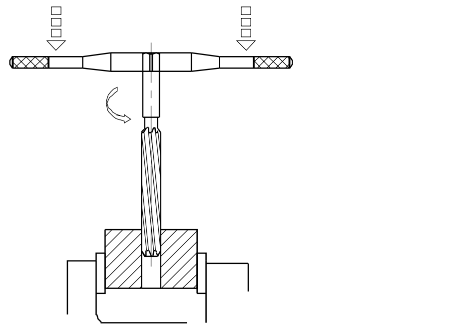
Reamers

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

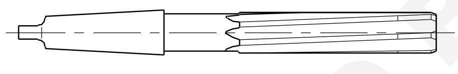
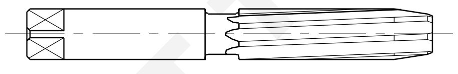


Fig 3



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.

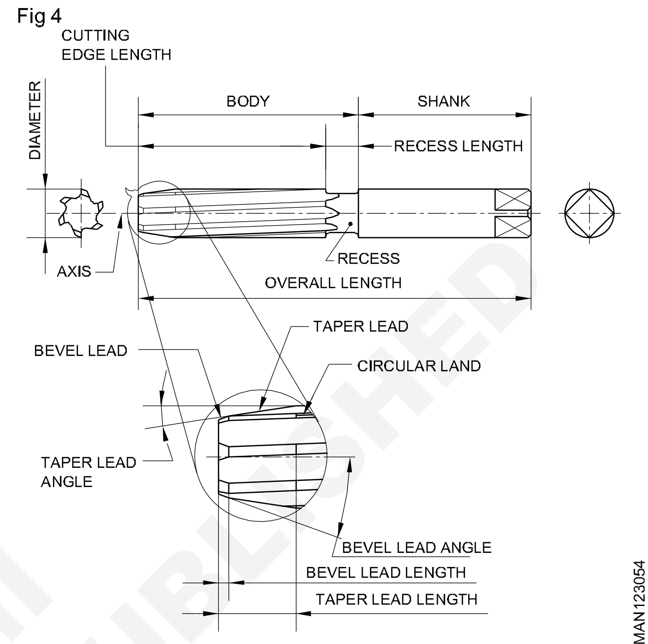
Machine reamers are provided with morse taper shanks for holding on machine spindles.

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.

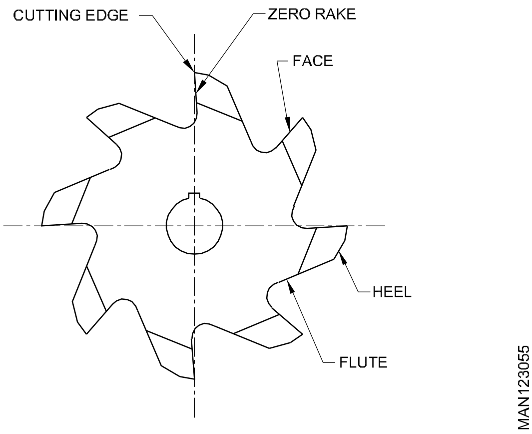
Taper lead angle

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)

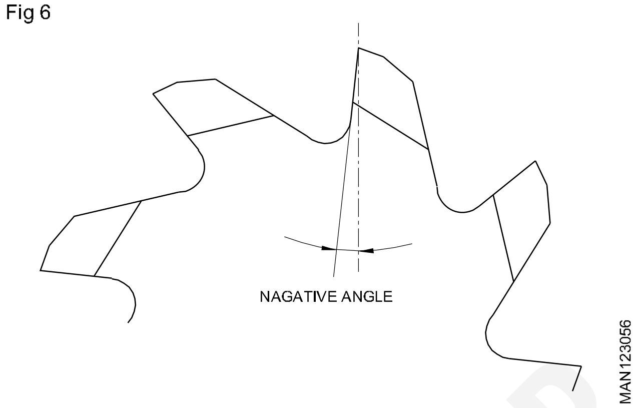
Face

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 diametral plane formed by the face and a radial line from the cutting edge. (Fig 6)

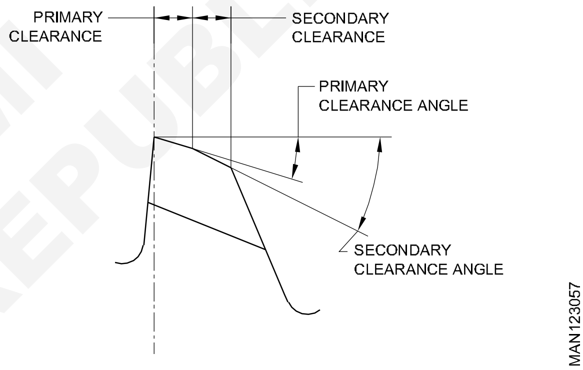
Fig 6



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)

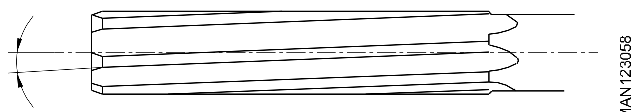
Fig 7



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.

Fig 1

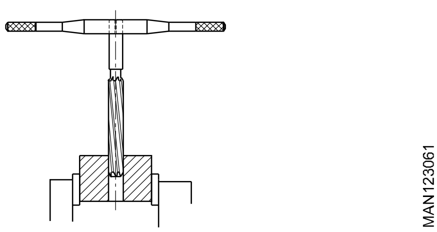
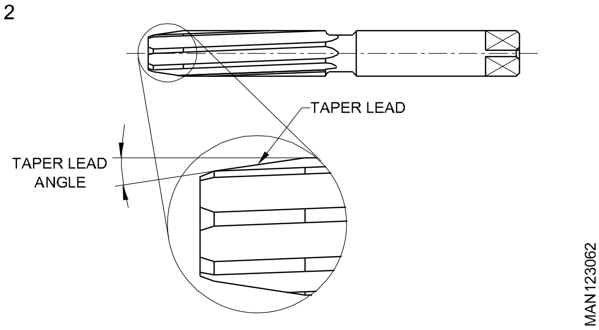


Fig 2

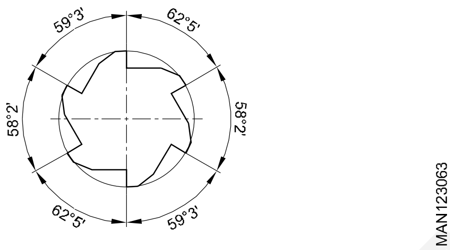


Most hand reamers are for right hand cutting.

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 3



Types, Features and Functions

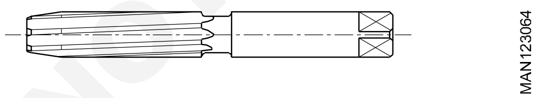
Hand reamers with different features are available for meeting different reaming conditions. The commonly used types are listed here under.

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.

Reamers commonly used in workshop produce H8 holes.

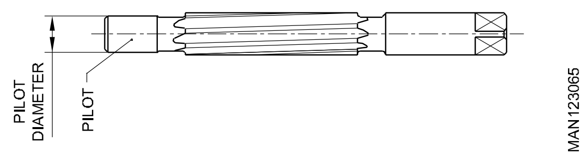
Fig 4



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

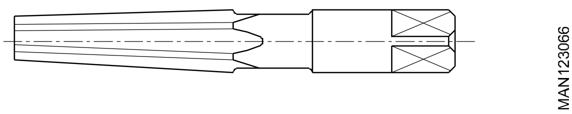
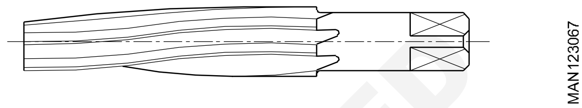


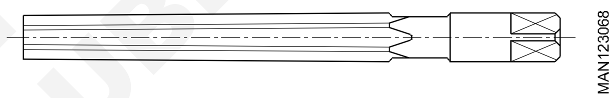
Fig 7



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.

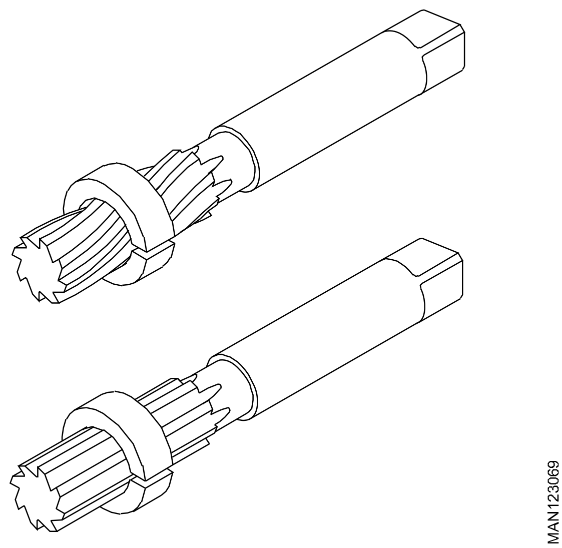
Fig 8



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

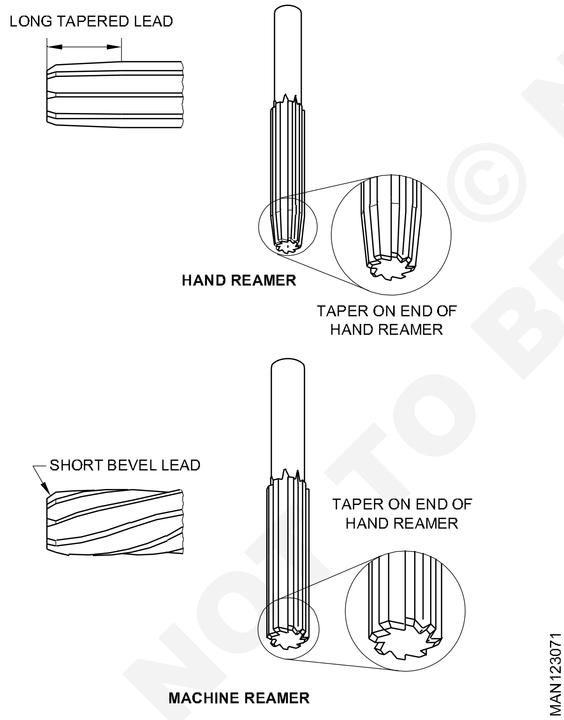
Hand reamer, Straight flute, Parallel shank of Ø 20 mm.

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

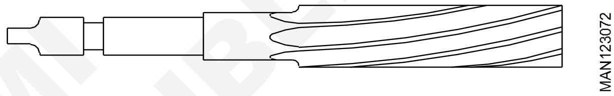


The shank end of the hand reamers will be square to facilitate reaming using tap wrenches. Machine reamers of small diameters will have parallel shank and the larger reamers are provided with taper shanks.

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)

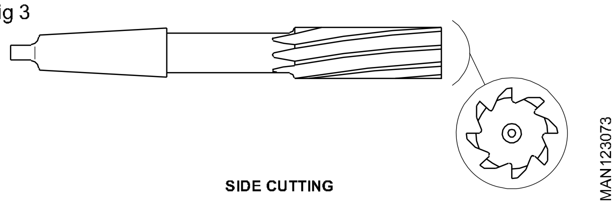
Fig 2



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.

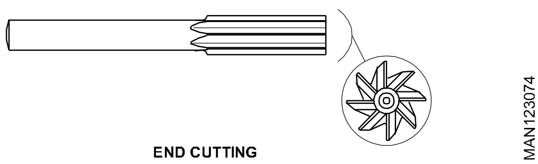
Fig 3



Rose reamer/rose chucking reamer (Fig 4)

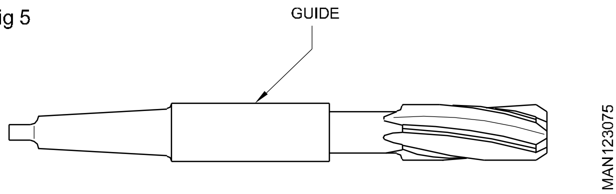
This reamer is designed to cut on its end. The flutes help in chip clearance and act as guides while cutting. This is used when a considerable amount of metal is to be removed, and the finish is not very critical. This is sometimes used as a roughing tool. Final finishing is done with other finishing reamers.

Fig 4



Machine jig reamers (Fig 5)

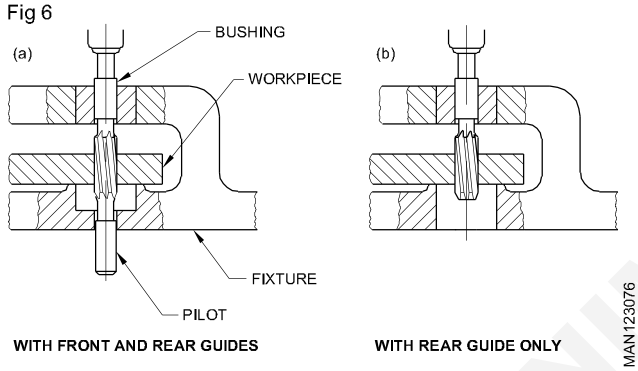
Fig 5



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.

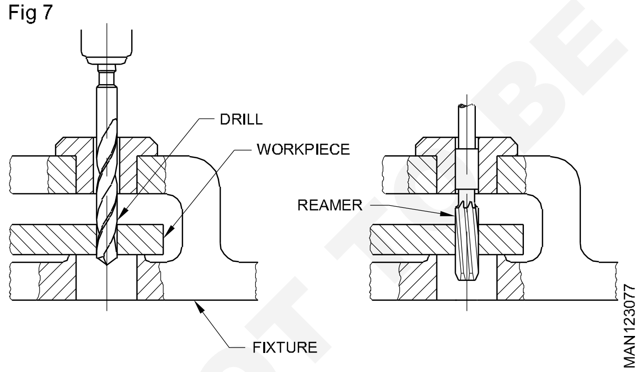
Reamers of this type are available with rear guides only or with front and rear guides. (Fig 6) They can produce very accurate holes in the spindle and bushes are aligned accurately. While reaming deep holes it is better to select the jig reamers with guides on both ends.

Fig 6



When reaming is carried out immediately after drilling in the same setting, renewable bushes are used on the jig. (Fig 7)

Fig 7



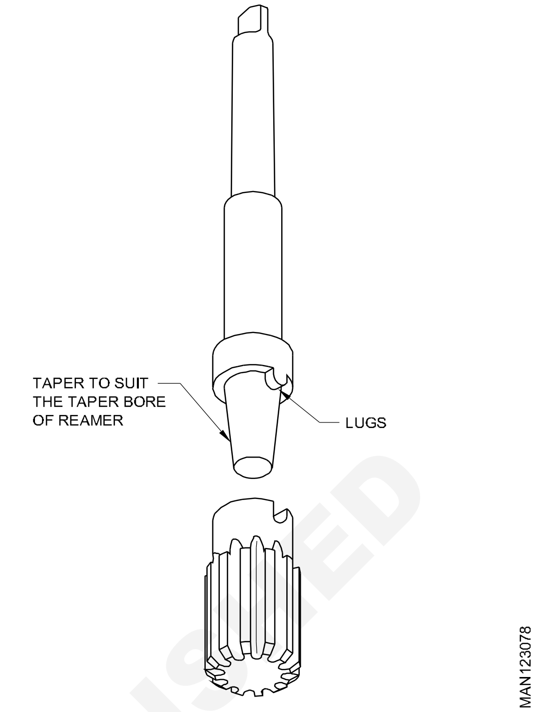
Shell reamer (Fig 8)

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

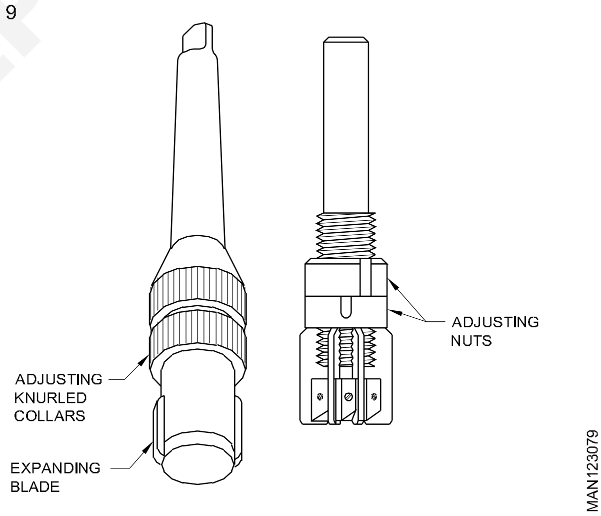
These reamers are easy to adjust when worn out. They can be re- sharpened and adjusted back to the correct size. As such these reamers have longer working life than ordinary reamers.

Fig 8



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 slightly.

Fig 9



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

Fig 10

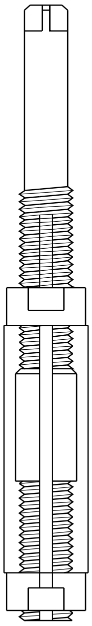
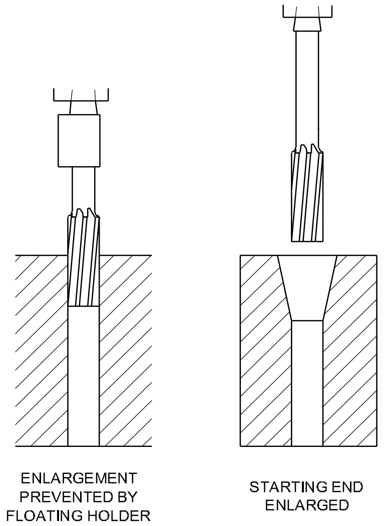
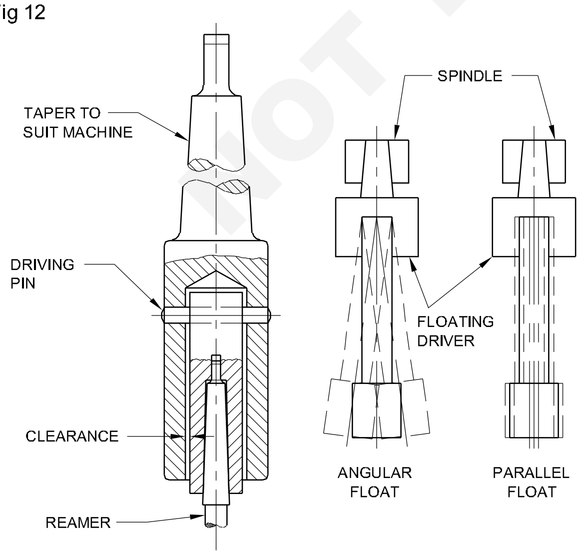


Fig 11



minor discrepancies in the axis alignment. Floating holders are available with angular floats and parallel floats. (Fig 12)

Fig 12



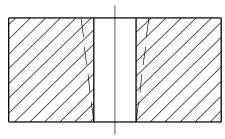
Taper reamers

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.

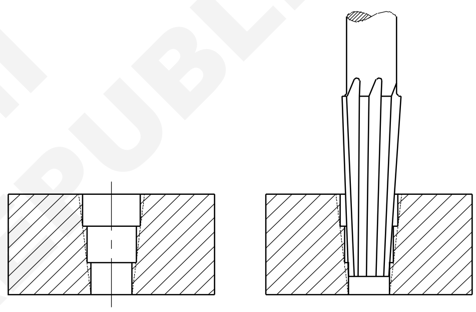
While reaming, the taper reamer will have to remove more material at the big end and less material at the small end. (Fig 13) While cutting, the entire length of the reamer will be in contact with the workpiece. This can cause chatter marks and poor finish.

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)

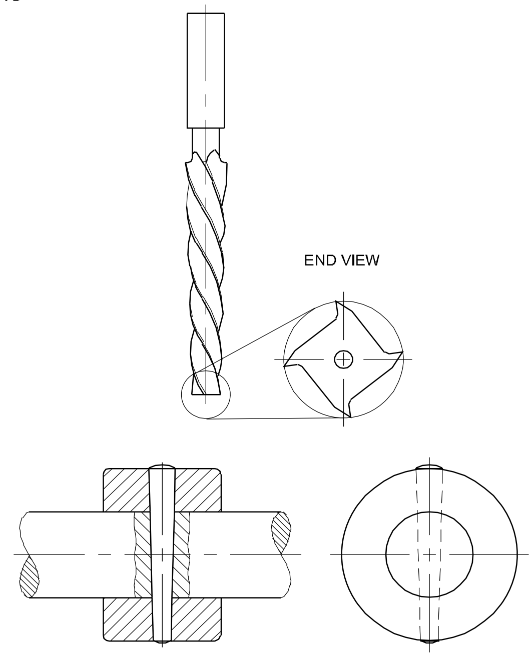
Fig 14



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 practiced 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

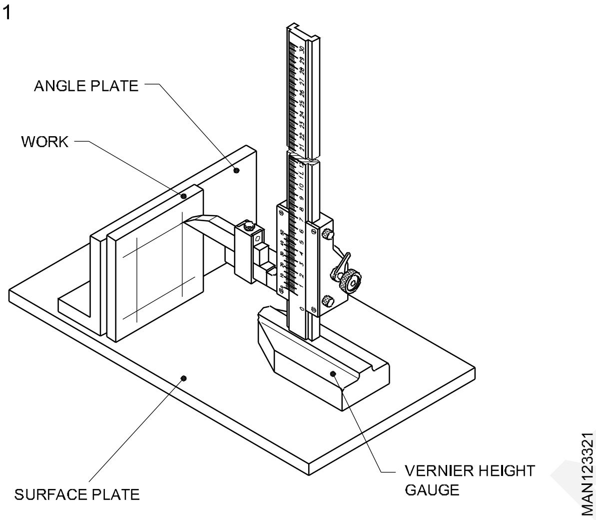
Vernier height gauge

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

Specific uses of a vernier height gauge

Accurate measurements are important in layout (marking off) and inspection work. (Figs 1 & 2)

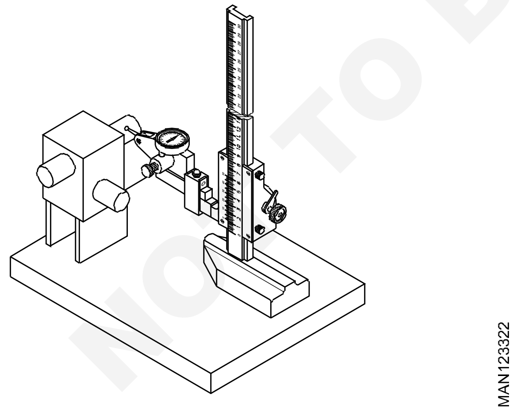
Fig 1



Vernier height gauges are particularly suitable for marking off accurate distances, and centre locations.

The graduations and readings are the same as those of a vernier caliper.

Fig 2



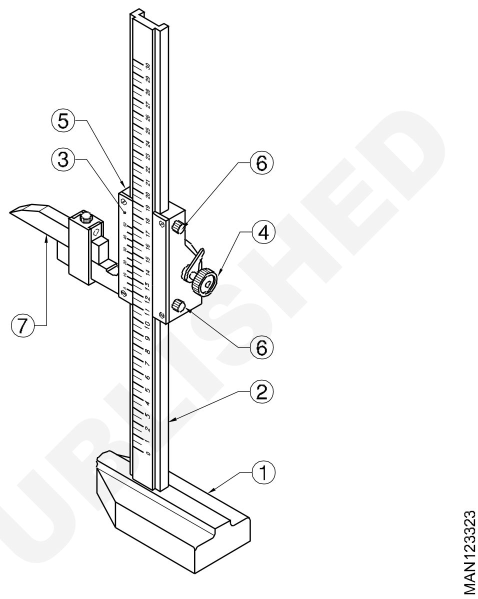
Parts of a vernier height gauge and their functions

The main parts of a vernier height gauge and their functions are given here. (Fig 3)

Base (1)

This is the datum from which measurements and settings are made. The underside of the base is hardened, ground and lapped.

Fig 3



Beam (2)

This is similar to the beam scale of a vernier caliper and is attached to the base.

Vernier slide (3)

This unit slides on the beam and carries the vernier plate (5), locking screws (6), fine setting device (4) and scriber (7). Some vernier height gauges are provided with a rack and pinion arrangement for moving the slide along the beam.

Vernier height gauges are provided with both straight and offset scribers. (Fig 4)

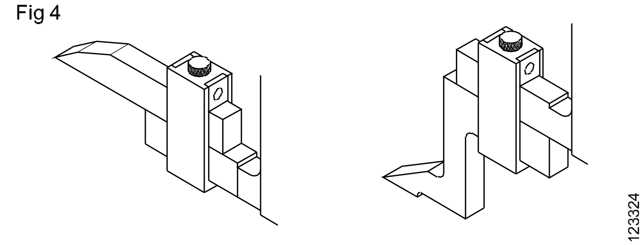
Zero setting of the vernier height gauge.

The offset scriber permits zero setting of the instrument from the datum surface.

While using a straight scriber, the zero setting of the instrument is at a level above the datum surface. In this case the zero setting is to be checked using the precision round block, supplied along with the instrument.

Vernier height gauges with which we can measure from the datum surface without the special offset scribers are also available. (Fig 5)

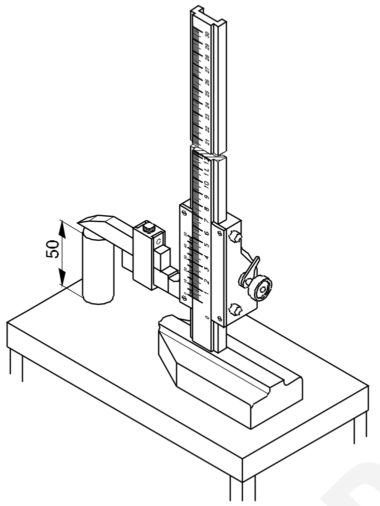
Fig 4



The size of the vernier height gauge is stated by the height of the beam. The most commonly used size has a beam of 300 mm height.

Vernier height gauges are used with surface plates or other accurate flat surfaces.

Fig 5



Counter sinking

Objectives: At the end of this lesson you shall be able to
- **explain counter sinking**
- **list the purposes of counter sinking**
- **state the angles of counter sinking for different applications**
- **explain the different types of counter sinks and their applications.**

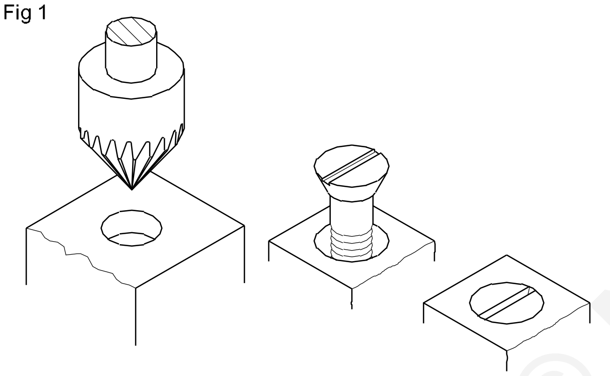
Counter sinking

Countersinking is an operation of beveling the end of a drilled hole. The tool used is called a countersink.

Counter sinking is carried out for the following purposes.

- To provide a recess for the head of a counter sink screw, so that it is flush with the surface after fixing. (Fig 1)

Fig 1



- To deburr a hole after drilling
- To accommodate counter sink rivet heads.
- To chamfer the ends of holes for thread cutting and other machining processes.

Angles for counter sinking

Counter sinks are available in different angles and for different uses.

75° Counter sink riveting.

80° Counter sink self-tapping screws.

90° Counter sink head screws and for deburring.

120° Chamfering ends of holes to be threaded or other machining processes.

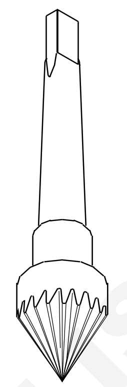
Counter sinks

Counter sinks of different types are available.

The commonly used counter sinks have multiple cutting edges and are available in taper shank (Fig 2) and straight shank.

For counter sinking small diameter holes special counter sinks with one or two flutes are available. This will reduce the vibration while cutting.

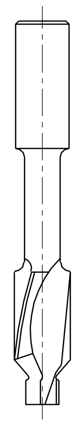
Fig 2



Counter sinks with pilot (Fig 3)

For precision counter sinking, needed for machine tool assembling and after machining process, counter sinks with pilots are used.

Fig 3



They are particularly useful for heavy duty work.

The pilot is provided at the end for guiding the counter sink to the hole.

Counter sinks with pilots are available with interchange able and solid pilots.

Counter sink hole sizes

The counter sink holes according to Indian Standards IS 3406 (Part 1) 1986 are of four types.

Type A

Type B

Type C

Type E

These types are used for different purposes.

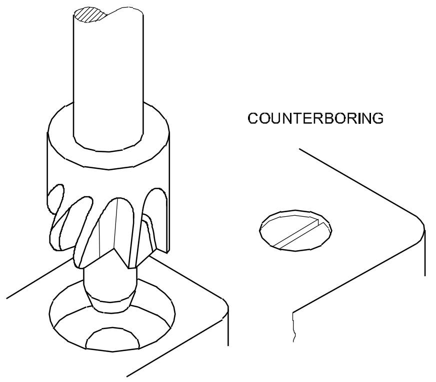
Counter boring and spot facing

Objectives: At the end of this lesson you shall be able to
- **explain the difference between counter boring and spot facing**
- **state the various types of counter bores and their uses**
- **state the correct counter bore sizes for different holes.**

Counter boring

Counter boring is an operation of enlarging a hole to a given depth, to house heads of socket heads or cap screws with the help of a counter bore tool. (Fig 1)

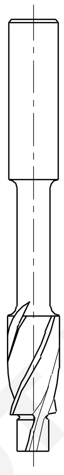
Fig 1



Counter bore (tool)

The tool used for counter boring is called a counter bore. (Fig.2) Counter bores 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.

Fig 2



The pilot also helps to avoid chattering while counter boring. (Fig. 3)

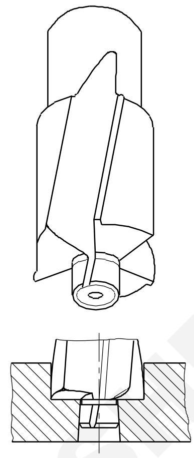
Counter bores are available with solid pilots or with interchangeable pilots. The inter-changeable pilots provide flexibility of counter boring on different diameters of holes.

Counter bores: sizes and specification

Counter bore sizes are standardized for each diameter of screws as per BIS.

There are two main types of counter bores. Type H and Type K. These types are used for different purposes.

Fig 3



Spot facing

Spot facing is a machining operation for producing a flat seat for a bolt head, washer or nut at the opening of the drilled hole. The tool is called a spot facer or a spot facing tool. Spot facing is similar to counter boring, except that the hole is shallower. Tools that are used for counter boring 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 4

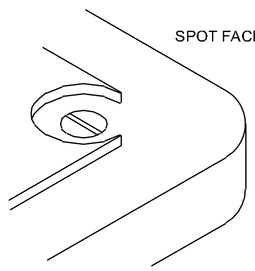
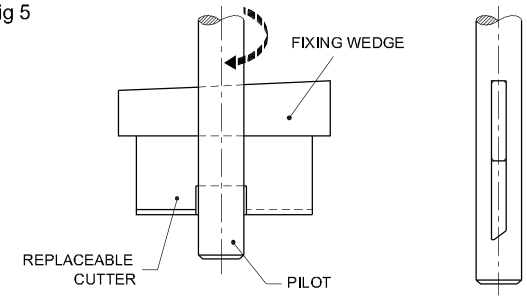


Fig 5



Drilling machines - Types & Application

Objectives: At the end of this lesson you shall be able to
- **state types of drilling machines**
- **explain applications 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

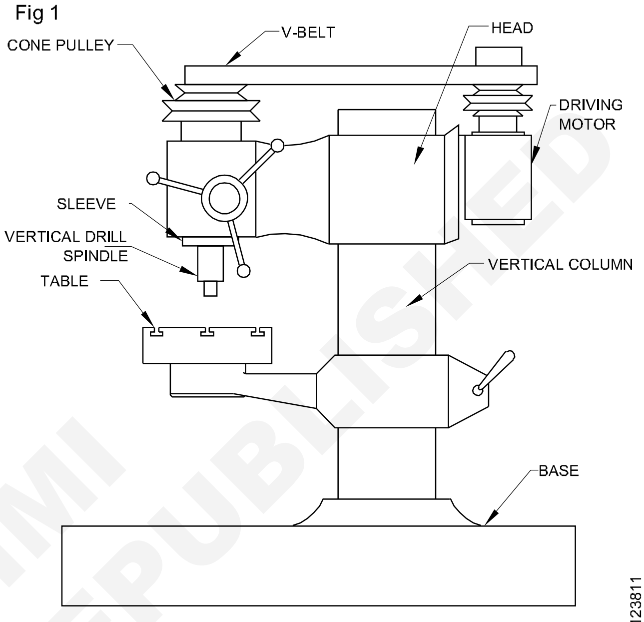
Portable Drilling machine

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 (Fig 1)

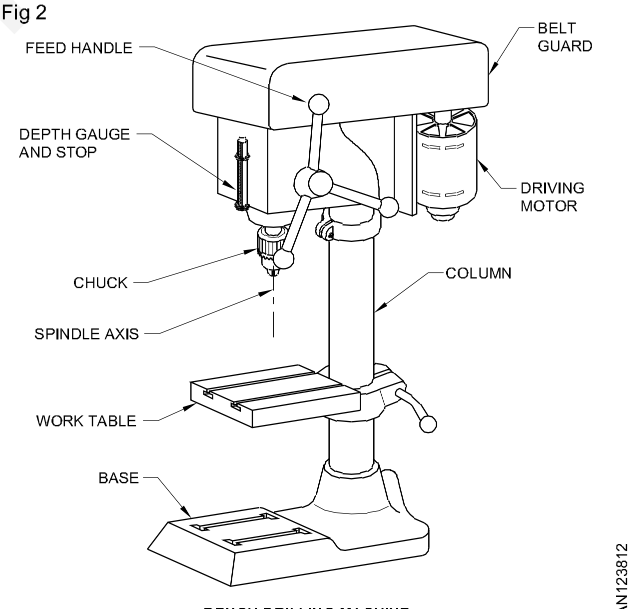
The sensitive drilling machine is a small machine designed for drilling a small hole at high speed in light jobs, the base of the machine may be mounted on a bench or on the floor. It consists of a vertical column, a horizontal table, a head supporting the motor and driving mechanism, and a vertical 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.

Fig 1



SENSITIVE DRILLING MACHINE

Fig 2

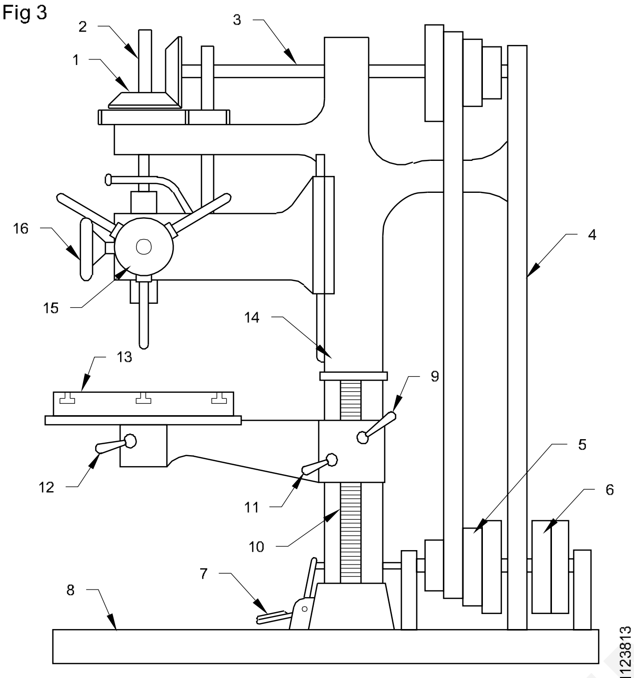


BENCH DRILLING MACHINE

Box column section upright drilling machine (Fig 3)

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



UPRIGHT PILLAR DRILLING MACHINE

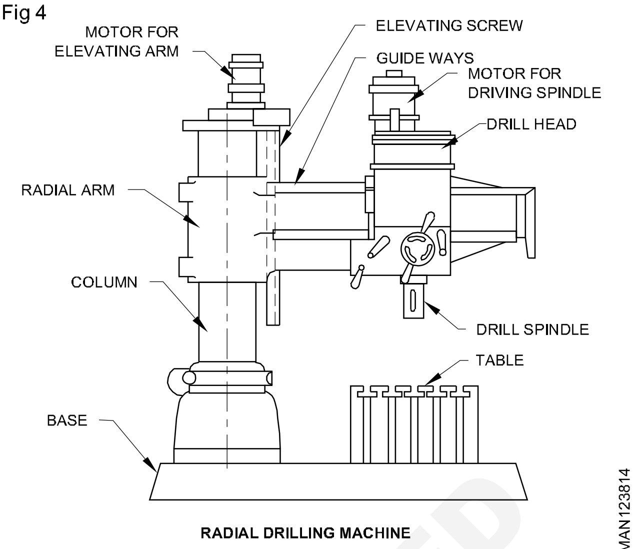
1. Bevel gear drive to spindle, 2 Spindle, 3 Overhead shaft, 4 Back stay, 5 Counter shaft cone pulley, 6. Fast and loose pulley, 7. Table elevating handle, 8. Foot pedal, 9. Base, 10. Rack 11. Table elevating clamp handle, 12. Table clamp, 13. Table, 14. Column, 15. Hand wheel for quick hand feed, 16. Hand wheel for sensitive hand feed.

Radial Drilling machine (Fig 4)

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 veracity 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.5.3 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

Fig 4

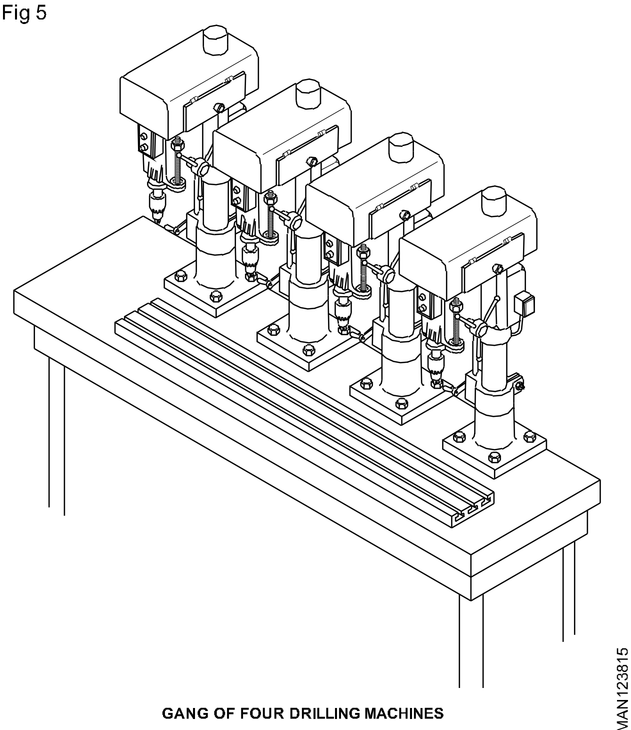


RADIAL DRILLING MACHINE

Gang Drilling Machine (Fig 5)

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.

Fig 5

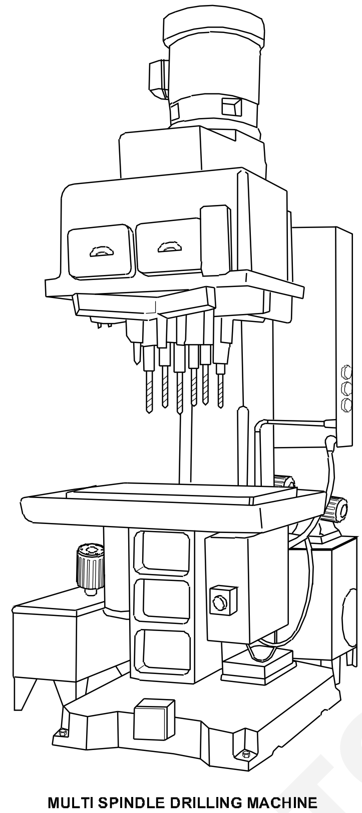


GANG OF FOUR DRILLING MACHINES

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



MULTI SPINDLE DRILLING MACHINE

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Automatic Drilling machine (Fig 7)

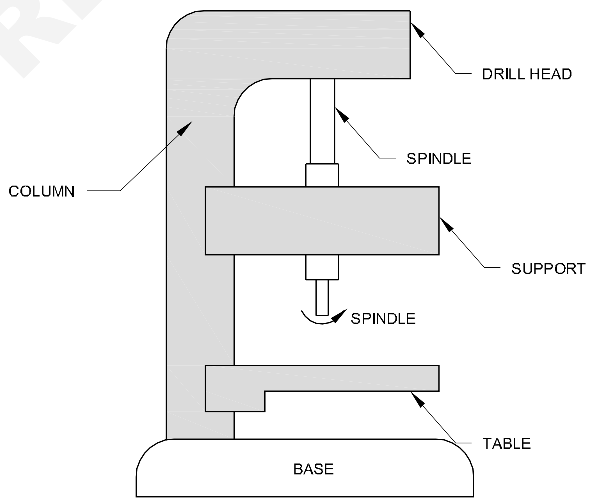
Automatic drilling machine can perform a series of machining operations at successive units and transfer the work from one unit to the other automatically. Once the work is loaded at the first machine, the work will move from one machine to the other where different operations can be performed and the 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)

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.

Fig 8



DEEP HOLE DRILLING MACHINE

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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 (Fig 1)

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.

- 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.

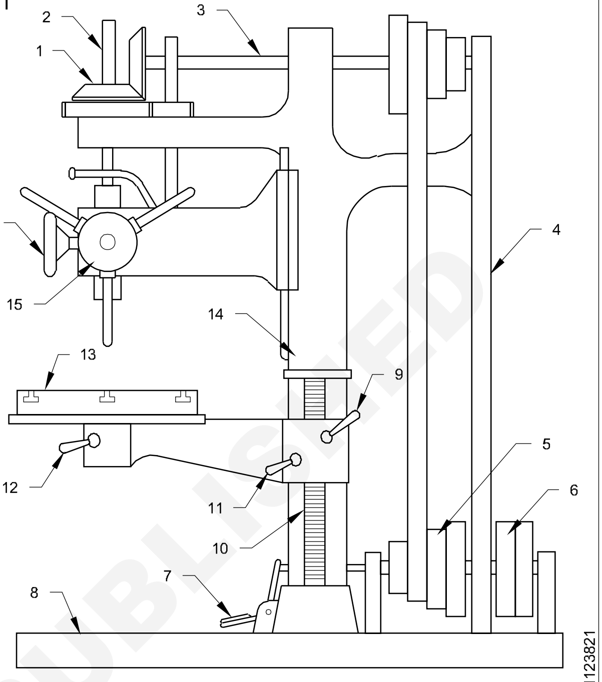
The construction of the machine being not very rigid and the table being supported on a horizontal arm, this is particularly intended for lighter work. The maximum size of holes that the machine can drill is not more than 50mm

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 quick hand feed and 16. Handwheel for sensitive hand feed.

The compund Table for a pillar type drilling machine (Fig 2)

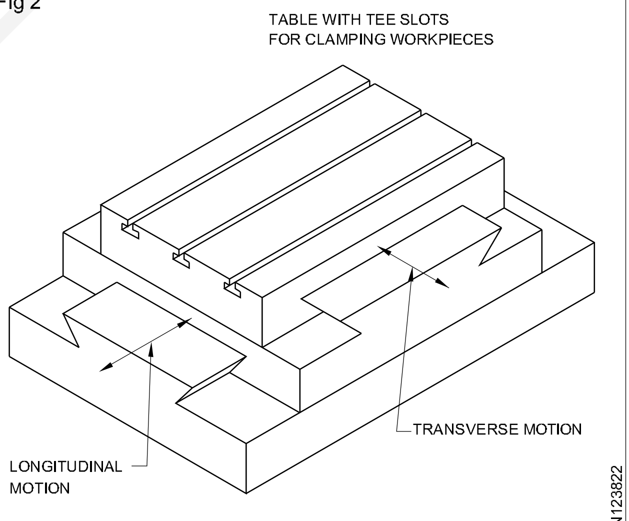
This is a development of the box-column type pillar drilling machine with a table mounted on the two slide ways to give horizontal motions at 90° to each other, and controlled by the operating screws.

Fig 1



UPRIGHT PILLAR DRILLING MACHINE

Fig 2

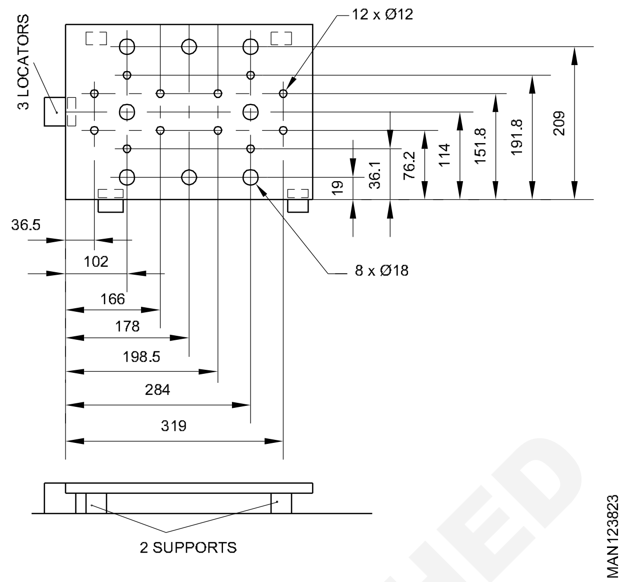


BASE REPLACES NORMAL MACHINE TABLE

A typical component for drilling on a compound table machine is shown in 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.

Fig 3



Radial drilling machines

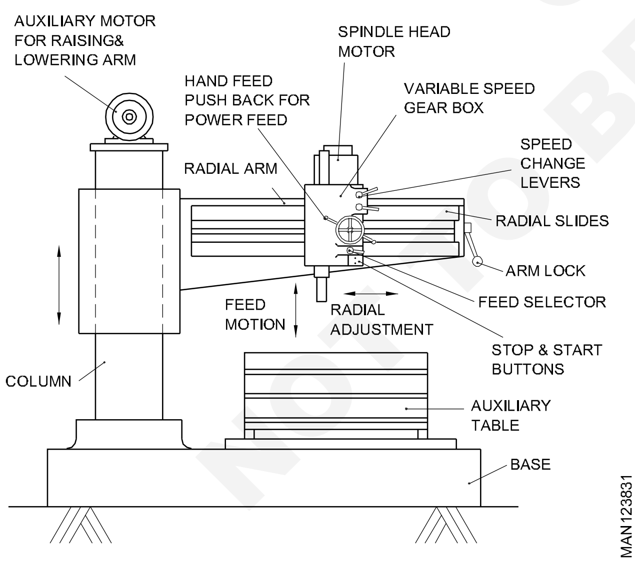
Objectives: At the end of this lesson you shall be able to
- **state the features of a radial drilling machine**
- **state the uses of a radial drilling machine.**

Features (Fig 1)

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.

Fig 1

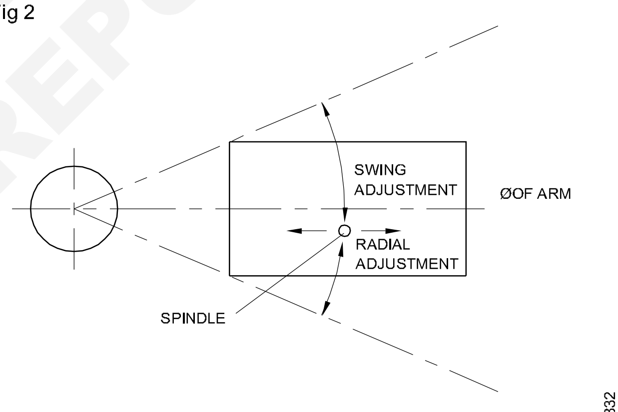


The arm is supported by a pillar (column). It can be rotated about with the pillar as centre. Therefore, the drill spindle can cover the entire working surface of the table. The arm can be lifted or lowered. (Fig 2)

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.

Fig 2



PLAN DIAGRAM SHOWING HOW ADJUSTMENTS ENABLE COMPLETE TABLE AREA TO BE COVERED

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.

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

π = 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)

Feed is expressed in hundredths of a millimetre.

Example - 0.040 mm

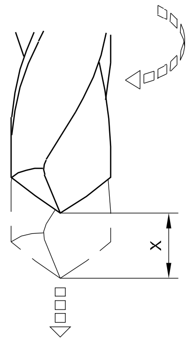
The rate of feed is dependent upon a number of factors.

Finish required

Type of drill (drill material)

Material to be drilled

Fig 1



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.

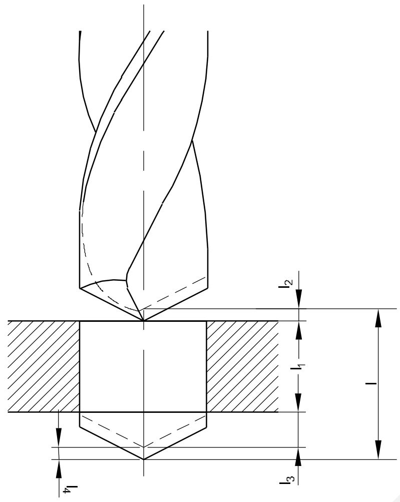
Cutting speed, feed, drilling time calculation

Machining Time in drilling

Machining time in drilling is determined by the formula:

$$T = \frac{L}{n \times s_r} \text{ min.}$$

Fig 2



Where, n = r.p.m. of the drill

S_r = 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 = overtravel

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

$$n = \frac{1000 \times 30}{3.143 \times 12} = 795$$

s_r - 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. Cutting speed, feed, drilling time.

Mass production and interchangeable manufacture

Objectives: At the end of this lesson you shall be able to
- **state the advantages and disadvantages of mass production**
- **explain the meaning of the term, 'interchangeability'**
- **state the necessity for the limit system**
- **state 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 work 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.

Manufacturing and measuring time is saved.

Disadvantages of mass production

Special purpose machines are necessary.

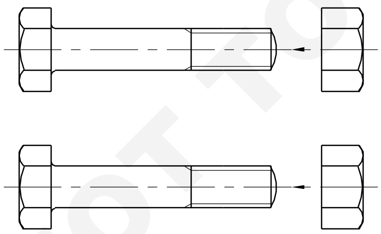
Jigs and fixtures are needed.

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

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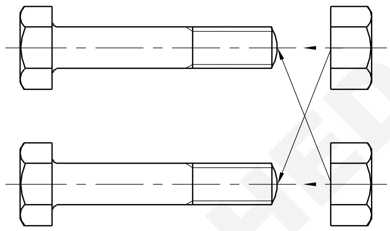
Non-selective assembly

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.

Fig 2



NON-SELECTIVE ASSEMBLY INTERCHANGABILITY

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In modern engineering production, i.e. mass production, there is no room for selective assembly. However, income 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.**

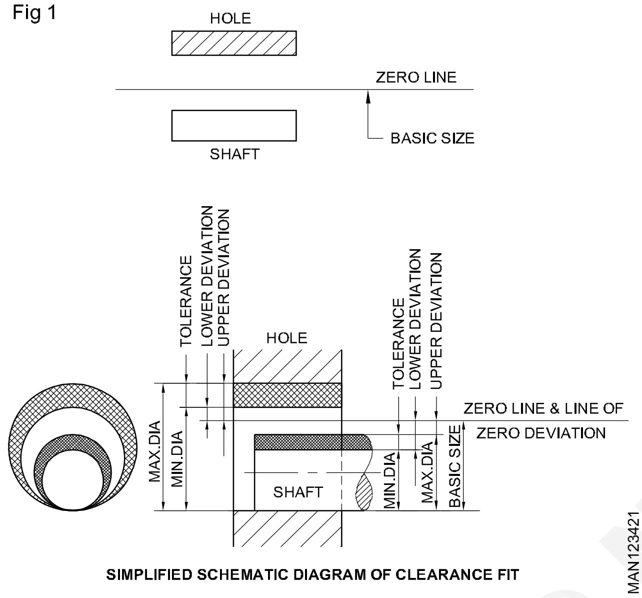
Size

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

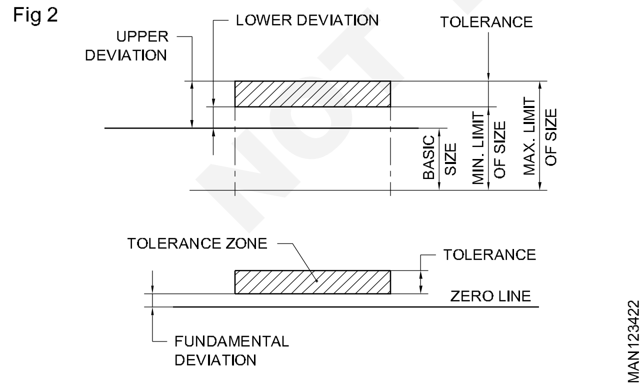
Actual size

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)

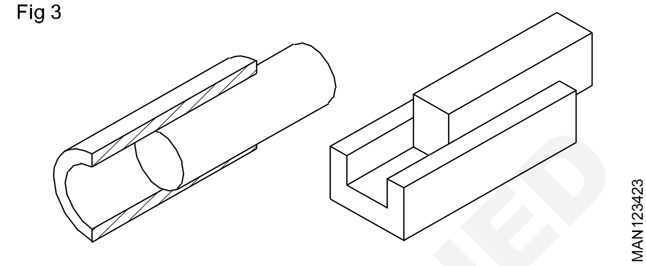
Minimum limit of size

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)

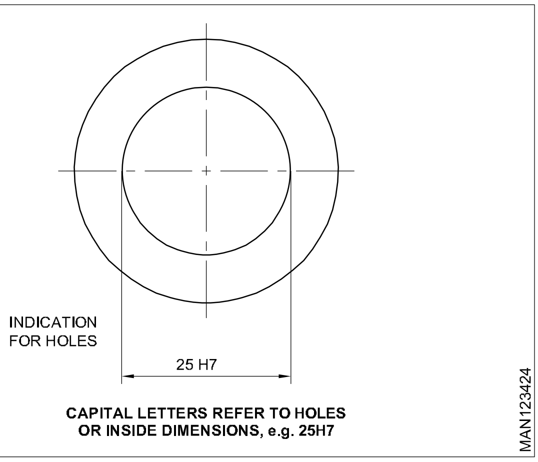
Zero line

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)

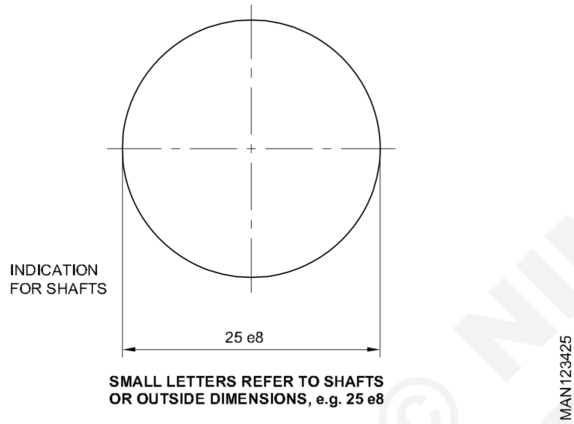
Fig 4



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



The position of tolerance zone with respect to the zero line is shown in Figs 6 and 7.

Fig 6

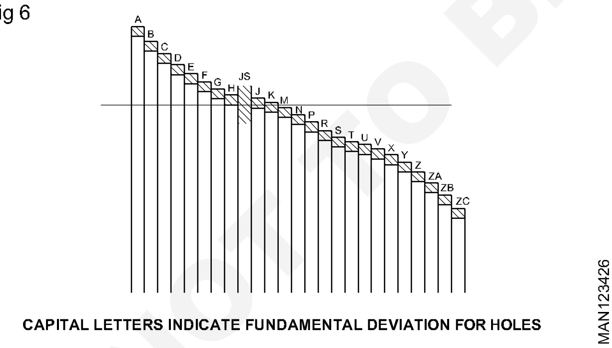
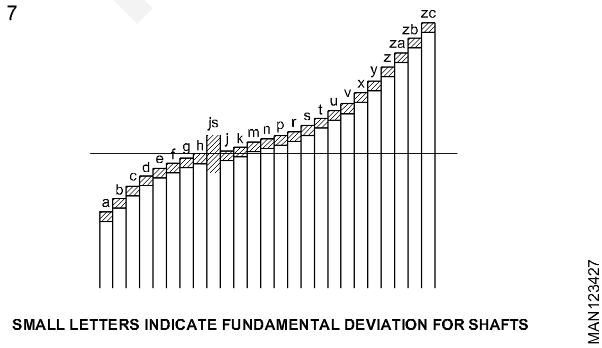


Fig 7



The fundamental deviations are for achieving the different classes of fits. (Figs 8 and 9)

Fig 8

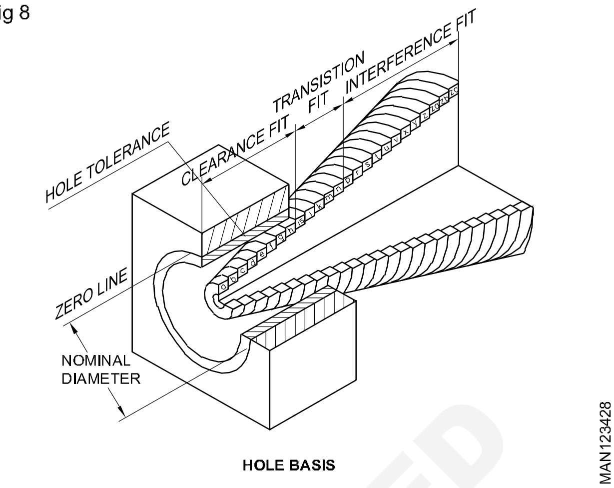
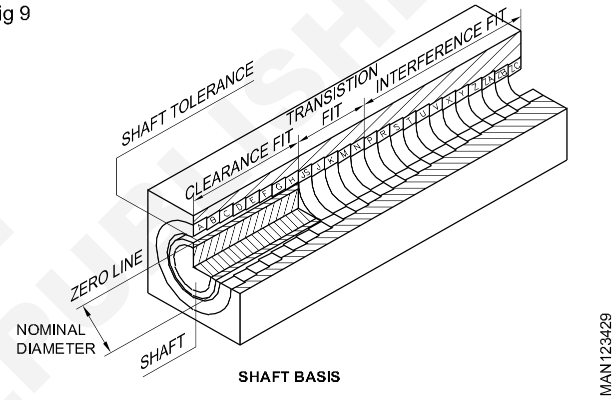


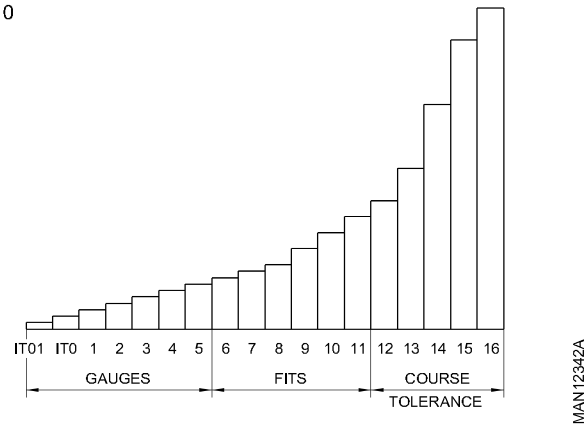
Fig 9



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)

Fig 10



A higher number gives a larger tolerance.

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.)

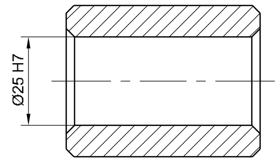
Tolerance size

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



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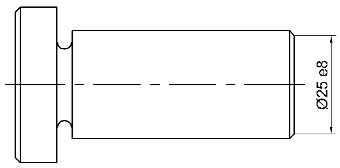
25 e8 - is the tolerance size of a shaft whose basic size is 25. The fundamental deviation is represented by the letter symbol and the grade of tolerance is represented by the number 8. (Fig 12)

Fig 12



MAN12342C

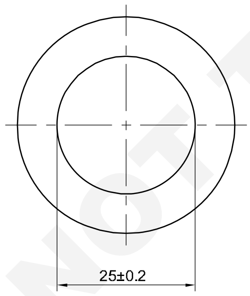
A very wide range of selection can be made by the combination of the 25 fundamental deviations and 18 grades of tolerances.

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.

As pointed out earlier, the permissible variation from the basic dimension is called 'DEVIATION'.

Fig 13



TOLERANCED SIZES OF HOLES

MAN12342D

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

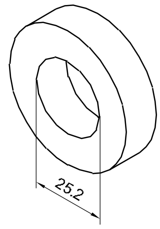
25 + 0.2 = 25.2 mm

or

25 - 0.2 = 24.8 mm.

25.2 mm is the maximum limit. (Fig 14)

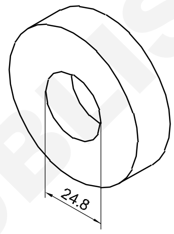
Fig 14



MAN12342E

24.8 mm is the minimum limit. (Fig 15)

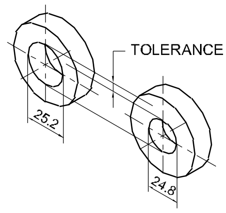
Fig 15



MAN12342F

The difference between the maximum and minimum limits is the TOLERANCE. Tolerance here is 0.4 mm. (Fig 16)

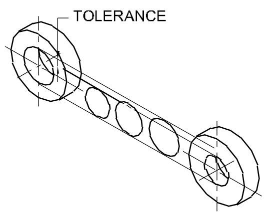
Fig 16



MAN12342G

All dimensions of the hole within the tolerance zone are of an acceptable size as shown in Fig 17.

Fig 17



MAN12342H

As per IS 696, while dimensioning the components as a drawing convention, the deviations are expressed as tolerances.

Different Standard System of fits & limits (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**
- **state 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

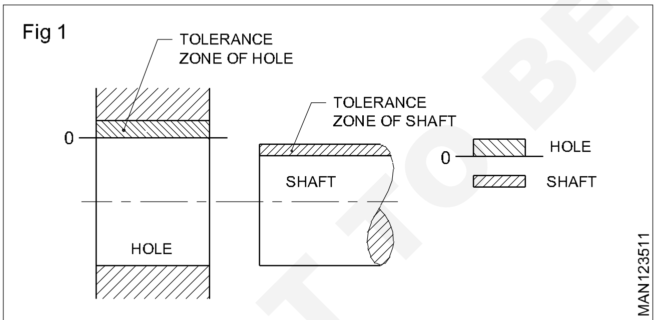
Clearance

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.

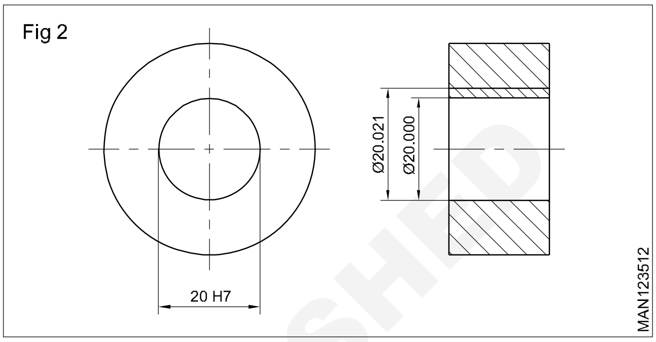
For a hole 20 H7 we find in Table 1, +21.

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.

Fig 2

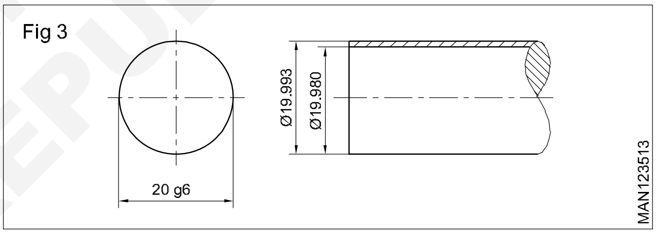


So the limits of the shaft are

20 – 0.007 = 19.993 mm

and 20 – 0.020 = 19.980mm. (Fig 3)

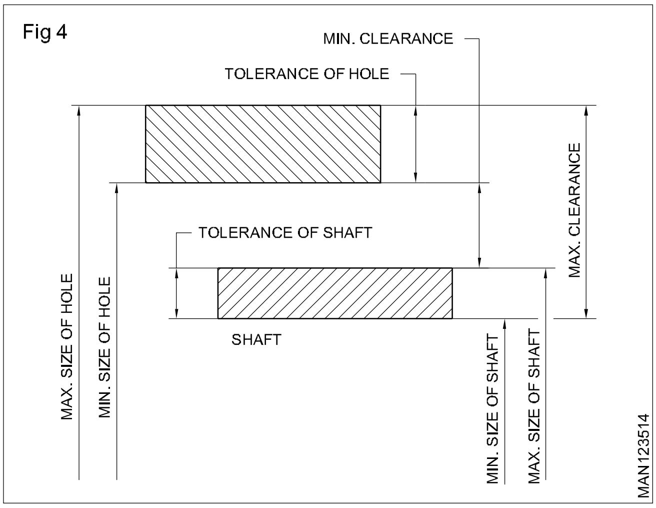
Fig 3



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.

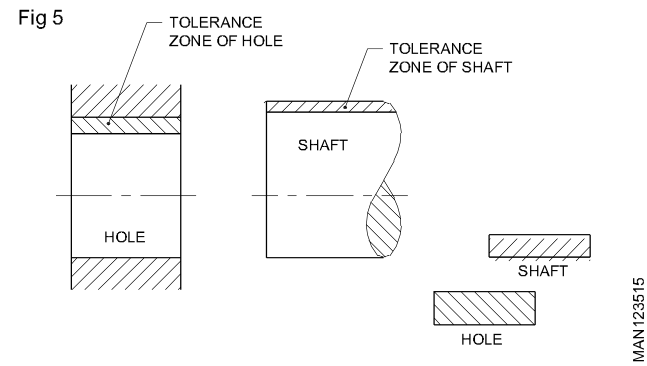
Interference

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

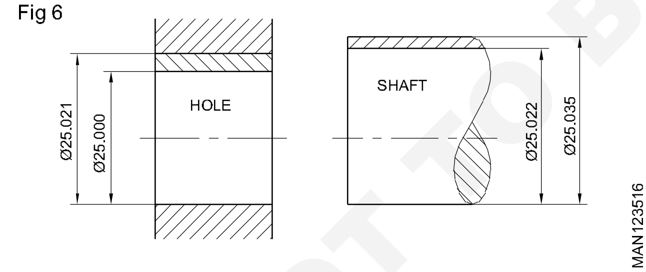


Example

Fit 25 H7/p6 (Fig 6)

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 size of the hole. This is an interference fit.

Fig 6



Maximum interference

In an interference fit, it is the algebraic difference between the minimum hole size and the maximum shaft size. (Fig 7)

Minimum interference

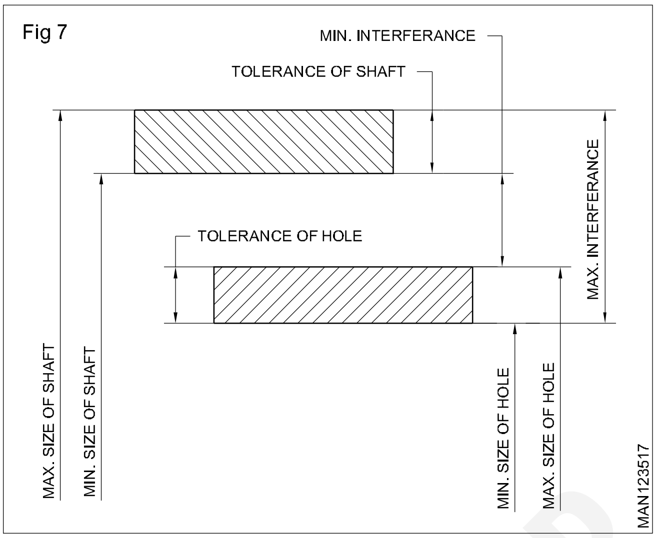
In an interference fit, it is the algebraic difference between the maximum hole size and minimum shaft size. (Fig 7 & 8)

In the example shown in figure 6,

the maximum interference is = 25.035 – 25.000

= 0.035.

Fig 7



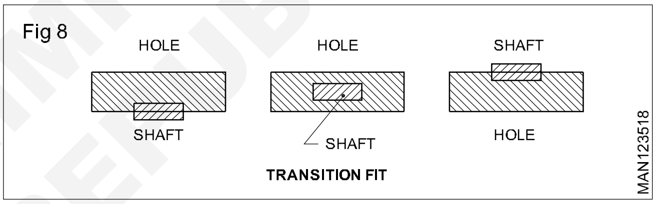
the minimum interference is = 25.022 – 25.021

= 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)

Fig 8



Example

Fit 75 H8/j7 (Fig 9)

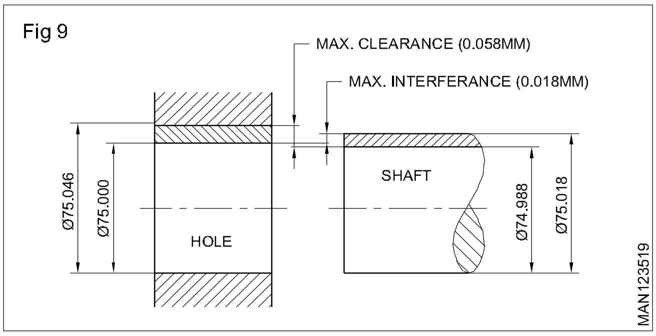
The limits of the hole are 75.000 and 75.046 mm and those of the shaft are 75.018 and 74.988 mm.

Maximum clearnace = 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.

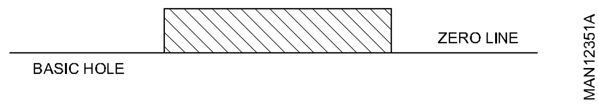
Fig 9



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)

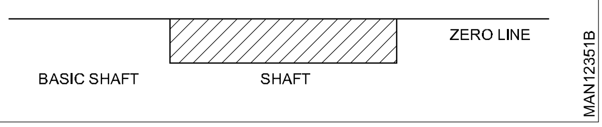
Fig 10



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 followed. This is because the upper deviation of the ‘h’ shaft is zero. It is known as the ‘basic shaft’. (Fig 11)

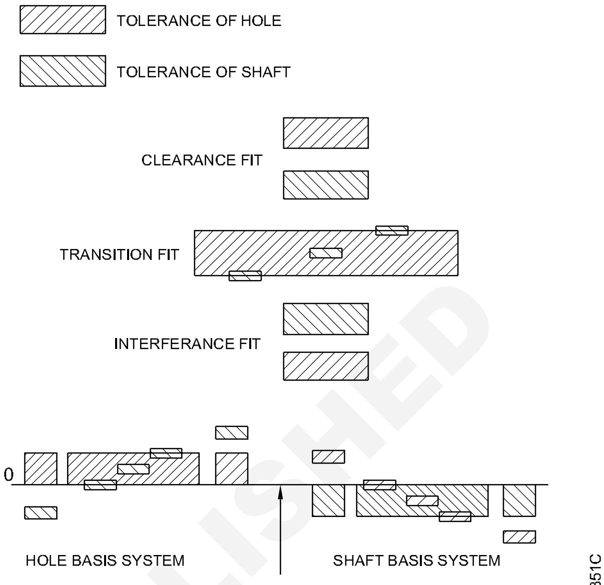
Fig 11



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.

The three classes of fits, both under the hole basis and the shaft basis, are illustrated in figure 12.

Fig 12



EXAMPLES ILLUSTRATING THE HOLE BASIS AND SHAFT BASIS SYSTEMS

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
- **explain to the standard limit system chart and state 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.

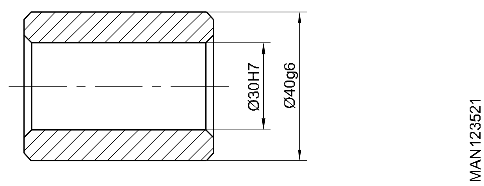
Note the combination of the fundamental deviation and the grade of tolerance.

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.

Example

30H7 (Fig 1)

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.
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)

Table for Tolerance zones & Limits (Dimensions in µm)

NOMINAL SIZE RANGE mm	s6	r6	p6	n6	k6	js6	h6	h7	h9	h11	g6	f7	e8	d9	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
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
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
Over 10 up to 14	+39 +28	+34 +23	+29 +18	+23 +12	+12 +1	+5.5 −5.5	0 −11	0 −18	0 −43	0 −110	−6 −17	−16 −34	−32 −59	−50 −93	−95 −205	−150 −260	−290 −400
Over 14 up to 18																	
Over 18 up to 24	+48 +35	+41 +28	+35 +22	+28 +15	+15 +2	+6.5 −6.5	0 −13	0 −21	0 −52	0 −130	−7 −20	−20 −41	−40 −73	−65 −117	−110 −240	−160 −290	−300 −430
Over 24 up to 30																	
Over 30 up to 40	+59 +43	+50 +34	+42 +26	+33 +17	+18 +2	+8 −8	0 −16	0 −25	0 −62	0 −160	−9 −25	−25 −50	−50 −89	−80 −142	−120 −280	−170 −330	−310 −470
Over 40 up to 50															−130 −290	−180 −340	−320 −480
Over 50 up to 65	+72 +53	+60 +41	+51 +32	+39 +20	+21 +2	+9.5 −9.5	0 −19	0 −30	0 −74	0 −190	−10 −29	−30 −60	−60 −106	−100 −174	−140 −330	−150 −380	−340 −530
Over 65 up to 80	+78 +59	+62 +43													−150 −340	−200 −390	−360 −550
Over 80 up to 100	+93 +71	+73 +51	+59 +37	+45 +23	+25 +3	+11 −11	0 −22	0 −35	0 −87	0 −220	−12 −34	−36 −71	−72 −126	−120 −207	−170 −390	−220 −440	−380 −600
Over 100 up to 120	+101 +79	+76 +54													−180 −400	−240 −460	−410 −630
Over 120 up to 140	+117 +92	+88 +63	+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	−200 −450	−260 −510	−460 −710
Over 140 up to 160	+125 +100	+90 +65													−210 −460	−280 −530	−520 −770
Over 160 up to 180	+133 +108	+93 +68													−230 −480	−310 −560	−580 −830
Over 180 up to 200	+151 +122	+106 +77	+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	−240 −530	−340 −630	−660 −950
Over 200 up to 225	+159 +130	+109 +80													−260 −550	−380 −670	−740 −1030
Over 225 up to 250	+169 +140	+113 +84													−280 −570	−420 −710	−820 −1110
Over 250 up to 280	+190 +158	+126 +94	+88 +56	+66 +34	+36 +4	+16 −16	0 −32	0 −52	0 −130	0 −320	−17 −49	−56 −108	−110 −191	−190 −320	−300 −620	−480 −800	−920 −1240
Over 280 up to 315	+202 +170	+130 +98													−330 −650	−540 −860	−1050 −1370
Over 315 up to 355	+226 +190	+144 +108	+98 +62	+73 +37	+40 +4	+18 −18	0 −36	0 −57	0 −140	0 −360	−18 −54	−62 −119	−125 −214	−210 −350	−360 −720	−600 −960	−1200 −1560
Over 355 up to 400	+244 +208	+150 +114													−400 −760	−680 −1040	−1350 −1710
Over 400 up to 450	+272 +232	+166 +126	+108 +68	+80 +40	+45 +5	+20 −20	0 −40	0 −63	0 −155	0 −400	−20 −60	−68 −131	−135 −232	−230 −385	−440 −840	−760 −1160	−1500 −1900
Over 450 up to 500	+292 +252	+172 +132													−480 −880	−840 −1240	−1650 −2050

NOMINAL SIZE RANGE mm	S7	R7	P7	N7	K7	JS7	H7	H8	H9	H11	G7	F8	E9	D10	C11	B11	A11
From 1 up to 3	−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	−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	−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	−21 −39	−16 −34	−11 −29	−5 −23	+6 −12	+9 −9	+18 0	+27 0	+43 0	+110 0	+24 +6	+43 +16	+75 +32	+120 +50	+205 +95	+260 +150	+400 +290
Over 14 up to 18																	
Over 18 up to 24	−27 −48	−20 −41	−14 −35	−7 −28	+6 −15	+10.5 −10.5	+21 0	+33 0	+52 0	+130 0	+28 +7	+53 +20	+92 +40	+149 +65	+240 +110	+290 +160	+430 +300
Over 24 up to 30																	
Over 30 up to 40	−34 −59	−25 −50	−17 −42	−8 −33	+7 −18	+12.5 −12.5	+25 0	+39 0	+62 0	+160 0	+34 +9	+64 +25	+112 +50	+180 +80	+280 +120	+330 +170	+470 +310
Over 40 up to 50															+290 +130	+340 +180	+480 +320
Over 50 up to 65	−42 −72	−30 −60	−21 −51	−9 −39	+9 −21	+15 −15	+30 0	+46 0	+74 0	+190 0	+40 +10	+76 +30	+134 +60	+220 +100	+330 +140	+380 +190	+530 +340
Over 65 up to 80	−48 −78	−32 −62													+340 +150	+390 +200	+550 +360
Over 80 up to 100	−58 −93	−38 −73	−24 −59	−10 −45	+10 −25	+17.5 −17.5	+35 0	+54 0	+87 0	+220 0	+47 +12	+90 +36	+159 +72	+260 +120	+390 +170	+440 +220	+600 +380
Over 100 up to 120	−66 −101	−41 −76													+400 +180	+460 +240	+630 +410
Over 120 up to 140	−77 −117	−48 −88	−28 −68	−12 −52	+12 −28	+20 −20	+40 0	+63 0	+100 0	+250 0	+54 +14	+106 +43	+185 +85	+305 +145	+450 +200	+510 +260	+710 +460
Over 140 up to 160	−85 −125	−50 −90													+460 +210	+530 +280	+770 +520
Over 160 up to 180	−93 −133	−53 −93													+480 +230	+560 +310	+830 +580
Over 180 up to 200	−105 −151	−60 −106	−33 −79	−14 −60	+13 −33	+23 −23	+46 0	+72 0	+115 0	+290 0	+61 +15	+122 +50	+215 +100	+355 +170	+530 +240	+630 +340	+950 +660
Over 200 up to 225	−113 −159	−63 −109													+550 +260	+670 +380	+1030 +740
Over 225 up to 250	−123 −169	−67 −113													+570 +280	+710 +420	+1110 +820
Over 250 up to 280	−138 −190	−74 −126	−36 −88	−14 −66	+16 −36	+26 −26	+52 0	+81 0	+130 0	+320 0	+69 +17	+137 +56	+240 +110	+400 +190	+620 +300	+800 +480	+1240 +920
Over 280 up to 315	−150 −202	−78 −130													+650 +330	+860 +540	+1370 +1050
Over 315 up to 355	−169 −226	−87 −144	−41 −98	−16 −73	+17 −40	+28.5 −28.5	+57 0	+89 0	+140 0	+360 0	+75 +18	+151 +62	+265 +125	+440 +210	+720 +360	+960 +600	+1500 +1200
Over 355 up to 400	−187 −244	−93 −150													+760 +400	+1040 +680	+1710 +1350
Over 400 up to 450	−209 −272	−103 −166	−45 −108	−17 −80	+18 −45	+31.5 −31.5	+63 0	+97 0	+155 0	+400 0	+83 +20	+165 +68	+290 +135	+480 +230	+840 +440	+1160 +760	+1900 +1500
Over 450 up to 500	−229 −292	−109 −172													+880 +480	+1240 +840	+2050 +1650

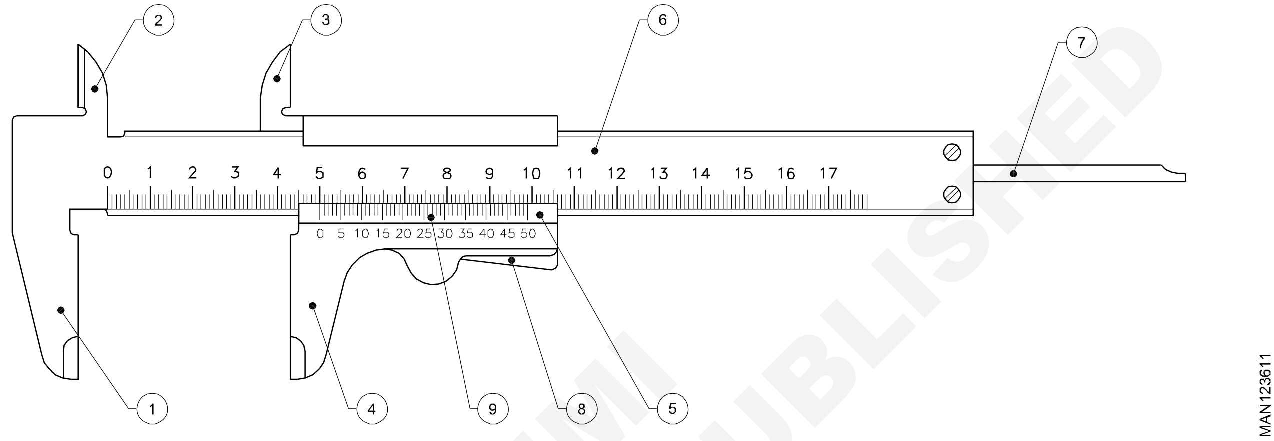
Vernier calipers

Objectives: At the end of this lesson you shall be able to
- **explain the parts of a vernier caliper**
- **state the constructional features of a vernier caliper**
- **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.

Fig 2

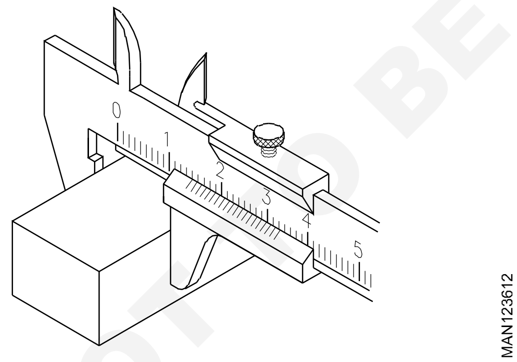
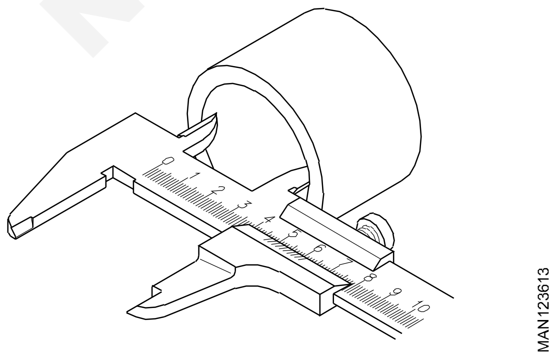


Fig 3



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)

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)

The depth bar is attached to the vernier slide and is used for measurement of depth.

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 graduated and 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, 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
- **explain the least count of a vernier caliper**
- **state how graduations are made on a vernier caliper with 0.02 mm least count**
- **expalin how to 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 size of the job to be measured.

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

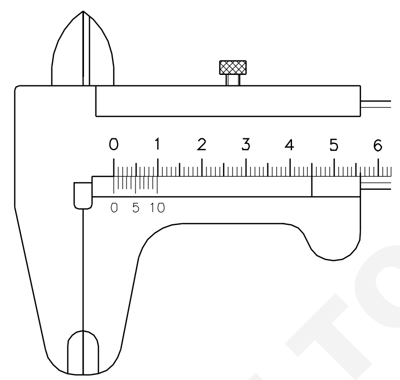
Vernier Principle

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) = 1mm

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

Least count = 1 MSD – 1 VSD

= 1 mm – 9/10 mm = 0.1 mm.

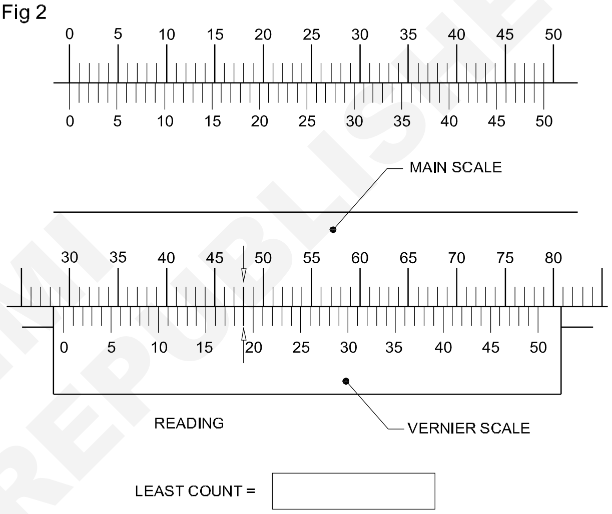
The difference between one

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.

Fig 2



Example

Calculate the least count of the vernier given in Figure 3.

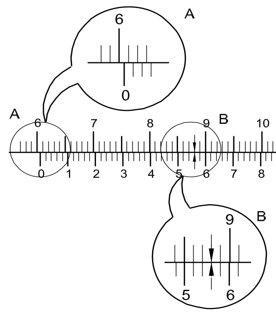
Least count = 1 mm – 49/50 mm

= 1/50 mm

= 0.02 mm.

Example for reading vernier caliper (Fig 3)

Fig 3



Main scale reading = 60 mm

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

= 0.56 mm

Reading = 60 + 0.56 = 60.56 mm.

Outside micrometer

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

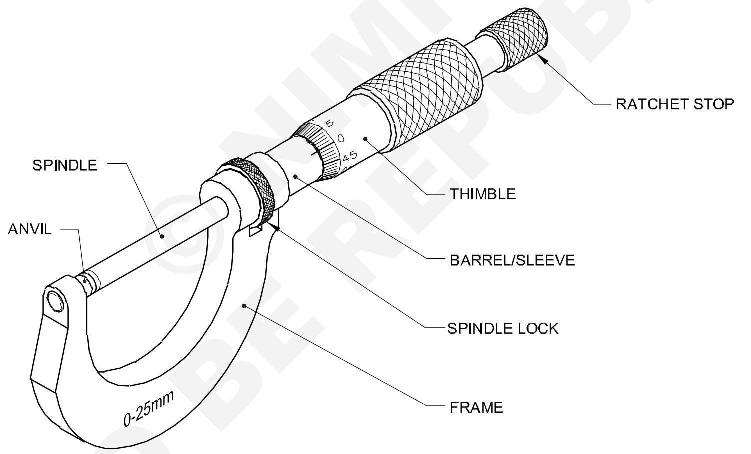
Spindle lock-nut

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**
- **explain 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.

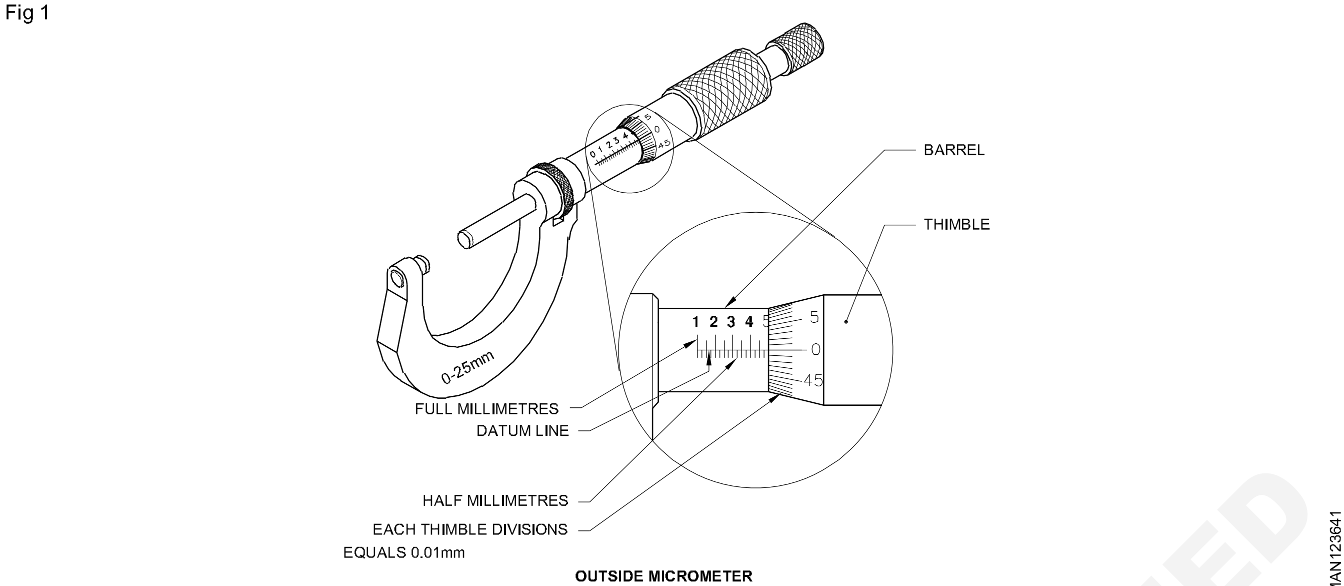
Thereby, in one rotation of the thimble, the spindle advances by 0.5 mm.

On the barrel a 25 mm long datum line is marked. This line is further graduated to millimetres and half millimeters (ie., 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 of the thimble = 0.5 x 1/50 = 0.01 mm.

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

Fig 1



OUTSIDE MICROMETER

Reading dimensions with outside micrometers

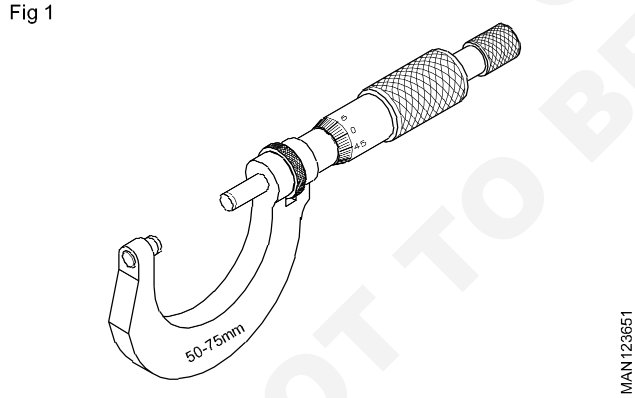
Objectives: At the end of this lesson you shall be able to
- **state the required range of a micrometer**
- **explain how micrometer measurements are taken.**

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 graduation marked on the barrel is only 0-25 mm. (Fig 1)

Fig 1



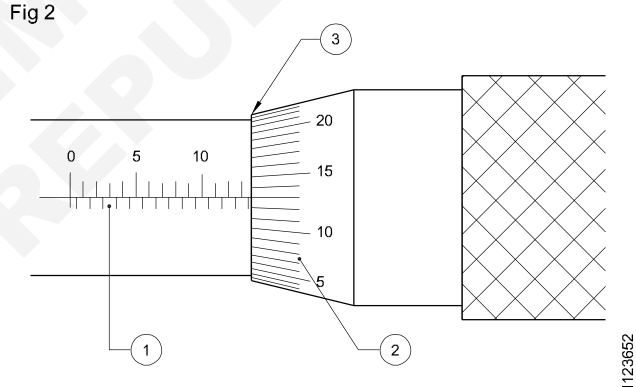
Reading micrometer measurements

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.

Fig 2



1.BARREL GRADUATIONS 2.THIMBLE GRADUATIONS

13.00 mm
+ 00.50 mm
13.50 mm

Next read the thimble graduations.

Read the thimble graduations in line with the barrel datum line, 13th div. (Fig 3)

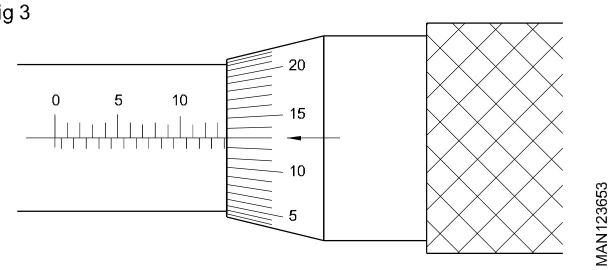
Multiply this value with 0.01 mm (least count). 13 x 0.01 mm = 0.13 mm)

Add

Minimum range	50.00 mm
Barrel reading	13.50 mm
Thimble reading	00.13 mm
Total	63.63 mm

The micrometer reading is 63.63 mm.

Fig 3



Vernier micrometer graduation and reading

Objectives: At the end of this lesson you shall be able to
- **state the graduations of a vernier micrometer (metric)**
- **state vernier micrometer.**

Vernier micrometer

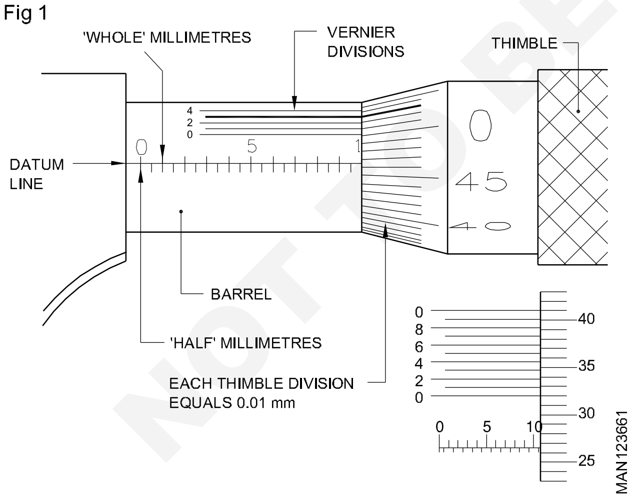
Ordinary metric micrometers can measure only to an accuracy of ±.01mm.

For taking more accurate measurements, vernier micrometers are useful. Vernier micrometers can measure to an accuracy of ±.001 mm.

Construction and graduation

Vernier micrometers are very similar to the ordinary micrometers in construction. The difference is in the graduation. These micrometers have additional, equally spaced graduations (vernier graduations) given above the datum line. There are ten such vernier graduation lines marked parallel above the datum line. (Fig 1) The space between these 10 lines is equal to 9 divisions in the thimble. (Fig 1)

Fig 1



The value of 10 vernier divisions is

0.0 1 mm X 9 = 0.09 mm

The value of a vernier division

$$= \frac{0.09mm}{10} = 0.009 \text{ mm.}$$

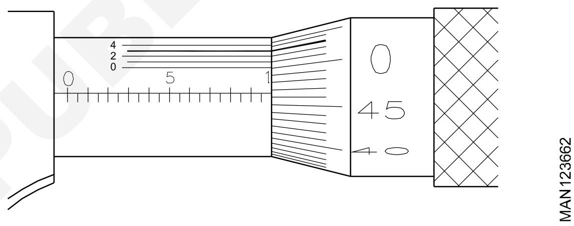
The least count =

1 thimble division – 1 Vernier division

0.01 – 0.009mm = 0.001 mm or 1/1000 mm.

Reading a vernier micrometer (Fig 2)

Fig 2



Example

After measuring, read the full mm divisions visible on the barrel.

9 full divisions	9 mm

Note the half divisions, if any, visible on the barrel.

1 half division	0.5 mm

Read the thimble divisions below the datum line. (Fig 2)

46 divisions	0.46 mm

Note the vernier division coinciding with the thimble division.

3 divisions	0.003 mm

Add up all the readings together.

Calculation

The range of micrometer is 0 to 25 mm.

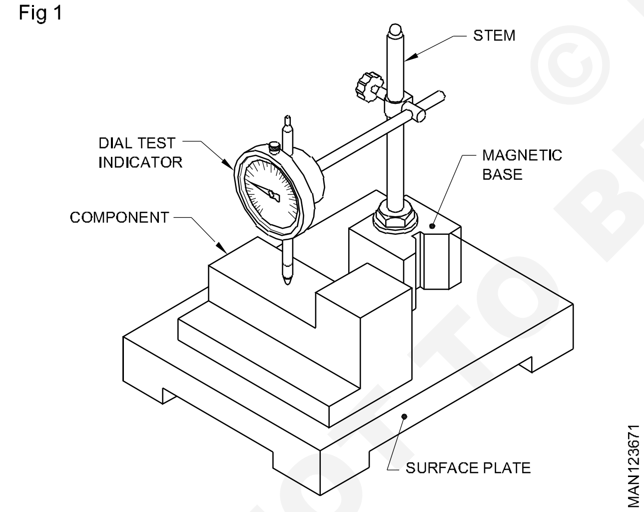
1	Full mm division visible before the thimble edge	9	=	9.000 mm
2	Half mm division visible after the full mm division on thimble	1	=	0.500 mm
3	Thimble division below the index line	46	=	0.460 mm
4	Vernier division coinciding with thimble division	3	=	0.003 mm
	Reading			9.963 mm

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

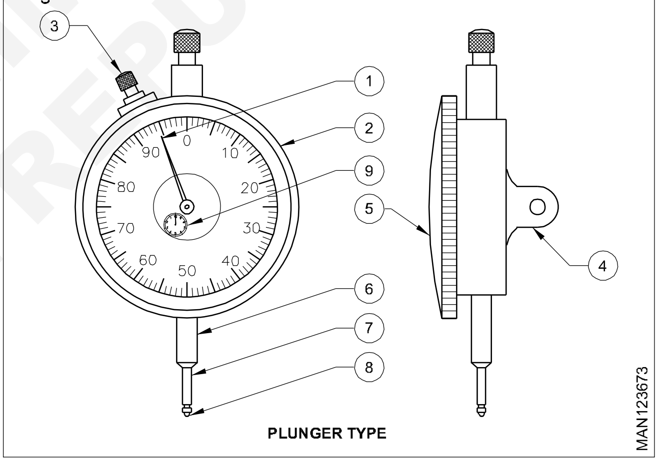
Two types of dial test indicators are in use according to the method of magnification. They are

- plunger type (Fig 3)
- 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.

Fig 3



1	Pointer	2	Rotatable bezel
3	Bezel clamp	4	Back lug
5	Transparent dial cover	6	Stem
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.

Fig 2

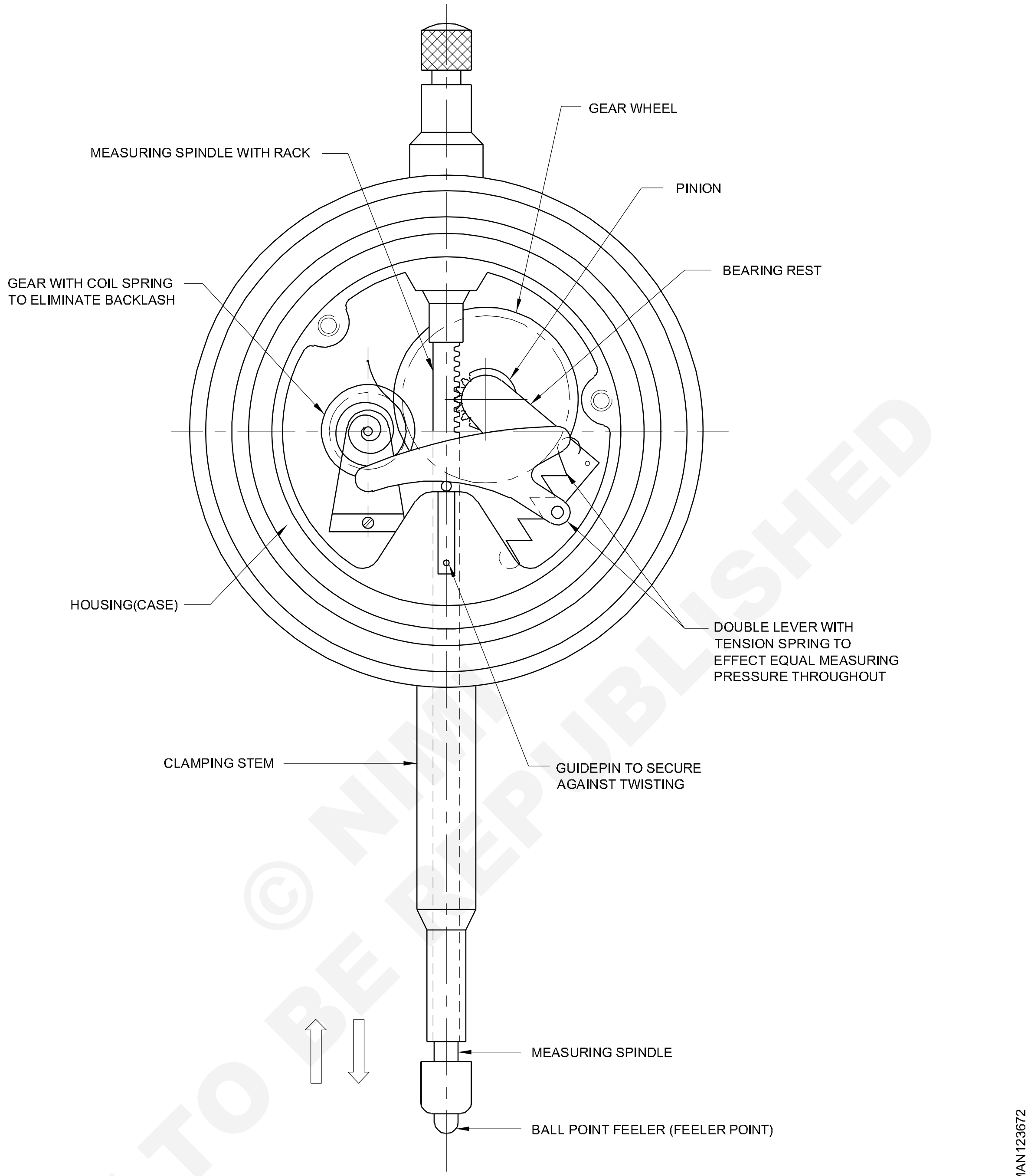
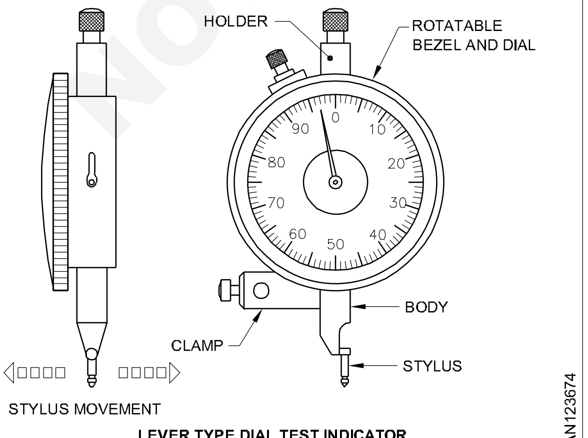
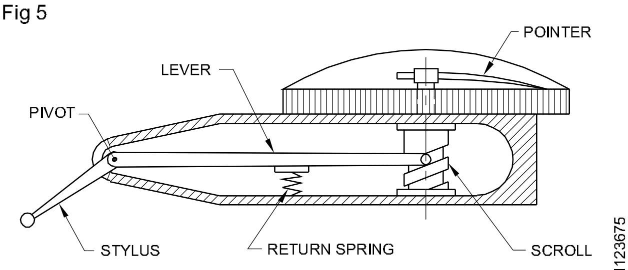


Fig 4



LEVER TYPE DIAL TEST INDICATOR

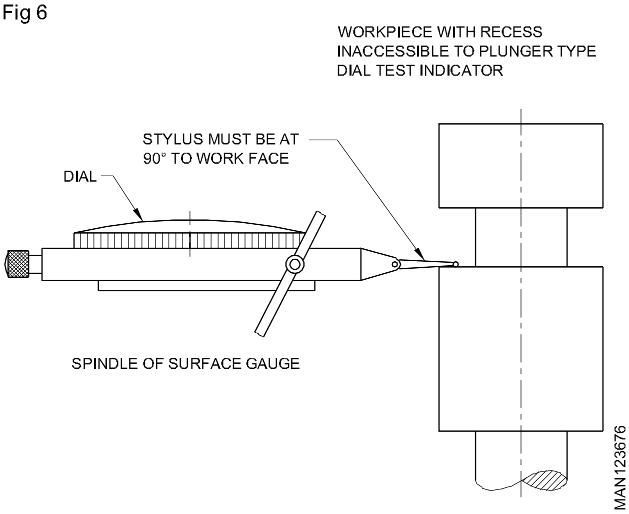
Fig 5



MECHANISM OF THE LEVER TYPE DIAL TEST INDICATOR

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 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
- 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 7

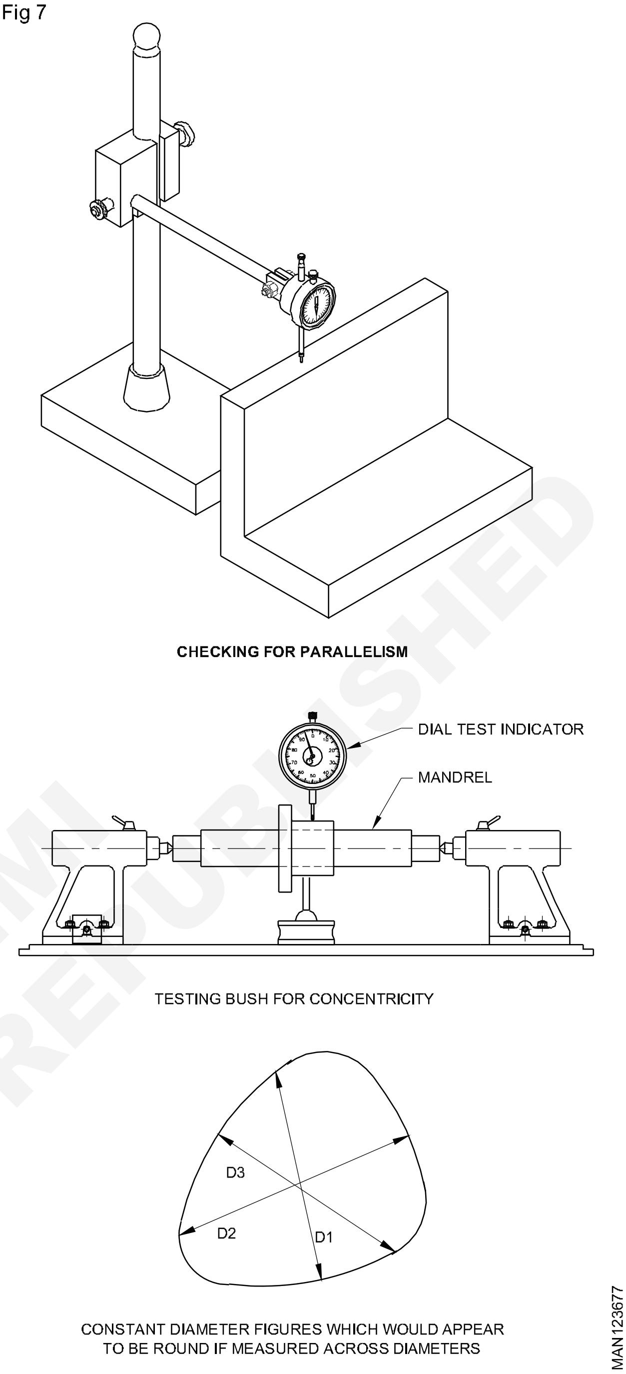


Fig 8

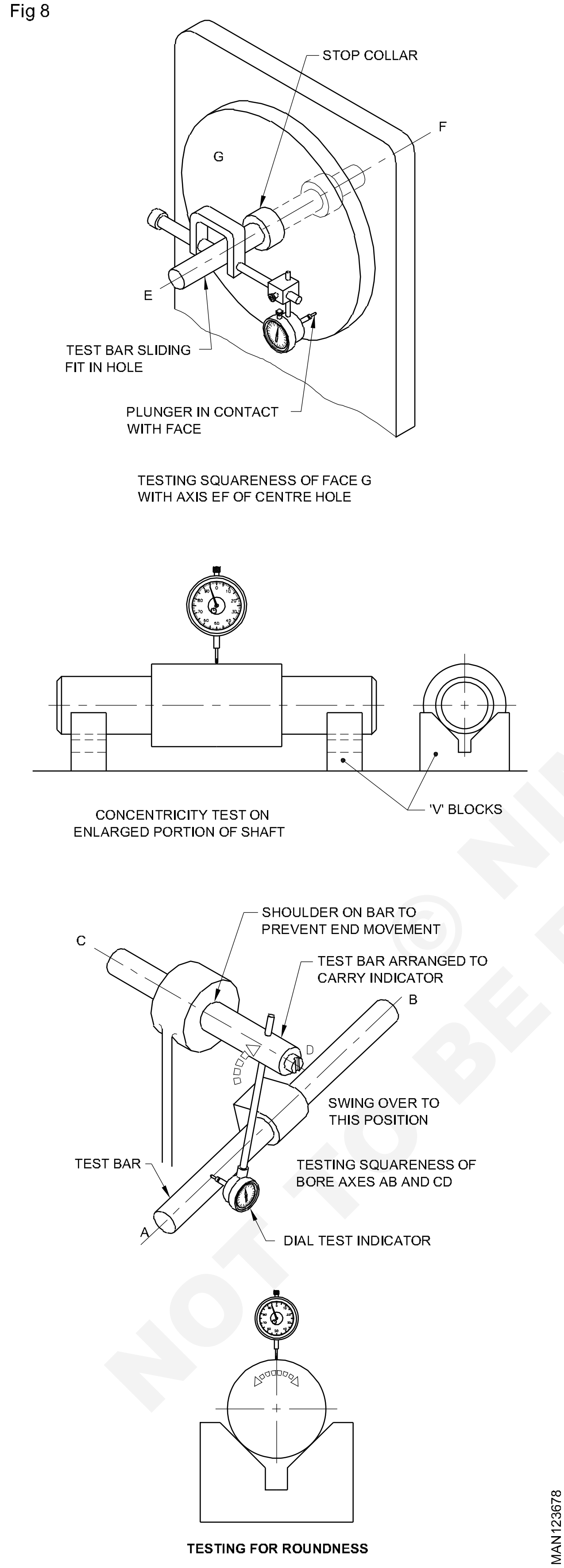
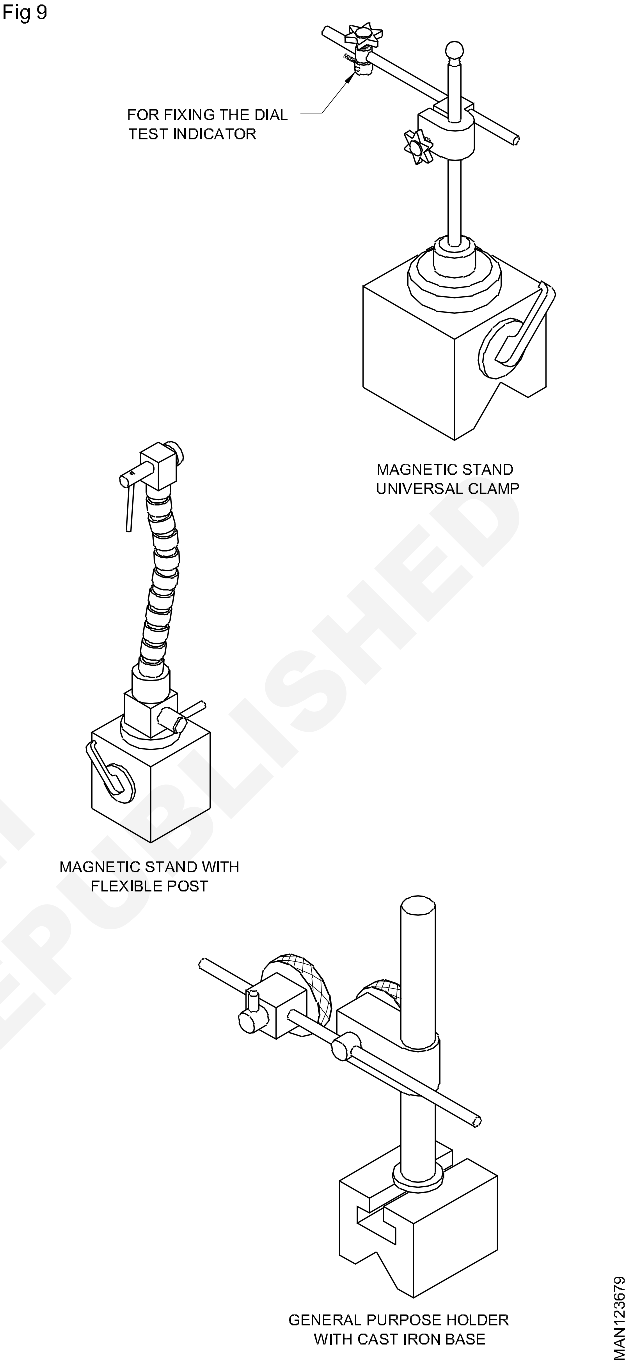

STOP COLLAR
F
G
E
TEST BAR SLIDING FIT IN HOLE
PLUNGER IN CONTACT WITH FACE
TESTING SQUARENESS OF FACE G WITH AXIS EF OF CENTRE HOLE
CONCENTRICITY TEST ON ENLARGED PORTION OF SHAFT
'V' BLOCKS
SHOULDER ON BAR TO PREVENT END MOVEMENT
C
TEST BAR ARRANGED TO CARRY INDICATOR
B
D
SWING OVER TO THIS POSITION
TEST BAR
TESTING SQUARENESS OF BORE AXES AB AND CD
A
DIAL TEST INDICATOR
TESTING FOR ROUNDNESS
MAN123678

Fig 9


FOR FIXING THE DIAL TEST INDICATOR
MAGNETIC STAND UNIVERSAL CLAMP
MAGNETIC STAND WITH FLEXIBLE POST
GENERAL PURPOSE HOLDER WITH CAST IRON BASE
MAN123679

Lathe and its parts

Objectives: At the end of this lesson you shall be able to
- **state the main parts of the lathe**
- **state the lever positions**
- **state the various lubrication points.**

Turning and centre lathe

Turning is a machining process to bring the raw material to the required shape and size by metal removal. This is done by feeding a cutting tool against the direction of rotation of the work.

The machine tool on which the job is made to rotate and turning is carried out is known as a lathe.

Constructional features of a lathe

A lathe should have provision:

- to hold the cutting tool, and feed it against the direction of rotation
- to have parts, fixed and sliding, to get a relative movement of the cutting tool with respect to the rotation of the work
- to have accessories and attachments for performing different operations.

Various Lubrication Points

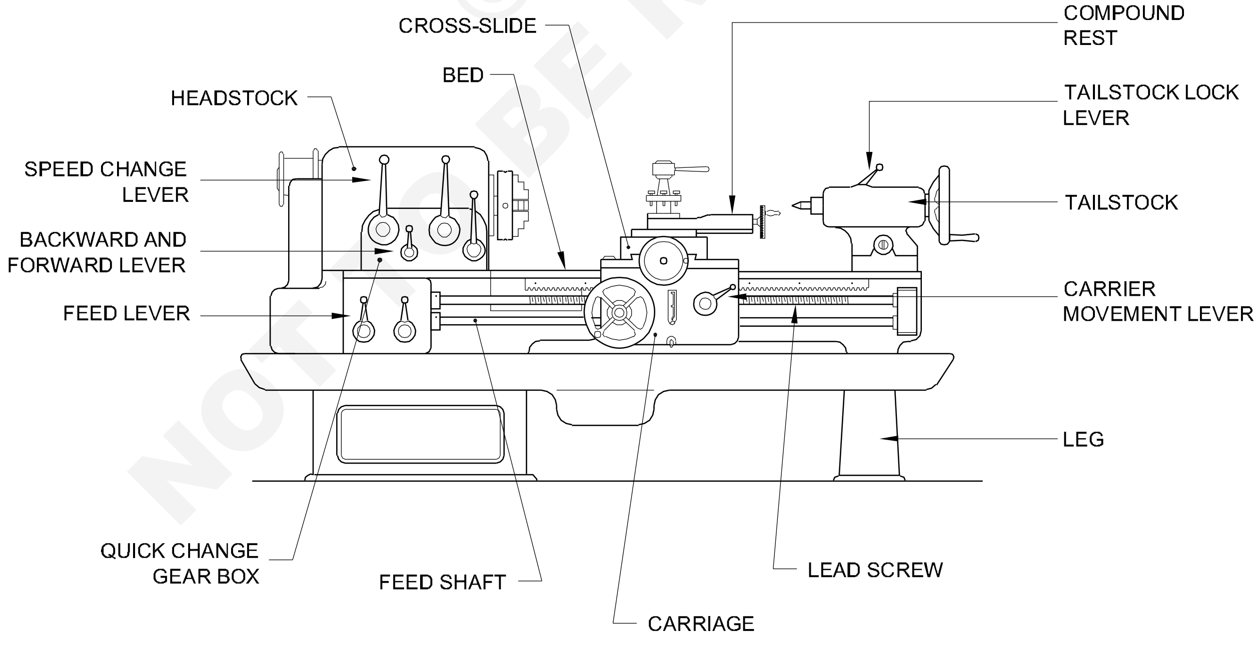
1 Place a few drops of oil on the rockershaft bearing and cams every time the lathe is in use.

2 Countershaft roller bearing - Fill both grease cups with automotive cup grease every two weeks. Give the grease cup caps a turn or so every time the lathe is used.

3 Place a few drops of oil on the rockershaft lever bearings and lever fulcrum bearing every time lathe is used.

4 Motor bearings - sleeve type motors have two oil cups which should be filled once a week with S.A.E. No. 10. Motor oil or equivalent. Ball bearing motors have a sealed in - type bearing - every six months the small headless screw in these bearings should be removed and a moderate quantity of automotive cup grease forced around the bearing.

Fig 1



CENTRE LATHE - MAJOR PARTS & LEVER POSITIONS

5 Left and right headstock bearings - oil with No.10 motor oil or equivalent every time the lathe is used.

6 Spindle pulley - every time the lathe is used in back gear, remove the small screw in the bottom of the second step of the idler pulley and oil freely with No. 10 motor oil or equivalent. Replace screw.

7 Back gear spindle - every time the back gears are used, remove the small screw in the centre of the back gear

spindle and oil freely with No 10 motor oil or equivalent. Replace screw.

8 Back gears and change gears - A small amount of keystone No. 122 heavy outer gear lubricant or equivalent applied to the gear teeth will aid in obtaining smoother, more quiet operation. Be sure to remove all oil in the gear teeth before applying this lubricant or it will not adhere.

9 Change gear bearings - put a few drops No.10 motor oil or equivalent on the change gear bearings each time the lathe is used.

10 Lead screw stub bearing and reversing gears - put a few drops of No. 10 motor oil or equivalent in the three oil holes on the top of the reversing gear box every time the lathe is used.

11 Carriage traverse gear case - every time the lathe is in use, put a few drops of No 10 motor oil in oil hole on top of gear case on back of carriage apron.

12 Carriage hand wheel bearing - put a few drops of No 10 motor oil or equivalent in the ball spring oil hole every time the lathe is used.

13 Cross feed gear bearing - put a few drops of oil in the ball spring oil hole every time lathe is used.

14 Half - nut lever bearing - put a few drops of No. 10 motor oil or equivalent in the ball spring oil hole every time the lathe is used.

15 Thread dial-once a week put a few drops of No.10 motor oil or equivalent around the rim of the top of the thread dial.

16 Wipers (front and back) - saturate the felts in the four wipers, located on the carriage with oil every time the lathe is used.

17 Cross slide screw - Put a few drops of No. 10 motor oil or equivalent in the oil hole above the front cross slide screw bearing after removing the small screw. Replace the screw. This should be done every time the lathe is used. Clean the cross slide screw regularly with a small stiff brush. Oil the screw threads by running the compound rest back and forth.

18 Cross feed gears - put a few drops of oil in the oil hole above the cross feed screw after removing the small screw. Replace the screw. This should be done every time the lathe is used.

19 Cross slide ways - clean regularly and apply a liberal quantity of No. 10 motor oil or equivalent to the ways whenever the lathe is used.

20 Compound slide screw - every time the lathe is used put a few drops of No. 10 motor oil or equivalent in the oil hole on top of compound rest and above the compound screw bearing.

21 Compound slide ways - clean regularly and apply a liberal quantity of No. 10 motor oil or equivalent to the ways whenever the lathe is used.

22 Lead screw - about once a month clean the lead screw threads with kerosene and a small stiff brush and apply a small amount of No. 10 motor oil or equivalent.

23 Rack (on bed, under front way) - about once a month apply a small amount of cup grease to the rack after cleaning with kerosene and a small stiff brush.

24 Lead screw bearing (right end of lathe) - put a few drops of No. 10 motor oil or equivalent in the oil hole on top of the bearing every time the lathe is used.

25 Place a few drops of oil between the handwheel and screw bearing when ever using lathe.

26 Tailstock centre lubricant - fill the small cup on the tailstock with a mixture of white lead and oil and apply to the tailstock center whenever turning between centres. If white lead is not available, used a liberal amount of cup grease on the center.

27 Tailstock ram - keep the outside surface of the tailstock ram well oiled.

28 Lathe bed ways - keep the bed ways oiled at all times with No. 10 motor oil or equivalent and free from chips. Wipe off the ways before using and cover with fresh oil. Always leave a generous film of oil on the ways when the lathe is not in use. The lathe should be completely covered when not in use. During all grinding operations cover bed ways with canvas or cardboard.

Keep all the lathe bearing surfaces perfectly clean. Dirt is the natural enemy to accurate lathe work.

Definition of machine and machine tool

Objectives: At the end of this lesson you shall be able to
- **explain difference between machine and machine tool**
- **state the history & gradual development of lathe.**

Definition of machine

Machine is a device that performs a related operation to produce desired product. It can be stitching of cloth by a sewing machine, producing a component in a forging machine, or it can be a main production by using a CNC machine technology

A machine tool is defined as a power driven machine capable of holding / supporting the work & tool at sametime, directing / guiding the cutting tool or job or both to perform various metal cutting operations for producing various shapes & sizes

Fundamental of machine tools

Machine tool is a device that utilizes electric energy for shaping and sizing a product by removing excess material in the form of chips, with the help of cutting tool.

Machine tools are used for producing components at a rapid rate. Optimum productivity from machine tool calls for a fairly high degree of skill. Properly carried out operations are capable of producing a large number of components at a fairly rapid rate.

Machine tools and machines are two different things. machine tools when taken as a group can produce a machine tool, which is not true of machines.

Lathe, milling machine, shaping machine, slotter etc., are all machine tools.

Every metal working machine cannot be called a machine tool merely because it removes material. Forging hammers, drawing dies, extruders, rolling machine etc., are not machine tools.

Functions of machine tools

1 To hold and support the workpiece to be machined.

2 To hold and support the cutting tool.

3 To provide requisite motion to the workpiece / tool or both.

4 To regulate the cutting speed and feed of the tool and workpiece.

5 To hold various attachments for different operations. Jobs and tools are held in properly designed devices on a machine tool. Different machine tools are provided with different holding devices.

In a workshop, a machine tool is generally used for producing different shapes and for finishing the surfaces.

Classification of machine tools

1 According to the type of the surface generated.

   i) Cylindrical work machine tools - Lathes, capstan,turret etc.,

   ii) Flat surface machine tools - milling machine, shaping machine planing machine etc.,

2 Classification based on the purpose of the machine tool.

   i) Single - purpose

   ii) Multi purpose

   iii) Special purpose

   iv) Transfer machine

   v) Numerically controlled

3 Classification based upon the size of chip

   i) Machine tools using cutting tools - lathe, milling, planner, slitter etc.,

   ii) Machine tools using abrasives - honing, lapping Grinding etc.,

Machine tool performance criteria

While designing a machine tool the following factors need consideration.

1 It should be safe and easy to operate.

2 It should be accurate.

3 It should have good production capacity.

4 The operational cost should be low.

5 Controls should be located at convenient points.

6 Blanks should be such that they can be loaded and clamped easily.

Factors in machinining operations

The operations of removing metal by means of the cutting tool using some sort of machine tool in order to obtain a desired shape is called machining.

It includes number of operations such as turning, boring, shaping, milling etc.,

The selection of a machine tool for a particular operation depends upon many factor such as

1 The shape and size of the product required.

2 The quantity of material to be removed.

3 The type of operation to be performed.

4 The number of components required.

5 The type of material to be handled

6 The degree of accuracy required.

The - longitudinal axis tool holding equipment

Lathe introduction

Lathe is a machine widely used for wood works and machining of metal parts. Lathe is a machine which turns the work piece against a machine tool. The lathe is used for facing, turning, knurling, taper cutting, threading, gear cutting and many other metal and wood works.

History of Lathe

Lathe is a very ancient tool and its first use dates back to 1300 BC in Egypt. Lathe was also known and used in syria and greece. Ancient romans came to know about this machine and they further developed this machine. During the period, the use of this machine had spread to most parts of Europe and it was during the industrial revolution when this machine gained popularity with its use in all the industries. After the development of electronics, automated lathes have been developed.

Evolution of lathe: The first lathe was a simple lathe which is now referred to as two person lathe. One person would turn the wood work piece using rope and the other person would shape the work piece using a sharp tool. This design was improved by ancient romans who added a turning bow which eased the wood work. Later a pedal (as in manual sewing machines) was used for rotating the work piece. This type of lathe is called “spring pole” lathe which was used till the early decades of the 20th century. In 1772, a horse - powered boring machine was installed which was used for making cannons. During the industrial revolution, steam engines and water wheels were attached to the lathe to turn the work piece at higher speed which made the work faster and easier. After 1950, many new designs were made improved the precision of work.

Lathes are classified depending upon their application and functionality.

Light duty lathe - These machine find their application in automobile, electronic, electrical industries and are manufactured from quality tested raw materials.

Medium duty lathe - These machines are powerful than the light duty lathes and can work on bigger work pieces and have more strength than the light duty lathes.

Heavy duty lathe - these machines are manufactured from hightest grades of materials like iron and steel. They are designed for high precision heavy duty operations.

All geared lathe - In all geared lathe, all the rotating components of the machines are driven by the same source at different speeds by using gears to perform various operations.

Imported lathe - imported lathes are high quality lathes used for high precision operations.

Depending upon the modes of operation, the lathe can be classified as

Manual lathe - In these lathes, the tool handling is done manually and so the precision of work also depends upon the skill of the person handling the machine.

CNC lathe - CNC lathes are completely automated lathes. We just have to feed the instructions into the computer and the lathe will perform the operations according to the data fed to the computer.

Introduction to Lathe

Objectives: At the end of this lesson you shall be able to
- **state the different types of lathes and their uses**
- **state the parts and their function**
- **state the method of specifying a centre lathe.**

Types of lathe

1 Speed lathe
   a) Wood working
   b) Centering
   c) Polishing
   d) Spinning
2 Engine lathe (or) centre lathe
   a) Belt drive
   b) Individual motor drive
   c) Gear head lathe
3 Bench lathe
4 Tool room lathe
5 Capstan and turret lathe
6 Special purpose
   a) Wheel lathe
   b) Gap bed lathe
   c) T-lathe
   d) Duplicating lathe
7 Automatic lathe
8 CNC Lathe

Speed lathe

- The speed lathe has been so named because of very high speed of the head stock spindle.
- It consists of head stock, tailstock and tool post mounted on adjustable slide.
- Tool is fed into the work by hand control.
- It has no gear box lead screw and carriage.
- Different speeds are obtained by cone pulley (1200-3600rpm)
- Wood working, spinning, polishing, centering operations can be performed.

Engine lathe (or) centre lathe

- The term engine is because of that early lathes were driven by steam engine.
- It consists of basic parts like bed, head-stock and tail stock but head-stock is more robust and has additional drive mechanism for multiple speeds.
- Engine lathe can feed cutting tool both in cross and longitudinal directions with the help of carriage, feed rod, and leadscrew.
- Belt drive lathe gets power from an overhead line shaft equipped with speed cone and one or more back gears.
- Individual motor driven lathe gets power from individual motor.
- A geared head lathe gets its power from constant speed motor and all speed changes are obtained by shifting various gears located in the headstock.

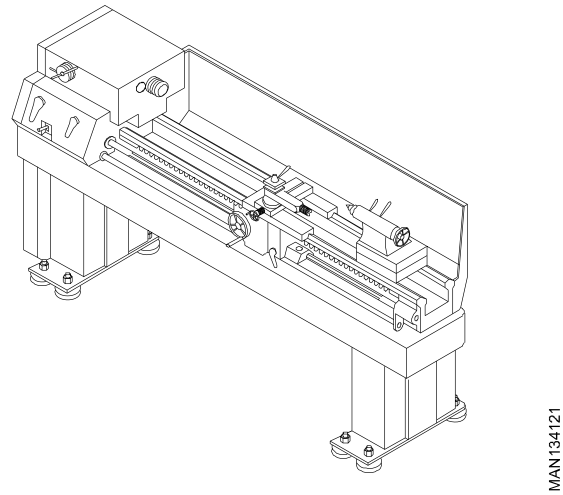
Bench lathe

- It is mounted on bench and has the same features like engine lathe.

Tool room lathe (Fig 1)

- It has the same features like engine lathe and has very low to high speed up to 2500rpm.

Fig 1



- It has taper turning attachment, draw in collet attachment, thread chasing dial, relieving attachment, steady and follower rest, pump for coolant.
- Used for precision work on tools, dies, gauges.

Capstan and turret lathe (Fig 2 & 3)

- Wheel lathe is used for finishing the journal and turning the thread on locomotive wheels.
- The gap bed lathe can accommodate the jobs having extra diameter.

Fig 2

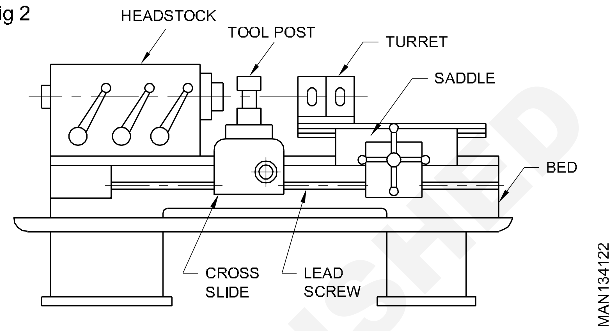
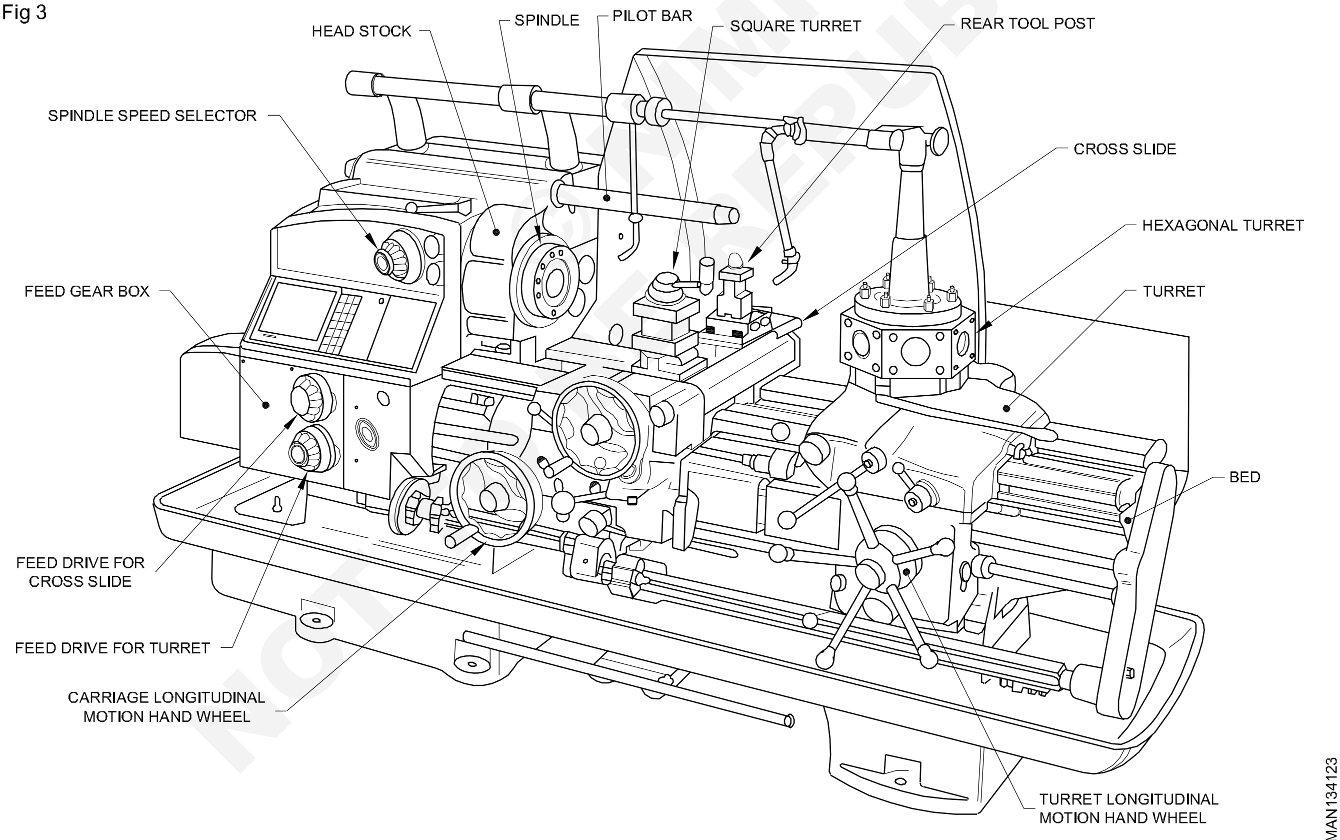


Fig 3



- T- lathe is intended for machining the rotors for jet engines, axis of bed is right angles to the axis of head stock spindle.
- Duplicating lathe is used for duplicating the shape of given template using mechanical or hydraulic system.

Special purpose lathe

- These are high speed, heavy duty, mass production lathes with complete automatic control.
- Once the tools are set and machine is started it performs automatically all the operations to finish at a time.

- Change of tools, speeds and feeds can be done automatically, operator can run 5 to 6 machines at a time.

CNC Lathe (CNC)

- Complex shapes machined easily.
- High production rate.
- Accuracy and repeatability is achieved.
- Less operation skill and involvement.
- Reduced space.

Centre lathe parts

The following are the main parts of a lathe.

Headstock

Tailstock

Carriage

Cross-slide

Compound slide

Bed

Quick change gearbox

Legs

Feed shaft

Lead screw

Head stock

The following are the functions of a headstock. (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.

Tailstock

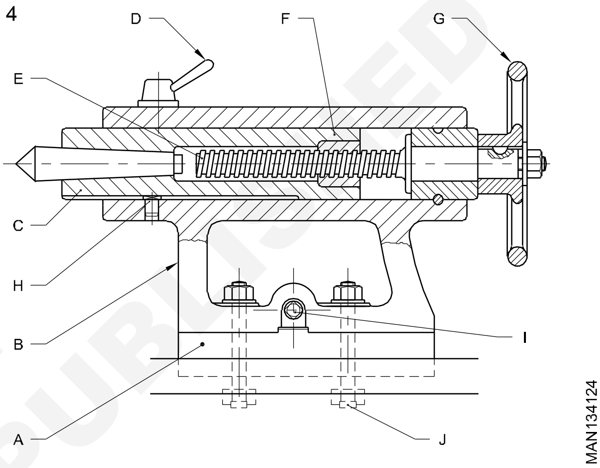
It is a sliding unit on the bed-ways of the lathe bed. It is situated on the right hand side of the lathe. It is made in two parts namely the 'base' and the 'body'. The base bottom is machined accurately and has 'V' grooves corresponding to the bed-ways. It can slide over the bed and can be clamped at 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 4)

- 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)

Fig 4



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**
- **explain the different types of bed-ways**
- **state the advantage of gap beds.**

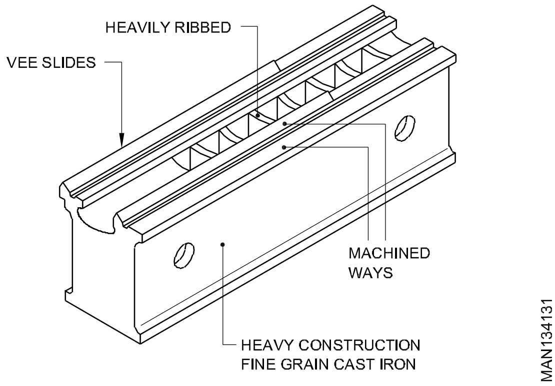
Functions of a lathe bed

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 sward 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)

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)

Fig 2

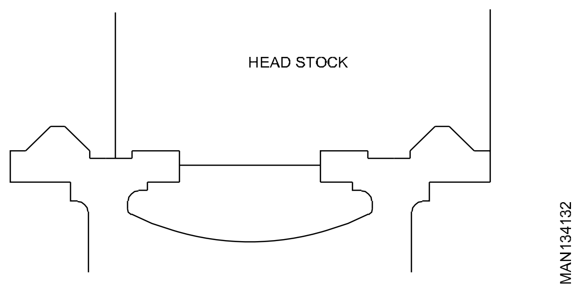


Fig 3

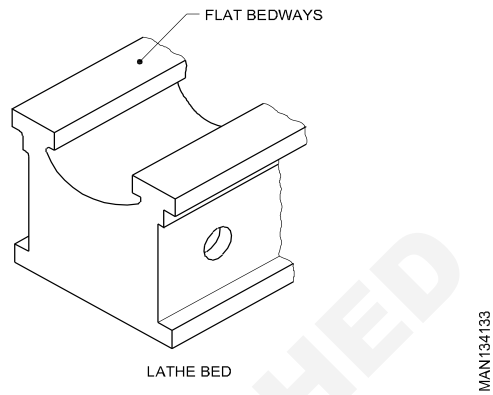
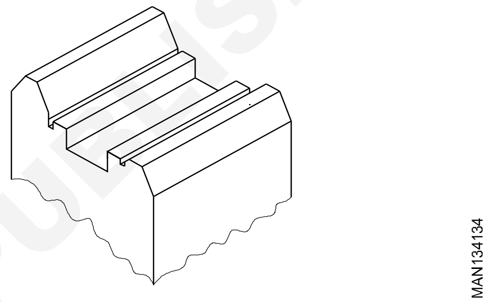


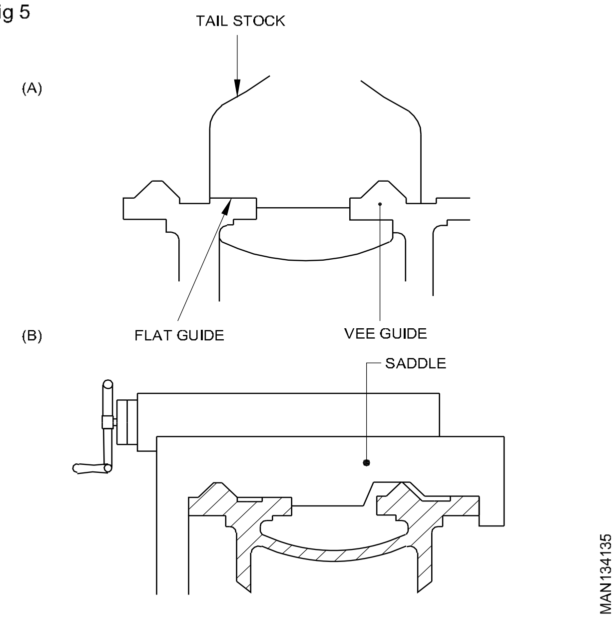
Fig 4



- Combination bed-ways (Fig 5 & 6)

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.

Fig 5

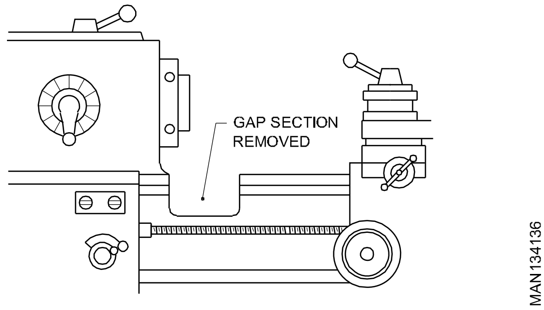


Some lathes have detachable section of the bed, which can be fitted when desired, to enable the saddle to operate close to the headstock. (Fig 6)

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.

Fig 6



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.

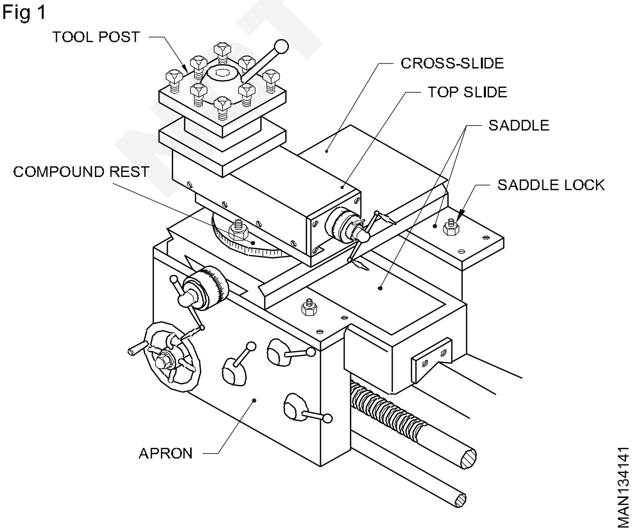
The saddle (Fig 1)

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

Fig 1



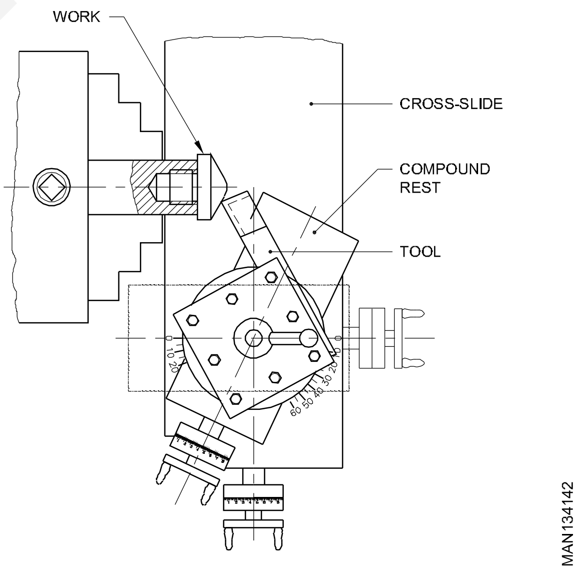
Cross-slide (Figs 1 & 2)

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°.

Fig 2



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.

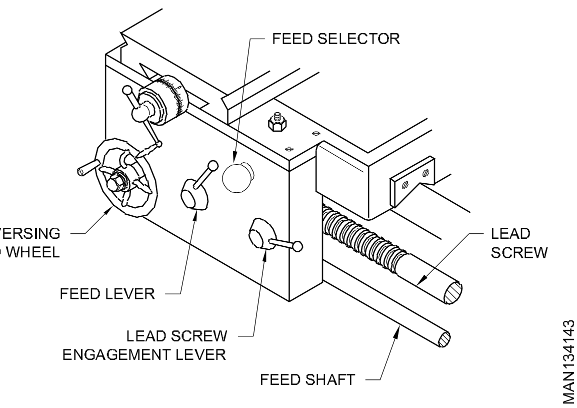
By swivelling the compound rest the top slide may be set to a desired angle to the cross-slide and fed at that angle, and turn tapers.

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.

Fig 3



Lead screw (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
- **explain the commonly used types of tool posts**
- **state 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)

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)

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.

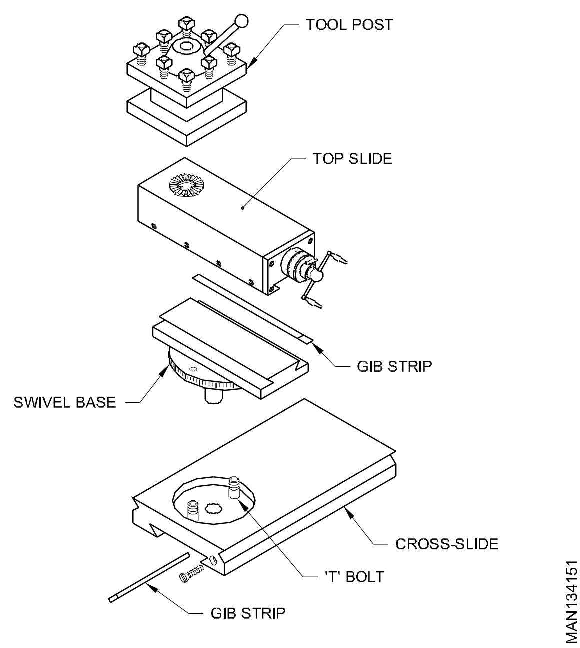
Indexing type tool post (Fig 3)

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.

Fig 1



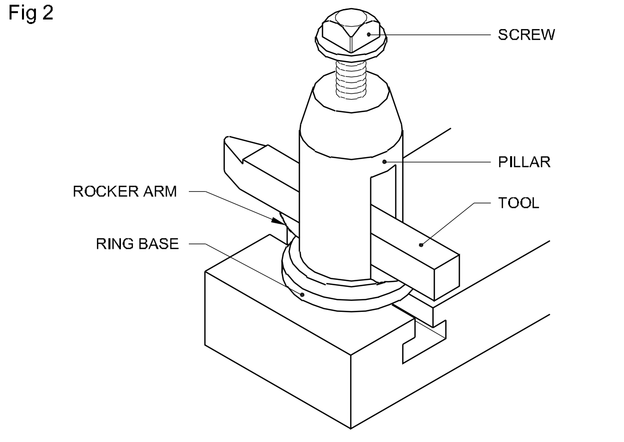


Fig 2

AMERICAN (PILLAR) TYPE TOOL POST

Frequent changing of the tool for different operations need not be done as all the four tools can be clamped at the same time.

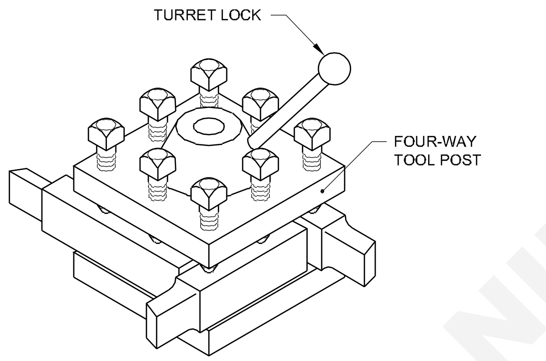


Fig 3

INDEXING TYPE TOOL POST

The disadvantage is that skill is required to set the tools, and it takes more time to set to the centre height.

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.

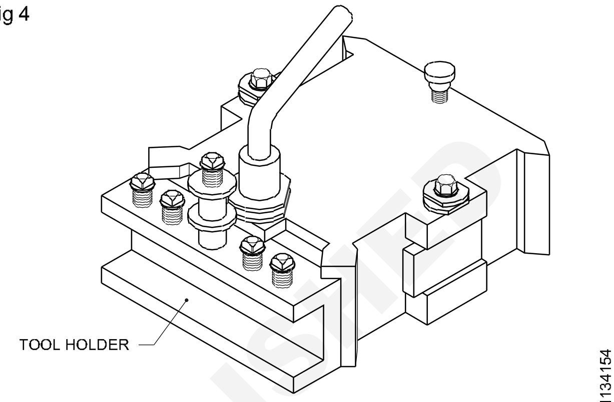


Fig 4

QUICK CHANGE TOOL POST

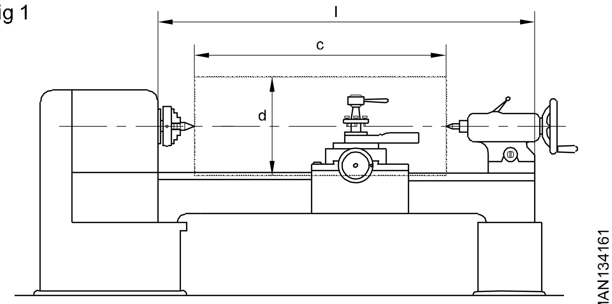
Centre lathe specification

Objective : At the end of this lesson you shall be able to
- **state 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



Safety to be observed while working on a lathe

Objective : At the end of this lesson you shall be able to
- **state the precautions to be observed before starting work on a lathe, during work and after.**

Before starting the work

Ensure that the lubricating system is functioning.

The mating gears should be in proper mesh and the power feed levers are in neutral position.

The work area should be clean and tidy.

The safety guards should be in place.

During work

Never try to stop a rotating chuck with your hand. A rotating chuck is dangerous.

Switch off the machine before making any adjustment on the lathe.

It is dangerous to leave the chuck key in the chuck. Remove it immediately after use. (Fig 1)

Single point tools are sharp and dangerous. Be extra careful when using them.

Chips are sharp and dangerous. Never remove them with your bare hands. Use a chip rake or brush.

You must always know where the emergency stop switch.

Fig 1

After work

Clean the lathe with a brush and wipe with cotton waste.

Oil the bedways and lubricating points.

Clean the surroundings of the lathe, wipe the dirt and coolant and remove the swarf.

Lathe cutting tools

Objectives : At the end of this lesson you shall be able to
- **explain difference between end-cutting and side-cutting tools**
- **state the features of each type**
- **explain the different shapes of cutting tools used for lathe operations**
- **state the characteristics and uses of different shapes of lathe tools.**

Cutting tools - classification

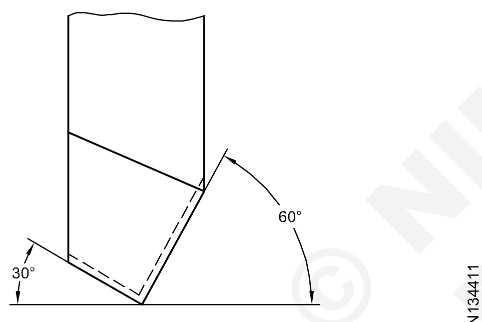
Cutting tools are classified as:

- 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)

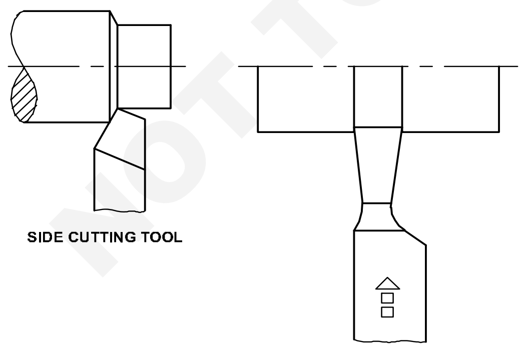
Fig 1



Single point cutting tools used on lathes may be grouped into:

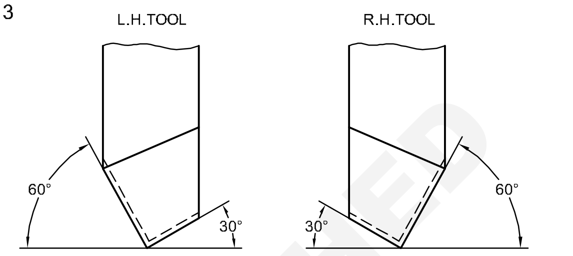
- side-cutting tools
- end-cutting tools. (Fig 2)

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.

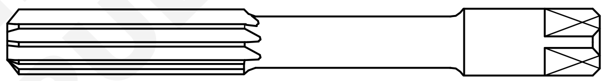
Fig 3



End-cutting tools have their cutting edge at the front end of the tools and are used on lathes for plunge-cut operations.

Multi-point cutting tools (Fig 4)

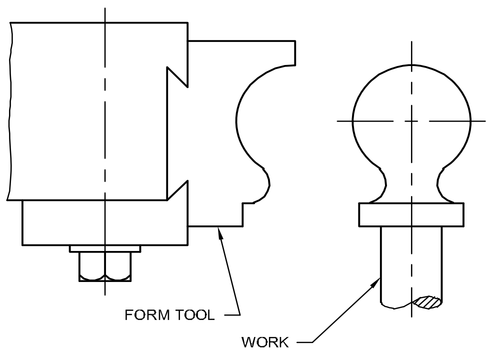
Fig 4



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.

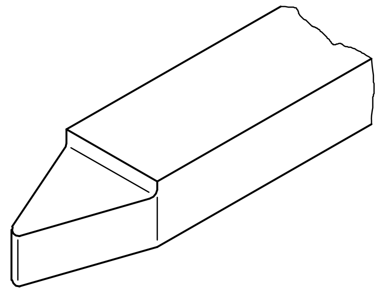
Lathe cutting tool - types

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



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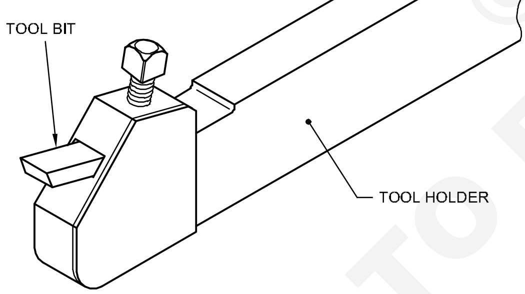
These are tools having their cutting edges ground on solid bits of square, rectangular and round cross-sections. Most of the lathe cutting tools are of the solid type, and high carbon steel and high speed steel tools are used. The length and cross-section of the tool depend upon the capacity of the machine, the type of tool post and the nature of the operation.

Inserted bits with holders (Fig 7)

Fig 7



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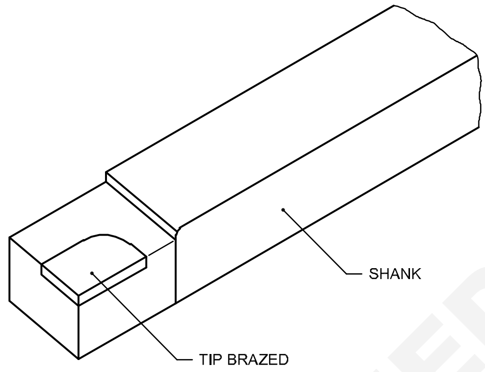
Solid high speed steel tools are costly, hence, sometimes inserted bits are used. These bits are small in size, and are inserted in the holes of the holder. These holders are held and clamped in the tool posts to carry out the operations. The disadvantage in this type of tools is that the rigidity of 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



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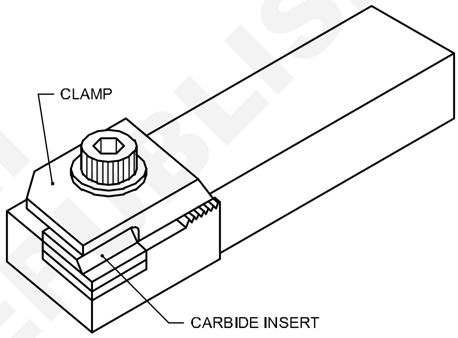
Throw-away type tools (Fig 9)

Fig 9



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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 Figs 10 &11.

Fig 10

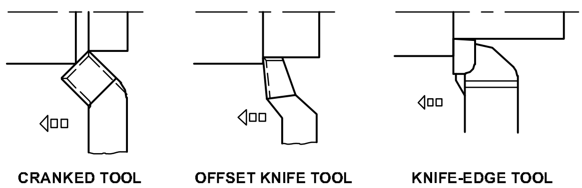

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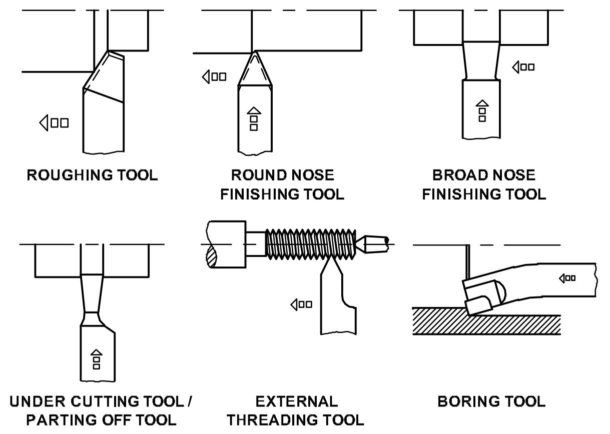
Fig 11

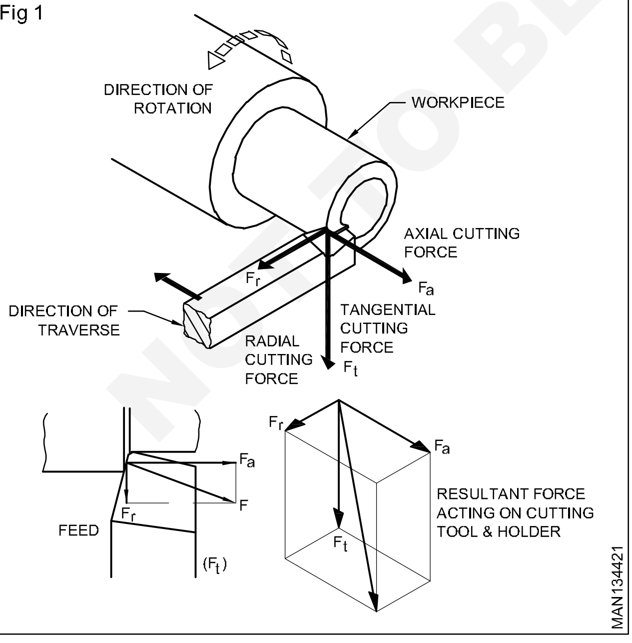


Lathe tools - angles and their functions

Objectives : At the end of this lesson you shall be able to
- **state the angles of a lathe cutting tool**
- **state the characteristics of a rake angle**
- **state the characteristics of a clearance angle**
- **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



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.

Fig 2

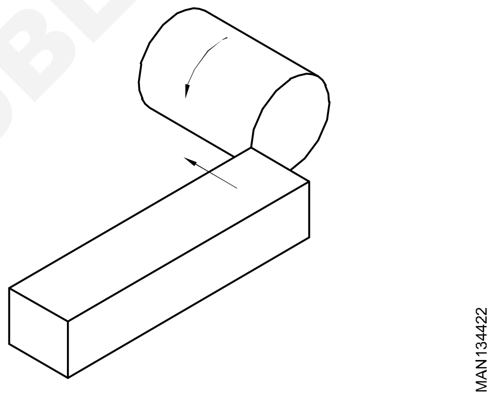


Fig 3

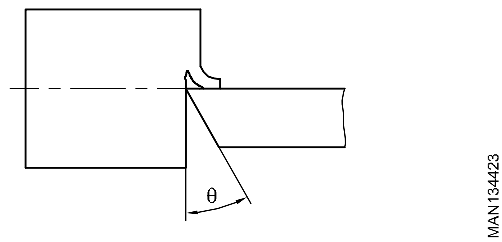
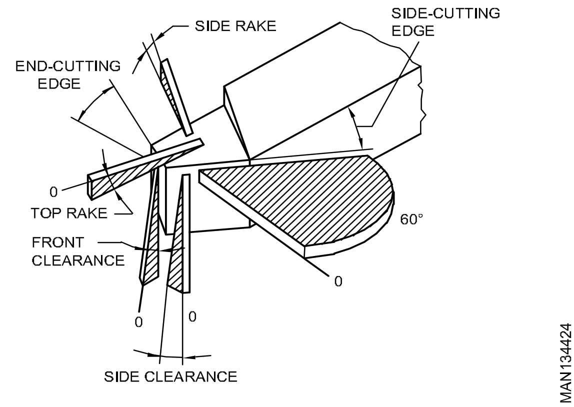


Fig 4



The angles are:

- side cutting edge angle
- end cutting edge angle
- top rake angle
- side rake angle
- front clearance angle
- side clearance angle.

Side cutting edge angle

(Approach angle) (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 5

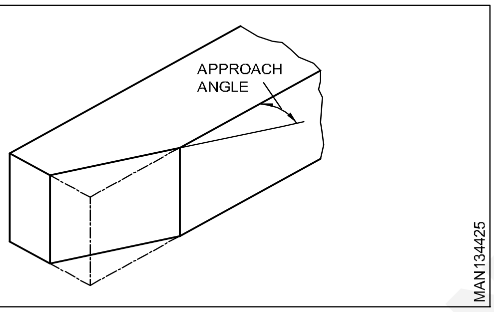
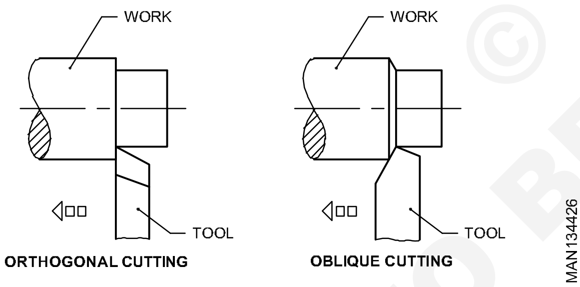
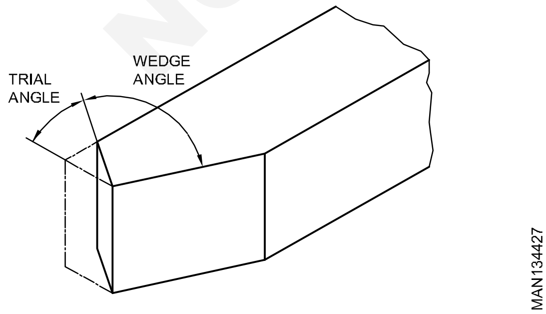


Fig 6



End-cutting edge angle (Trial angle) (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.

Fig 7

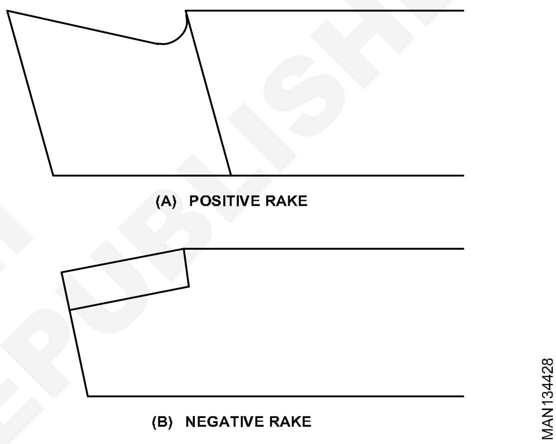


Top or back rake angle (Fig 8**)**: The rake angle ground on a tool controls the geometry of chip formation for any given material. It controls the mechanics of the cutting action of the tool. The top or back rake angle of the tool is ground on the top of the tool, and it is a slope formed between the 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.

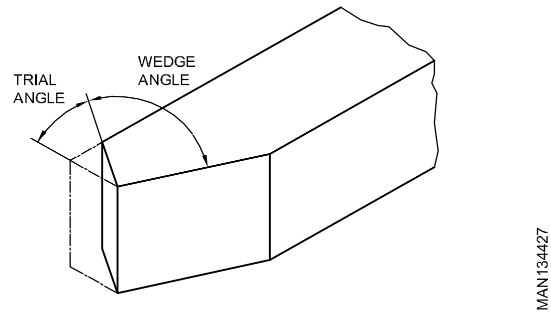
When turning hard metals with a carbide tool it is the usual practice to give a negative top rake. Negative top rake angle tools have more strength than the positive top rake angle tools.

Fig 8



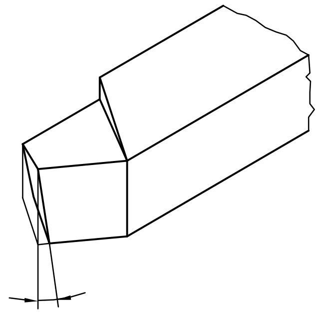
Side rake angle (Fig 9): The side rake angle is the slope between the side of the cutting edge to the top face of the tool widthwise. The slope is from the cutting edge to the rear side of the tool. It varies from 0° to 20° according to the material to be machined. The top and side rakes, ground on a 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.

Fig 7



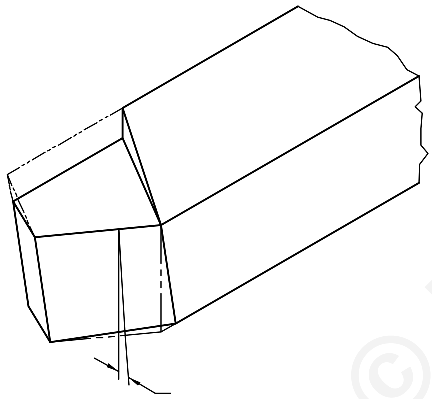
Front clearance angle (Fig 10): **T**his angle is the slope between the front of the cutting edge to a line perpendicular to the axis of the tool drawn downwards. The slope is from the top to the bottom of the tool, and permits only the cutting edge to contact the work, and avoids any rubbing action. If the clearance ground is more, it will weaken the cutting edge.

Fig 10



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.

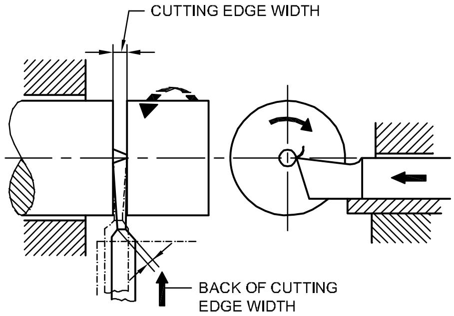
Fig 11



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 indicate the performance of the tool and if any modification is needed for the angles ground on the tool.

Side relief angle (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.

Fig 12

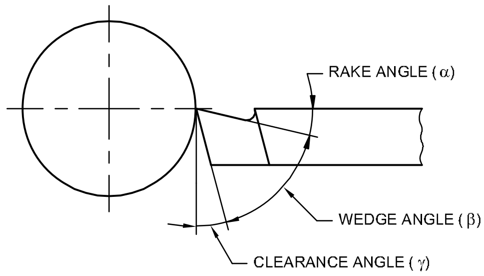


This permits clearance between the sides of the tool and the groove walls formed by the plunging action of the tool, thereby, preventing the tool from getting jammed in the groove and causing breakage. The relief is kept as minimum as possible. Too much of relief will weaken the tool cutting edge, and 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



Types of chips and chip brakes

Objectives: At the end of this lesson you shall be able to
- **state the types of chips**
- **state the function of chip breakers and identify the different types.**

Types of chip: The form and dimension of a chip in metal machining indicate the nature and quality of a particular machining process, but the type of chip formed is greatly influenced by the properties of the material being cut and various cutting conditions.

In engineering manufacture particularly in metal machining processes hard brittle metals have a very limited use, and ductile metals are mostly used. Chips of ductile metals are removed by varying proportions of tear, shear, and flow. This results in three general types of shapes (Fig 1)

1 The discontinuous or segmental form.

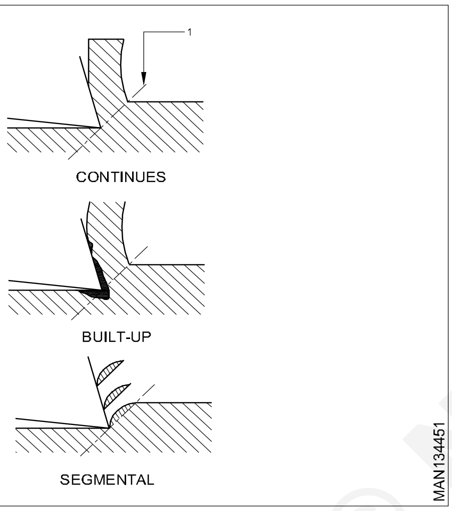
2 The continuous or ribbon type.

3 The continuous with built-up edge.

Discontinuous or segmental chips consist of elements fractured into fairly small pieces ahead of the cutting tool. This type of chip is obtained in machining most brittle materials, such as cast iron and bronze. These materials rupture during plastic deformation, and form chips as separate small pieces. As these chips are produced, the cutting edge smoothes over the irregularities, and a fairly good finish is obtained. Tool life is also reasonably good, and the power consumption is low. Discontinuous chips can also be formed on some ductile metals only under certain conditions particularly at very low speeds and if the coefficient of friction is low. With ductile metals however the surface times is bad end the tool life is short

Conditions tending to promote its formation include: brittle metal, greater depth of cut, low cutting speed and small rake angle.

Fig 1



Continuous chips consist of elements bonded firmly together without being fractured. Under the best conditions the metal flows by means of plastic deformation, and gives a continuous ribbon of metal which, under the microscope, shows no signs of tears or discontinuities. The upper side of a continuous chip has small notches while the lower side, which slides over the tool face, is smooth and shiny. The continuous form is considered most desirable face, is smooth and shiny. The continuous form is considered most desirable for low friction at the rool-chip interface, lower power consumption, long tool life and good surface finish.

Factor favorable to its formation are: ductile metal, such as mild steel, copper, etc., fine feed, high cutting speed, large rake angle, keen cutting edge, smooth tool face and an efficient lubrication system.

The term built-up edge implies the building up of a ridge of metal on the top surface of the tool and above the cutting edge. It appears that, when the cut is started in ductile metals, a pile of compressed and highly stressed metal forms at the extreme edge of the tool. Owing to the high heat and pressure generated there, this piled up metal is welded to the cutting tip and forms a “false” cutting edge tool. This is usually referred to as the “built up edge”. This weld metal is extremely strain hardened and brittle. So the weaker chip metal tears away from the weld as the chip moves along the tool face. The buit-up becoming unstable, breaks down and some fragments leave with the chip as it passes off and the rest adheres to the work surface producing the characteristic rough surface. The built-up edge appears to be a rather permanent structure as long as the cut is continuous at relatively high speeds and has the effect of slightly altering the rake angle. At very high speeds, usually associated with sintered carbide tools, the the built-up edge is very small or nonexistent, and a smooth machined surface results.

Conditions tending to promote the formation of built-up edges include: low cutting speed, low rake angle, high feed, lack of cutting fluid and large depth of cut.

The chip breakers and their uses

Objective: At the end of this lesson you shall be able to
- **state the function of chip breakers and identify the different types**

Chip breaker: Chip breaker means with which the continuous long curly chips are broken into comparatively small pieces for easy handling, thus preventing it from becoming a work hazard.

Types of chip breakers (Fig 1)

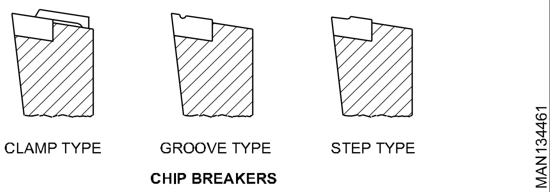
- Step type - built in
- Groove type - built in
- Clamp type - mechanical

The common methods of breaking the chips in normal shop practice are summarized here.

- By clamping a piece of sheet metal in the path of the coil.
- By a step type chip breaker in which a step is ground on the face of the tool, along the cutting edge.
- By a groove type chip breaker in which a small groove is ground behind the cutting edge.
- By a clamp type chip breaker in which a thin carbide plate or clamp is brazed or screwed on the face of the tool.

Throw-away tip tool-holders are provided with chip breakers.

Fig 1



CHIP BREAKERS

Necessity for breaking the chips: Long and unbroken chips produced while turning ductile materials are difficult to handle and injurious to the operator. They should be broken into convenient lengths for easy disposal and also to protect the finished work-surfaces. Therefore, tools are provided with devices to curl and break the chips. These devices, which are called chip breakers are in the form of ground chip breakers in the case of brazed carbide tools, and external or pre–sintered chip breakers in the case of disposable, indexable inserts.

However, with high speed steel tools, this problem may not arise because at low cutting speeds the chip has often natural curl and tends to be brittle enough to break on its own.

Tool life and factors effecting tool life

Objectives: At the end of this lesson you shall be able to
- **state what is tool life**
- **explain the factors effecting the tool life.**

Tool life is a most important factor in the evaluation of machinability,

It is the period of time in which the tool cuts effectively and efficiently.

The methods of expressing tool life.

There are many ways of expressing the tool life, such as

- Time unit - It is the most commonly used tool life unit.
- Volume of material removed by tool during its total lifespan.
- Number of work pieces machined by a tool.

Tool life most commonly expressed in minute, expected life of some tool material is given below

Cast tool steel - 120 minute

High speed steel tool - 60 to120 minute

Cemented carbide tool - 420 to 480minute

Factor affecting tool life:

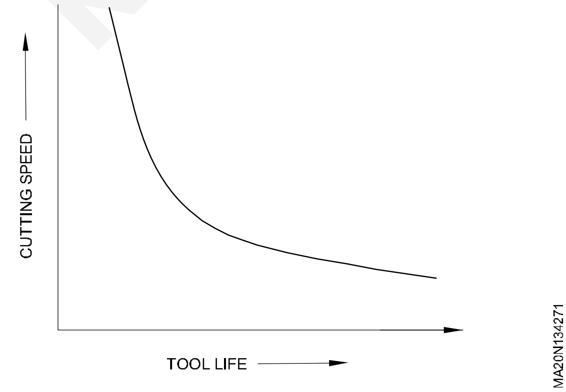
- Cutting speed
- Feed and depth of cut
- Tool geometry
- Tool material
- Work material
- Nature of cutting
- Rigidity of machine tool and work
- Cutting fluids

Cutting speed:

It is major for affecting tool life.

It varies inversely with tool life which leads to parabolic curve as shown. in Fig 1

Fig 1



Tool life relation is invented by F.W.Taylor.

$VT^n = C$

V = Cutting speed in m/min,

T = Tool life in min,

n = Tool life index

C = machining constant

N and C are constant for a given set of conditions

Feed Rate and Depth of Cut: According to the Taylor's tool life equation, tool life decreases when feed rate increases. Also, same for the depth of cut.

Tool Geometry: The tool geometry greatly affects the tool life. the effect of all the tool parameters on tool life is as follows

- Back Rake Angle.
- Principal Cutting Edge.
- Clearance Angle.
- Nose Radius.

Back Rake Angle: Larger the rake angle smaller will be the cutting angle and larger will be shear angle, this reduces the cutting force and power, and hence less heat generated during cutting, means reduced cutting temperature, results in longer tool life.

But on the other hand, increasing the rake angle results in mechanically weak cutting edge the positive rake tool experiences shear stress and the tip is likely to be sheared-off.

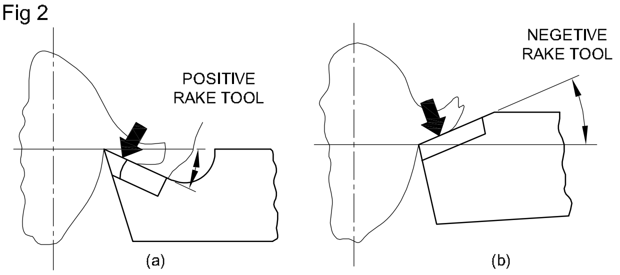
Negative rake increases cutting force and power, hence more heat and temperature generated results in smaller tool life.

Therefore, there lies an optimum value of the back rake which depends upon tool material and work material. It ranges from -5° to +15°. An optimum value of rake angle is about 14° which gives maximum tool life.

Fig 2 shows cutting process using positive and negative rake tools. The positive rake tool experiences shear stress and the tip is likely to be sheared off. Whereas tool with negative rake experiences

compressive stress. The carbide and ceramic tools are generally given negative rake because they are weak in shear and good in compression

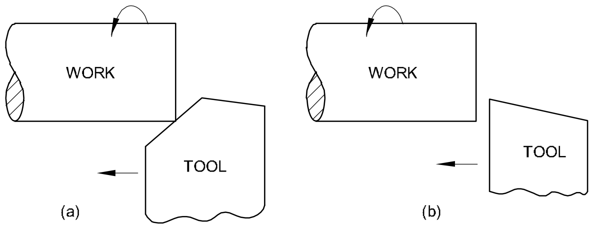
Fig 2



CUTTING PROCESS USING POSITIVE AND NEGATIVE RAKE TOOLS

Principal Cutting Edge: Fig. 3 shows two different arrangements of principal cutting edge angles. Fig. 3 (a), the contact is gradually starting from a point quite away from the tip. Therefore, the tool experiences the cutting force gradually and over a larger area. Hence the tool is safer and tool life is more as compared to the Fig. 2(b) in which the principal cutting edge angle is 90°.

Fig 3



PRINCIPAL CUTTING EDGE

Clearance Angle: Increase in clearance angle results in significant reduced flank wear, so increased tool life. But the cutting edge will become weaker as the clearance angle is increased. There fore an optimum value is required. The best compromise is 5° (with carbide tools) to 8° (with H.S.S. tools) for common work materials.

Nose Radius: The nose radius improves tool life and surface finish.

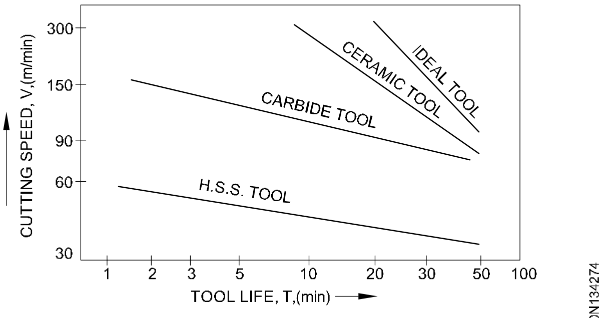
There is an optimum value of nose radius at which the tool life is maximum.

- If the radius exceeds optimum value, the tool life decreases.
- Larger radius means larger area of contact between the tool and work piece. Due to which more frictional heat is generated, results in increased cutting force. Due to which the work piece may starts, vibrating, hence if rigidity is not very high, brittle tools (carbides and ceramics) will fail due to chipping of cutting edge.

Tool Material:

- The major requirements of cutting tool materials are: Hot hardness, impact toughness, and wear resistance. For better tool life, the material must have the above properties. Fig. 4 shows tool life variation against cutting speeds for different tool materials.

Fig 4



TOOL LIFE PLOTS FOR VARIOUS TOOL MATERIALS

- It is very clear from the figure; at any cutting speed the tool life is maximum for ceramic tool and lowest for the high speed steel tool. So using ceramic tool maximum volume of material could be removed at any cutting speed for a specific tool life.

Hardness of Work piece:

As the hardness increases, the permissible velocity decreases for a given tool life. For example, the tool life is 50 minutes for cutting less hard material, now if say harder material is to be cut then to maintain the tool life as 50 minutes, the cutting velocity should be reduced proportionate.

Nature of Cutting:

If the cutting is intermittent, the tool bears impact loading, results in chance of its quick failure. In continuous and steady cutting, the tool life is more.

Rigidity of Work Piece-Machine Tool System:

Higher is the rigidity of system higher will be the tool life. Lower the rigidity of the system, higher is the chance of tool failure, by vibrations of tool or work piece. Rigidity is the prime requirement in case of intermittent cutting especially when brittle tools are used.

Type of Cutting Fluid and its Method of Application:

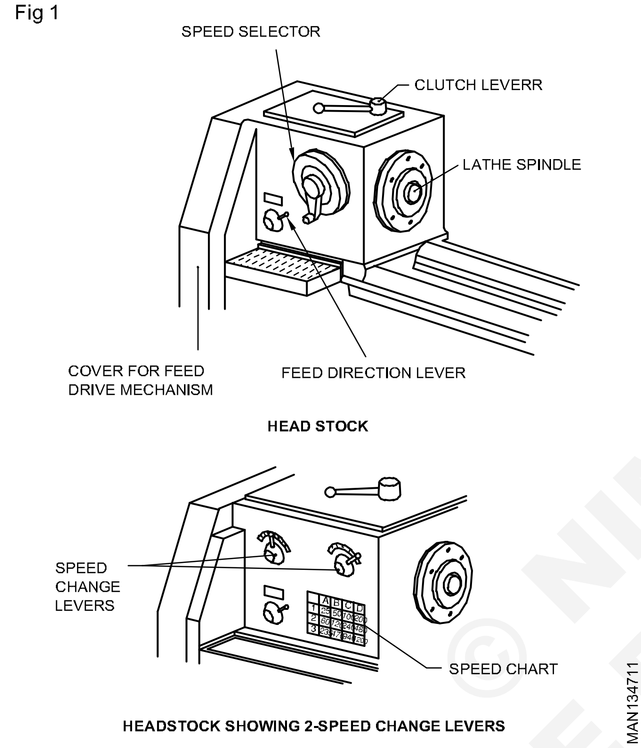
Application of suitable cutting fluid obviously increases tool life or in other words, for the same tool life, allowable cutting speed increases. Fig. 9.30 shows the effect of cutting fluid on tool life for different tool materials. The tool life even increases by 150 per cent at some speeds. All types of cutting fluids do not have equal effect, some of them more, some are less

Lathe driving mechanism for all gear types

Objectives: At the end of this lesson you shall be able to
- **state the functions of headstock**
- **explain the difference 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 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

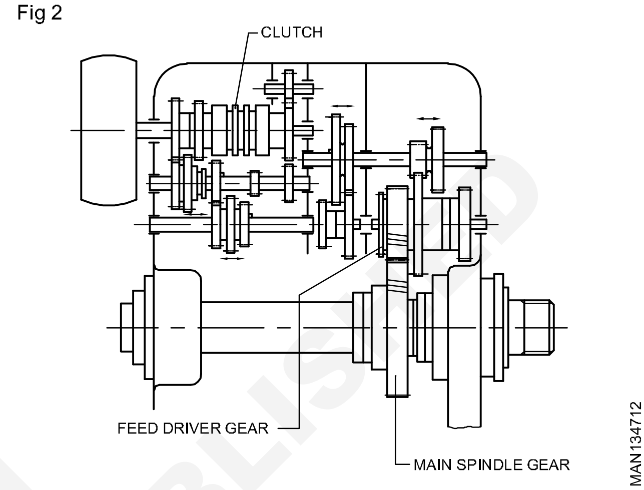
Have a means for lubricating the gears, shafts and bearings.

Constructional features of all-geared headstock (Fig 2)

It is a box-section alloy iron casting having a top cover which can be removed, if needed, 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.

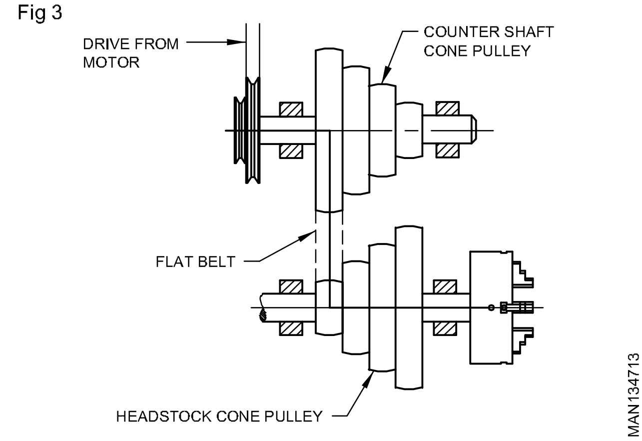
Fig 2



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

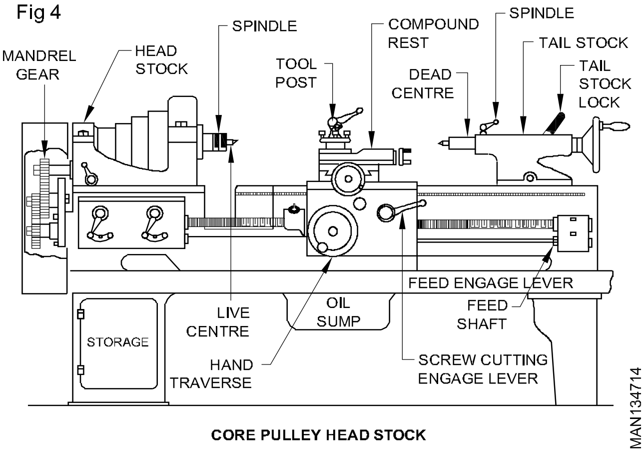


It has a stepped cone pulley mounted on the main spindle and is free to revolve. It is connected by means of a flat belt to a similar cone pulley, the steps arranged in a reversing order. This cone pulley gets the drive from the main motor.

The spindle is mounted on the bush bearings in the headstock casting and a gearwheel called ‘bullgear’ 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)

Fig 4



CORE PULLEY HEAD STOCK

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.

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 the number of steps in the cone pulley.

Takes time to change spindle speeds.

Needs adjustments of bush bearings.

Back gear

Objectives: At the end of this lesson you shall be able to
- **state the construction details of Back gear assembly**
- **state the function and purpose of Back gear.**

Back gear

As its name implies "back gear" is a gear mounted at the back of the head stock. It is used to reduce the speed.

Necessity of back gear: For machining big job, taking rough cut use need more power at reduced speed of spindle the back gear provides this feature in a lathe

Use of backgear

It enables to rotate the chuck at very slow speed

It provides increased turning power

It is highly suitable for turning large diameter casing (200 rpm)

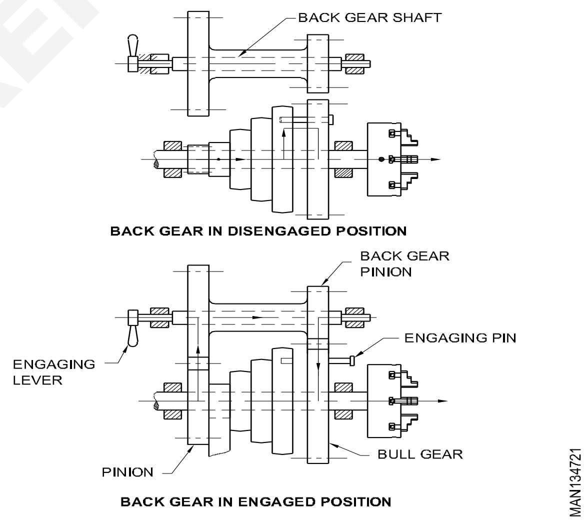
It reduces the rpm but increases the torque

Even the largest face plate mounted job can be turned successfully

The spindle is mounted on the bush bearings in the headstock casting and a gear wheel called 'bullgear' 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 eccentric 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 1)

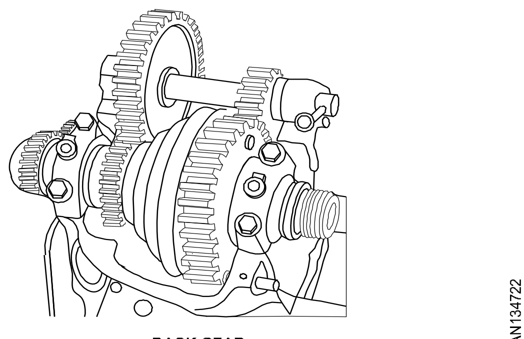
A three-stepped cone pulley headstock provides three direct ranges of speeds through the belt connection, and with the back gear in engagement, three further ranges of reduced speeds. (Fig 2)

Fig 1



BACK GEAR IN ENGAGED POSITION

Fig 2



BACK GEAR

Tumbler gear set

Objectives: At the end of this lesson you shall be able to
- **state the purpose of the tumbler gear mechanism**
- **state the construction details of the tumbler gear mechanism.**

Tumbler gear mechanism (Fig 1)

The tumbler gear mechanism is used for changing the direction of rotation of the lead screw and feed shaft. It is normally situated between the spindle drive and the feed gear box. It consists of 3 gears arranged in a simple gear train, mounted on a bracket can be shifted into 3 positions.

For forward rotation of the lead screw and feed shaft.

For neutral position (no rotation of lead screw and feed shaft)

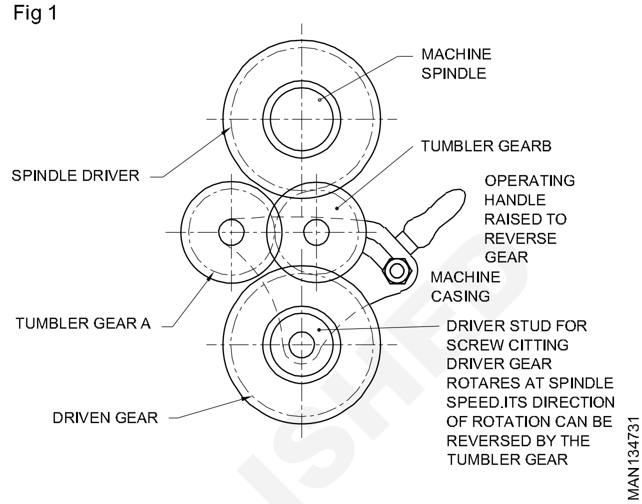
For the reverse rotation of the lead screw and feed shaft.

In practice, the first driver gear of a screw cutting train is not fitted directly to the lathe spindle but is mounted on a driver stud which rotates at the same speed as the spindle.

The driving gear on the spindle drives the fixed stud gear, and, since they have the same speed, they must be of the same size. Tumbler gear A is always in mesh with the driven gear and in mesh with the fellow tumbler gear B. In the figure, the drive is directed through the tumbler gear A, and tumbler gear B is idle.

If the tumbler bracket is moved upwards, tumbler gear A rolls around the driven gear until it is out of mesh with the driver gear, and tumbler gear B moves into mesh with the driver, reversing the direction of the driven gear. Thus the two trains available are:

Fig 1



Forward: Driver —> A —> Driven

Reverse: Driver —> B —> A —> Driven.

In yet another position of the tumbler bracket, tumbler gears A or B do not mesh with the driver gear and no drive is transmitted to the driven gear. No feed movement or thread cutting is possible.

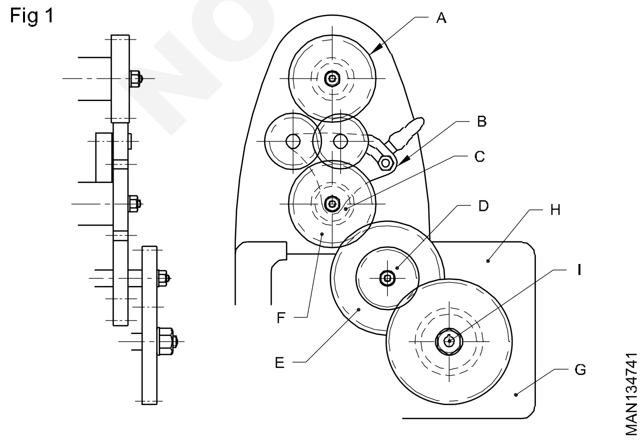
Feed mechanism of lathe & cutting speed

Objectives: At the end of this lesson you shall be able to
- **explain the parts of the feed mechanism**
- **state the functional features of the feed mechanism.**

Feed mechanism (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.

Fig 1



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. (Fig 1)

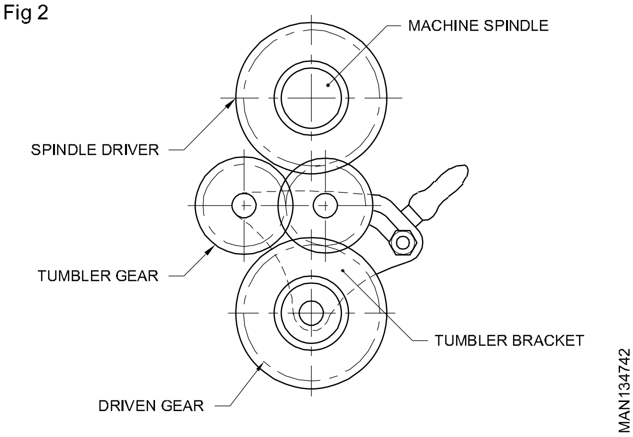
Spindle gear

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 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



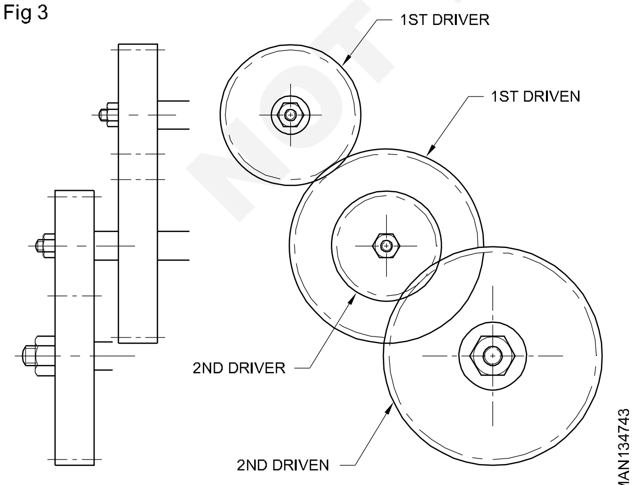
The fixed stud gear

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)

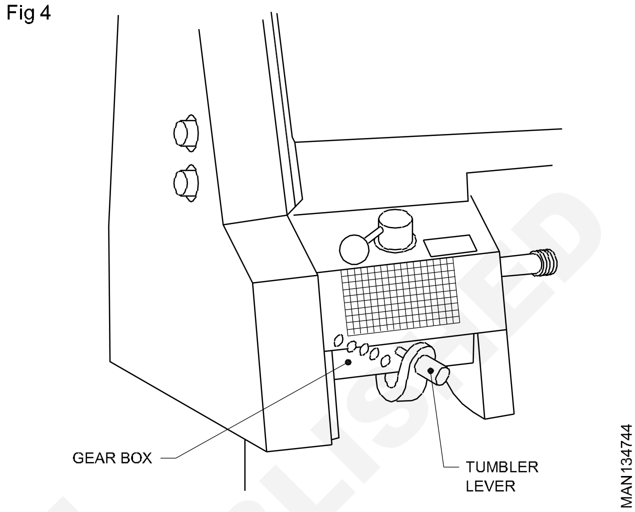
Fig 3



Quick change gearbox

The quick change gearbox is provided with levers outside 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



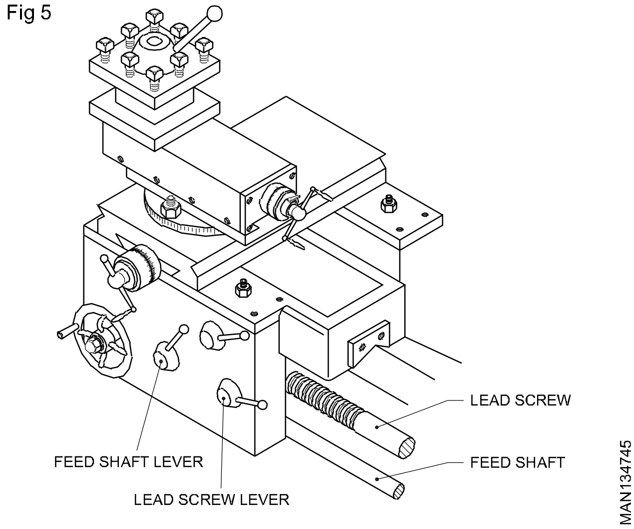
The feed shaft

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 tool. (Fig 5)

Fig 5



Cutting speed and feed, depth of cut and recommended speed

Objectives: At the end of this lesson you shall be able to
- **explain the recommended cutting speed for different materials from the chart**
- **state the factors governing the cutting speed**
- **state the factors governing feed.**

Cutting speed (Fig 1)

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 πxD. 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.

Example

Find out the rpm of the spindle for a 50 mm bar to cut at 25 m/min.

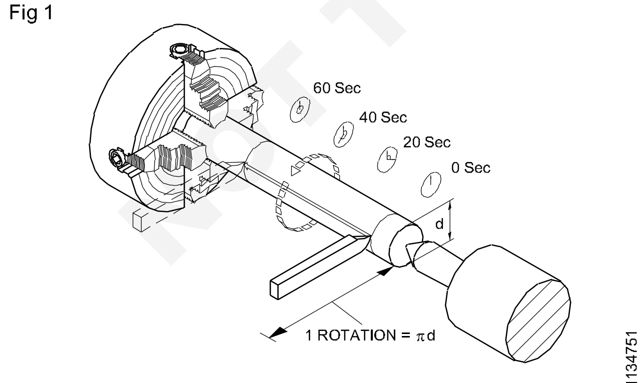
$$V = \frac{\pi DN}{1000}$$

$$N = \frac{1000V}{\pi D}$$

$$= \frac{1000 \times 25}{3.14 \times 50}$$

$$= 159 \text{ r.p.m}$$

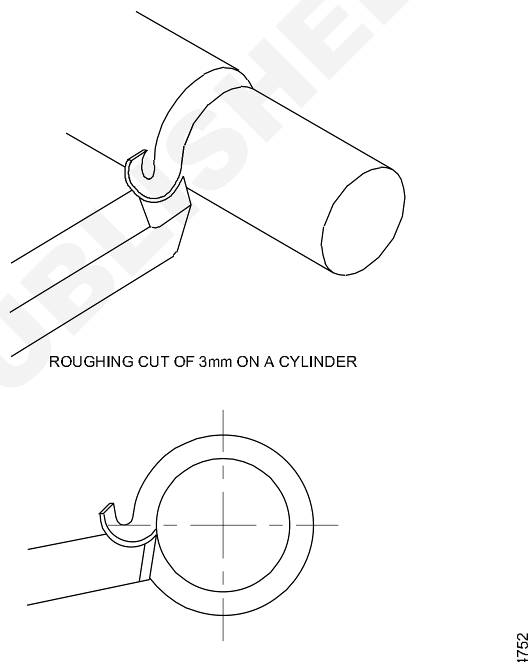
Fig 1



CUTTING SPEED FOR TURNING OPERATION

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 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)

Fig 2



DEPTH OF CUT

Factors governing the cutting speed

Finish required

Depth of cut

Tool geometry

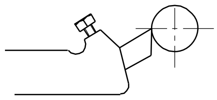
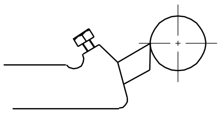
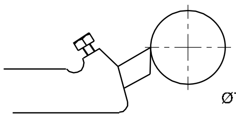
Properties and rigidity of the cutting tool and its mounting

Properties of the workpiece material

Rigidity of the workpiece

Type of cutting fluid used & Rigidity of machine tool

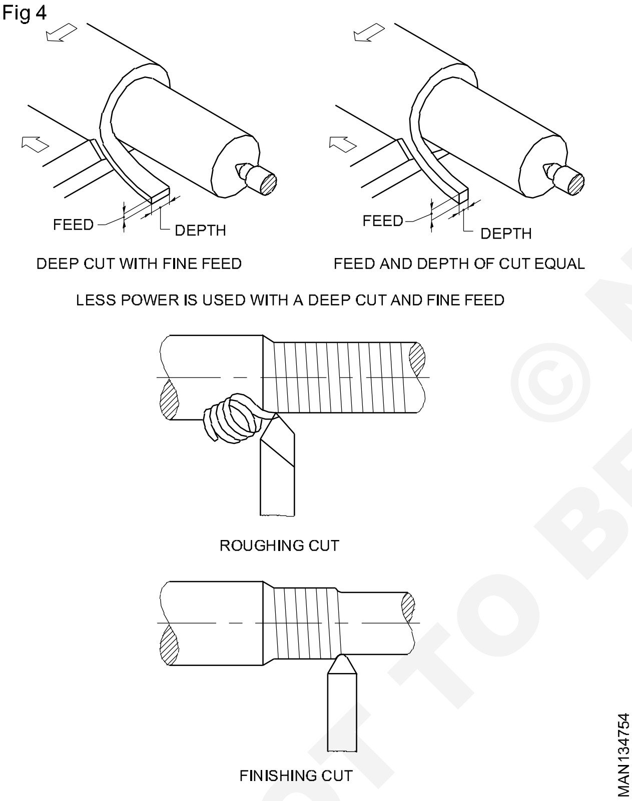
Relationship of r.p.m to the cutting speed on different diameter

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

Feed (Fig 4)

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.

Fig 4



Factors governing feed

Tool geometry

Surface finish required on the work

Rigidity of the tool

Coolant used.

Depth of cut (Fig 4)

It is defined as the perpendicular distance measured between the machined surface (d) and the un-machined surface (D) expressed in mm.

$$\text{Depth of cut} = \frac{D - d}{2}$$

Rate of metal remove

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.

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 - 15	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
- **explain the spindle speed for of different materials of different diameters with different tool materials**
- **state the turning time with the given date.**

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.

$$= \frac{\pi \times D \times N}{1000} \text{metr/min. where D is in mm.}$$

$$N = \frac{CS \times 1000}{\pi \times D}$$

To determine the spindle speed (N)

Example 1

Calculate the spindle speed to turn a MS rod of φ 40 mm.

Using HSS tool date in the above problem, since the material is mild steel and tool is HSS, the recommended cutting speed from the chart is 30m/min.

φ = 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 D = 40 mm using a HSS tool.

Date: The cutting speed for hard cast iron from the chart is 15 m/min.

φ = 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 φ 40 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.

φ 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 calculated r.p.m.

Turning time calculation

The time factor is very important to decide the manufacturing 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 ‘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 and 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.

Orthogonal cutting and oblique cutting

Objectives: At the end of this lesson you shall be able to
- **explain difference between orthogonal cutting and oblique cutting**
- **state the advantage and disadvantages of orthogonal cutting**
- **state about the work holding devices**
- **state the advantages and disadvantages of oblique cutting.**

Orthogonal cutting (Fig 1)

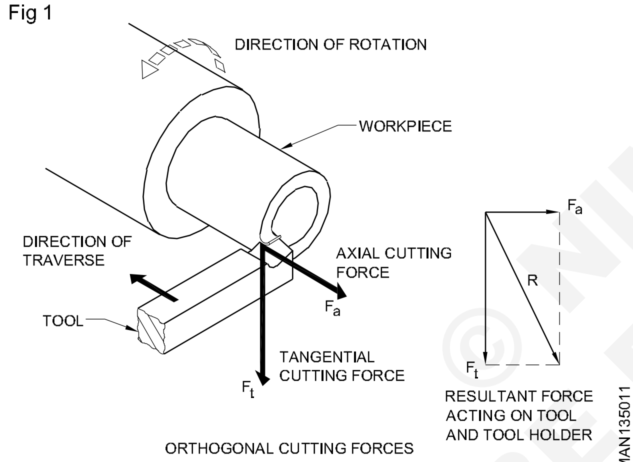
Orthogonal cutting is a process of cutting operation where only two forces are acting on the tool which are shown in figure 1, They are:

- tangential force

- axial force.

In orthogonal cutting, the cutting edge is parallel to the axis of the tool.

Fig 1



ORTHOGONAL CUTTING FORCES

The major force is the tangential force, but the following factors affect the magnitude of both the forces.

Rake angle

Depth of cut

Rate of feed

Resistance to cutting by the material of the work piece

Friction between the chip and the tool

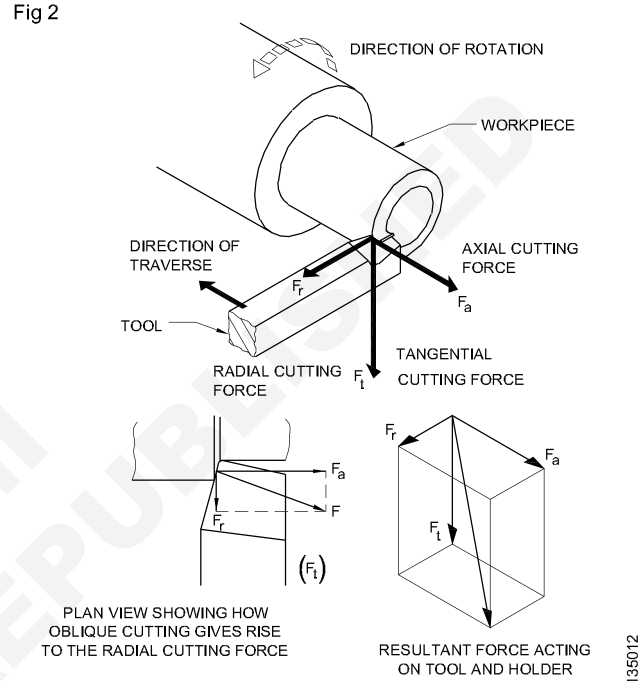
Orthogonal cutting is suitable for finish turning where the depth of cut is less. The chattering during turning is much reduced. The main disadvantage is at the start of the cutting itself as the load will act suddenly on the tool.

Oblique cutting (Fig 2)

Oblique cutting is a process of cutting operation where three forces are acting on the tool as shown in the figure. They are:

- axial force
- tangential cutting force
- radial force.

Fig 2



OBLIQUE CUTTING FORCES

Though the radial force does not affect the power consumed, it gives stability to the cutting operation. This force keeps the cross-slide screw and nut in contact. In oblique cutting the cutting edge is at an angle to the axis of the tool.

Advantages of oblique cutting

For the given depth of cut the load is distributed at the start of the cutting operation.

As the length of the cutting edge is more, load per unit area is less.

It is suitable for rough turning.

Disadvantages of oblique cutting

The tool has to be ground for the approach angle. So more cutting tool material is consumed.

As it produces an angular shoulder to make it a square shoulder, another cutting tool should be used.

Lathe accessories - work holding devices: Four jaw chuck

Objectives : At the end of this lesson you shall be able to
- **explain the parts of a Four jaw chuck**
- **state the constructional features of a Four jaw chuck.**

Four-jaw chuck (Fig 1)

Fig 1

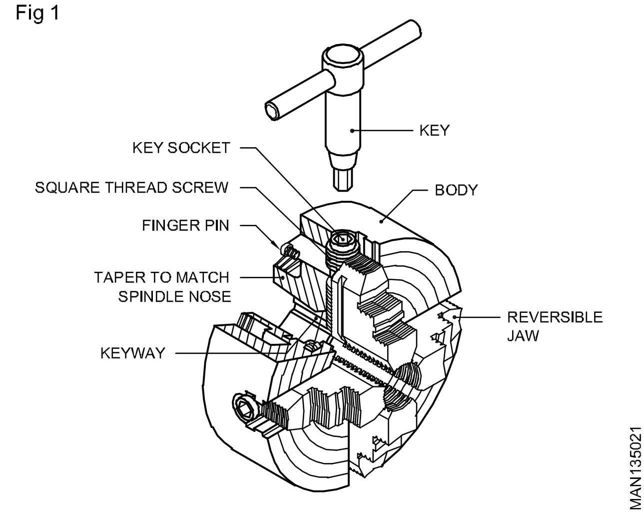
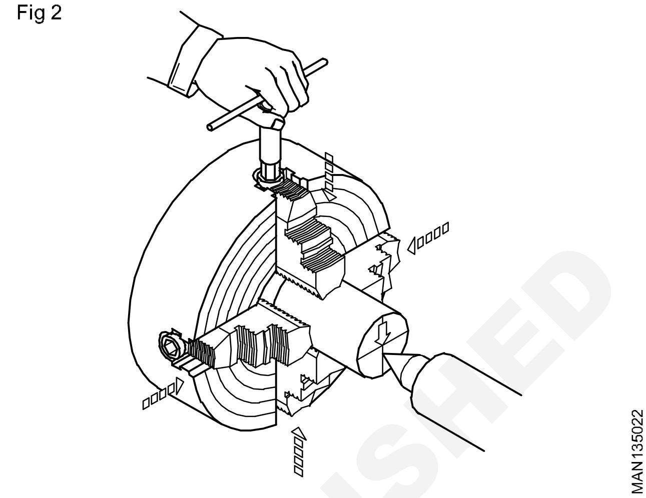


Fig 2



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.

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 equip-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

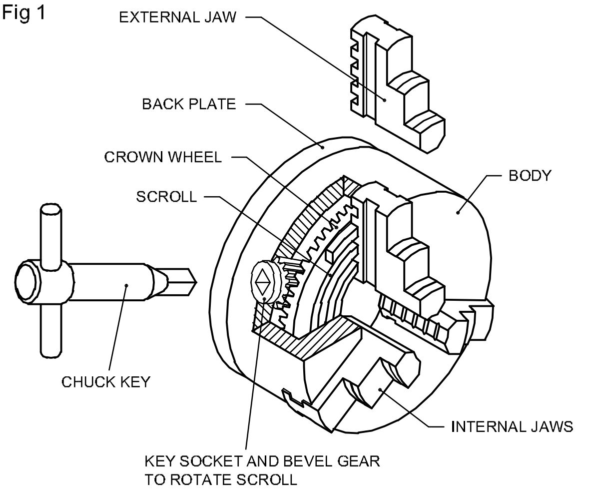
The screw shaft is made out of high carbon steel, hardened, tempered and ground. The top portion of the screw shaft is provided with a square slot to accommodate the chuck key. On the body portion, a left hand square thread is cut. In the middle of the screw shaft, a narrow step is made and held by means 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
- **explain the parts of a three jaw chuck**
- **state the constructional features of a three jaw chuck**
- **explain the difference 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**

The three jaw chuck (Fig 1)

Fig 1



THREE - JAW CHUCK

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

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.

- 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
- **explain 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
- collet chuck
- magnetic chuck
- hydraulic chuck or air operated chuck.

Two jaw concentric chuck (Fig 1)

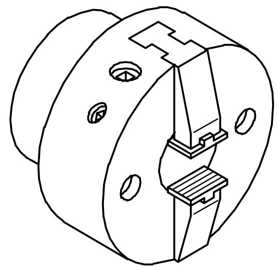
The constructional features of this chuck are similar to those of Three jaw and Four jaw chucks.

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.

Fig 1



TWO JAW CONCENTRIC CHUCK

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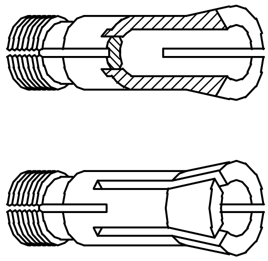
This kind of chuck is used in places where duplicate workpieces are to be machined. One piece is accurately set as done in a four jaw chuck, and the subsequent jobs are held by operating the centering arrangement.

Collet (Fig 2)

Fig 2



SPLIT COLLET

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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)

Push-out chucks (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)

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.

Fig 3

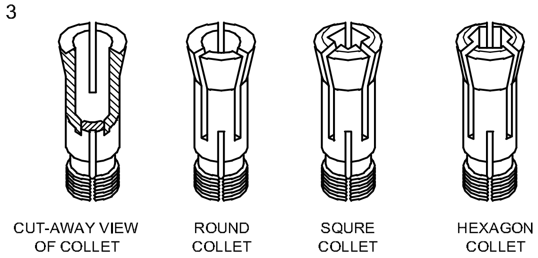

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Fig 4

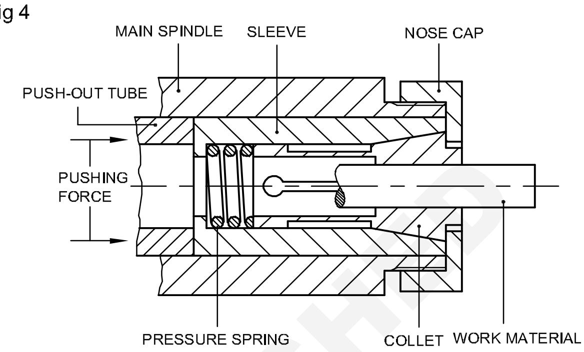

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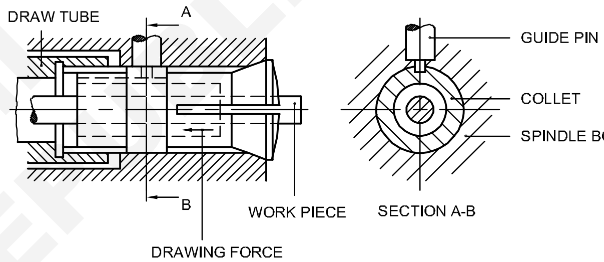
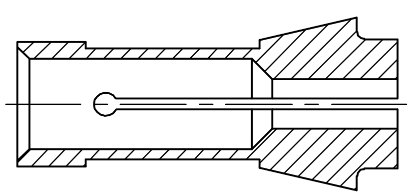
Fig 5



MAN135045

Dead length bar chucks (Fig 6)

Fig 6



SPRING COLLET USED IN DEAD LENGTH BAR CHUCK

MAN135046

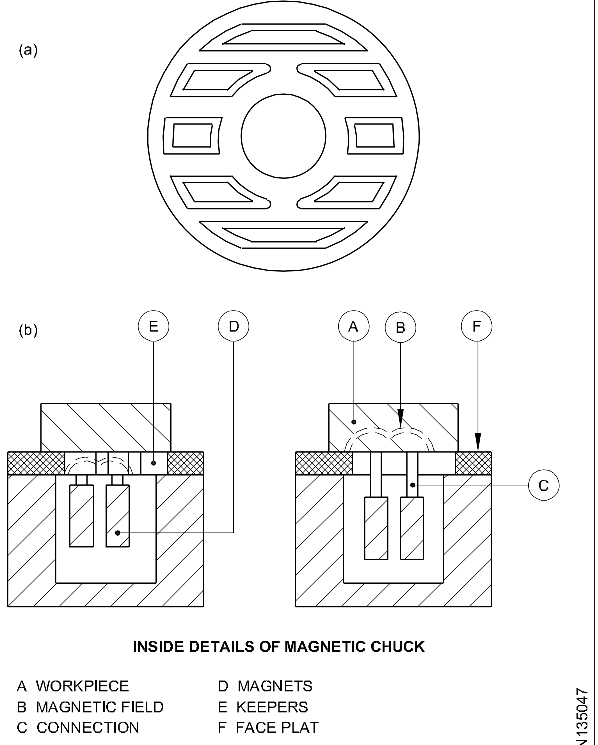
These chucks are widely used in modern machines as they provide an accurate end-wise location of the workpiece. The chuck does not move end-wise during gripping or closing operation. These chucks are made to hold round, hexagonal or square bars, and when they are not gripping, they maintain contact with the core thus preventing sward 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.

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.

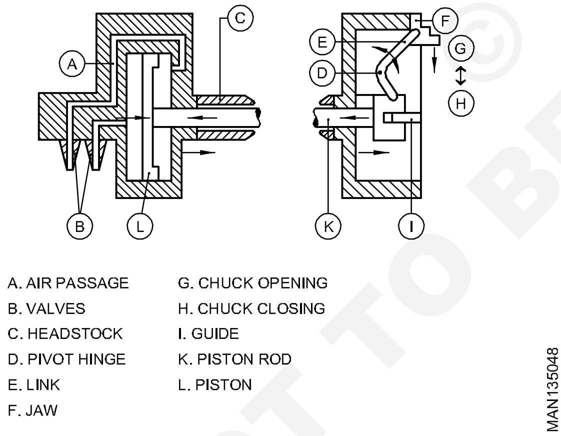
Fig 7



MAGNETIC CHUCK

Hydraulic chuck or air-operated chuck (Fig 8)

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.

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.

Driving plate and face plate

Objectives : At the end of this lesson you shall be able to
- **explain between the features and the uses of different driving plates**
- **explain and name the parts of a face-plate**
- **state the features and uses of different face-plates**
- **explain face-plate accessories.**

When turning jobs in between centres, driving plates are used.

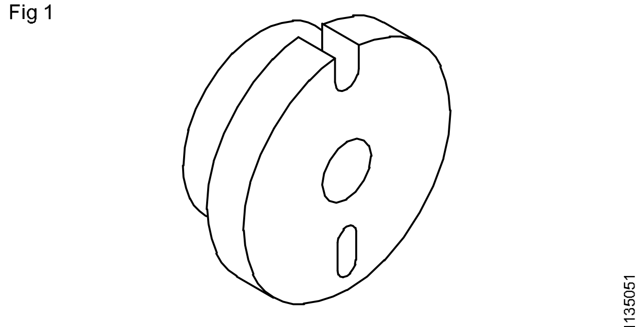
They are:

- 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

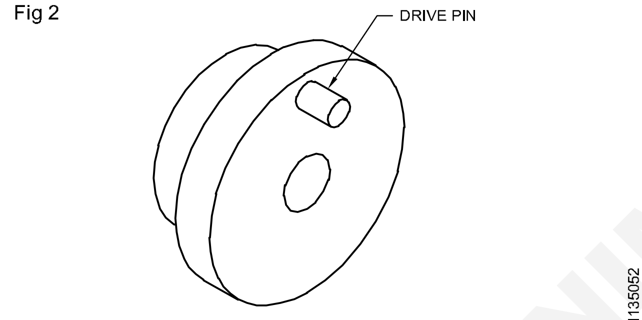


CATCH PLATE

Driving plate with pin

It is designed with a projected pin which locates the straight tail of the lathe carrier. (Fig 2)

Fig 2

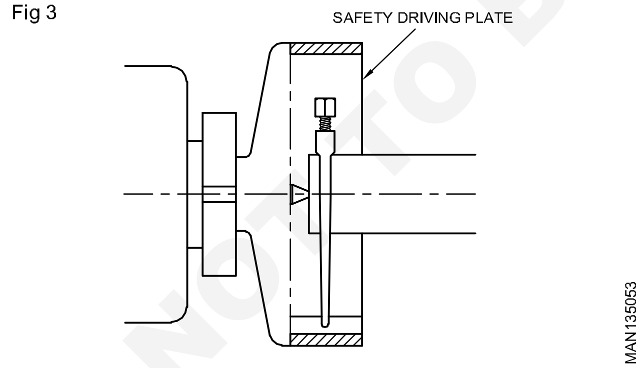


DRIVE PLATES

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.

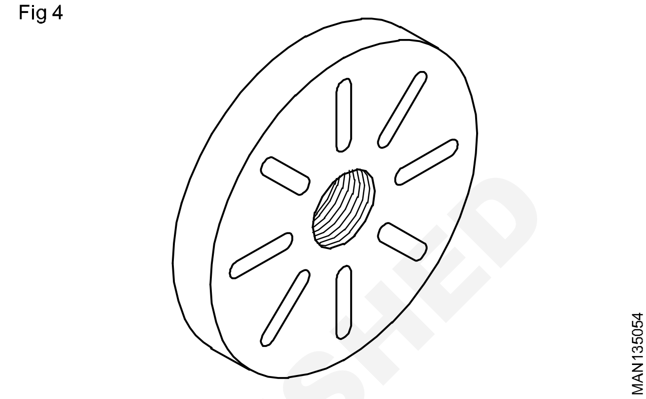
Face-plates

They are similar in construction to that of the lathe catch plates but are larger in diameter.

The different types of face-plates are:

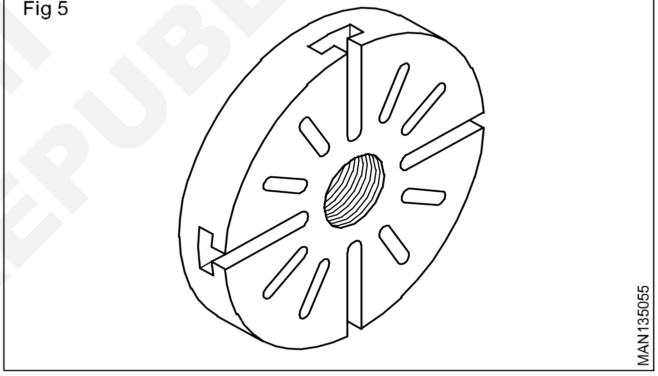
- face-plates with only elongated radial slots (Fig 4)

Fig 4



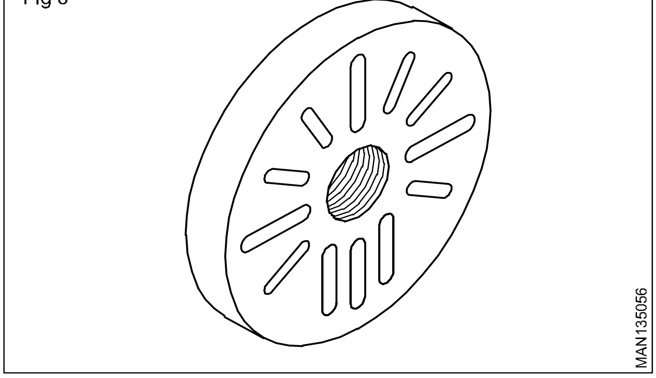
- face-plates with elongated slots and 'T' slots (Fig 5)

Fig 5



- face-plates with elongated radial slots and additional parallel slots. (Fig 6)

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.

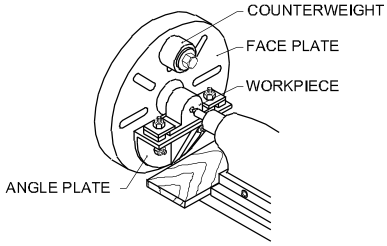
A work can be mounted on a face-plate while the face-plate is on the lathe spindle or on the workbench. If the workpiece is heavy or awkward to hold, the workpiece is mounted while the face-plate is on the workbench. Before mounting the face-plate and it is set up to the spindle, it is advantageous to 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.

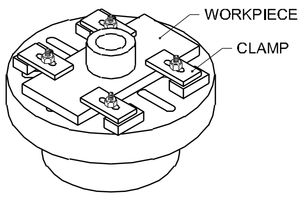
The application of the face-plate with the accessories in different set ups is shown in the sketches below. (Figs 7,8 and 9)

Fig 7



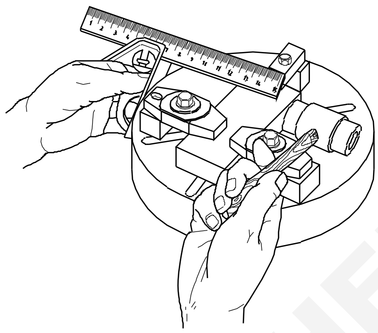
WORK HELD ON AN ANGLE PLATE

Fig 8



WORK CLAMPED DIRECTLY TO FACE PLATE

Fig 9



LOCATING WORK ON A FACE PLATE

Graduations on universal bevel protractor

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

The main scale graduations

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, 0 to 90 degrees and 90 degrees to 0 degrees. 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 3rd 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)

One vernier scale division (VSD) (Fig 2)

$$\frac{23^\circ}{12} = 1\frac{11^\circ}{12} = 1^\circ 55'$$

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 2nd main scale division. (Fig 2)

2 MSD - 1 VSD

The least count $= 2^\circ - \frac{23}{12} = \frac{1^\circ}{12} = 5'$.

Fig 1

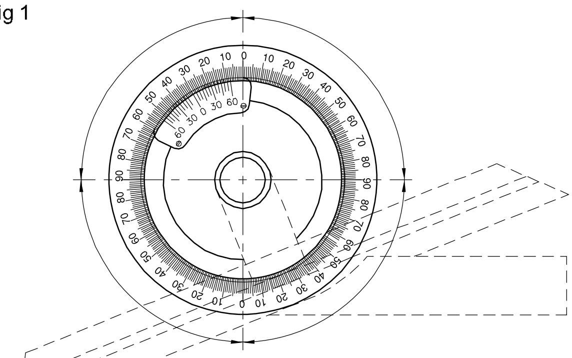
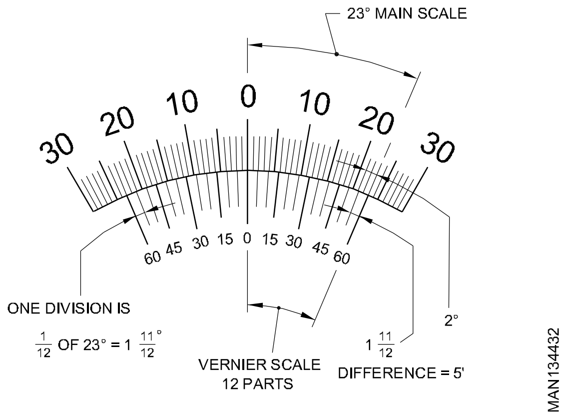
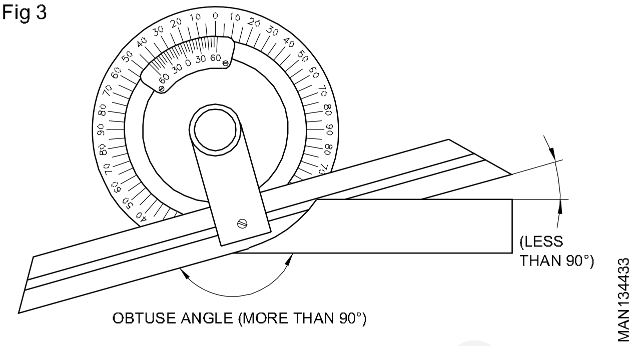


Fig 2



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)

Fig 3



Reading of universal bevel protractor

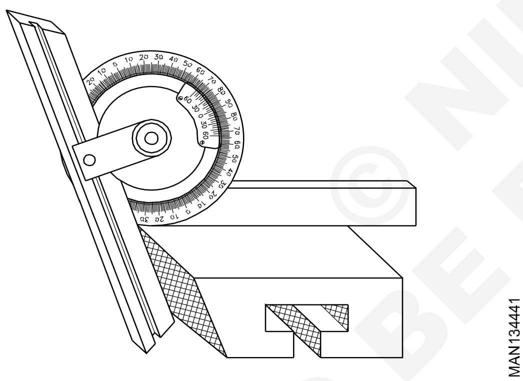
Objectives: At the end of this lesson you shall be able to

- **explain acute angle setting**
- **explain obtuse angle setting.**

For reading acute angle set up (Fig 1)

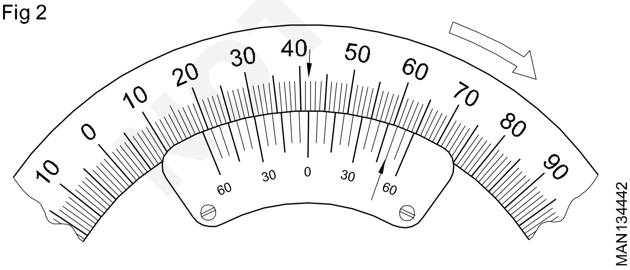
First read the number of whole degrees between zero of the main scale and zero of the vernier scale.

Fig 1



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)

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.

If you read the main scale in a clockwise direction, read the vernier scale also in a clockwise direction from zero.

For obtuse angle set up (Fig 3)

The vernier scale reading 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 3

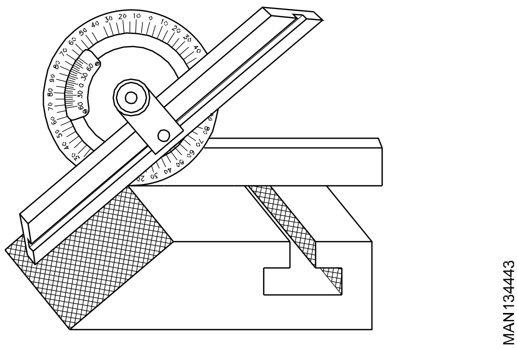
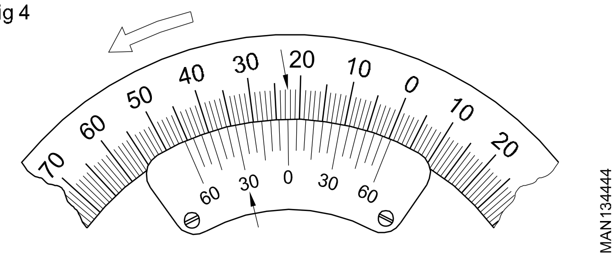


Fig 4



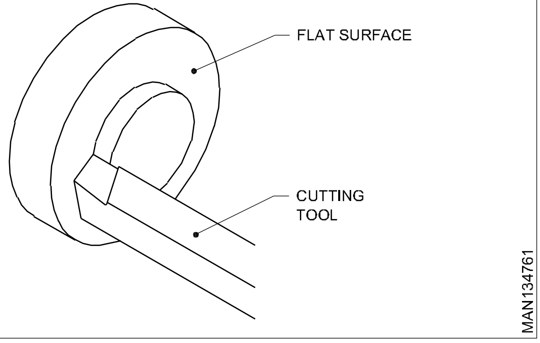
Lathe operations - facing

Objectives : At the end of this lesson you shall be able to
- **state the meaning of facing**
- **state the purpose of facing**
- **explain the defects in faced works**

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.

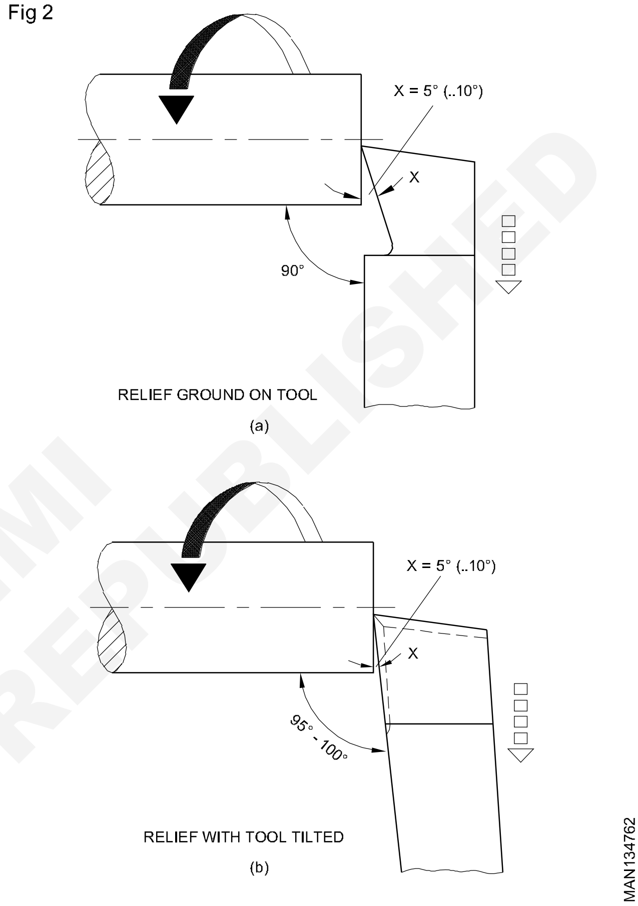
Rough facing is done by feeding the tool from the periphery of the work towards the centre of the work. Finish facing is the operation to have a smooth face by removing the rough surface produced by the rough facing.

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.

Fig 2



The following are the defects found in facing a work. (Fig 3)

step lengths of the work.

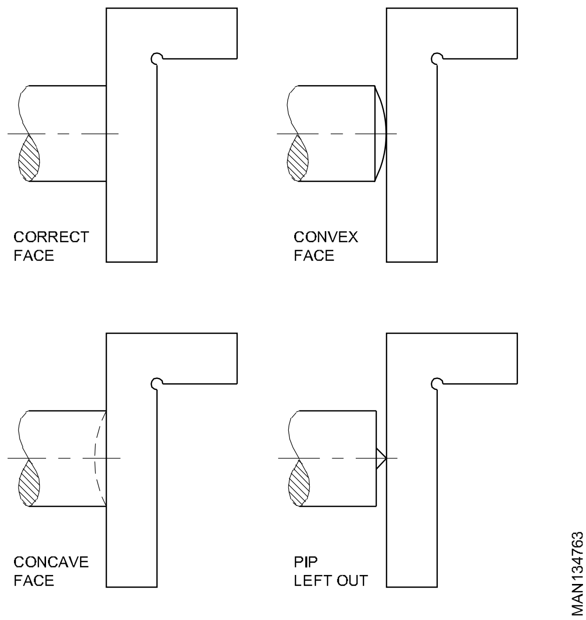
A concave face

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.

Fig 3



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 & Step turning

Objectives : At the end of this lesson you shall be able to
- **state the meaning of plain turning**
- **explain the two stages of plain turning.**

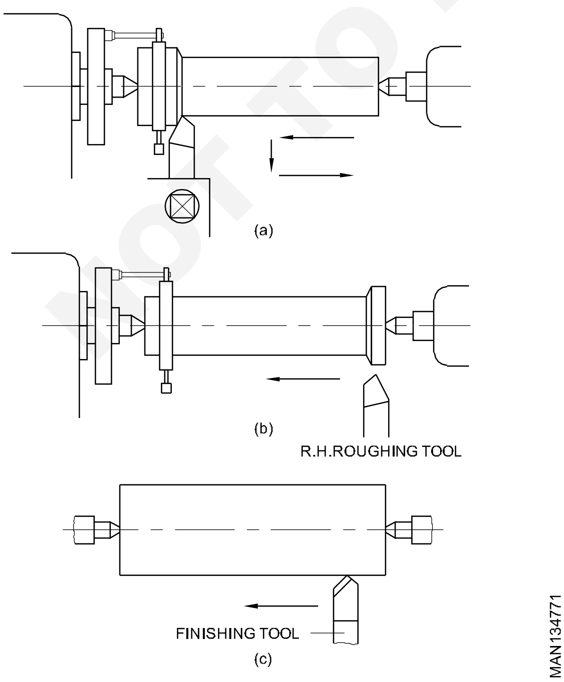
Plain turning (Parallel turning)

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)

Fig 1



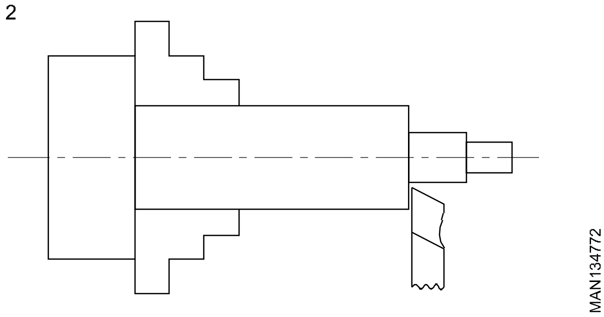
It is done after rough turning, and it aims to bring the size of the work within the specified accuracy and with better surface finish. The tool to be used in this case will be a finish turning tool. Finish turning is also carried out from the tailstock end towards the headstock end.

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.

Step turning (Fig 2)

Step turning is an operation performed on lathe machine where the excess material is removed from the work piece to obtain various steps at different diameters

Fig 2



Lathe Operations - Centre Drilling

Objectives : At the end of this lesson you shall be able to
- **state what is centre drilling**
- **state the purpose of centre drilling**
- **state the defects in centre drilling**

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 the 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)

Fig 1

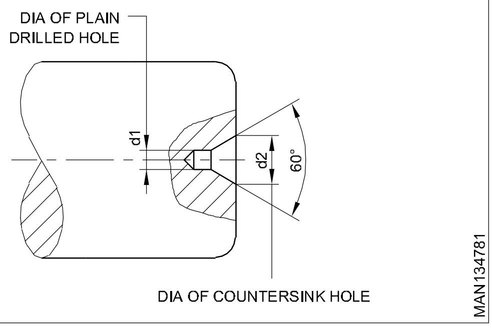
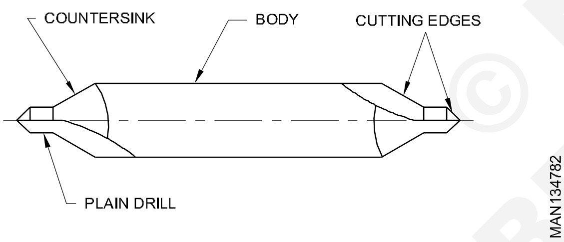


Fig 2

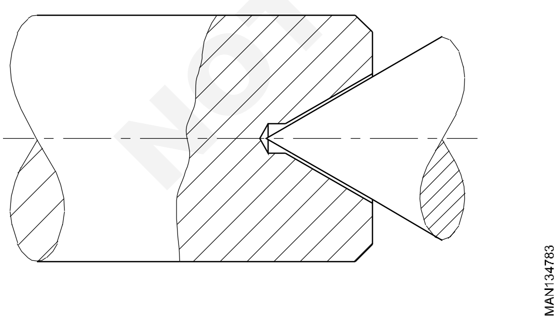


Defects in centre drilled holes

The two major defects in centre drilling are:

- Insufficient depth of plain drilled portior (Fig 3)

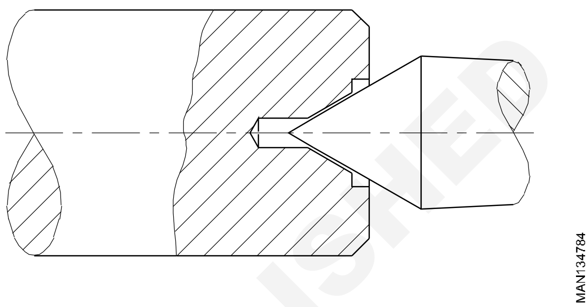
Fig 3



- centre drilling done to deep. (Fig 4)

The first depth 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 upto 3/4 th of the 60° countersink, this defect is avoided.

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, work permits, and feed the centre drill to the recomended length.

Centre drills

It is made of high 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 D.

The differences 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.

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 third type, 'D' 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 5

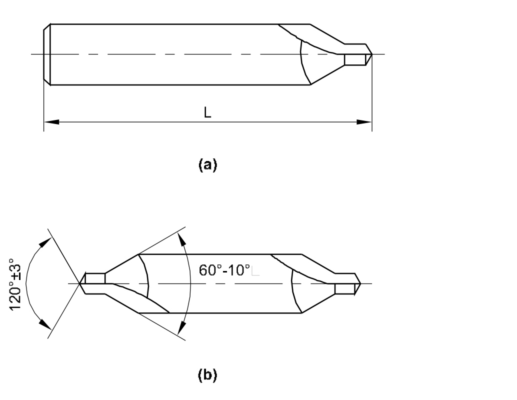
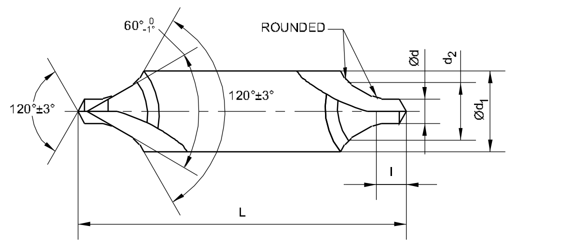


Fig 6



Methods of centre drilling

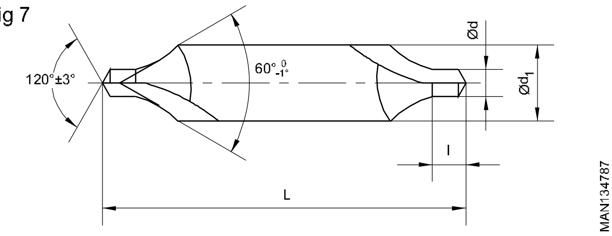
Centre drilling can be done on a

- drilling machine
- lathe
- centering machine.

The selection of a particular method of centering depends on the size and shape of the component.

A drill chuck is used to hold the centre drill, Sometimes special holders/collets are also used. In mass production,

Fig 7



the raw material ends are centered using a centre drillling machine.

While central drilling ensure the following

Choose the right size and type of centre drill according to the diameter of the work.

Select the recommended cutting speed and calculate the spindle r.p.m. taking into consideration the small plain drilling diameter of the centre drill.

The job diameter does not have influence on the spindle speed

The face of the work should be free from any 'pip'.

The alignment of lathe centres is perfect

The drill chuck used has no damages on the holding fingers and also on the morse taper shank.

All the three jaws of the chuck act simultaneously.

The overhang of the tailstock barrel should be as minimum as possible.

If any one of the above points is not observed, htere are possibilities to have a centre hole with defects, and breakage of centre drill might result.

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 precautions 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.

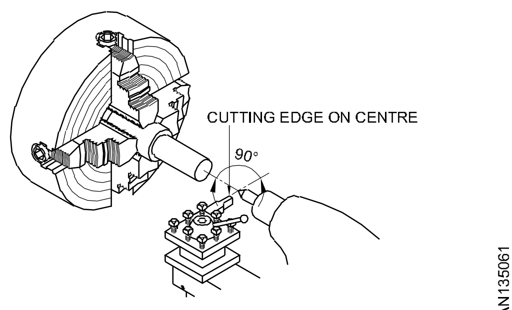
Setting of parting tool

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)

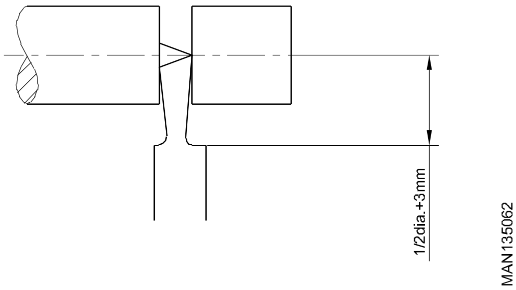
> **If the cutting tool is too high, it will not cut through the workpiece. If it is too low, the work may be bent and the cutting tool damaged.**

Fig 1



CORRECT CUTTING EDGE POSITION

Fig 2



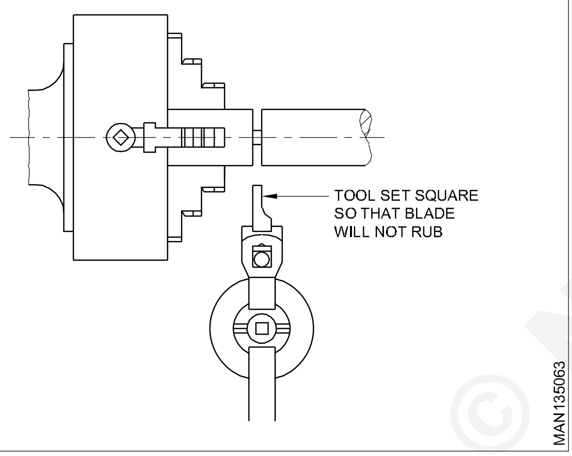
Procedure

Select the correct type of tool for a specified job.

Hold the work with the minimum overhang in a chuck.

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)

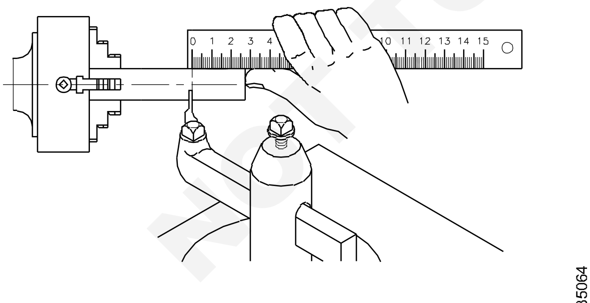
Fig 3



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.

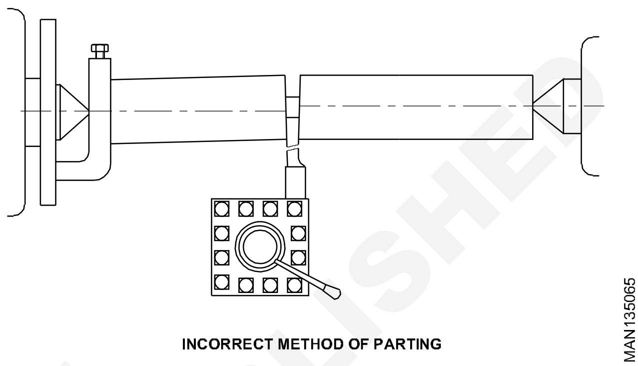
Precautions

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



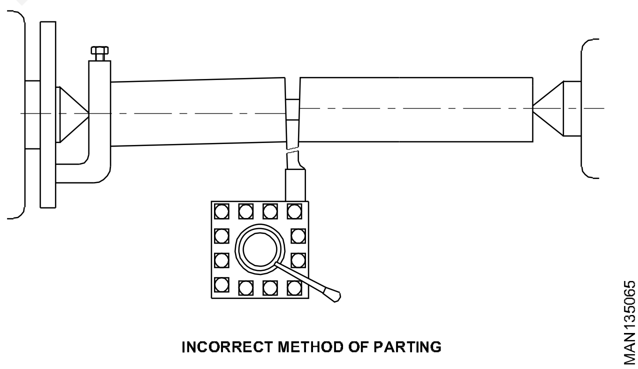
INCORRECT METHOD OF PARTING

Use a right hand offset tool-holder. (Fig 6)

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.**

Fig 5



INCORRECT METHOD OF PARTING

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.

Grooving

Objectives: At the end of this lesson you shall be able to
- **state what is grooving**
- **explain the types of grooves**
- **state the specific uses of each type of groove.**

Grooving

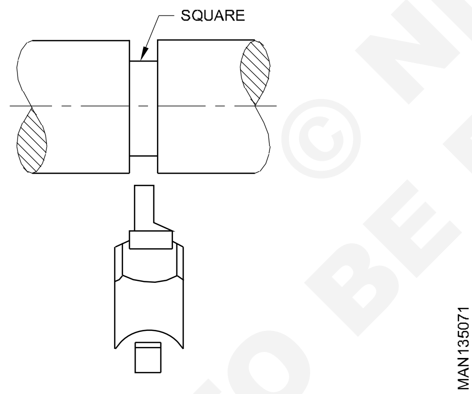
Grooving is the process of turning a grooved form or channel on a cylindrically turned workpiece. The shape of the cutting tool and the depth to which it is fed determine the shape of the groove.

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.

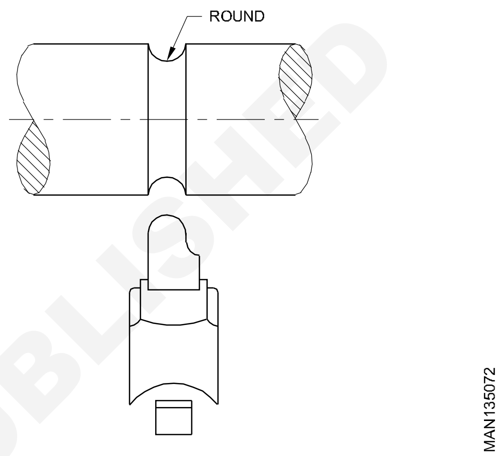
Square grooves are cut with a tool bit ground to the width of the square groove to be formed.

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)

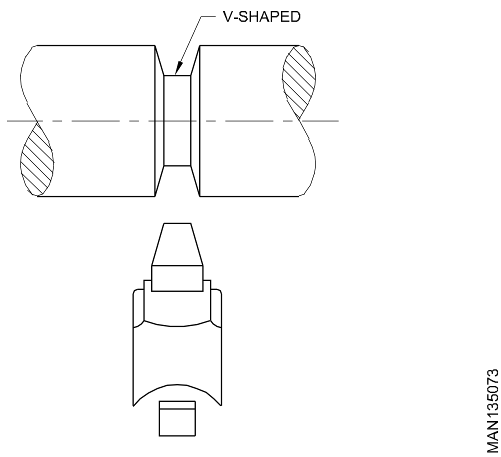
Fig 2



'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)

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.

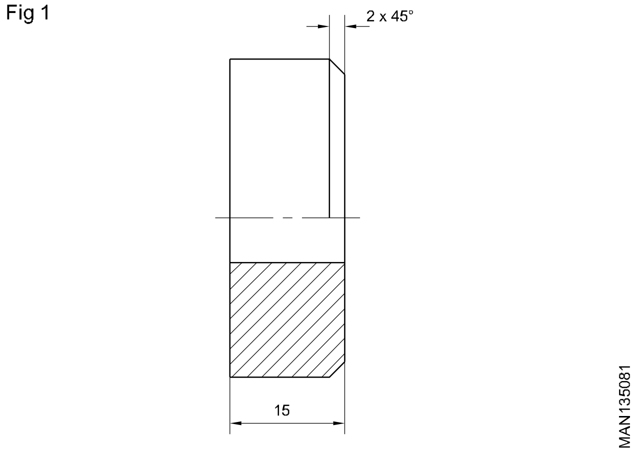
Chamfering

Objectives : At the end of this lesson you shall be able to
- **state the meaning of chamfering**
- **state the purpose of chamfering**
- **state the methods of chamfering**
- **explain the different methods of chamfering.**

Chamfering (Fig 1)

It is the operation of beveling the edge of a cylinder or a bore to a definite length.

Fig 1



Purpose of chamfering

The following are the purposes of chamfering.

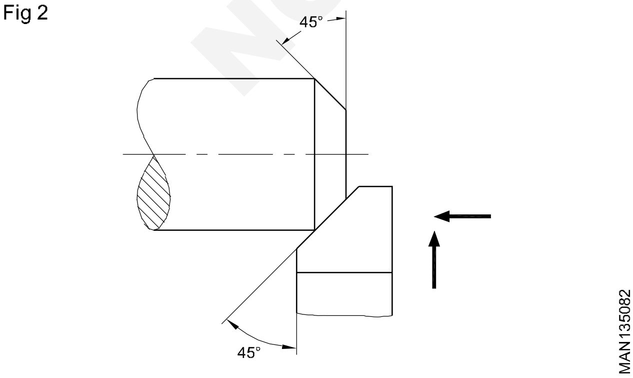
- To remove burrs and sharp edges from the turned components to make their handling safe.
- To permit for easy assembly of mating components (a shaft and a hole).
- To avoid the formation of feather edges on the threaded parts.
- To provide better appearance.

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)

Fig 2

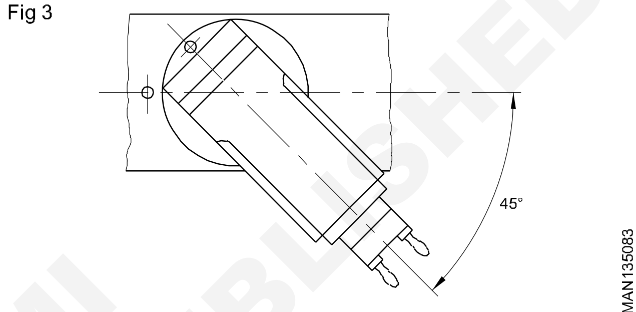


The tool is fed either longitudinally or crosswise. Depth is calculated by the graduated collars.

Compound slide method

Chamfering is also done by a tool fixed on the tool post, swiveling the compound slide to the angle of chamfer. Then the carriage is locked and the tool is fed by the top slide. (Fig 3)

Fig 3

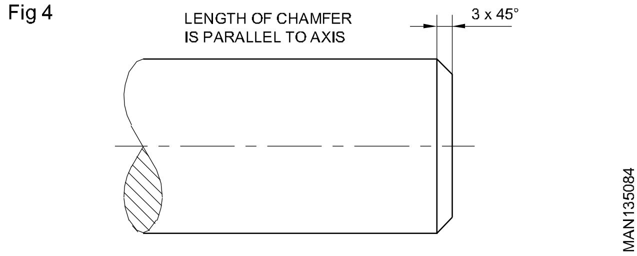


Filing method

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)

Fig 4



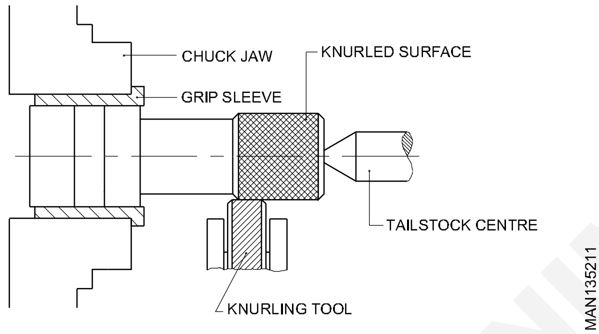
Knurling

Objectives: At the end of this lesson you shall be able to
- **define knurling operation**
- **state the purpose of knurling**
- **state the different types of knurls and knurling patterns**
- **explain the grades of knurls**
- **explain the various types of knurling tool-holders.**

Knurling (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 times the turning speed). Soluble oil is to be used as coolant mostly and, sometimes straight cutting oil may be used to get better finish.

Fig 1



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

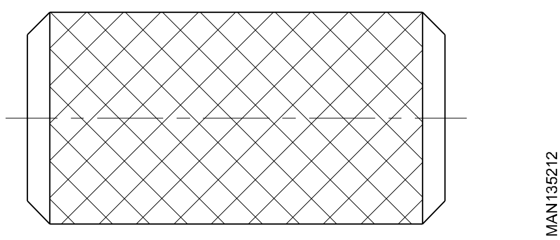
The following are the different types of knurling patterns.

Diamond knurling, Straight knurling, Cross knurling, Concave knurling and Convex knurling.

Diamond knurling (Fig 2)

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.

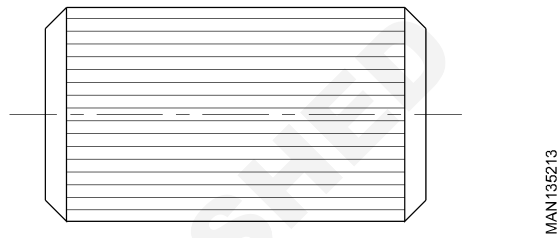
Fig 2



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.

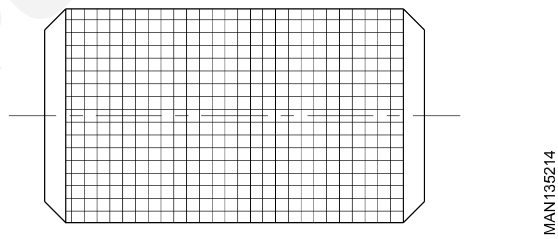
Fig 3



Cross knurling (Fig 4)

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.

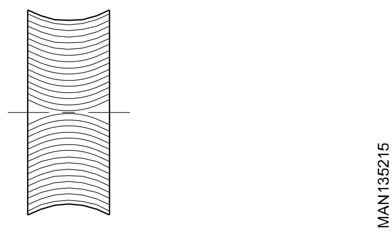
Fig 4



Concave knurling (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.

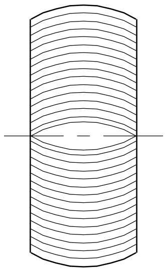
Fig 5



Convex knurling (Fig 6)

This is done by using a concave knurl of a convex surface. This is also done by plunging the tool.

Fig 6



Grades of knurling (Fig 7)

Knurling can be done in three grades.

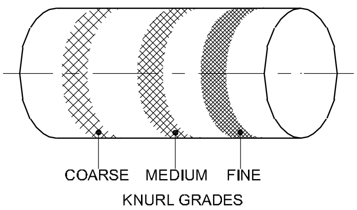
Coarse knurling, Medium knurling and Fine knurling

Coarse knurling is done by using coarse pitched knurls of 1.75mm 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 0.75mm pitch. (33 TPI)

Fig 7



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 types of 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

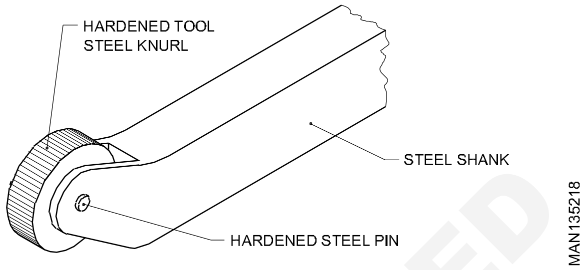
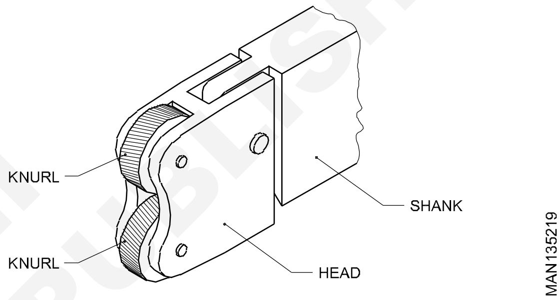


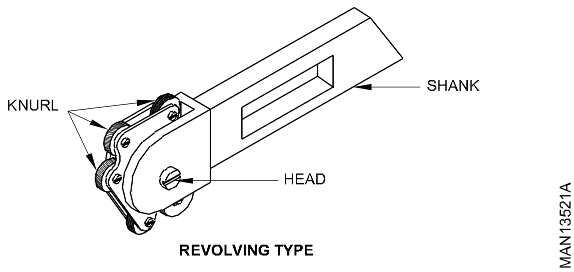
Fig 9



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 with pivots on a hardened steel pin. It is also self-centering.

Fig 10



Differences between different types types of knurling tool-holders are given in Table -1

Table -1

Single roller	Knuckle joint	Revolving type
Only one roller is used.	A pair of rollers are used.	Three pairs of rollers are used.
Only one pattern of knurling can be produced with this type of knurling tool-holder.	Cross or diamond knurling pattern can be produced.	Knurling patterns of different pitches can be produced.
It is not self-centering.	It is self-centering.	It is self-centering.

Knurling - Speed and Feed

The tables shown be used as a guide for determining the amount of end-feed or in-feed per revolution of the work. The rate of the feed for diamond pattern knurling is slower than that for straight or diagonal knurling.

Straight or Diagonal
End -FEED KNURLING

Approximate
FEED per REVOLUTION

T.P.I	Alum Brass	Mild Steel	Alloy Steel
12	.008”	.006”	.004”
16 - 20	.010”	.008”	.005”
25 - 35	.013”	.010”	.007”
40 - 80	.017”	.012”	.009”

Straight or Diagonal
IN - FEED KNURLING

Approximate
REVOLUTION

T.P.I	Alum Brass	Mild Steel	Alloy Steel
12	12	15	25
16 - 20	10	13	22
25 - 35	8	11	20
40 - 80	6	9	18

Boring tool and boring

Objectives : At the end of this lesson you shall be able to
- **explain the different types of boring tools**
- **state 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 core 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)

Fig 1

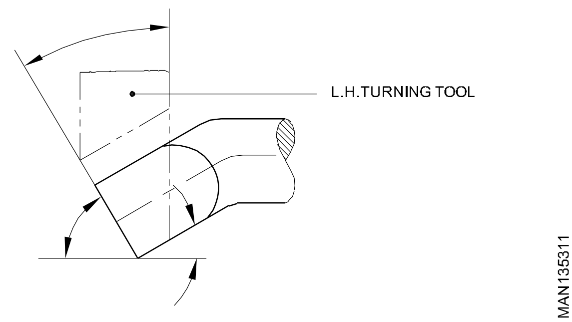
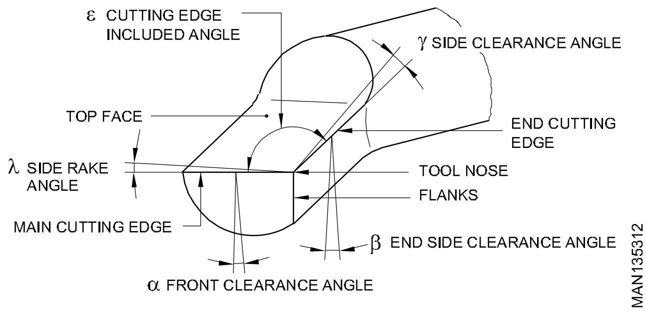


Fig 2



Parts of a rough boring tool (Figs 1,2 & 3)

Types of boring tools

The following are the different types of boring tools.

- Solid forged tools
- Boring bars with bits
- Brazed tools (Fig.4)
- Throw-away bits inserted in special holders.

Fig 3

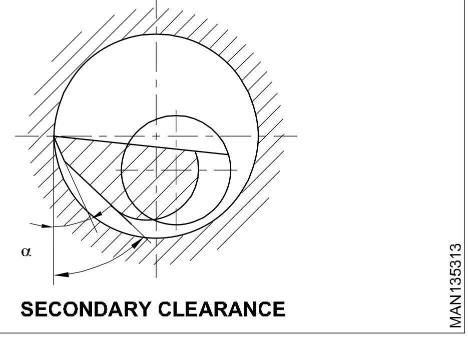
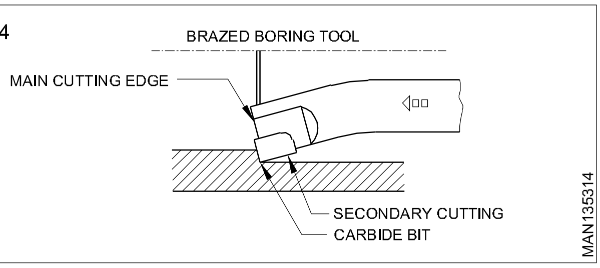


Fig 4

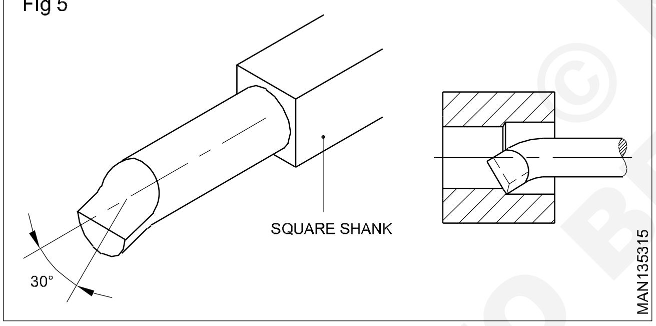


Solid forged tools (Fig 5)

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.

Occasionally tungsten carbide or high speed steel tips are brazed to low carbon bars, for economy.

Fig 5



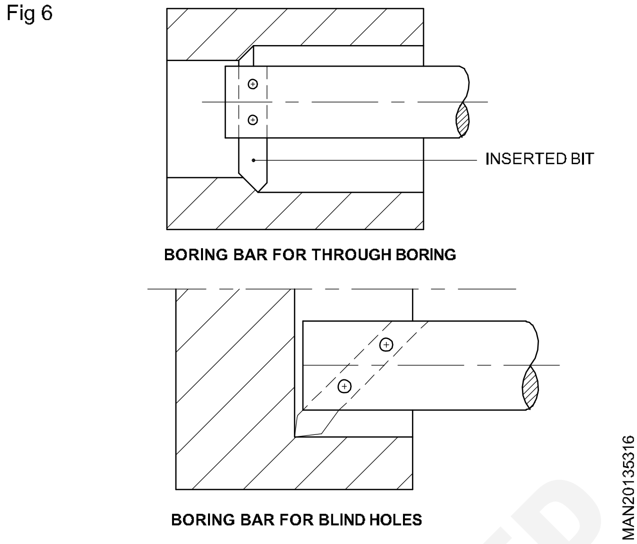
Boring bars with inserted bit (Fig 6)

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.

Fig 6



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.

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**
- **state the different standard tapers and their uses**

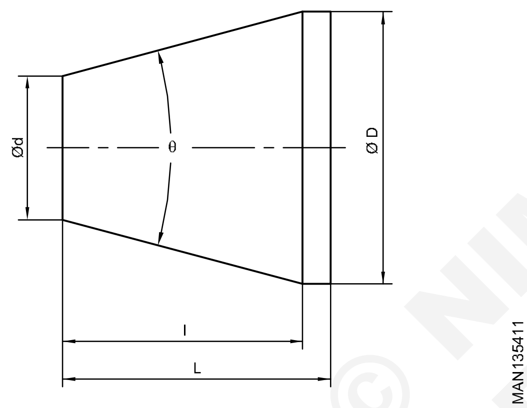
A taper is uniform increase or decrease in diameter along the length of a cylinder.

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.

Fig 1



Elements of taper (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

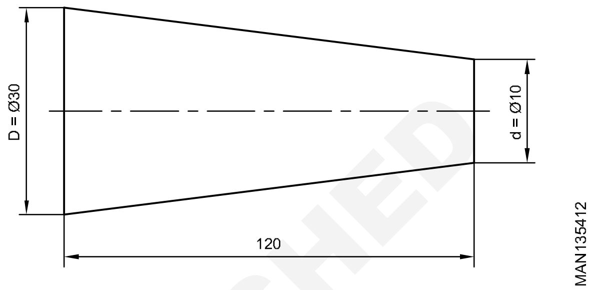


Fig 3

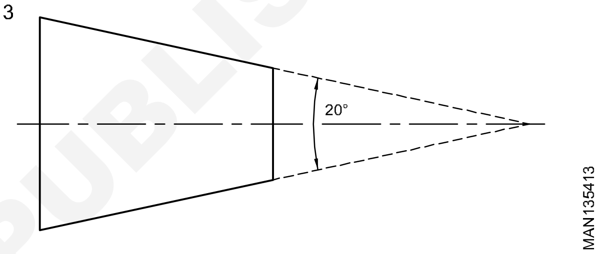


Fig 4

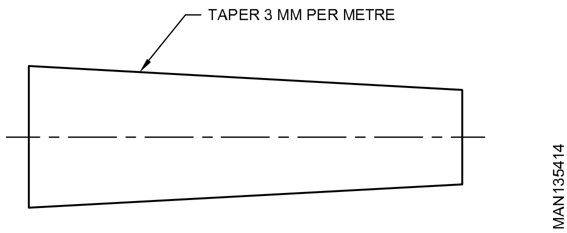
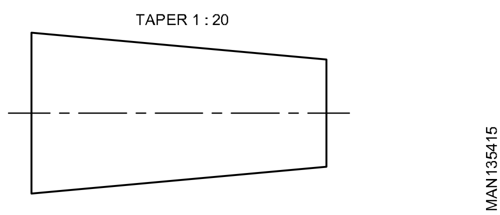


Fig 5



- 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

$$\text{Tan}\ \alpha = \frac{D - d}{2\ell}$$

$$\tan\alpha = \frac{TPF}{24} \text{ or } \frac{TPM}{2000}$$

$$\tan\alpha = \frac{Ratio}{2}$$

Classification of tapers

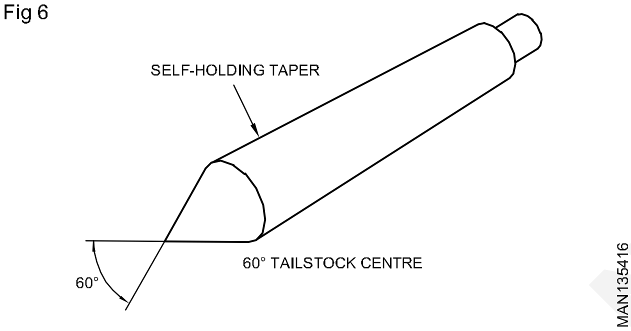
Tapers are classified as

- self-holding tapers
- quick releasing tapers.

Self-holding taper (Fig 6)

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°.

Fig 6



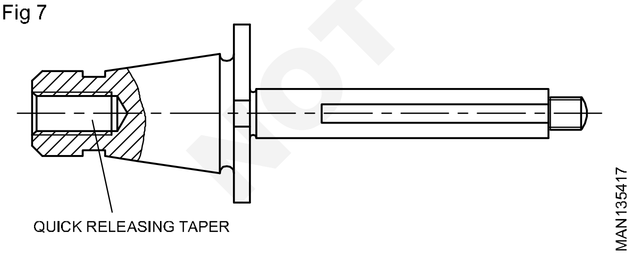
Example

Taper shank of drills, reamers and sleeves.

Quick releasing taper (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.)

Fig 7



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.

Big diameter of taper $= \frac{Number}{8}$

Small diameter of taper $= \frac{Number}{10}$

Length of taper $= \frac{Number}{2}$

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
- **state 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:

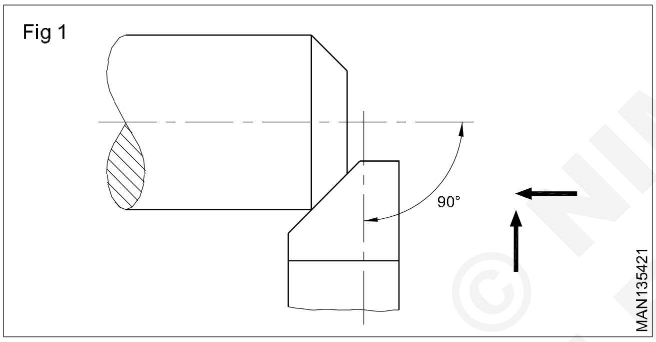
- form tool method
- compound rest method
- tailstock offset method
- taper turning attachment method
- taper turning by combining feeds.

Form tool method (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.

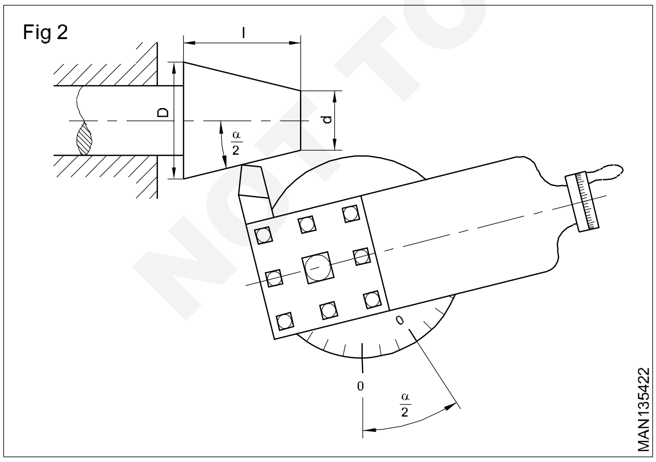
Fig 1



Compound rest method (Fig 2)

In this method, the compound rest is swiveled to half the included angle of the taper, and the taper is turned by feeding the top slide.

Fig 2



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 diameter of taper

d = small diameter of taper

ℓ = length of taper

$\frac{\alpha}{2}$ = 1/2 included angle in degrees.

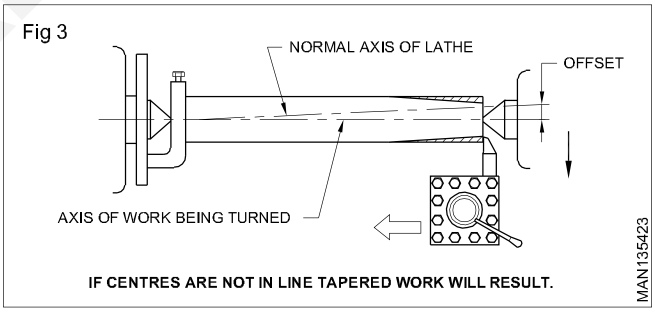
Advantages

- 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.

Fig 3



Tailstock offset method (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 diameter of taper

d = small diameter of taper

ℓ = taper length

L = total length of the job.

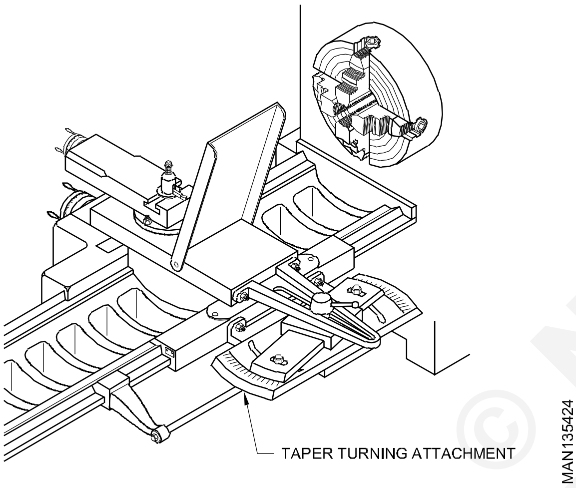
Advantages

- 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.

Fig 4



Taper turning attachment method (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

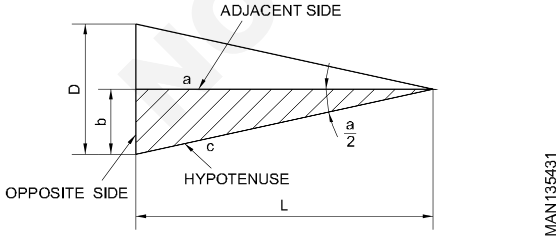
- Use is limited to turning of slow taper angles only.

Calculation of the compound slide swivel angle

Objectives : At the end of this lesson you shall be able to
- **derive a formula to determine the swivel angle**
- **solve problems involving taper calculation**
- **refer to tables and determine the value of the angle for the arrived result**
- **determine the depth of cut to reduce the taper length**

Derivation of the formula

Fig 1



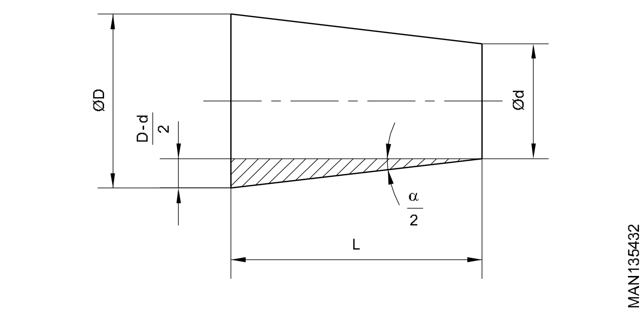
For convenience a tapered job whose small diameter is zero is taken (Fig 1) to illustrate as to how the formula can be derived.

The taper is divided into two angled triangles by the centre line. By referring to the shaded right angled triangle in (Fig 1) the side (b) shown against the half included angle of taper θ/2, is termed as the opposite side. The side (a) is termed as the adjacent side and side (c) is termed as the hypotenuse. There is a relationship between the sides of the triangle and the θ/2. They can be expressed as ratios. The ratio of the sides (b) and (a) is a constant value for a given angle θ/2. This ratio b/a does not change for a given value of θ/2. This means that if 'b' increase or decrease there will be a proportionate increase or decrease of side 'a' making the ratio b/a constant. This ratio between the opposite side to the adjacent side of an angle in a right angled triangle is referred to as the tangent value of the angle.

The equation for the tangent θ/2 is therefore, Tan θ/2 = b/a. Since this value is the same for a particular angle, the tangent values for all angles are put together into tables under the heading 'Natural Tangents'. Therefore, they need no longer be calculated individually, but can be taken from the tables.

Referring to Fig 2, which has a small diameter also, the shaded triangle D-d refers to 'b' of the formula and l refers to 'a' of the formula.

Fig 2



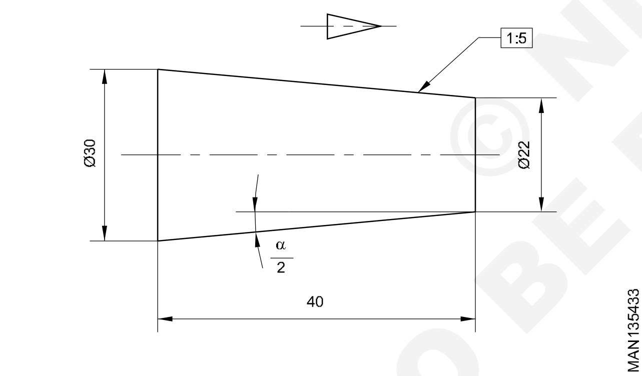
D = 30 mm d = 22 mm & l =40 mm

Now the formula becomes

$$\text{Tan}\,\alpha/2 = \frac{D-d}{\frac{2}{l}} = \frac{D-d}{2xl} = \frac{D-d}{2l}.$$

For example, referring to Fig 3 we have

Fig 3



$$\text{Tangent}\,\alpha/2 = \frac{D-d}{2l} = \frac{30-22}{80}$$

$$= \frac{8}{80} = \frac{1}{10} = 0.1.$$

Referring to the logarithm tables of Natural Tangents we find that the angle whose tangent value is O.1, is 5°. 45', and this is the top slide swivelling angle to turn the tapered job of Fig 3.

Taper expressed as a ratio to determine the swivelangle

The general formula is $\text{Tan}\,\frac{\alpha}{2} = \frac{D-d}{2l}$

This can be rewritten as

$$\text{Tan}\,\frac{\alpha}{2} = \frac{D-d}{l} x \frac{1}{2}$$

This $\frac{D-d}{l}$ is the taper ratio

Hence the formula becomes

$$\text{Tan of half the included angle} = \frac{\text{Taper ratio}}{2}.$$

The taper ratio is given as 1:5

$$\text{Tan of half included angle of taper} = \frac{\text{Taper ratio}}{2}.$$

$$\text{Tan}\,\frac{\alpha}{2} = \frac{1/5}{2} = \frac{1}{10} = 0.1$$

$$\frac{\alpha}{2} = 5°\,45'.$$

The compound slide swivel angle is 5° 45'.

Taper per foot is given to determine the compound slide swivelling angle.

Example

(Given 5/8" TPF)

This means that the different in diameter (D-d) is 5/8" for taper length of 1 foot or 12".

$$\text{Tan}\,\alpha/2 = \frac{D-d}{2l}$$

There D - d =5/8" and l = 12"

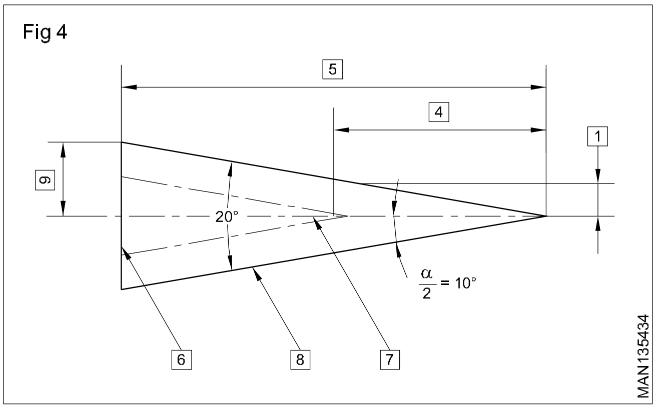
$$\text{Tan}\,\alpha/2 = \frac{\frac{5"}{8}}{2 \times 12} = \frac{5}{8x24} = 0.0260$$

$$\alpha/2 = 1°26'$$

$$\text{The formula is Tan of half included} = \frac{\text{Taper per foot}}{24}$$

Remember that it is half included angle of the taper to which the tops slide is to be swivelled

To determine the depth of cut to be given to get a definite in length of the taper, the taper angle remaining same. (Fig 4)



Referring to Fig4, 9 is the radius at the bigger end, (also the difference in diameter divided by 2, since the small diameter of the taper is zero) 5 is the length of the taper, 4 is the change in the taper length, 1 is the depth of cut to be given to get the change in taper length.

6 Opposite side to $\frac{\alpha}{2}$

7 Adjacent side

8 Hypotenuse

Then I = 4 x tan α/2.

Example

The taper length 5 of Fig 4 with an included angle of 20° is to be shortened by 2 mm. What should be the depth of cut?

$$I = 4 \times \tan \frac{\alpha}{2}$$

$$1 = 2 \text{ mm} \times \frac{\tan 20^\circ}{2}$$

=2 mm x tan 10°

=2 x 0.1763

= 0.3526 mm.

Hence a depth of cut of 0.35 mm is to be given in order to reduce the taper length by 2 mm, the taper included angle remaining the same 20°.

Taper turning by offsetting tailstock

Objectives : At the end of this lesson you shall be able to
- **describe the amount of offset by expressing the diameter**
- **describe the amount of offset by expressing TPF**

Calculation of the amount of offset

If the taper is expressed by giving the big diameter (D) the small diameter (d) the length of taper (l), then

$$\text{offset} = \frac{(D-d)\times L}{2l}$$

Where L = total length of job

Example

The big diameter of a tapered job (D) = 30 mm.

The small diameter of the tapered job (d) = 26 mm.

The length of taper portion (l) = 100 mm.

Total longth of job (L) = 200 mm

$$\text{offset} = \frac{(D-d)\times L}{2l}$$

$$= \frac{(30-26)\times 200}{2\times 100}$$

$$= \frac{4\times 200}{2\times 100}$$

= 4 mm

If the taper is expressed in TPF then the amount of offset

$$= \frac{TPF\times L}{2}$$

where TPF is given in inches

L = total length of job

If taper is expressed as a ratio then the amount of offset

$$= \frac{\text{ratio}\times L}{2}$$

If taper is expressed by included angle i.e. 2

Offset = L x tan θ

where L = total length

= 1/2 included angle in degrees.

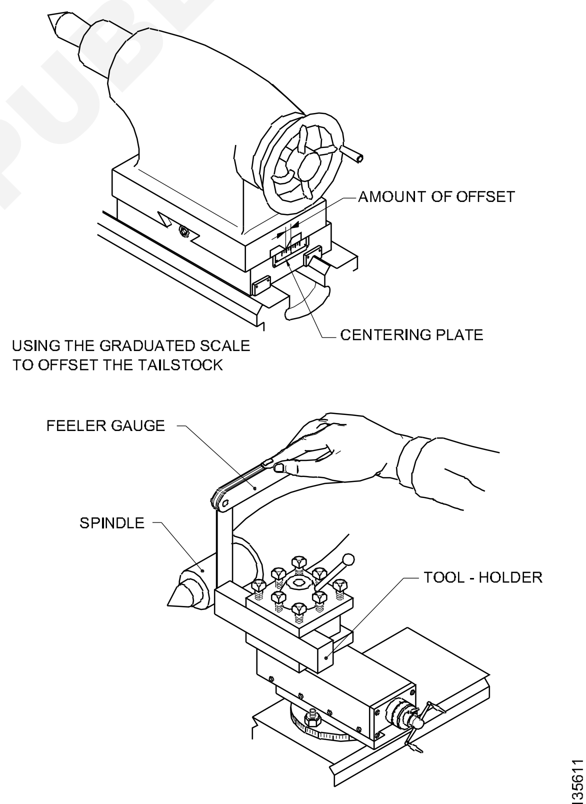
Different methods of offsetting the tailstock (Fig 1)

Setting offset with the help of the inside measuring jaws of a vernier caliper to the required mm, if direct graduation is not provided on the base of the tailstock.

Using a dial test indicator.

Using a cross-slide graduated collar and feeler gauge.

Fig 1



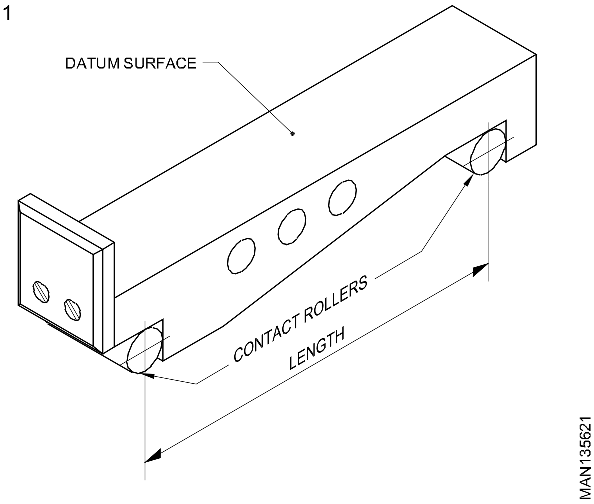
USING A FEELER GAUGE TO OFFSET THE TAILSTOCK

Sine bar - Description and uses

Objectives: At the end of this lesson you shall be able to
- **state the principle of a sine bar**
- **state 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

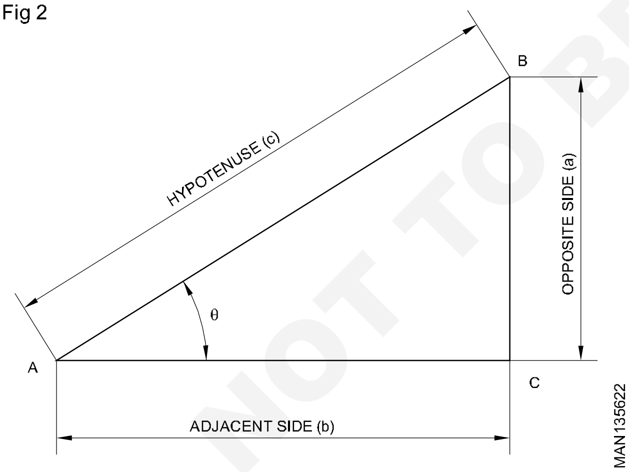


The principle of a sine bar

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.

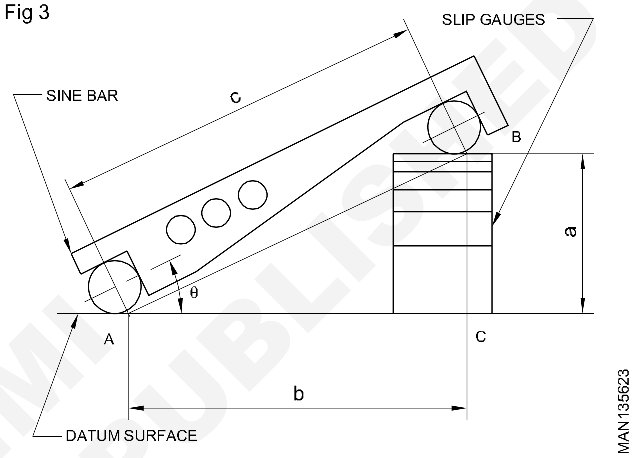
The sine bar, the slip gauges and the datum surface upon which they are set to form a right angled triangle. (Fig 3)

The sine bar forms the hypotenuse (c) and the slip gauge stack forms the side opposite (a).

Sin of the angle $\theta = \dfrac{\text{Opposite side}}{\text{hypotenuse}}$

$$\text{Sin}\,\theta = \frac{a}{c}$$

Fig 3



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

- measuring angles (Fig 4)
- marking out (Fig 5)
- setting up for machining. (Fig 6)

Fig 4

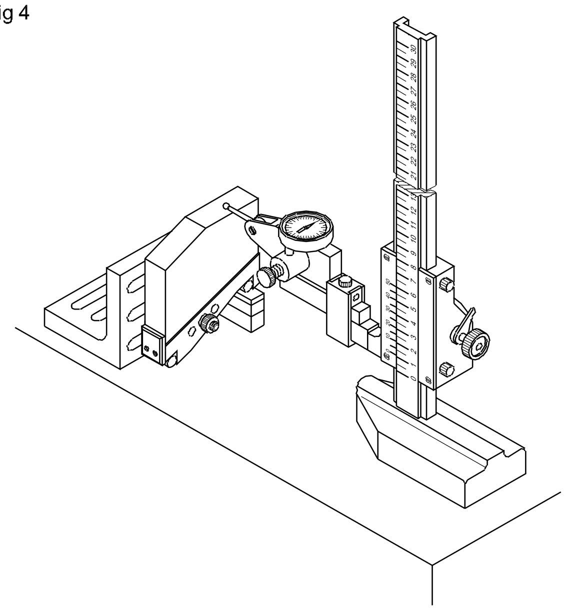


Fig 6

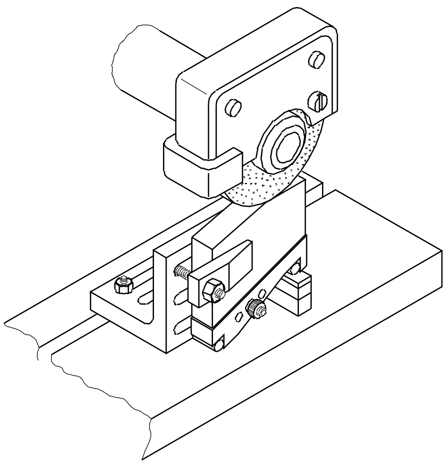
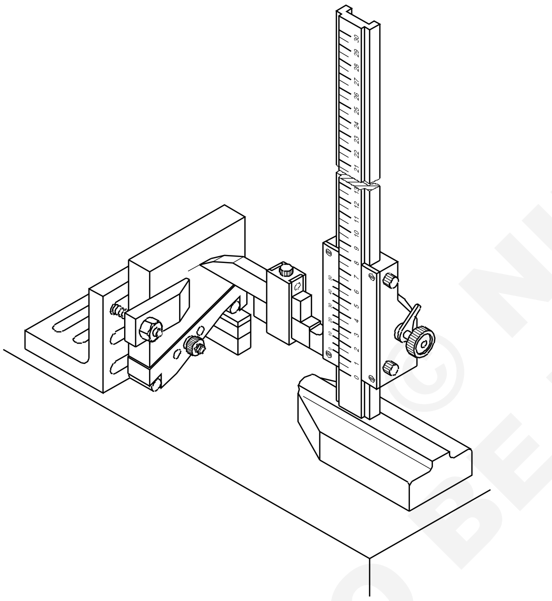


Fig 5



Determining taper using sine bar and slip gauges

Objectives: At the end of this lesson you shall be able to
- **state correctness of a known angle**
- **explain 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°.

The use of a sine bar is based on trigonometric function. The sine bar forms the hypotenuse of the triangle and the slip gauges form 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)

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.

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

Fig 1

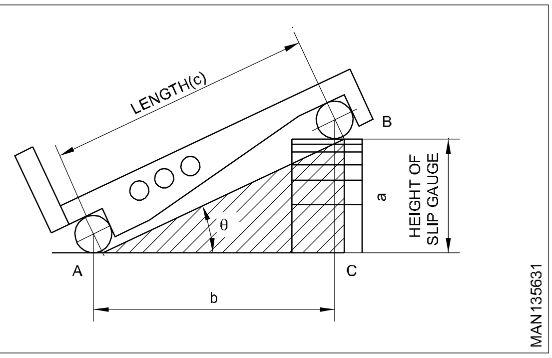
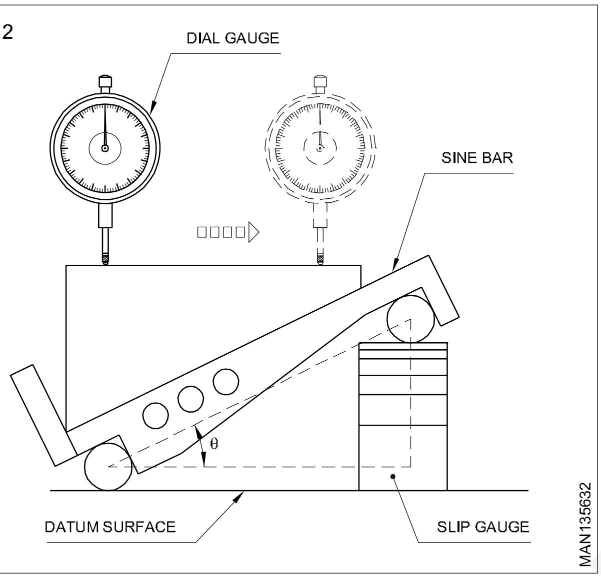


Fig 2

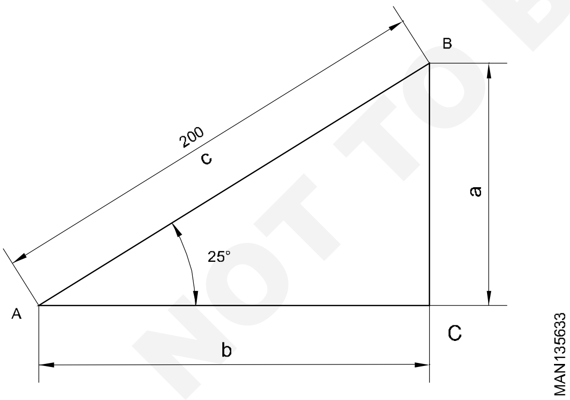


until the dial test indicator reads zero on both ends. The actual angle can then be calculated and the deviation, if any, will be the error.

Method of calculating the slip gauge height

Example (Fig 3)

Fig 3



Example 1

To determine the height of slip gauge for an angle of 25° using a sine bar of 200 mm long.

$$\text{Sin}\,\theta = \frac{a}{c}$$

$\theta = 25^\circ$

a = C Sine θ

= 200 x 0.4226

a = 84.52 mm

The height of the slip gauge required is 84.52 mm.

The value of sinθ 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.

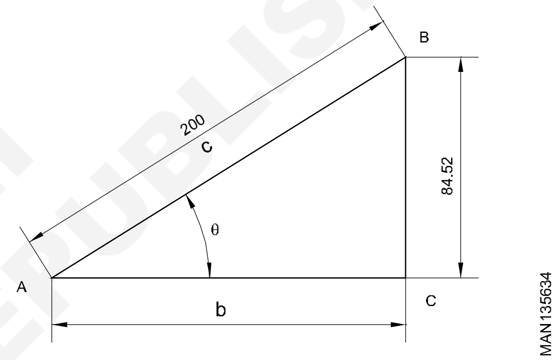
Calculating the angle for tapered components

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)

Fig 4



$$\text{Sin}\,\theta = \frac{a}{c}$$

$$= \frac{84.52}{200}$$

Sine θ = 0.4226

The angle whose sine value is 0.4226 is 25°. Hence the angle of tapered component is 25°.

Classroom Assignment

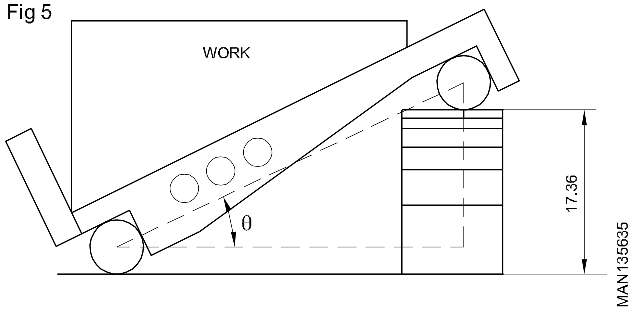
1 What will be the angle of the workpiece if the slip gauge pack height is 17.36 mm and the size of the sine bar used is 100 mm? (Fig 5)

Answer ____________________

2 Calculate the height of the slip gauge pack to raise a 100 mm sine bar to an angle of $3^\circ\ 35^1$.

Answer ____________________

Fig 5

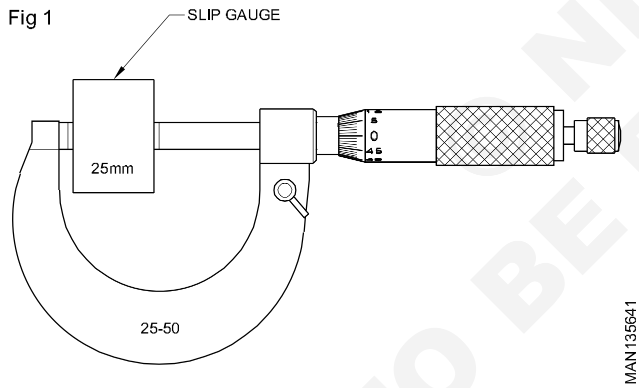


Slip gauges

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.**

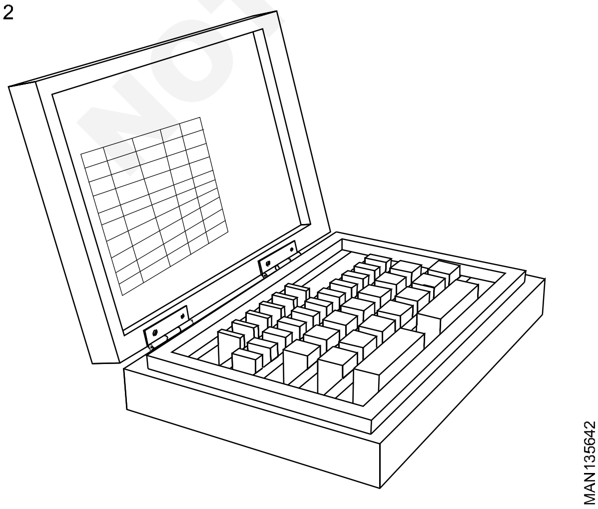
Slip gauges or gauge blocks are used as standards for precision length measurement. (Fig 1) These are made in sets and consist of a number of hardened blocks, made of high grade steel with low thermal expansion. They are hardened throughout, and heat treated further for stabilization. The two opposite 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)

Fig 2



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.

Fig 3

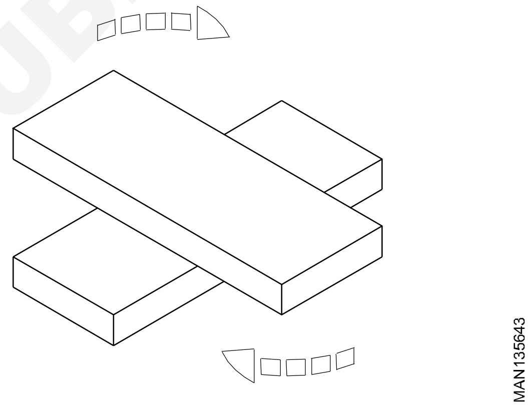
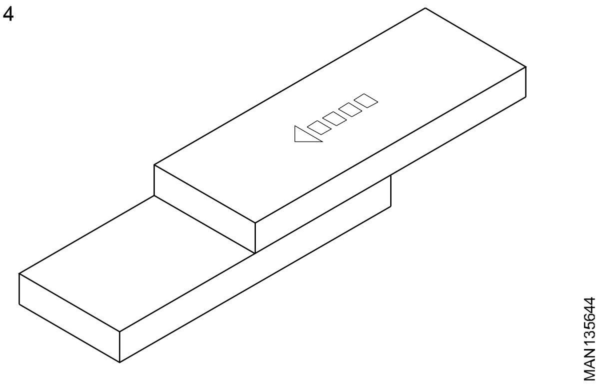


Fig 4



some slip gauge sets are made up of high wear resistant materials like steel or tungsten carbide with standard thickness called as “protractor slip” 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 gauges are recommended as per IS 2984 - 1981

Grade 00, Grade 0, grade 1, grade 2 in this grades 0,1 and 2 are intended for general use.

Grade '00' is kept in the standards room and it used for inspection/calibration of high precision only.

Grade '0' is an inspection - grade slip gauge. It is used for inspection purpose with limited use.

Grade '1' is used for tool room application for setting up a sine bar, dial indicators, calibration of Vernier micrometer

Grade '2' this grade is the workshop - grade slip gauges used for setting tools, cutters and checking dimensions roughly on the shop floor.

B.I.S recommendations:

Bureau of Indian standards (B.I.S) recommended three grades of slip gauges as per IS 2984, they are.

- 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).

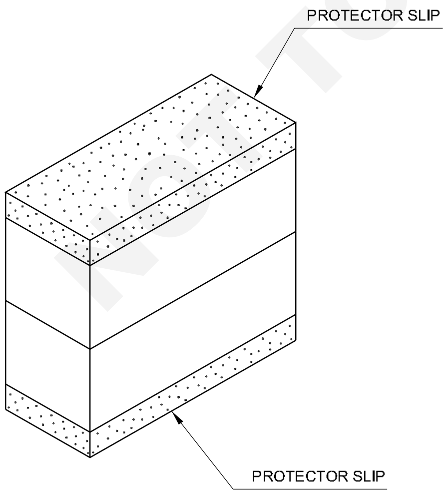
Use a minimum number of blocks as far as possible while building up a particular dimension.

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



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 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**

Set of 9 pieces (M 9)

Range (mm)	Steps (mm)	No.of pieces
1.001 to 1.009	0.001	9

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)

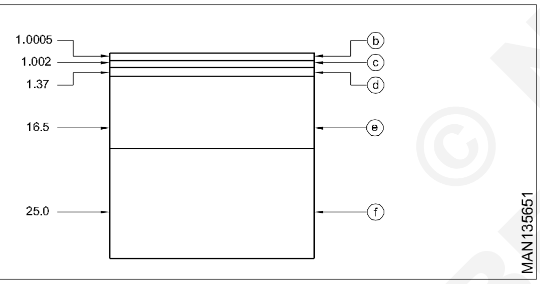
Set of 112 pieces

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

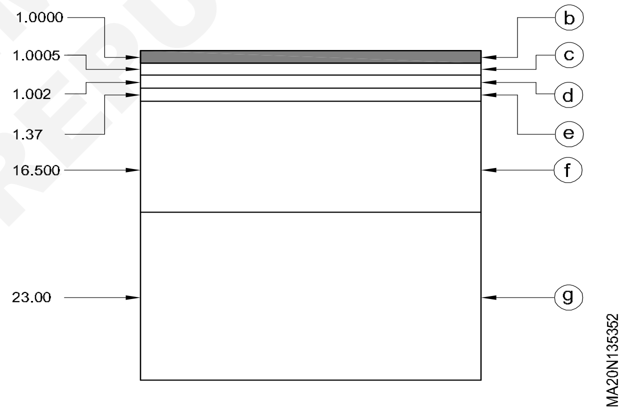
Procedure	Slip pack	Calculation
a First write the required dimension.		44.8725
b Select the slip gauge having the 4th decimal place.	1.0005 Subtract	1.0005 43.872
c Select 1st series slip that has the same last figure.	1.002 Subtract	1.002 42.87
d Select the 2nd series slip that has the same last figure and that will leave .0 or 0.5 as the last figure.	1.37 Subtract	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 Subtract	16.5 25.00
f Select a slip that eliminates the final figure. Add	25.0 Subtract 44.8725	25.00 0

Fig 1



Procedure	Slip gauge pack	Calculation
a First write the . required dimension		44.8725
b Two numbers of protectorslips of 1mm each	2.000 Subtract	2.0000 42.8725
c Select the slip gauge having the 4th decimal place	1.0005 Subtract	1.0005 41.8720
d Select 1st series slip that has the same last figure	1.002 Subtract	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 Subtract	1.3700 39.5000
f Select a 3rd series slip that will leave the nearest 4th series slip	16.5000 Subtract	16.5000 23.0000
g Select a slip that eliminates the final figure	23.0000 Subtract	23.0000

Fig 2



Care and maintenance of slip gauges & sine bar

Objective: At the end of this lesson you shall be able to

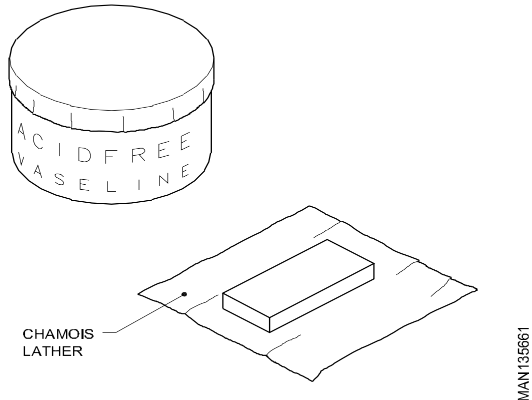
- **state the preventive measures to be taken for protecting slip gauges and sine bar**

Precision measuring instruments play an important role in maintaining the quality of the products. Measuring Instruments are also very expensive. It is important that the instruments are well looked after and maintained by the person who uses it.

Protection against corrosion: High atmospheric humidity and sweat from hands can cause corrosion to instruments. Avoid this. Acid-free vaseline (petroleum jelly) applied lightly on the instruments can give protection against corrosion. (Fig 1)

Be sure that the instruments are thoroughly cleaned and free from water or moisture before applying vaseline Use chamois leather for giving a light coating of vaseline. Always clean the slip gauges with carbon tetrachloride and apply petroleum jelly after use.

Fig 1



Types of thread

Objectives : At the end of this lesson you shall be able to
- **explain the various types of 'V' threads used for thread fastening**
- **distinguish between the features of different 'V' thread forms**
- **designate the different types of 'V' threads.**

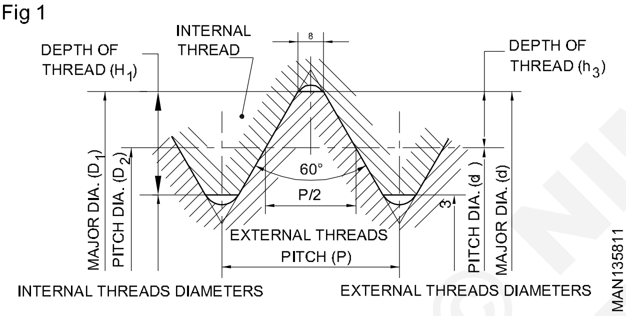
Types of 'V' threads

'Vee' threads are available in different standards. The type of 'Vee' threads used for general engineering threaded fasteners are:

- ISO metric thread
- ISO inch (unified thread)
- British Standard Whitworth thread
- British Standard fine thread.

ISO metric thread (Fig 1)

Fig 1



This is the form of thread approved by B.I.S. for threaded fastening. Two series of threads have been identified by them. They are:

- **ISO metric : coarse**
- **ISO metric : fine.**

The thread angle is 60°. The root of the external thread is rounded. The crest of the external thread is flat, but sometimes it is rounded depending on the type of the manufacturing process. The root of the internal thread is cleared beyond the width equal to one eighth of the pitch, and is rounded. The crest of the internal thread is left flat.

Designation of ISO metric thread

ISO metric coarse thread is designated as M12 and fine thread as M12 x 1.25 etc.

Example M 12

The symbol M indicates that it is ISO metric thread and 12 indicates the diameter of the thread. For the coarse series the pitch of the threads is standardized for each diameter.

ISO Metric fine threads are designated as,

M12 x 1.25.

The addition of 1.25 in this case indicates the pitch of the thread.

ISO inch (unified) thread

The ISO inch system (unified) is a recognized standard for interchangeability with the American National Thread.

These threads are used for general purpose engineering fastening, and are of two types.

- Unified coarse (UNC)
- Unified fine (UNF)

For unified threads the angle is 60°. The thread profile is similar to that of the ISO metric thread.

Designation of ISO inch (unified) threads

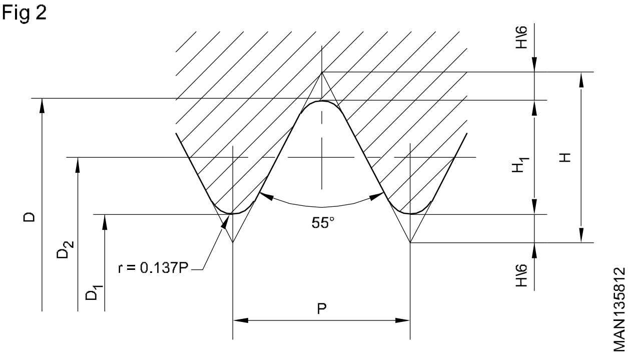
Examples a) 1/4 20 UNC

b) 1/4 28 UNF

Example(a) indicates that the diameter of the thread is 1/4", it has 20 threads per inch (TPI) and the ISO thread series is UNC (unified coarse). Example (b) has 28 TPI and is of UNF series.

British Standard Whitworth (BSW) thread (Fig 2)

Fig 2



This thread is gradually being replaced by ISO metric thread. However, the application of this thread is still being continued in a limited manner, particularly in the production of spare parts and repair works.

These threads have a 55° angle, and are rounded at the crest and the root. There are a definite number of threads per inch for a particular diameter.

These threads are designated by the diameter in inches followed by the abbreviation of the thread series.

Example - 1/2" BSW

British Standard fine (BSF) thread

This thread has the same form as BSW, but with fine pitches.

The threads are designated by the diameter in inches followed by the thread series.

Example - 3/8" BSF.

Square and trapezoidal threads

Objectives : At the end of this lesson you shall be able to

- **state the relationship between the pitch and the other elements of square threads**
- **explain square thread and its applications**
- **explain different forms of trapezoidal threads and their uses**
- **state the relationship between the pitch and the other elements of all the different forms of trapezoidal threads.**

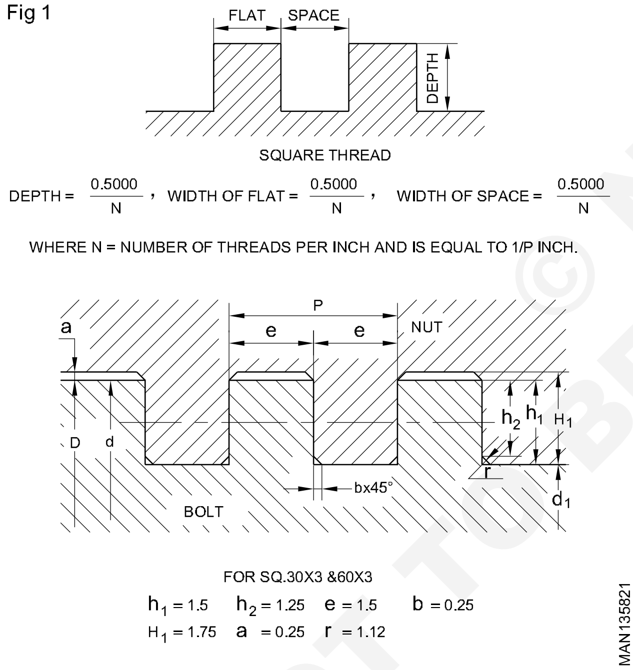
Square and trapezoidal threads

Square and trapezoidal threads have more cross-sectional area than 'V' threads. They are more suitable to transmit motion or power than 'V' threads. They are not used for fastening purposes.

Square thread

In this thread the flanks are perpendicular to the axis of the thread. The relationship between the pitch and the other elements is shown in Fig 1.

Fig 1



Square threads are used for transmitting motion or power. Eg. screw jack, vice handles, cross-slide and compound slide, activating screwed shafts.

Designation

A square thread of nominal dia. 60mm and pitch 9mm shall be designated as Sq. 60 x 9 IS: 4694-1968. The dimensions a, b, e, p, H1, h1, h2 & d1 are changed as per thread series (fine, normal & coarse).

Modified square thread

Modified square threads are similar to ordinary square threads except for the depth of the thread. The depth of thread is less than half pitch of the thread. The depth varies according to the application. The crest of the thread is chamfered at both ends to 45° to avoid the formation of burrs. These threads are used where quick motion is required.

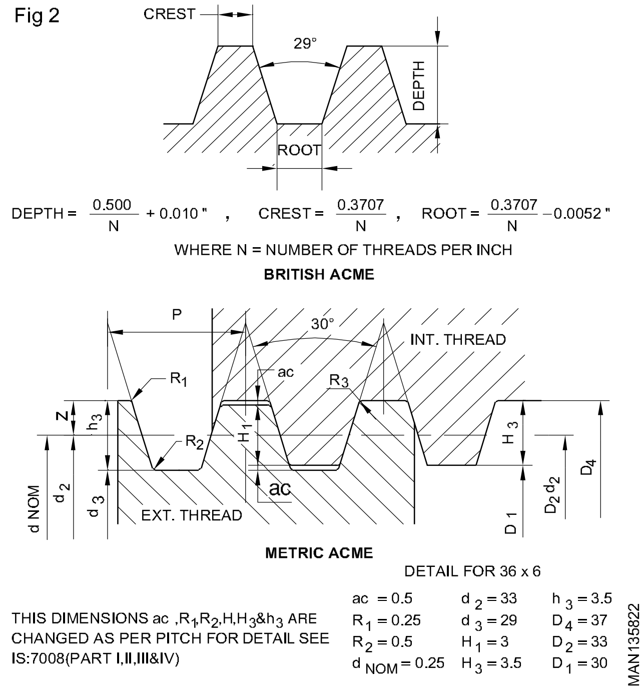
Trapezoidal threads

These threads have a profile which is neither square nor 'V' thread form and have a form of trapezoid. They are used to transmit motion or power. The different forms of trapezoidal threads are:

- acme thread
- buttress thread
- saw-tooth thread
- worm thread.

Acme thread (Fig 2)

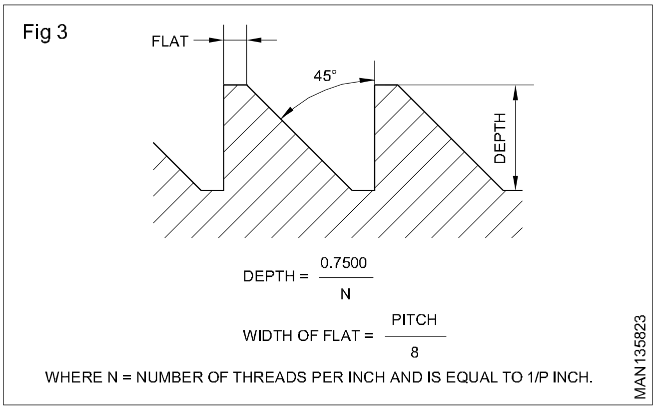
Fig 2



This thread is a modification of the square thread. It has an included angle of 29°. It is preferred for many jobs because it is fairly easy to machine. Acme threads are used in lathe lead screws. This form of thread enables the easy engagement of the half nut. The metric acme thread has an included angle of 30°. The relationship between the pitch and the various elements is shown in the figure.

Buttress thread (Fig 3)

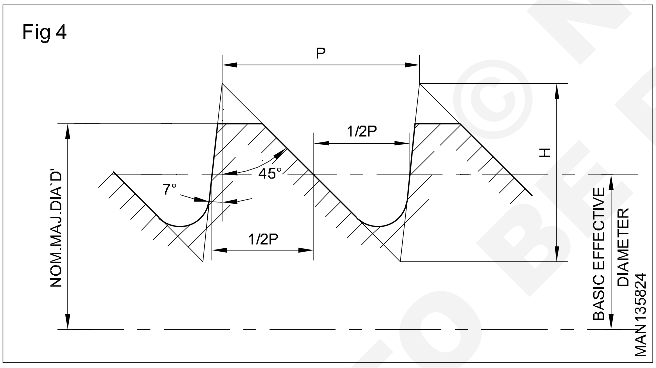
Fig 3



In buttress thread one flank is perpendicular to the axis of the thread and the other flank is at 45°. These threads are used on the parts where pressure acts at one flank of the thread during transmission. Figure 3 shows the various elements of a buttress thread. These threads are used in power press, carpentry vices, gun breeches, ratchets etc.

Modified buttress thread as per B.I.S. (Fig 4)

Fig 4



This is a modified form of the buttress thread. Figure 4 shows the various elements of the modified buttress thread. The bearing flank is inclined by 7° as per B.I.S. and the other flank has a 45° inclination.

Saw-tooth thread as per B.I.S. 4696

This is also a modified form of buttress thread. In this thread, the flank taking the load is inclined at an angle of 3°, whereas the other flank is inclined at 30°. The basic profile of the thread illustrates this phenomenon. (Fig 5) The proportionate values of the dimensions with respect to the pitch are shown in Figs 6 and 7.

The equations associated with the dimensions indicated in the two figures (Figs 6 and 7) are given below.

H1 = 0.75 P

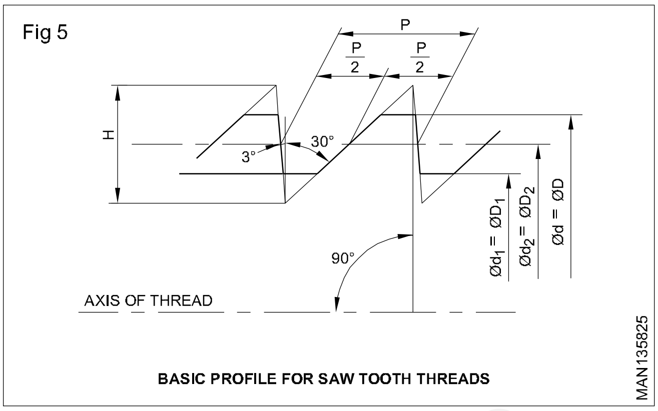
h3 = H1 + ac = 0.867 77 P(where 'P' is the axial play)

a = 0.1 x P (axial play)

ac = 0.117 77 P

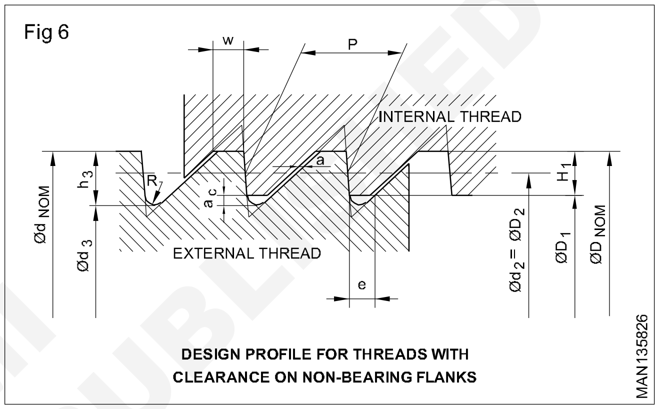
W = 0.263 84 P

Fig 5



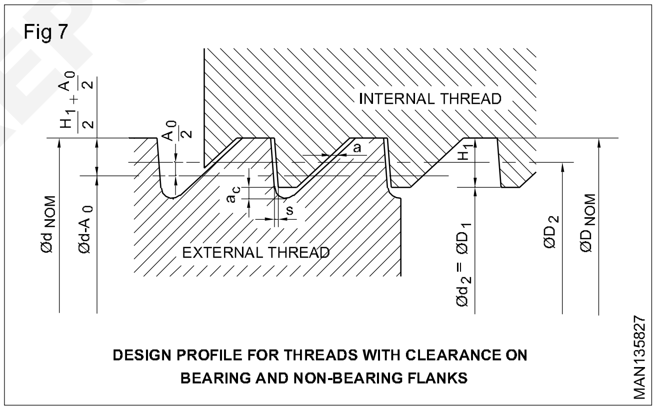
BASIC PROFILE FOR SAW TOOTH THREADS

Fig 6



DESIGN PROFILE FOR THREADS WITH CLEARANCE ON NON-BEARING FLANKS

Fig 7



DESIGN PROFILE FOR THREADS WITH CLEARANCE ON BEARING AND NON-BEARING FLANKS

P = W – a

e = 0.263 84 P – 0.1

R = 0.124 27 P

D1 = d – 2 H1 = d – 1.5 P

d3 = d – 2 h3

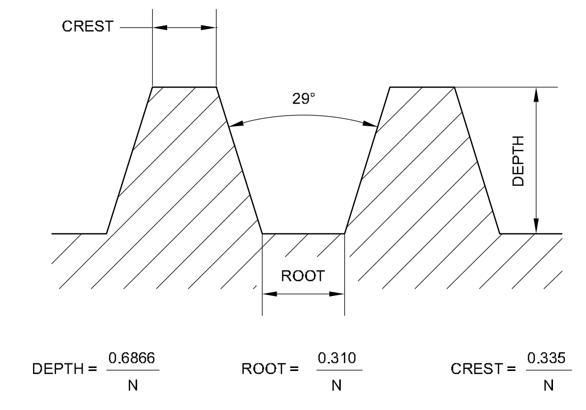
d2 = D2 = d – 0.75 P

S = 0.314 99 Ao, where Ao = basic deviation = (upper deviation) for external thread in the pitch diameter.

Worm thread

This is similar to the acme thread in shape but the depth of thread is more than that of the acme thread. This thread is cut on the worm shaft which engages with the worm wheel. Figure 8 shows the elements of a worm thread.

Fig 8



WORM THREAD

The worm wheel and worm shaft are used in places where motion is to be transmitted between shafts at right angles. It also gives a high rate of speed reduction. The worm wheel is generally cut by diametral pitch (D.P) or module pitch cutters. Diametral pitch (D.P) is the ratio between the number of teeth to the pitch diameter (P.D.) of the gear.

Module is the ratio between the pitch diameter of the gear and the number of teeth of the gear.

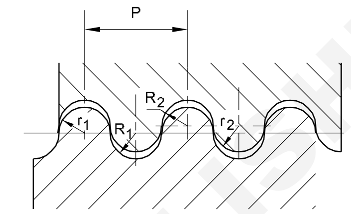
The linear pitch of the worm thread must be equal to the circular pitch of the worm gear. When the worm gear is of D.P. then the linear pitch of the worm thread in mesh is equal to π/DP. When the worm gear is of module teeth, then the linear pitch of the worm thread is equal to module xπ.

In some of the lathes, a chart illustrates the position of levers of the quick change gearbox together with the change gear connections for cutting D.P. or module worm threads.

Knuckle threads

The shape of the knuckle thread is not trapezoidal but it is round in shape. It has limited application. The figure shows the form of knuckle thread. It is not sensitive against damage as it is rounded. It is used for valve spindles, railway carriage couplings, hose connections etc. (Fig 9)

Fig 9



BASIC PROFILE OF KNUCKLE THREAD

Gear calculation for cutting metric thread on british lathe and Vice versa

Objectives : At the end of this lesson you shall be able to
- **state the formula of the gear ratio for cutting metric thread on a British lathe**
- **state the formula of the gear ratio for cutting British thread on a metric lathe**
- **solve the problems involving cutting metric thread on British lathe and vice versa.**

Gear ratio for cutting metric thread on British lathe

The formula of the gear ratio for cutting metric thread on a metric lathe is

$$\frac{\text{Driver}}{\text{Driven}} = \frac{\text{Lead to be cut on the job}}{\text{Lead of lead screw}}.$$

Now, for cutting metric thread on a British lathe, the lead of the work to be cut in mm is converted to inches by multiplying with the constant 5/127.

Because 25.4 mm = I"

1 mm = 1/25.4"

= 10/254

= 5/127"

Therefore, Gear ratio

$$\frac{DR}{DN} = \frac{\text{Lead to be cut in mm on job x 1 x 5}}{\text{Lead of L.S x 127}}$$

$$\frac{DR}{DN} = \frac{\text{Lead to be cut in mm on job x T.P.I on L.S x 5}}{127}$$

A translating gear of 127 teeth is provided for cutting metric thread on a British lathe. This gear wheel is used as the driven wheel. The worked out example illustrates this statement.

Gear ratio for cutting British thread on metric lathe

The general formula for cutting British thread on a British lathe is

$$\frac{DR}{DN} = \frac{\text{Lead to be cut on job}}{\text{Lead of lead screw}}.$$

Now for cutting British thread on a metric lathe the lead screw in mm is converted into inches by multiplying with a constant of 5/127.

$$\frac{DR}{DN} = \frac{\text{Lead to be cut in inch on job}}{\text{Lead of lead screw in mm x } \frac{5}{127}}$$

$$\frac{DR}{DN} = \frac{\text{Lead to be cut in inch on job x 1 x 127}}{\text{Lead of lead screw in mm x 5}}$$

$$\frac{DR}{DN} = \frac{1}{\text{T.P.I to be cut}} \times \frac{1}{\text{Lead of lead screw}} \times \frac{127}{5}$$

But in practice, it is advisable to have a larger wheel as a driven gear as far as possible. But in this case the 127 teeth wheel has to be used as a DRIVER only.

Gear ratio for cutting metric thread on British lathe using 63 teeth as driver wheel.

Instead of taking the constant

$\frac{63}{1600}$ is taken because 1 metre = 39.37".

1 metre = 39.375" (approx.)

1000 mm = 39.375" = $39\frac{3"}{8}$

$$1 \text{ mm} = \frac{315}{1000 \times 8}$$

$$= \frac{63}{1600}.$$

Gear ratio

$$\frac{DR}{DN} = \frac{\text{Lead to be in mm x TPI on LS x 63}}{1600}$$

Gear ratio for cutting British thread on metric lathe using the 63 teeth wheel as the driven wheel:

$$\frac{DR}{DN} = \frac{1}{\text{T.P.I to be cut}} \times \frac{1}{\text{Lead of lead screw}} \times \frac{1600}{63}$$

screw in mm

Lathe constant

Lathe constant is the number of threads per inch that can be cut when the change gear ratio is 1 and the ratio between the main spindle gear and the fixed stud gear is also 1.

On some machines the ratio of the spindle gear to the fixed stud gear is more than 1 in which case the lathe constant is equal to:

$$\frac{\text{spindle gear x T.P.I. on lead screw}}{\text{fixed stud gear}}$$

When the lathe constant is given

(Gear ratio for cutting thread)

$$\frac{DR}{DN} = \frac{\text{Lathe constant}}{\text{T.P.I. to be cut}}.$$

Find the gears required to cut 4.5 mm pitch in a lathe having a lead screw of 6 T.P.I. Gears available from 20 to 120 teeth by 5 teeth range with a conversion gear of 127 teeth.

Data.

Lead of work = 4.5 mm

TPI of L.S = 6

Lead of L.S $= \frac{1}{6}$

Gear ratio $= \frac{DR}{DN} = \frac{5}{127} \times \frac{\text{Lead of work}}{\text{Lead of lead screw}}$

$$= \frac{5}{127} \times \frac{4.5}{1/6}$$

$$= \frac{5 \times 6 \times 4.5}{127 \times 1}$$

Now it is not possible to have a change gear train with a simple gear train. So a compound gear train is used,

i.e $\frac{30}{127} \times \frac{4.5}{1}$

$$= \frac{30}{127} \times \frac{45}{10}$$

$$= \frac{45 \times (30 \times 2)}{127 \times (10 \times 2)} = \frac{45}{127} \times \frac{60}{20}$$

45 T & 60 T are drivers

127 T & 20 T are driven.

Problems involving cutting metric threads on British lathe and vice versa

Example 1

Find the gears required to cut a 3 mm pitch in a lathe having a lead screw of 6 T.P.I. Gears available from 20 to 120 teeth by 5 teeth with a special gear of 127 teeth.

Data given

Lead of work $= 3$ mm

T.P.I of L.S $= 6$ T.P.I

Lead of L.S $= \frac{1}{6}$

$$\text{Gear ratio} = \frac{DR}{DN} = \frac{5 \times \text{Lead of work}}{127 \times \text{Lead of lead screw}}$$

$$= \frac{5}{127} \times \frac{3}{1/6}$$

$$= \frac{5}{127} \times \frac{3 \times 6}{1}$$

$$= \frac{90}{127}$$

90 teeth gear is the driver.

127 teeth gear is the driven.

Example 2

Find the gears required to cut 6 T.P.I on job in a lathe having a lead screw of 6 mm pitch.

Gears available from-20 T to 120 by 5 teeth range with a special gear of 127 teeth.

Data

Lead of work = 1/6"

Lead of L/s = 6 mm

$$\text{Gear ratio} = \frac{DR}{DN} = \frac{127}{5} \times \frac{\text{Lead of work}}{\text{Lead of L.S}}$$

$$= \frac{127}{5} \times \frac{1/6}{6} = \frac{127}{30} \times \frac{(1 \times 20)}{(6 \times 20)}$$

$$= \frac{127}{30} \times \frac{20}{120}$$

20 T and 127 T are drivers

30 T and 120 T are driven

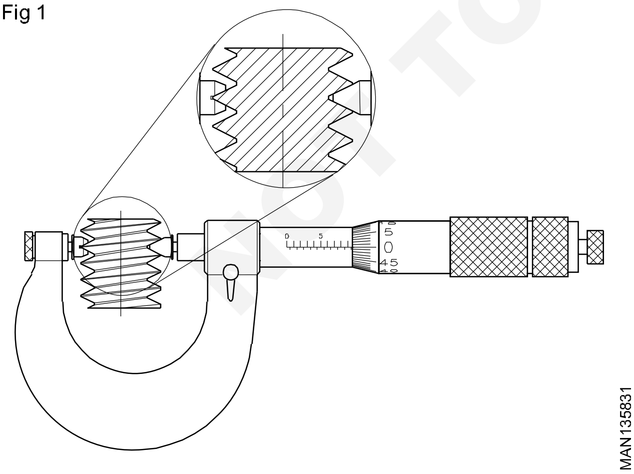
Measurement of threads by three wire methods

Objectives : At the end of this lesson you shall be able to
- **state the features of a screw thread micrometer**
- **state the features of the three-wire system of measurement with the help of tables**

The screw thread micrometer

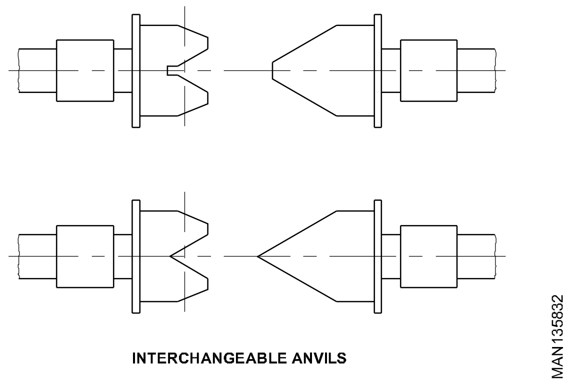
This micrometer (Fig 1) is used to measure the effective diameter of the screw threads. This is very similar to the ordinary micrometer in construction but has facilities to change the anvils.

Fig 1



The anvils are replaceable and are changed according to the profile and pitch of the different systems of threads. (Figs 2 & 3)

Fig 2



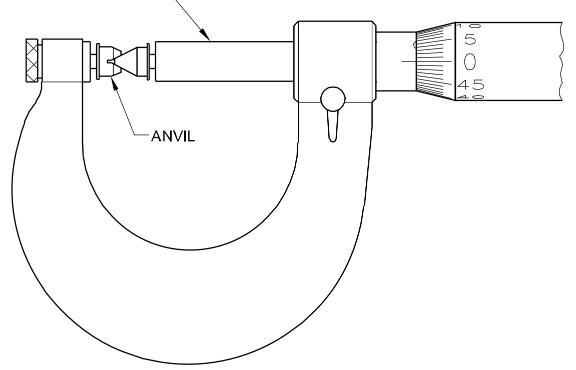
The three-wire method

This method uses three wires of the same diameter for checking the effective diameter and the flank form. The wires are finished with a high degree of accuracy.

The size of the wire used depends on the pitch of the thread to be measured.

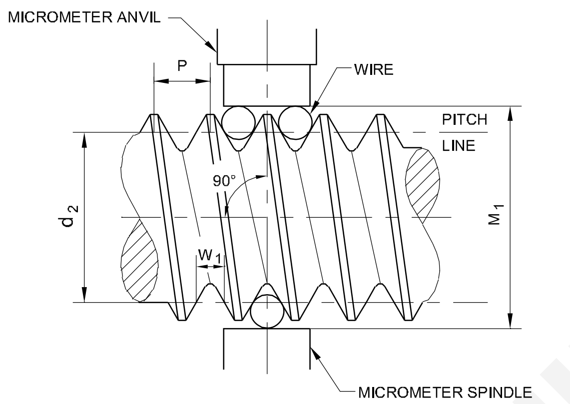
For measuring the effective diameter the three wires suitable for the thread pitch are placed between the threads. (Fig 4)

Fig 3



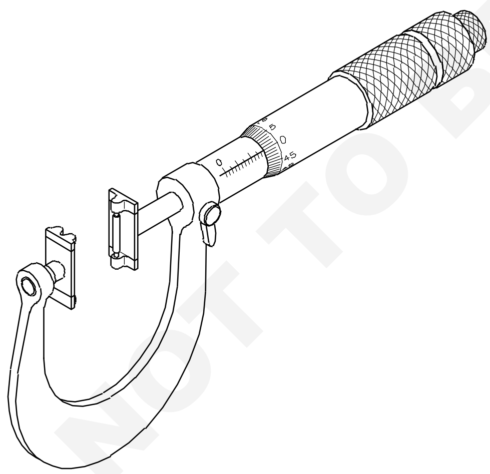
SPINDLE AND ANVIL OF MICROMETER AT ZERO SETTING

Fig 4



The measuring wires are fitted in wire-holders which are supplied in pairs. One holder has provisions to fix one wire, and the other two wires. (Fig 5)

Fig 5



While measuring the screw thread, the holder with one wire is placed on the spindle of the micrometer and the other holder with two wires is fixed on the fixed anvil. (Fig 6)

Fig 6

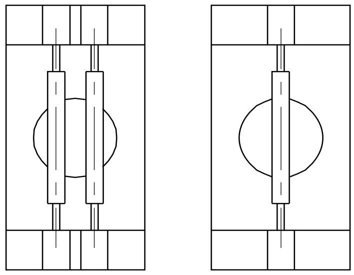


TABLE 1

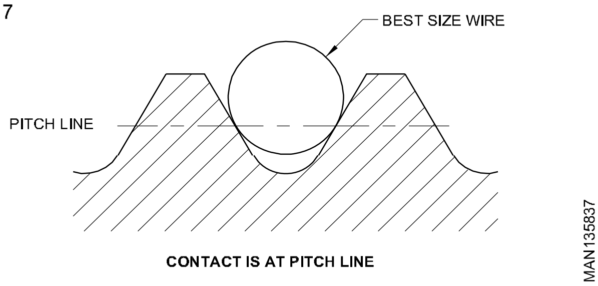
Measurement with measuring wires. Metric threads with coarse pitch (M)

Thread designation	Pitch P mm	Basic measurement d_2 mm	Measuring wire dia. mean W_1 mm	Dimension over wire M_1 mm
M 1	0.25	0.838	0.15	1.072
M 1.2	0.25	1.038	0.15	1.272
M 1.4	0.3	1.205	0.17	1.456
M 1.6	0.35	1.373	0.2	1.671
M 1.8	0.35	1.573	0.2	1.870
M 2	0.4	1.740	0.22	2.055
M 2.2	0.45	1.908	0.25	2.270
M 2.5	0.45	2.208	0.25	2.569
M 3	0.5	2.675	0.3	3.143
M 3.5	0.6	3.110	0.35	3.642
M 4	0.7	3.545	0.4	4.140
M 4.5	0.75	4.013	0.45	4.715
M 5	0.8	4.480	0.45	5.139
M 6	1	5.350	0.6	6.285
M 8	1.25	7.188	0.7	8.207
M 10	1.5	9.026	0.85	10.279
M 12	1.75	10.863	1.0	12.350
M 14	2	12.701	1.15	14.421
M 16	2	14.701	1.15	16.420
M 18	2.5	16.376	1.45	18.564
M 20	2.5	18.376	1.45	20.563
M 22	2.5	20.376	1.45	22.563
M 24	3	22.051	1.75	24.706
M 27	3	25.051	1.75	27.705
M 30	3.5	27.727	2.05	30.848

Selection of 'best wire' (Fig 7)

The best wire is the one which, when placed in the thread groove, will make contact at the nearest to the effective diameter. The selection of the wire is based on the type of thread and pitch to be measured.

Fig 7



The selection of the wire can be calculated and determined but readymade charts are available from which the selection can be made.

TABLE 2

Measurement with measuring wires. Metric threads with fine pitch (M)

Thread designation	Basic measurement d_2 mm	Measuring wire dia. mean W_1 mm	Dimension over wire M_1 mm
M 1 x 0.2	0.870	0.12	1.057
M 1.2 x 0.2	1.070	0.12	1.257
M 1.6 x 0.2	1.470	0.12	1.557
M 2 x 0.25	1.838	0.15	2.072
M 2.5 x 0.35	2.273	0.2	2.570
M 3 x 0.35	2.773	0.2	3.070
M 4 x 0.5	3.675	0.3	4.142
M 5 x 0.5	4.675	0.3	5.142
M 6 x 0.75	5.513	0.45	6.214
M 8 x 1	7.350	0.6	8.285
M 10 x 1.25	9.188	0.7	10.207
M 12 x 1.25	11.188	0.7	12.206
M 14 x 1.5	13.026	0.85	14.278
M 16 x 1.5	13.026	0.85	14.278
M 18 x 1.5	17.026	0.85	18.277
M 20 x 1.5	19.026	0.85	20.277
M 22 x 1.5	21.026	0.85	22.277
M 24 x 2	22.701	1.15	24.420
M 27 x 2	25.701	1.15	27.420
M 30 x 2	28.701	1.15	30.419

Screw pitch gauge

Objectives : At the end of this lesson you shall be able to
- **state the purpose of a screw pitch gauge**
- **state the uses of a screw pitch gauge.**

Purpose

A screw pitch gauge is used to determine the pitch of a thread.

It is also used to compare the profile of threads.

Constructional features

Pitch gauges are available with a number of blades assembled as a set. Each blade is meant for checking a particular standard thread pitch. The blades are made of thin spring steel sheets, and are hardened.

Some screw pitch gauge sets will have blades provided for checking British Standard threads (BSW, BSF etc.) at one end and the metric standard at the other end.

The thread profile on each blade is cut for about 25 mm to 30 mm. The pitch of the blade is stamped on each blade. The standard and range of the pitches are marked on the case. (Fig 1)

For obtaining accurate results while using the screw pitch gauge, the full length of the blade should be placed on the threads. (Fig 2)

Fig 1

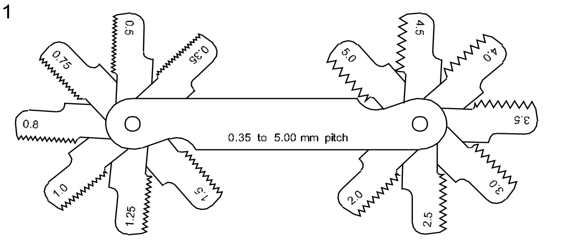
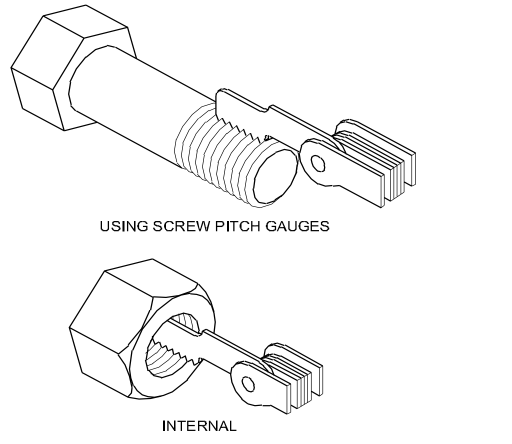


Fig 2



Slotter - Classification

Objectives: At the end of this lesson you shall be able to
- **state and explain principle, construction, safety precaution in slotting machine**
- **explain indexing process on a slotted**
- **describe rotary table graduations.**

Principle of slotting machine

The slotting machine is a reciprocating type machine tool. In a slotting machine, the ram holding the tool reciprocates in a vertical axis and removes the metal with the single point tool. The workpiece which is clamped to the table is fed to the tool. The slotting machine is capable of undertaking a wide range of work not conveniently held and machined on other machines.

The slotting machine can be used on any type of work where vertical tool movement considered essential and advantageous.

Classification of slotting machines

Slotting machines are classified according to their purpose and size. The purpose is determined by the type of work to be performed. The size of the slotting machine is specified by the maximum length stroke of the ram.

The following are the different types of slotting machines.

- General purpose slotting machine
- Precision tool room slotting machine
- Die slotting machine
- Locomotive frame slotting machine
- Travelling head slotting machine

General purpose slotting machine

This machine is used for general slotting operations as the name implies. It is manufactured in various sizes to meet the requirements of both light and heavy industry.

Precision tool room slotting machine

This machine is used for precision work. For angular movement of the tools, the column of this machine can be tilted to enable tapered work to be slotted. For fine adjustment, micrometer collars are provided in these machines.

Die slotting machine

For machining cavity in blank dies, this machine is used. This work table of this machine can be fed longitudinally and transversely so that any outline can be brought under the cutting tool.

Locomotive frame slotting machine

The locomotive frame slotting machine is specially designed for finishing locomotive frames. The machine is very large. It has two or three slotting heads. These slotting heads can function independently.

Travelling head slotting machine

Normally a vertical slotting movement is provided in the slotting machine. But in the travelling head slotting machine, a horizontal shaping movement is provided in addition to the vertical. The frame of this machine is made of two sections. The upper section carries the tool head and driving mechanism and can slide horizontally on ways formed on the top end of the table lower section. The work is positioned by adjusting the table longitudinally and ram moves to and fro.

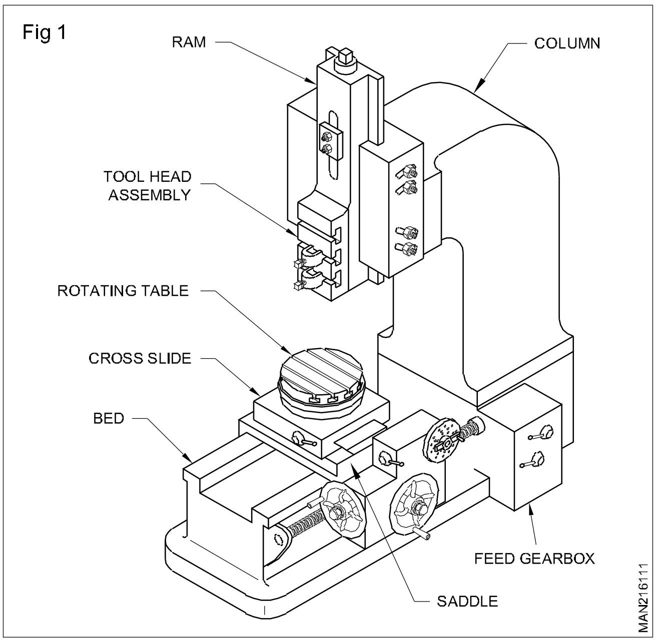
Constructional features of a slotting machine

Objectives: At the end of this lesson you shall be able to
- **state the purpose of a slotting machine**
- **name the parts of a slotting machine**
- **state the function of each part of a slotting machine**
- **state the importance of safety**
- **list out the safety precautions to be observed in a machine shop**
- **list out the personal safety precautions to be observed**
- **list out the safety precautions to be observed while working on the machines.**

The slotting machine (Fig 1) is used mainly to machine vertical surfaces, produce forms, keyways, feather-ways, internal and external dovetails, slots of various shapes, etc. It is also used to machine internal and external, flat or curved surfaces which cannot be machined conveniently on other machines.

Base or bed

The bed or base is a massive casting capable of withstanding the force of the cut and supporting the weight of the machine. The top of the bed has either square or dovetail guideways to carry the saddle.



Column

The column in some machines are cast integral with the bed. In some machines, it is a seperate casting, dowelled and secured to the base. The column houses the driving mechanism and the front face of the column is accurately finished to carry the ram perpendicular to the bed.

Saddle

The saddle is mounted on the guide ways of the bed. The longitudinal feed can be given to the work by moving the saddle manually or with the automatic feed. The top face of the saddle is machined to provide guideways for the cross-slide.

Cross-slide

The cross-slide is mounted on the saddle. This will move perpendicular to the direction of movement of the saddle with either by manually or automatic feed.

Rotating table

A rotary table is mounted on the top of the cross-slide.

Ram

The function of the ram is similar to that of the shaper, and it carries the tool head and reciprocates vertically on the front of the column. A slot is cut on the body of the ram for changing the position of the ram stroke. The weight of the ram is balanced by a counterweight which is connected to the oscillating slotted link.

Tool head

The tool head is the integral part of the ram in some slotting machines. The tool post attached to the tool holder is designed to take a solid tool or a tool holder when tool bits are used.

Speed gearbox

The power is transmitted from the main drive gear or pulley through the drive shaft to the sliding gears which are in the speed gear box. By setting the speed variation lever, the sliding gears can be moved to obtain the required ram speed.

Feed gearbox

The feed gearbox contains the feed changing gears and clutch. The feed is changed by setting the feed change lever. In some designs the feed is obtained by means of a ratchet and pawl mechanism.

Safety precautions of slotting machine

Safety precautions regarding operations

- No alteration or adjustment should be done other machine parts while machine runs.
- The machine is to be stopped before cleaning the metal.
- The measuring of the work should be done only after the machine is stopped.
- The operator should not such assistant for starting and stopping the machine.
- Cleaning should not adjusted while machine is running.

Safety regarding the slotting machine

- The workpiece is to be positions in such a way that the ram will not hit the workpiece while performing the stroke.
- While adjusting the stroke length ram should be lowest.
- Stroke length of the raw and the position of stroke are to be set corrects before performing the stroke.
- Ensure that the tool post are tool holder will not hit the job clearance should be maintain.
- Machine should be stopped while adjusting stroke length.
- Work holding drive like clamp, vice should hold in the machine properly.

Rotary table construction and uses

Objectives: At the end of this lesson you shall be able to
- **state the constructional details of a rotary table**
- **state the purpose of a rotary table.**

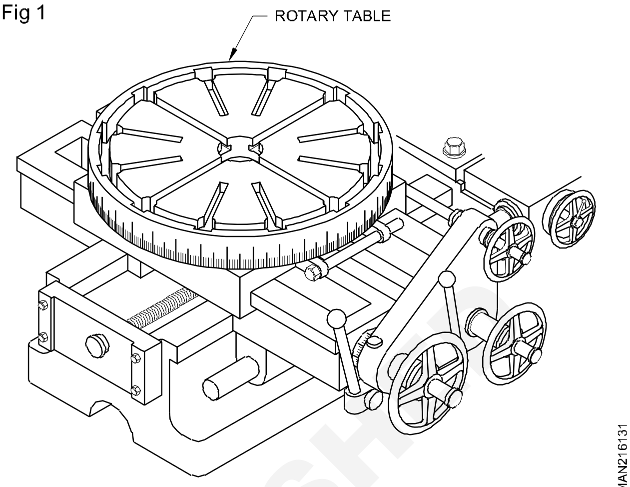
The rotary table (fig 1) is a circular table which is mounted on the top of the cross-slide. The table may be rotated either manually or automatically through worm and worm wheel which are connected to the underside of the rotary table. The drive can be disengaged and the table can be rotated freely by hand at the time of setting the work. A clamp is used to lock the table in position. The table is provided with 'T' slots for clamping the work using work-holding devices. The table can be moved across the saddle either by power feed or manually. This table is graduated in degrees around its entire periphery. These graduations enable the table to be rotated for indexing or dividing the periphery of the job into an equal number of parts.

Indexing is achieved by engaging a spring-loaded plunger with one of the twelve equally spaced holes located on the underside of the table.

Some types of tables can be tilted to 18° for angular slotting.

The rotary table helps to generate circular or contoured surfaces on workpieces.

Fig 1

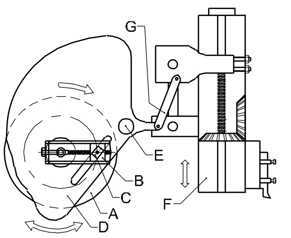


Driving mechanism - quick return mechanism and speed ratio

Objectives: At the end of this lesson you shall be able to
- **state how the rotary motion is converted into reciprocating motion**
- **state how the stroke length can be varied**
- **state the necessity of the quick return mechanism**
- **describe how the quick return mechanism operates**
- **state how the idle time is reduced.**

The driving mechanism converts the rotary motion of the bull gear into reciprocating motion of the ram. (Fig 1).

Fig 1



In a driving mechanism, initially the drive from the motor is transmitted to a gear through a clutch with a built in brakes. The large helical-toothed stroke wheel or bull gear (A) takes its drive from the gear and carries the sliding die block (B). This sliding block is connected to another block (C) which slides in the ways cut on the face of the large oscillating 'slotted link' (D), hinged at (E). This slotted link is connected to the ram (F) of the machine by a connecting link (G).

One side of the slotted link is big and heavy to balance the weight of the ram.

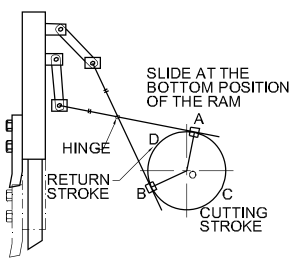
Thus the circular motion of the bull gear is converted into reciprocating motion of the ram with the help of the slotted link, sliding block and connection rod.

The stroke length of the machine is adjusted by changing the radius at which the sliding block (C) rotates with the bull gear.

Quick return mechanism of a slotting machine

In slotting machines the material removal takes place only in the downward cutting stroke. The upward stroke is just a return idle stroke. To reduce the idle time a quick return mechanism is employed in the slotting machine. (Fig 2)

Fig 2



The block attached to the slotted link also rotates when the bull gear is rotating. At the same time the slotted link oscillates. When the block is at position 'A', the ram will be with the lowest position of the stroke. But if the block is in position 'B' the ram will be at the highest position of the stroke. For the cutting stroke, the block will cover an arc ABC, and for the return stroke, it will cover the arc of BDA.

The arc ACB is bigger than the arc BDA. Thereby the distance travelled by the arc ACB is more. In other words the cutting stroke time is more than the return stroke time. Thus the quick return motion is obtained. The speed ratio of forward stroke and return stroke is 2:3.

Safety points to be observed while working on slotting machine

No alternation or adjustment should be done on the machine parts while the machine is running.

Clamps holding the work should not be adjusted while the machine is in motion.

The machine is to be stopped before cleaning the metal chips.

The sharp edges of the work should be handled with care

The measuring of the work should be done only after the machine is switched off.

The operator should not seek the assistance of others for starting and stopping the machine.

Machining of precise parts and internal surfaces of the work piece are to be carried out with great care and safe.

The work piece is to be positioned in such a way that the ram will not hit the workpiece while performing the forward stroke.

Stroke length of the ram and the position of stroke are to be set correctly before performing the cutting

Proper holding of the work should be work holding devices like clamps and vice jaws should not come in the way of the reciprocating tool.

We have to ensure that the tool or the tool post or the ram will not hit the job or the job holding clamps or the vice.

The machine should be stopped before making any adjustment to the stroke length, position of stroke, apron and tool.

Job holding devices

Objectives: At the end of this lesson you shall be able to
- **explain vices, clamps, v-block, parallel block**
- **types of slotting tools, tool angles.**

Work holding device

Work pieces that are to be machined should be held with support firmly such that there is no slackening of the work while machining. Otherwise the jobs will be damaged, dimensional accuracies will vary, and sometimes the cutting tool/ cutter itself will break. Due to this reason, the operator may be injured.

The different types of work holding/supporting devices are as follows.

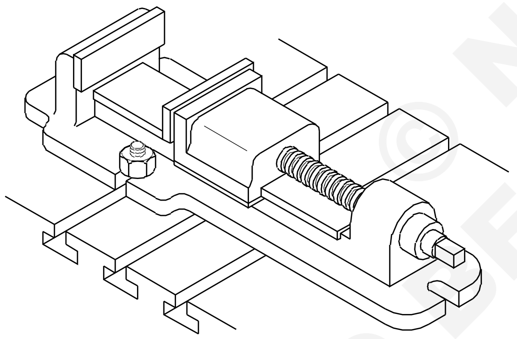
Machine vices and clamps

There are two main types of machine vices used on slotter.

Plain machine vice (Fig 1)

It is very robust in construction and so it is used on machines where it is used only for squaring and stock removal.

Fig 1



Swivel base vice (Fig 2)

It is the most commonly used on a slotter. The base can be swiveled to the desired angle to machine angular jobs.

Strap clamps (Fig 3)

They are used for clamping the workpiece directly on the machine table. Straps come in different shapes and they are used in conjunction with T bolts/nuts.

Tee bolts (Fig 4a)

These bolts having Tee shaped heads are suitable for the table slots of a machine. The body of the bolt is provided with sufficient length of threads so that the same bolt can be used for holding jobs of various thicknesses.

Different clamping arrangements are shown in Fig 4b to 10.

Fig 2

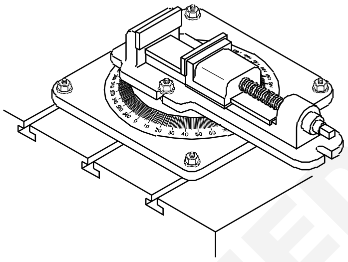
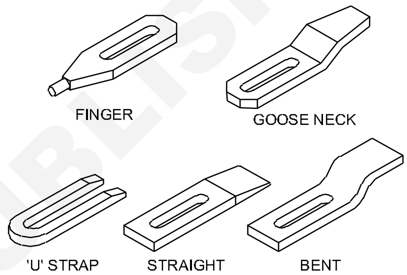
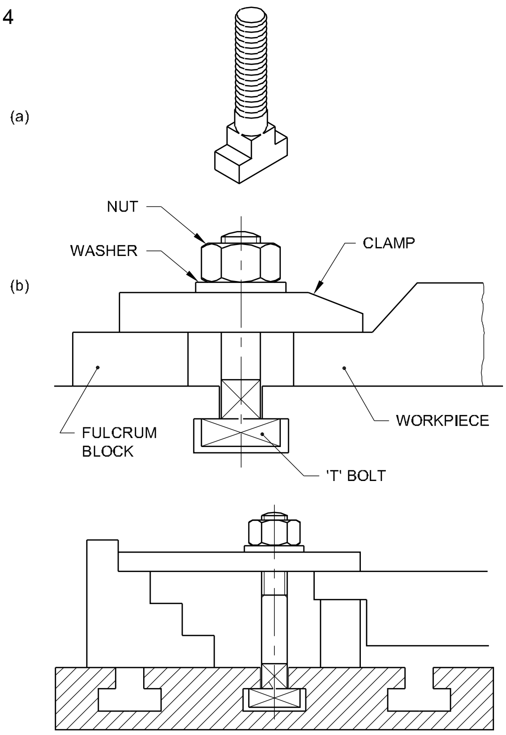


Fig 3



A normal clamping unit (Fig 4b) consists of a Tee bolt, nut washer, clamp and fulcrum block - plain/stepped.

Fig 4



Toe dogs and poppets

These are used for machining the top surfaces of huge jobs having no holes on the side, or small repetitive jobs as shown in Figs 5 & 6 (parallel plate A, workpiece B protective strip C, poppet D, toe dog E, stop F).

Fig 5

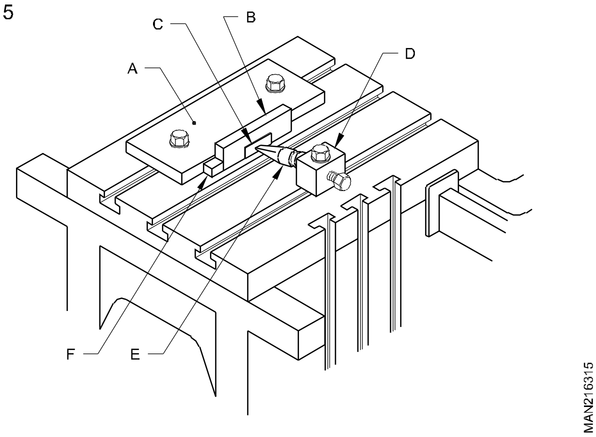
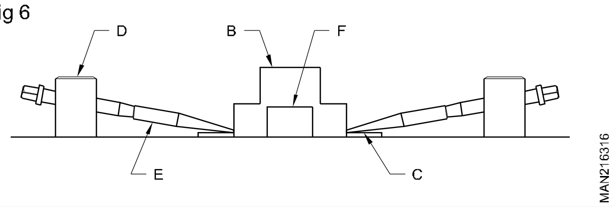


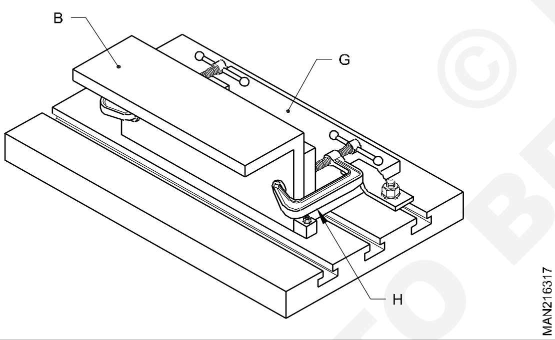
Fig 6



Angle plate (Fig 7)

'C' clamp (H)

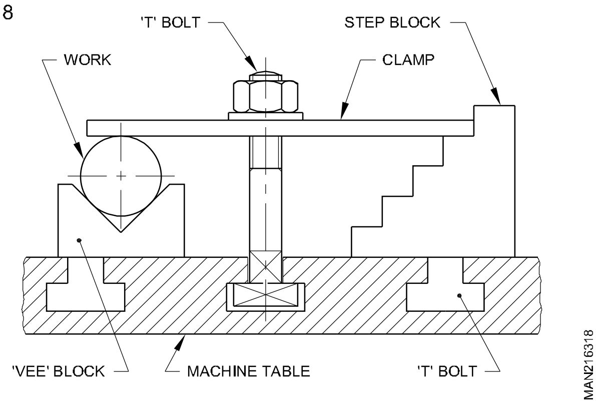
Fig 7



Vee block (Fig 8)

These are 'V shaped blocks and are used for supporting round jobs in clamping.

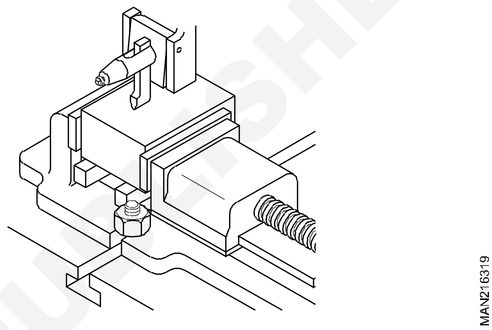
Fig 8



Parallel strips (Fig 9)

These are perfectly ground steel strips used for elevating/ supporting the workpiece. They should be used only on machined surfaces.

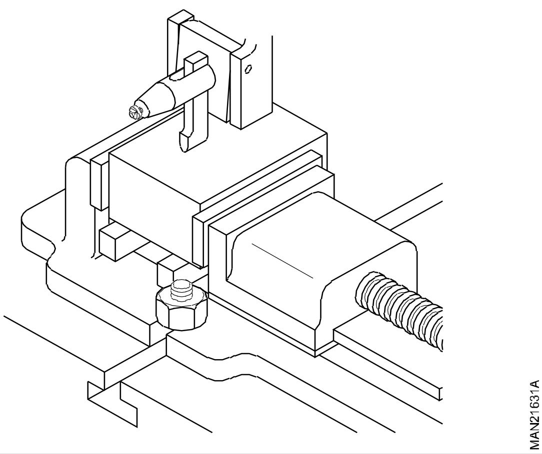
Fig 9



Degree parallels (Fig 10)

These are the steel strips with ground angular surface: Because of this, angular surfaces can be generated without swiveling the tool head.

Fig 10



Types of slotting tools and tool angles

Objectives: At the end of this lesson you shall be able to
- **list the different types of tools used for slotting**
- **state the purpose of each type of tool**
- **state the geometrical features of the slotting tools.**

There are various shapes of slotting tools available. The selection of the slotting tools depends upon the nature of the operations to be performed.

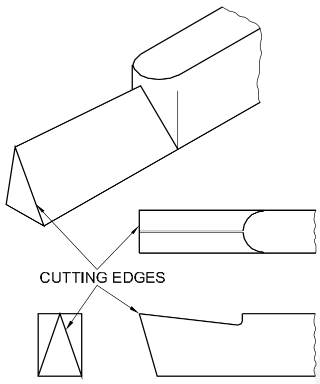
The following are the various shapes of slotting tools commonly used in the workshop.

- Roughing tool
- Keyway cutting tool
- Finishing tool
- Cornering tool
- Parting tool
- Form tool
- Sizing tool

Roughing tool (Fig 1)

Roughing tools are used for heavy cuts until dimensions close to the final size of the workpiece are attained. The roughing tool is usually ground to leave a large amount of metal at the point. That large area quickly dissipates the heat generated in taking heavy cuts, thus lengthening the life of the cutting edge. Normally straight roughing tools are used for roughing out and removing large quantities of material. If these tools are provided with a sharper nose they can be used for finishing cuts.

Fig 1



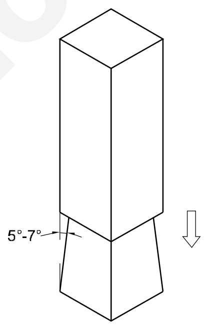
ROUGHING TOOL

Finishing tool (Fig 2)

Finishing tools bring the roughly machined surface to the required final size and standard of finish. They are designed to cut in either direction. They are usually broad, straight edged tools. They take light cut with fast cross-feed.

> **An undesirable characteristic of the finishing tool is the tendency to chatter and dig into the workpiece**

Fig 2

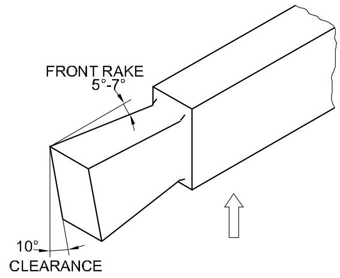


BROAD FINISHING TOOL

Parting tool (Fig 3)

A parting or grooving cutting tool has a narrow square nose with a long neck. It is used for cutting narrow grooves, slots, wider keyways, slotting faces in restricted areas and for thinning out square corners.

Fig 3

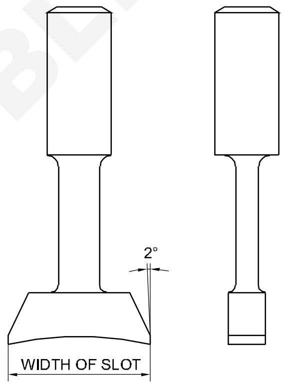


GROOVING OR PARTING TOOL

Sizing tool (Fig 4)

A sizing tool has two cutting edges which are accurately ground to the width of the required slot. This tool is used only to size the slot, that is, to finish the slot to the precise dimensions required.

Fig 4

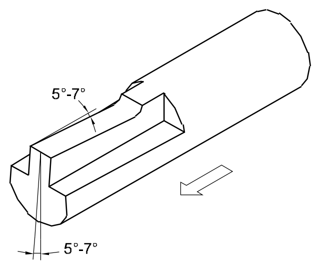


SIZING TOOL

Keyway cutting tool (Fig 5)

For slotting keyways up to about 10 mm width, the tool width is ground centrally to the shank and up to 10 mm deep approximately. Tools for keyways are also prepared from tool steel having a diameter between 5 to 10 mm. These tools are to be mounted in tool bars. These are used for cutting long keyways in deep areas.

Fig 5

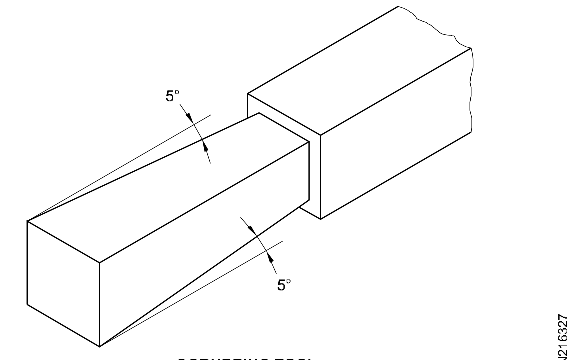


KEYWAY CUTTING TOOL

Cornering tool (Fig 6)

Cornering tools are used to slot the corners. These tools are thinner at the cutting edge than that of the finishing tools.

Fig 7



CORNERING TOOL

Form tool

This is a special purpose tool used for slotting the required profiles, forms, shapes, etc. These are to be prepared as per requirements.

Tools angles

The cutting properties of the slotting tool are largely determined by the size of the angles to which it is ground.

The cutting edge. must be sharp enough to penetrate the workpiece. It must have sufficient support behind the cutting point to withstand the force acting on it during cutting.

Slotting tools differ widely from shapers or planer tools as in slotting metal is removed during the vertical cutting stroke. Due to this, there is a lot of difference in the tool shape.

In a slotting tool, the cutting pressure acts along the length of the tool.

Slotting tools have front rake and clearance angles as shown in the figure 1. Slotting tools do not have any side rake angle.

The rake and clearance angles of a slotter are apparently different from those of a lathe or shaper tool as these angles are determined with respect to the vertical plane for a slotting tool.

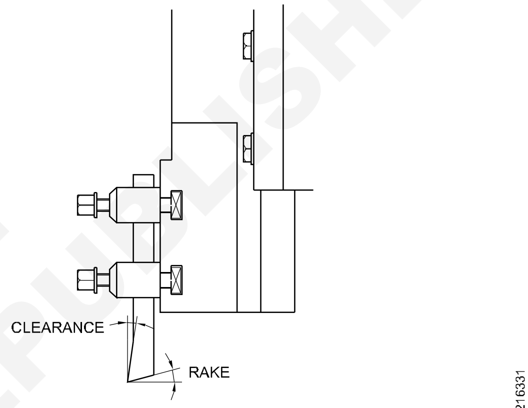
The amount of rake angle is similar to that of a shaping tool.

The slotting tools are robust in their cross-section and are of forged type. Bit type of tools fitted in heavy duty tool-holders are also used for slotting.

The cutting tool material should be harder and stronger than the material being cut.

It should also be tough to resist shock loads and be resistant to abrasion - thus contributing to long tool life.

Fig 1



RAKE AND CLEARANCE ANGLES

Tool holder for internal slotting

Objectives: At the end of this lesson you shall be able to
- **state the shape of tool holder for internal slotting**
- **state the precautions to be observed during internal slotting**
- **state the use of curves on slotting table.**

Internal slotting tool holder - Types of tool holder

- Slotting bar tool holder
- Heavy duty tool holder
- Inserted tool holder

Slotting bar tool holder (Fig 1a)

A tool bit is to be mounted in the cutter bar.

The cutter bar must be strong enough to take the force of the cut.

The tool bit and the cutter bar should be held short for rigidly

They must permit full length of stroke

The diameter of cutter bar must be less than diameter of hole to be slotted.

Heavy duty tool holder (Fig 1b)

The slotting tools are robust their cross section and are of forced type. Bit type tool fitted in heavy duty tool holders are also used for internal slotting.

Slotting tools have front rake and clearance angles as shown in fig 1b. Slotting do not have side rake angles.

Inserted type tool holder

Carbide tool bits are fixed in tool holder (Fig 2a)

The tool holder is fixed with adopter using the grub screw

The key way cutting tool holder is shown in (fig 2b)

Precautions to be observed during slotting internal operations

The ram should not hit the work piece on forward stroke

Fig 1

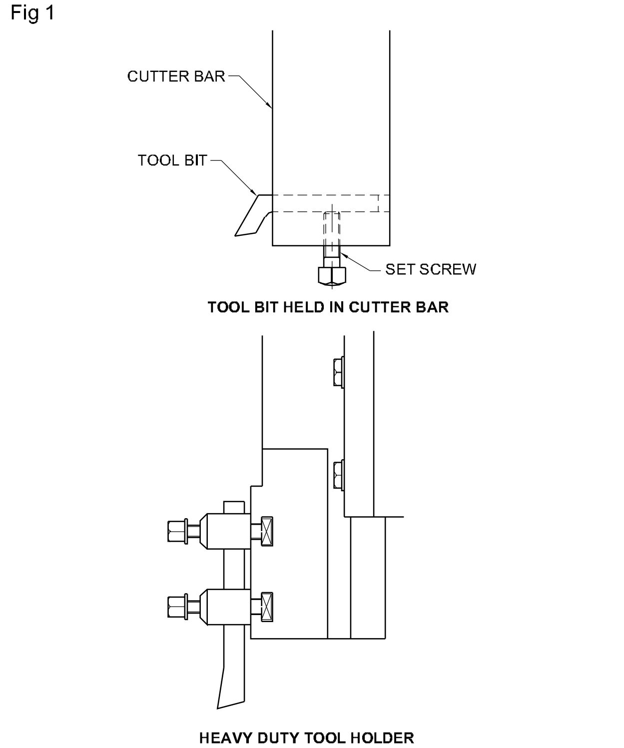
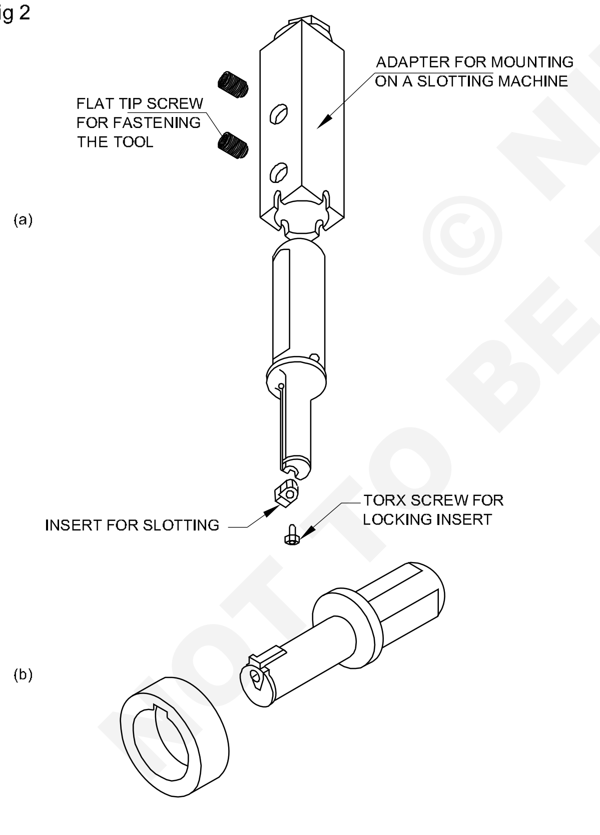


Fig 2



Stroke length and position of the ram are to be set correctly

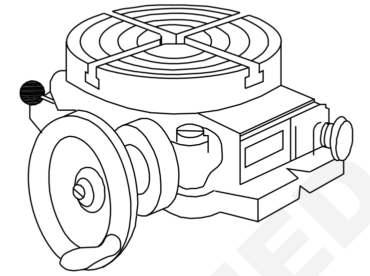
The work holding devices should not come in the way of reciprocating tool

Ensure that the tool or tool reset will not hit the job.

The machine should be stopped before making any adjustment.

Use of circular marks on the slotting table (Fig 3)

Fig 3



Circular marks on the slotting table is used to locate the job concentric to the table.

Used for spacing the clamps evenly for clamping the job.

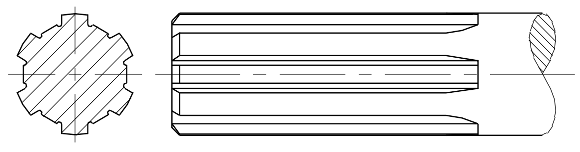
Spline types and uses

Objectives: At the end of this lesson you shall be able to
- **state the uses and form of spline**
- **state the purpose of lubricants**
- **classification of lubricants.**

Spline

A spline is an arrangement of a number of keys and keyways formed integrally over the periphery of a cylindrical shaft. (Fig 1)

Fig 1



SPLINED SHAFT WITH SIX SPLINES

Use of a spline

The spline formation enables, the gear mounted to it to slide longitudinally and also transmits torque when the gear is engaged to another mating gear or in gear train.

Example

All-geared formation stock of a lathe

Feed mechanism of milling machine

Norton gearbox of a lathe

Forms of splines

The two forms of splines are

Straight spline

Involute spline

Straight spline (Fig 2)

The spline form is similar to parallel key when it is external and parallel keyway when it is internal. The spline seat is flat and parallel and a clearance fit is provided. Basic spline profile for external and internal are listed in table1.

Involute spline (Fig 3 & 4)

The spline form is involute and is used for higher power transmitting. These forms are cut by hobbling cutters similar to gear profiles. The angles of involute spline forms are in 14 1/2°, 25°, 20°, 30°, 37.5° and 45°.

The spline with 6 number of spline keys, having inner diameter 28 mm, outer diameter 34 mm is designated as spline 6 x 28 x 34, IS 2327.

Involute splines

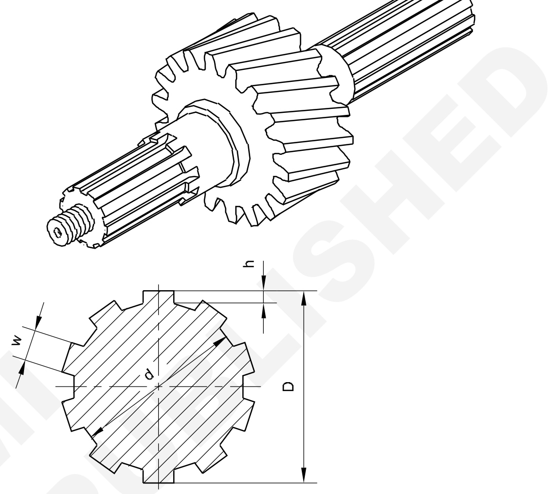
N = Number of spline teeth

P = Diametrical pitch

D = N/P = Pitch dia

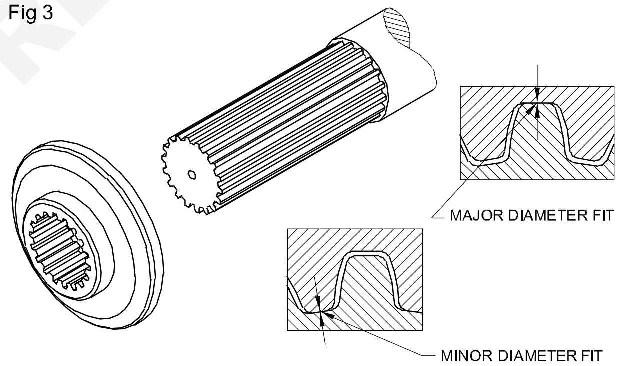
$p = \pi / p$ = Circular pitch

Fig 2



STRAIGHT SIDED

Fig 3

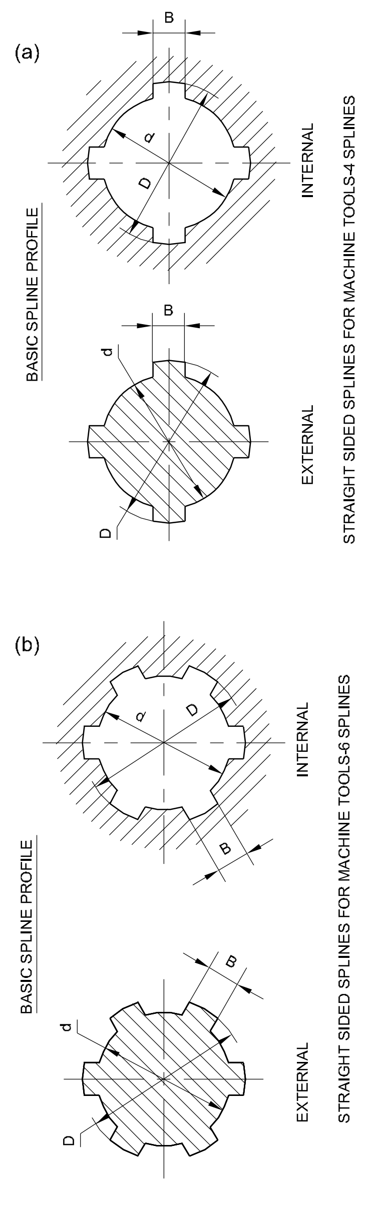


INVOLUTE FORM

Minor dia

$$\text{Internal} = \frac{N - 1}{p}$$

$$\text{External} = \frac{N - 1.35}{p}$$



STRAIGHT SIDED SPLINES FOR MACHINE TOOLS-4 SPLINES

DESIGNATION N x d x D	B
4 x 16 x 20	6
4 x 18 x 22	
4 x 21 x 25	8
4 x 24 x 28	
4 x 28 x 32	10
4 x 32 x 38	
4 x 36 x 42	12
4 x 42 x 48	
4 x 46 x 52	14
4 x 52 x 60	
4 x 56 x 65	16
4 x 62 x 70	
4 x 68 x 78	

STRAIGHT SIDED SPLINES FOR MACHINE TOOLS-6 SPLINES

DESIGNATION N x d x D	B
6 x 21 x 25	5
6 x 23 x 28	6
6 x 26 x 32	
6 x 28 x 34	7
6 x 32 x 38	8
6 x 36 x 42	
6 x 42 x 48	10
6 x 46 x 52	12
6 x 52 x 60	14
6 x 58 x 65	
6 x 62 x 70	16
6 x 68 x 78	
6 x 72 x 82	
6 x 90 x 90	
6 x 82 x 95	
6 x 88 x 100	

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Major dia

$$\text{Internal} = \frac{N + 1.35}{p} \text{ side fit}$$

$$= \frac{N + 1}{p} \text{ major dia fit}$$

$$\text{External} = \frac{N + 1}{p}$$

Standard diametral pitches and lengths

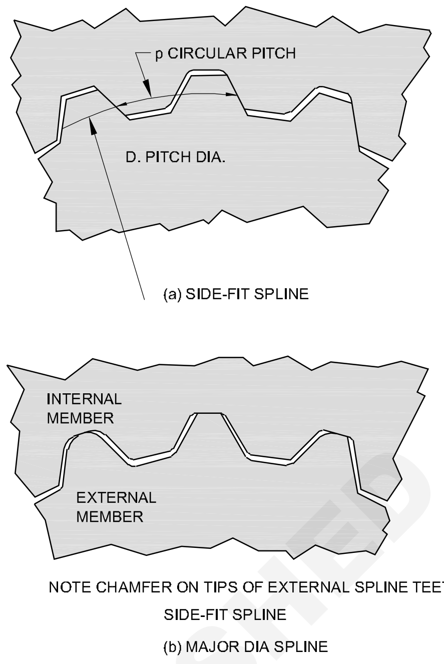
There are seventeen diametral pitches in common use:

2.5, 3, 4, 5, 6, 8, 10, 12, 16, 20, 24, 32, 40, 48, 64, 80,................128

Standard length diametral pitches

Common designs use spline lengths of .75 D to 1.25 D, where D is the pitch diameter of the spline. When these standard lengths are used, the shear strength of the splines will exceed of the shaft from which they are made.

Fig 5



INVOLUTE SPLINES

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Types of spline

There are several types of splines:

Parallel key spline

Where the sides of the equally spaced grooves are parallel in both directions, radial and axial.

Involute spline

Where the sides of the equally grooves are involute, as with an involute gear, but not as tall. The curves increase strength by decreasing stress concentrations.

Crowned splines

Where the sides of the equally spaced grooves are usually involute, but the male teeth are modified to allow for misalignment.

Serrations

Where the sides of the equally spaced grooves form a "V". These are used on small diameter shafts.

Helical splines

Where the equally spaced grooves form a helix about the shaft. The sides may be parallel or involute. This can either minimize stress concentrations for a stationary joint under high load, or allow for rotary and linear motion between the parts.

Ball splines

Where the "teeth" of the outer part are implemented with a ball bearing to allow for free linear motion even under high torque.

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.**

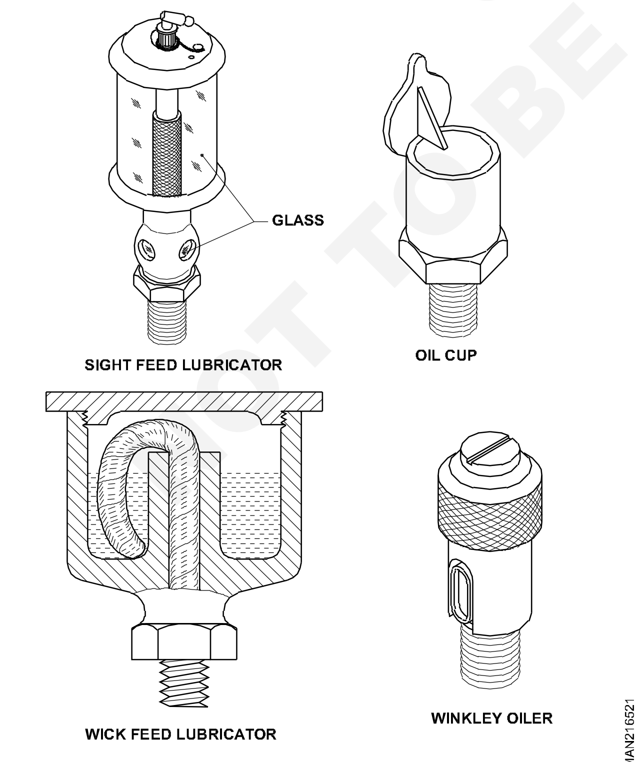
The following methods are used for efficient lubrication.

- 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

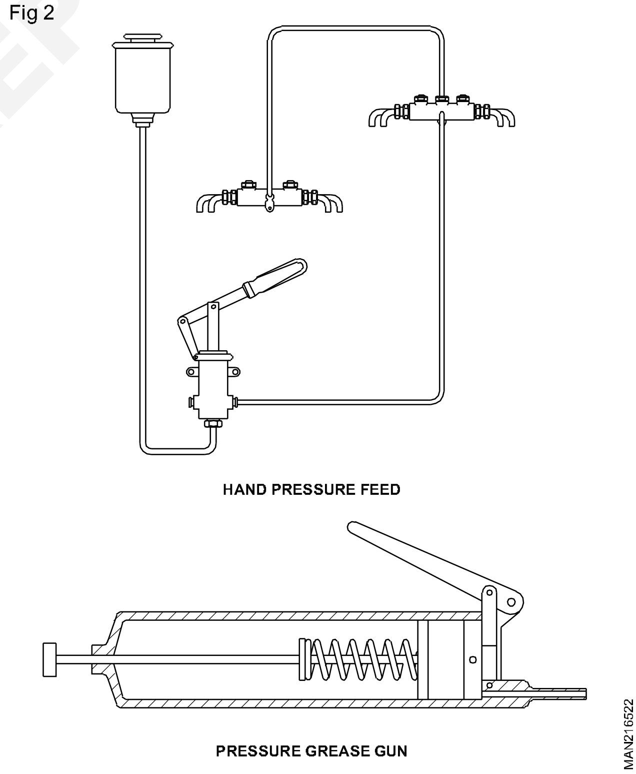


Force (Pressure) feed method

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

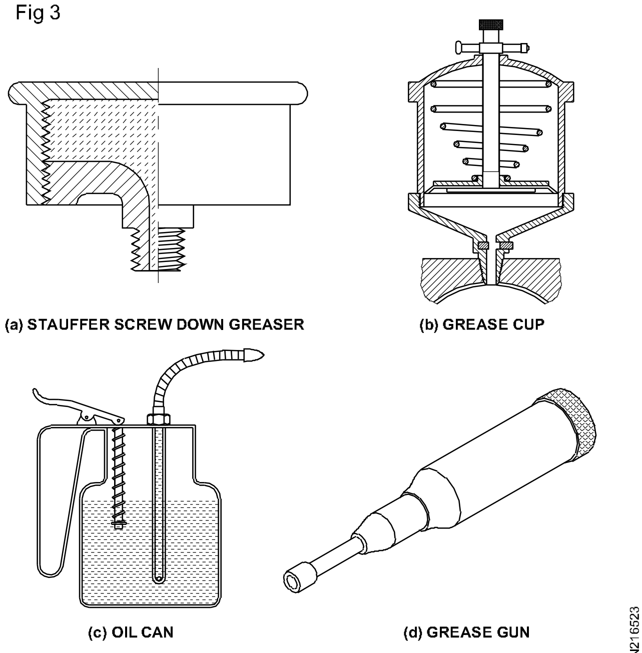
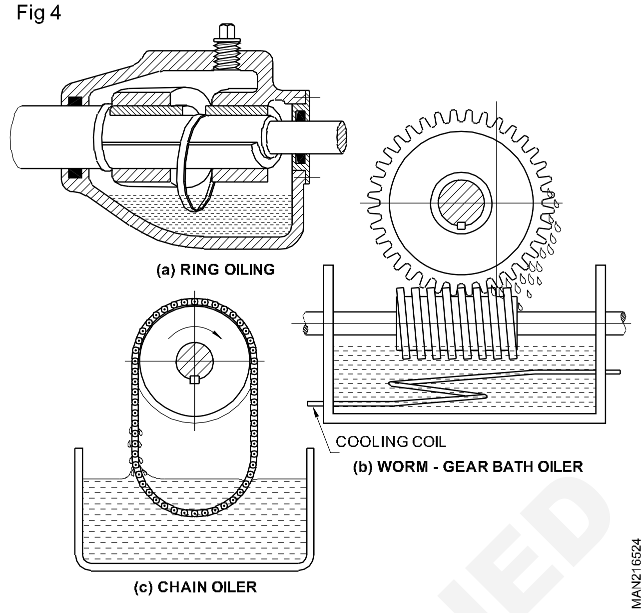


Fig 4



A common method of employing splash lubrication is known as 'ring oiling.'

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)

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.

Milling machines

Objectives: At the end of this lesson you shall be able to
- **state the introduction of milling machines**
- **classify the types of milling machines**
- **state the specification of milling machine.**

Introduction

A milling machine is a machine tool that removes metal as the work is fed against a rotating multipoint cutter. The cutter rotates at a high speed and because of the multiple cutting edges it removes metal at a very fast. The machine can also hold one or more number of cutters at a time. This is why a milling machine finds wide application in production work. This is superior to other machines as regards accuracy and better surface finish, and is designed for machining a variety of tool room work.

Principle of milling (cutting)

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 comparision with other machine tools. (Fig1)

Job (b) can be machined manually or automatically.

By milling we can produce flat (horizontal, vertical, angular) and formed surfaces. (Fig 2)

Fig 1

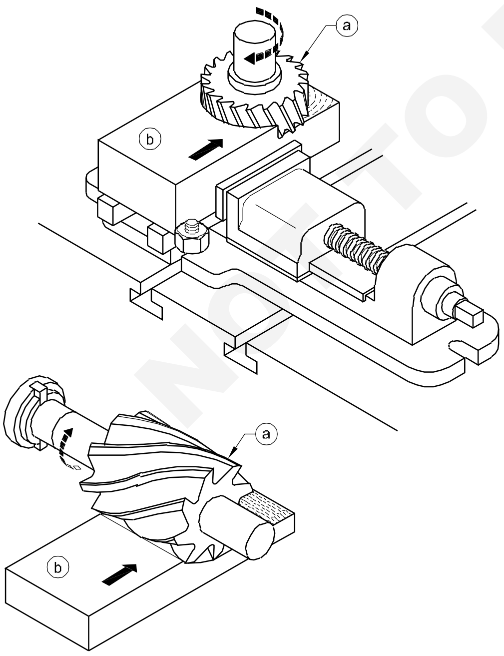
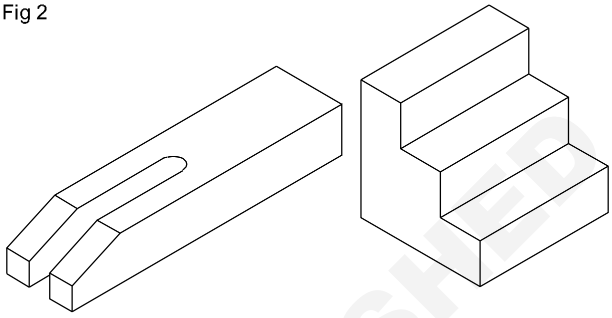


Fig 2



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.

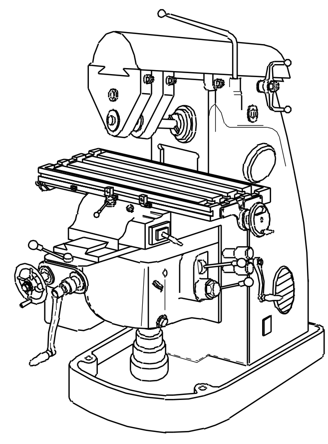
¨ Plain/horizontal milling machine (Fig 3)

¨ Vertical milling machine (Fig 4)

¨ Universal milling machine (Fig 5)

1 Plain milling machine (Fig 3)

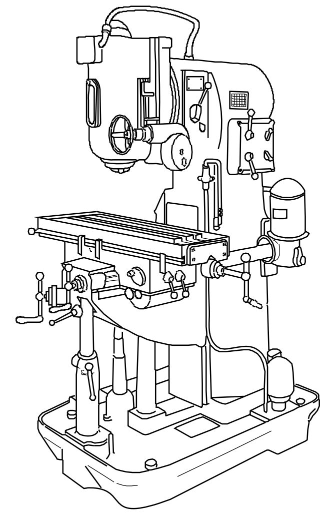
Fig 3



- More rigid and sturdy than other machines and accommodate heavy work.
- Table may be fed either by hand or by power against a rotating cutter and in the three directions namely longitudinately.
- Milling cutters mounted on the horizontal arbor.
- Spindle rotates horizontally and parallel to the machine table.

2 Vertical milling machine (Fig 4)

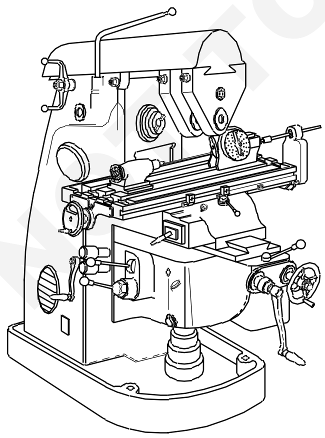
Fig 4



- Distinguished from the horizontal milling machine by position of the spindle vertical or perpendicular to the work table.
- The spindle rotates about the vertical axis.
- Spindle moved up and down by spindle feed and also may be felted or swiveled.
- Most suitable for boring, pocket milling, profile milling and for making keyways.

3 Universal milling machine (Fig 5)

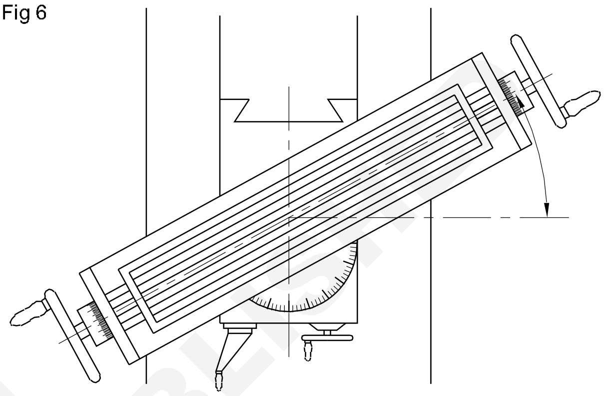
Fig 5



- Table apart from having movements in 3 directions and also can be swivelled about its horizontal axis.
- Maximum swivelling can be made is 45° both in clockwise and anticlockwise direction.
- As angular feeding is possible suitable for milling helical gears, helical grooves etc,.

The universal millling 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 the clockwise and anticlockwise directions. (Fig 6)

Fig 6



The 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.

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.

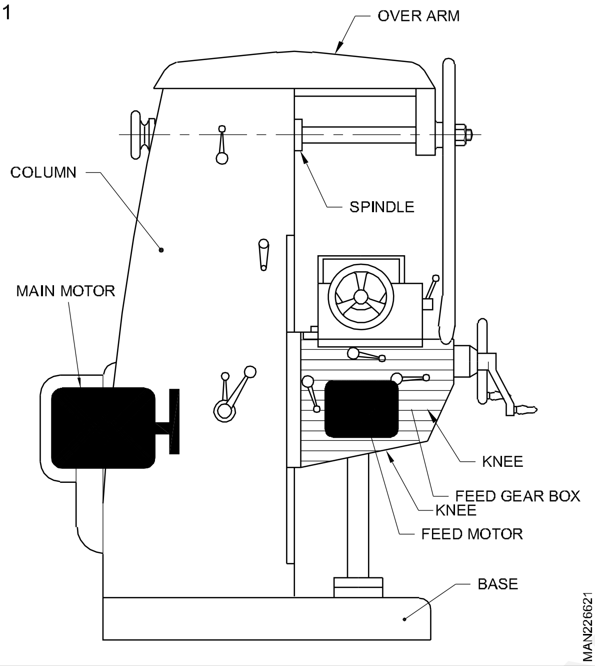
Parts and construction of milling machine

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 principle 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 study box base, which incorporates the cutting fluid tank.

Knee

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.

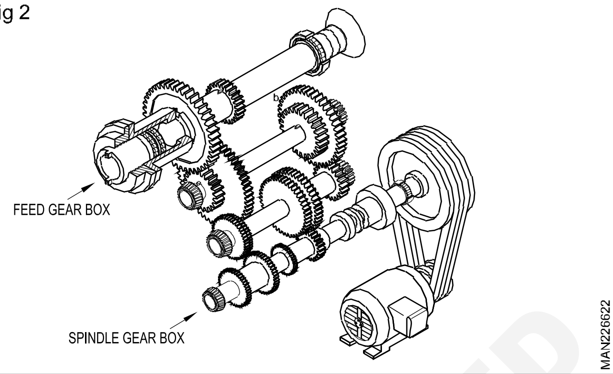
Gearbox

The gearbox for the spindle drive comprises shafts with bearings and gears, Fig 2 and controls for the setting of the spindle speed.

Spindle

The spindle is housed in the upper part of the column and receives power from the motor and transmits it to the arbor.

Fig 2



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 machine 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 horizontal milling machine and vertically in the vertical milling machine. (Fig 3 & 4)

Fig 3

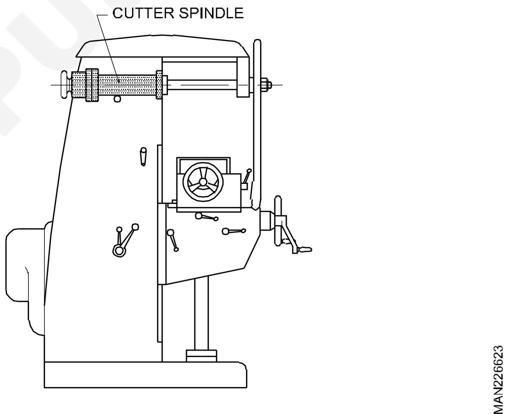
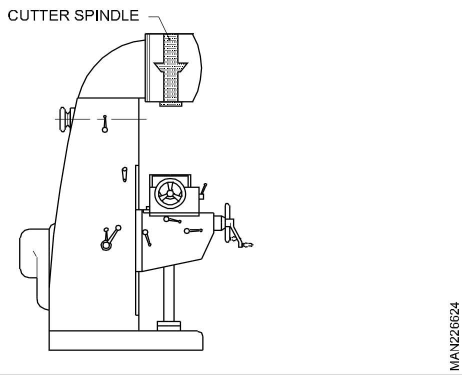


Fig 4



Saddle (Fig 5)

The saddle is placed on the top of the knee which slides come 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.

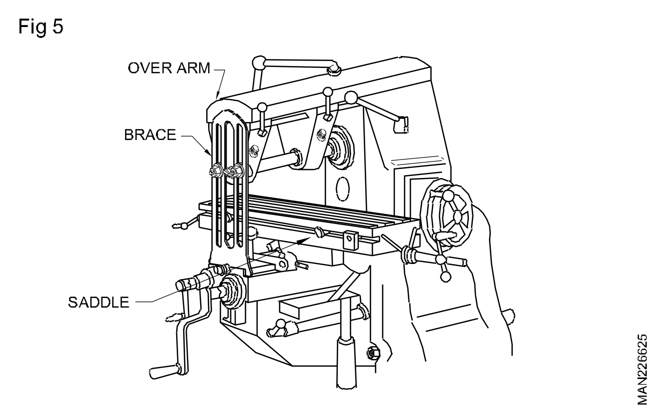


Fig 5

Table (Fig 6)

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. This 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.

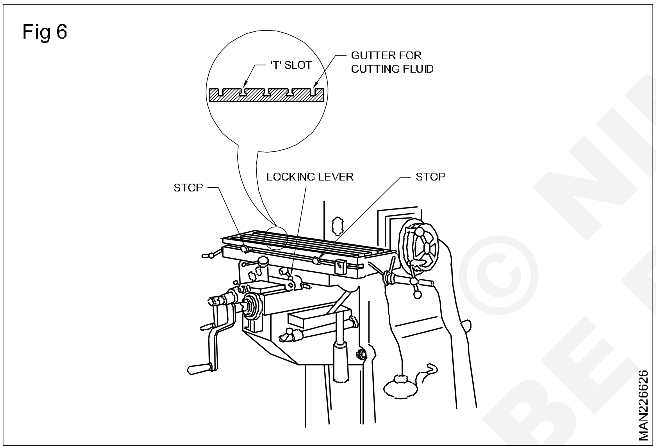


Fig 6

Overarm and brace

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.

The brace provides extra stability to the machine. It must be loosened before the table elevation setting is altered.

Electrical equipment (Fig 7)

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.

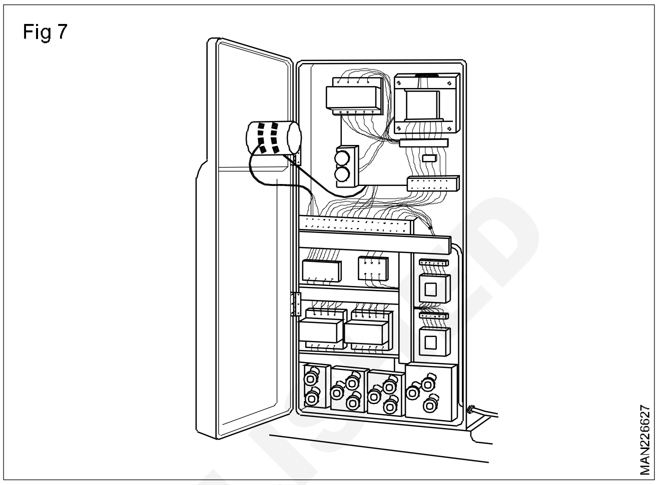


Fig 7

Cutting fluid equipment (Fig 8)

The cutting fluid equipment consists of a pump, piping and hoses, a nozzle and shut-off valve, and a tank in the machine base.

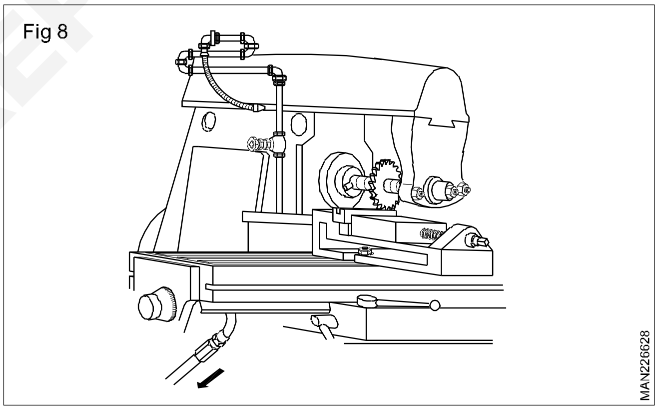


Fig 8

Driving and feed mechanism of milling machine

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

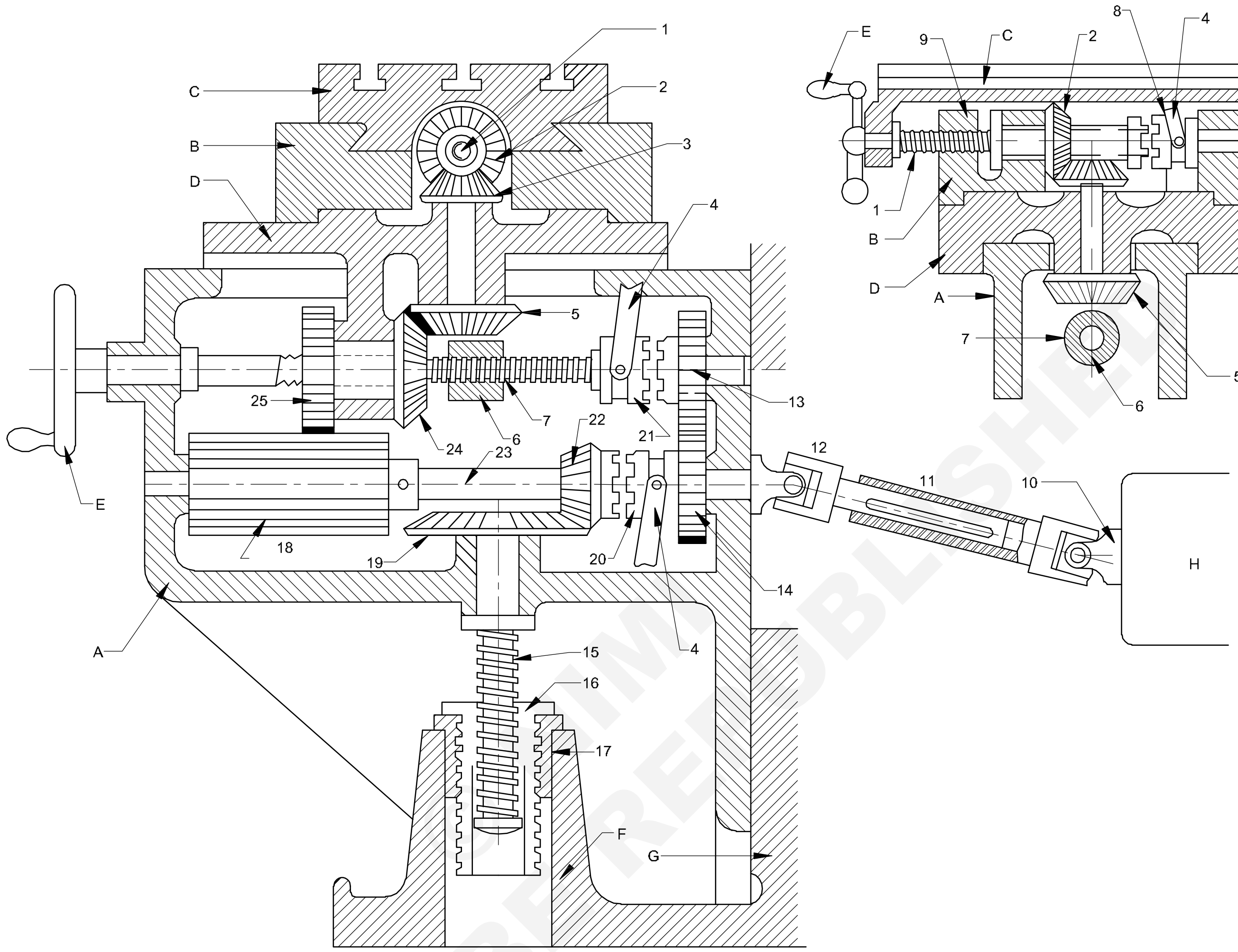
F Bed

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



MILLING MACHINE POWER FEED MECHANISM

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

MA20N156411

Different types of milling cutter and their uses - cutter nomenclature

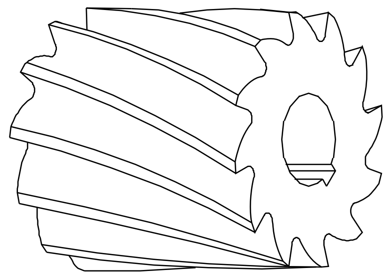
Objectives: At the end of this lesson you shall be able to
- **state the two main categories of milling cutters**
- **state the different types of plain milling cutters**
- **state the uses of plain milling cutters.**

Milling cutters

Milling cutters generally fall into two categories, solid cutters and inserted tool cutters.

Solid cutters (Fig 1)

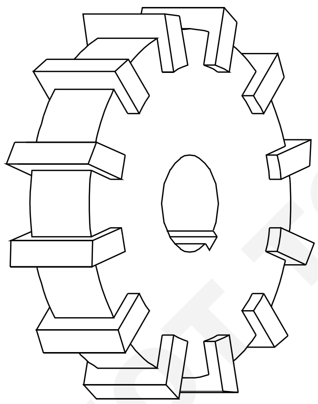
Fig 1



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)

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.

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

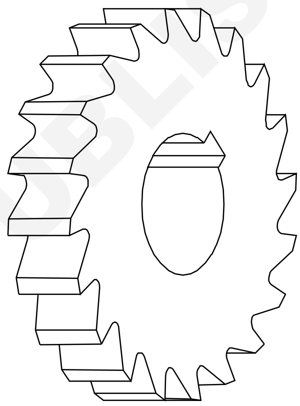
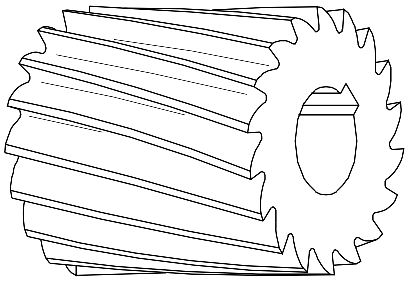


Fig 4



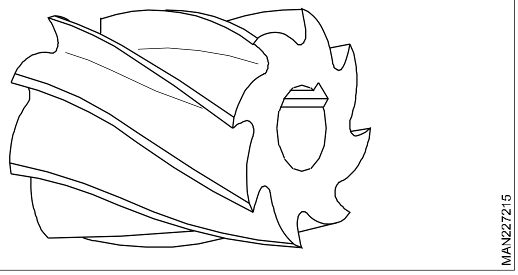
This type of cutter is used only for light milling operations since it has too many teeth to permit the chip clearance required for heavier cuts.

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°.

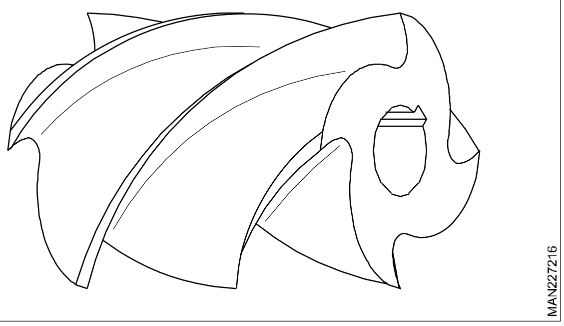
The greater helix angle on the teeth produces a smoother surface due to shearing action and reduces chatter. Less power is required for the cutter than what the straight tooth and small helix angle cutters require.

Fig 5



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.

Fig 7

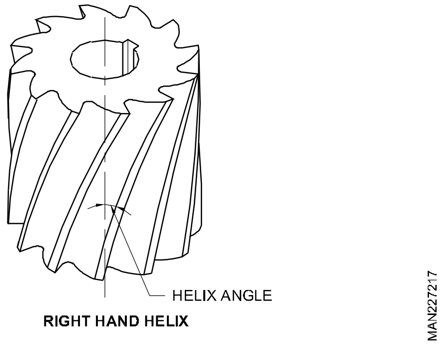


Fig 8

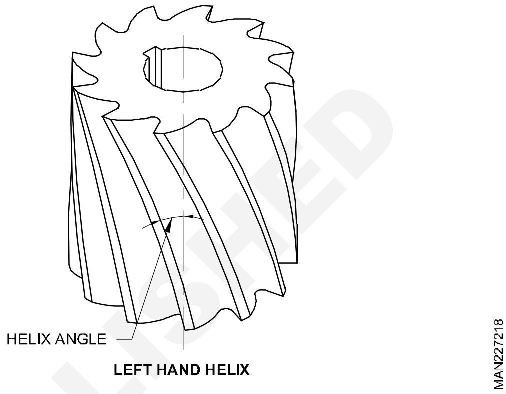


Fig 9

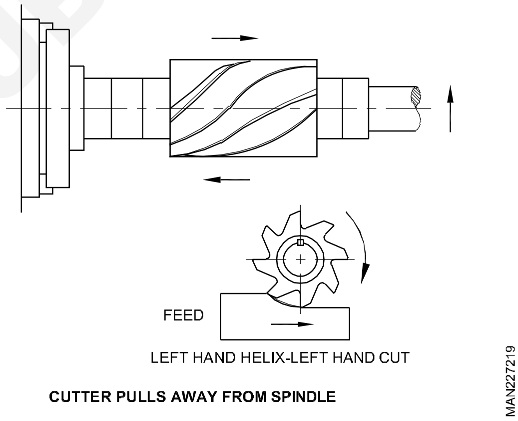
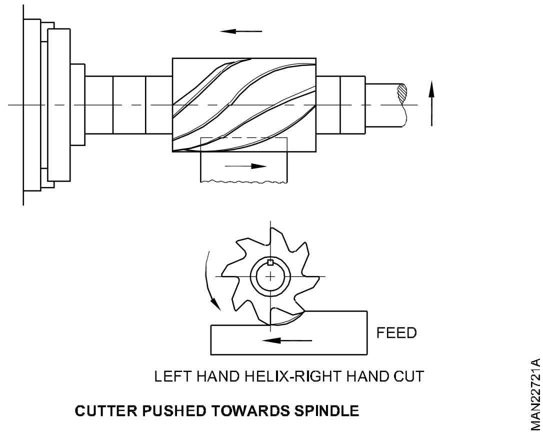


Fig 10



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.

Side and face cutters

Objective: At the end of this lesson you shall be able to
- **state the different types of side and face milling cutters and their uses.**

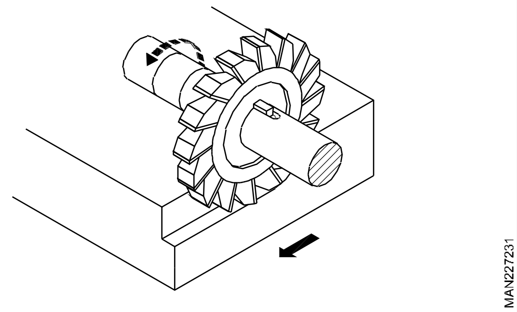
These cutters differ from plain milling cutters due to the fact that they have teeth on the periphery and face.

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)

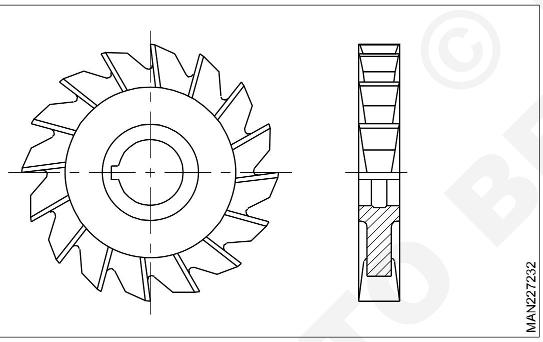
Fig 1



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

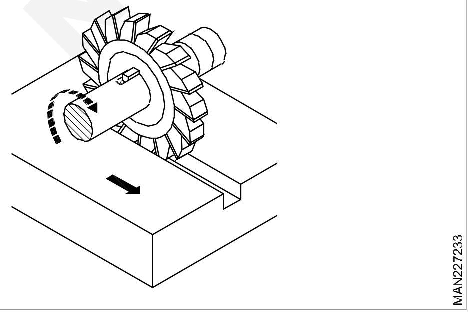
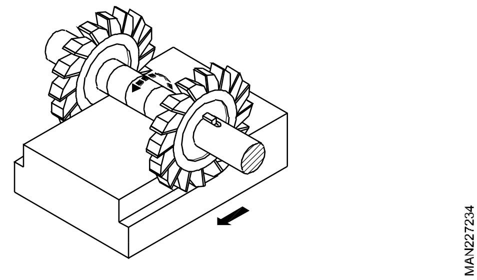


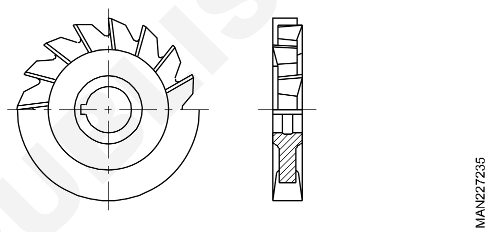
Fig 4



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.

Fig 5

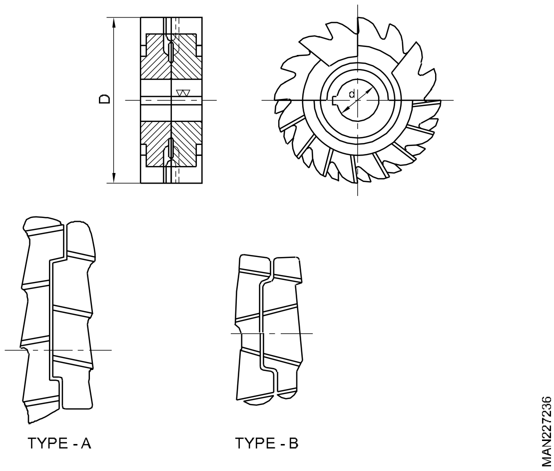


Interlocking side milling cutter (Fig 6)

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.

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

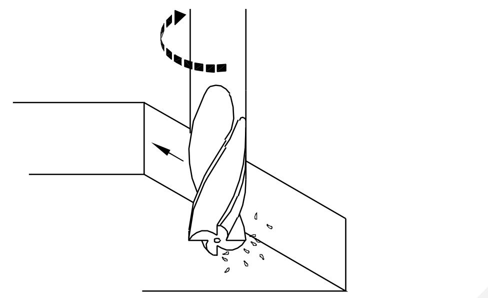


Fig 2

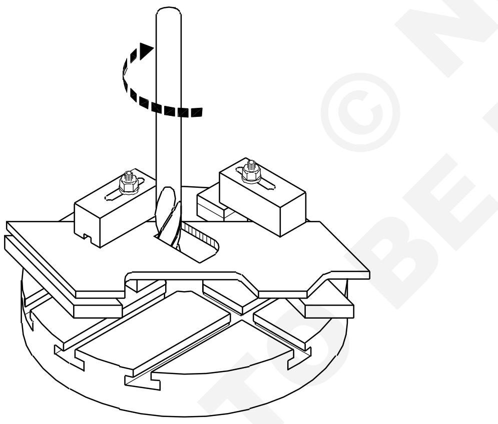


Fig 3

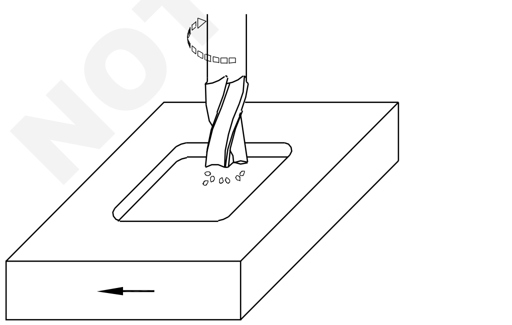
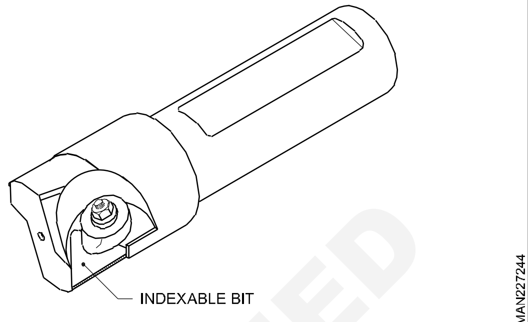
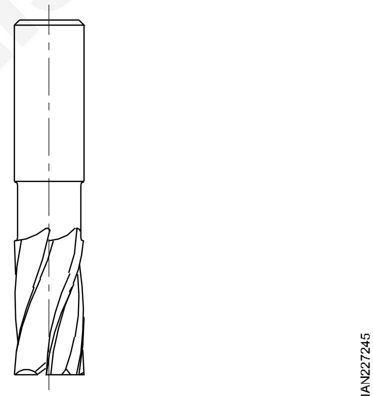


Fig 4



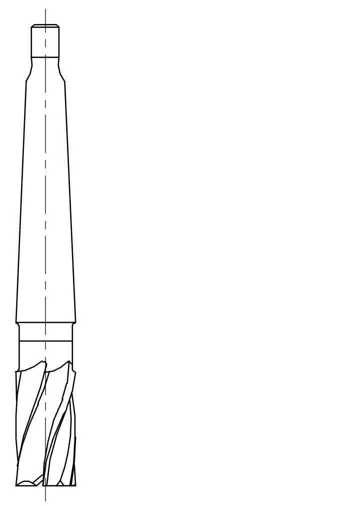
End mill cutters are solid type of cutters in which the shank and the cutters are integral. (Fig 5)

Fig 5



End mill cutters have straight shank (Fig 5) or taper shank (Fig 6).

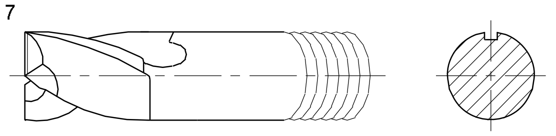
Fig 6



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 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.**

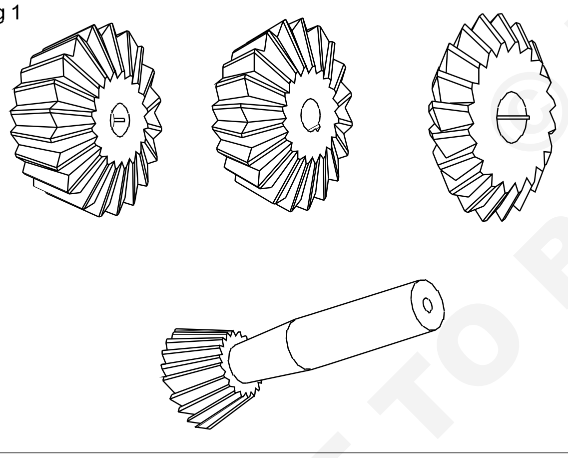
Angular milling cutters

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

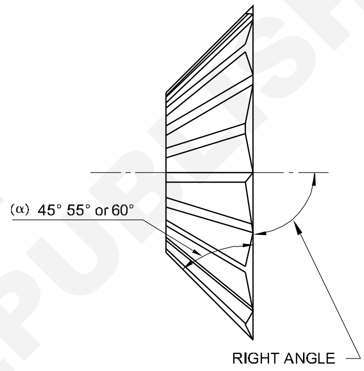
These cutters have teeth on the angular surface, and may or may not have teeth on the flat side. The included angle between the flat face and the angular face designates the cutters, such as 45° or 60° angular cutter. (Fig 2) They may be of the shell or shank type.

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.

Fig 2



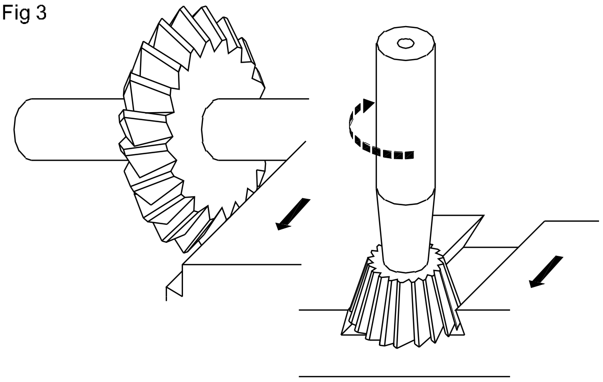
A dovetail milling cutter type A having diameter D = 20 mm, angle μ = 60° of tool type 'N' for right hand cutting shall be specified as

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)

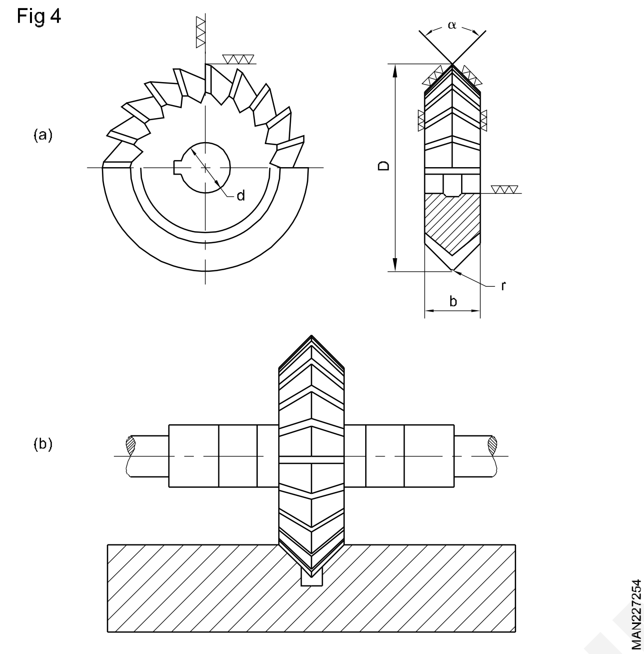
Fig 3



Equal angle milling cutters

These cutters have two intersecting angular surfaces with cutting teeth on both sides. 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 4



Specification

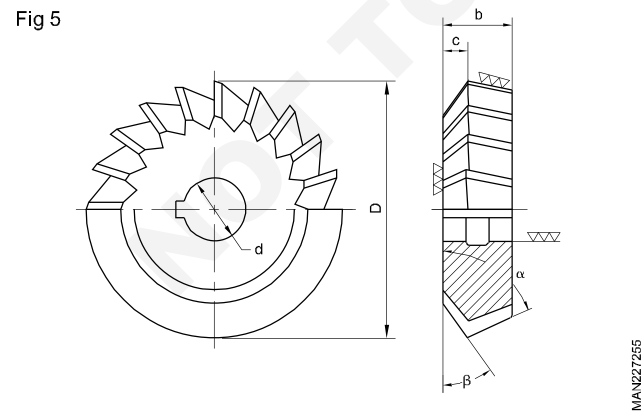
An equal angle milling cutter of diameter D = 56 mm for angle 60° of 'tool type' N shall be specified as Equal angle milling cutter 56 x 60° N IS 6326.

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)

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

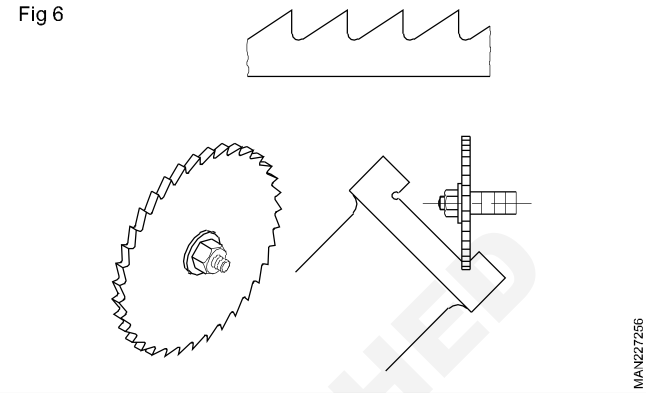
A double angle milling cutter of diameter D = 50 mm, b = 12 mm and angle 75° of 'tool type H and for right hand cutting shall be specification as

Double angle milling cutter 50 x 12 x 75°H IS 6325.

Slitting saw

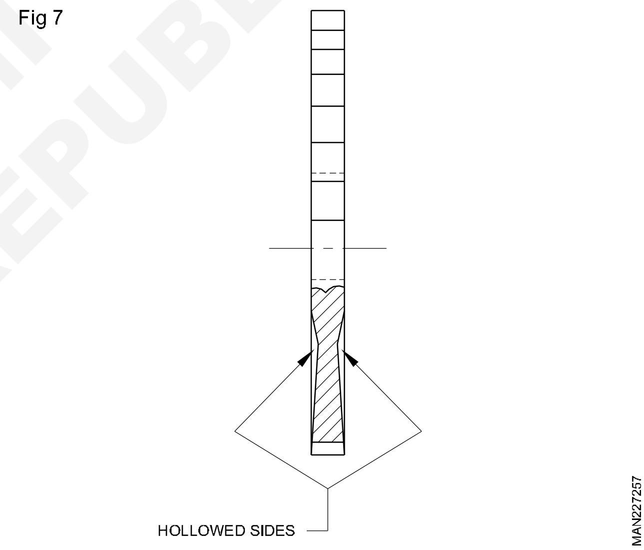
It is basically a thin plain milling cutter. It has a large number of teeth. (Fig 6)

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)

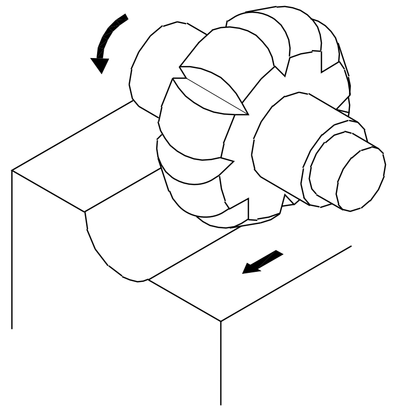


Fig 1

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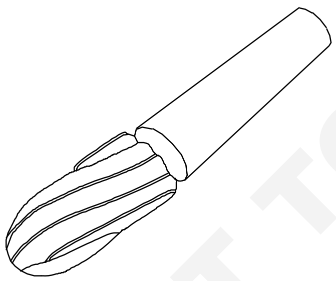
Fig 2

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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).

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.

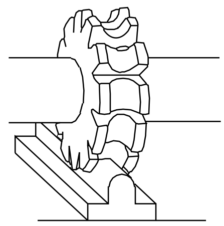
Fig 3

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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)

The cutters are specified by the type, diameter width, radius of the form and bore size.

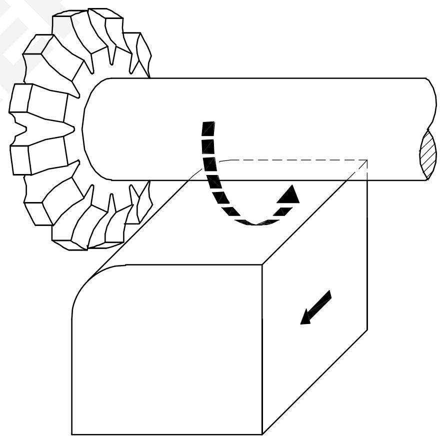
Fig 4

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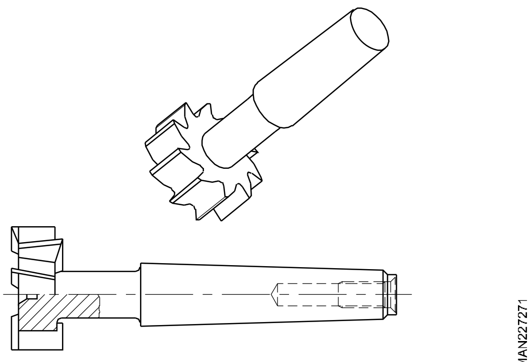
‘T’ slots cutters

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

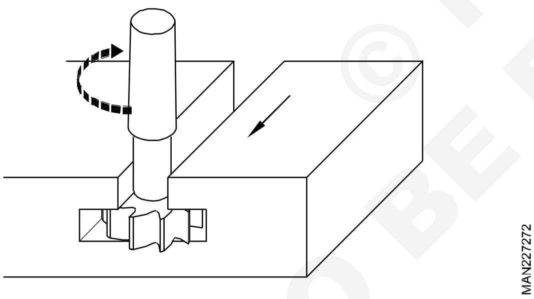
These cutters are profile-sharpened side milling cutters with a straight or taper shank. (Fig 1) They have staggered teeth and are either solid or tipped in construction. Due to the staggered teeth the chips are cleared without clogging.

Fig 1



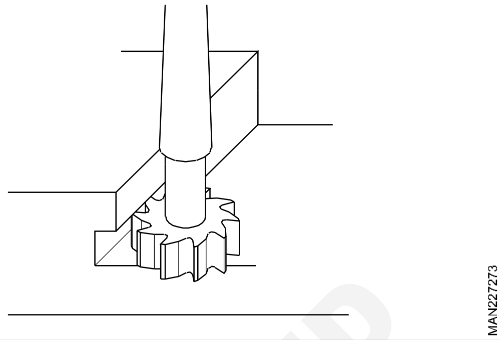
The ‘T’ slot cutter is used to cut ‘T’ shaped slots in machine tool work tables. (Fig 2) Before cutting the ‘T’ slot, a narrow vertical groove is machined with an end mill or a slot milling cutter.

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 paralled 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

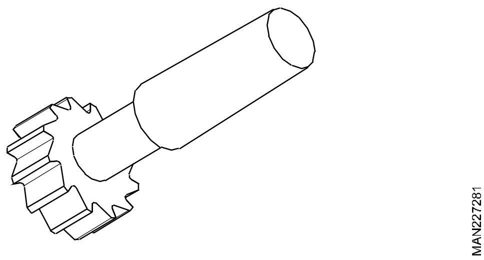
Objectives : At the end of this lesson you shall be able to
- **state the woodruff keyway cutter, thread cutter, gear cutter, tap and reamer cutter and state their uses**
- **state the sprocket cutter, spline cutter, fly cutter and bolted cutter and state their uses.**

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

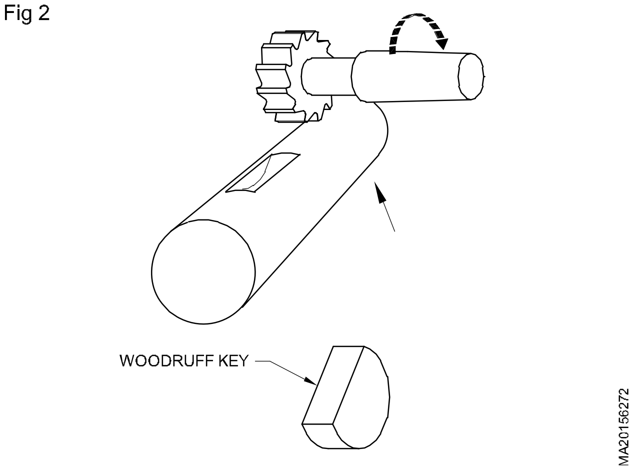
These are similar in appearance to ‘T’ slot cutters. These cutters have cutting edges on the periphery only. There are no side teeth. (Fig 1)

Fig 1



They are used for milling semi-cylindrical keyways in shafts for woodruff key seats. (Fig 2)

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.

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.

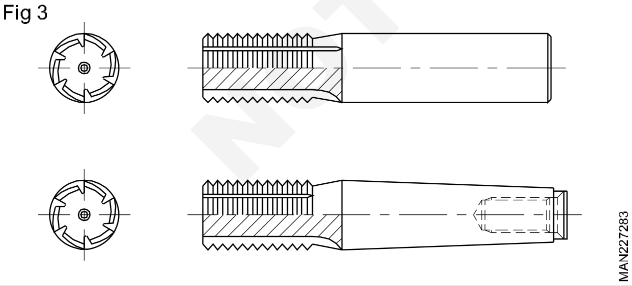
Type 'A' is for straight teeth and type B for staggered teeth.

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)

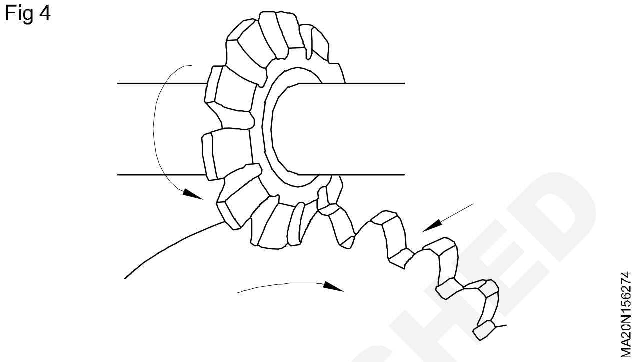
These cutters are used to machine gear teeth by milling.

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

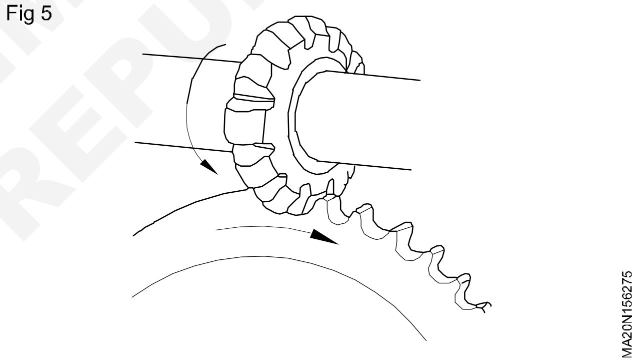
Fig 4



Sprocket cutters (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.

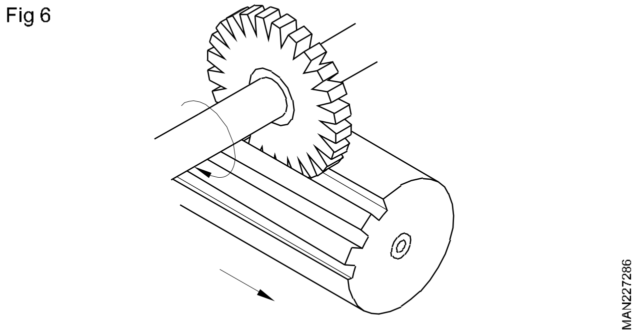
Fig 5



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

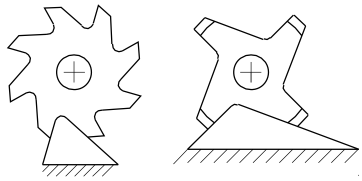


Tap and reamer cutter (Fig 7)

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.

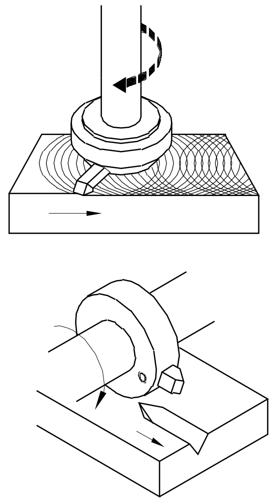
Fig 7



Fly cutters (Fig 8)

Fly cutters are single point tools having only one cutting edge. These tools are held in various types of holders.

Fig 8



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.

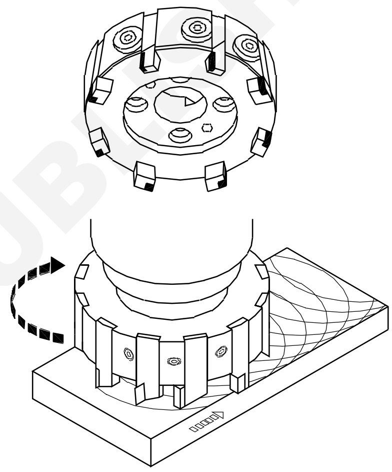
Bolted cutters (Fig 9)

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.

Angle of a milling cutter

A milling cutter tooth is more or less identical to that of a single point tool. (Fig 2)

Fig 1

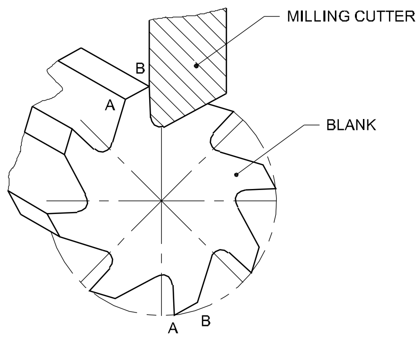
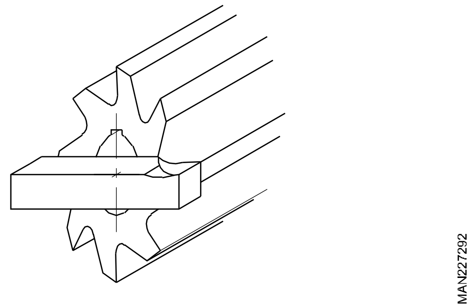


Fig 2



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)

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 relieived 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)

Fig 3

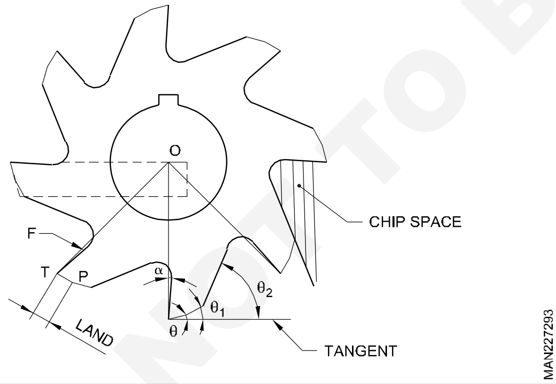
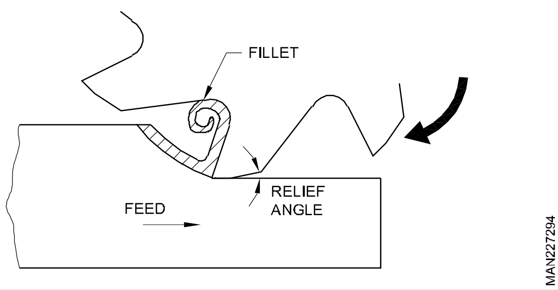


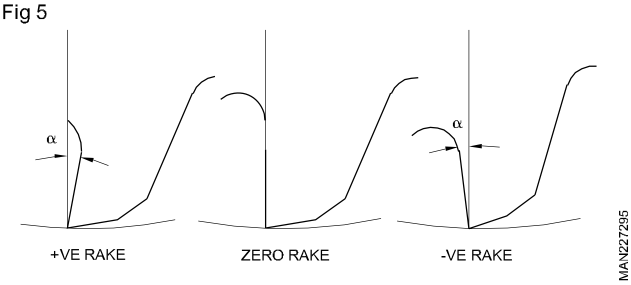
Fig 4



Positive, zero and negative rake

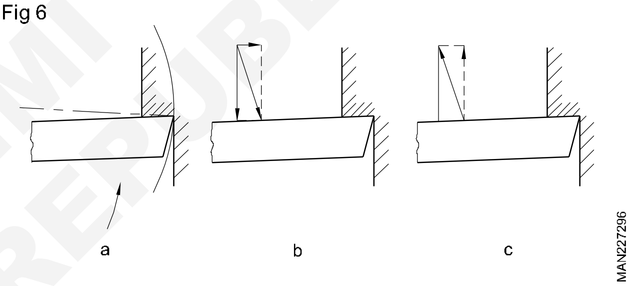
The rake angle may be positive, zero or negative as shown in fig 5.

Fig 5



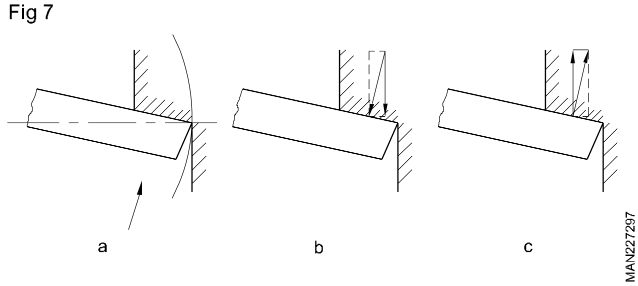
The positive rake is used for general purpose, and is used specially for milling materials which produce continuous chips. In the positive rake, the weakest point is presented to cut first. (Fig 6a) The reaction forces tend to pull the cutter into the work (Fig 6b) and the cutter forces tend to lift 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)

Fig 7



The zero rake is ideal for milling material like cast iron, brass etc. which produce broken chips.

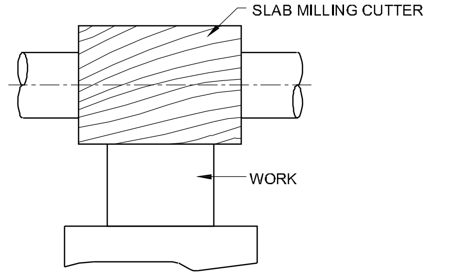
Different milling operation

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

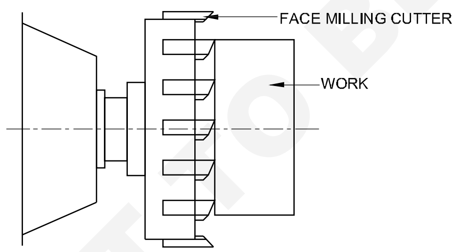


PLAIN MILLING OPERATION

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

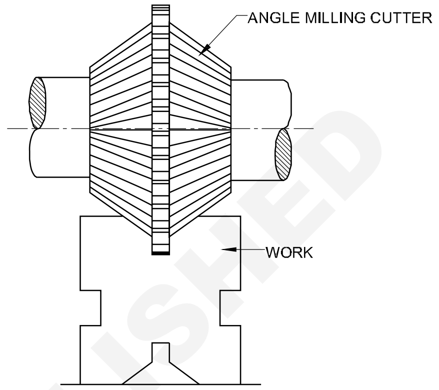
Angular milling

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

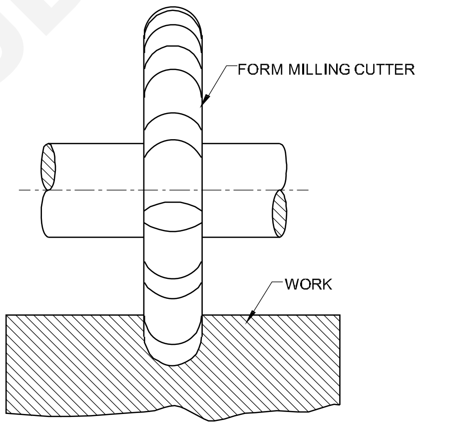
The form milling is the operation of production of irregular contours by using form cutters. Machining convex and concave surfaces and gear cutting are some examples of form milling. Fig 4 shows form milling operation.

Fig 3



ANGULAR MILLING OPERATION

Fig 4

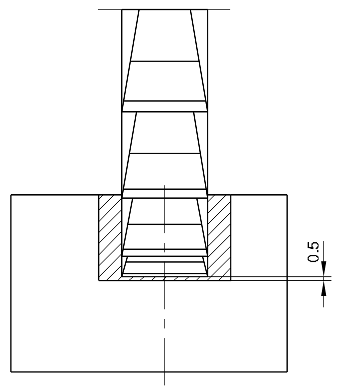


FORM MILLING OPERATION

Slot milling (Fig 5)

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.

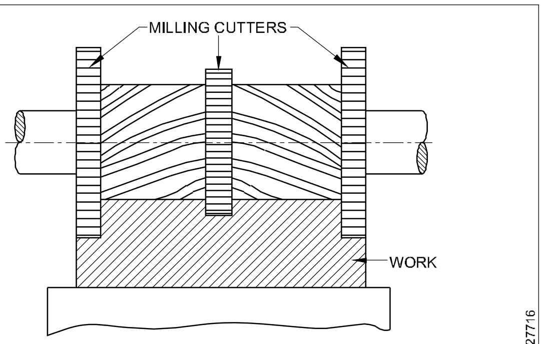
Fig 5



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

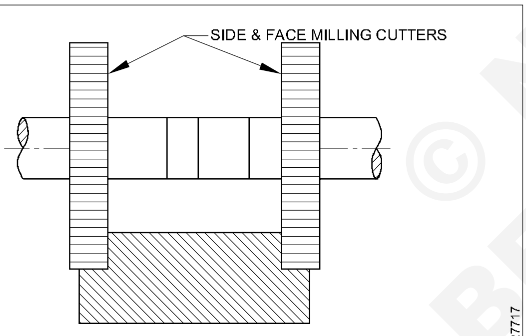


STRADDLE MILLING OPERATION

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

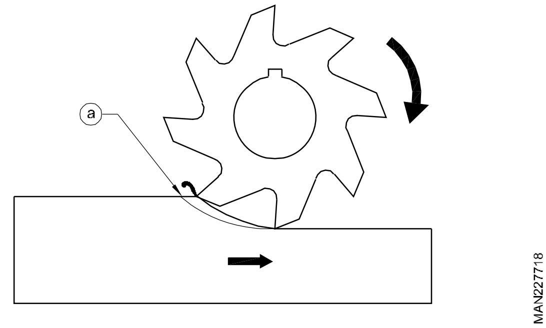


STRADDLE MILLING OPERATION

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.

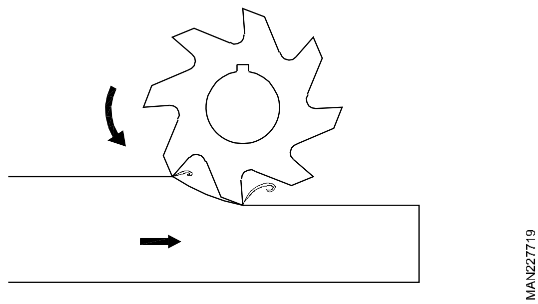
Down-cut milling

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



Milling attachments

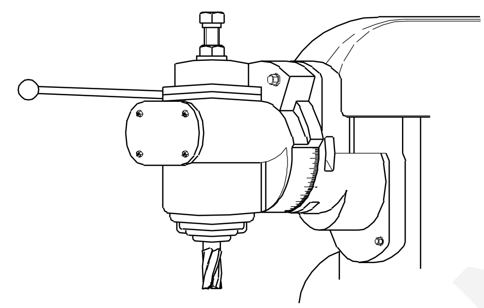
Objectives: At the end of this lesson you shall be able to
- **state the different types of milling machine attachments and their application.**

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)

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 1:1 ratio. The spindle has a standard taper and drive lugs for the cutters.

Fig 1



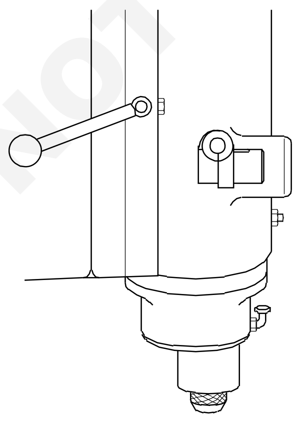
HEAVY DUTY VERTICAL ATTACHMENT

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



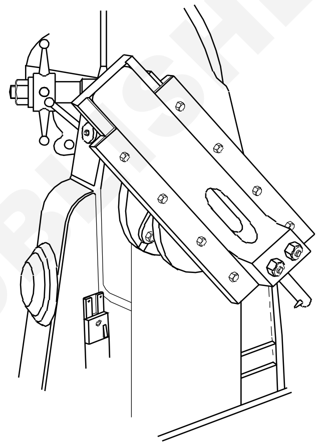
HIGH SPEED ATTACHMENT

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 attached (Fig 3)

Fig 3

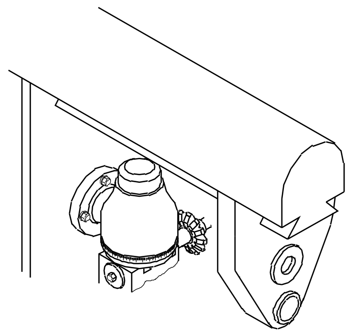


SLOTTING ATTACHMENT

The slotting attached 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.

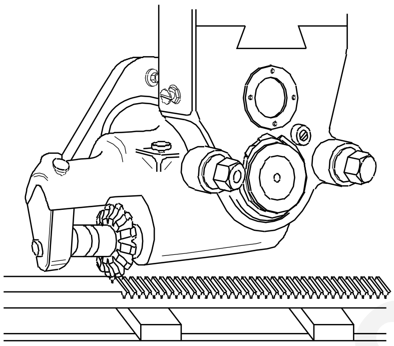
Rack milling attachment

The rack milling 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)

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 5

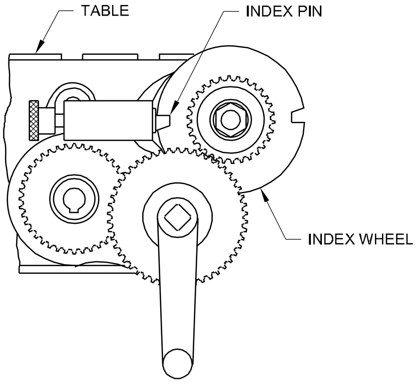


RACK MILLING ATTACHMENT

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.

Fig 6



RACK INDEXING ATTACHMENT

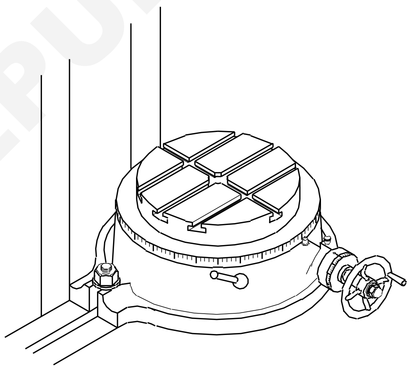
This method is positive and much more reliable than setting the table to a graduated dial directly fitted to the table feed screw.

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



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.

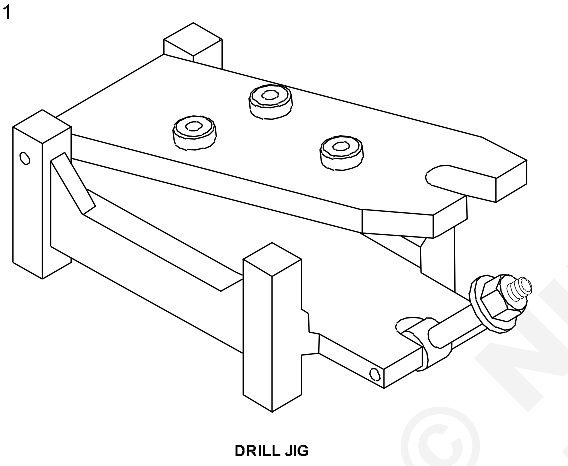
Jigs and fixtures

Objectives: At the end of this lesson you shall be able to
- **state the advantages and disadvantages of using jigs and fixtures**
- **distinguish between the functions of jigs and fixtures**
- **state the operations which can be performed on drill jigs**
- **state the different operations for which fixtures are used.**

A great deal of importance is placed today on improving productivity in manufacturing processes. Application of jigs and fixtures has contributed a lot towards this direction.

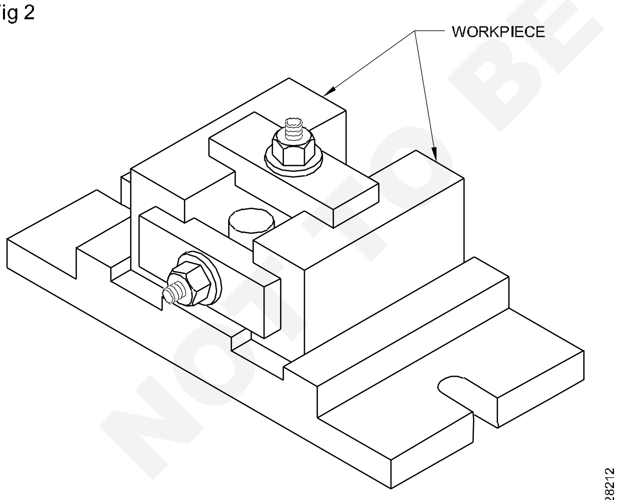
Jigs and fixtures (Fig 1 and 2) are devices used in manufacturing or assembling. They also facilitate in carrying out special operations accurately.

Fig 1



DRILL JIG

Fig 2



MILLING FIXTURE

Advantages of using jigs and fixtures

- It eliminates the setting time required before machining.
- It increases the machining accuracy and also increases production capacity.
- Requires less skilled operation.
- They reduce the production cost.
- Increases the machine and labor utilization.
- They simplify the work handling.
- Increase the quality of production in the industry.
- They enable the quick setting of a tool and proper positioning of the work.

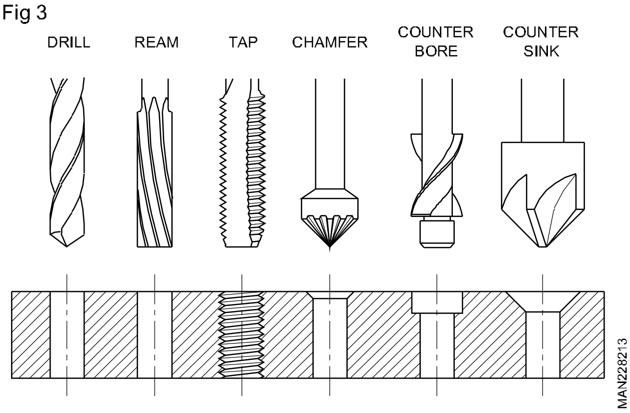
Insert Dis advantages of jigs and fixtures

- Dis advantages of jigs and fixtures
- Can wear away over time
- Can have complicated designs
- High initial set up casts and time
- Can use a lot of material and be bulky.
- Insert above the topic jigs.

Jigs: A jig is a special device which holds, supports, located and also guides the cutting tool during operation. Jigs are designed to accommodate one or more components at a time.

Jigs are available for drilling or boring. Drilling jigs are used to drill, ream, tap and to perform other allied operations. (Fig 3)

Fig 3



Boring jigs are used to bore holes which are either too large to drill or of odd size. (Fig 4)

Fixtures: A fixture is a production tool that locates and holds the work piece. It does not guide the cutting tools, but the tools can be positioned before cutting with the help of setting blocks and feeler gauges etc. (Fig 5)

Fig 4

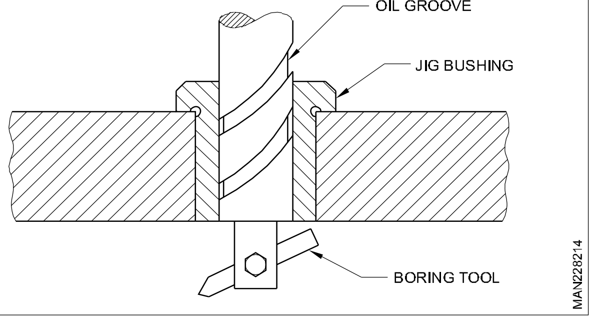
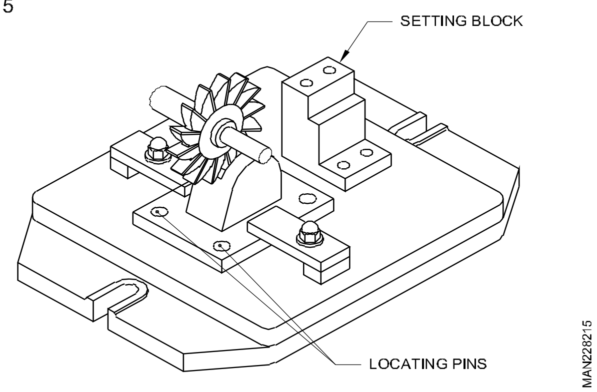


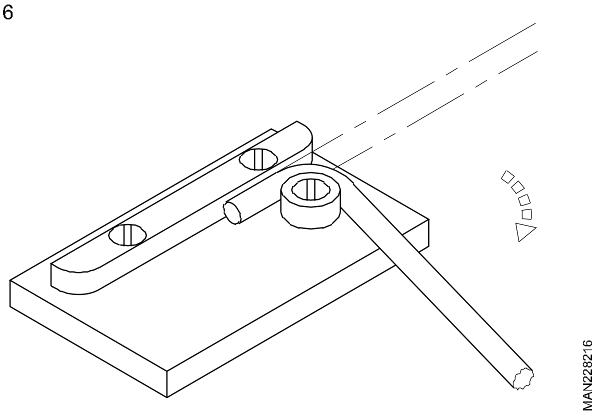
Fig 5



Fixtures of different types are made for:

- milling
- turning

Fig 6



- grinding
- welding
- assembly
- bending etc. (Fig 6)

Disadvantages of using jigs and fixtures

1 Can wear away over time

2 Can have complicated designs

3 High initial set up costs (and time)

4 Can use a lot of material and be bulky.

Types of drill jigs

Objectives: At the end of this lesson you shall be able to

- **state the different types of drill jigs**
- **state the constructional features of each type of drill jig**
- **state the different types of jigs.**

Drill jigs of different types are made according to the shape of the component and the operations to be performed.

- Plate jig and channel jig
- Solid jig
- Post jig
- Sandwich jig
- Table jig (Turnover jog)
- Box (Tumble jig)
- Trunnion jig
- Latch jig/leaf jig etc.

The design of a particular type of jig will be based on:

- the position wherein the drilling or its allied operation/ operations are to be performed
- the shape of the piece part.

Plate and channel jigs: This jig consists of a drill plate which rests on the component to be drilled. For correct positioning/locating, pins and clips are provided. For heavier piece parts, sometimes clamps are not used. Generally a base plate will not be available for this type of jigs. (Fig 1,2 and 3)

When this type of jig is in the form of a channel, it is known as a channel jig.

Fig 1

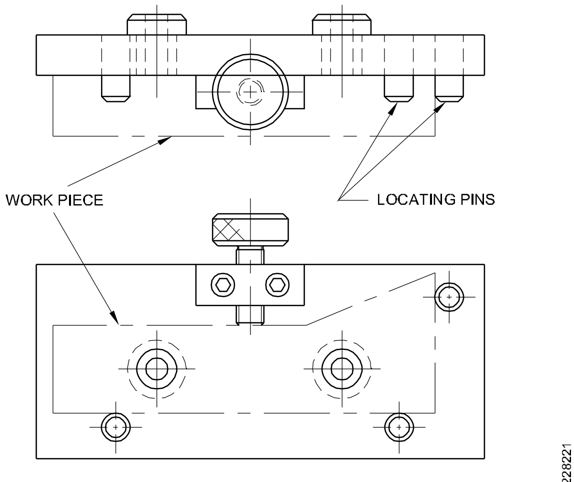


PLATE JIG

Fig 2

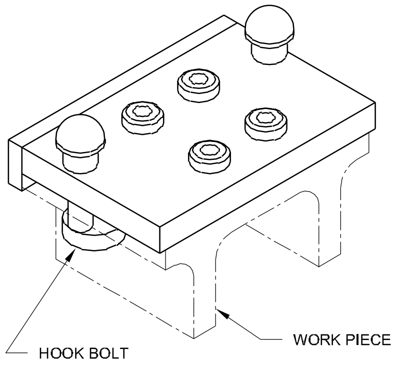
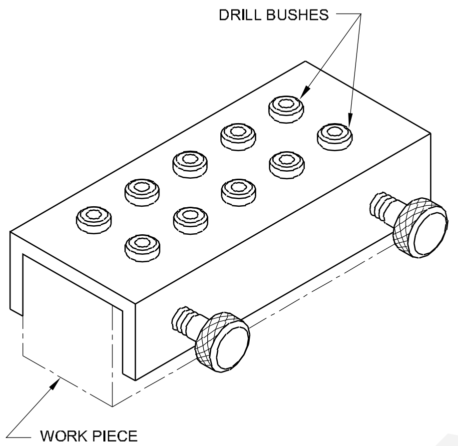


PLATE JIG

Fig 3

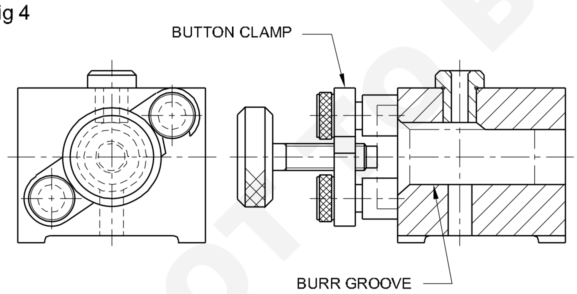


CHANNEL JIG

Solid jig

This can be used while drilling small piece parts. The body of this jigs is machined from a solid block of steel. (Fig 4)

Fig 4



SOLID JIG

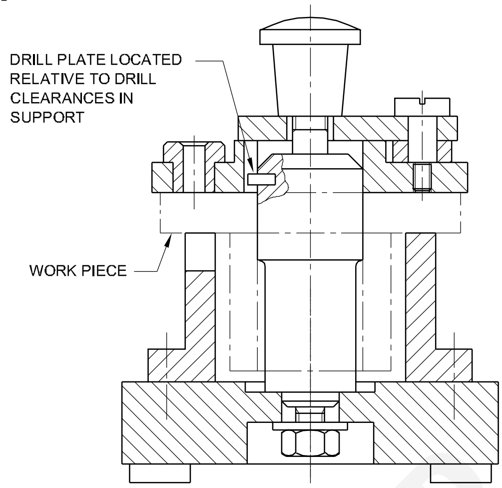
Post jigs

This is used for location from a bore. The post should be as short as possible to facilities loading and at the same time it must be long enough to support the workpiece. (Fig 5)

Sandwich jig

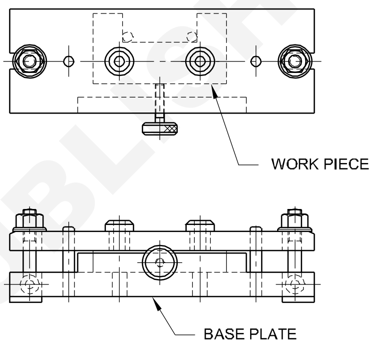
This is ideal for thin or soft workpieces which may bend or warp due to force while machining. In this type of jigs, the component will be sandwiched between the base plate and the drill plate. (Fig 6)

Fig 5



POST JIG

Fig 6



SANDWICH JIG

Table jig (Turnover)

This is used when it is necessary to locate the piece part from its face. For accurate seating of the jig on the machine table, four legs will be provided on this type of jig. (Fig 7)

Fig 7

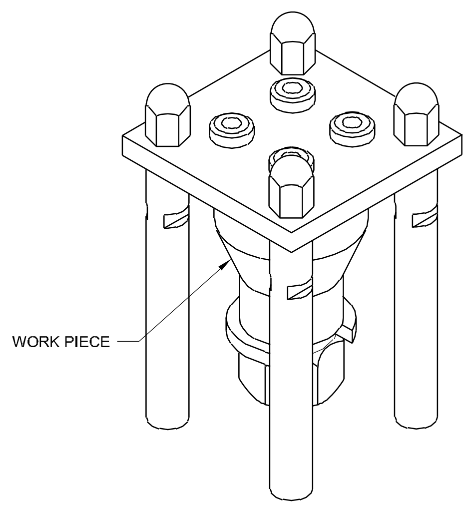
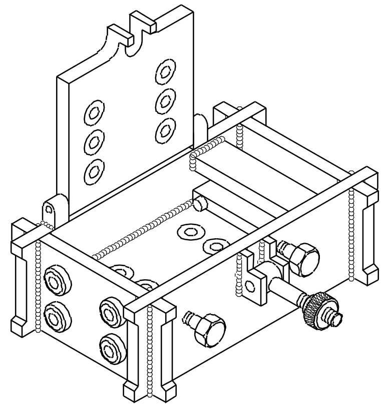


TABLE OR TURNOVER JIG

Box jig

This is made in the form of a box or a frame work. The component is located and clamped at one position but drilling can be done from different directions as required. When a box jig contains bushings on two or more sides for drilling from different directions, it is called a tumble jig. (Fig 8) This jig is meant small components only.

Fig 8



BOX / TUMBLE JIG

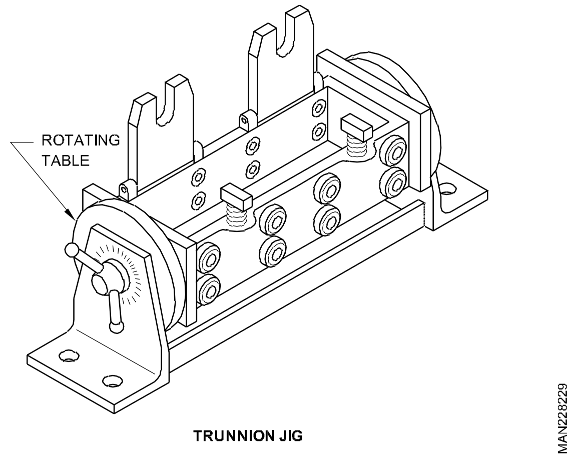
Trunnion jig

This can be used when large or awkwardly shaped workpiece are to be drilled from different directions. This a further modification of the box jig which is carried on truning and rotated from station to station and positioned using an indexing device. (Fig 9)

Latch or leaf jig

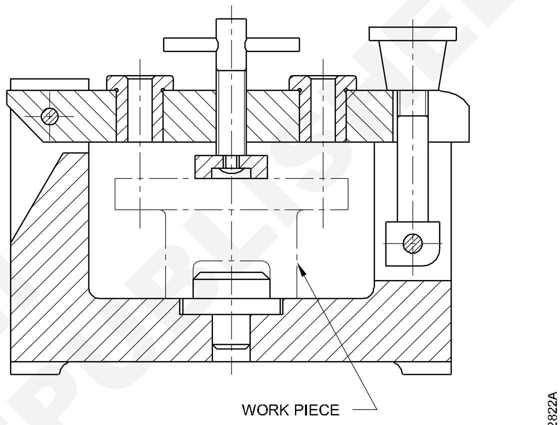
This type of jig will have a hinged cover with the latch clamps for easy loading and unloading of components. The cover with latch must be positively located and clamped so that the bushes are accurately located with respect to the component. (Fig 10)

Fig 9



TRUNNION JIG

Fig 10



LATCH JIG

Physical and mechanical properties of metals and heat treatment

Objectives: At the end of this exercise you shall be able to
- **state the different physical and mechanical properties of materials**
- **state the characteristics of the mechanical properties of metals.**

Properties of metals

Metals have different properties. Depending on the type of application, different metals are selected.

Physical properties of metals

- Colour
- Weight/Specific gravity
- Structure
- Conductivity
- Magnetic property
- Fusibility

Colour

Different metals have different colours. For example, copper is of a distinctive red colour. Mild steel is of a blue/ black sheen.

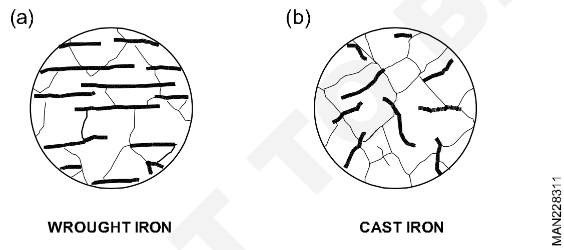
Weight

Metals differ based on their weight. A metal, like aluminium, weighs lighter (specific gravity 2.8) than many others, and a metal, like lead, is heavy (specific gravity 9).

Structure (Figs 1 a and b)

Generally metals can also be differentiated by their internal microstructure. Metals like wrought iron and aluminium will have a fibrous structure, and metals like cast iron and bronze will have a granular structure.

Fig 1 (a) (b)



Conductivity

Thermal conductivity and electrical conductivity are the measure of the ability of a material to conduct heat and electricity. Conductivity will vary from metal to metal. Copper and aluminium are good conductors of heat and electricity.

Magnetic property

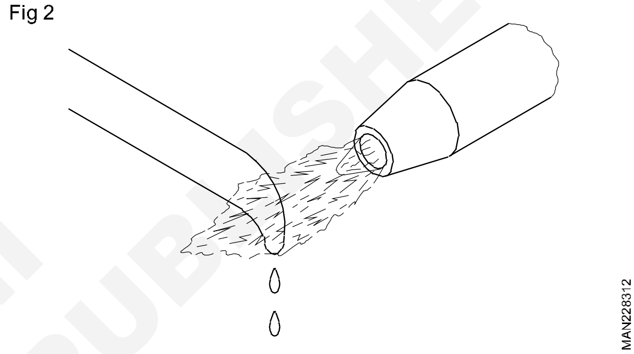
A metal is said to possess magnetic property, if it is attracted by a magnet.

Almost all ferrous metals, excepting some types of stainless steel, can be attracted by a magnet and all non-ferrous metals and their alloys will not be attracted by a magnet.

Fusibility (Fig 2)

It is the property possessed by a metal by virtue of which it melts when heat is applied. Many materials are subject to the transformation in shape (i.e.) from solid to liquid at different temperatures. Tin has a low melting temperature (232^{0}C) and tungsten melts at a high temperature (3370^{0}C).

Fig 2



Mechanical properties

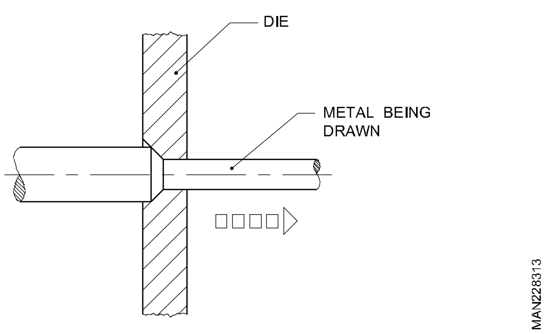
The mechanical properties of a metal are

- ductility
- hardness
- toughness
- elasticity
- malleability
- brittleness
- tenacity

Ductility (Fig 3)

A metal is said to be ductile when it may be drawn out in tension without rupture. Wire-drawing depends upon ductility for its successful operation. A ductile metal must be both strong and plastic. Copper and aluminium are good examples of ductile metals.

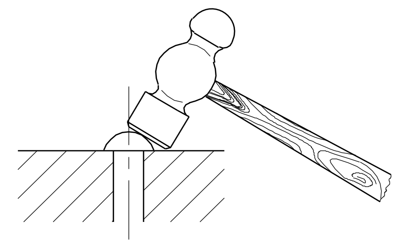
Fig 3



Malleability (Figs 4)

Malleability is the property of permanently extending in all directions without rupture by hammering, rolling etc, to change its size and shape. Lead is a very malleable metal.

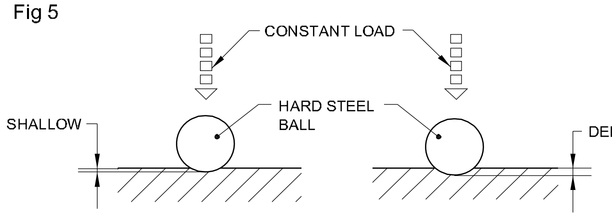
Fig 4



Hardness (Fig 5)

Hardness is a measure of a metal's ability to withstand scratching, wear, abrasion and penetration.

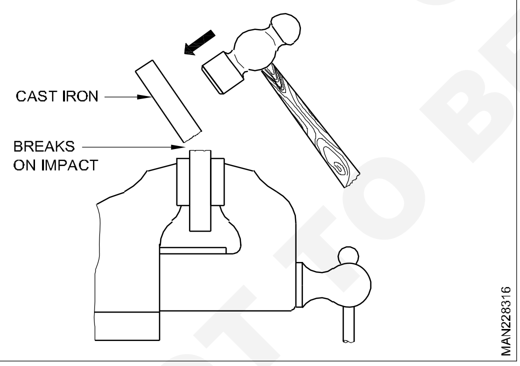
Fig 5



Brittleness (Fig 6)

Brittleness is that property of a metal which permits no permanent distortion before breaking. Cast iron is an example of a brittle metal, and it will break rather than bend under shock or impact.

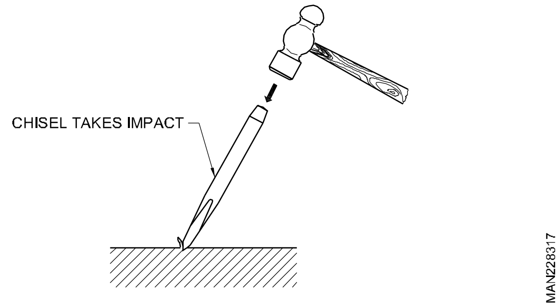
Fig 6



Toughness (Fig 7)

Toughness is the property of a metal to withstand shock or impact. Toughness is the property opposite to brittleness. Wrought iron is an example of a tough metal.

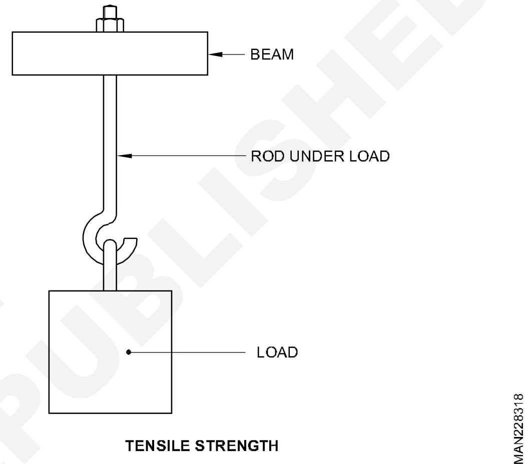
Fig 7



Tenacity (Fig 8)

Tenacity of a metal is its ability to resist the effect of tensile forces without rupture. Mild steel, wrought iron and copper are examples of tenacious metals.

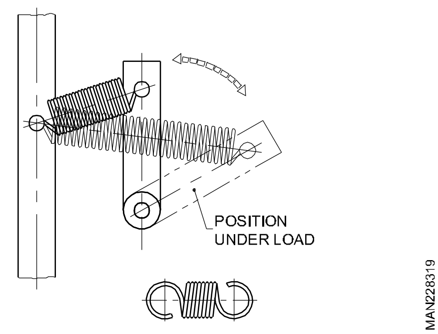
Fig 8



Elasticity (Fig 9)

Elasticity of a metal is its power of returning to its original shape after the applied force is released. Properly heat-treated spring is a good example of elasticity.

Fig 9



Annealing of steel

Objectives: At the end of this lesson you shall be able to
- **state the annealing of steel**
- **state the purpose of annealing**
- **state the processes of annealing.**

The annealing process is carried out by heating the steel above the critical range, soaking it for sufficient time to allow the necessary changes to occur, and cooling at a predetermined rate, usually very slowly, within the furnace.

Purpose

To soften the steel

To improve the machinability.

To increase the ductility.

To relieve the internal stresses.

To refine the grain size and to prepare the steel for subsequent heat treatment process.

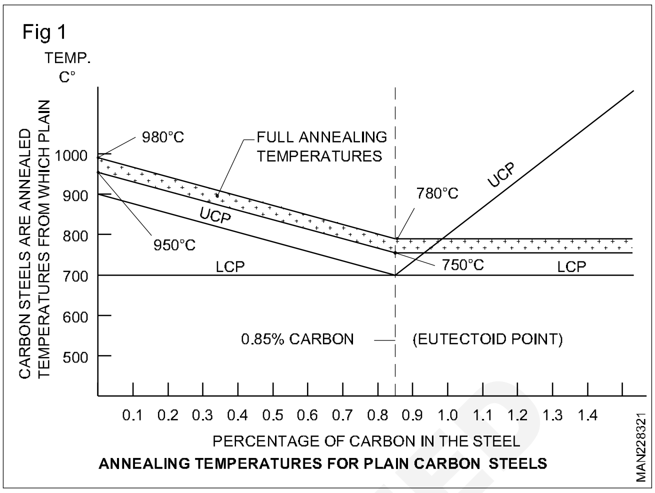
Annealing process

Annealing consists of heating of hypo eutectoid steels to 30 to 50^{0}C above the upper critical temperature and 50^{0}C above the lower critical temperature for hypereutectoid steels. (Fig 1)

Soaking is holding at the heating temperature for 5mts./ 10mm of thickness for carbon steels.

The cooling rate for carbon steel is 100 to 150^{0}C/hr.

Steel, heated for annealing, is either cooled in the furnace itself by switching off the furnace or it is covered with dry sand, dry lime or dry ash.



Hardening of carbon steel

Objectives: At the end of this lesson you shall be able to
- **state the hardening of steel**
- **state the purpose of hardening the steel**
- **state the process of hardening.**

What is hardening?

Hardening is a heat treatment process in which steel is heated to 30-50^{0}C above the critical range. Soaking time is allowed to enable the steel to obtain a uniform temperature throughout its cross-section. Then the steel is rapidly cooled through a cooling medium.

Purpose of hardening

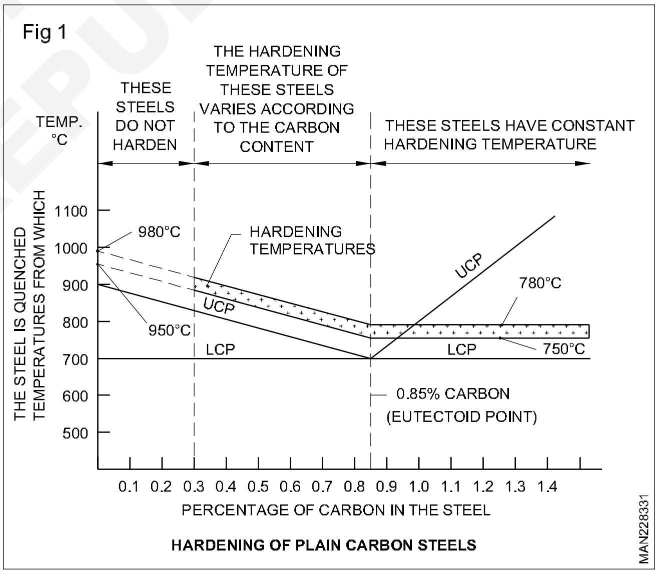
To develop high hardness and wear-resistance properties

Hardening affects the mechanical properties of steel like strength, toughness, ductility etc.

Hardening adds cutting ability.

Process of hardening

Steel with a carbon content above 0.4% is heated to 30-500C above the upper critical temperature (Fig 1). A soaking time of 5mts./ 10 mm thickness of steel is allowed. (Fig 1) Then the steel is cooled rapidly in a suitable medium. Water, oil, brine or air is used as a cooling medium, depending upon the composition of the steel and the hardness required.



Tempering the hardened steel

Objectives: At the end of this lesson you shall be able to
- **state what is tempering**
- **state the purpose of tempering**
- **relate the tempering colours and temperatures with the tools to be tempered**
- **state the process of tempering of steels.**

What is tempering?

Tempering is a heat treatment process consisting of reheating the hardened steel to a temperature below 400^{0}C followed by cooling.

Purpose of tempering the steel

Steel in its hardened condition is generally too brittle to be used for certain functions. Therefore, it is tempered.

The aims of tempering are:

- to relieve the internal stresses

- to regulate the hardness and toughness

- to decrease the brittleness

- to restore some ductility

- to induce shock resistance.

Process of tempering the steel

The tempering process consists of heating the hardened steel to the appropriate tempering temperature (Table 1) and soaking at this temperature, for a definite period.

The period is determined from the experience that the full effect of the tempering process can be ensured only, if the tempering period is kept sufficiently long.

Table - 1

Tools or articles	Temperature Centigrade Degrees	Colour
Turning tools	230	Pale straw
Drills and milling cutters	240	Dark straw
Taps and shear blades	250	Brown
Punches, reamers, twist drills	260	Red brown
Rivets, snaps	270	Brown purple
Press tools, cold chisels	280	Dark purple
Cold set for cutting steels	290	Light blue
Springs, screwdrivers	300	Dark blue
	320	Very dark blue
	340	Greyish blue
For toughening without undue hardness	450-700	No colour

Normalising steel

Objectives: At the end of this lesson you shall be able to
- **state the meaning of normalising steel and its purpose**
- **state the process of normalising steel**
- **state the precaution to be taken while normalising steel.**

The process of removing the internal defects or to refine the structure of steel components is called normalising.

Purpose

To produce fine grain size in the metal.

To remove stresses and strains formed in the internal structure due to repeated heating and uneven cooling or hammering.

To reduce ductility.

To prevent warping.

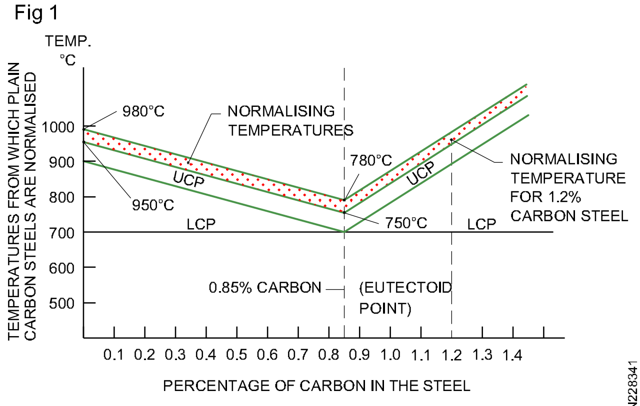
Process

To get the best results from normalizing, the parts should be heated uniformly to a temperature of 30 to 400C above the upper critical temperature (Fig 1), followed by cooling in still air, free from drought, to room temperature. Normalizing should be done in all forgings, castings and work-hardened pieces.

Precautions

Avoid placing the component in a wet place or wet air, thereby restricting the natural circulation of air around the component. Avoid placing the component on a surface that will chill it.

Fig 1



NORMALISING TEMPERATURES FOR PLAIN CARBON STEELS

Heat treatment of plain carbon steels

Objectives: At the end of this lesson you shall be able to
- **state the purpose of heat treatment of steel**
- **state the types of structure, constituents and properties of plain carbon steels.**

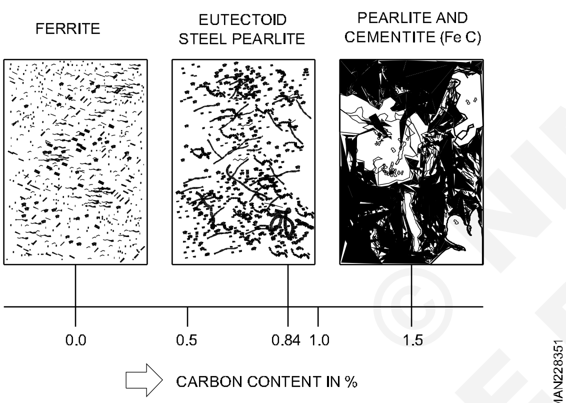
Heat treatment and its purpose

The properties of steel depend upon its composition and its structure. These properties can be changed to a considerable extent, by changing either its composition or its structure. The structure of steel can be changed by heating it to a particular temperature and then allowing it to cool at a definite rate. The process of changing the structure and thus changing the properties of steel, by heating and cooling, is called 'heat treatment of steel'.

Types of structures of steel (Fig 1)

The structure of steel becomes visible when a piece of the metal is broken. The exact grain size structure can be seen through a microscope. Steel is also classified according to its type of structure.

Fig 1



Steel is an alloy of iron and carbon. But the carbon content in steel does not exceed 1.7%

Ferrite

Pig - iron or steel with 0% carbon is called FERRITE which is relatively soft and ductile but comparatively weak.

Cementite

When carbon exists in steel as a chemical compound of iron and carbon it is called 'iron carbide' or CEMENTITE. This alloy is very hard and brittle but it is not strong.

Eutectoid / Pearlite steel

A 0.84% carbon steel or eutectoid steel is known as PEARLITE steel. This is much stronger than ferrite or cementite.

Hypereutectoid steel

More than 0.84% Carbon steel or hypereutectoid steel is pearlite and cementite.

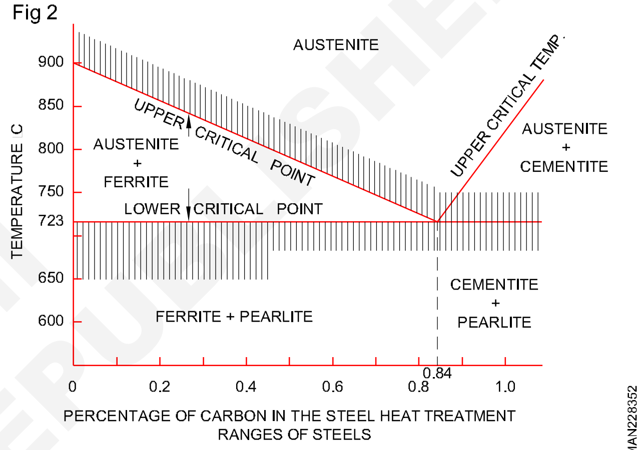
Hypo eutectoid steel

Less than 0.84% carbon steel or hypo eutectoid steel is pearlite and ferrite.

Structure of steel when heated (Fig 2)

If steel is heated, a change in structure commences from 723^{0}C. The new structure formed is called 'AUSTENITE'. Austenite is non - magnetic. If the hot steel is cooled slowly, the old structure is retained and it will have fine grains which makes it easily machin able.

Fig 2



If the hot steel is cooled rapidly the austenite changes into a new structure called 'MARTENSITE'. This structure is very fine, very hard and magnetic. It is extremely wear resistant and can cut other metals.

Heat treatment processes and purposes

Because steel undergoes changes in structure on heating and cooling, its properties may be greatly altered by suitable heat treatment.

The following are the various heat treatments and their purposes.

Hardening : To add cutting ability.
To increase wear resistance.

Tempering : To remove extreme brittleness caused by hardening to an extent.
To induce toughness and shock-resistance.

Annealing : To relieve strain and stress.
To eliminate strain / hardness.
To improve machinability.
To soften the steel.

Normalising : To refine the structure of the steel.

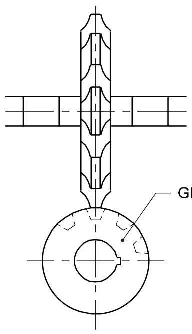
Indexing

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.**

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



Indexing is also used to rotate the workpiece at a predetermined ratio to the table feed rate to produce cams, helical grooves etc.

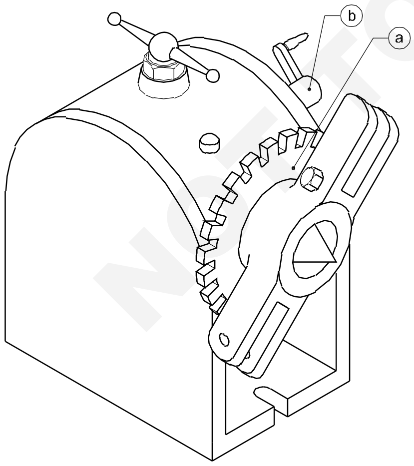
This operation is performed on a milling machine by means of an indexing attachment which is called as indexing head or the dividing head.

Types of indexing heads

The most common types of indexing heads are

- direct indexing head (Fig 2)

Fig 2



- simple indexing head (Fig 3)
- universal indexing head. (Fig 4)

Direct indexing

Purpose of direct indexing

Fig 3

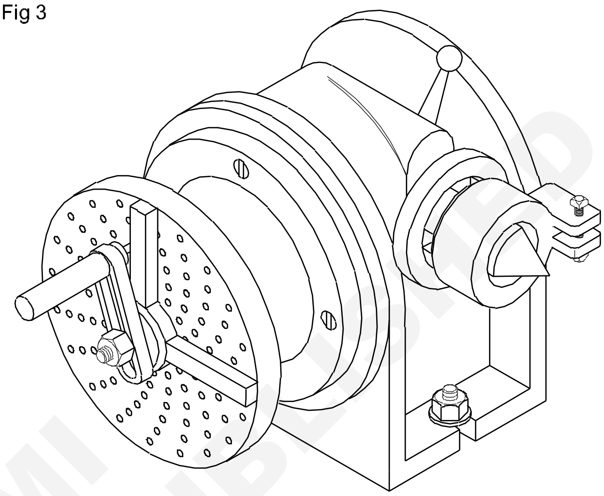
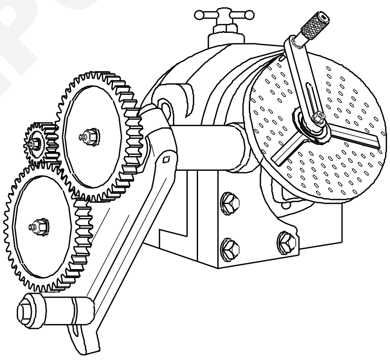


Fig 4



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.

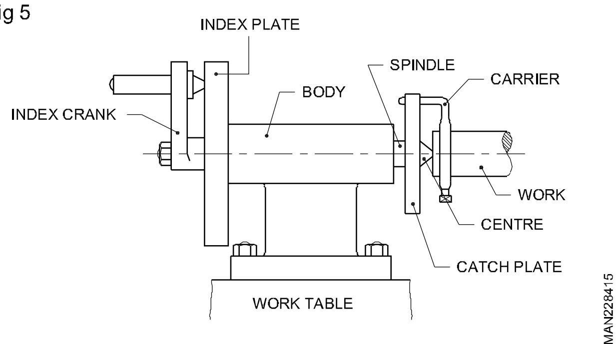
Direct indexing mechanism (Fig 5)

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.

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 5



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 6

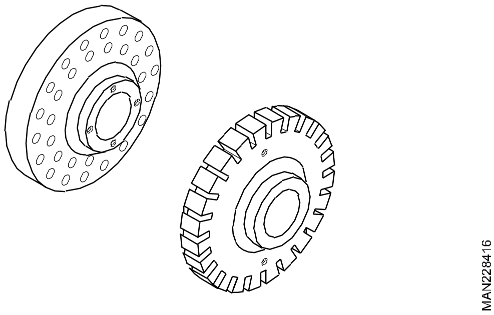
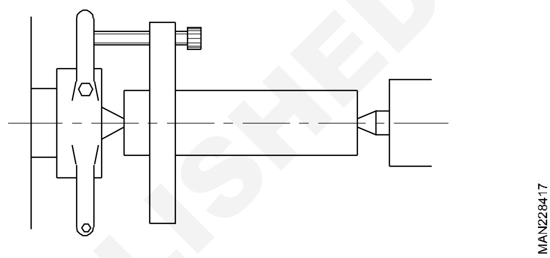


Fig 7



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.**

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)

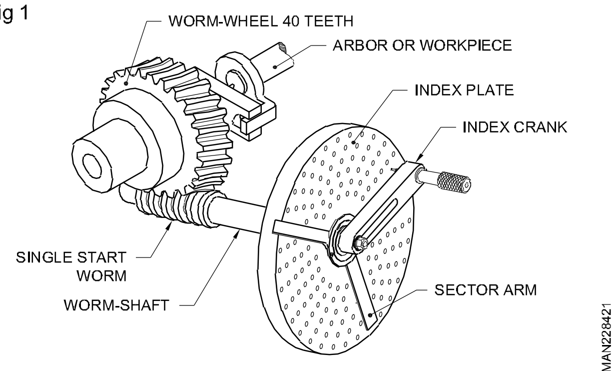
The simple indexing mechanism consists of a 40 tooth worm-wheel fastened to the spindle, a single start worm, a crank for turning the work shaft and an index plate and sector.

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.

Fig 1



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.

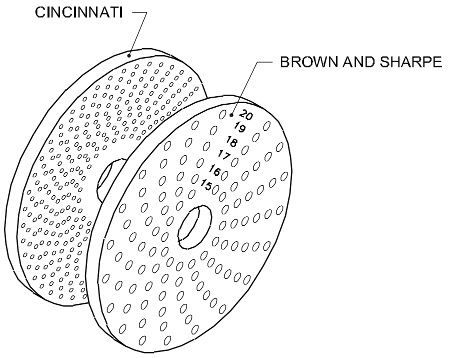
The object of these plates is to allow the worm to be moved a fractional part of a turn.

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.

Fig 2



INDEX PLATES

MAN228422

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.

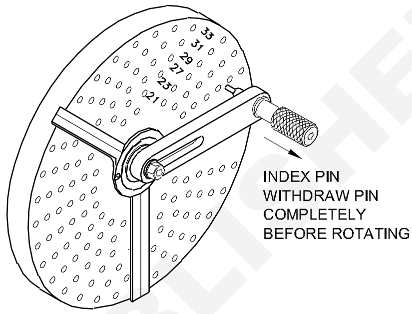
The arms eliminate the need for counting the number of holes each time the crank has to be turned by a set number of divisions.

Formula for simple indexing

$$\text{Index crank movement} = \frac{40}{N}$$

'N' is the number of turns of the crank required.

Fig 3



INDEX CRANK

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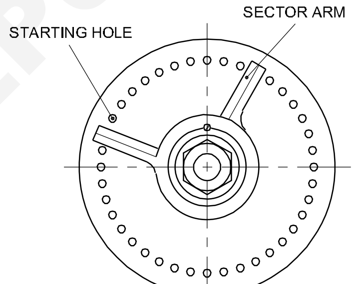
Fig 4



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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.**

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)

Angular indexing can be carried out using a simple indexing head equipment.

Principle

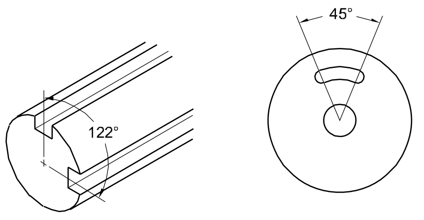
Most indexing heads require 40 turns of the crank to rotate the spindle once.

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)

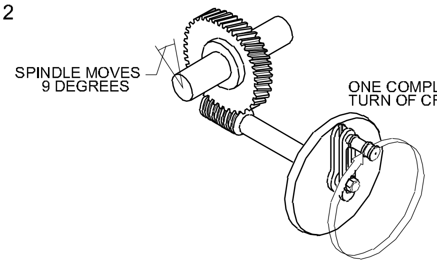
It follows that 1/9 turn of the crank will give a spindle movement of 1 degree.

Fig 1



EXAMPLES OF ANGULAR INDEXING

Fig 2



PRINCIPLE OF ANGULAR INDEXING

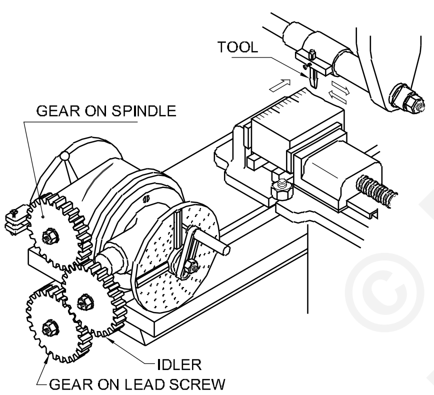
Linear Indexing

Objectives : At the end of this lesson you shall be able to
- **state the purpose of linear indexing**
- **state the principle of linear indexing, using an indexing head**
- **state the crank movement for linear indexing.**

Linear indexing

The operation of producing accurate spaces on a piece of flat stock, or that of linear graduating is easily accomplished on the horizontal milling machine Fig 1.

Fig 1



LINEAR INDEXING

In this process the work may be clamped to the table or held in a vice, depending on the shape and size of the part. Care must be taken to align the workpiece parallel to the table travel.

Principle

To produce an accurate longitudinal movement of the table, the dividing head spindle is geared to the lead screw of the milling machine.

If the dividing head spindle and the lead screw are connected with gears of 1:1 ratio, ie. With equal number of teeth and the index crank turned one revolution, the spindle and lead screw on an inch milling machine, would revolve one fortieth (1/40th) of a revolution. This rotation of the lead screw having 4 threads per inch 1/40 x 1/4 (is equal to) 1/160 = 0.00625 inch (0.15875 mm). Thus five turns of the index crank would move the table 5 x 0.00625, or 1/32 in (0.79375 mm).

Differential indexing

Objectives : At the end of this lesson you shall be able to
- **explain the function of a universal indexing head**
- **state the purpose of differential indexing**
- **explain the principle of differential indexing.**

Universal indexing head

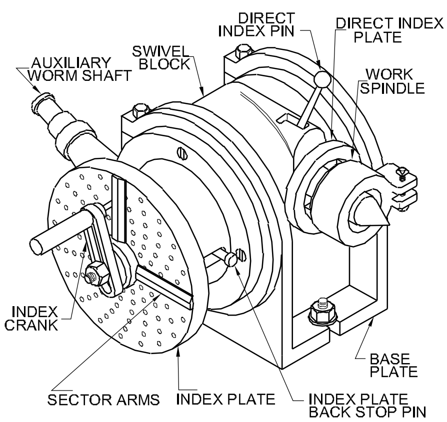
Differential indexing is possible on universal indexing head. (Fig 1)

The universal indexing head has the same operating parts as the simple head.

Part of its body forms a swivel block clamped in a cradle. The spindle can be tilted vertically through 90° or more, and wider range of operations can be set up.

Gear trains may be mounted on universal indexing heads to enable spiral milling.

Fig 1



UNIVERSAL INDEXING HEAD

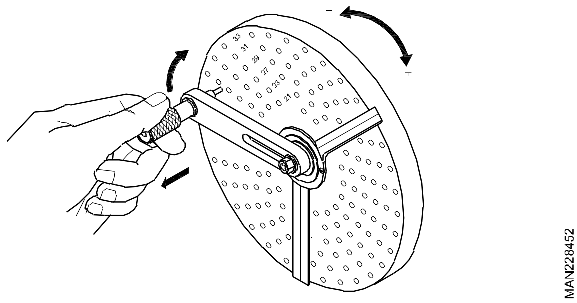
Differential indexing

Differential indexing enables a wider range of divisions to be indexed than can be obtained using simple indexing with a standard indexing plate.

Principle

Differential indexing means the difference of two combined motions. The required division is obtained by a movement of the index crank combined with a movement of the index plate either in the same or opposite direction. (Fig 2)

Fig 2



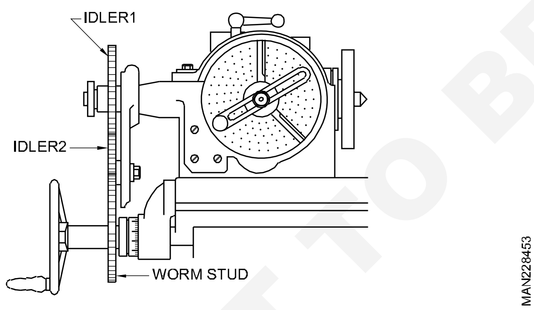
The actual movement of the crank is either smaller or greater than its movement in relation to the index plate.

The movement of the plate for a turn of the crank is controlled by change gears arranged between the indexing head spindle and its auxiliary worm shaft.

Gear arrangement (Fig 3)

An extended spindle is fitted to the rear of the indexing head work spindle. A gear train, connected by idler gears held on an adjustable bracket connects the extended spindle to the auxiliary worm shaft drive.

Fig 3



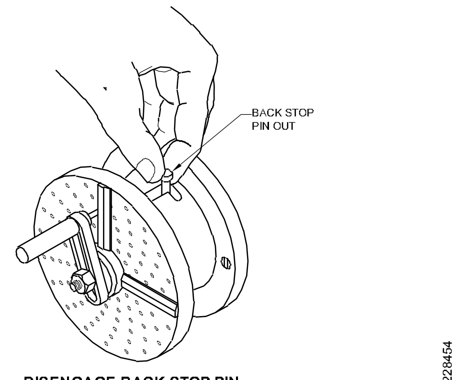
Gear operation

Prior to indexing the back stop pin must be disengaged to permit rotation of the index plate. (Fig 4)

When the index crank is turned, the index head spindle will rotate in the ratio of 40:1, as in simple indexing. The driving gear fitted to the end of the index head spindle will also turn and drive through the idler gear, to turn the auxiliary worm shaft which is connected to the index plate.

The amount of index plate movement is relative to the movement of the index crank and it depends on the ratio of the driving gear to the driven gear.

Fig 4



DISENGAGE BACK STOP PIN

The plate moves in the same or opposite direction to the crank, depending on the number of idler gears used and the design of the indexing head.

Index Plate and crank revolve in same direction (Fig 5)

If equal driver and driven gears are used, 40 revolutions of the crank will rotate the spindle and plate one complete revolution.

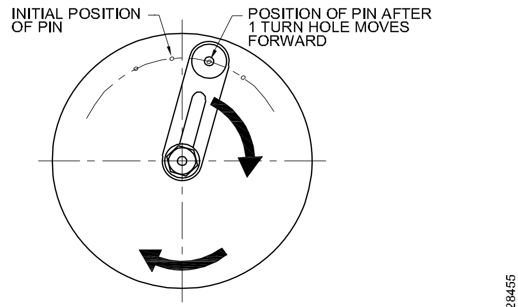
One revolution of the crank will rotate the plate 1/40 of a division and the hole from which the index pin started will advance 1/40 of a revolution. When the pin is advanced to the hole from which it started, the index crank will have made 1 and 1/40 of a revolution.

Index Plate and crank revolve in opposite directions (Fig 6)

When the crank is rotated, the index plate will turn in the opposite direction, 1/40 of a turn for each turn of the crank.

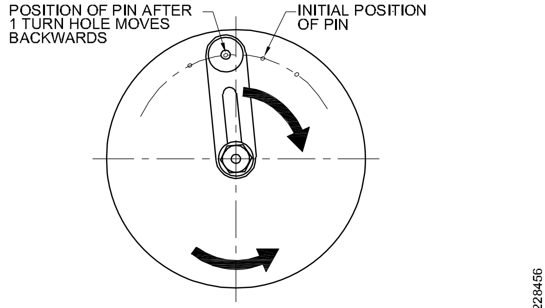
If the index pin is brought up to the same hole from which it started, the crank will have turned 1/40 of a turn less than a full turn.

Fig 5



INDEX PLATE TURNS WITH CRANK

Fig 6



INDEX PLATE TURNS AGAINST CRANK

Calculating of indexing

Objectives: At the end of this exercise you shall be able to
- **explain the indexing movement required for direct indexing**
- **explain the indexing movement required for simple indexing**
- **explain the indexing movement for angular indexing**
- **explain the crank movement for linear indexing.**

Direct indexing

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°, 45°, 30° and 15°. This indexing can also be performed by simple indexing head by disengaging worm from worm wheel. (Fig 1)

Simple indexing

Find the number of turns of the crank required to index 12 divisions.

$$\text{Index crank movement} = \frac{40}{N} = \frac{40}{12} = 3\frac{1}{3}$$

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.

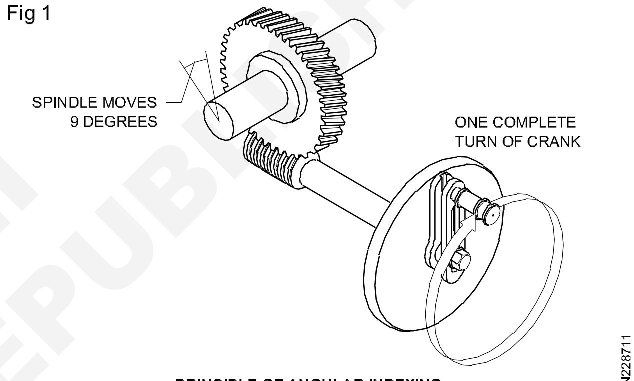
$$\text{Index crank movement} = \frac{40}{N} = \frac{40}{43}$$

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

Index for 45°

Fig 1



PRINCIPLE OF ANGULAR INDEXING

$$T = \frac{D}{9}$$

$$= \frac{45}{9} = 5 \text{ complete turns}$$

Index for 122°

$$T = \frac{D}{9}$$

$$= \frac{122}{9} = 13\frac{5}{9} \text{ turns}$$

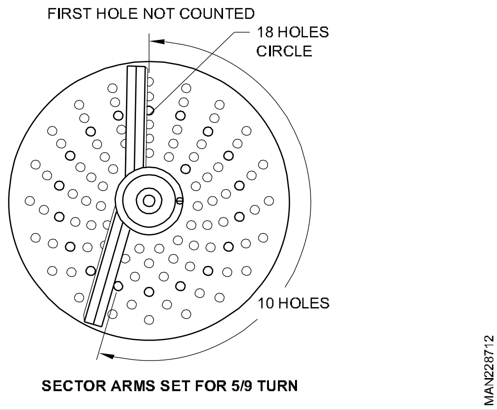
That is 13 complete turns and 5/9 of a turn. This is obtained by setting an index plate with a circle of holes divisible by 9 and setting the sector arms of 5/9 of a turn.

If a 18 hole circle is used

5/9 x 18 = 10 holes

Then T = 13 turns + 10 holes of the 18 holes in the circle. (Fig 2) using brown and sharp company index plate No.1

Fig 2



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 3 to 5)

To index an angle of 34°40'

Angle in minutes = 34 x 60 + 40 = 2080

$$T = \frac{M}{540} = \frac{2080}{540} = \frac{208}{54} = \frac{104}{27} = 3\frac{23}{27}$$

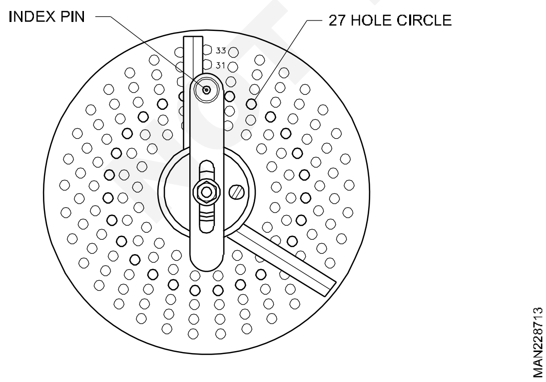
3 complete turns plus 23 holes spaces in the 27 hole circle will give an index angle of 34° 40' by using brown and sharp company plate No.2

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

Fig 3



Index crank movement =

$$\frac{\text{Angular displacement of work in seconds}}{32400}$$

Fig 4

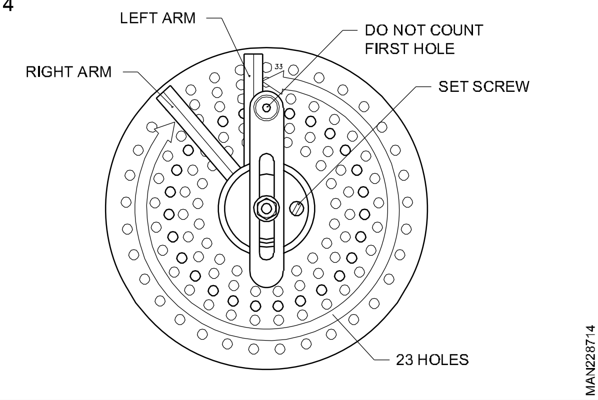
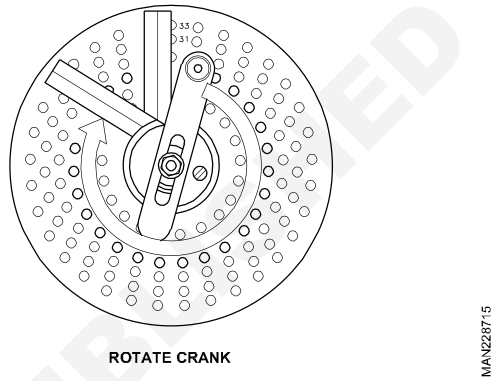


Fig 5



Linear indexing

Calculation

The formula for calculating the indexing for linear graduations in thousands of an inch is

$$\text{Rule } T = \frac{N}{0.00625}$$

where N = spacing required in inch

T = No.of turns of index crank

If the lead screw of a metric milling machine has a pitch of 5mm, one turn of the index crank would move the table one-fortieth of 5mm, or 0.125 mm. Therefore, it would require four complete turns on the crank to move the table by 0.5 mm.

The formula for calculating the indexing for linear graduations in millimeters is

$$\text{Rule } T = \frac{N}{0.125}$$

where N = spacing required in mm

T = No.of turns of index crank

Other suitable movements may be obtained by using the appropriate hole circle and/or different change gears ratio, other than 1:1.

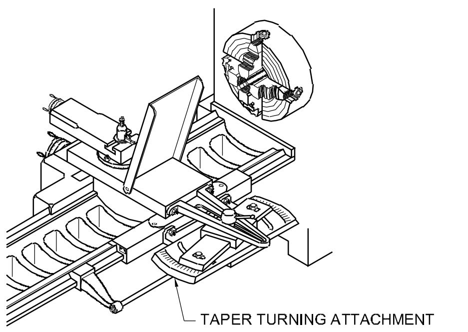
Turning of taper by taper turning attachment

Objectives: At the end of this lesson you shall be able to
- **state the features of taper turning attachment**
- **state the advantages of taper turning attachment**
- **state the angle of taper.**

Taper turning attachment method (Fig 1)

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.

Fig 1



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

Calculation of angle

The formula used here is the same as used for swivelling compound rest method i.e.

$$\tan = \frac{\alpha}{2} = \frac{D-d}{2l}$$

where

D = major diameter in mm; d = minor diameter in mm

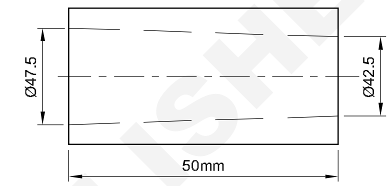
l = length of taper in mm

$\frac{\alpha}{2}$ = half of the included taper angle of work

$\frac{\alpha}{2}$ = is the angle to which the attachment is set

Taper calculation

Fig 2



$$\text{Tan}\frac{\alpha}{2} = \frac{D-d}{2\ell}$$

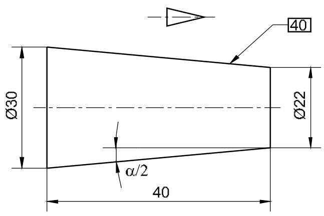
$$\frac{47.5-42.5}{2\text{x}50} = \frac{5}{100} = 0.05\text{mm}$$

Set natural Tangent value 2°52'

D = 30mm d = 22mm & l = 40 mm

$$\text{Tan}\frac{\alpha}{2} = \frac{D-d}{\frac{2l}{S}} = \frac{D-d}{2\text{x}l} = \frac{D-d}{2l}$$

Fig 3



$$\text{Tan}\frac{\alpha}{2} = \frac{D-d}{2l} = \frac{30-22}{80}$$

$$= \frac{8}{80} = \frac{1}{10} = 0.1$$

For example, referring to Fig 3 we have

Referring to the logarithm tables of Natural Tangents we find that the angle whose tangent value is 0.1, is 5° -45', and this is the top slide swiveling angle to turn the tapered job of fig 3.

Types of mandrels and their uses

Objectives: At the end of this lesson you shall be able to
- **define a mandrel**
- **state the constructional features of a solid mandrel**
- **explain different types of mandrels**
- **state the uses of different mandrels.**

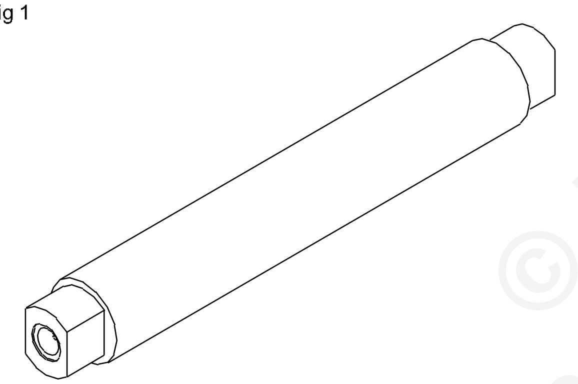
Types of mandrels and their uses

Sometimes it is necessary to machine the outer surfaces of cylindrical works accurately in relation to a hole concentric that has been previously bored in the centre of the work. In such cases the work is mounted on a device known as a mandrel.

Mandrel (Fig 1)

Lathe mandrels are devices used to hold the job for machining on lathes. They are mainly used for machining outside diameters with reference to bores which have been duly finished by either reaming or boring on a lathe.

Fig 1

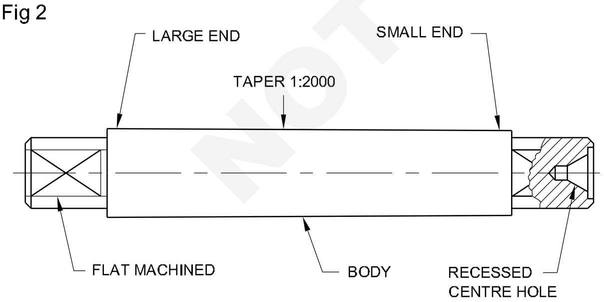


MANDREL

Constructional features of a solid mandrel (Fig 2)

The standard solid mandrel is generally made of tool steel which has been hardened and ground to a specific size and is ground with a taper of 1:2000.

Fig 2



DETAILS OF THE STANDARD SOLID MANDREL

It is pressed or driven into a bored or reamed hole in a workpiece so that it can be mounted on a lathe. The ends of the mandrel are machined smaller than the body and are provided with a flat for the clamping screw of the lathe carrier. This preserves accuracy and prevents damage to the mandrel when the lathe carrier is clamped on. The centres made in these mandrels are 'B' type i.e. protected centres. In such centres the working portion is deep and does not get damaged while handling.

Types of mandrels

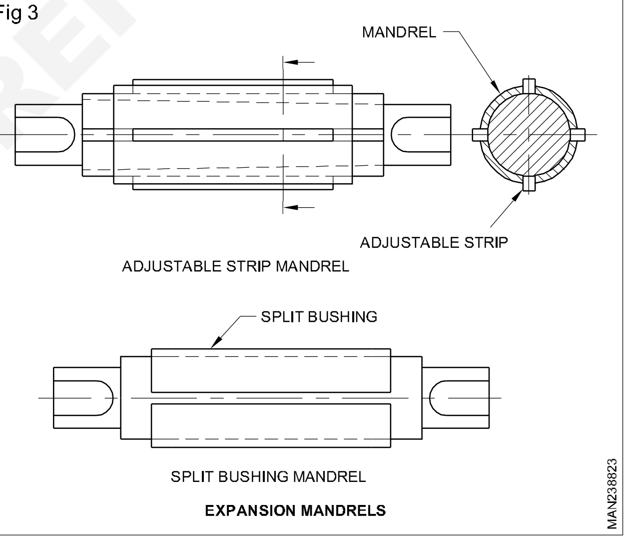
- Expansion mandrel
- Gang mandrel
- Stepped mandrel
- Screw or threaded mandrel
- Taper shank mandrel
- Cone mandrel

Expansion mandrel (Fig 3)

The two most common types of expansion mandrels are:

- split bushing mandrel
- adjustable strip mandrel.

Fig 3



EXPANSION MANDRELS

Split bushing mandrel

A split bushing mandrel consists of a solid tapered mandrel, and a split bushing, which expands when forced on to the mandrel. The range of application of each solid mandrel is greatly increased by fitting any number of different sized bushings. As a result only a few mandrels are required.

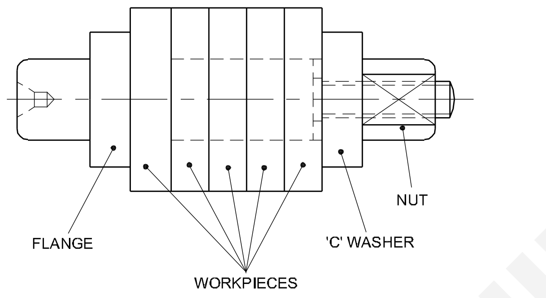
Adjustable strip mandrel

The adjustable strip mandrel consists of a cylindrical body with four tapered grooves cut along its length, and a sleeve, which is slotted to correspond with the tapered grooves. Four strips are fitted in the slots. When the body is driven in, the strips are forced out by the tapering grooves and expanded radially. Sets of different sized strips greatly increase the range of each mandrel. This type of mandrel is not suitable for thin walled work, since the force applied by the strips may distort the workpiece.

Gang mandrel (Fig 4)

A gang mandrel consists of a parallel body with a flange at one end and a threaded portion at the other end. The internal diameters of workpieces are larger than the mandrel body diameters by not more than 0.025 mm. A number of pieces can be mounted and held securely when the nut is tightened against the 'U' washer. The nut should not be over-tightened, otherwise inaccuracies will result. A gang mandrel is especially useful when machining operations have to be performed on a number of thin pieces which might easily be distorted, if held by any other method.

Fig 4



GANG MANDREL

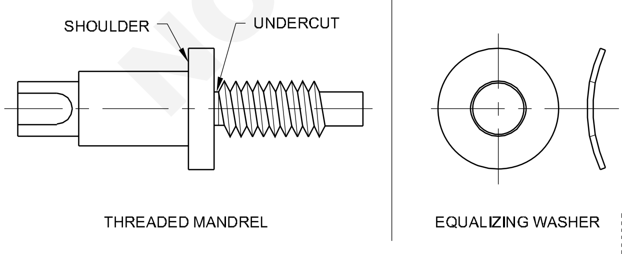
Stepped mandrel

The stepped mandrel is manufactured in order to reduce the number of mandrels. It differs from the plain mandrel in the fact that a number of steps are provided on it. Its use saves time in holding various bored works.

Screw or threaded mandrel (Fig 5)

A threaded mandrel is used when it is necessary to hold and machine workpieces having a threaded hole. This mandrel has a threaded portion which corresponds to the internal thread of the work to be machined. An undercut at the shoulders ensures the work to fit snugly (tightly) against the flat shoulder.

Fig 5

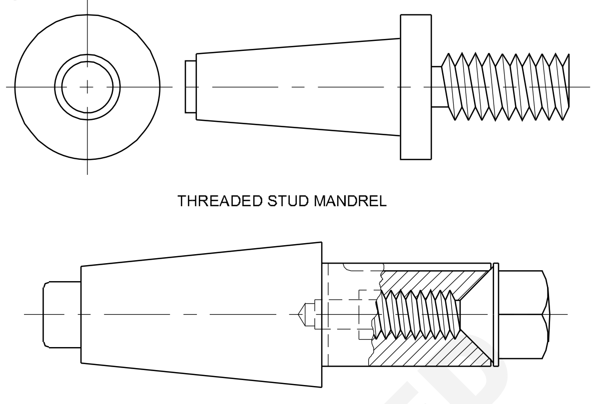


THREADED MANDREL

Taper shank mandrel (Fig 6)

Taper shank mandrels are not used between lathe centres. They are fitted to the internal taper of the headstock spindle. The extending portion can be machined to suit the workpiece to be turned. Taper shank mandrels are generally used to hold small workpieces.

Fig 6



TAPER SHANK MANDRELS

Two common types of taper shank mandrels are:

- expansion stud mandrel
- threaded stud mandrel.

Expansion stud mandrel

The expansion stud mandrel is slotted and has an internal thread. When a tapered screw is tightened, the outside diameter of the stud expands against the inside of the workpiece. This type of mandrel is useful when machining a number of similar parts whose internal diameters vary slightly.

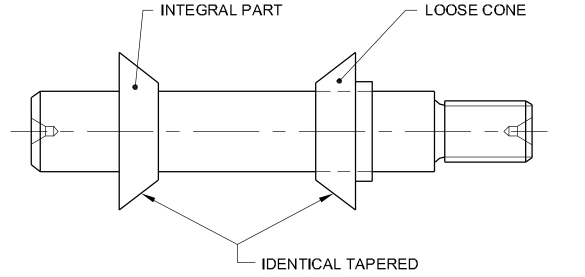
Threaded stud mandrel

The threaded stud mandrel has a projecting portion which is threaded to suit the internal thread of the work to be machined. This type of mandrel is useful for holding workpieces which have blind holes.

Cone mandrel (Fig 7)

A cone mandrel is a solid mandrel. It has a portion taper turned with a steep taper and integral with the body. One end of the mandrel is threaded. A loose cone slides over the plain turned portion of the body of the mandrel. It has the same steep taper as that of the tapered integral part. A job of large bore, can be held between these two tapers and tightly secured by means of nut, washer and spacing collars.

Fig 7



CONE MANDREL

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**
- **explain the different types of lathe centres**
- **explain 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).

Fig 1

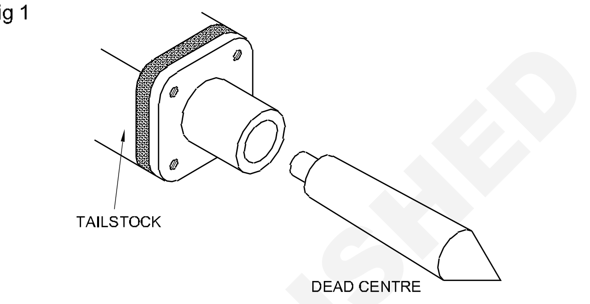
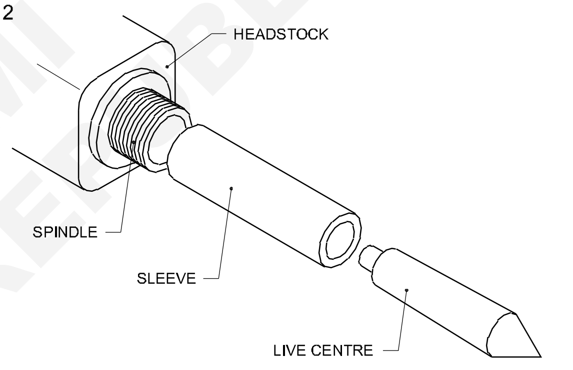


Fig 2



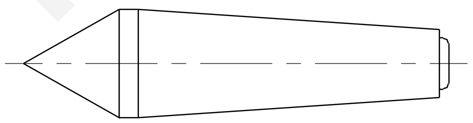
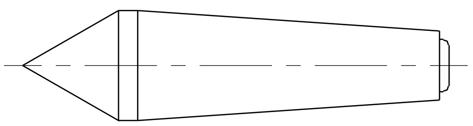
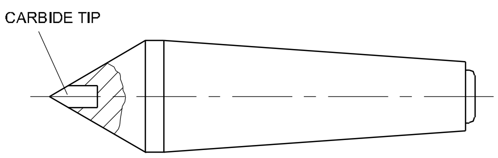
Types of centres and their uses

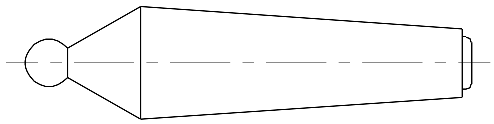
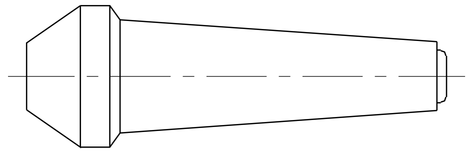
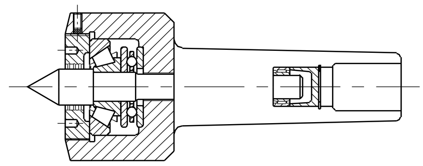
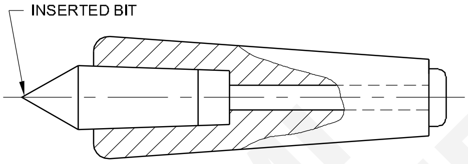
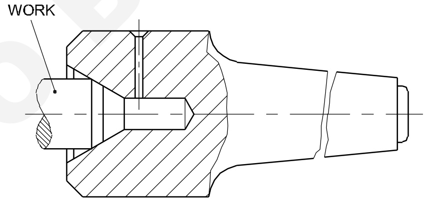
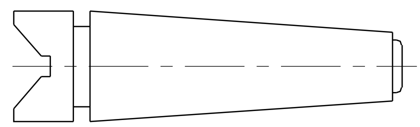
The dead centre is made of high carbon steel, hardened and ground whereas the live centre need not have its conical tip hardened as it revolves with the work. A good lubricant should be used for the dead centre.

The Table 1 gives the names of the most widely used types of lathe centres, their illustrations and specific uses.

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 centre, 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.

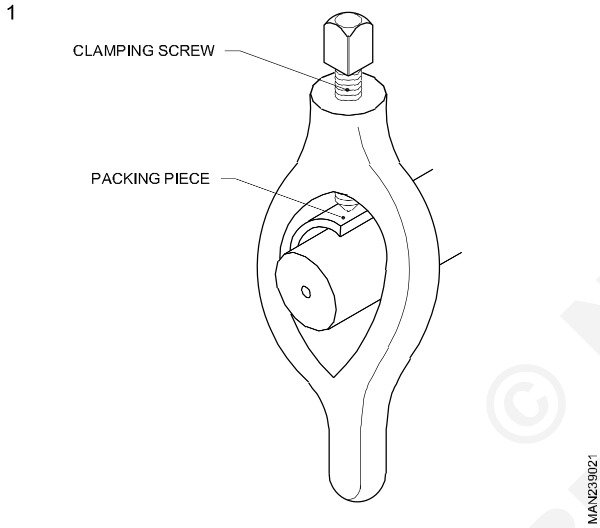
Sl. No	Name	Sketch	Uses
4	Ball centre		Minimum wear and strain. Particularly suitable for taper turning by tailstock offset method.
5	Pipe Centre		Used for supporting pipes, shells and hollow end jobs.
6	Revolving centre		Frictionless. Used for centre supporting heavy jobs revolving with high speeds. 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 the 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 carriers

Objectives: At the end of this lesson you shall be able to
- **state the functions of lathe carriers**
- **state 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

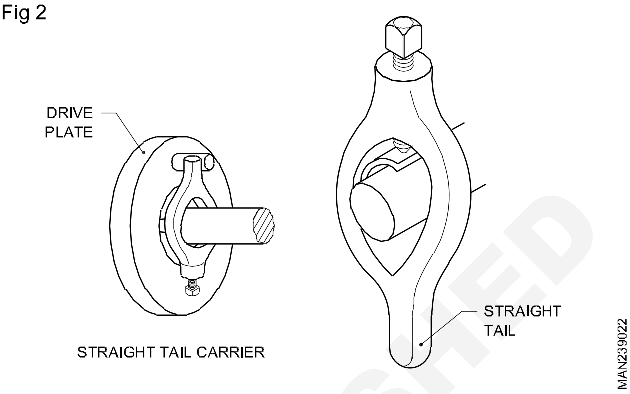


Fig 3

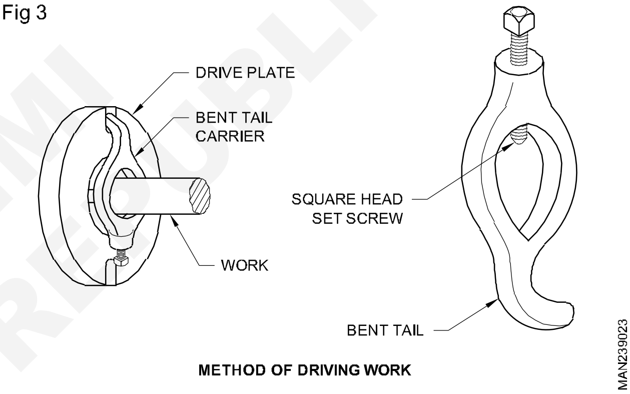
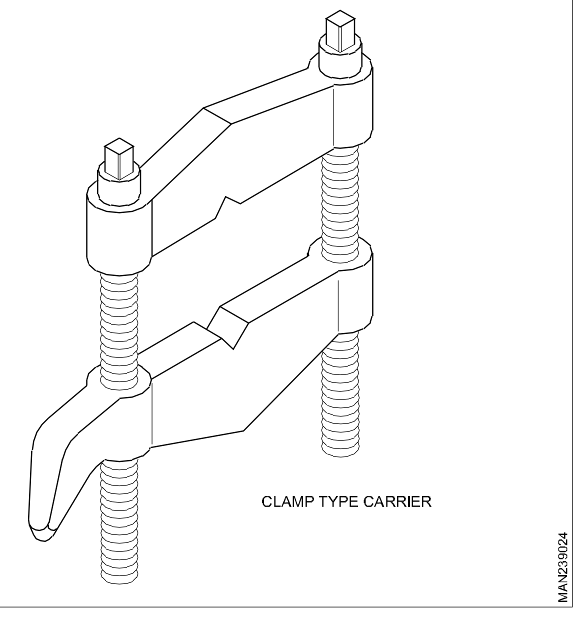


Fig 4



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**
- **explain the parts of a face-plate**
- **distinguish between the features and uses of different face-plates**
- **state the face-plate accessories.**

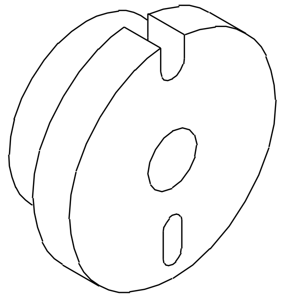
When turning jobs in between centres, driving plates are used. They are:

- 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

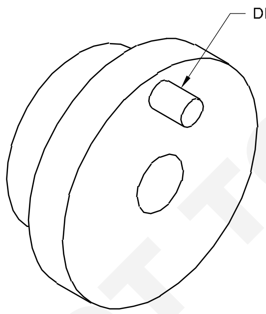


CATCH PLATE

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 PLATES

Safety driving plate

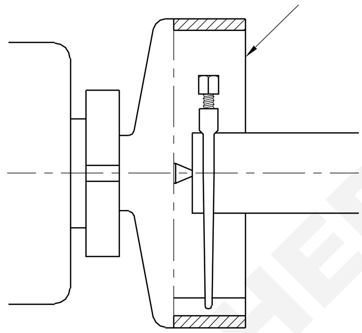
It is similar in construction to that of a driving plate but is equipped with a cover to protect the operator from any injuries. (Fig 3)

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.

Fig 3



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.

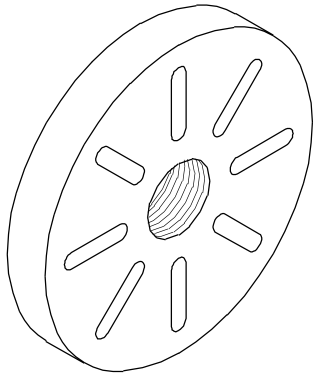
Face-plates

They are similar in construction to that of the lathe catch plates but are larger in diameter.

The different types of face-plates are:

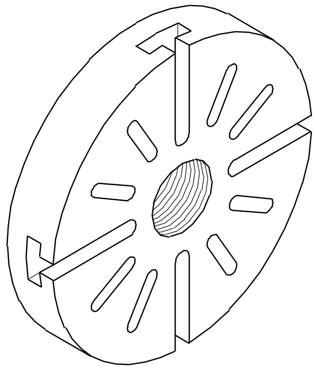
- face-plates with only elongated radial slots (Fig 4)

Fig 4



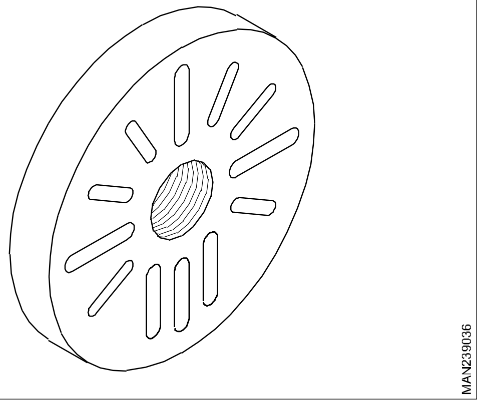
- face-plates with elongated slots and 'T' slots (Fig 5)

Fig 5



- face-plates with elongated radial slots and additional parallel slots. (Fig 6)

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.

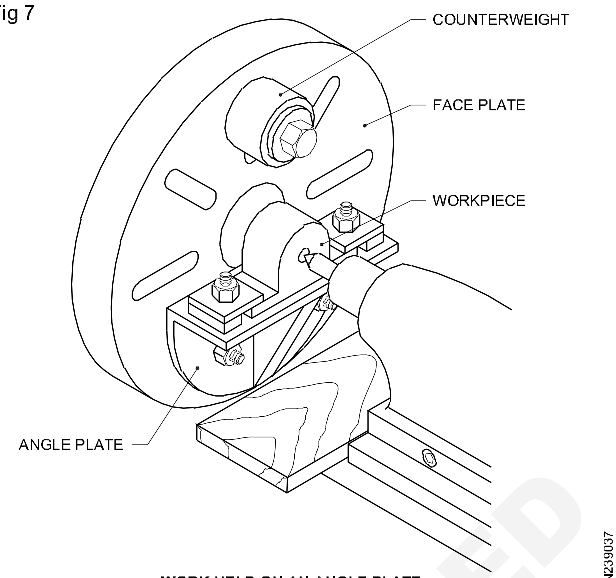
A work can be mounted on a face-plate while the face-plate is on the lathe spindle or on the workbench. If the workpiece is heavy or awkward to hold, the workpiece is mounted while the face-plate is on the workbench. Before mounting the face-plate and it is set up to the spindle, it is advantageous to 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.

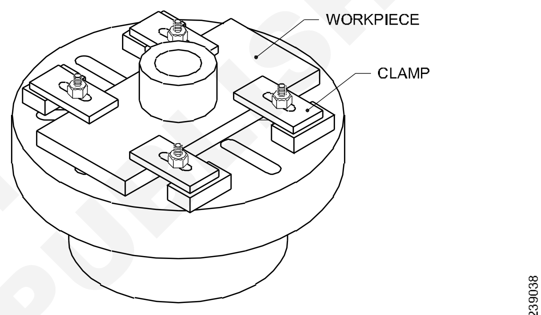
The application of the face-plate with the accessories in different set ups is shown in the sketches below. (Figs 7,8 and 9)

Fig 7



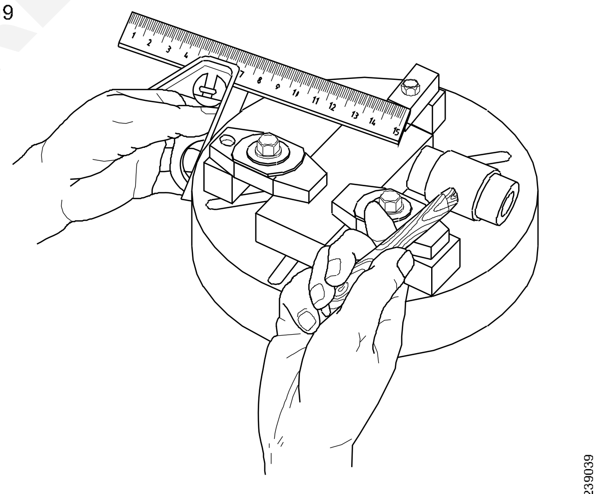
WORK HELD ON AN ANGLE PLATE

Fig 8



WORK CLAMPED DIRECTLY TO FACE PLATE

Fig 9



LOCATING WORK ON A FACE PLATE

Lathe accessories - steady rest

Objectives : At the end of this lesson you shall be able to
- **state what is a steady rest**
- **explain the types of steady rests**
- **distinguish between fixed steady rest and follower steady rest**
- **state the uses of a steady rest.**

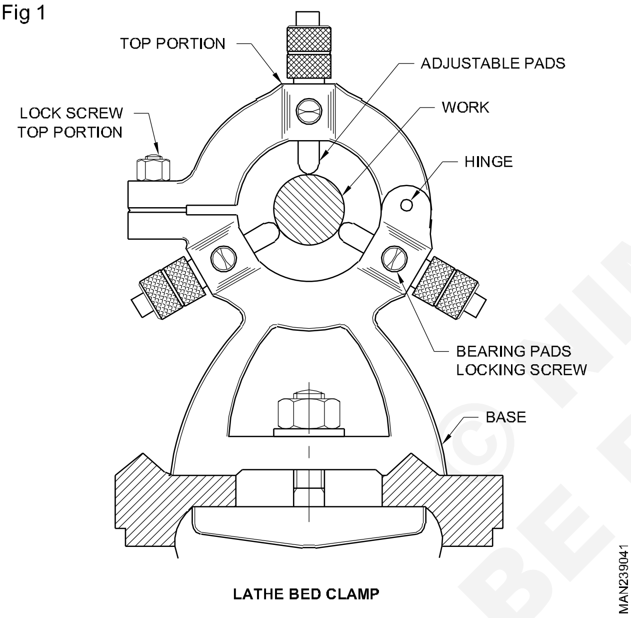
A steady rest is a lathe accessory used to give extra support for a long slender workpiece in addition to the centre support during turning.

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.

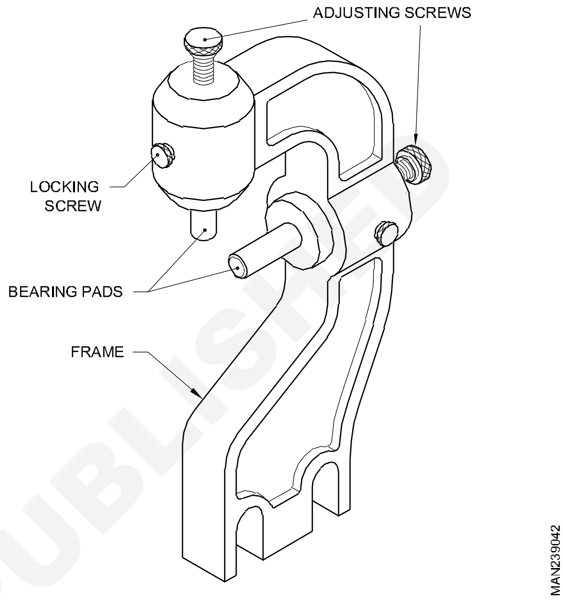
It consists of a frame containing three adjustable pads.

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)

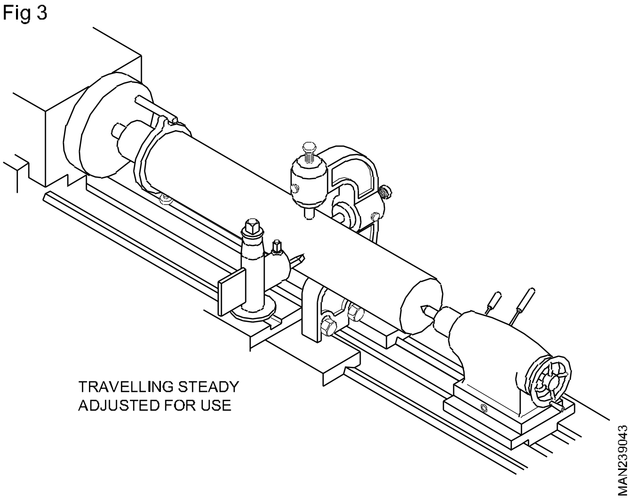
Fig 2



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



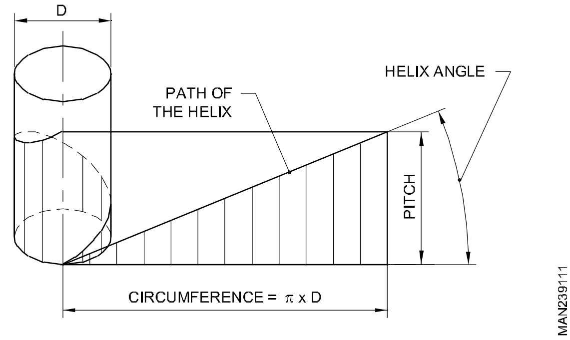
Screw threads and elements

Objectives: At the end of this lesson you shall be able to
- **state the uses of screw threads**
- **differentiate between external and internal 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)

Fig 1



An external screw thread is formed on the outer surface of a cylindrical part.

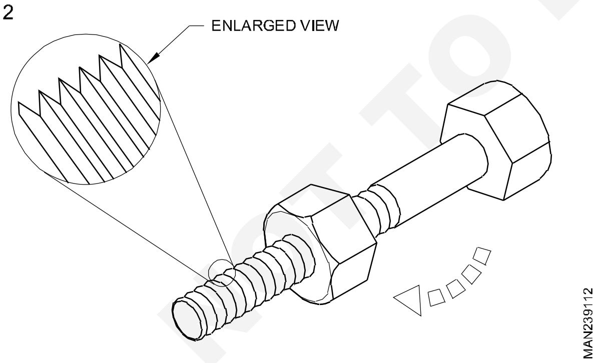
Example: bolts, screws, studs, threaded spindles, etc. (Fig 1)

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 machine from one unit to another (Fig 4)
- to make accurate measurements (Fig 5)
- to apply pressure (Fig 6)

Fig 3

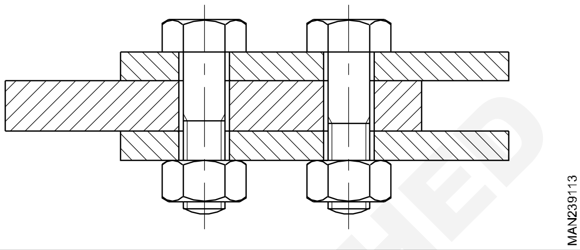


Fig 4

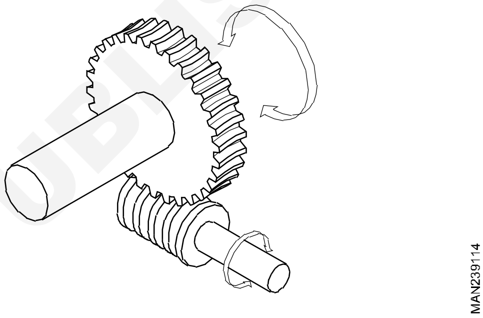


Fig 5

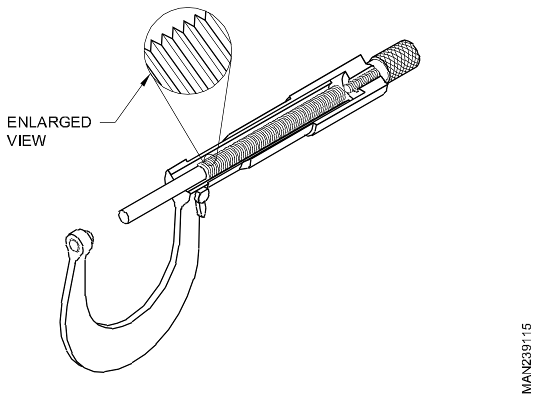
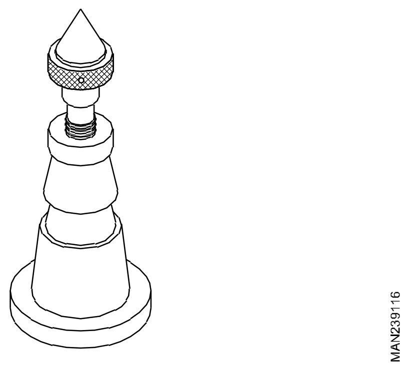
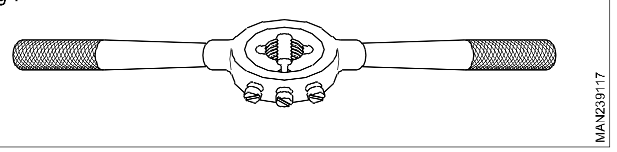


Fig 6



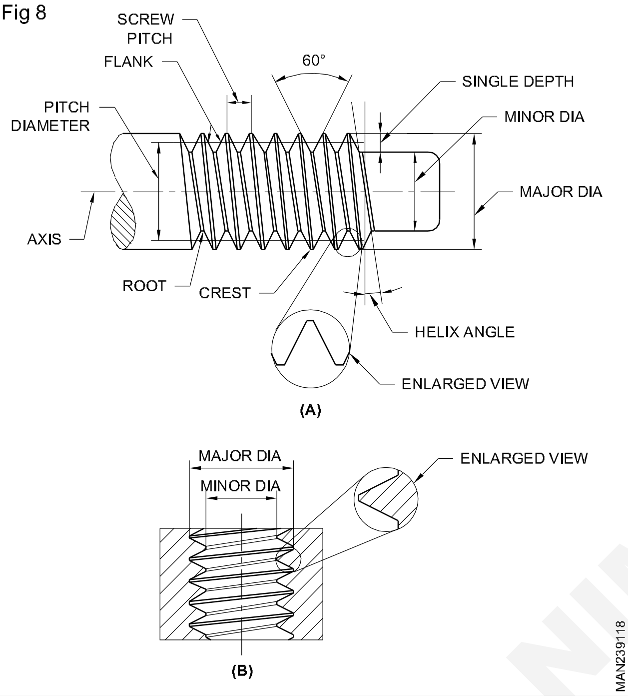
- to make adjustments. (Fig 7)

Fig 7



- Parts of a screw thread (Fig 8A)

Fig 8



Crest (Fig 8B)

This is the top surface joining the two sides of a thread.

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.

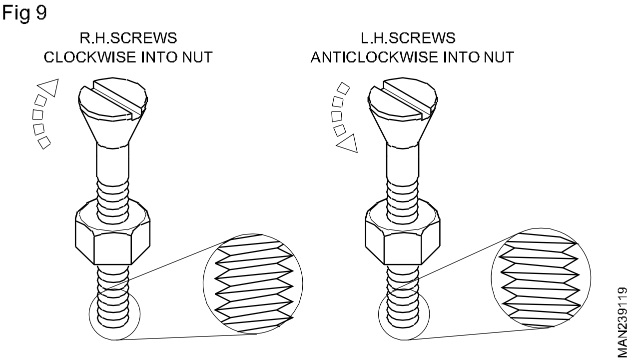
Helix angle

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



Simple and compound gear trains

Objectives: At the end of this lesson you shall be able to
- **state what is a change gear train**
- **explain the different types of change gear trains**
- **distinguish between a simple gear train and a compound gear train**
- **calculating for fractional pitch threads.**

Change gear train

Change gear train is a train of gears serving the purpose of connecting the fixed stud gear to the quick change gearbox. The lathe is generally supplied with a set of gears which can be utilized to have a different ratio of motion between the spindle and the lead screw during thread cutting. The gears which are utilized for this purpose comprise the change gear train.

The change gear train consists of driver and driven gears and idler gears.

Simple gear train

A simple gear train is a change gear train having only one driver and one driven wheel. Between the driver and the driven wheel, there may be an idler gear which does not affect the gear ratio. Its purpose is just to link the driver and the driven gears, as well as to get the desired direction to the driven wheel.

Fig 1 shows an arrangement of a simple gear train.

Fig 1

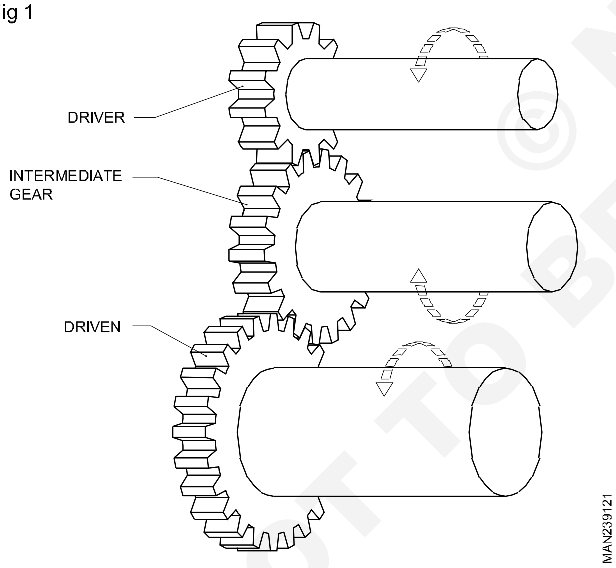
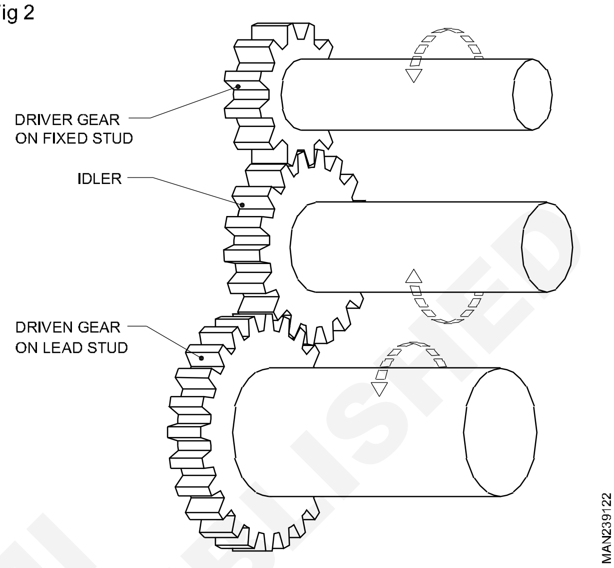


Fig 2 shows mountings of the driver and driven gears in a lathe.

The driver gear and the driven gear are changed according to the pitch of the thread to be cut on the job.

Fig 2

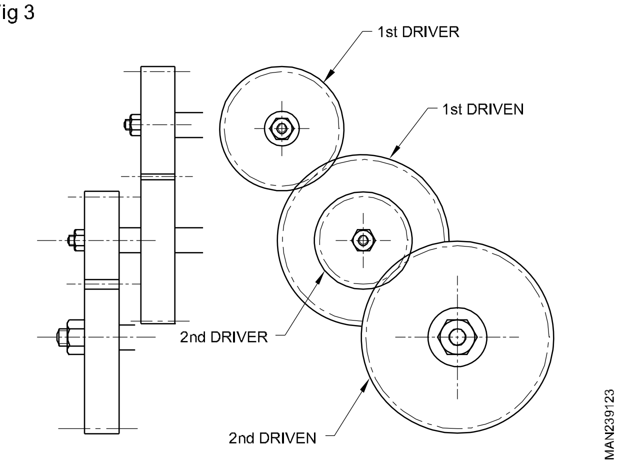


Compound gear train

Sometimes, for the required ratio of motion between the spindle and the lead screw, it is not possible to obtain one driver and one driven wheel. The ratio is split up and then the change gears are obtained from the available set of gears which will result in having more than one driver and one driven wheel. Such a change gear train is called a compound gear train.

Fig 3 shows the arrangement of a compound gear train.

Fig 3



Change wheel calculations for fractional pitch threads

Objectives : At the end of this lesson you shall be able to
- **explain change wheels for cutting fractional pitch threads (British System)**
- **explain change wheels for cutting decimal fractional pitch threads (British System)**
- **explain change wheels for fractional pitch threads by continued fraction method.**

It is necessary to calculate the ratio of change gears to cut fractional leads for worms, hobs etc. on a centre lathe at times.

To obtain a formula; suppose it is required to cut a lead of 1/4" on a lathe which has a lead of 1/2". If one to one ratio were used between the driver and the driven gears, the carriage would move 1/2" per revolution of the lathe spindle. Therefore, to cut a lead of 1/4" the ratio of the driver and driven gears must be as

$$\frac{1}{4}\ \frac{1}{2}$$

That is $\frac{1/4}{1/2}$ or $\frac{1}{2} \equiv \frac{\text{Driver}}{\text{Driven}}$

Expressed as a formula:-

$$\frac{DR}{DN} \equiv \text{ratio of change gears} \equiv \frac{\text{Lead screw to be cut}}{\text{Lead of lead screw}}$$

or alternatively:-

$$\frac{\text{lead of screw to be cut}}{1} \times \frac{1}{\text{lead of screw}} = \frac{\text{Driver}}{\text{Driven}}$$

lead of screw to be cut x

No.of threads / inch of lead screw $= \frac{\text{Driver}}{\text{Driven}}$

Example

Calculate the change gears necessary to cut a thread of 7/16" lead on a lathe with a lead screw of 4 threads per inch.

lead of screw to be cut x

No.of threads / inch of lead screw $= \frac{\text{Driver}}{\text{Driven}}$

$$= \frac{7}{16} \times 4 = \frac{28}{16} = \frac{7}{4}$$

$$= \frac{7}{4} \times \frac{10}{10} = \frac{70}{40} = \frac{\text{Driver}}{\text{Driven}}$$

If the lead to be cut is a whole number and a simple fraction, change it to an improper fraction and apply the above formula.

Example

Calculate the change gears required to cut an oil groove having 8 turns in 11 inches on a lathe with a lead screw of 4 threads per inch.

Pitch of the groove x

No. of threads / inch of lead screw $= \frac{\text{Driver}}{\text{Driven}}$

$$\text{Pitch of groove} = \frac{\text{travel or given number of turns}}{\text{number of turns}}$$

$$= \frac{11}{8} \text{inches}$$

$$\text{Gear ratio} = \frac{\frac{11}{8}}{\frac{1}{4}}$$

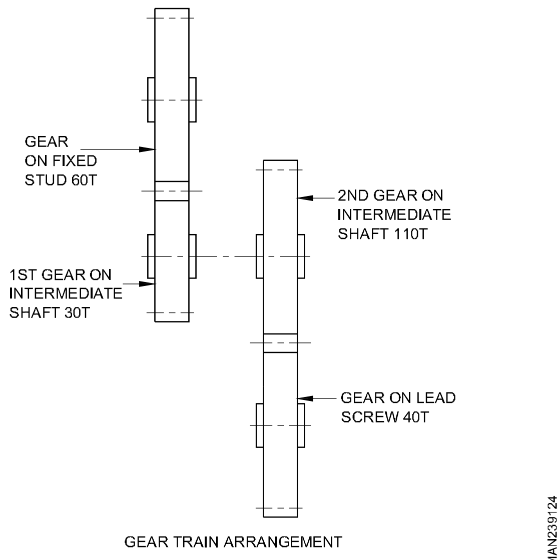
$$\frac{11}{8}4 = \frac{44}{8} = \frac{4x11}{2x4} = \frac{4}{2} \times \frac{11}{4}$$

$$\text{First fraction} = \frac{4}{2} \times \frac{15}{15} = \frac{60}{30}$$

$$\text{2nd fraction} = \frac{11}{4} \times \frac{10}{10} = \frac{110}{40}$$

Thus $\frac{DR}{DN} = \frac{60}{30} \times \frac{110}{40}$ (Fig 1)

Fig 1



GEAR TRAIN ARRANGEMENT

Example

Calculate the change gears to cut a worm of 0.35 inches lead on a lathe with a lead screw having 4 threads per inch. lead to be cut x no.of threads/inch of lead screw

$$= \frac{DR}{DN} = 0.35 \times 4$$

$$= \frac{35}{100} \times \frac{4}{1} = \frac{7}{5} \times \frac{10}{10} = \frac{70}{50} = \frac{driver}{driven}$$

When the lead occurs as a decimal, it may be necessary to use the method of continued fractions to obtain a suitable approximation of the change gear ratio, for which the change gears may be selected from the available set of gears.

Example

Calculate the change gears required to cut a worm of 0.55 inches lead on a lathe, with a lead screw of 6 threads per inch.

lead to be cut x no.of threads/inch of lead screw $= \frac{DR}{DN}$

$= 0.55 \times 6$

$$= \frac{55}{100} \times \frac{6}{1}$$

$$\text{1st fraction} = \frac{55}{100}$$

$$\text{2nd fraction} = \frac{6}{1} \times \frac{20}{20} = \frac{120}{20}$$

$$\frac{driver}{driven} = \frac{55}{100} \times \frac{120}{20}$$

Example

Calculate the change gears required to cut a worm of 0.95 inches lead on a lathe with a lead screw of 6 threads per inch.

lead to be cut x no.of threads/inch of lead screw $= \frac{DR}{DN}$

$= 0.95 \times 6$

$$= \frac{95}{100} \times \frac{(6 \times 20)}{(1 \times 20)} = \frac{95}{100} \times \frac{120}{20}$$

$$\frac{driver}{driven} = \frac{95}{100} \times \frac{120}{20}$$

Example

Calculate the change gears to cut 2BA threads (0.81mm pitch) on a lathe which has a lead screw of 1/4 inch - pitch by the continued fraction method.

This could be cut exactly if the 1/5 ratio were combined with a 81T driver and a 127T driven change gears.

If special gears are not available we have to obtain the nearest fraction by the continued fraction method. For this nearest fraction gears may be selected from the available set of gears.

$$\text{Ratio : } \frac{driver}{driven} = \frac{0.81}{1/4 \times 25.4} = \frac{0.81}{6.35}$$

$$\frac{driver}{driven} = \frac{81}{635} \times \frac{1 \times 81}{5 \times 127}$$

Determining the convergent by the continued fraction method.

```
81)   635 (7
      567
      ----
      68 ) 81  (1
           68
          ----
          13 ) 68 (5
               65
              ----
               3) 13 (4
                  12
                 ----
                  1) 3 (3
```

		7	1	5	4	3
1	0	1	1	6	25	81
0	1	7	8	47	196	635
		7	1	5	4	3

The convergents are : $\frac{1}{7}; \frac{1}{8}; \frac{6}{47}; \frac{25}{196}; \frac{81}{635}$

The 4th convergent : $\frac{25}{196}$ may be written $\frac{5}{14} \times \frac{5}{14}$

$$\frac{driver}{driven} = \frac{25}{70} \times \frac{25}{70}$$

and this could be obtained with duplicate 25 T and 70 T gears, a circumstance not unlikely, provided two similar lathes are available.

The actual pitch obtained from this driver and driven gears is:

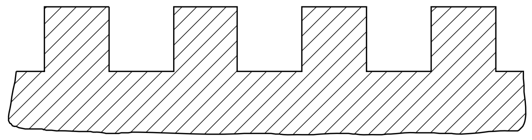
an error of 0.00005mm, which is equivalent to a total pitch error of about 0.0016mm (0.00006 in) over a 1 in. length of the thread. This is well within the permissible limits of accuracy of an ordinary commercial lead screw.

Square thread and its form - calculation

Objectives: At the end of this lesson you shall be able to
- **explain the helix angles of square tool**
- **brief the clearance angle in square threading tool**
- **state the standard thread chart.**

Square threads (Fig 1)

Fig 1



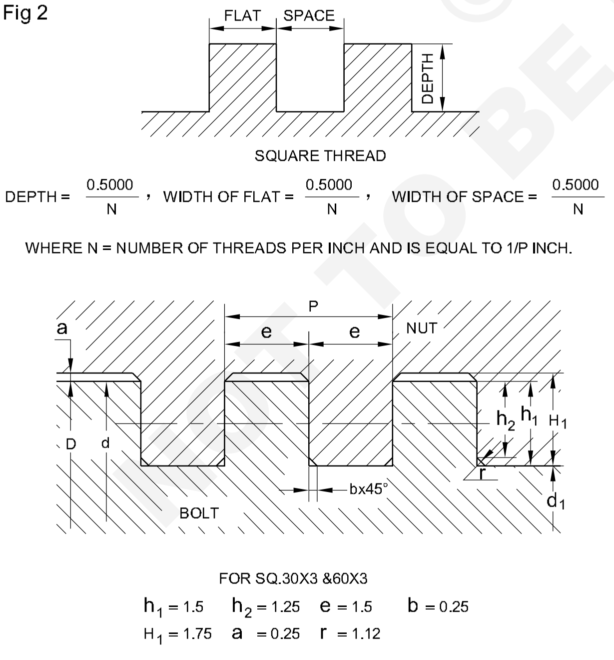
The cross-section of these threads is square in shape. These threads are very strong, and are used on fly presses screw jacks, vices and spindles cross-slide and compound slide.

Square and trapezoidal threads have more cross-sectional area than 'V' threads. They are more suitable to transmit motion or power than 'V' threads. They are not used for fastening purposes.

Square thread

In this thread the flanks are perpendicular to the axis of the thread. The relationship between the pitch and the other elements is shown in fig 2.

Fig 2



Designation

A square thread of nominal dia.60 mm and pitch 9mm shall be designated as Sq. 60 x 9 IS: 4694 - 1968. The dimensions a,b,e,p,H_1,h_1,h_2 & d_1 are changed as per thread series (fine, normal & coarse)

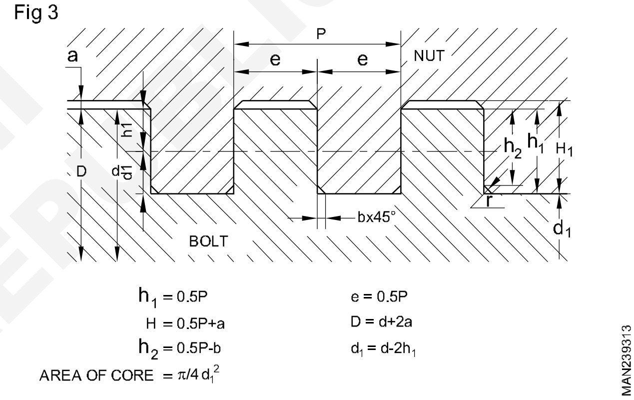
Modified square thread

Modified square threads are similar to ordinary square threads except for the depth of the thread. The depth of thread is less than half pitch of the thread. The depth varies according to the application. The crest of the thread is chamfered at both ends to 45° to avoid formation of burrs. These are used where quick motion is required.

Square Threads of calculation

Basic profile of square threads

Fig 3



Basic dimensions for square threads-normal series in millimeters

Nominal diameter	Major diameter		Minor diameter	Pitch, P
	Bolt, d	Nut, D		
22	22	22.5	17	5
26	26	26.5	21	5
30	30	30.5	24	6
36	36	36.5	30	6
40	40	40.5	33	7
44	44	44.5	37	7
48	48	48.5	40	8
52	52	52.5	44	8
60	60	60.5	51	9

Designation: Example: SQ 30 x 6-IS: 4694-1498
A square threads of nominal dia.30 mm & pitch 6 mm

Single and multi start threads

Objectives: At the end of this lesson you shall be able to
- **differentiate between single and multi start threads**
- **explain multi start thread**
- **explain the merits and demerits of multi start threads.**

The 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 SINGLE START thread. In a single start thread the LEAD and PITCH are the same. (Fig 1) in the case of TWO START threads (DOUBLE START) one thread is wound within the other exactly in the middle. (Fig 2) This enables the lead of the helix to be increased without increasing the pitch.

Fig 1

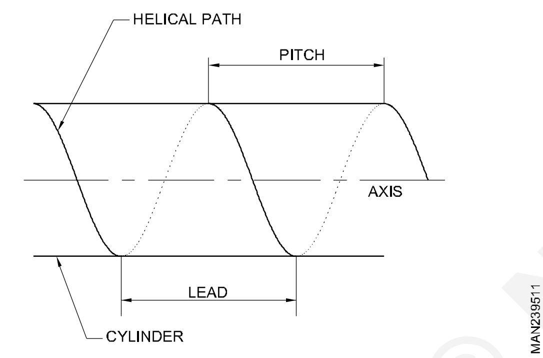
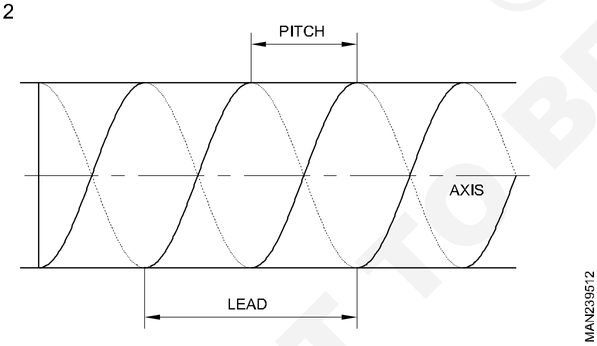
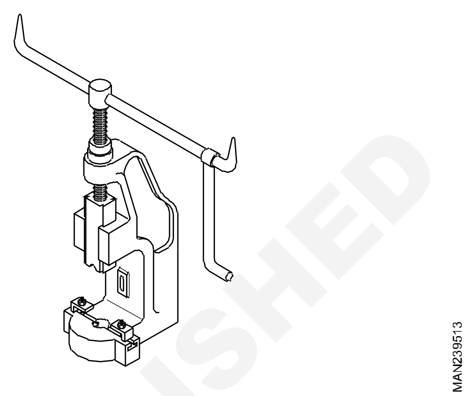


Fig 2



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 found in fly press, pen cap etc. (Fig 3) Multi-start thread allows to keep the depth of the thread to be less and provides for rapid axial movement of the screws.

Fig 3



Difference between single and multi start threads

A single-start thread is by far the most common type, with a single helix spiraling up the length of a screw. A multi-start thread has more than one parallel, non-crossing helix - commonly two or four. The **pitch** of the thread is the proportional fraction of the **lead** of the thread, for example 1/2 or 1/4. This allows a small-pitch (for example to get multiple threads engaged in thin material) to have a large lead (to allow for faster screw driving).

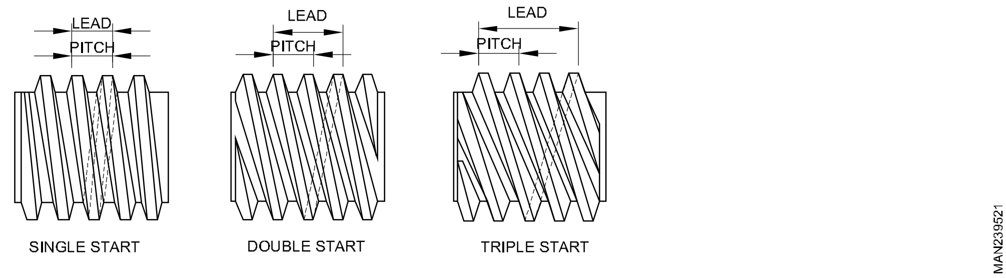
Multi-start threads, so called because they have more than helix multiple launch points around the end of the screw, are useful for quick start threads and also short turn threads for applying load.

A **single - start thread** has one continuous thread running along the body of the screw. They are usually cheap and commonly used.

A multi - start thread consists of two or more intertwined running parallel to one another. The lead distance of a double start thread is twice that of the single start thread and a triple start thread has twice that of the single start thread.

Multi - start threads maintain a shallow thread depth relative to their longer lead distance. Another design advantage of a multi-start thread is that more contact surface is engaged in a single thread rotation.

Fig 1



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.

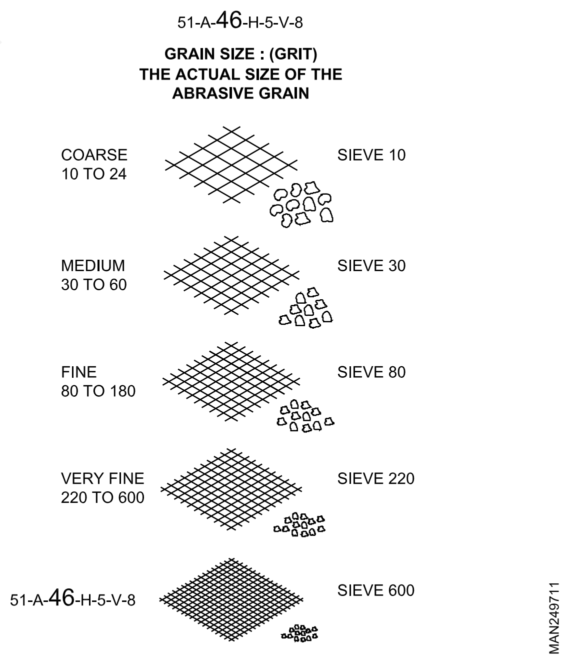
Aluminium oxide is used for grinding die steels.

Grain size (Grit size) (Fig 1)

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.

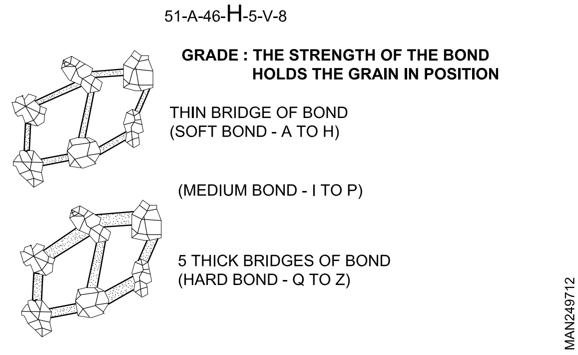
Fig 1



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.

Fig 2



Alphate letters are used to indicate the grade of wheel

A to H - Soft

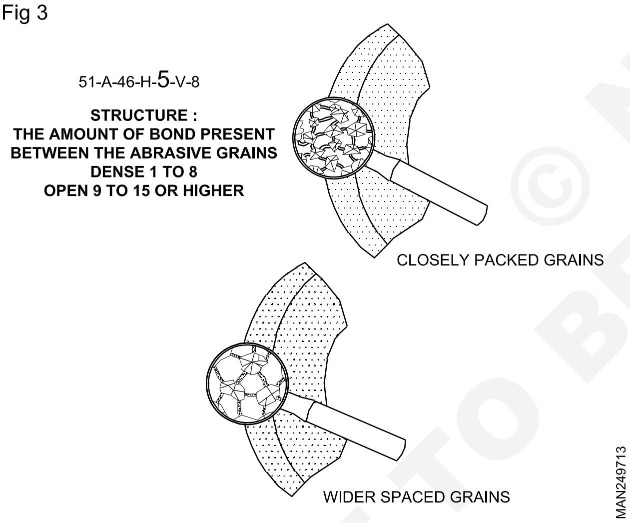
I to P - Medium

Q to Z - Hard

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

Vitrified 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.

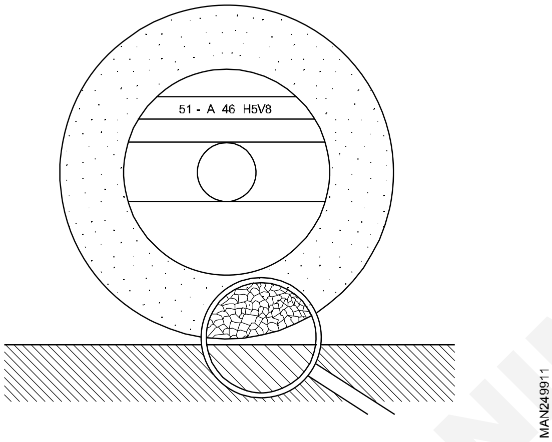
Marking system and selection of grinding wheel

Objectives: At the end of this lesson you shall be able to
- **explain marking system of grinding wheel**
- **state the selection of grinding wheel.**

Introduction

Standard wheel marking specifying all the important wheel characteristics. The marking system comprises of seven symbols which are arranged in the following order. (Fig 1)

Fig 1



Example

Marking system

51 - A46 H5V8

Specification of grinding wheels

A grinding wheel is specified by the:

standard wheel marking

outer diameter of the wheel

bore diameter of the wheel

thickness of the wheel

type (shape) of the wheel

Example

32 A46 H8V 15

250 x 20 x 32

Straight wheel

Table 1

Position 0	Position 1	Position 2	Position 3	Position 4	Position 5	Position 6
Manufacture's symbol for abrasive (optional)	Type of abrasive	Grain size	Grade	Structure (optional)	Type of bond (optional)	Manufacture's own mark
51	A	46	H	5	V	8

Selection of grinding wheels for internal grinding

Objectives: At the end of this lesson you shall be able to
- **list the nine factors considered while selecting grinding**
- **list three types of applications of internal grinding.**

Internal grinding are widely used in bearings and automobile industry.

Such as bore grinding of inner rings, bore grinding of gears, track grinding of outer rings and steering nuts etc.

In internal grinding, the grinding of internal surfaces the conformity between the wheel and workpiece, is substantially higher.

For selection of grinding wheels IS: 1249 - 1958 provides recommendations on the general considerations, which guides the selection of grinding wheels for different applications.

The main factors considered while selecting grinding wheel are:

- Material to be ground and its hardness
- Stock removal

- Severity of operation
- Surface finish
- Area of grinding contact
- Wheel speed
- Wet and dry grinding
- Machine condition
- Work speed

Fig 1

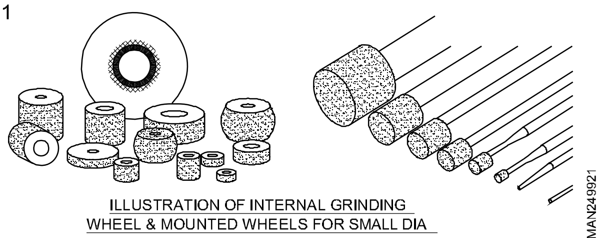
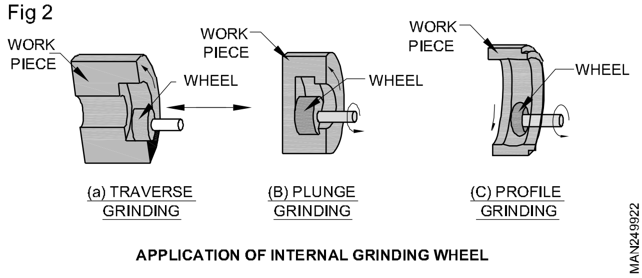


ILLUSTRATION OF INTERNAL GRINDING WHEEL & MOUNTED WHEELS FOR SMALL DIA

Fig 2



APPLICATION OF INTERNAL GRINDING WHEEL

The illustration and working application of internal grinding wheels one shown in Fig 1 and 2.

Selection and use of grinding wheels for different applications are usually given in grinding wheel manufactures catalogue

Standard size of wheels are available.

Selection of grinding wheel for tool and cutter grinder

Objective: At the end of this lesson you shall be able to
- **state the factors which affect the selection of grinding wheel.**

For grinding a job the right grinding wheel is to be selected. The selection of a grinding wheel will depend on the following factors.

- **Factors affecting the selection of abrasive**
  - a Materials of high tensile strength, viz. alloy steel, hard bronzes steel and wrought iron. - Aluminium oxide
  - b Hardened tool steel high speed steel drills cutters and for cool and precision grinding. - White Aluminium oxide
  - c Materials of low tensile strength, viz., Aluminium, copper, cast-iron, stone ad marble. - Silicon carbide.
  - d Tungsten carbide tipped tools - Green silicon carbide.
- **Factors affecting the selection of grit.**
  - a Great amount of stock to remove - Coarse grain.
  - b Soft and tough materials - Coarse grain.
  - c Fine finish - Fine grain.
- **Factors affecting the selection of grade**
  - a Hard materials - Soft wheel.
  - b Soft materials - Hard wheel.
  - c Great area of contact - Soft wheel.
  - d Low wheel surface speed - Hard wheel.
  - e Unstable and shaky foundation of grinding machine. - Hard wheel.
  - f Off-hand grinding - Hard wheel.
- **Factors affecting the selection of structure**
  - a Soft and tough material - Open structure.
  - b Fine finish - dense structure.
  - c cylindrical and tool grinding - medium structure
  - d External grinding - dense structure.
- **Factors affecting the selection of bond.**
  - a General purpose and maximum cutting efficiency - vitrified
  - b Wheels of very large diameter and wheels required quickly to special order. - silicate
  - c very thin wheel - shellac or rubber.
  - d very high finish where rapid cutting is not important - shellac or rubber

Grinding wheel dressing

Objectives: At the end of this lesson you shall be able to
- **state three important purposes of dressing a grinding wheel**
- **differentiate between dressing and truing**
- **state the types of wheel dressers and their uses.**

Dressing is an operation to change the cutting action of a wheel or to recondition the grinding surface. Grinding wheels should be dressed and trued regularly to improve the followings:

Work production

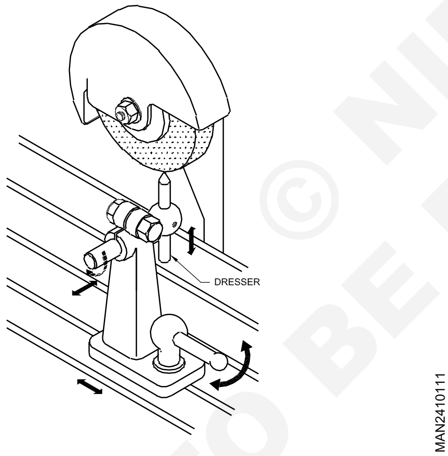
Wheel performance

Grinding economy

Dressing (Fig 1)

Dressing refers to the removing of clogs and blunt abrasive grains from the surface of the grinding wheel. Dressing grains exposes the cutting edges which restore the correct cutting action of the wheel. Dressing is done on a glazed or loaded wheel to recondition it.

Fig 1



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 to remove the run out.

Truing is done on the wheel which is out of shape due to long use. Sometimes a wheel is also trued to change the shape of the grinding wheel face for a specific grinding operation like form grinding. (Fig 2)

In most of the cases both dressing and truing are done at the same time.

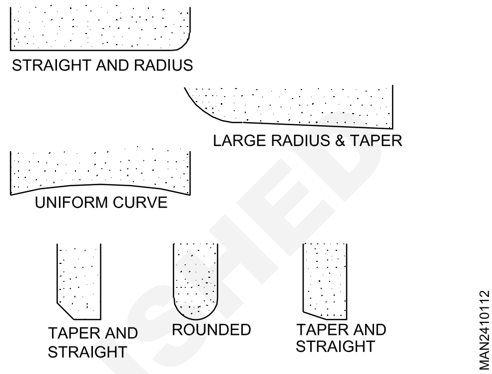
There are three basic types of wheel dressers. They are:

- diamond - steel - abrasive

Diamond dressers (Fig 3)

A diamond dressing tool has a hard diamond mounted in a metal shank. The shank is fitted in a tool holder for location on the grinding machine to perform dressing.

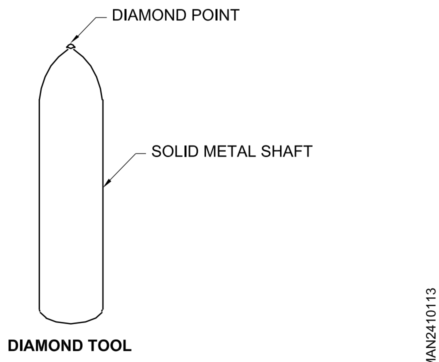
Fig 2



Diamond dressers are most effective for dressing precision grinding wheels.

A low feed of a diamond dresser can glaze the wheel. They are specified by their weight in carats. Usually 0.5 carat to 1 carat diamonds are used for dressing upto 200 mm dia. wheels.

Fig 3



Steel dressing tools (Fig 4)

Steel dressers for dressing grinding wheel have rotary cutting surfaces made from hard steel.

They are held in place against the grinding wheel by hand and moved across the face of the grinding wheel to do the dressing. A tool rest or other rigid support must be used during this operation.

The main types of steel dresser are:

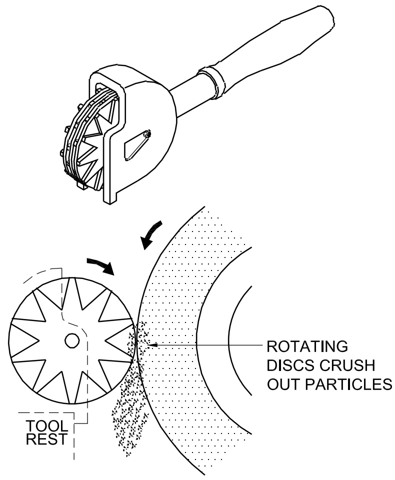
star and disc dresser (used for coarse grained wheel)

corrugated disc dresser (used for smooth finish)

lock disc dresser (used for medium roughing wheel)

solid cylinder dresser (used for instead of a diamond dress)

Fig 4



CUTTING ACTION OF A STEEL DRESSING TOOL

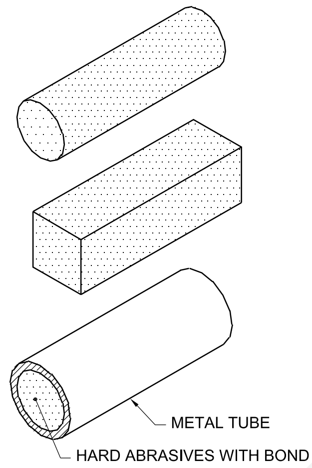
MAN2410114

Abrasive dressers (Fig 5)

When only light dressing is required abrasive sticks can be used. There are abrasive materials made in the form of square or round sticks or put in metal tubes for convenient handling.

This type of dressers is more convenient in tool and cutter grinders where frequent dressing and truing is necessary.

Fig 5



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Glazing and loading, their effects, causes and remedies

Objectives: At the end of this lesson you shall be able to
- **differentiate between glazing and loading of a grinding wheel**
- **state the effects of a glazed and loaded wheel while grinding**
- **state the causes and remedies for glazing**
- **state the causes and remedies for loading.**

Glazing

When the surface of a grinding wheel develops a smooth and shining appearance, it is said to be glazed. (Fig 1) This indicates the abrasive particles on the wheel face are not sharp. These are worned down to bond level.

Loading

When soft materials like aluminium, copper, lead, etc. are ground the metal particles get clogged between the abrasive particles. This condition is called loading. (Fig 2)

The effects of a glazed or a loaded grinding wheel are almost the same. They are:

- excessive cutting pressure between wheel and work
- more heat generation
- burning of the ground surface
- poor surface finish
- inaccuracies in the size and shape of the workpiece
- wheel breakage (sometimes)

A dull or glazed wheel should be dressed for the following reasons

To reduce heat generated between the work surfaces and the grinding wheel.

To reduce the strain on the grinding wheel and the machine

To improve the surface finish and accuracy of the work

To increase the rate of metal removal

Cause and remedies of glazing

Wrong selection of glazing

Wrong selection of grinding wheels means hard grade wheel in place of soft wheel and fine grain size in place of medium grain size.

Select a grinding wheel of the right grade and size.

High wheel speed

Set the wheel to the recommended speed.

Feed too fine

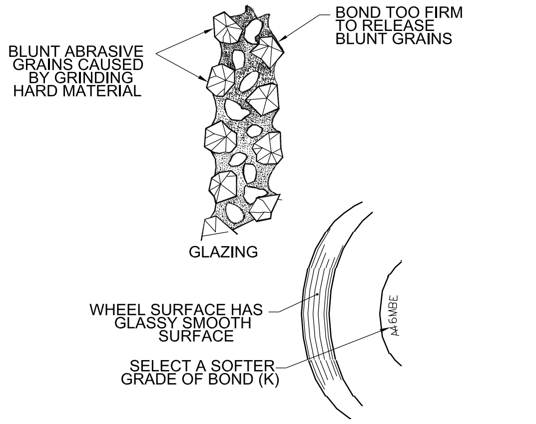
Set the feed rate correctly.

Dirty coolant

Change the coolant

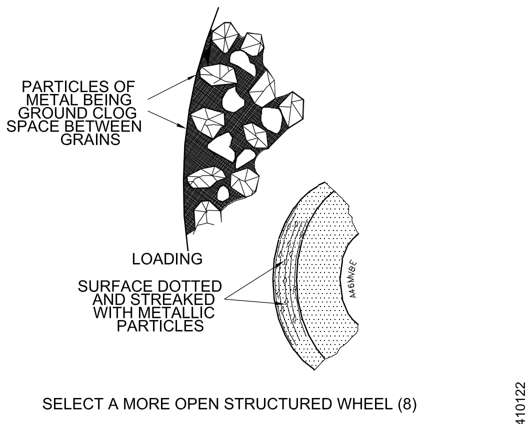
A glazed or a loaded grinding wheel can be reused after removing the glazed or loaded particles from the grinding wheel face.

Fig 1



GLAZED WHEEL

Fig 2



LOADED WHEEL

Roughness values symbols and surface quality

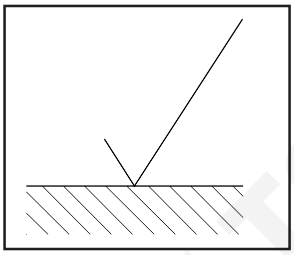
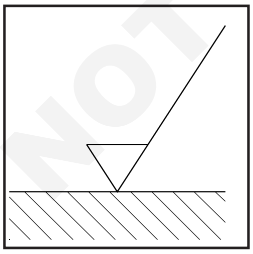
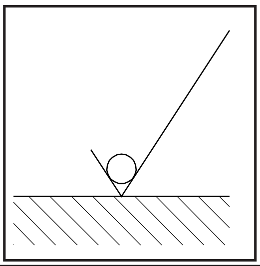
Objectives: At the end of this lesson you shall be able to
- **state the values of surface roughness**
- **state the indication of surface roughness.**

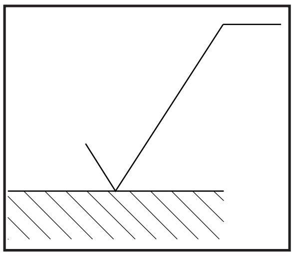
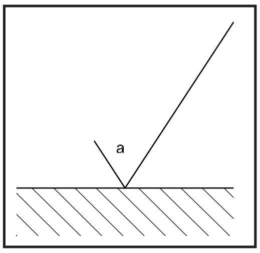
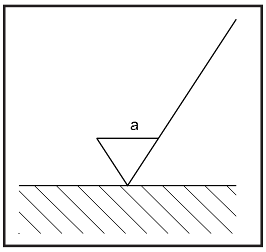
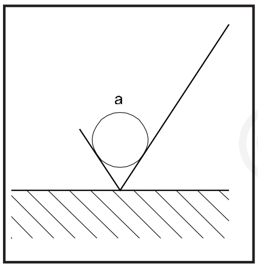
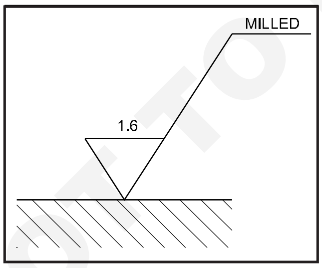
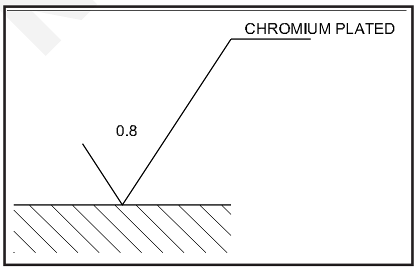
Letter symbols for roughness

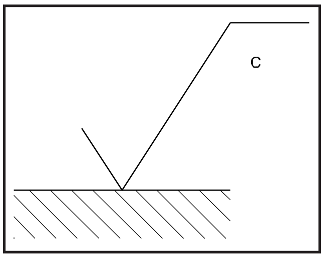
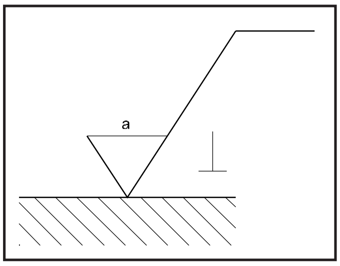
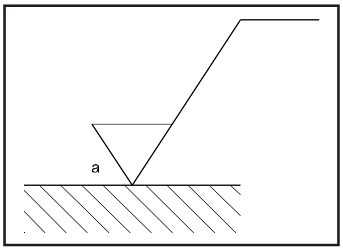
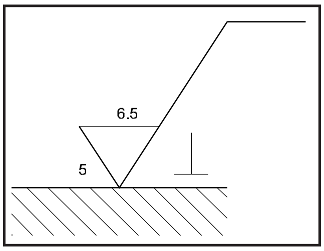
Indication of surface roughness values.

S. No.	Roughness value Ra in microns	Roughness grade Number	Roughness Symbol	Manufacturing process
1.	50	N12	~	Flame cutting, hacksaw cut, bandsaw cut, shot blast etc.
2.	25.0	N11	∇	Sand casting, planning, shaping filling etc.
3.	6.3 3.2 1.6	N9 N8 N7	∇∇	Milling, drilling, die casting, turning,forging,boring etc.
4.	0.8 0.4 0.2	N6 N5 N4	∇∇∇	Centreless grinding, cylindrical grinding, cold rolling, internal grinding,extrusion,surface grinding,broaching,hobbing EDM, reaming etc.
5.	0.1 0.05 0.025	N3 N2 N1	∇∇∇∇	Super finishing, lapping honning etc.

Surface symbol indications

Symbol	Symbol stands for
	**Surface symbol indication** 1 The basic symbol consists of two legs of unequal length inclined at approximately 60°.
	A bar is added to the basic symbol, if the material removal by machining is required.
	A circle is added to the basic symbol, if the material removal is not permitted.

Symbol	Symbol stands for
	A line is added to the larger leg, if some special characteristics have to be indicated.
	Surface roughness obtained by any production method.
	Surface roughness obtained by removal of material by machining.
	Surface roughness obtained by removal of material by machining.
	Indicating the production method.
	Indicating the surface treatment or coating unless otherwise stated, the numerical value of the roughness, applies to the surface roughness after treatment coating.

Symbol	Symbol stands for
	Indicating the sampling length.
	Direction of lay, surface pattern by the production method employed.
	Indicating of allowance in mm.
	Surface texture.

Surface quality

Objectives: At the end of this lesson you shall be able to
- **state the meaning of roughness value**
- **state the parameters on which surface quality depends**
- **state the method of measuring roughness**
- **define the symbols for surface roughness.**

When components are produced either by machining or by hand processes, the movement of the cutting tool leaves certain lines or patterns on the work surface. This is known as surface texture. These are, in fact, irregularities, caused by the production process with regular or irregular spacing which tend to form a pattern on the workpiece. (Fig 1)

The components of surface texture

Roughness (Primary texture)

The irregularities in the surface texture result from the inherent action of the production process. These will include traverse feed marks and irregularities within them. (Fig 2a)

Waviness (Figs 2b & 2c)

This is the component of the surface texture upon which roughness is superimposed. Waviness may result from machine or work deflections, vibrations, chatter, heat treatment or warping strain.

The requirement of surface quality depends on the actual use to which the component is put.

Examples

In the case of slip gauges (Fig 3) the surface texture has to be extremely fine with practically no waviness. This will help the slip gauges to adhere to each other firmly when wrong together.

Fig 1

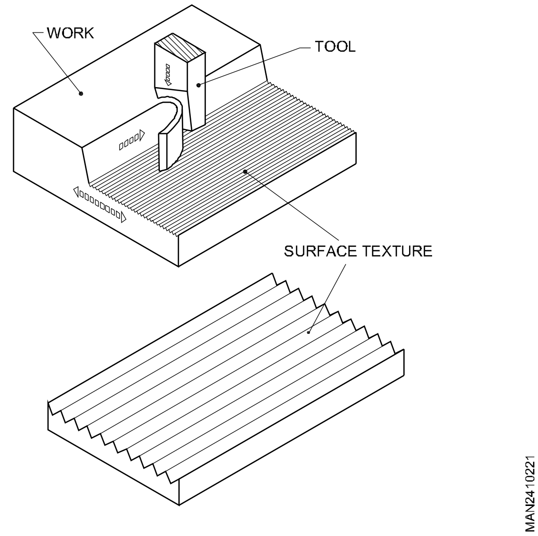


Fig 2

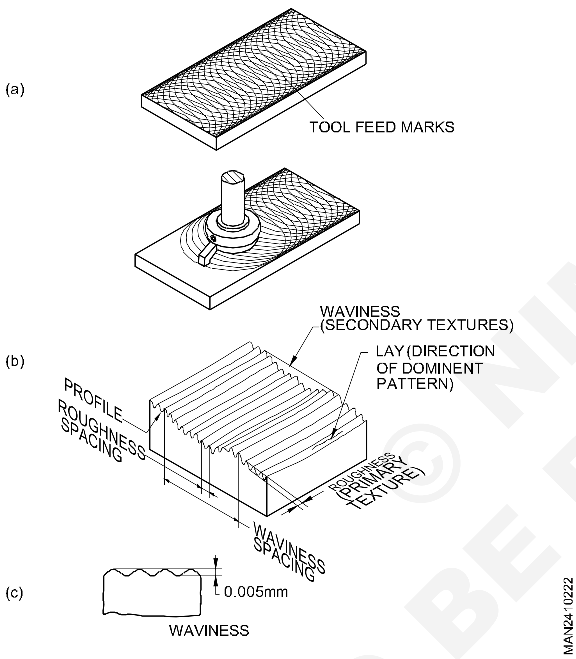
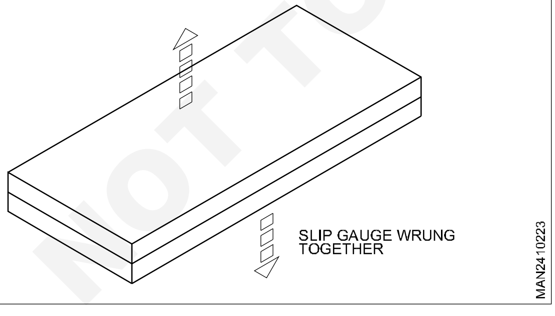


Fig 3



The cylinder bore of an engine (Fig 4) may require a certain degree of roughness for assisting the lubrication needed for the movement of the piston.

For sliding surfaces the quality of surface texture is very important.

When two sliding surfaces are placed one over the other, initially the contact will be only on the high spots. (Fig 5) These high spots will wear away gradually. This wearing away depends on the quality of the surface texture.

Fig 4

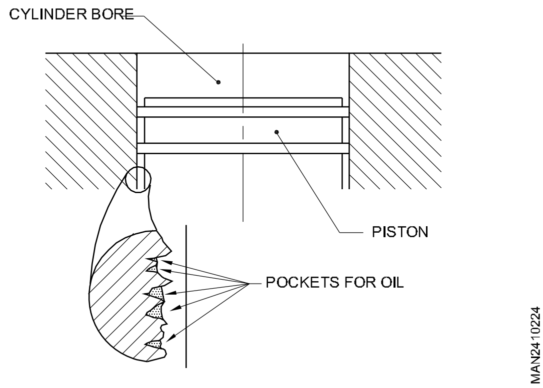
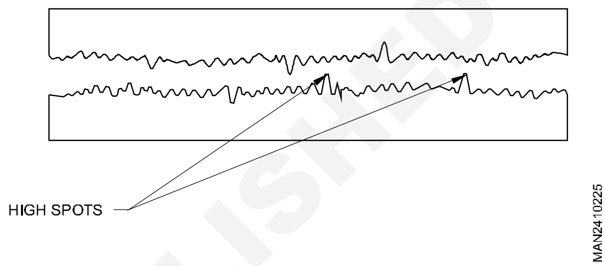


Fig 5



Due to this reason it is important to indicate the surface quality of components to be manufactured.

The surface texture quality can be expressed and assessed numerically.

'Ra' Values

The most commonly used method of expressing the surface texture quality numerically is by using Ra value. This is also known as centre line average (CLA).

The graphical representation of Ra value is shown in Figures 6 & 7. In Figure 6 a mean line is placed cutting through the surface profile making the cavities below and the material above equal.

The profile curve is then drawn along the average line so that the profile below this is brought above.

Fig 6

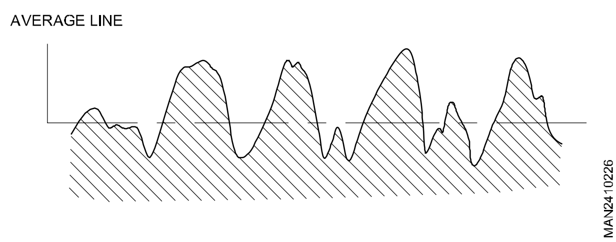
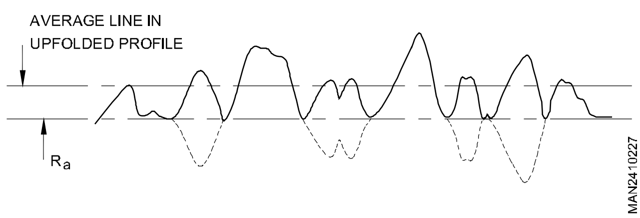


Fig 7



A new mean line (Fig 7) is then calculated for the curve obtained after folding the bottom half of the original profile.

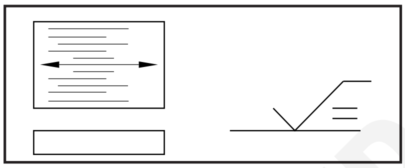
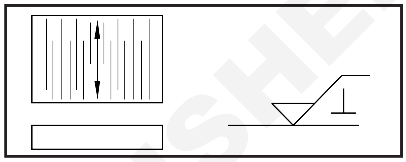
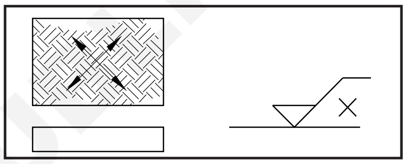
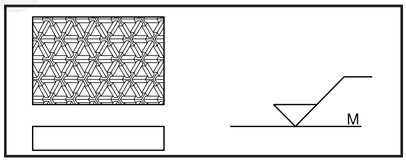
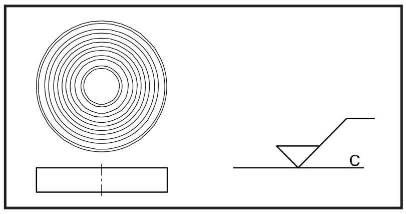
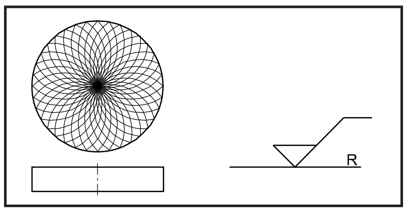
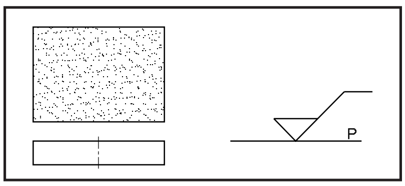
The distance between the two lines is the 'Ra' value of the surface.

The 'Ra' value is expressed in terms of micrometre (0.000001) or (m); this also can be indicated in the corresponding roughness grade number, ranging from N_1 to N_{12}.

When only one 'Ra' value is specified, it represents the maximum permissible value of surface roughness.

Lay: Symbols for designating the direction of lay are shown and interpreted in table 1.

TABLE 1

Example showing	Interpretation	Direction of tool marks
=	Lay approximately parallel to the line representing the surface to which, the symbol is applied.	
⊥	Lay approximately perpendicular to the line representing the surface to which the symbol is applied.	
X	Lay angular in both direction to line representing the surface to which the symbol is applied.	
M	Lay multidirectional.	
C	Lay approximately circular relative to the centre of the surface to which the symbol is applied.	
R	Lay approximately radial relative to the centre of the surface of which the symbol is applied.	
P	Lay particulate, non-directional, or protuberant.	

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)
- Horizontal spindle rotary table (Fig 2)
- Vertical spindle reciprocating table (Fig 3)
- Vertical spindle rotary table (Fig 4)

Fig 1

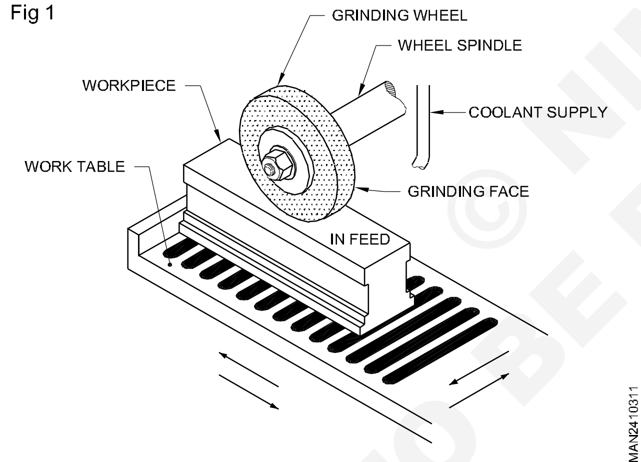


Fig 2

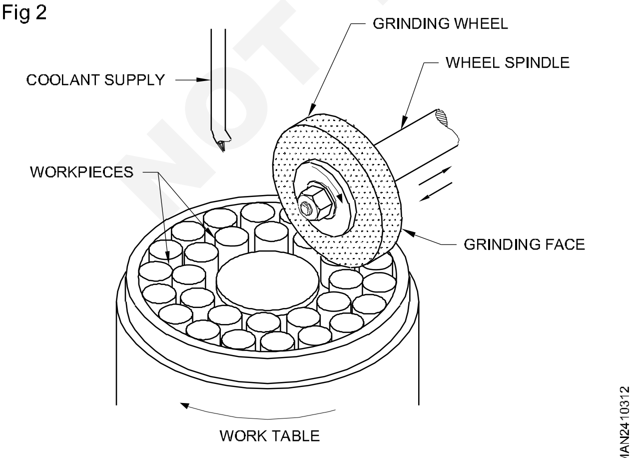


Fig 3

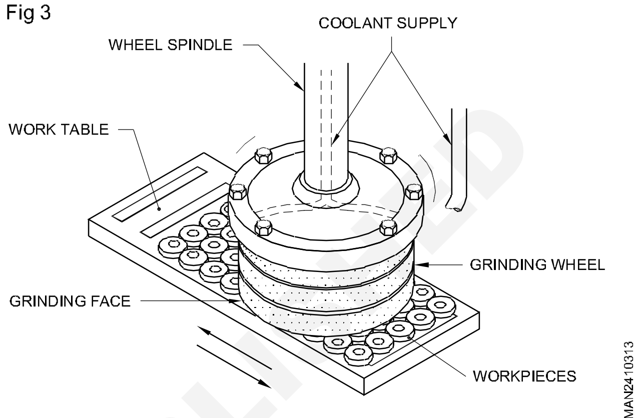
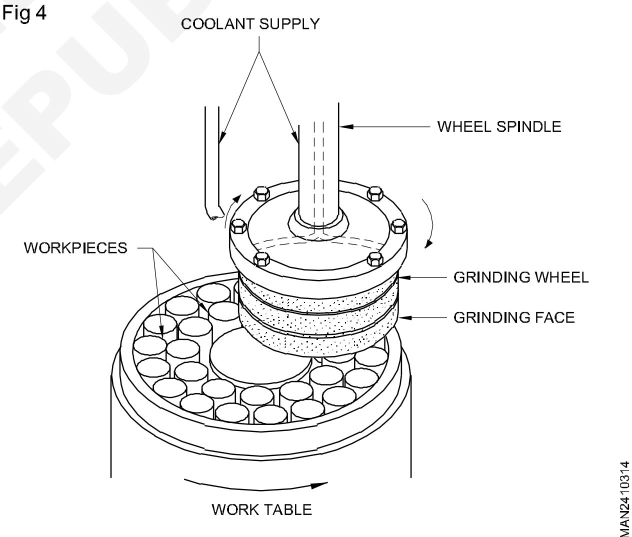


Fig 4



Parts

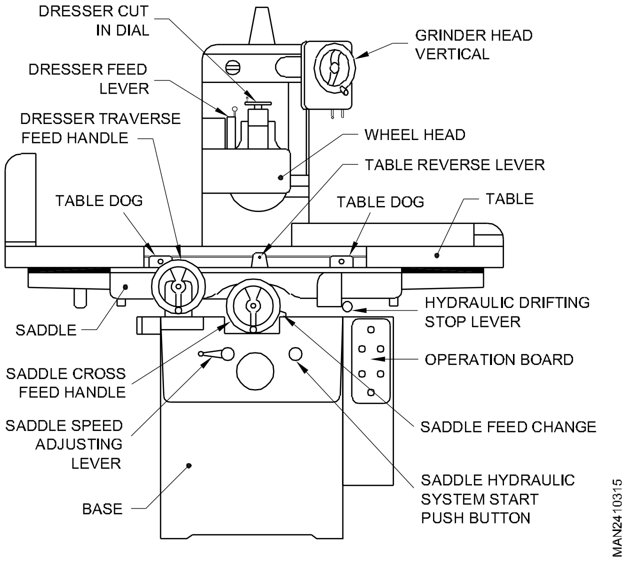
Horizontal spindle reciprocating table surface grinder main parts (Fig 5).

- Base
- 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.

Fig 5



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)
- 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)

Fig 1

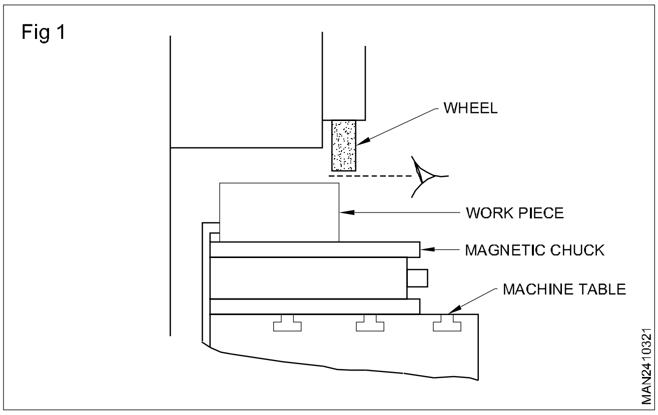
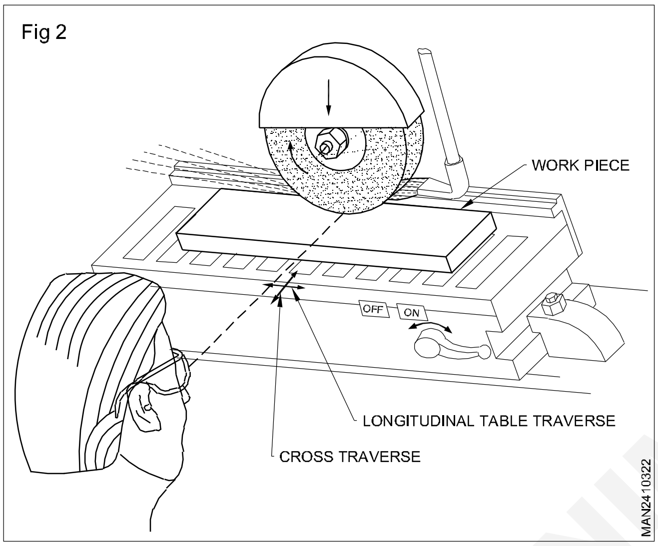


Fig 2

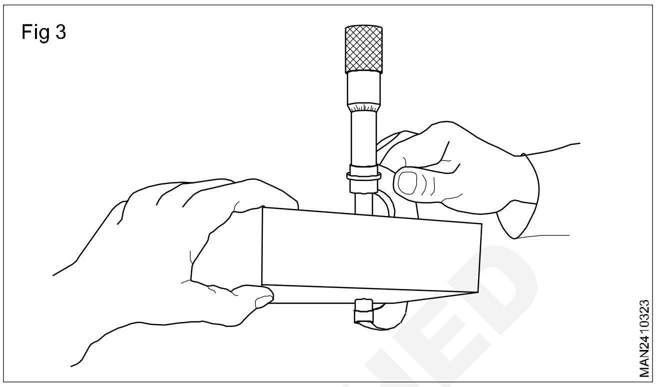


- Stop cross traverse of wheel-head. Apply further drawn feed and reset reverse traverse. Repeat the process until the face is fully cleaned up. Remove the workpiece from the chuck.
- Dress wheel for finish grinding.
- Set the workpiece again on the chuck
- Engage longitudinal table transeverse. With the help of cross traverse, bring the edge of the workpiece under the wheel.
- Feed the wheel-head down until the wheel is lightly in contact with the workpiece.
- Move the workpiece away from the wheel. Apply down feed 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)
- 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.

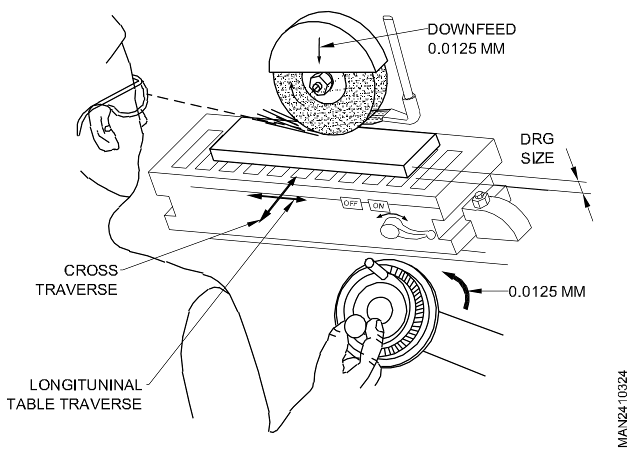
Fig 3



- 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)

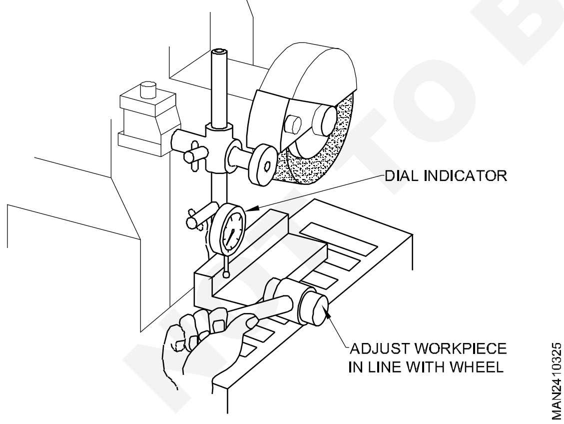
Fig 4



Grinding a flat face and shoulder

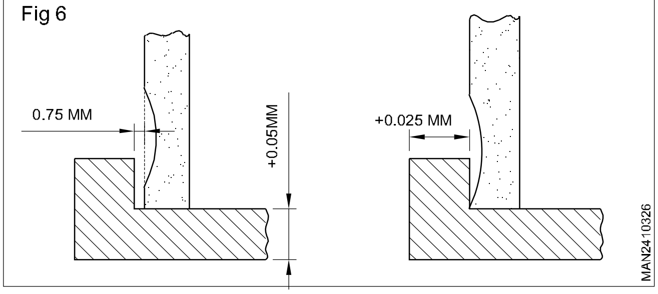
- Dress the face of the wheel. Relieve its rear.
- Mount the workpiece on magnetic chuck, first visually align workpiece shoulder face in line with wheel and then click and adjust alignment with a dial indicator. (Fig 5) If the chuck has a back plate, it can be used as a datum surface for correctly setting 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)

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.
- 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.

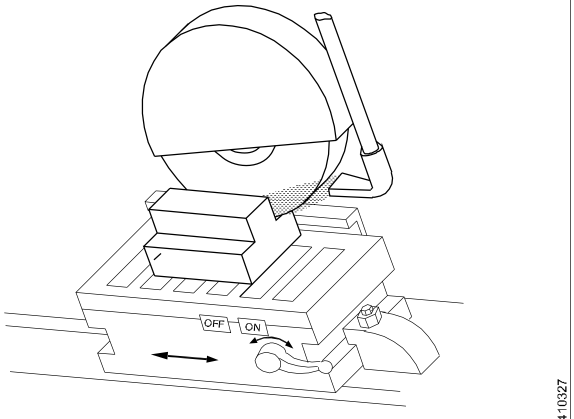
For cleaning up back vertical face, bring the wheel approximately 0.375 mm above horizontal face and 0.375 mm from vertical face. Feed the wheel-head down carefully until the wheel makes a light contact with the horizontal face. Then feed cross traverse until the wheel makes a light contact with vertical 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)

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.

Fig 7



GRINDING BACK VERTICAL FACE

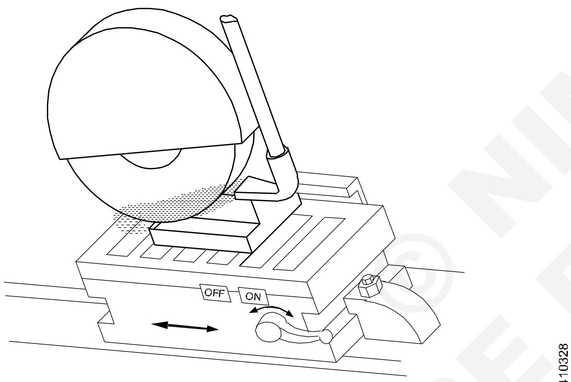
Re-set the workpiece and rough grind front vertical face by applying cuts until the face is within 0.05 mm of the finished size.

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)

Fig 8



GRINDING FRONT VERTICAL FACE

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.

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 9

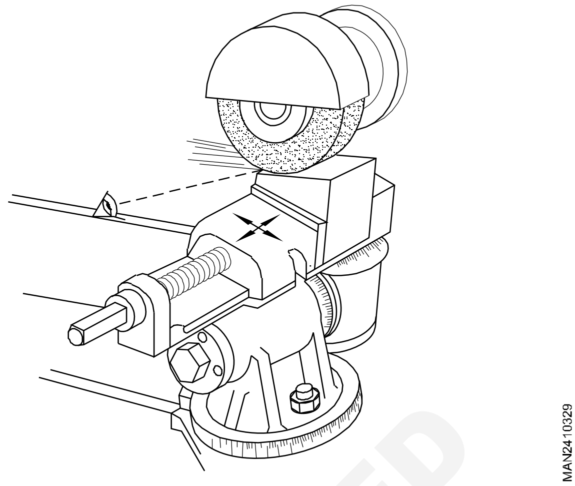
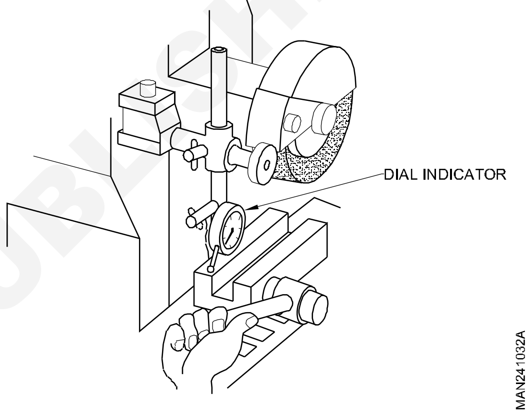
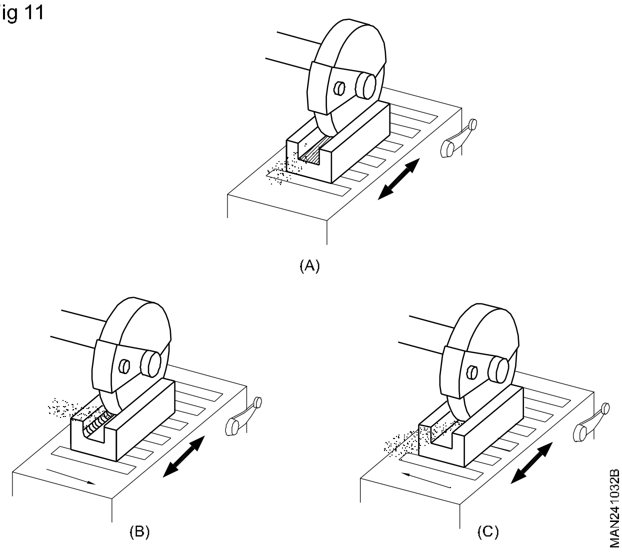


Fig 10



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)

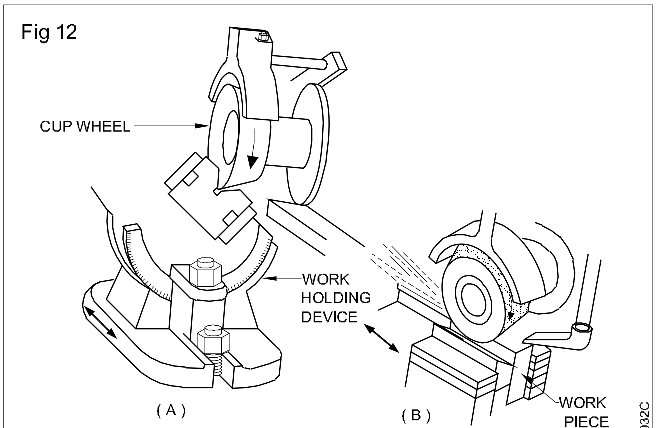


Fig 12

(A) GRINDING VEE USING CUP WHEEL.
(B) GRINDING DOVETAIL USING FORMED WHEEL.

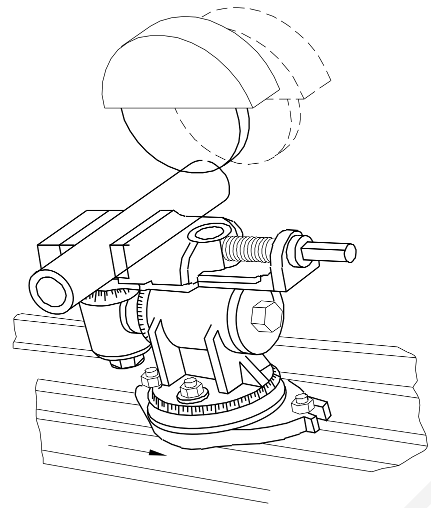


Fig 13

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 hardend 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.

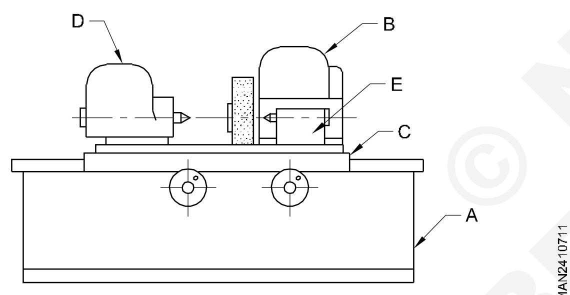
By cylindrical grinding the diameter of a workpiece can be maintained to a close tolerance (upto 0.0025 mm), and high quality surface finish can be obtained (upto N4).

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

Besure to allowable clearance between hand and grinding wheel

Before starting of hydraulic system donot 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.**

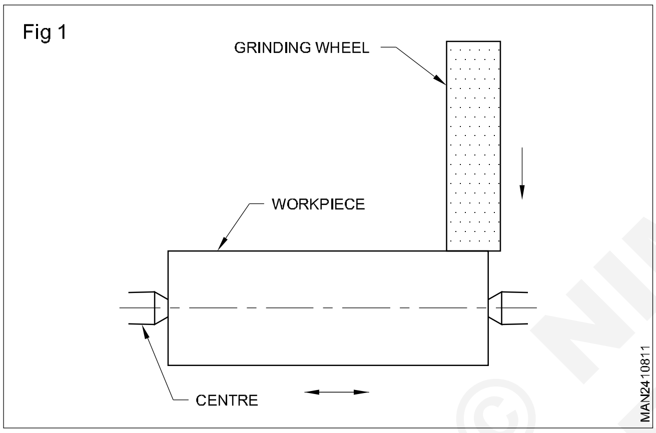
Cylindrical grinding operations

The figures given here show the various types of cylindrical grinding operations.

Grinding plain cylindrical (Fig 1)

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.

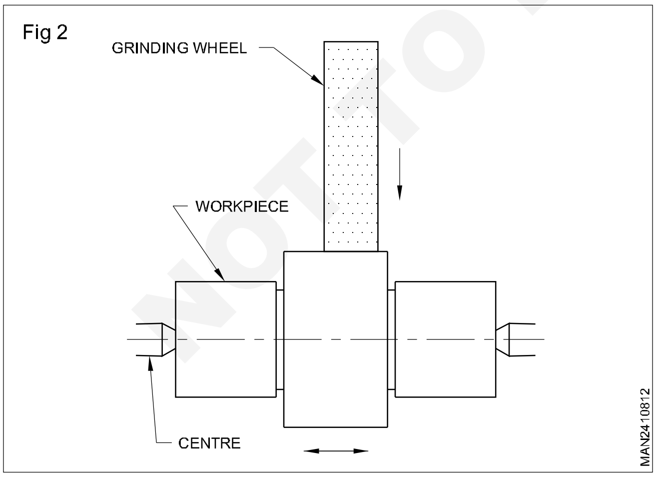
Fig 1



Grinding stepped cylindrical (Fig 2)

Stepped cylindrical grinding is the process of grinding a different diameters in stepped form on a cylindrical grinding workpiece.

Fig 2



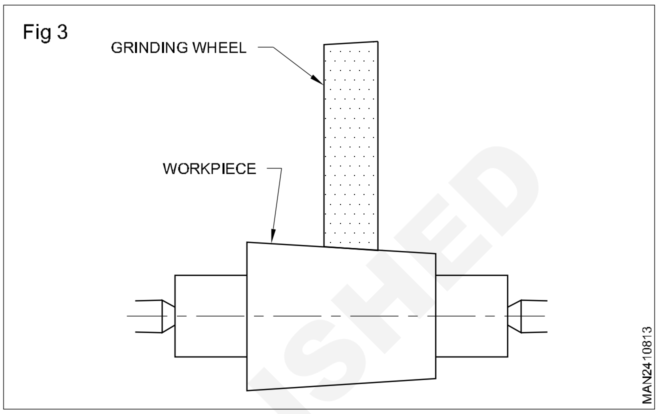
Grinding taper cylindrical (Fig 3)

Methods of taper cylindrical grinding

The table work head and wheel head may be swivelled

The grinding wheel may be dressed at an angle

Fig 3



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

Wheel dressing at an angle for taper cylindrical

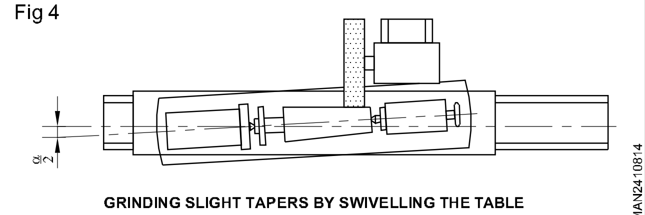
Dressing taper parts can be checked with taper ring gauge.

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)

Fig 4



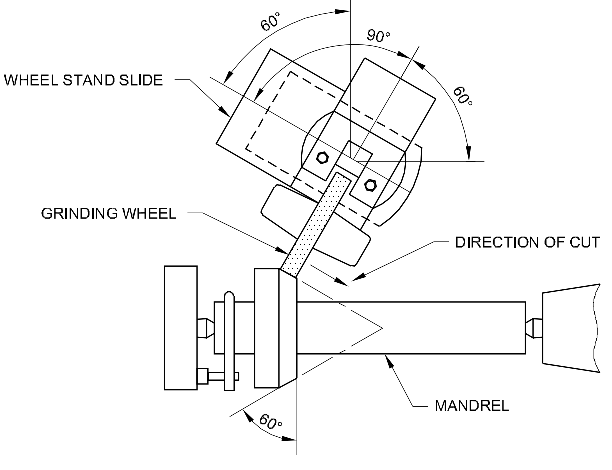
GRINDING SLIGHT TAPERS BY SWIVELLING THE TABLE

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.

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.

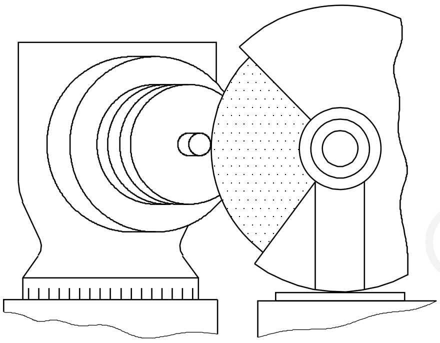
Fig 5



GRINDING A STEEP TAPER

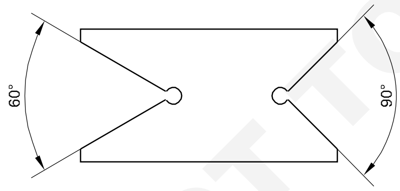
Fig 6 shows the setting for 60° grinding and Fig 7 is the flat centre gauge.

Fig 6



GRINDING A 60° MACHINE CENTRE

Fig 7



FLAT CENTRE GAUGE

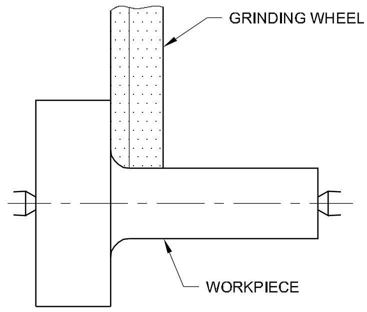
Shoulder grinding (Fig 8)

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.

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.

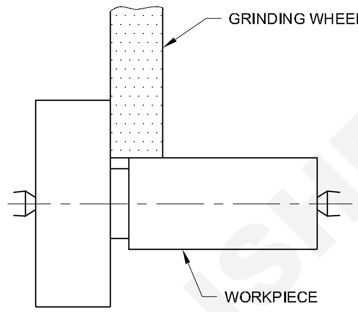
When work has to be ground upto a shoulder it should be undercut so that the wheel may grind the diameter without touching the shoulder. (Fig 9)

Fig 8



SHOULDER GRINDING

Fig 9



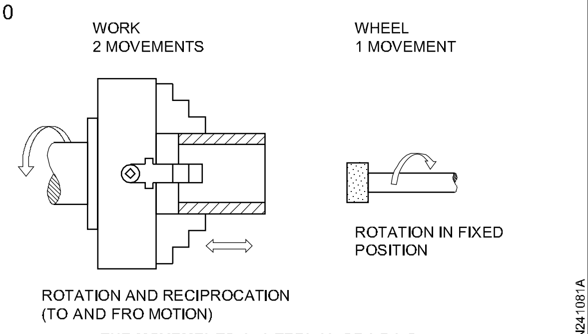
Do not operate a wheel above its recommented speed.

Internal cylindrical (Fig 10 & 11)

Internal grinding is used to grind plain or parallel bore, step bore and taper bore in workpieces.

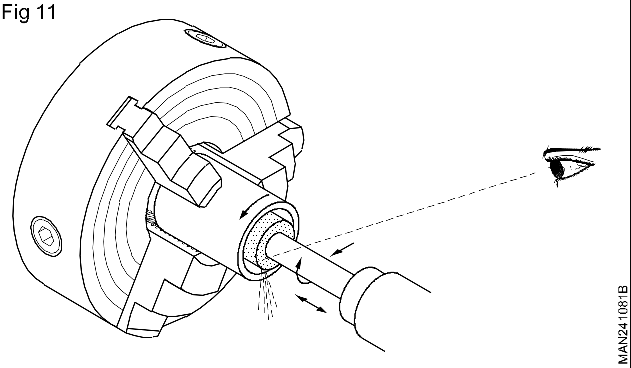
The wheel rotates in a fixed position. The work is rotated and reciprocated that it moves backwards and forwards to obtain traverse.

Fig 10



THE MOVEMENTS IN INTERNAL GRINDING

Fig 11



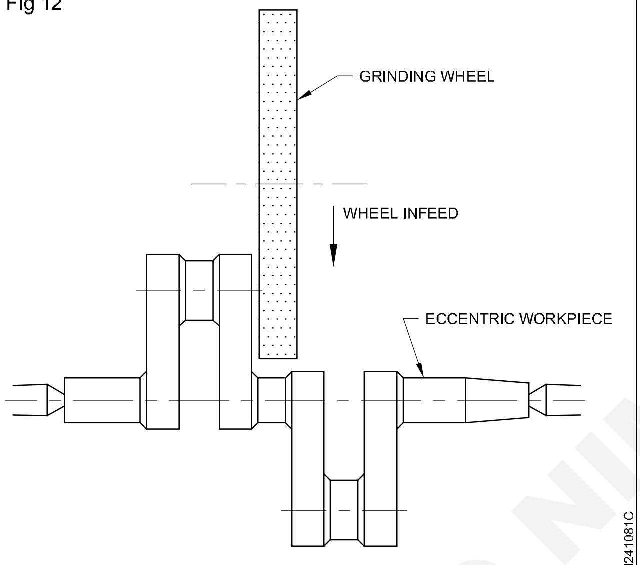
The work is held on three jaw chuck, four jaw chuck, face plate, spring collect chuck and fixture.

Eccentric cylindrical (Fig 12)

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.

Fig 12

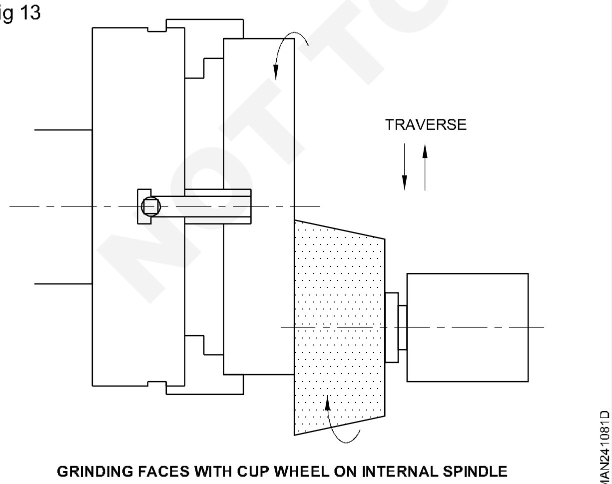


ECCENTRIC CYLINDRICAL GRINDING

Face grinding (Fig 13)

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.

Fig 13

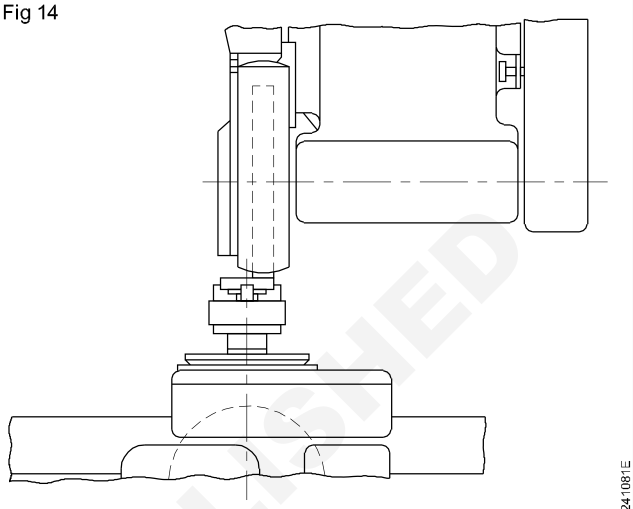


GRINDING FACES WITH CUP WHEEL ON INTERNAL SPINDLE

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).

Cutting speed, feed and depth of cut

Objectives: At the end of this lesson you shall be able to
- **state what is the 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 1

Table 1

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:

$$n = \frac{V3 \times 1000 \times 60}{\pi d}$$

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 2 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.

Table 1

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,

$$n_w = \frac{V_w \times 1000}{\pi d}$$

V_w = Circumferential speed of the workpiece in m/min

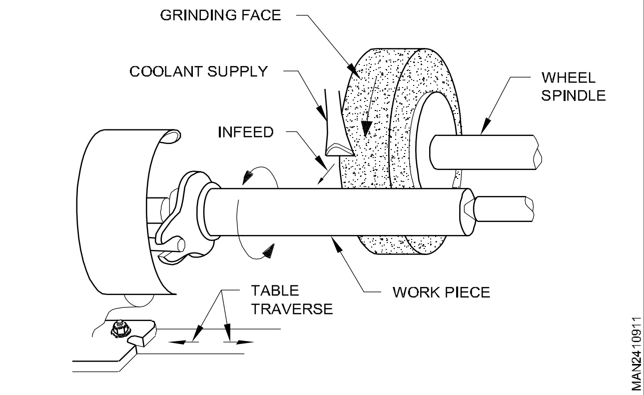
d = diameter of workpiece in mm

nw = R.P.M of the work piece

Table traverse (Fig 1): 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 1/4th to 1/3rd 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.

Fig 1



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 2)

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 ;

Machining time: (Tm)

With feed adjustment at every stroke of the table

i $Tm = \frac{L \times i}{f \times \eta_w}$ ii $Tm = \frac{L \times i}{f \times \eta_W}$

Example:

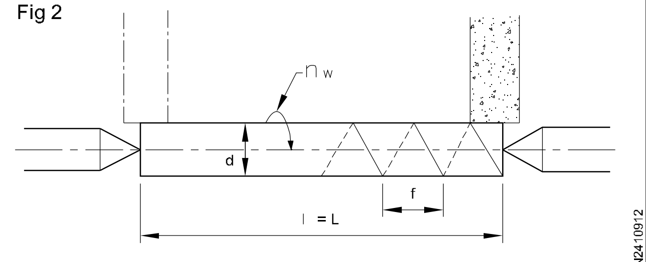
A steels shaft θ 50.3 mm, 500 mm long is to be ground to θ 50 mm, width of grinding wheel = 40 mm, feed adjustment per stroke = .005 mm circumferential work speed = 12 m/min feed = 1/2 width of grinding wheel per revolution of workpiece.

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

Fig 2



MACHINING TIME FOR CYLINDRICAL GRINDING

$$\text{No.of cuts (i)} = \frac{\text{Grinding allowance}}{\text{Infeed adjustment}}, i = \frac{0.15}{0.005} = 30$$

R.P.M of workpiece,

$$n_w = \frac{v_w \times 1000}{\pi \times d}$$

$$= \frac{12 \times 1000}{\pi \times 50}$$

=76 R.P.M

$$\text{machining time (Tm)} = \frac{L \times i}{f \times \eta\, w}$$

$$= \frac{500 \times 30}{20 \times 76}$$

= 9.868 minutes

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.**

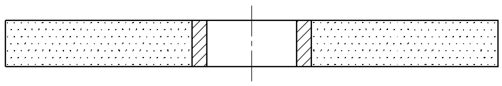
Grinding wheels are made in different shapes and sizes for grinding different jobs and for use in different machines. The size may differ in diameter, face width and bore dia.

The following are the standard shapes of grinding wheels.

Straight wheel: Type 1 (Fig 1)

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.

Fig 1



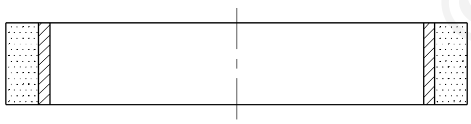
STRAIGHT

MAN2411311

Cylinder: Type 2 (Fig 2)

This type of wheel is used on both horizontal and vertical spindle surface grinders for the surface grinding operations.

Fig 2



CYLINDER

MAN2411312

Tapered (both sides) Type 4 (Fig 3)

It is mainly used for rough grinding. The tapered sides reduce the chance of breaking.

Fig 3

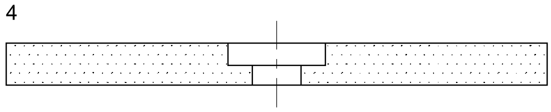
TAPERED TWO SIDES

MAN2411313

Recessed one side: Type 5 (Fig 4)

It is used for cylindrical, surface and centreless grinding. The recess provides clearance for the flange.

Fig 4



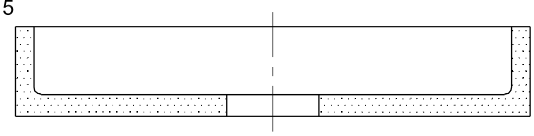
RECESSED ONE SIDE

MAN2411314

Straight cup: Type 6 (Fig 5)

It is used on surface grinders and on tool and cutter grinders to grind flat surfaces.

Fig 5



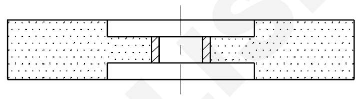
STRAIGHT CUP

MAN2411315

Recessed both sides: Type 7 (Fig 6)

Used on cylindrical, surface and centreless grinders. The recesses provide clearance for both flanges.

Fig 6



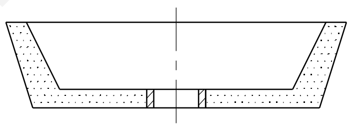
RECESSED TWO SIDES

MAN2411316

Flaring cup: Type 11 (Fig 7)

It is used on tool and cutter grinders mainly to sharpen milling cutters and reamers.

Fig 7



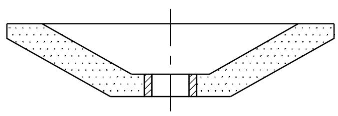
FLARING CUP

MAN2411317

Dish: Type 12 (Fig 8)

Used on tool and cutter grinders to sharpen milling cutters with narrow slots like formed relieved cutters, hobs etc.

Fig 8



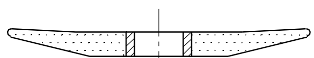
DISC WHEEL

MAN2411318

Saucer: Type 13 (Fig 9)

It is used for sharpening circular and handsaws. It is also used for gashing milling cutter teeth.

Fig 9



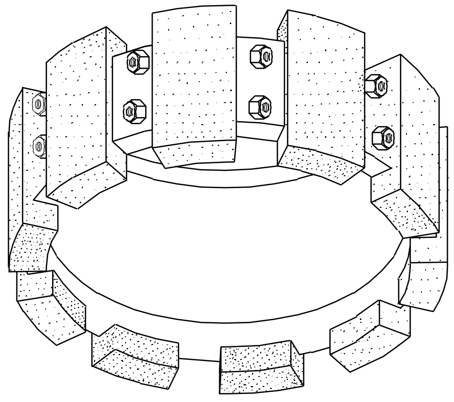
SAUCER WHEEL

MAN2411319

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.

Fig 10

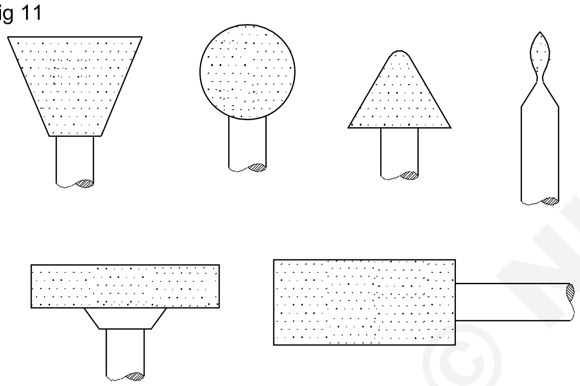


SEGMENTED WHEEL

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. Used on pneumatic or electric grinders.

Fig 11



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)

Fig 12

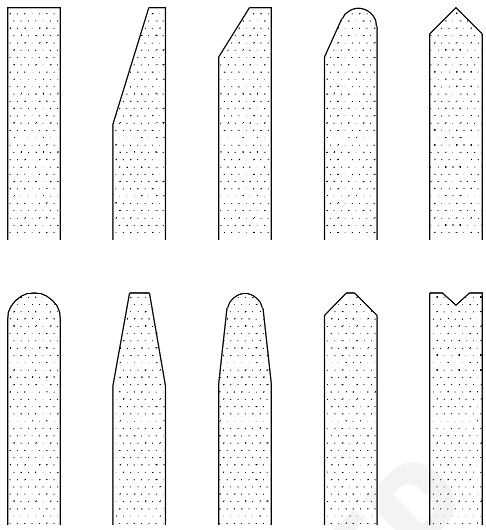
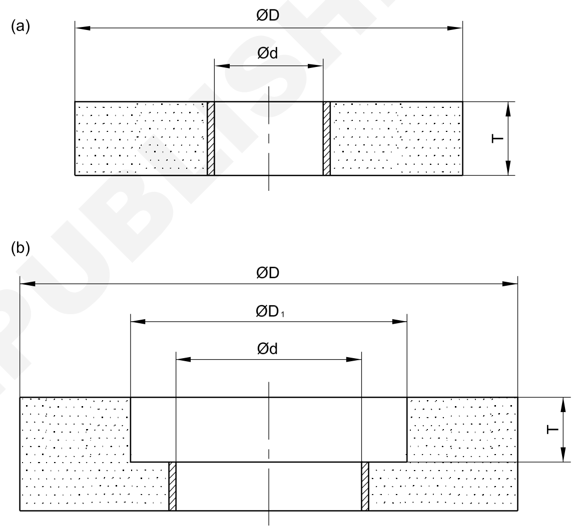


Fig 13



Grinding wheel marking system

eg. A 56 K 5 V 75

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

Wet grinding	Dry grinding
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 the	Reduce the rate of traverse and work speed depth of cut.