MECHANIC MACHINE TOOL MAINTENANCE

NSQF LEVEL - 4

1st Year

TRADE THEORY

SECTOR: CAPITAL GOODS & MANUFACTURING

(As per revised syllabus July 2022 - 1200 Hrs)

Directorate General of Training

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

NATIONAL INSTRUCTIONAL MEDIA INSTITUTE, CHENNAI

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

Sector : Capital Goods & Manufacturing

Duration : 2 Years

Trade : MMTM - 1st Year - Trade Theory - NSQF Level - 4 (Revised 2022)

Developed & Published by

National Instructional Media Institute
Post Box No.3142
Guindy, Chennai - 600 032
INDIA
Email: chennai-nimi@nic.in
Website: www.nimi.gov.in

First Edition : January 2024 Copies: 1000

Rs.410/-

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 comprising 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 **MMTM - 1st Year - Trade Theory NSQF Level - 4 (Revised 2022) in CG & M Sector under** under Annual pattern. The NSQF Level - 4 (Revised 2022) Trade Practical 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

Atul Kumar Tiwari, *I.A.S*
Secretary
Ministry of Skill Development & Entrepreneurship,
Government of India.

January 2024
New Delhi - 110 001

PREFACE

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

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

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

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

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

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

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

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

Chennai - 600 032 **EXECUTIVE DIRECTOR**

ACKNOWLEDGEMENT

National Instructional Media Institute (NIMI) sincerely acknowledges with thanks for the co-operation and contribution extended by the following Media Developers and their sponsoring organisation to bring out this IMP **(Trade Theory)** for the trade of **MMTM** under the **CG & M** Sector for ITIs.

MEDIA DEVELOPMENT COMMITTEE MEMBERS

A. Vijayaraghavan	-	Asst. Director of Training (Retd) ATI, Chennai - 32.
M. Sampath	-	Training officer (Retd) CTI, Chennai - 32.
Shri. V. Alagaiah	-	Assistant Training officer Govt ITI, Ambattur, Chennai

NIMI COORDINATORS

Shri. Nirmalya Nath	-	Deputy Director, NIMI, Chennai - 32.
Shri. V. Gopala Krishnan	-	Manager NIMI, Chennai - 32.

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

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

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

INTRODUCTION

TRADE PRACTICAL

The trade practical manual is intented to be used in practical workshop. It consists of a series of practical exercises to be completed by the trainees during the course of the **MMTM - 1st** year trade supplemented and supported by instructions/ informations to assist in performing the exercises. These exercises are designed to ensure that all the skills in compliance with NSQF LEVEL - 4 (Revised 2022) syllabus are covered.

This manual is divided into nine modules. The nine modules are given below

Module 1	Basic Fitting - I
Module 2	Basic Fitting - II
Module 3	Machining (Shaping & Milling)
Module 4	Heat Treatment
Module 5	Advance Fitting
Module 6	Mechanical Power Transmission
Module 7	Lubricants & Coolants
Module 8	Machine installation and maintenance
Module 9	Turning

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

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

TRADE THEORY

The manual of trade theory consists of theoretical information for the Course of the **MMTM - 1st** year Trade Theory NSQF LEVEL - 4 (Revised 2022) in CG & M. The contents are sequenced according to the practical exercise contained in NSQF LEVEL - 4 (Revised 2022) syllabus on TradeTheory attempt has been made to relate the theoretical aspects with the skill covered in each exercise to the extent possible. This correlation is maintained to help the trainees to develop the perceptional capabilities for performing the skills.

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

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

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

CONTENTS

LEARNING / ASSESSABLE OUTCOME

On completion of this book you shall be able to

Sl.No.	Learning Outcome	Exercise No.
1	Plan and organize the work to make job as per specification applying different types of basic fitting operation and Check for dimensional accuracy following safety precautions. [Basic fitting operation – marking, Hack-sawing, Chiseling, Filing, Drilling, Taping and Grinding etc. Accuracy: ± 0.25mm] **NOS:CSC/N0304**	1.1.01 - 1.2.44
2	Make different fit of components for assembling as per required tolerance observing principle of interchange ability and check for functionality. [Different Fit – Sliding, Angular, Step fit, Required tolerance: ±0.20 mm, angular tolerance: 1 degree] **NOS:CSC/N0304**	1.1.45 - 1.2.46
3	Set the different parameters to produce components involving basic operations on different machine observing standard procedure and check for accuracy. [Different machines – Shaper, Lathe & Milling, Different machining parameters – feed, speed & depth of cut.] **NOS:CSC/N0304**	1.3.47 - 1.3.59
4	Prepare components for assembly by carrying out different Heat Treatment and surface finishing operations. [Different Heat Treatment: - Hardening, Tempering case hardening, different surface finish- scrapping, lapping] **NOS:CSC/N0304**	1.4.60 - 1.4.66
5	Make different fit of components for assembling as per required tolerance observing principle of interchange ability and check for functionality. [Different Fit – square fits, T-fits, hexagonal fit, dovetail fit; surface accuracy: ±0.1 mm, angular tolerance:30 min.] **NOS:CSC/N0304**	1.5.67 - 1.5.71
6	Dismantle, Repair and Assemble of mechanical power transmission elements in machine tools and check for functionality. **NOS: CSC/N0901**	1.6.72 - 1.6.94
7	Carryout preventive maintenance of lubrication & cooling system of different machines as per manufactures guidelines. [Different machines- lathe, drilling, grinding] **NOS:CSC/N0901**	1.7.95 - 1.7.103
8	Prepare machine foundation for erection, install different machines and carry out geometrical tests. [Different machines – shaper, pedestal grinding] **NOS:CSC/N0304**	1.8.104 - 1.8.116
9	Conduct preventive maintenance, perform dismantling & assembly of different components and test for accuracy to carryout advance lathe operation. [Different components- head stock apron, saddle, tool post tail stock; Different advance lathe operation – taper turning, thread cutting] **NOS:CSC/N0901**	1.9.117 - 1.8.121

SYLLABUS FOR MECHANIC MACHINE TOOL MAINTENANCE

Duration	Reference Learning Outcome	Professional Skills (Trade Practical) With Indicative Hours	Professional Knowledge (Trade Theory)
Professional Skill 260Hrs; Professional Knowledge	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, Hacksawing, Chiselling, Filing, Drilling, Taping and Grinding etc. Accuracy: ± 0.25mm] (Mapped NOS: NOS:CSC/ N0304)	1. Importance of trade training, List of tools & Machinery used in the trade. (1 hr) 2. Safety attitude development of the trainee by educating them to use Personal Protective Equipment (PPE). (3 hrs) 3. First Aid Method and basic training. (2 hrs) 4. Safe disposal of waste materials like cotton waste, metal chips/burrs etc. (1 hrs) 5. Hazard identification and avoidance. (2 hrs) 6. Safety signs for Danger, Warning, caution & personal safety message. (1 hr) 7. Preventive measures for electrical accidents & steps to be taken in such accidents.(2 hrs)	All necessary guidance to be provided to the new comers to become familiar with the working of Industrial Training Institute system including stores procedures. Soft Skills, its importance and Job area after completion of training. Importance of safety and general precautions observed in the 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)
		8. Use of Fire extinguishers.(2 hrs) 9. Study the drawing to plan the job/ work. Identification of tools &equipments as per desired specifications for marking, filling & sawing. (3 hrs) 10. Visual inspection of raw material for rusting, scaling, corrosion etc.(1 hr) 11. Familiarisation of bench vice. (1 hr) 12. Filing- Flat and square (Rough finish). (8 hrs) 13. Marking with scriber and steel rule (2hrs) 14. Filing practice, surface filing, marking of straight and parallel lines with odd leg callipers and steel rule. (08 hrs)	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. (04 hrs)

		15. Filing Channel, Parallel. (4 hrs) 16. Filing- Flat and square (Rough finish), (08 hrs) 17. Filing practice, surface filing, marking of straight and parallel lines with odd leg callipers and steel rule. (5 hrs) 18. Marking practice with dividers, odd leg callipers and steel rule (circles, ARCs, parallel lines). (5 hrs)	Bench vice construction, types, uses, care & maintenance, vice clamps,hacksaw frames and blades, specification, description, types and their uses, method of using hacksaws.Files- specifications, description, materials, grades, cuts, file elements, uses. Types of files, care and maintenance of files. Measuring standards (English, Metric Units), angular measurements. (04 hrs)
		19. Marking off straight lines and ARCs using scribing block and dividers. (5 hrs) 20. Chipping flat surfaces along a marked line. (05 hrs) 21. Marking, filing, filing square and check using tri-square.(05 hrs)	Marking off and layout tools, dividers, scribing block, odd leg callipers, punchesdescription, classification, material, care & maintenance. Try square, ordinary depth gauge, protractor- description, uses and cares. Callipers- types, material, constructional details, uses, care & maintenance of cold chisels- materials, types, cutting angles. (04hrs)
		22. Marking according to drawing for locating, position of holes, scribing lines on chalked surfaces with marking tools. (5 hrs) 23. Finding centre of round bar with the help of 'V' block and marking block. (5 hrs) 24. Prepare mushroom head and round bar and bending metal plate by hammering. (10hrs)	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)
		25. Chipping flat surfaces along a marked line. (10 hrs) 26. Make a square from a round job by chipping upto 20mm length. (8hrs) 27. Slot, straight and angular chipping (5hrs) 28. Mark off and drill through holes. (5 hrs) 29. Drill and tap on M.S. flat. (8 hrs) 30. Cutting external thread on M.S. rod using Die.(5hrs) 31. Punch letter and number (letter punch and number punch) (5 hrs)	Drill, Tap, Die-types & application. Determination of tap drill size. Reamer- material, types (Hand and machine reamer), parts and their uses, determining hole size for reaming, Reaming procedure. (7 hrs)

		32. File steps and finish with smooth file to accuracy of ± 0.25 mm. (10 hrs) 33. File and saw on M.S. Square and pipe. (15 hrs)	Micrometer- outside and inside – principle, constructional features, parts graduation, leading, use and care. Micrometer depth gauge, parts, graduation, leading, use and care. Digital micrometer. (04 hrs)
		34. File radius along a marked line (Convex & concave) & match. (15 hrs) 35. Chip sheet metal (shearing). (5 hrs) 36. Chip step and file. (5 hrs)	Vernier calipers, principle, construction, graduations, reading, use and care. Vernier bevel protractor, construction, graduations, reading, use and care, dial Vernier Calliper, Digital verniercalliper. (04 hrs)
		37. Truing of pedestal grinding wheel. (10 hrs) 38. Grinding and resharpening of hand tools. (10 hrs) 39. Repair and maintenance of hand tools. (10 hrs) 40. Dressing of grinding wheel by diamond dresser tool. (15hrs)	Pedestal grinder – Introduction, care & use. Procedure of wheel mounting & wheel dressing. Related hazards, risk and precautions. (10 hrs)
		41. Counter sinking, counter boring and reaming with an accuracy ± 0.04 mm.(5 hrs) 42. Drill blind holes with an accuracy 0.04 mm.(2 hrs) 43. Form internal threads with taps to standard size (blind holes).(3 hrs) 44. Prepare studs and bolt to standard size and watch with nut. (15 hrs)	Drilling machines-types &their application, construction of Pillar & Radial drilling machine. Countersunk, counter bore and spot facingtools and nomenclature. Cutting Speed, feed, depth of cut and Drilling time calculations. (05hrs)
Professional Skill 40Hrs; Professional Knowledge 08hrs	Make different fit of components for assembling as per required tolerance observing principle of inter change ability and check for functionality. [Different Fit – Sliding, Angular, Step fit, Required tolerance: ±0.20 mm, angular tolerance: 1 degree] (Mapped NOS: **NOS:CSC/N0304)** Set the different parameters to produce components involving basic	45. File and make Step fit, angular fit, with surface accuracy of ±0.20 mm (Bevel gauge accuracy 1 degree). (20hrs) 46. Make simple open and sliding fits. (20hrs)	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 systems of fits and limits. (British standard system & BIS system (08 hrs)

Professional Skill 90Hrs; Professional Knowledge 20Hrs	operations on different machine observing standard procedure and check for accuracy. [Different machines – Shaper, Lathe & Milling, Different machiningparameters – feed, speed & depth of cut.] (Mapped NOS: **NOS:CSC/N0304)**	47. Perform the holding job on shaper machine vice, setting length of stroke, setting of feed in a shaper machine. (5 hrs) 48. Make a square block in shaper machine. (10 hrs) 49. Perform preventive maintenance of shaping machine. (5hrs)	Shaper:Introduction to Shaper machine parts & constructional details, its function and operations. Quick return mechanism of shaper. Calculation of cutting Speed, feed & depth of cut. (04 hrs)
		50. Grinding of R.H & L.H tools, V tool, parting tool, round nose tool & 'V' tools. (10 hrs) 51. Perform facing operation to correct length. (5hrs) 52. Centre drilling & drilling operations to required size. (5hrs) 53. Perform parallel turning & step turning. (05hrs) 54. Perform drilling, boring, undercut, parting, grooving, chamfering operation. (10hrs)	Grinding wheel: Abrasive, grade structures, bond, specification, use, mounting and dressing. Selection of grinding wheels. Bench grinder parts and use.Radius/fillet gauge, feeler gauge, hole gauge, and their uses, care and maintenance. (08 hrs)
		55. Demonstrate working principle of milling machine. (3hrs) 56. Set arbor and cutter on arbor of milling machine. (4hrs) 57. Sequence of milling six faces of a solid block. (08hrs) 58. Perform step milling and slot milling with side & face cutter. (10hrs) 59. Make 'V' block using horizontal milling machine (accuracy ±0.02mm) (10hrs)	**Milling:** Introduction to milling machine, parts & constructional details, types. Safety precaution followed during milling operation. Milling machine attachments. Different types of milling cutters and its materials. Nomenclature of milling cutters. Milling cutter holding devices, work holding devices, Milling machine operations, Up milling and Down milling. Calculation of cutting speed, feed, machining time for milling machine. Indexing methods and its calculations. (08 hrs)
Professional Skill 65 Hrs; Professional Knowledge 15Hrs	Prepare components for assembly by carrying out different Heat Treatment and surface finishing operations. [Different Heat Treatment: - Hardening, Tempering casehardening, different surface finishscrapping, lapping] (Mapped NOS: **NOS:CSC/N0304)**	60.Hardening and tempering &Normalising. (10 hrs) 61. Case Hardening. (5 hrs) 62. Hardness Testing. (5 Hrs)	Heat Treatment: Iron Carbon Equilibrium Diagram, Time-TemperatureTransformation Curve. Annealing, Case Hardening, Tempering, Normalizing and Quenching (07 hrs)

		63. Scraping practice on flat & curved surface. (15hrs) 64. Make a plain flat surface of by scraping the high spots using Prussian blue. (20 hrs) 65. Lapping the surface with lapping stone. (5 hrs) 66. Fixing hammer handle. (5 hrs)	Classification, construction, materials and functional detail of Chisels & Hammers. Chipping technique. Related hazards, risk and precautions while working. Scrapers: Introduction, Its types, material and use. Types of nuts, bolts, studs, locking devices for nut, wrench and spanner, pliers, screw drivers, Circlip, split pin, washers, spring washer. Concept of torque & torque wrench. Different types of rivets and their applications. Identification of different fasteners & operating them by using proper hand tool (08 hrs)
Professional Skill 85Hrs; Professional Knowledge 15Hrs	Make different fit of components for assembling as per required tolerance observing principle of interchange ability and check for functionality. [Different Fit – square fits, T fits, hexagonal fit, dovetail fit; surface accuracy: ±0.1 mm, angular tolerance: 30 min.] (Mapped **NOS: CSC/N0304)**	67. Make Male & Female 'T' fitting with an accuracy ±0.15 mm and 30 minutes. (25hrs) 68. Make male female square fit with accuracy ±0.1 mm. (20hrs)	Surface finish - importance, symbol, measuring techniques. Lapping & honing process. Gauges: Classification and uses of Sine bar, Slip gauge, Limit gauge, Feeler gauge, thread gauge, screw pitch gauge, taper gauge. (6 hrs)
		69. Make Male & Female Hexagon fitting with accuracy ±0.1 mm and 30 min. (20 hrs)	Tolerances & interchangeability - Definition and its necessity, basic size, actual size, limits, deviation, Tolerance, allowance, clearance, interference, Fitsdefinition, types, description with sketches. Method of expressing Tolerance as per BIS, Hole and Shaft basis (BIS standard). Related calculation on Limit, Fit and Tolerance. (03 hrs)
		70. Make male & female dovetail fitting scraping the surface within an accuracy ±0.1 & 30 min 71. Identify different components of power transmission. (5 hrs)	**Fasteners:** Introduction to fasteners, screw threads, related terminology and specification.Keys- types & use, (parallel, sunk, tangential, gib head, woodruff, key ways.) Related hazards, risk and precautions, while working. (06 hrs)
Professional Skill 130Hrs; Professional Knowledge 20 Hrs	Dismantle, Repair and Assemble of mechanical power transmission elements in machine tools and check for functionality. (Mapped NOS: **NOS:CSC/N0901)**	72. Dismantle and assemble different components of power transmission. (10 hrs) 73. Safety precautions related to power transmission. (5 hrs) 74. Identify different types clutches in machine tools and their maintenance. (05 hrs)	**Maintenance Practice and Mechanical Assembly** Introduction to various maintenance practices such as preventive maintenance, predictive maintenance, breakdown maintenance & reconditioning. Organization Structure for maintenance, Roles and responsibility, advantage and disadvantage of TPM. Transmission of Power Elements of mechanical power transmission, type of

			spindles and shafts (Universal spindle, Plain shaft, Hollow shaft, crank shaft, cam shaft). Positive and Non-positive drive, Friction drive, Gear drive, Belt drive, Chain drive and Rope drive. (04 hrs)
		75. Making key and mounting of coupling on the shaft with key. (05 hrs) 76. Identification and inspection of components of different types of brakes in machine tools (04hrs) 77. Fitting of hub and shaft with key. (05 hrs) 78. Installation of belt in transmission with adjusting the tension. (05 hrs)	Clutches Function of Clutches, its types and use in power transmission system. Function of mechanical & electromagnetic system in clutch mechanism. Couplings: Concept of coupling and its type viz. Rigid coupling- Muff coupling, Flange coupling, Flexible coupling, Pin-bush coupling, Chain coupling, Gear coupling, Spider coupling, Tyre coupling, Grid coupling, Oldham-coupling, Fluid coupling, Universal coupling and their specific applications. **Brakes& Braking** Mechanism: Types & Functions. Inspection of brakes for safe & effective working. **Belts** Belt types (Flat and V) and specifications. Pulleys used for belt drive. Installation, Alignment of belts. Problems related to belts(Creep and slip) Belt maintenance. Sheave alignment, Chain drive- Roller chain, Silent chain, alignment of sprockets, and maintenance of chain drive. (04 hrs)
		79. Identification of various types of bearings in machine tools. (4 hrs) 80. Impression testing of split bush bearing for proper contact on journal & housing. (4 hrs) 81. Preloading of Precision angular contact bearing (4 hrs) 82. Dismantling, inspection and mounting of ball bearing on shaft with press & pullers. (10hrs) 83. Dismantling & assembly of tail stock of a lathe. (10hrs) 84. Demonstrate of different types of knots and hitches used in material handling. (5 hrs) 85. Splicing of manila rope. (2 hrs) 86. Inspection of wire rope/ steel rope/ belts. (2 hrs) 87. Lift an object by using slings. (2 hrs)	**Bearing:** Description and function of bearing, its types - Solid Bush, Split Bush, Collar, Pivot and Plummer Block Bearing. Mounting of bearings, measurement and adjustment of clearances in bearings. Types of bearing fitting on shaft and hubs. Type of Roller contact bearings- Ball bearings- single row & double row, Deep groove ball bearing, Angular contact, Self aligning and Thrust bearing. Roller bearing- Cylindrical, Needle roller, Taper roller, Spherical roller, self aligning and Spherical roller thrust bearing. Use of ISO bearing designation code to generate market survey and purchase. Checking and adjustment of bearing clearance. Methods of Mounting and dismounting of roller contact bearing, taper roller bearing

			and angular contact ball bearing. (Back-to-back, Faceto-face, tandem) Mounting-dismounting and adjustment of Taper bore bearings with adopter and withdrawal sleeve. Handling and storage of bearings. Related hazards, risk and precautions. Rigging Knowledge of different tools & tackles used in rigging. Construction and capacity of wire rope/steel rope/belts. Application of knots and hitches. Care and maintenance of all types of ropes. (6 hrs)
		88. Identification different types of gears and gear bones used in machine tools. (5 hrs) 89. Checking of gear elements as PCD, gear tooth thickness, clearance concentricity. (08 hrs) 90. Checking of backlash and root clearance by feeler gauge, DTI & lead wire in gear meshing. (07 hrs)	**Gear:** Type, description and function of gearsSpur, Helical, Spiral, Bevel, Straight and Spiral bevel, Worm gears, Rack and pinion. Gear Terminology. Gear train- simple, compound, reverted and epicyclic. (03 hrs)
		91. Inspection & replacing the lubricating oil of a givengearbox.(5hrs) 92. Overhauling of gear box of lathe & milling machine. (08hrs) 93. Write a inspection report for maintenance job. (5hrs) 94. Prepare a action plan for maintenance work. (5 hrs)	Types of Gear box Gear meshing: Checking of backlash and root clearances with Feeler Gauge, Dial Test Indicator and lead wire. Impression testing of gear mesh with Prussian blue. Running maintenance Related hazards, risk and precautions. (03 hrs)
Professional Skill 65 Hrs; Professional Knowledge 15Hrs	Carryout preventive maintenance of lubrication &cooling system of different machines as per manu factures guidelines. [Different machineslathe, drilling, grinding] (Mapped **NOS: CSC/N0901)**	95. Identification of various types of lubrication system and their components. (5hrs) 96. Cleaning of lubrication lines and oil filters. (07 hrs) 97. Fittings of different types of seals and oil rings. (07rs) 98. Preparing and fitting of gasket for different joint surface. (08hrs) 99. Preventive maintenance of lubrication system of lathe, drilling and grinding machines. (08hrs)	Lubrication and its importance, lubricating systems Concept of lubrication Types and properties of Oil and Grease. Methods of oil lubricationOnce through and centralized lubrication system. (05 hrs) Methods of grease lubrication system- grease guns, centralized lubrication system. Warning & protective devices used in centralized lubrication system (Pressure switch, temperature gauge, level indicator and relief valve.)

			Lubrication fittings. Storage and handling, Contamination control, Leakage prevention- Shaft seals, sealing devices and "O" rings. (05 hrs)
		101 Identification of components of coolant system. (5hrs) 102 Preventive maintenance of coolanT system. (10hrs) 103.Breakdown maintenance of coolan Tsystem. (10hrs)	Cutting Fluids and Coolants. Essential parts of a basic coolant system used in the cutting of metals. Various types of coolants, its properties and uses ,coolantsystem type-soluble oils-soaps, sudsparaffin,soda water etc.Cutting Fluids and Coolants. Essential parts of a basic coolant system used in the cutting of metals. Various types of coolants, its properties and uses ,coolantsystem type-soluble oils-soaps, sudsparaffin,soda water etc. Effect of cutting fluids in metal cutting. Difference between coolant and lubricants. (05 hrs) Effect of cutting fluids in metal cutting. Difference between coolant and lubricants. (05 hrs)
Professional Skill 85Hrs; Professional Knowledge 16Hrs	Prepare machine foundation for erection, install different machines and carry out geometrical tests. [Different machines – shaper, pedestal grinding] (Mapped **NOS: CSC/N0304)**	104.Marking location, grouting and installation of foundation bolts. (10hrs) 105. Erection and installation of a small machine like shaper/ pedestal grinder machine. (10hrs)	MACHINE FOUNDATION Purpose & methods employed for installation & erection of precision &heavy duty machines. Location & excavation for foundation. Different types of foundations – structural, reinforced, wooden, isolated foundations. (04 hrs)
		106. Levelling of small machine like shaper. (10hrs) 107.Levelling of a lathe & milling machines. (10hrs) 108.Alignment of shaft with the help of feeler gauge & dial test indicator & taper gauges. (5hrs) 109.Alignment of pulley & sprocket with straight edge & thread. (5hrs) 110.Geometrical alignment test of machine as per test chart. (10hrs)	Foundation bolt: types (rag, Lewis cotter bolt) description of each erection tools, pulley block, crow bar, spirit level, Plumb bob, wire rope, manila rope, wooden block. The use of lifting appliances, extractor presses and their use. Practical method of obtaining mechanical advantage. The slings and handling of heavy machinery, special precautions in the removal and replacement of heavy parts. Energy usage in relevance for Mechanical assembly. (04 hrs)

		111.Dismantling, checking and assembly of various parts of drilling machine such as Motor, spindle head, gear box & arm. (10hrs) 112.Measure Current, Voltage and Resistance using Simple Ohm`s Law Circui And Familiarizing Multimeter. (3hrs) 113. Soldering Techniques. (3hrs) 114. Step up and step down transformers. (3hrs) 115.Working with Solenoids and Relays. (3hrs)	Maintenance - Total productive maintenance - Autonomous maintenance - Routine maintenance - Maintenance schedule - Retrieval of data from machine manuals Geometrical tests and inspection method with instruments. Preventive maintenanceobjective and function of Preventive maintenance, section inspection. Visual and detailed, lubrication survey, system of symbol and colour coding. Revision, simple estimation of materials, use of handbooks and reference table. Possible causes for assembly failures and remedies. Hazardous waste management. **Basic Electrical:** Study of basic ElectricalsVoltage – Current etc. Working Of Solenoids, Inductors, Motors, Generator Based On Electromagnetic Induction Principle. (08hrs)
Professional Skill 20Hrs; Professional Knowledge 05Hrs	Conduct preventive maintenance, perform dismantling & assembly of different components and test for accuracy to carryout advance lathe operation. [Different components- head stock apron, saddle, tool post tail stock; Different dvance lathe operation – taper turning, thread cutting] (Mapped NOS: NOS:CSC/N0901)	116.Working of Motor& Generators. (3hrs) 117.Perform taper turning in the lathe by different methods. (04hrs) 118.Perform external thread cutting operation on the lathe machine. (04hrs) 119.Dismantling and assembly of head stock apron, saddle, tool post tail stock, Removing Broken Studs / Bolts of lathe machine. (08hrs) 120.Accuracy checking of lathe machine after assembly. (2hrs) 121.Perform preventiv maintenance of lathe machine. (2hrs)	Safely precautions to be observed while working on a lathe, Lathe specifications, and constructional features. Lathe main parts descriptions- bed, head stock, carriage, tail stock, feeding and thread cutting mechanisms. Holding of job between centers, works with catch plate, dog, simple description of a facing and roughing tool and their applications. (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

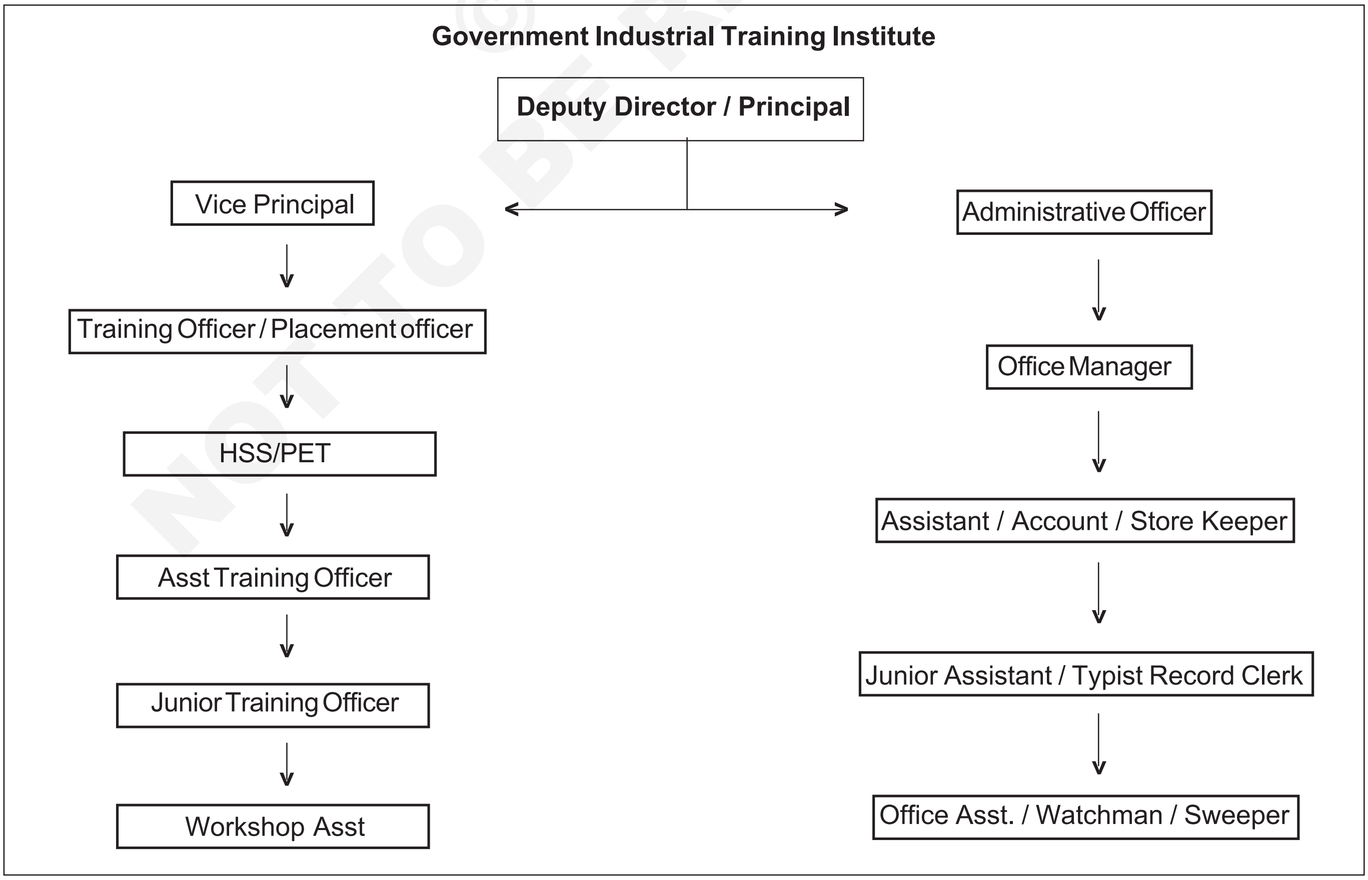
The objective of an ITI is to ensuring a steady flow of skilled workers and to reduce unemployment among the educated youth by training & equipping for suitable industrial employment and as well as for self employment.

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. 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, Fitter, 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 are 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.

Common Soft Skills

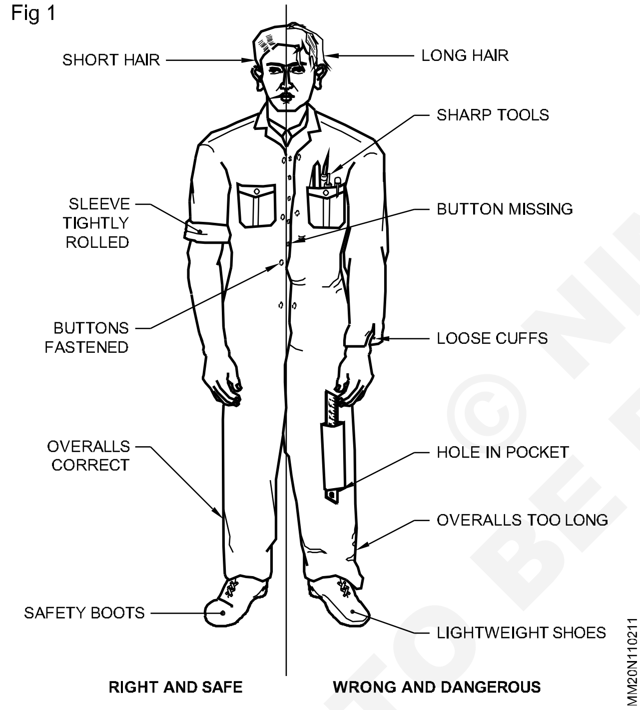
- Strong work ethic
- Positive attitude
- Good communication skills
- Interpersonal skills
- Time management abilities
- Problem-solving skills
- Team work
- Initiative, Motivation
- Self-confidence
- Loyalty
- Ability to accept and learn from criticism
- Flexibility, Adaptability
- Working well under pressure

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.

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.

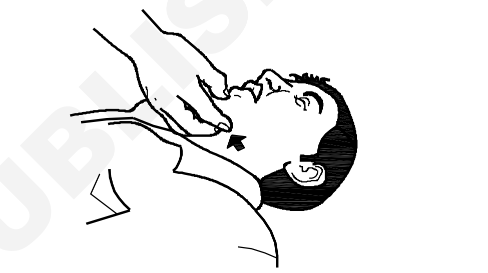
Call emergency services: Call for help or tell someone else to call for help as soon as possible. If alone in at the accident scene, try to establish breathing before calling for help, and do not leave the victim alone unattended.

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 jeweler 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 (Cerebra-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

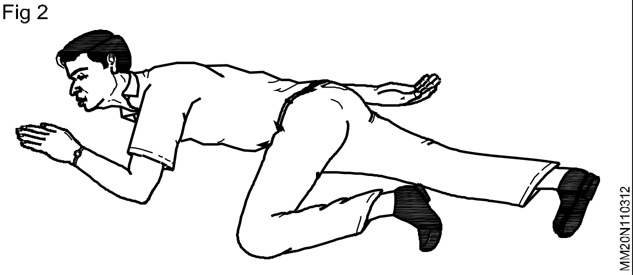
- Do not give an unconscious person any food or drink.
- Do not leave the person alone.
- Do not place a pillow under the head of an unconscious person.
- Do not slap an unconscious person's face or splash water on the face to try to revive him.

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 (Fig 2)

- **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

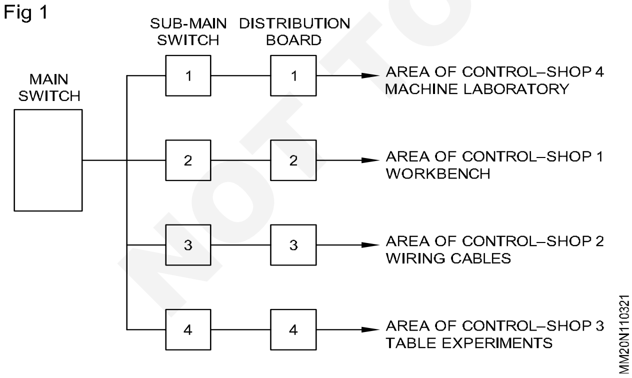
Objectives : At the end of this lesson you shall be able to
- **explain the term 'emergency'**
- **explain the need to switch off the circuit during emergency**
- **explain the method of locating the area sub-main and switches in the shop floor**
- **explain the position of handle with respect to ON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

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

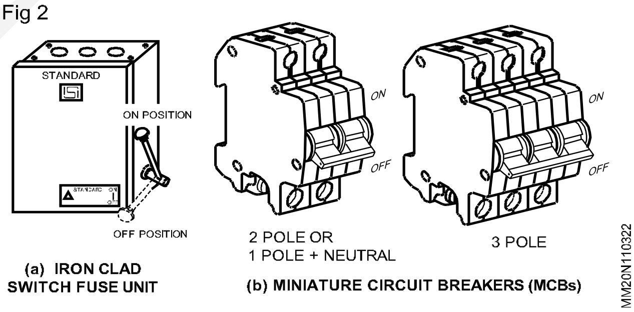
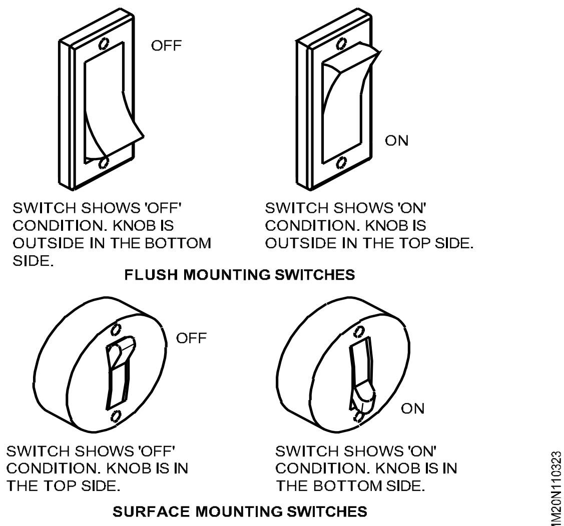


Fig 3



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. Unsafe working 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 firm 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 earthing 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.

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.

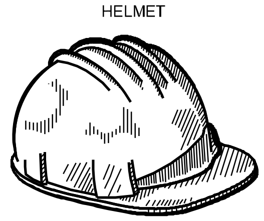
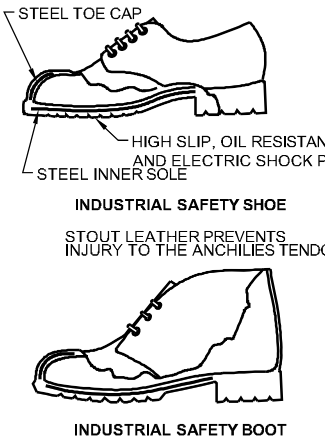
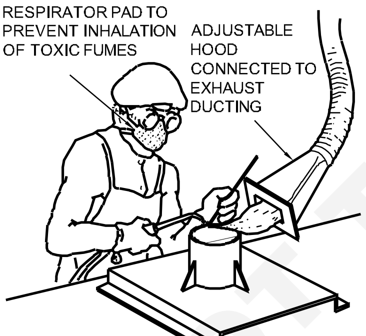
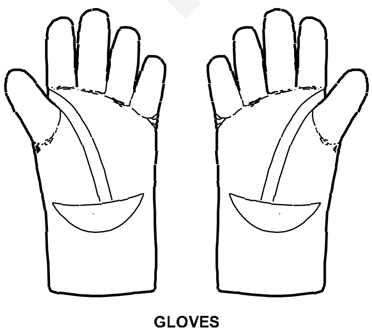
They are to meet the applicable BIS (Bureau of Indian Standards) standards for different types of PPE.

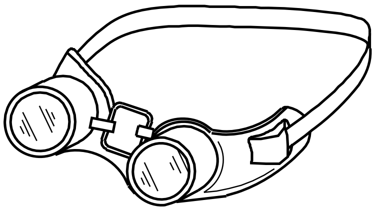
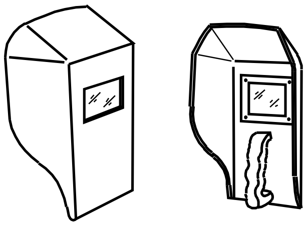
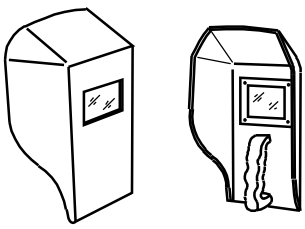
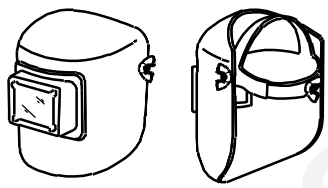
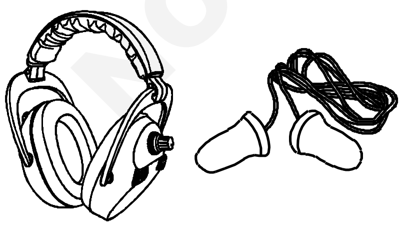
The guidelines on 'Personal Protective Equipment' is issued to facilitate the plant management in maintaining an effective program with respect to protection of persons against hazards, which cannot be eliminated or controlled by engineering methods listed in table 1.

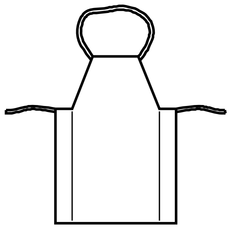
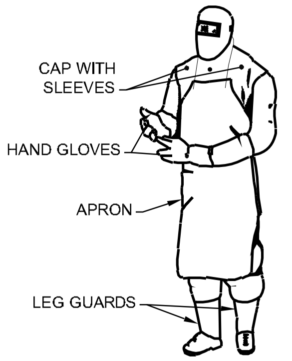
Table 1

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 and their uses and hazards are listed in Table 2

Types of protection	Hazards	PPE to be used
Head protection (Fig 1) 	1. Falling objects 2. Striking against objects 3. Spatter	Helmets
Foot protection (Fig 2) 	1. Hot spatter 2. Falling objects 3. Working wet area	Leather leg guards Safety shoes Gum boots
Nose (Fig 3) 	1. Dust particles 2. Fumes/gases/ vapours	Nose mask
Hand Protecion (Fig 4) 	1. Heat burn due to direct contact 2. Blows spark moderate heat 3. Electric shock	Hand gloves

Types of protection	Hazards	PPE to be used
Eye protection (Fig 5 & Fig6)   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 6 &Fig 7)  HAND SCREEN  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
Ear protection (Fig 7) EAR MUFFS EAR PLUG 	1. High noise level	Ear plug Ear muff

Types of protection	Hazards	PPE to be used
Body protection (Fig 8, & Fig 9)  APRON LEATHER APRONS  	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
- Easy 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.

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 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 managements 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, sward from respective containers regularly
- **Tools Storage-** Use special racks, holders for respective tools
- **Storage Spaces:** Identify 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

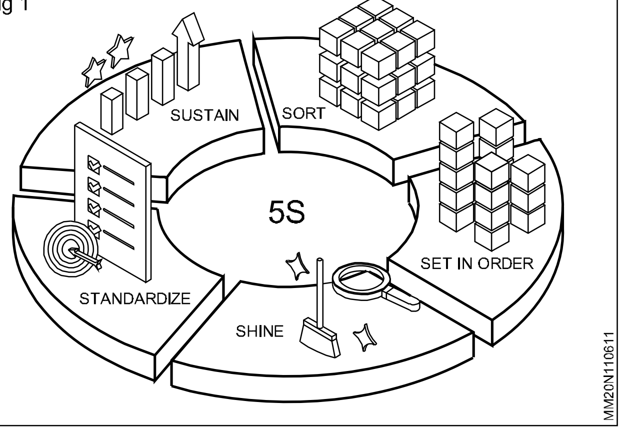
5S is a philosophy and a way of organizing and managing the workspace and work flow with the intent to improve efficiency by eliminating waste, improving flow and reducing process unreasonableness. There are five steps in the system, each starting with the letter S:

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



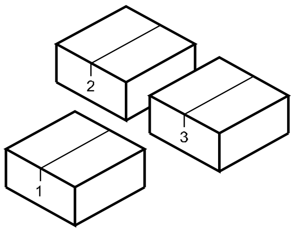
Explanation of 5S techniques are listed in Table

Step Name	Japanese term	Explanation
1	Sort Seri (tidiness)	Remove unnecessary items from each area
2	Set In Order	Seiton (orderliness) Organize and identify storage for efficient use
3	Shine Seiko (cleanliness)	Clean and inspect each area regularly
4	Standardize	Seiketsu (standardization) Incorporate 5S into standard operating procedures
5	Sustain Shinseki (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)

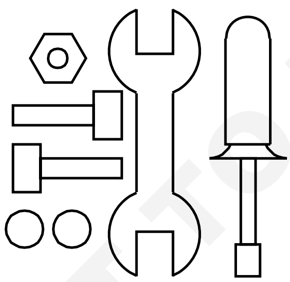
Fig 2



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



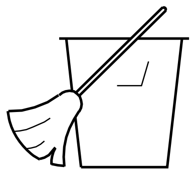
Implementation steps of Set in order

- 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)

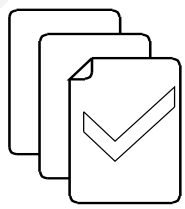
Fig 4



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



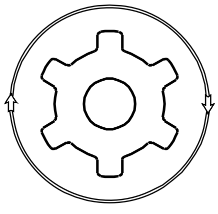
Tools for Standardizing

- 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



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

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.

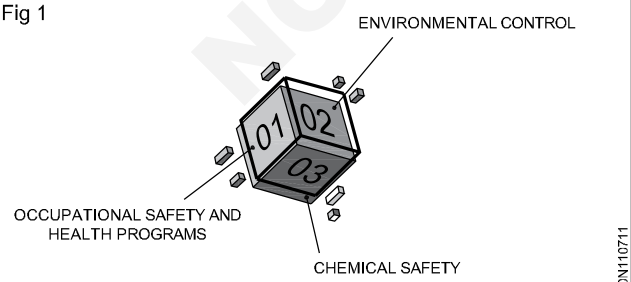
Environmental safety

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

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.

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 equipment.**

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.

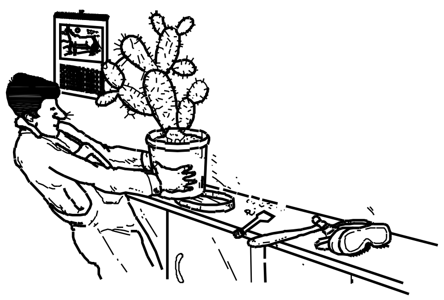
Types of injuries and how to prevent them?

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



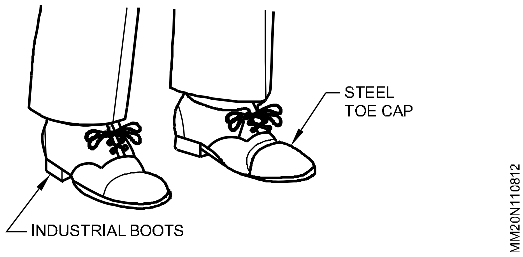
MM20N110811

Crushing of feet or hands

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

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

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.

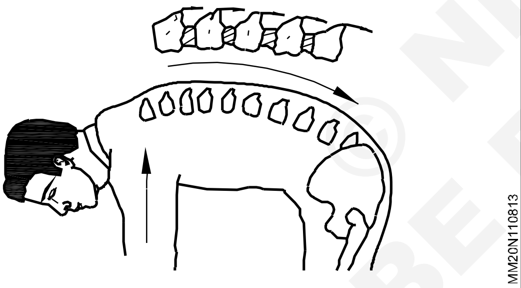
Sudden and awkward movements such as twisting or jerking during a lift can put severe strain on muscles.

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.

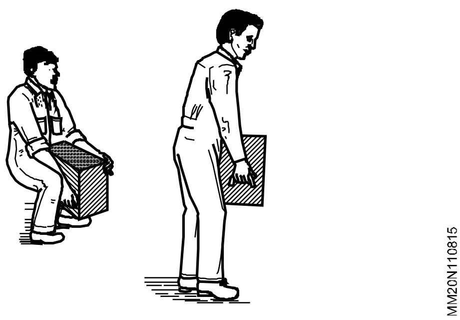
Correct manual lifting techniques

- 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 straightened and held as near the vertical position as possible. (Fig4)

Fig 4

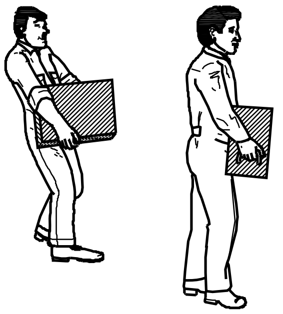
- To raise the load, first straighten the legs. This ensures that the lifting strain is being correctly transmitted and is being taken by the powerful thigh muscles and bones.
- Look directly ahead, not down at the load while straightening up, and keep the back straight, this will ensure a smooth, natural 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



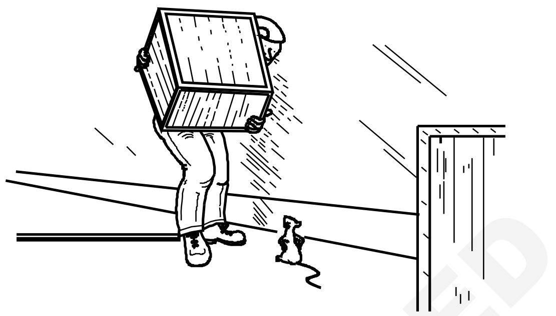
Keeping the load well near to the body, carry it to the place where it is to be set down. When turning, avoid twisting from the waist- turn the whole body in one movement.

Lowering the load

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

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

Fig 7



Linear measurement

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

Length - SI UNITS and MULTIPLES

Base unit

The base unit of length as per the Systems International is meter. The table given below lists some multiples of a meter.

METRE(m) = 1000 mm

CENTIMETRE (cm) = 10 mm

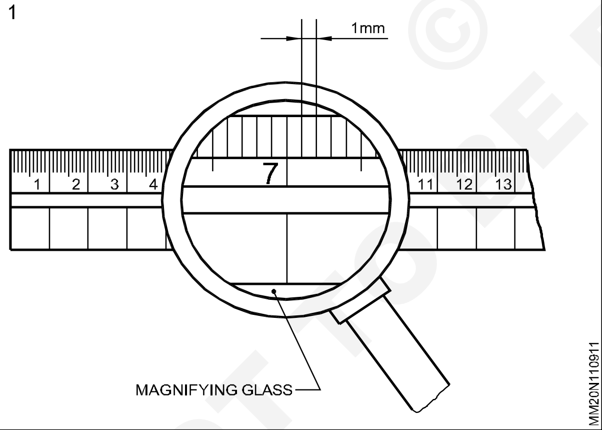
MILLIMETRE (mm) = 1000μ

MICROMETRE (μm) = 0.001 mm

Measurement in engineering practice

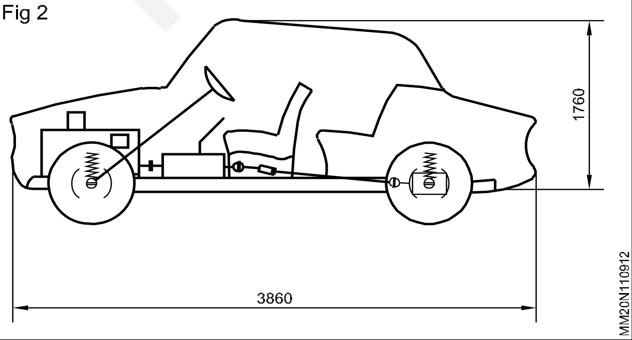
Usually, in engineering practice, the preferred unit of length measurement is millimetre. (Fig 1)

Fig 1



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

Fig 2

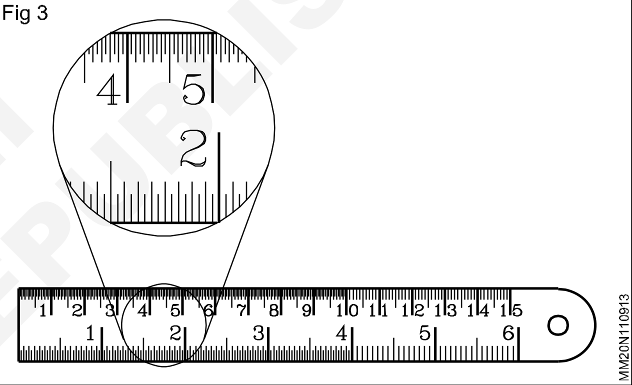


The British system of length measurement

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.

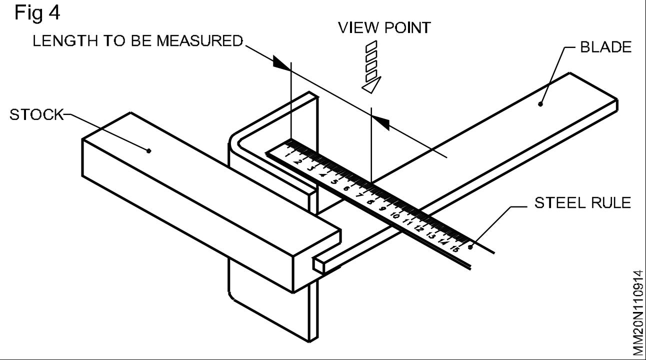
Fig 3



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.

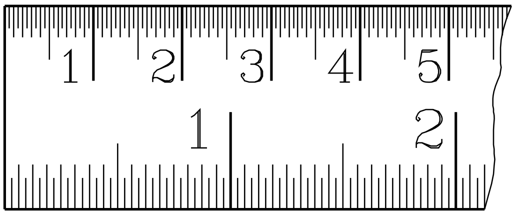
For accurate reading it is necessary to read directly to avoid errors arising out of parallax. (Fig 4)

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



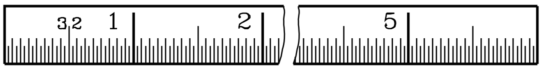
Other types of rule

- narrow steel rules
- short steel rules
- full flexible steel rule with tapered end.

Narrow steel rule

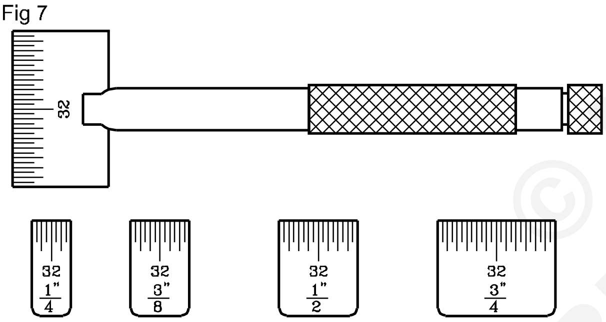
Narrow steel rule is used to measure the depth of key-ways and depth of smaller dia, blind holes of jobs, where the ordinary steel rule can not reach. Its width is approximately 5 mm and thickness 2 mm. (Fig 6)

Fig 6



Short steel rule (Fig 7)

Fig 7



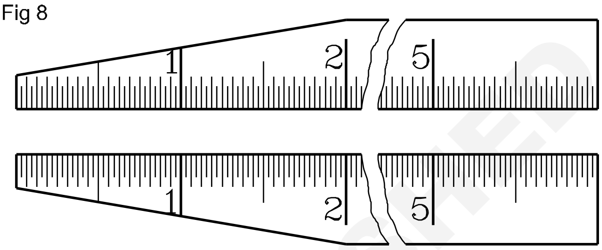
This set of five small rules together with a holder is extremely useful for measurements in confined or hard to reach locations which prevent the use of ordinary steel rules. It is used suitably for measuring grooves, short shoulder, recesses, key ways etc. in machining operation on shapers, millers 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", 1/2", 3/4" and 1" and each rule is graduated in 32[nds] 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

Fig 8



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)

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

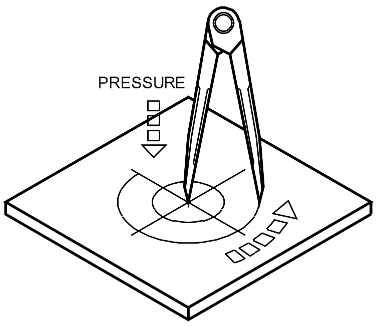
Measurement of length				
Metric			**British**	
Micron	1µ	= 0.001 mm	Thousand[th] of an inch	= 0.001"
Millimetre	1 mm	= 1000µ	Inch	= 1"
Centimetre 1 cm		= 10 mm	Foot 1 ft	= 12"
Decimeter 1 dm		= 10 cm	Yard 1yd	= 3 ft
Metre 1 m		= 10 dm	1 furlong 1 fur	= 220 yds
Decametre 1 dam		= 10 metre	1 mile	= 8 fur

Dividers

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

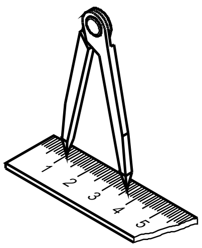
Dividers are used for scribing circles, arcs and for transferring and stepping off distances. (Fig 1,2 and 3)

Fig 1



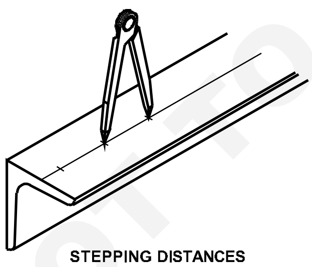
SCRIBING CIRCLES

Fig 2



SETTING MEASUREMENT

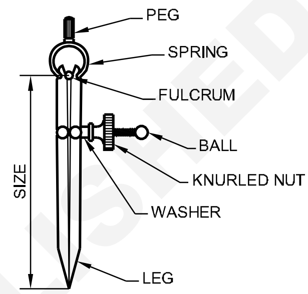
Fig 3



STEPPING DISTANCES

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 4



SPRING JOINT DIVIDER

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

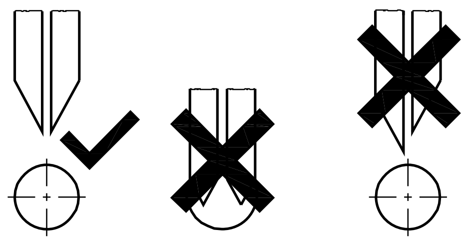
The distance from the point to the centre of the fulcrum roller (pivot) is the size of the divider. (Fig 4)

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

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

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

Fig 5



Calipers

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

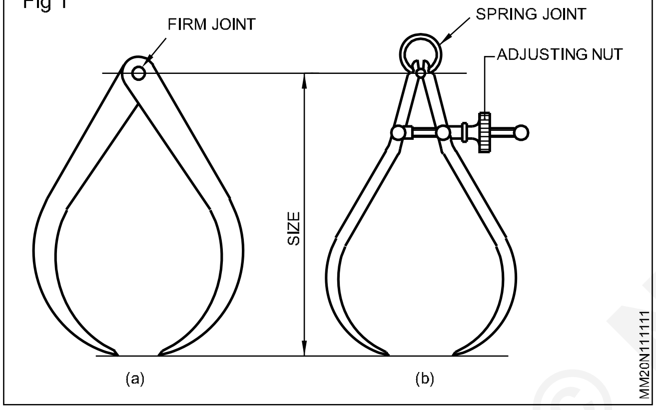
Calipers are indirect measuring instruments used for transferring measurements from a steel rule to a job, and vice versa.

Calipers are classified according to their joints and their legs.

Joint

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

Fig 1



Legs

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

Fig 2

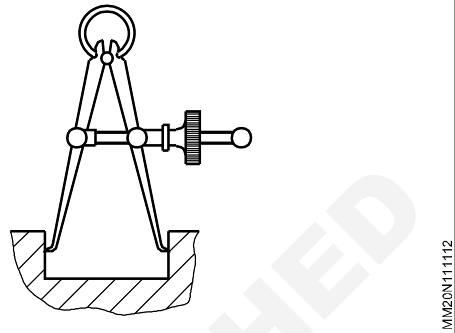
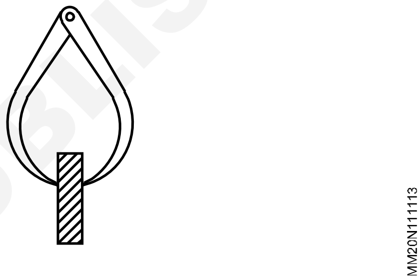


Fig 3



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.

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.

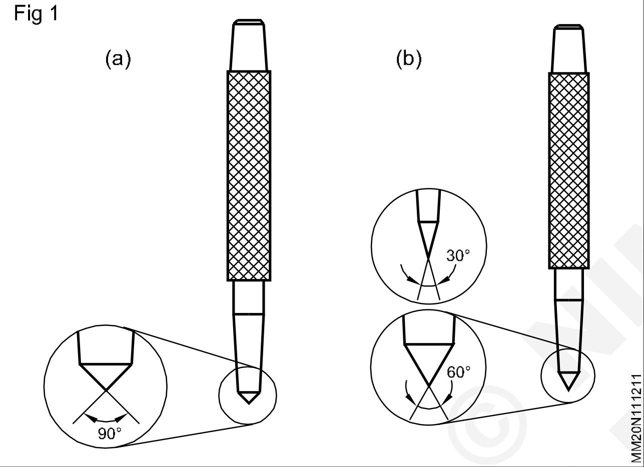
Types of marking punches

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

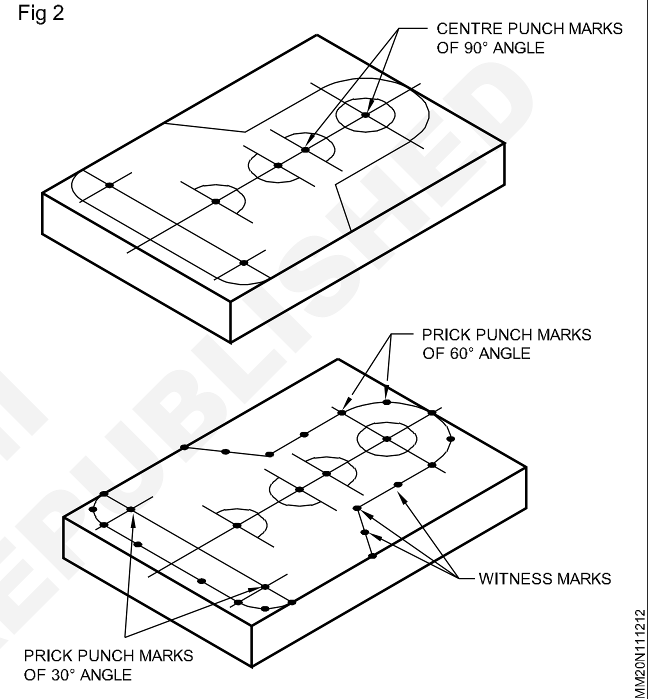
Fig 1



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.(Fig 1)

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 the 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.

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

– ball pein (Fig.2a)

– cross-pein (Fig.2b)

– straight pein. (Fig 2c)

Fig 1

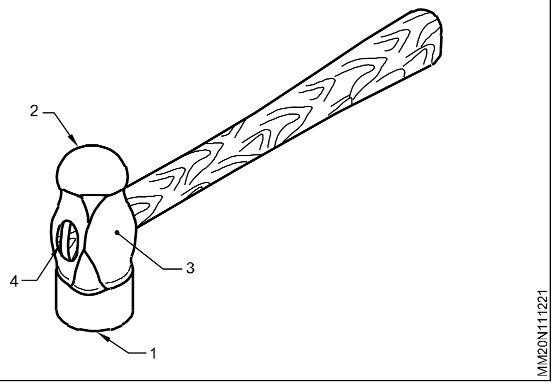
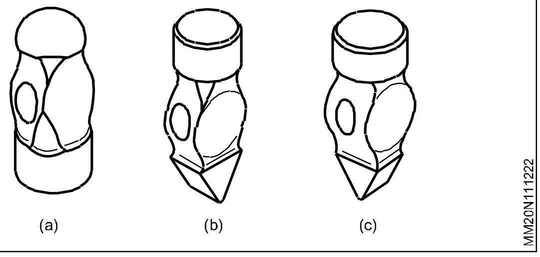


Fig 2



The face and the pein are case hardened.

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

This portion of the hammer-head is left soft.

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

Fig 3

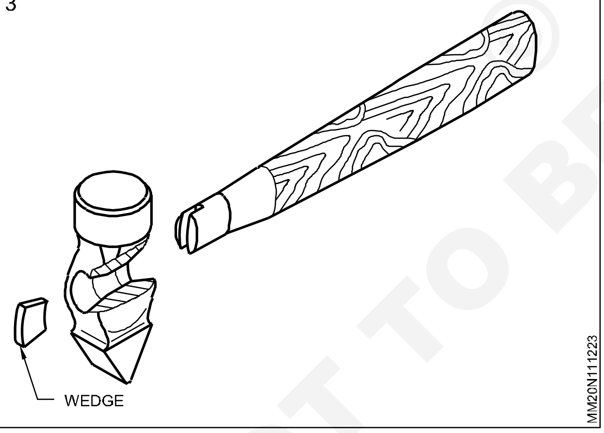
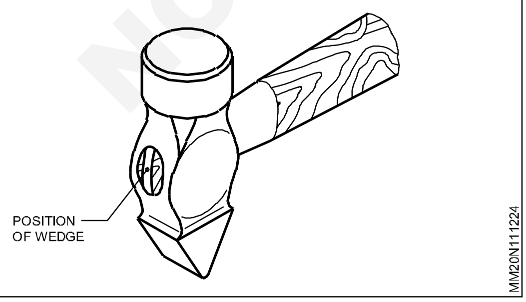


Fig 4



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

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

Fig 5

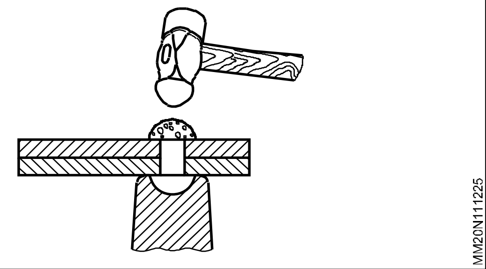
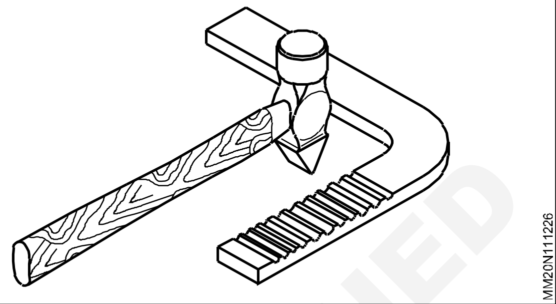
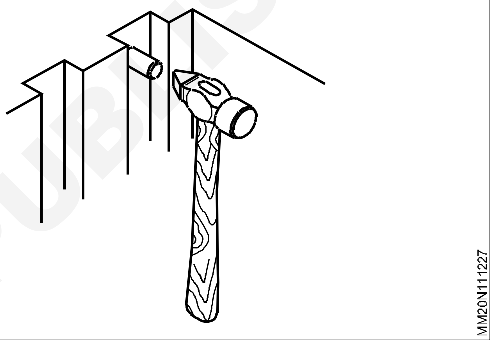


Fig 6



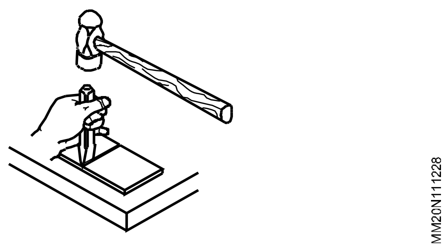
The straight pein is used at the corners. (Fig 7)

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 purposes, is 250 gms.

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**
- **write the uses of marking tables**
- **state the maintenance aspects concerning marking tables.**

Marking off

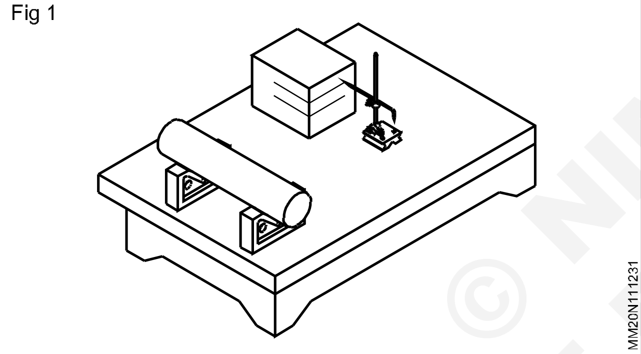
Marking off or layout is carried out to indicate the locations of operation to be done, and provide guidance during rough machining or filing.

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)

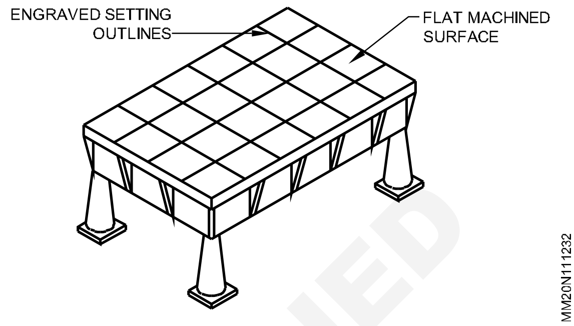
Fig 1



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

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

Fig 2



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.

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.

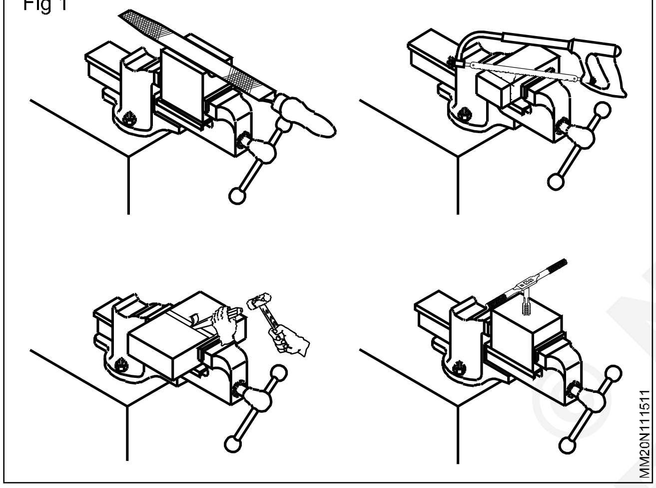
Bench vice

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

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 work for filing, sawing, threading and other hand operations. (Fig 1)

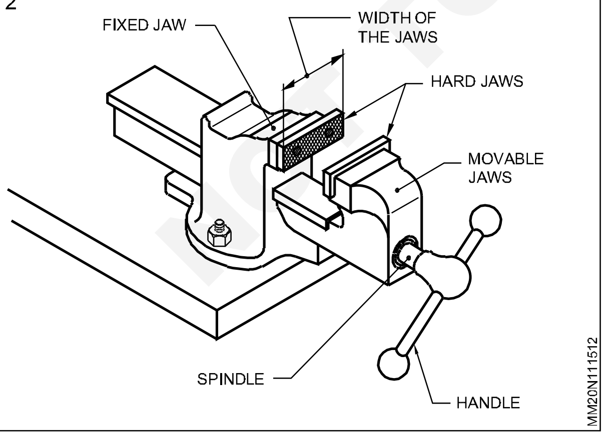
Fig 1



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

Parts of a bench vice (Fig 2)

Fig 2



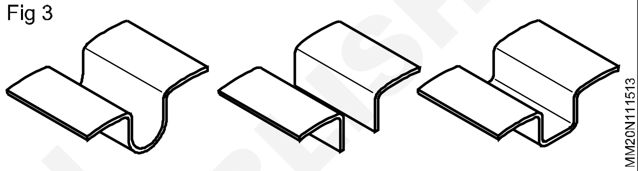
The following are the parts of a vice.

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 3)

Fig 3



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

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

Care and maintenance of vices

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

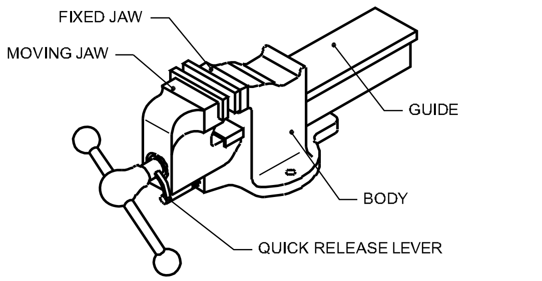
Types of vices

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

There are different types of vices used for holding workpieces. 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.

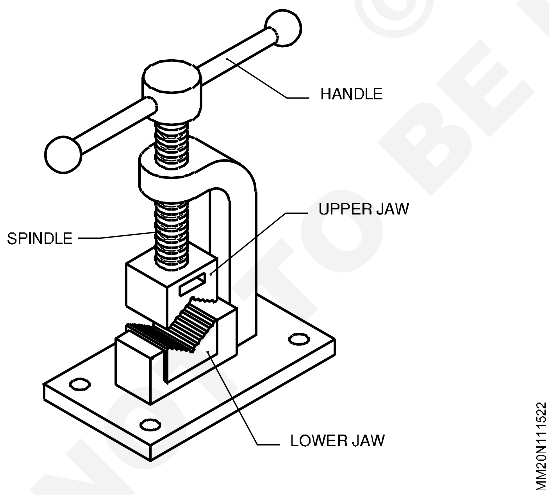
Fig 1



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.

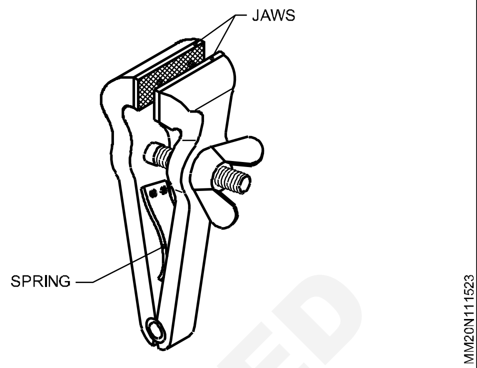
The pipe vice grips the work at four points on its surface. The parts of a pipe vice are shown in Fig 2.

Fig 2



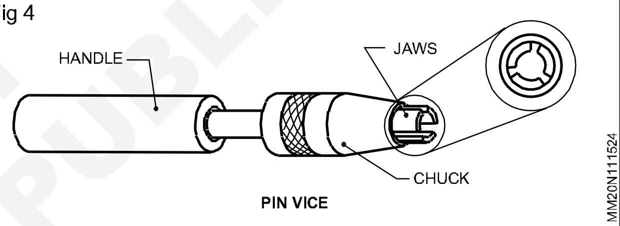
Hand vice (Fig 3)**:** Hand vices are used for gripping screws, rivets, keys, small drills and other similar objects which are too small to be conveniently held in the bench vice. A hand vice is made in various shapes and sizes. The length varies from 125 to 150 mm and the jaw width from 40 to 44 mm. 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 3



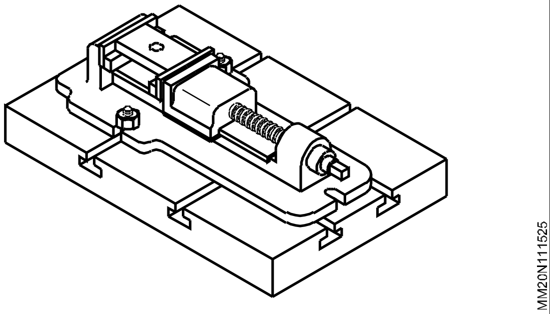
Pin vice (Fig 4)**:** The pin vice is used for holding small diameter jobs. It consists of a handle and a small collet chuck at one end. The chuck carries a set of jaws which are operated by turning the handle.

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.

Fig 5



Toolmaker's vice is accurately machined.

Leg vice

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

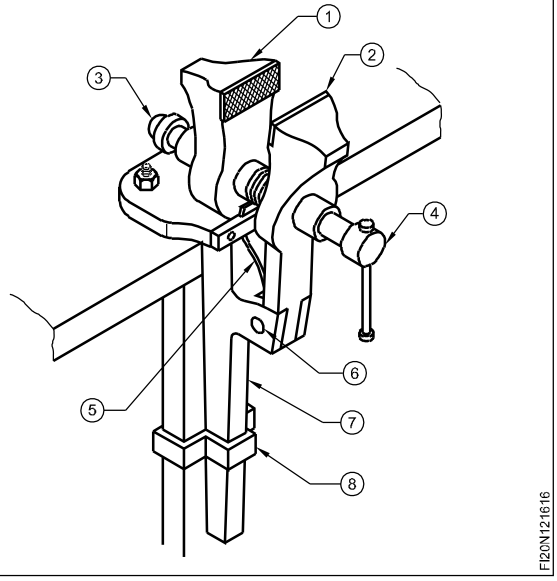
Main pats of a leg vice (Fig 6**)**

The following are the main parts of a leg vice.

1 Solid jaw
2 Movable jaw
3 Threaded jaw

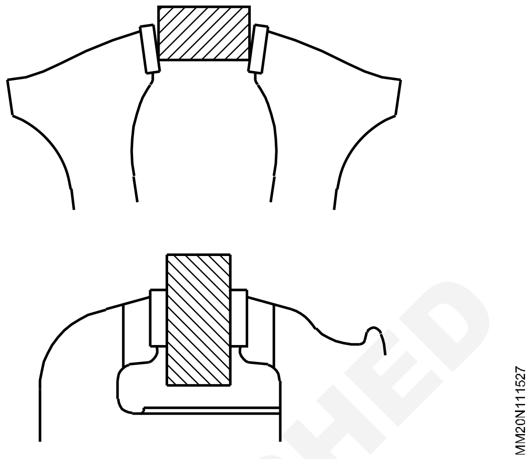
4 Spindle
5 Spring
6 Pivot
7 Leg
8 Clamp

Fig 6



Since the hinged jaw moves in a radial path, the job held in this vice in 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
- **name the different types of hacksaw frames**
- **specify hacksaw blades**
- **name the different types 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 10" - 12"

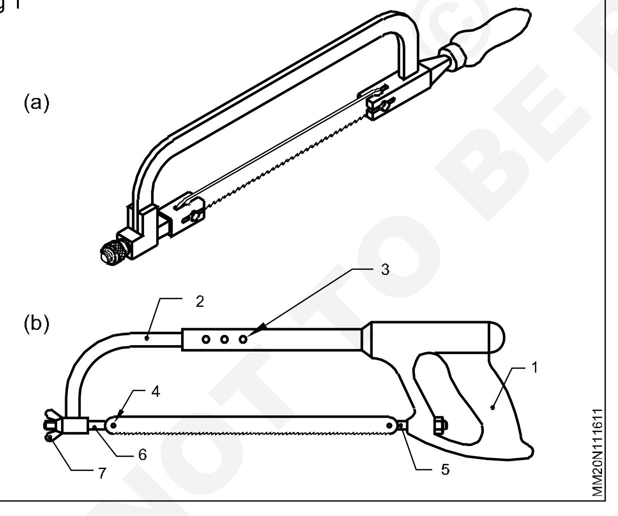
Types of hacksaw frames

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

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

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

Fig 1



Parts of a hacksaw frame

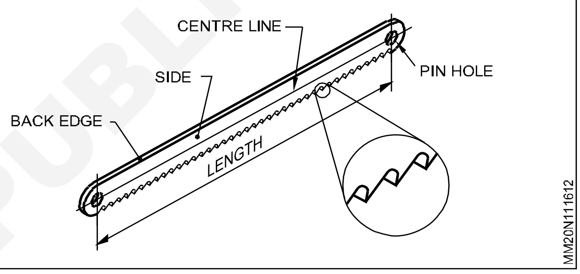
1 Handle
2 Frame
3 Tubular frame with holes for length adjustment
4 Retaining pins
5 Fixed blade-holder
6 Adjustable blade-holder
7 Wing-nut

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

Parts of a hacksaw blade (Fig 2)

1 Back edge
2 Side
3 Centre line
4 Pin holes

Fig 2



Type of hacksaw blades

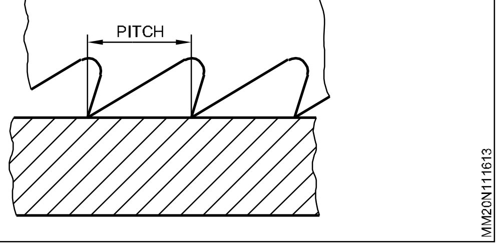
All-hard blade: The full length of the blade between the pins is hardened and it is used for harder metals such as tool steel, die steel and HCS.

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)

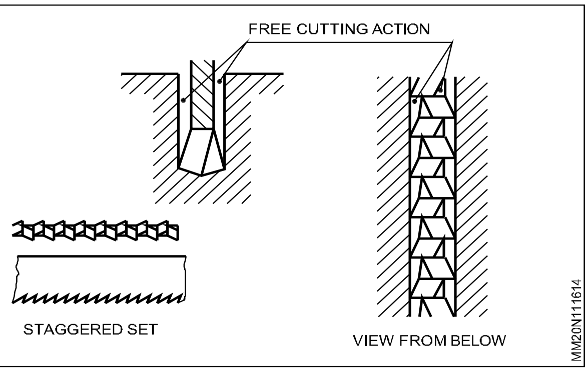
Example

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.

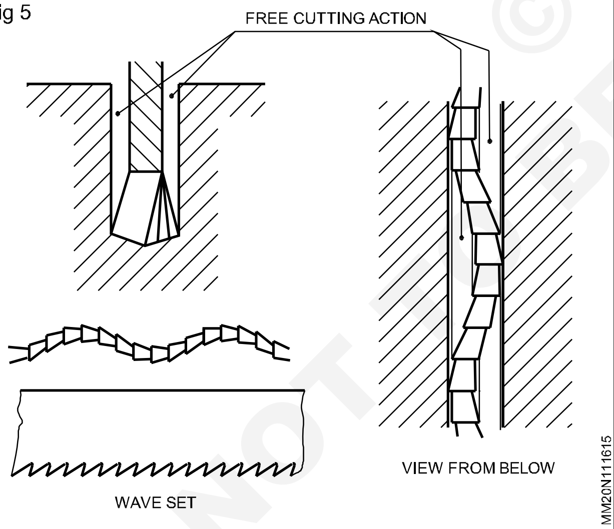
Staggered set (Fig 4)**:** Alternate teeth or groups of teeth are staggered. This arrangement helps for free cutting, and provides for good chip clearance.

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:

Fig 5



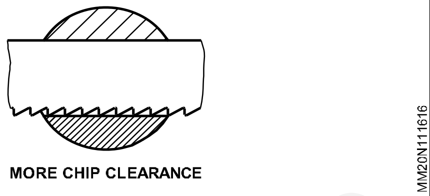
Pitch	Type of set
0.8 mm	Wave-set
1.0 mm	Wave-set or staggered
Over 1.0 mm	Staggered

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

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

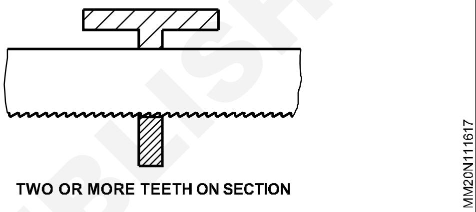
Pitch selection (Fig 6)**:** For soft materials such as bronze, brass, soft steel, cast iron, heavy angles etc. use a 1.8 mm pitch blade.

Fig 6



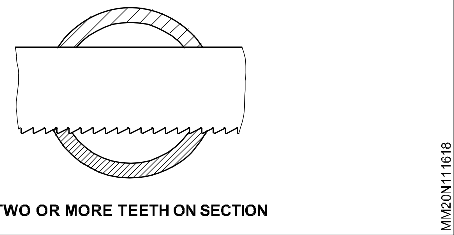
For tool steel, high carbon, high speed steel etc. use a 1.4 mm pitch. For angle iron, brass tubing, copper, iron pipe etc. use a 1 mm pitch blade. (Fig 7)

Fig 7



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

Fig 8



Method of sawing

Select the correct blade for the material to be cut.

HSS - Blades are used for tough resistant materials

High Carbon Steel - General cutting

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

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

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

Files

Objectives: At the end of this lesson you shall be able to
- **describe elements of files**
- **state the specifications and types of files and care and maintenance**
- **describe the measuring standards are angular measurements.**

Methods of material cutting: The three methods of metal cutting are abrasion (Fig.1), fusion (Fig 2) and incision (Fig 3)

Filling is a method for removing excess material from a workpiece by using a file which acts as a cutting tool. Figure 4 shows how to hold a file. Files are available in many shapes and sizes.

Fig 1

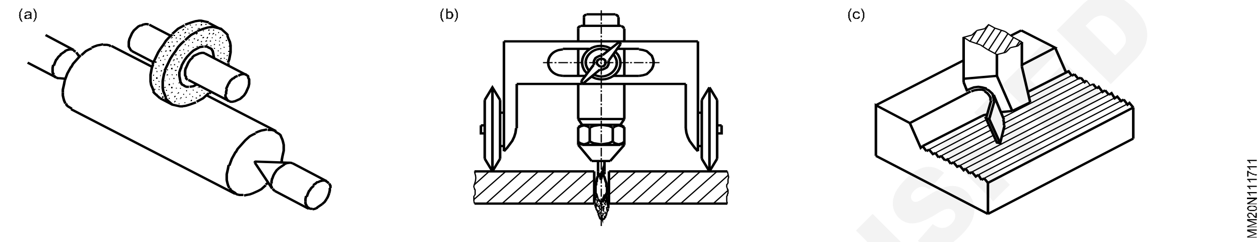
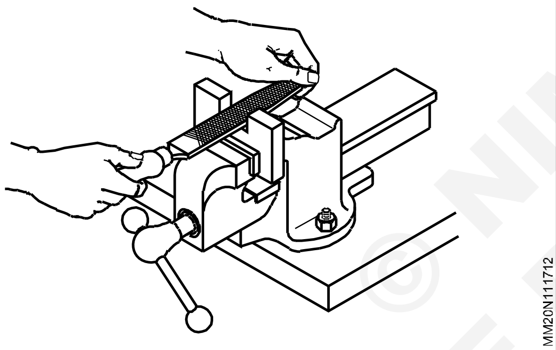


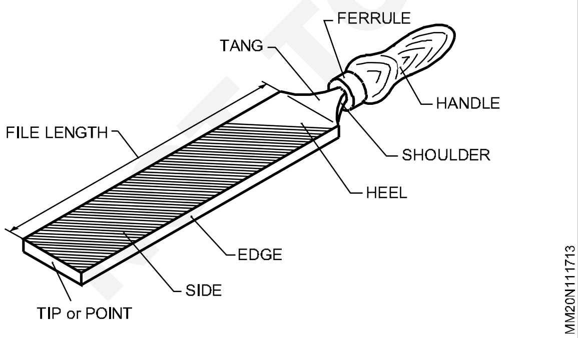
Fig 2



Parts of a file (Fig 3)

The parts of a file can be seen in figure 3, are

Fig 3



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.

Cut of files

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

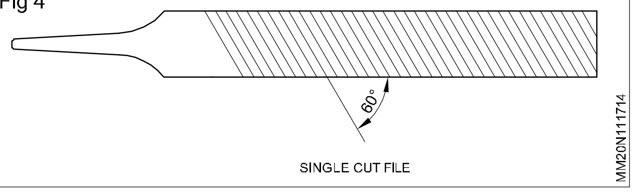
Basically there are four types.

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

Single cut file (Fig 4)

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 4

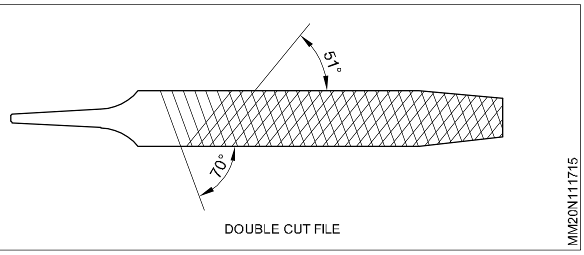


Single cut files do not remove stock as fast double cut files, but the surface finish obtained is much smoother.

Double cut file (Fig 5)

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.

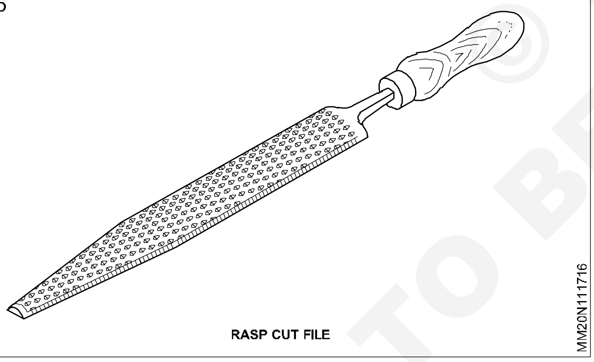
Fig 5



Rasp cut file (Fig 6)

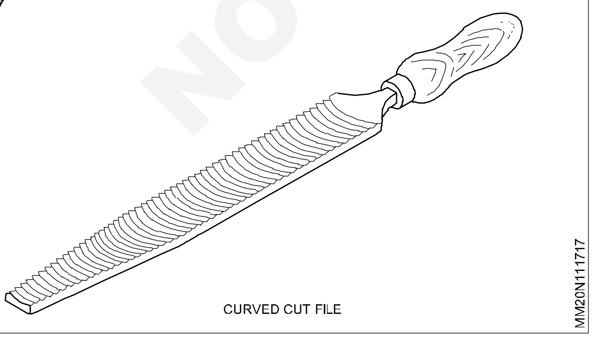
The rasp cut has individual, sharp, pointed teeth in a line, and is useful for filing wood, leather and other soft materials. These files are available only in half round shape.

Fig 6



Curved cut file (Fig 7)

Fig 7



These files have deeper cutting action and are useful for filing soft materials like - aluminium, tin, copper, and plastic.

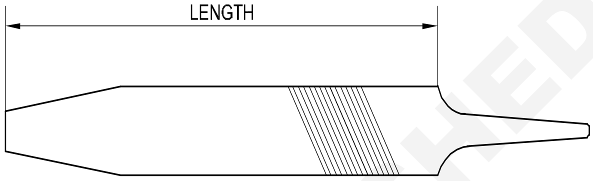
The curved cut files are available only in a flat shape.

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

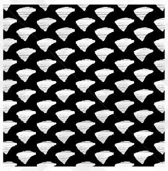
Files are manufactured in different types and grades to meet the various needs.

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

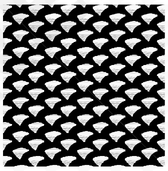
Length is the distance from the tip of a file to the heel.



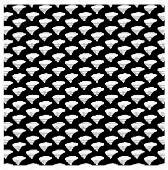
File grades are determined by the spacing of the teeth.



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.

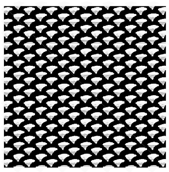


A **bastard file** is used in cases where there is a heavy reduction of material

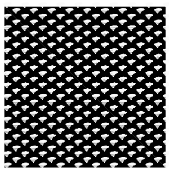


A **second cut file** is used to give a good finish on metals. It is excellent to file hard metals. It is useful for bringing the jobs close to the finishing size.

It may also be observed that the number of cutting edges in rows of a file changes according to the Length of a file.



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 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

Types of files

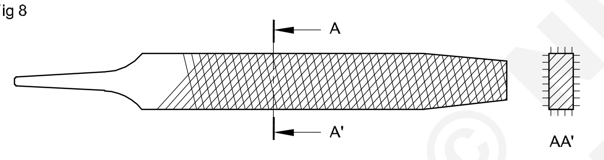
For filing and finishing different profiles, files of different shapes are used

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 8)

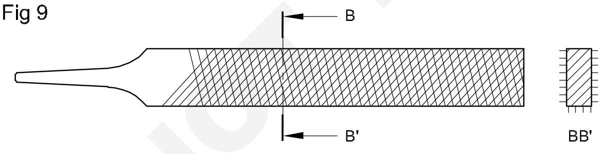
Fig 8



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

Hand file (Fig 9)

Fig 9

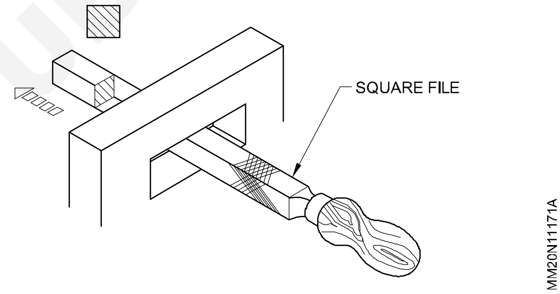


These files are similar to the flat files in their cross section. The edges along the width are parallel throughout the length. The faces are double cut. One edge is single cut whereas the other is safe edge. Because of the safe edge, they are useful for filing surfaces which are at right angles to surfaces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

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

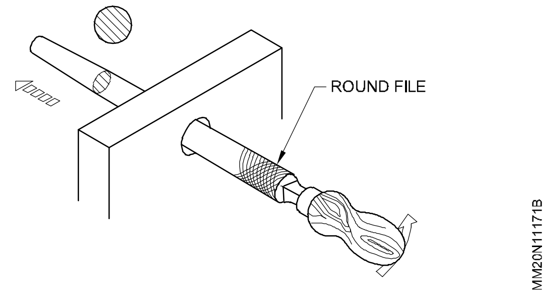
Square File: The square file is square in its cross section. It is used for filing square holes, internal square corners, rectangular openings, keyways and splines. (Fig 10)

Fig 10



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 11)

Fig 11



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 12)

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° (Fig 13)

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

Fig 12

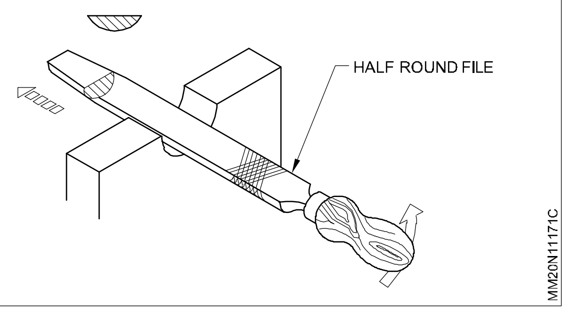
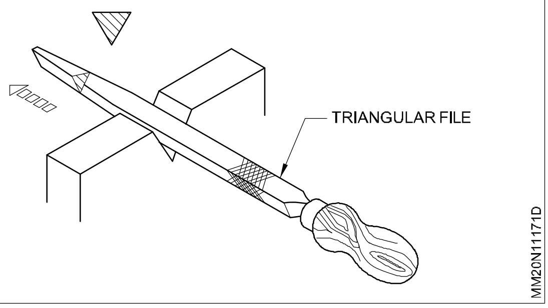


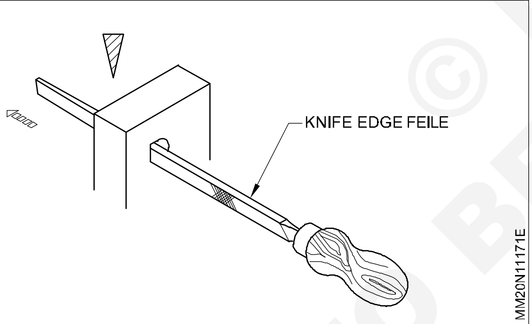
Fig 13



Triangular file: A triangular file is of a triangular cross section. It is used for filing corners and angles which are more than 60°. (Fig 14)

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 14



Pinning of files

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

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

Pinning of the files is removed by using a file brush also called a file card, (Fig 15) with either forward or backward stroke.

Filings which do not come out easily by the file card should be taken out with a brass or copper strip. (Fig 16)

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

Fig 15

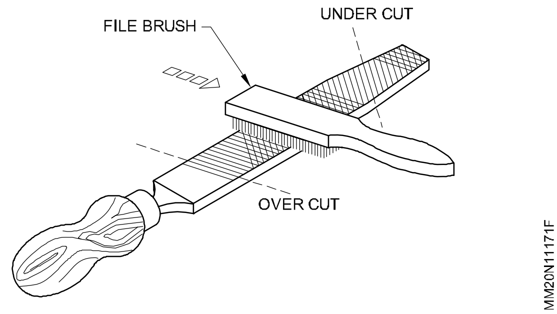
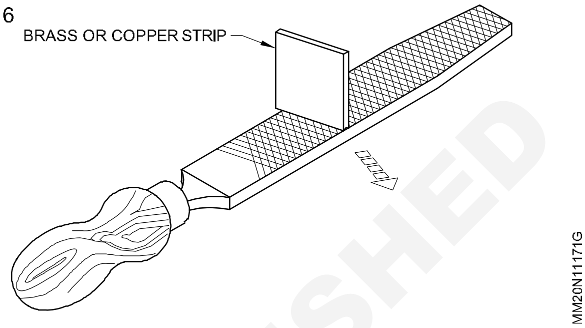


Fig 16



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

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

Care and maintenance

- 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)

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 classification.

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.

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

Table - 1

Basic Quantity	Metric Unit		British units	
	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	Farenheit	F°
Light intensity	Candela	Cd	Candela	Cd

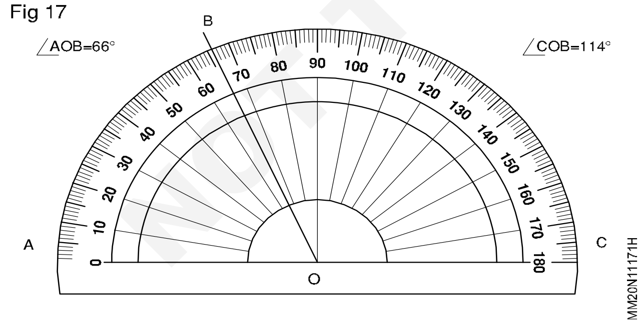
Fundamental units and derived units are the two classification of units.

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

Measurement of angles

The unit of an angle: For angular measurements a complete circle is divided into 360 equal parts. Each division is called a degree. (A half circle will have 180°) (Fig 17)

Fig 17



Subdivisions of an angle: For more precise angular measurements, one degree is further divided into 60 equal parts. This division is one MINUTE (‘). The minute is used to represent a fractional part of a degree and is written as 30° 15’.

One minute is further divided into smaller units known as seconds (“). There are 60 seconds in a minute.

An angular measurement written in degrees, minutes and seconds would read as 30° 15' 20".

Examples for angular divisions

1 complete circle 360°
1/2 circle 180°
1/4 of a circle 90°
(right angle)

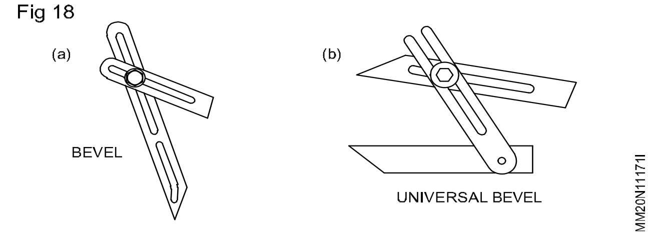
Sub divisions 1 degree or 1° = 60 mts or 60'
1 min or 1' = 60 secs or 60"

Angular measuring instruments (Semi-precision)

The most common instruments used to check angles are the:

bevel or bevel gauge (Fig 18a)
universal bevel gauge (Fig 18b)
bevel protractor. (Fig 19)

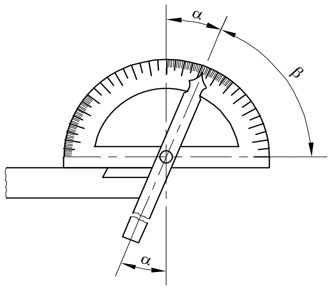
Fig 18



Bevel gauges : The bevel gauges cannot measure angles directly. They are, therefore, indirect angular measuring instruments. The angles can be set and measured with bevel protractors.

Bevel protractor (Fig 19)**:** The bevel protractor is a direct angular measuring instrument, and has graduation marked from 0° to 180°. Angles can be measured within an accuracy of 1° using this instrument. (Fig 19)

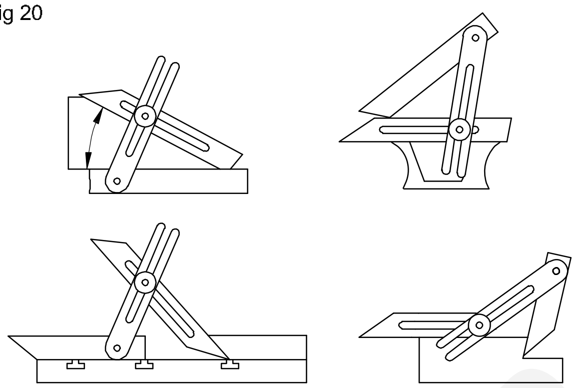
Fig 19



BEVEL PROTRACTOR

Universal bevel gauges : The universal bevel gauge has an additional blade. This helps in measuring angles which cannot be checked with an ordinary bevel gauge. (Fig 20)

Fig 20



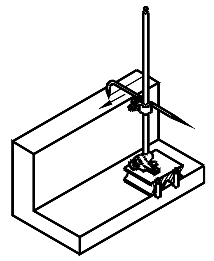
Marking tools

Objectives: At the end of this lesson you shall be able to
- **state the uses of surface gauges, jenny calipers and try square.**

The surface gauge is one of the most common marking tools used for:

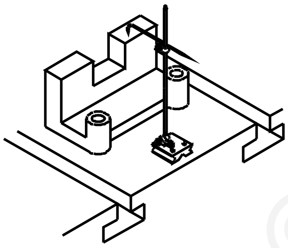
scribing lines parallel to a datum surface (Fig.1)

Fig 1



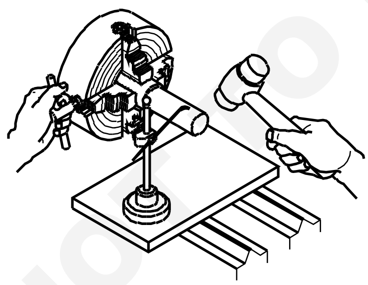
Setting jobs on machines parallel to a datum surface (Fig.2)

Fig 2



Checking the height and parallelism of jobs, setting jobs concentric to the machine spindle. (Fig 3)

Fig 3



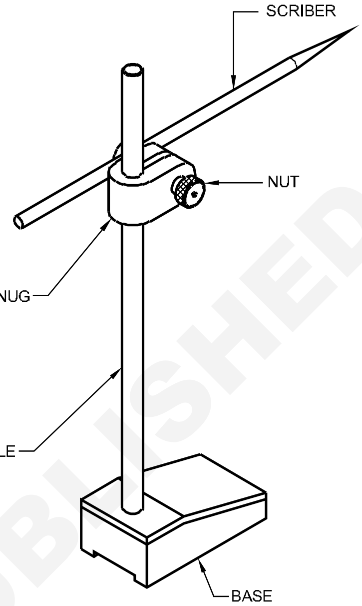
Types of surface gauges

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

Surface gauge - fixed type (Fig 4)

The fixed Type of surface gauge consists of a heavy flat base and a spindle, fixed upright, to which a scriber is attached with a snug and a clamp nut.

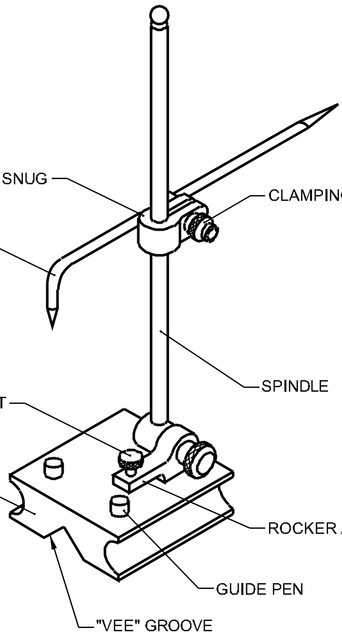
Fig 4



Universal surface gauge (Fig 5)

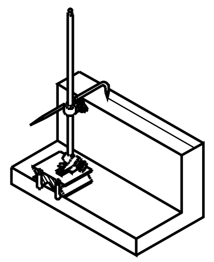
This has the following additional features: The spindle can be set to any position. Fine adjustment can be made quickly. Can also be used on cylindrical surfaces.

Fig 5



Parallel lines can be scribed from any datum edge with the help of guide pins. (Fig 6)

Fig 6



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.

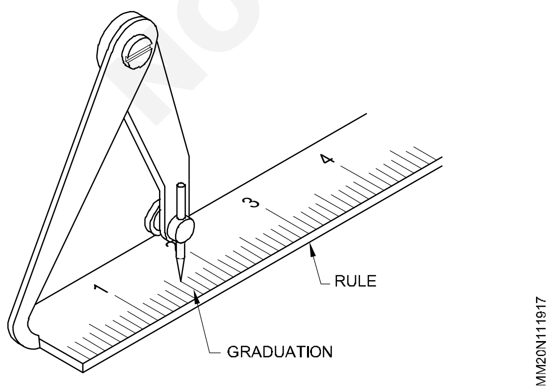
Care and maintenance

- Clean before and after the use
- Apply thin layer of oil to the bottom of the surface base before using for marking.
- Sharpen the Scriber if necessary.
- Do not exert more pressure while marking

Jenny calipers

Jenny calipers have one leg with an adjustable divider point while the is a bent leg. (Fig 7) These are available in sizes of 150mm, 200mm, 250mm and 300mm.

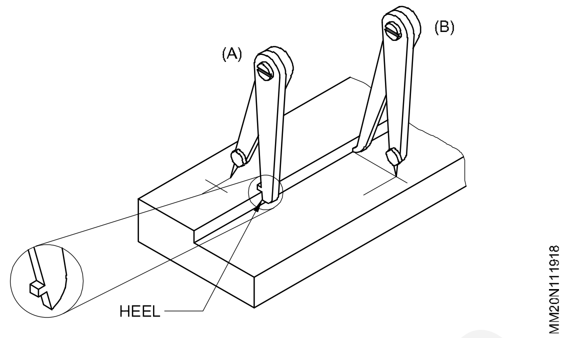
Fig 7



Jenny calipers are used

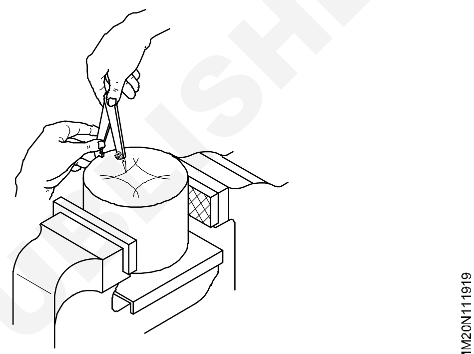
- For marking lines parallel to the inside and outside edges (Fig 8)

Fig 8



- For finding the centre of round bars. (Fig 9)

Fig 9



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

Calipers with bent leg (Fig 8B) are used For drawing lines parallel along an inside edge, and the heel type (Fig 8A) is used for drawing parallel line along the outer edges.

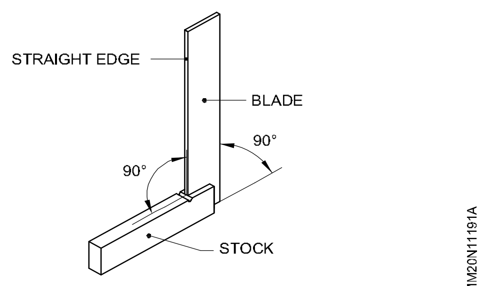
The other names for this caliper are:

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

Try square

The try square (Fig 10) is an instrument which is used to check squareness (angles of 90°) of a surface.

Fig 10



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

Try squares are made of hardened steel.

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

Uses:

The try-square is used to:

– check the squareness (Fig 11)

– check the flatness (Fig 12)

Fig 11

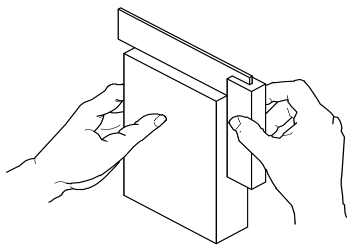
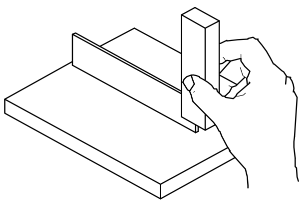


Fig 12



– mark lines at 90° to the edges of workpieces (Fig 13)

– set workpieces at right angles. (Fig 14)

Fig 13

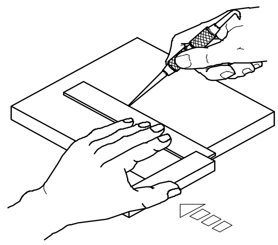
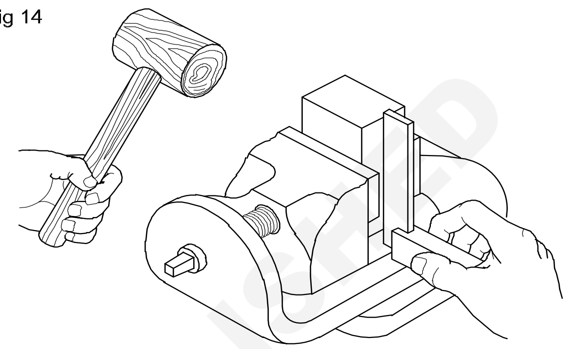


Fig 14

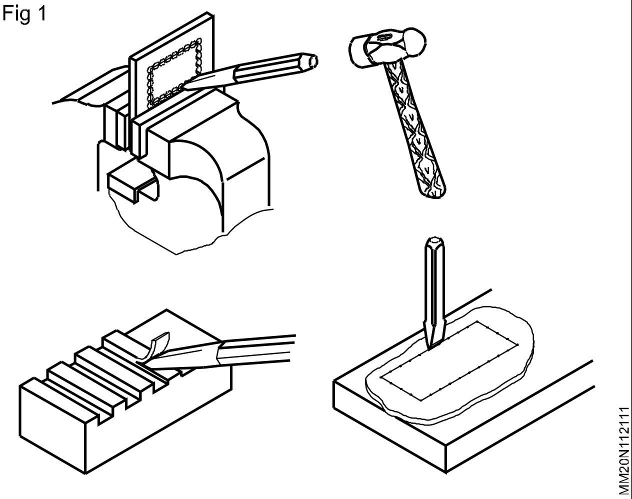


Cold Chisel

Objectives: At the end of this lesson you shall be able to
- **list the uses of a cold chisel**
- **name the parts of a cold chisel**
- **state the different types of chisels and chisel angles**
- **name the parts of depth gauge.**

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

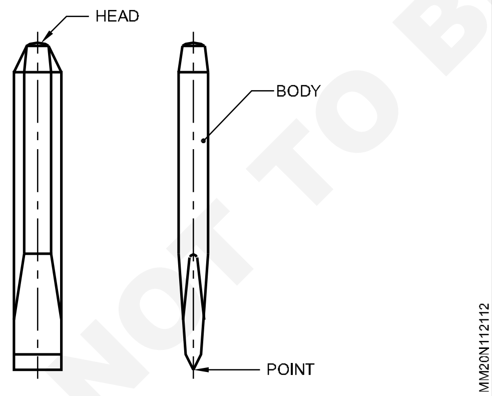
Fig 1



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.

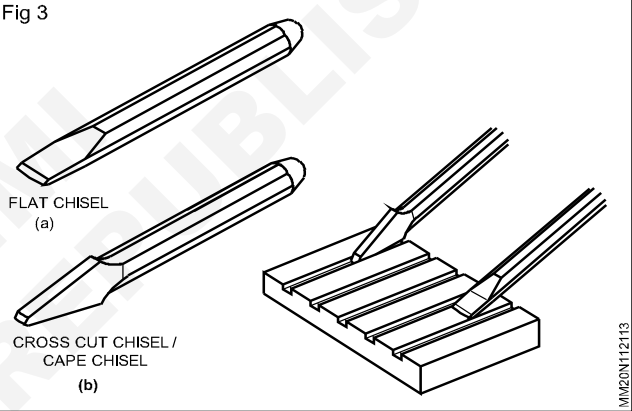
Common types of chisels: There are five common types of chisels.

– 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.

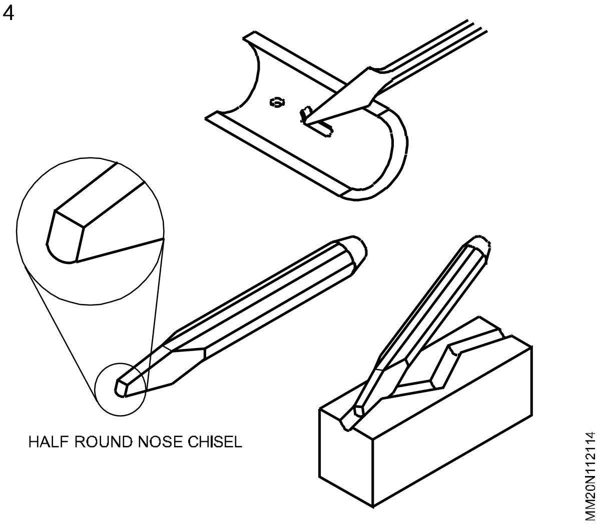
Cross-cut or cape chisels (Fig.3b)**:** These are used for cutting key ways, grooves and slots.

Fig 3



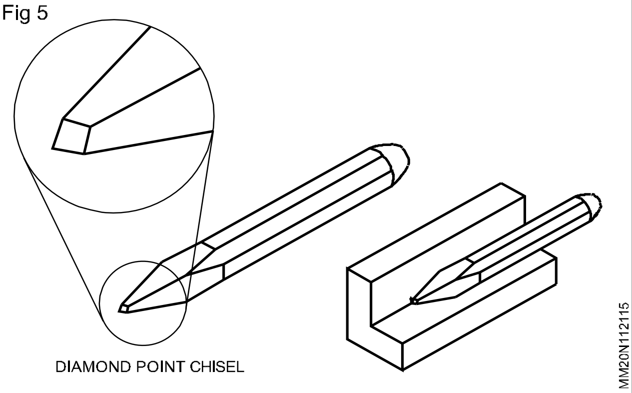
Half-round nose chisels (Fig 4)**:** They are used for cutting curved grooves (oil grooves).

Fig 4



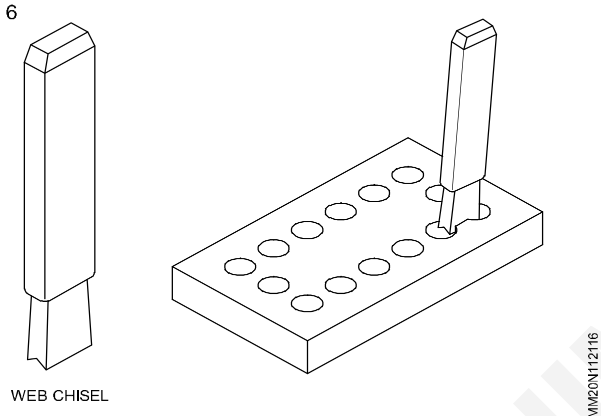
Diamond point chisels (Fig 5)**:** These are used for squaring materials at the corners, joints.

Fig 5



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

Fig 6



Chisels are specified according to their

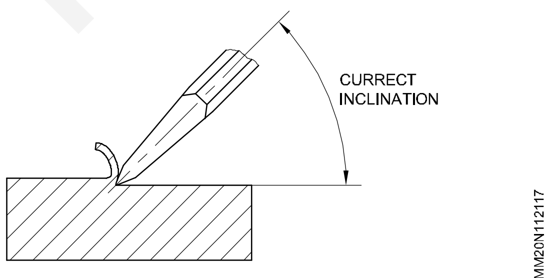
- length
- width of the cutting edge
- type
- cross-section of the body.
- chisel materials

Angles 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.

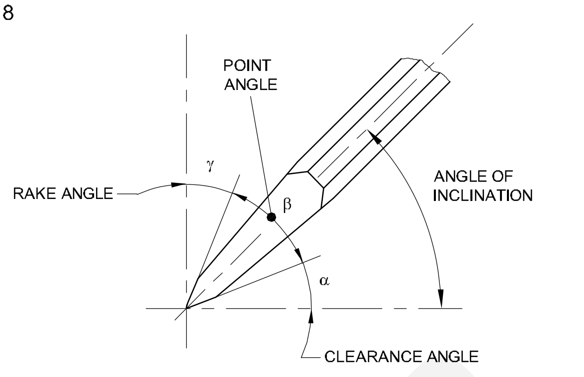
The correct point and angle of inclination generate the correct rake and clearance angles. (Fig 7)

Fig 7



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 8)

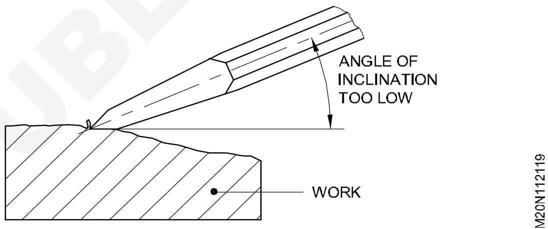
Fig 8



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 8)

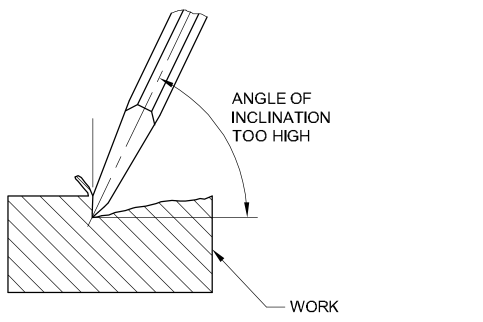
If the clearance angle is too low or zero, the rake angle increases. The cutting edge cannot penetrate into the work. The chisel will slip. (Fig 9)

Fig 9



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 10) The correct point angle and angle of inclination for different materials for chipping is given in Table 1.

Fig 10



Crowning: A slight curvature is ground called "Crowning" to the cutting edge of the chisel, to prevent digging of corners, which leads to breakage of chisel point. "Crowning" allows the chisel to move freely along a straight line while chipping.

Table 1

Material to be cut	Point angle	Angle inclination
High Carbon Steel	65°	39.5°
Cast iron	60°	37°
Mild steel	55°	34.5°
Brass	50°	32°
Copper	45°	29.5°
Aluminium	30°	22°

Care & maintenance

- Sharpen the chisel before use.
- Apply oil to avoid rust.
- Don't use the mushroom head chisel.
- Use safety goggles while chipping.
- No greasy subject on the head of the chisel.

Ordinary depth gauge (Fig 11)

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

Parts of ordinary depth gauge

1 Graduated beam

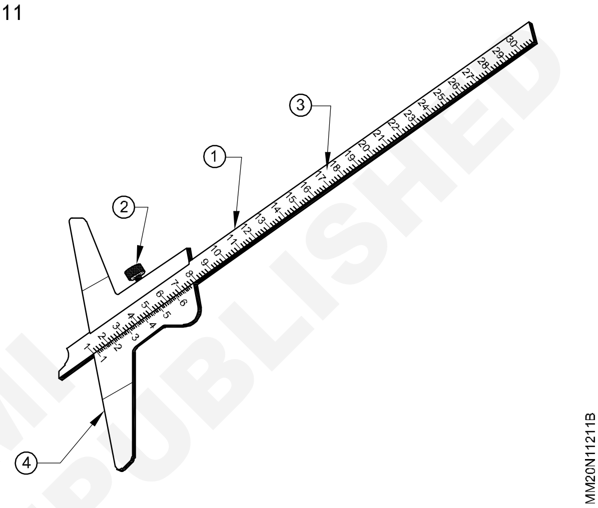
2 Clamping screw

3 Scale

4 Base

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

Fig 11



Marking media

Objectives: At the end of this lesson you shall be able to
- **state the purpose of marking media**
- **name the common types of marking media**
- **select 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 and castings with oxidised surface. (Fig 1)

Whitewash is not recommended for workpieces of high accuracy.

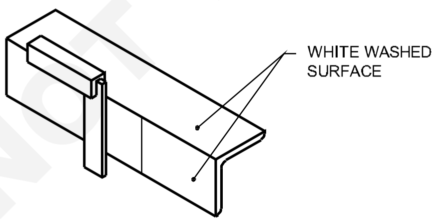
Marking blue

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 1

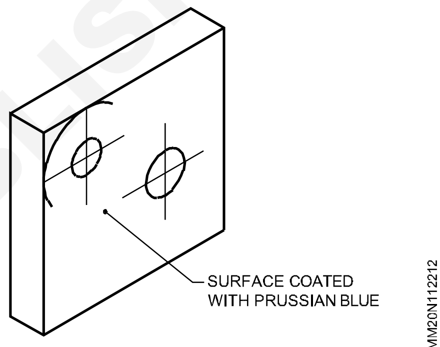


Copper sulphated

The solution is prepared by mixing copper sulphate 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 carefully 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.

Fig 2



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.**

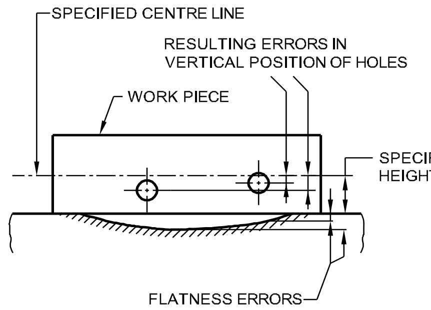
Marking equipments

Objectives: At the end of this lesson you shall be able to
- **state the necessity of surface plate**
- **Describe the 'V' Blocks**
- **use of angle plate, 'V' Blocks and parallel.**

Surface plates - their necessity

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

Fig 1



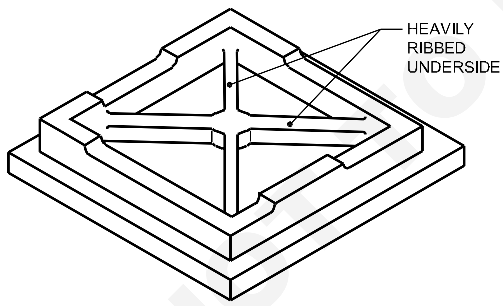
EFFECT OF MARKING-OUT FROM NON-FLAT SURFACE. NOTE THAT THE ERRORS IN THE HOLE POSITIONS ARE EQUAL TO THE FLATNESS ERRORS

Materials and construction

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

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

Fig 2

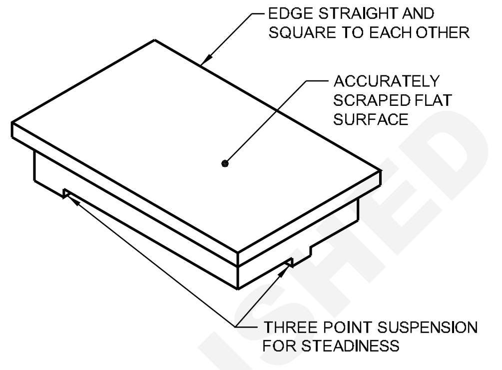


CAST IRON SURFACE PLATE

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

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

Fig 3



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

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 4 and 5.

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

Fig 4

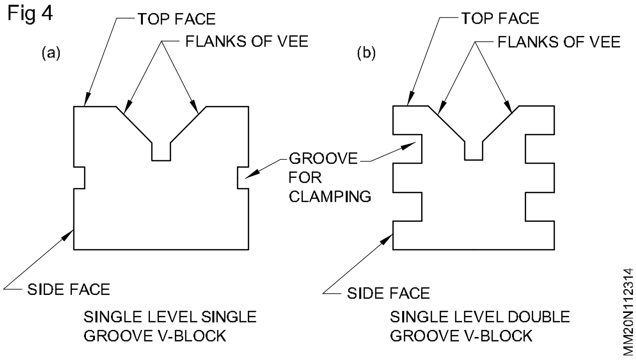
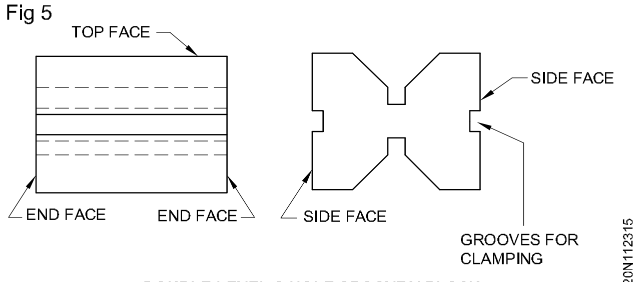


Fig 5



DOUBLE LEVEL SINGLE GROOVE V-BLOCK

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 4a)

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 4b)

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

Double level single groove 'V' Block (Fig 5)

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.

Matched pair 'V' Block (Figs 6 and 7)

Fig 6

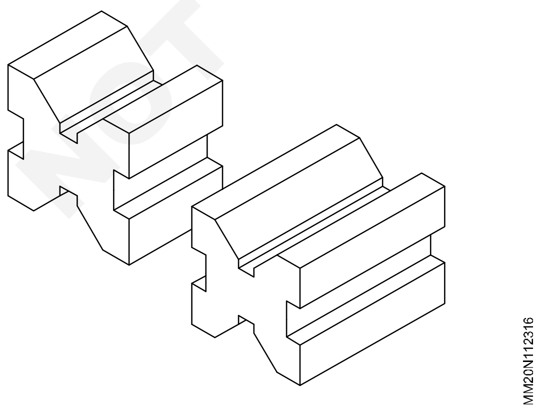
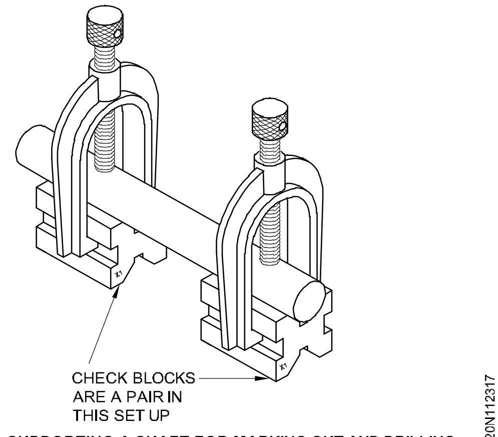


Fig 7



VEE BLOCKS SUPPORTING A SHAFT FOR MARKING OUT AND DRILLING

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.

Grades and materials

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

Grade A 'V' Blocks

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

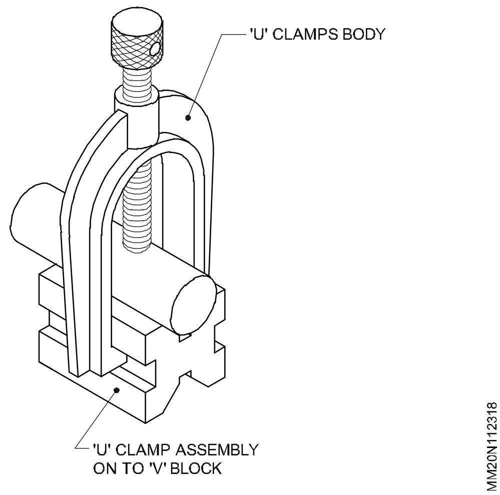
Grade B 'V' Blocks

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 8)

Fig 8



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.

Care and maintenance

- Clean before and after use.
- Choose the correct size of 'V' block according to the job requirement.
- Apply oil after the use.

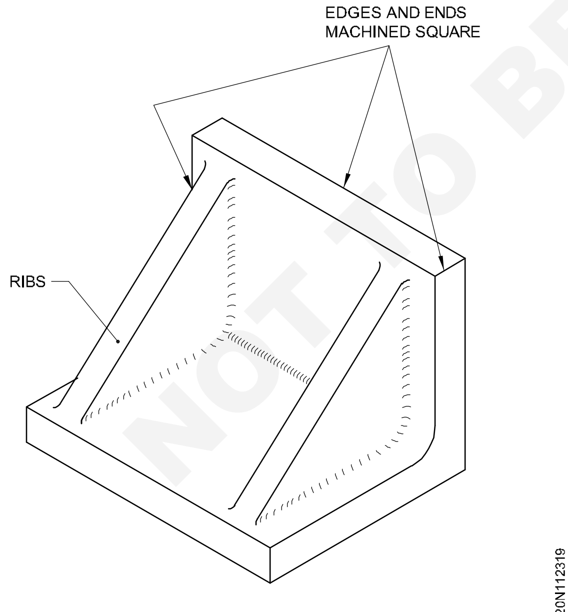
Angle plates

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 machined part for good rigidity and to prevent distortion.

Types of angle plates

Plain solid angle plate (Fig 9)

Fig 9

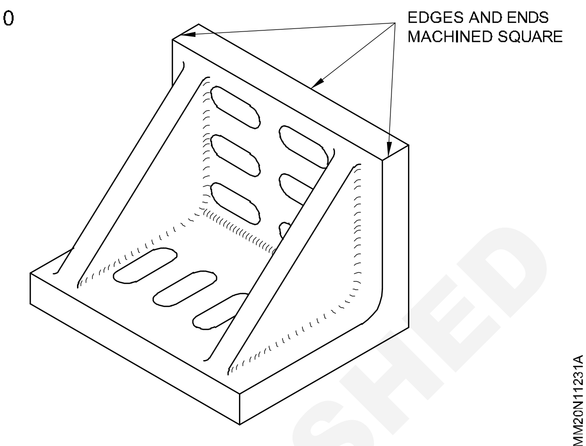


ANGLE PLATE

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 10)

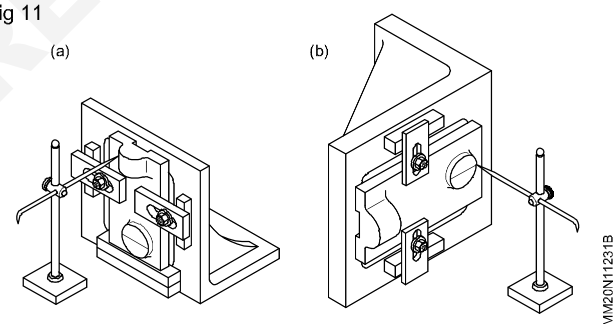
Fig 10



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 11a and 11b)

Fig 11



Swivel type angle plate (Fig 12)

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 13)

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 12

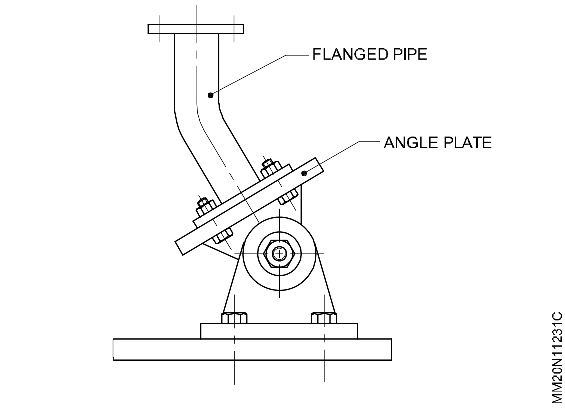
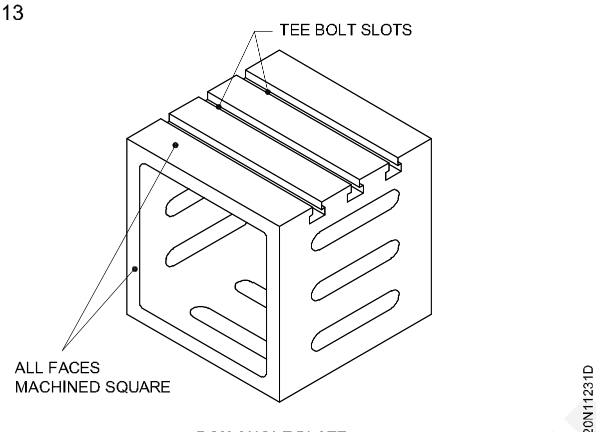


Fig 13



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.

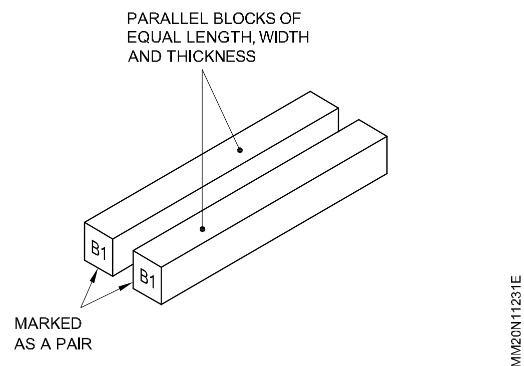
Parallel blocks

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 14)

Fig 14



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.

They are hardened and ground, and, sometimes, finished by lapping.

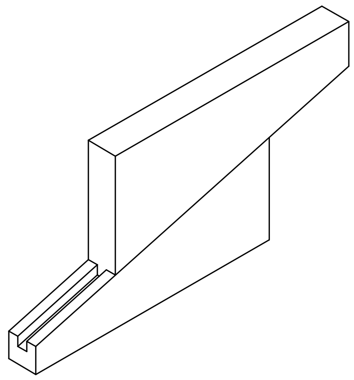
Parallels are machined to close limits, and are perfectly flat, square, and parallel throughout the length. These are made in pairs of identical dimensions.

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 15)

Fig 15



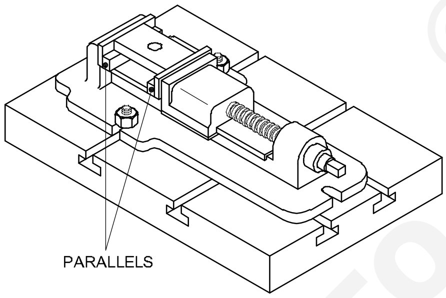
MM20N11231F

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 16)

Fig 16



MM20N11231G

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.

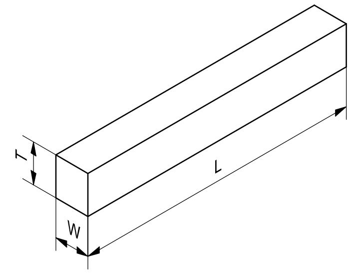
Sizes of parallels

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 17

Fig 17



MM20N11231H

Examples

Solid parallel A5 x 10 x 100 IS: 4241

Adjustable parallel 10 x 13 IS:4241

Table 1

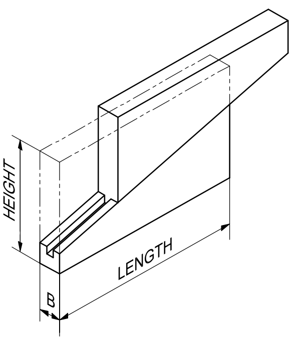
Sizes of solid parallels

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 (Fig 18)

Fig 18



MM20N11231J

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

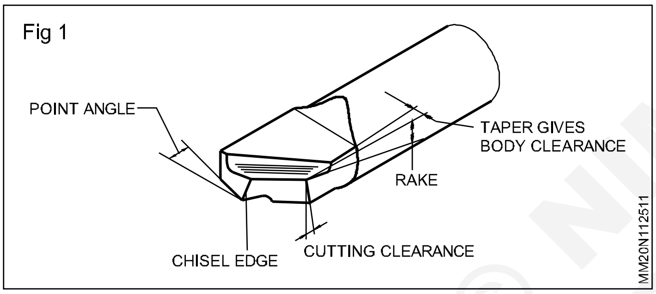
Drills

Objectives: At the end of this lesson you shall be able to
- **state drilling and drill material**
- **state the necessity of drilling**
- **name the types of drills used**
- **list the parts of a twist drill and drill angles.**

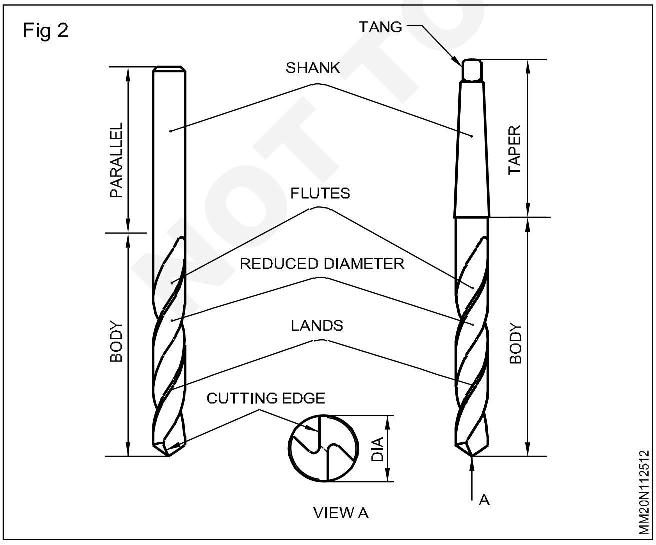
Drilling: Drilling is the production of cylindrical holes of definite diameters in workpieces by using a multi-point cutting tool called a ‘drill’. It is the first operation done internally for any further operation. The fluted part (or) body of a drill is made of either high carbon steel (or) High speed steel.

Types of drills and their specific uses

Flat drill (Fig 1) **:** The earliest form of drill was the flat drill which is easy to operate, besides being inexpensive to produce. The chip removal is poor and its operating efficiency is very low.

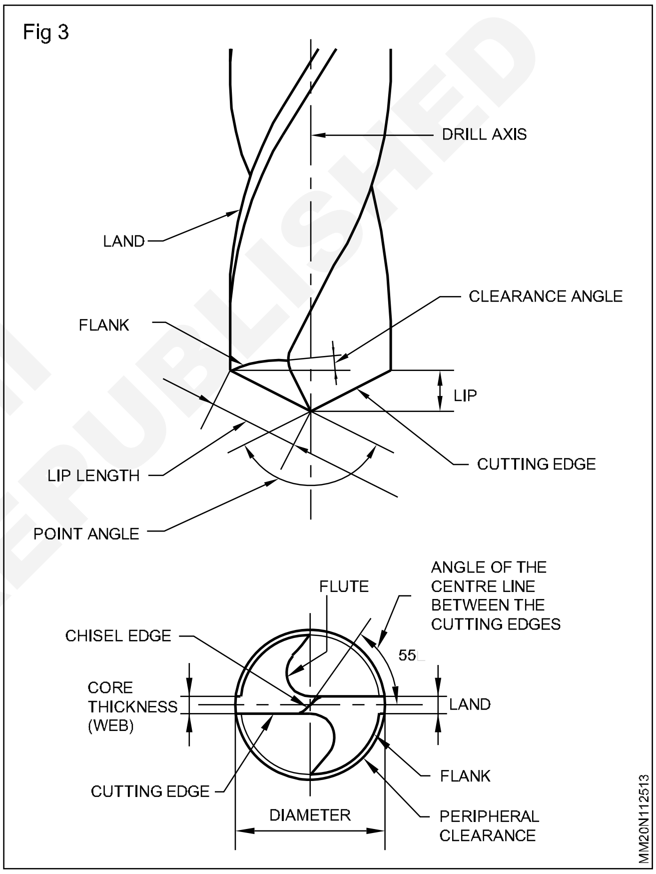


Twist drill : Almost all drilling operation is done using a twist drill. It is called a twist drill as it has two or more spiral or helical flutes formed along its length. The two basic types of twist drills are, parallel shank and taper shank. Parallel shank twist drills are available below 13mm size (Fig 2).



Parts of a twist drill : Drills are made out of high speed steel. The spiral flutes are machined at an angle of 27 1/2° to its axis.

The flutes provide a correct cutting angle which provides an escape path for the chips. It carries the coolant to the cutting edge during drilling. (Fig 3)



The portions left between the flutes are called ‘lands’. The size of a drill is determined and governed by the diameter over the lands.

The point angle is the cutting angle, and for general purpose work, it is 118°. The clearance serves the purpose of clearing the back of the lip from fouling with the work. It is mostly 8°.

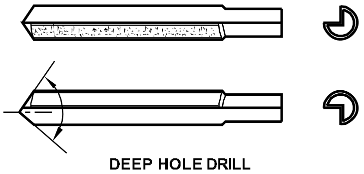
Deep hole drills

Deep hole drilling is done by using a type of drill known as ‘D’ bit (Fig 4)

Drills are made of high speed steel.

Drills are manufactured with varying helix angles for drilling different materials. General purpose drills have a standard helix angle of 27 1/2°. They are used on mild steel and cast iron. (Fig 5a)

Fig 4

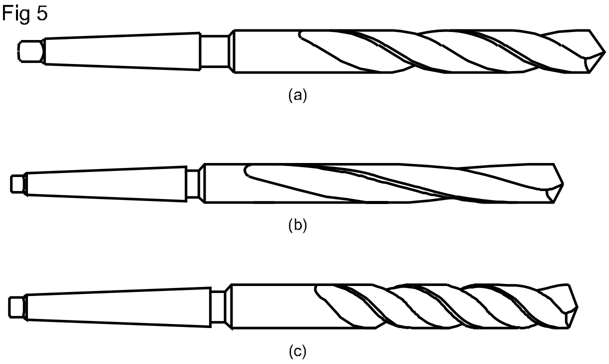


A slow helix drill is used on materials like brass, gun metal, phosphor-bronze and plastics. (Fig 5b)

A quick helix drill is used for copper, aluminium and other soft metals (Fig 5c)

> **A quick helix drill should never be used on brass as it will 'dig in' and the workpiece may be thrown from the machine table.**

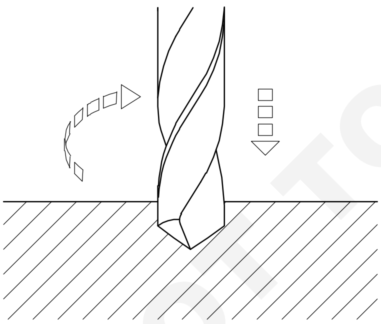
Fig 5



Drill (Parts and functions)

Drilling is a process of making holes on workpieces. The tool used is a drill. For drilling, the drill is rotated with a downward pressure causing the tool to penetrate into the material. (Fig 6)

Fig 6



Parts of a Drill (Fig 7)

The various parts of a drill can be identified from figure 2.

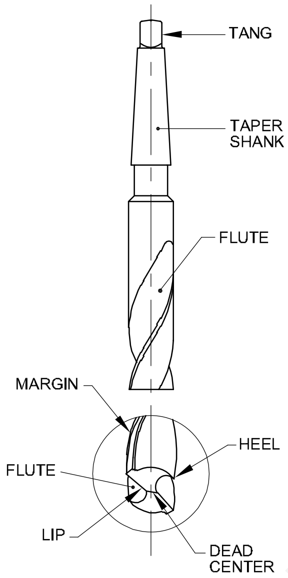
Point

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

Shank

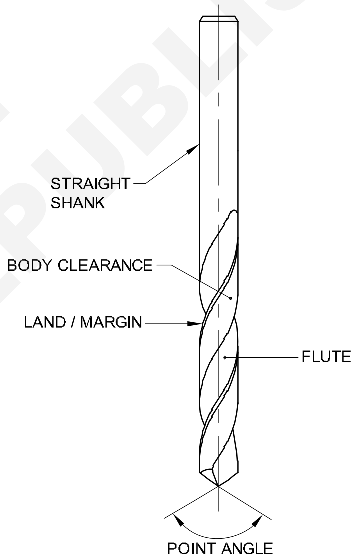
This is the driving end of the drill which is fitted on to the machine. Shanks are of two types.

Fig 7



Taper shank, used for larger diameter drills, and straight shank, used for smaller diameter drills. (Fig 8)

Fig 8



Tang

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

Body

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

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

Flutes (Fig 8)

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

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

Land/Margin (Fig 8)

The land/margin is the narrow strip which extends to the entire length of the flutes.

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

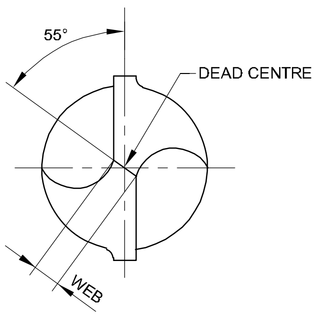
Body clearance (Fig 8)

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

Web (Fig 9)

Web is the metal column which separates the flutes. It gradually increases in thickness towards the shank.

Fig 9



Like all cutting tools the drills are provided with certain angles for efficiency in drilling.

Drill angles

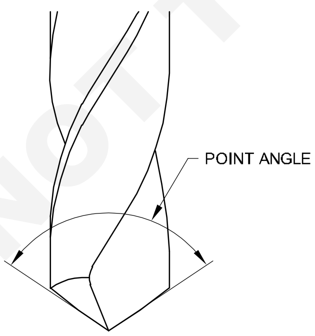
They are different angles for different purposes. They are listed below.

Point angle, helix angle, rake angle, clearance angle and chisel edge angle.

Point angle/ cutting angle (Fig 10)

The point angle of a general purpose (standard) drill is 118°. This is the angle between the cutting edges (lips). The angle varies according to the hardness of the material to be drilled.

Fig 10



Helix angle (Figs 11,12 and 13)

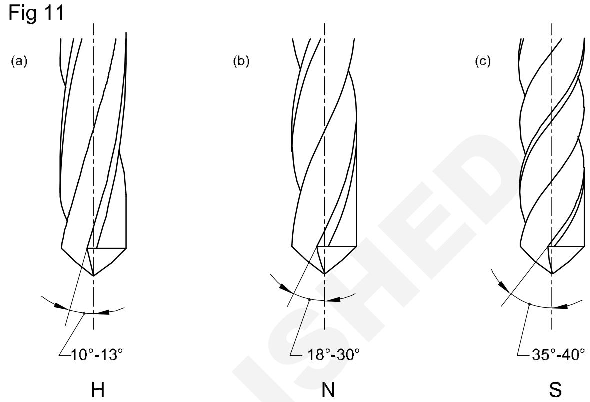
Twist drills are made with different helix angles. The helix angle determines the rake angle at the cutting edge of the twist drill.

The helix angles vary according to the material being drilled. According to Indian standards, three types of drills are used for drilling various materials.

- Type N - For normal low carbon steel.
- Type H - For hard and tenacious materials.
- Types S - For soft and tough materials.

The type of drill used for general purpose drilling work is type N.

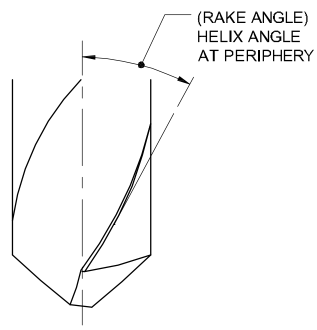
Fig 11



Rake angle (Fig 12)

Rake angle is the angle of flute (helix angle).

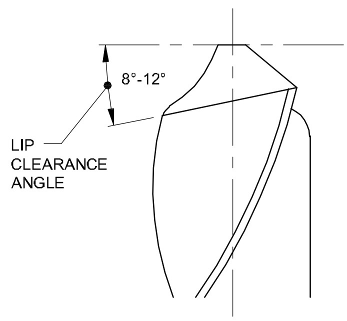
Fig 12



Clearance angle (Fig 13)

The clearance angle is meant to prevent the friction of the tool behind the cutting edge. This will help in the penetration of the cutting edges into the material. If the clearance angle is too much, the cutting edges will be weak, and if it is too small, the drill will not cut.

Fig 13



Chisel edge angle/web angle (Fig 14)

This is the angle between the chisel edge and the cutting lip.

Designation of drills

Twist drills are designated by the

- Diameter
- Tool type
- Material

Example

A twist drill of 9.50 mm dia. of tool type 'H' for right hand cutting and made from HSS is designated as:

Twist drill 9.50 - H - IS5101 - HS

where H = tool type

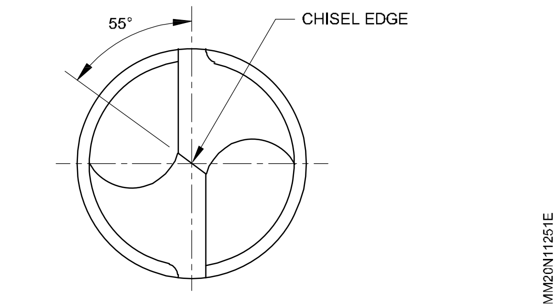
IS5101 = IS Number

HS = tool material

9.5 = diameter of the drill.

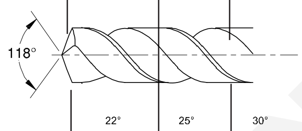
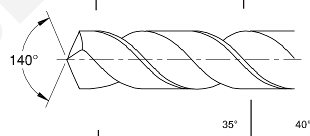
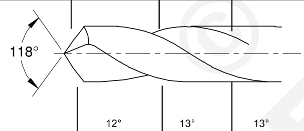
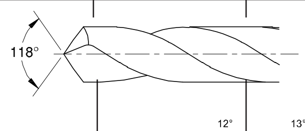
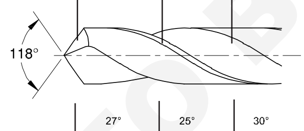
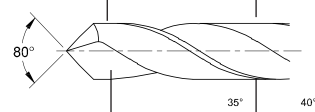
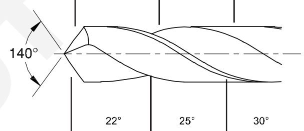
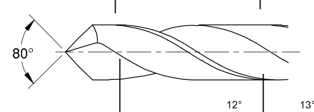
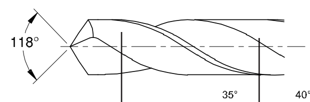
If the tool type is not indicated in the designation, it should be taken as type 'N' tool.

Fig 14



DRILLS FOR DIFFERENT MATERIALS

Drills for different materials are shown in Table

Recommended drills					
Material to be drilled	**Point angle**	**Helix angle** d=3.2-5 5-10 10-	**Material to be drilled**	**Point angle**	**Helix angle** d=3.5-5 5-
Steel and cast steel up to 70 kgf/mm² strength Gray cast iron Malleable cast iron Brass German silver, nickel.			Copper (up to 30 mm drill diameter) Al-alloys, forming curly chips Celluloid		
Brass, CuZn 40			Austenitic steels Magnesium alloys		
Steel and cast steel 70...120 Kgf/mm²			Moulded plastics (with thickness s>d)		
Stainless steel; Copper (drill diameter more than 30 mm) Al-alloy, forming short broken chips			Moulded plastics, with thickness s<d Laminated plastics, hard rubber (ebonite) marble, slate, coal		
			Zinc alloys		

Hand taps and wrenches

Objectives: At the end of this lesson you shall be able to
- **state the uses of threading hand taps**
- **state the features of hand taps**
- **distinguish between different taps in a set**
- **name the different types of tap wrenches**
- **calculate tap drill size**
- **state the characteristic of machine Taps.**

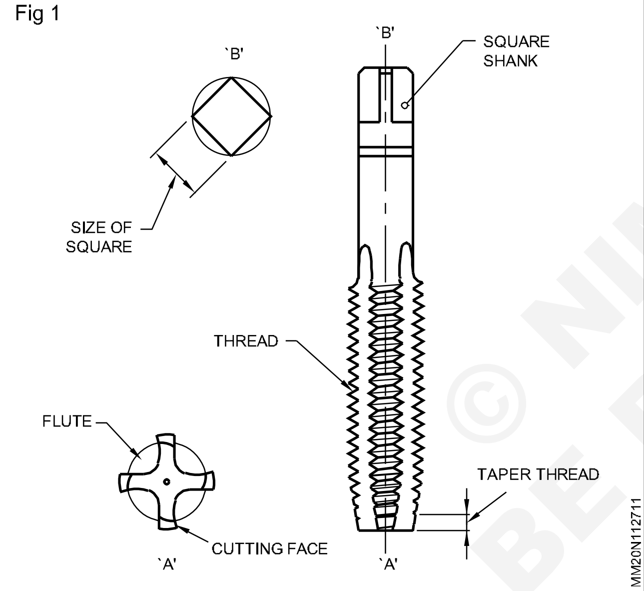
Use of hand taps

Hand taps are used for internal threading of components.

Features (Fig 1)

They are made from high carbon steel or high speed steel, hardened and ground.

Fig 1



Threads are cut on the surface, and are accurately finished.

To form the cutting edges, the flutes are cut across the thread.

For holding and turning the taps while cutting threads, the ends of the shanks are squared.

The ends of the taps are chamfered (taper lead) for assisting, aligning and starting of the thread.

The size of the taps and the type of the thread are usually marked on the shank.

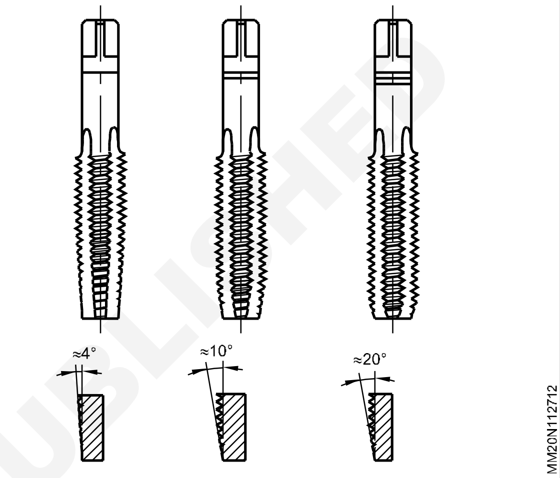
In certain cases, the pitch of the thread will also be marked.

Markings are also made to indicate the type of tap i.e. first, second or plug.

Types of Taps in a set

Hand taps for a particular thread are available as a set consisting of three pieces. (Fig 2)

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 as 1, 2 and 3 or rings are marked on the shank.

The taper tap has one ring, the intermediate tap has two rings and the bottoming tap has three rings. (Fig 2)

Tap Wrenches

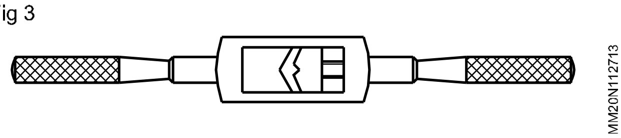
Tap wrenches are used to align and drive the hand taps correctly into the hole to be threaded.

Tap wrenches are of different types.

Double ended adjustable wrench, T-handle tap wrench, solid type tap wrench.

Double-ended Adjustable Tap Wrench or Bar Type Tap Wrench (Fig 3)

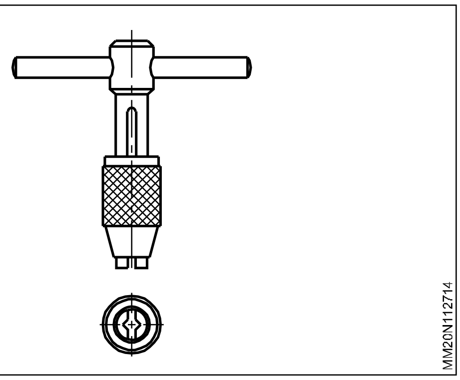
Fig 3



This is the most commonly used type of tap wrench. It is available in various sizes. 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.

T-Handle tap wrench (Fig 4)

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.

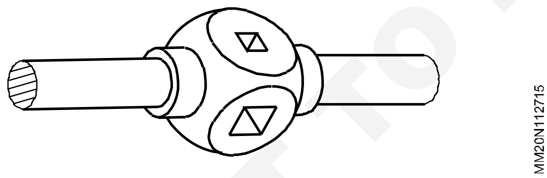
This wrench is not available for holding large diameter taps.

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

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

Tapping drill size

for M10 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 (D1)=10 mm – 1.839 mm

=8.161mm or 8.2 mm

This tap drill will produce 100% thread because this is equal to the minor diameter of the thread. 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 – pitch

= 10 mm - 1.5 mm

= 8.5 mm.

Compare this with the table of tap drill sizes for ISO metric threads.

ISO Inch (Unified) threads Formula

Tap Drill size =

$$\text{Major diameter} - \frac{1}{\text{number of threads per inch}}$$

For calculating the tap drill size for 5/8" UNC thread

Tap drill size = 5/8" – 1/11"

= 0.625" – 0.091"

= 0.534"

Machine taps

Machine taps: Machine taps of different types are available. The two important features of machine taps are

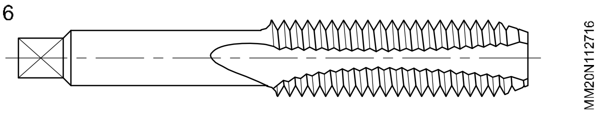
– Ability to withstand the torque needed for threading holes

– Provision for eliminating chip jamming.

Types of machine taps

Gun tap (Spiral pointed tap) (Fig 6)

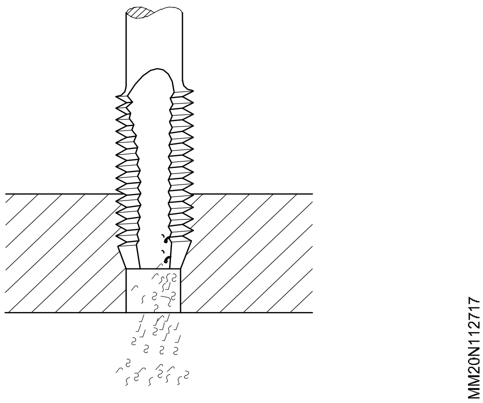
Fig 6



These taps are especially useful for machine tapping of through holes. In the case of blind hole tapping, there should be sufficient space below to accommodate the chips. While tapping, the chips are forced out ahead of the tap. (Fig 7)

This prevents the clogging of the chips and thus reduces the chances of tap breakage. These taps are stronger since the flutes are shallow. The flutes of these taps do not convey chips.

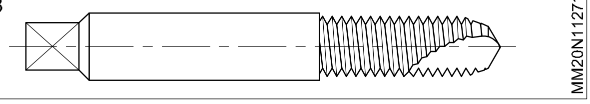
Fig 7



Flute-less spiral pointed tap (Stub flute taps) (Fig 8)

These taps have short angular flutes ground on the chamfered end, and the rest of the body is left solid. These taps are stronger than gun taps.

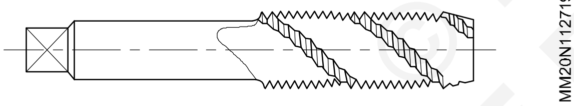
Fig 8



Flute-less taps are used for tapping through holes on materials which are not thicker than the diameter of the holes. Flutes spiral point taps are best suited for tapping soft materials or thin metal sections.

Helical fluted taps/spiral fluted taps: These taps have spiral flutes which bring out the chips from the hole being tapped. (Fig 9)

Fig 9



These are useful for tapping holes with slots. The helical land of the tap will bridge the interruption of the surface being threaded. The helical flutes of the tap provide a shear cutting action, and are mostly used to tap holes in ductile materials like aluminium, brass, copper etc.

Spiral fluted taps are also available with fast spiral. (Fig 10) These taps are best suited for tapping deep holes as these can clear the chips faster from the hole. (Fig 11)

Fig 10

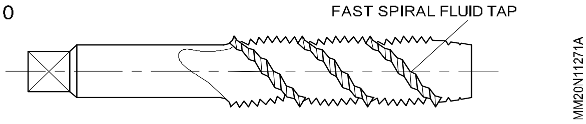
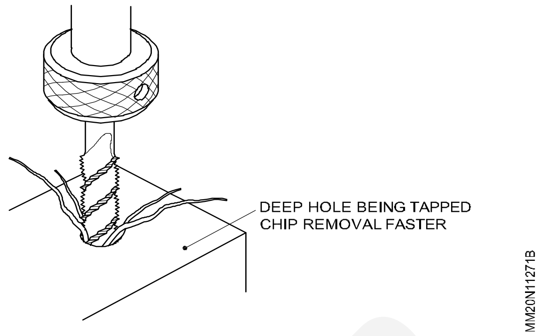


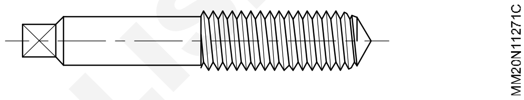
Fig 11



Thread forming taps (Fluteless taps)

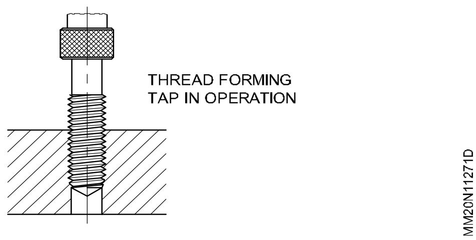
These taps form threads in the hole by displacing the material and not by cutting action. (Fig 12)

Fig 12



These taps have projecting lobes which actually help in forming the thread. (Fig 13) Since there are no chips in the process, it is very valuable in places where chip removal poses problems. These taps are excellent for tapping copper, brass, aluminium, lead etc. The thread finish is also comparatively better than in the fluted taps.

Fig 13



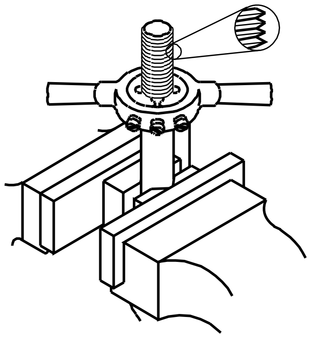
Dies and die stock

Objectives: At the end of this lesson you shall be able to
- **list the different types of dies and uses**
- **name the type of diestock for each type of die**
- **determine the diameter of blank size for external threading**
- **External threading using dies.**

Uses of dies

Threading dies are used to cut external threads on cylindrical workpieces. (Fig 1)

Fig 1



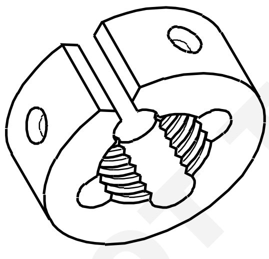
Types of dies

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

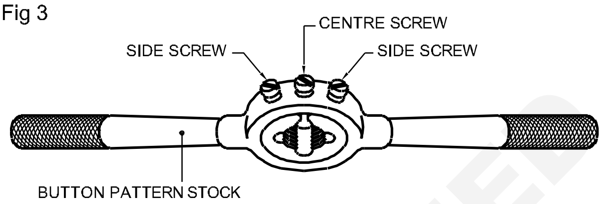


This has a slot cut to permit slight variation in size.

Dies are made of high speed steel

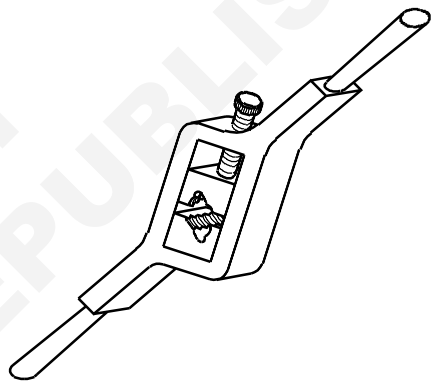
When held in the diestock, variation in the size can be made by using the adjusting screws. This permits increasing or decreasing of the depth of cut. When the side screws are tightened the die will close slightly. (Fig 3) For adjusting the depth of the cut, the centre screw is advanced and locked in the groove. This type of die stock is called button pattern stock

Fig 3



Half die (Fig 4)

Fig 4



Half dies are stronger in construction.

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

These dies are available in matching pairs and should be used together.

By adjusting the screw of the diestock, the die pieces can be brought closer together or can be moved apart.

They need a special die holder.

Adjustable screw plate die (Fig 5)

This is another type of a two piece die similar to the half die.

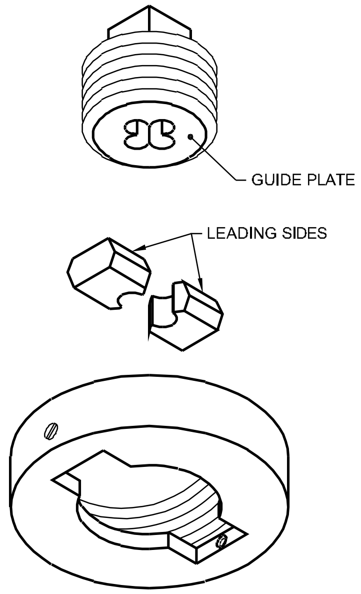
This provides greater adjustment than the split die.

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.

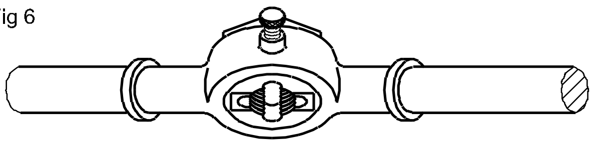
The die pieces can be adjusted, using the adjusting screws on the collar. This type of die stock is called quick cut diestock. (Fig 6)

Fig 5



MM20N112915

Fig 6



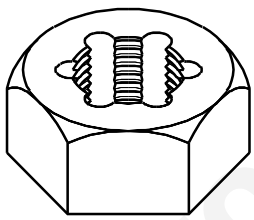
MM20N112916

The bottom of the die halves is tapered to provide the lead for starting the thread. On one side of each die head, the serial number is stamped.

Both pieces should have the same serial numbers.

Die Nut (Solid Die) (Fig 7)

Fig 7



FI20N157117

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

Die nuts are not to be used for cutting new threads.

The die nuts are available for different standards and sizes of threads.

The die nut is turned with a spanner.

Blank size for external threading

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 assembly of external and internal threaded components very difficult. To overcome this, the diameter of the blank is slightly reduced before commencing the threading.

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 1.75mm pitch the diameter of the blank is 11.80.

Formula, D = d - p/10

= 12mm - 0.175mm

= 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 x1.5?

Answer

....

....

....

External threading using dies

Check blank size.

Blank size = Threads size -0.1 × pitch of thread

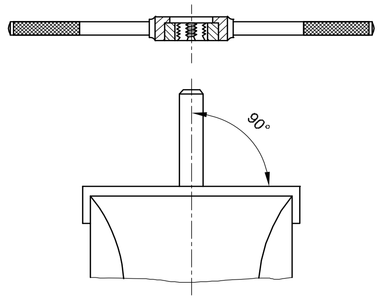
Procedure: Fix the die in the diestock and place the leading side of the die opposite to the step of the diestock. (Figs 8a & 8b)

Use false jaws for ensuring a good grip in the vice.

Project the blank above the vice - just the required thread length only.

Place the leading side of the die on the chamfer of the work (Fig 9)

Fig 9



MM20N112919

Make sure that the die is fully open by tightening the centre screw of the diestock. (Fig 10)

Start the die, square to the bolt centre line. (Fig 11)

Apply pressure on the diestock evenly and turn clockwise direction to advance the die on the bolt blank. (Fig 12)

Fig 8

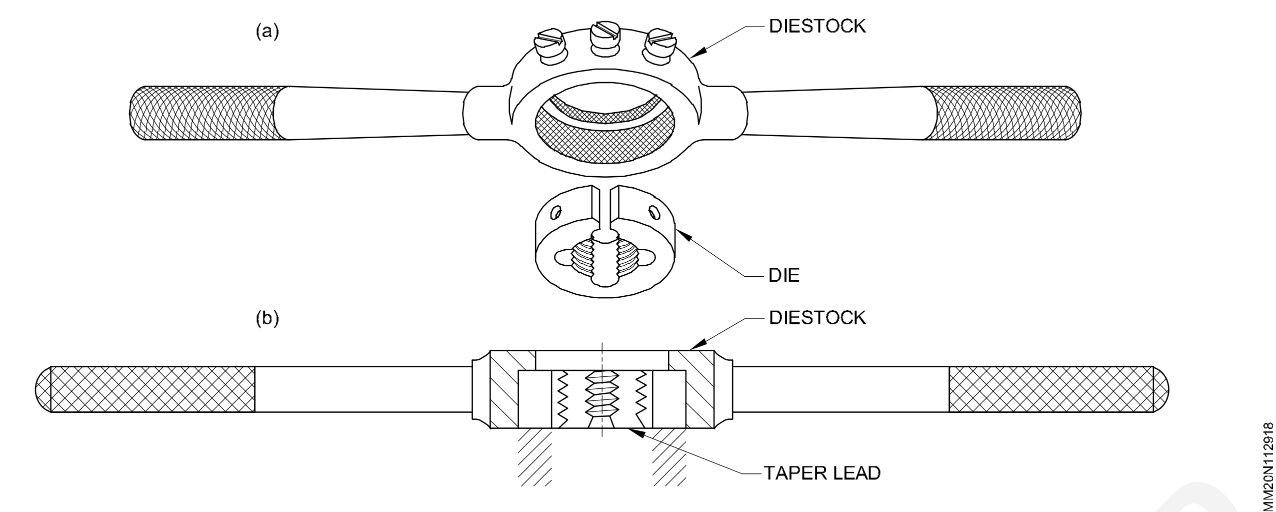


Fig 10

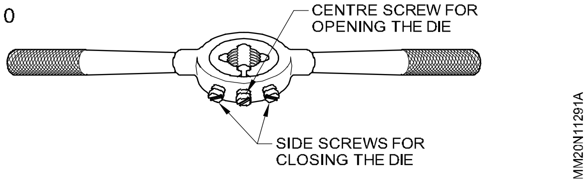
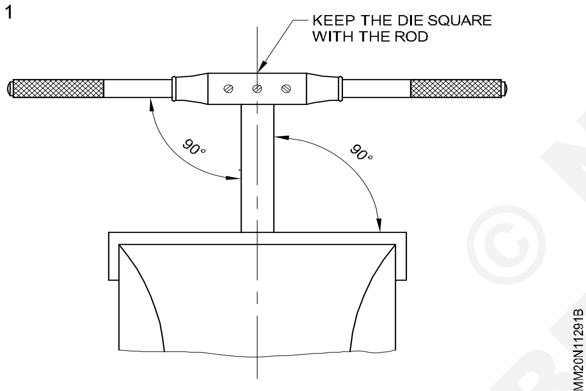


Fig 11



Cut slowly and reverse the die for a short distance in order to break the chips

Use a cutting lubricant.

Increase the depth of the cut gradually by adjusting the outer screws.

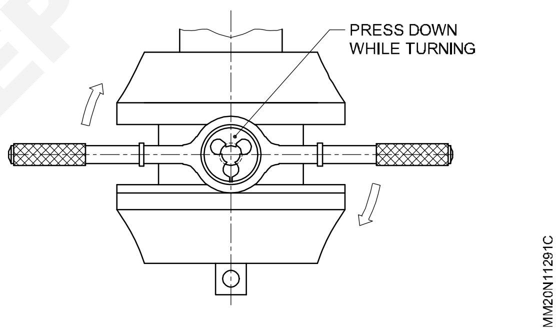
Check the thread with a matching nut.

Repeat the cutting until the nut matches.

Too much depth of cut at one time will spoil the threads. It can also spoil the die.

Clean the die frequently to prevent the chips from clogging and spoiling the thread.

Fig 12



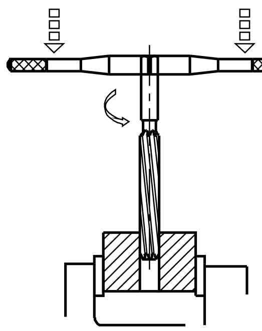
Reamers and reaming

Objectives: At the end of this lesson you shall be able to
- **state the use of reamers**
- **state the general features of hand reamers**
- **determine the hole size for reaming**
- **procedure for hand reaming and machine reaming.**

Reamer

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

Fig 1



MM20N113011

Advantages of 'reaming'

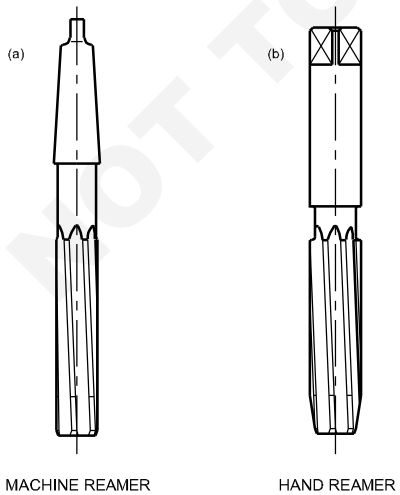
Reaming produces

- 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 2a and 2b)

Fig 2



MM20N113012

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.

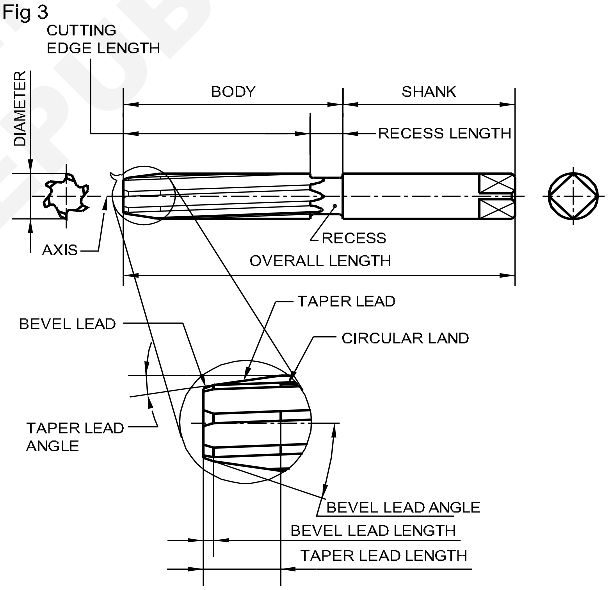
Machine reamers are provided with morse taper shanks for holding on machine spindles.

Hand reamers have straight shanks with 'square' at the end, for holding with tap wrenches. (Figs 2a) and (2b)

Parts of a hand reamer

The parts of a hand reamer are listed hereunder. Refer to Fig 3.

Fig 3



MM20N113013

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 of the shank.

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 taper.

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 hole. 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

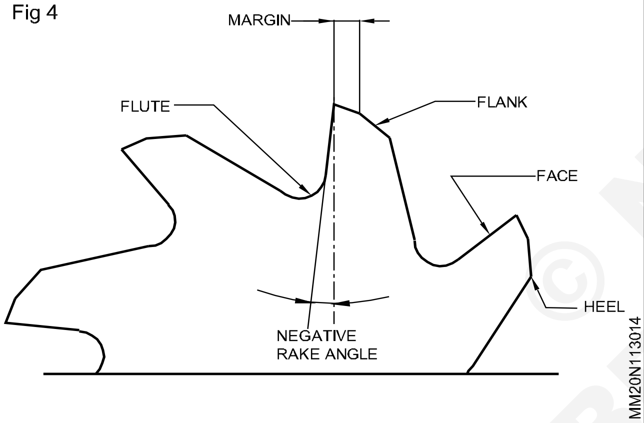
Flutes: The grooves in the body of the reamer to provide cutting edges, to permit the removal of chips, and to allow the cutting fluid to reach the cutting edges. (Fig 4)

Heel: The edge formed by the intersection of the surface left by the provision of a secondary clearance and the flute. (Fig 4)

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 4)

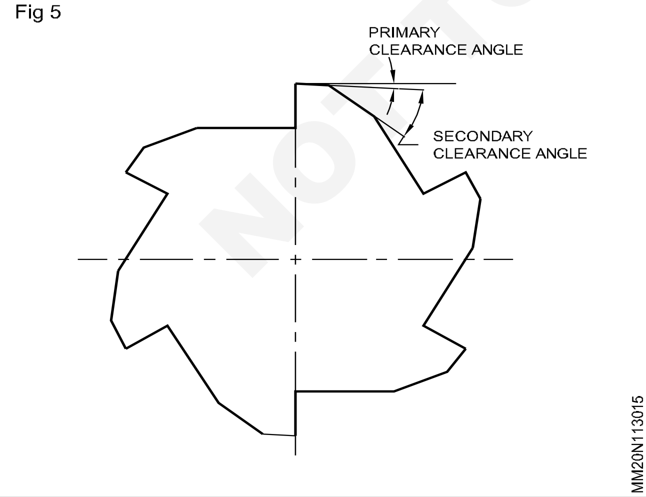
Face: The portion of the flute surface adjacent to the cutting edge on which the chip impinges as it is cut from the work. (Fig 4)

Fig 4



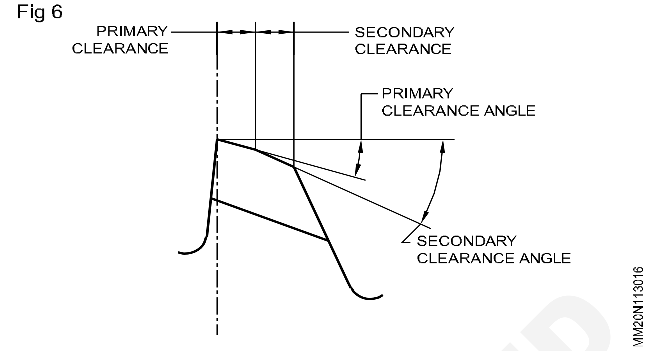
Rake angles: The angles in a diametric plane formed by the face and a radial line from the cutting edge. (Fig 5)

Fig 5



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 6)

Fig 6



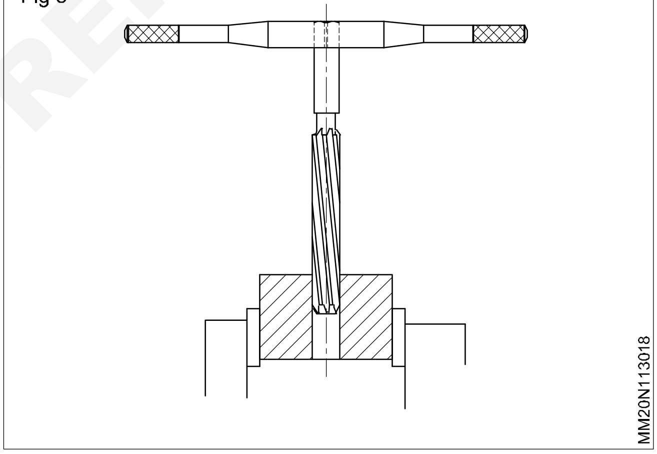
Helix angle: The angle between the edge and the reamer axis. (Fig 7)

Fig 7

Hand reamers

General features of hand reamers (Fig 8)

Fig 8



Hand reamers are used to ream holes manually using tap wrenches.

These reamers have a long taper lead.(Fig 9) This allows to start the reamer straight and in alignment with the hole being reamed.

Most hand reamers are for right hand cutting.

Helical fluted hand reamers have left hand helix. The left hand helix will produce smooth cutting action and finish.

Most reamers, machine or hand, have uneven spacing of teeth. This feature of reamers helps to reduce chattering while reaming. (Fig 10)

Fig 9

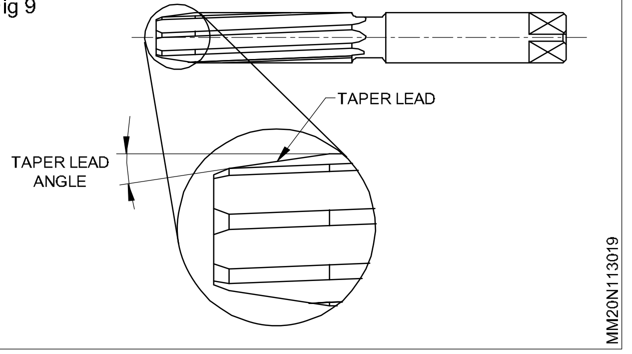
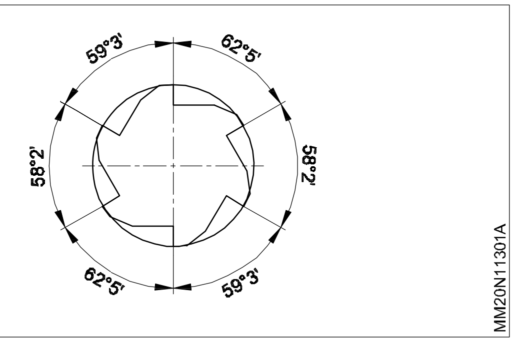


Fig 10



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 11a)

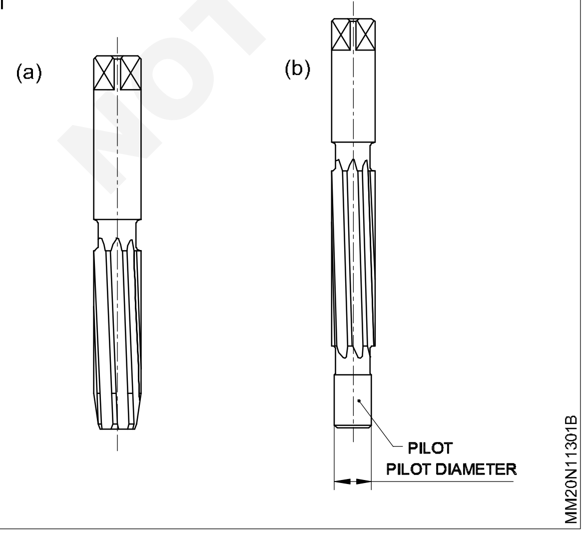
A reamer which has virtually parallel cutting edges with taper and bevel lead. The body of the reamer is integral with a shank. The shank has the nominal diameter of the cutting edges. One end of the shank is square shaped for tuning it with a tap wrench. Parallel reamers are available with straight and helical flutes. This is the commonly used hand reamer for reaming holes with parallel sides.

Reamers commonly used in workshop produce H7 holes.

Hand reamer with pilot (Fig 11b)

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 11



Socket reamer with parallel shank (Figs 12a and 12b)

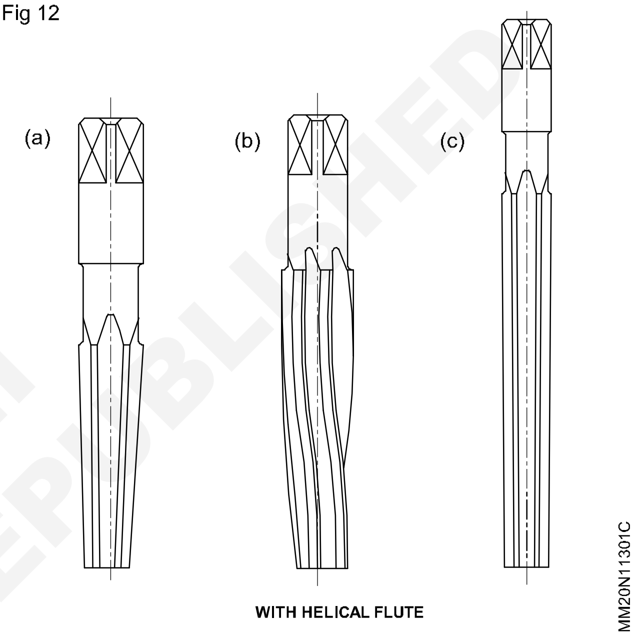
This reamer has tapered cutting edges to suit metric morse tapers. The shank is integral with the body, and is square shaped for driving. The flutes are either straight or helical.

The socket reamer is used for reaming internal morse tapered holes.

Taper pin hand reamer (Fig 12c)

This reamer has tapered cutting edges for reaming taper holes to suit taper pins. A taper pin reamer is made with a taper of 1 in 50. These reamers are available with straight or helical flutes.

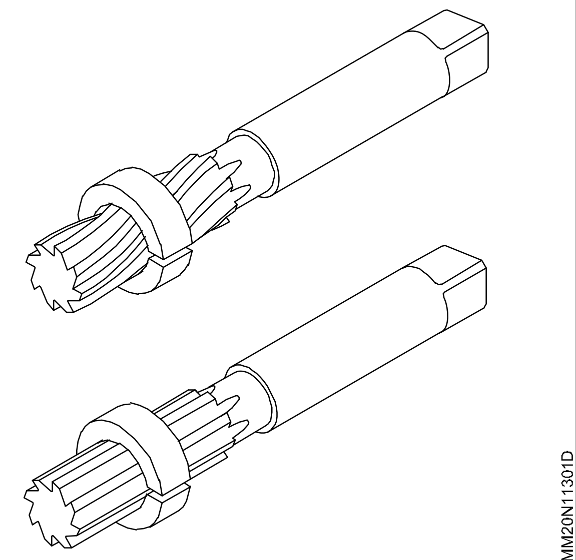
Fig 12



Use of straight and helical fluted reamers (Fig 13)

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 13



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 high 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.

Drill 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 practicedin 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

Oversize: It is generally considered that a twist drill will make a hole larger than its diameter. The oversize for calculation purposes is taken as 0.05 mm - for all diameters of drills.

For light metals the undersize will be chosen 50% larger.

Example: A hole is to be reamed on mild steel with a 10 mm reamer. What will be the diameter of the drill for drilling the hole before reaming?

Drill size = Reamed size – (Undersize + Oversize)

(Finished size) = 10 mm

Undersize as per table = 0.2 mm

Oversize = 0.05 mm

Drill size = 10 mm -- 0.25 mm

= 9.75 mm

Determine the drill hole sizes for the following reamers:

i 15 mm

ii 4 mm

iii 40 mm

iv 19 mm

Answer

i ______________________________

ii ______________________________

iii ______________________________

iv ______________________________

Note: If the reamed hole is undersize, the cause is that the reamer is worn out.

Always inspect the condition of the reamer before commencing reaming.

For obtaining good surface finish

Use a coolant while reaming. Remove metal chips from the reamer frequently. Advance the reamer slowly into the work.

Defects in reaming - Causes and Remedies

- **Reamed hole undersize**
  - If a worn out reamer is used, it may result in the reamed hole bearing undersize. Do not use such reamers.
  - Always inspect the condition of the reamer before using.
- **Surface finish rough**
  - The causes may be any one of the following or a combinations thereof.
  - Incorrect application
  - Swarf accumulated in reamer flutes
  - Inadequate flow of coolant
  - Feed rate too fast
  - While reaming apply a steady and slow feed-rate.
  - Ensure a continuous supply of the coolant.
  - Do not turn the reamer in the reverse direction.

Reaming

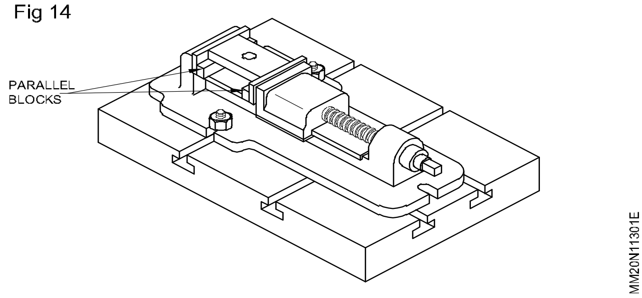
Reaming: Reaming is the operation of finishing and sizing a hole which has been previously drilled, bored, casted holes. The tool used is called a reamer, which has multiple cutting edges. Manually it is held in a tap wrench and reamed. Machine reamer are used in drilling machine using sleeves (or) socket. Normally the speed for reaming will be 1/3rd speed of drilling.

Hand Reaming

Drill holes for reaming as per the sizes determined.

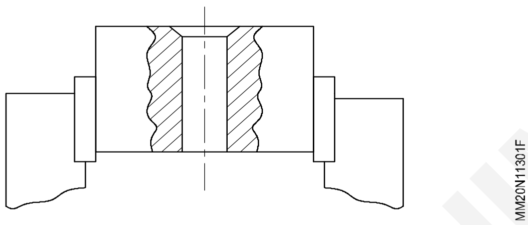
Place the work on parallels while setting on the machine vice. (Fig 14)

Fig 14



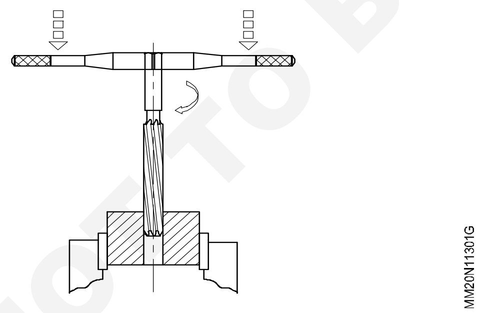
Chamfer the hole ends slightly. This removes burrs and will also help to align the reamer vertically. (Fig 15) Fix the work in the bench vice. Use vice clamps to protect the finished surfaces. Ensure that the job is horizontal. (Fig 15)

Fig 15



Fix the tap wrench on the square end and place the reamer vertically in the hole. Check the alignment with a try square. Make corrections, If necessary. Turn the tap wrench in a clockwise direction applying a slight downward pressure at the same time. (Fig 16) Apply pressure evenly at both ends of the tap wrench.

Fig 16

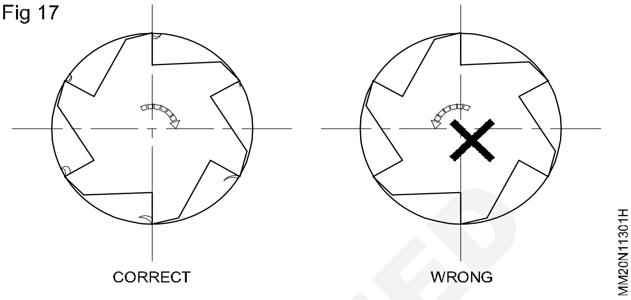


Apply cutting force: Turn the tap wrench steadily and slowly, maintaining the downward pressure.

Do not turn in reverse direction it will scratch the reamed hole. (Fig 17)

Ream the hole through, ensure that the taper lead length of the reamer comes out well and clear from the bottom of the work. Do not allow the end of the reamer to strike on the vice.

Fig 17

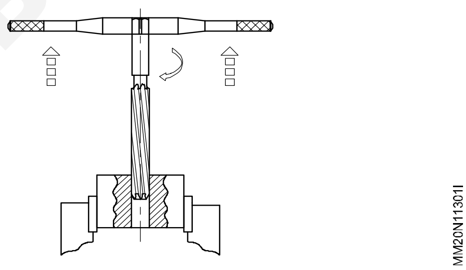


Remove the reamer with an upward pull until the reamer is clear of the hole. (Fig 18)

Remove the burrs from the bottom of the reamed hole.

Clean the hole. Check the accuracy with the cylindrical pins supplied.

Fig 18



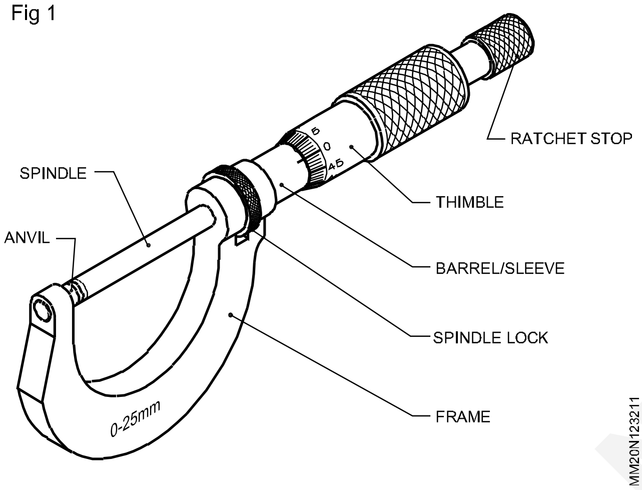
Micrometers

Objectives: At the end of this lesson you shall be able to
- **describe parts reading and constructional features of outside micrometer**
- **identify the parts and features of inside micrometer**
- **describe the parts and features of depth micrometer**
- **state the uses of digital micrometers.**

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)

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 beveled 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.

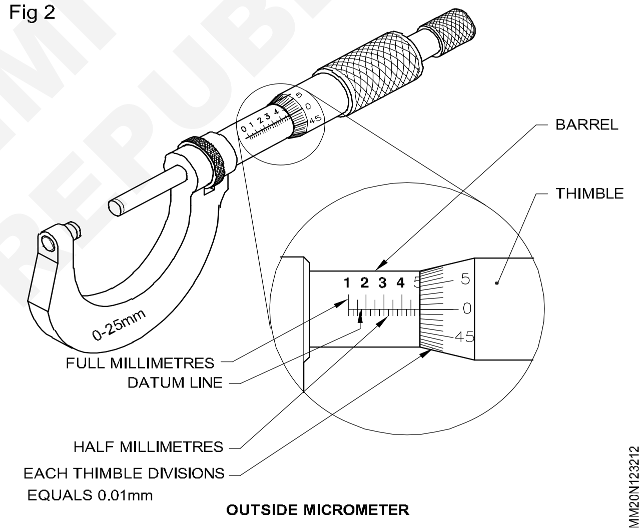
Graduations of metric outside micrometer

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 2)

Fig 2



In metric micrometers the pitch of the spindle thread is 0.5 mm.

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

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

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

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

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

= 0.01 mm

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

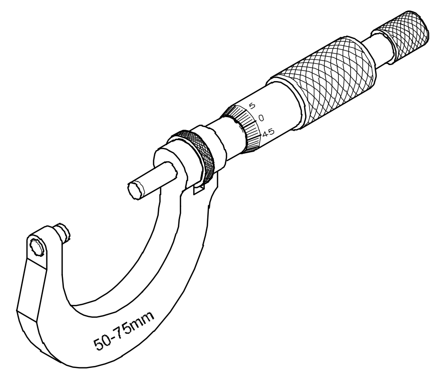
Reading dimensions with outside micrometer

Ranges of outside micrometer

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

For all ranges of micrometers, the graduations marked on the barrel is only 0-25 mm. (Fig 3)

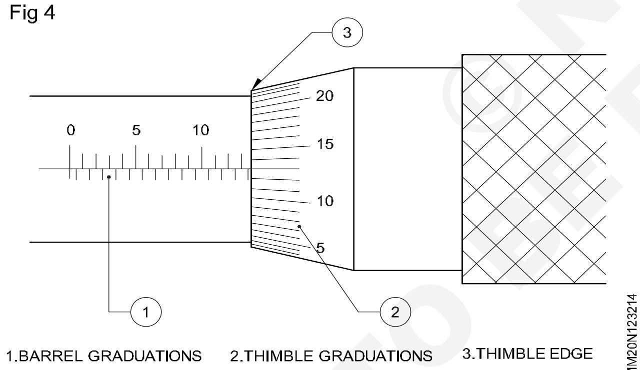
Fig 3



Reading micrometer measurements

How to read a measurement with an outside micrometer? (Fig 4)

Fig 4



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

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

13.00 mm (Main division reading on barrel)

+ 00.50 mm (Sub division reading on barrel)

13.50 mm (Main division + sub - division value)

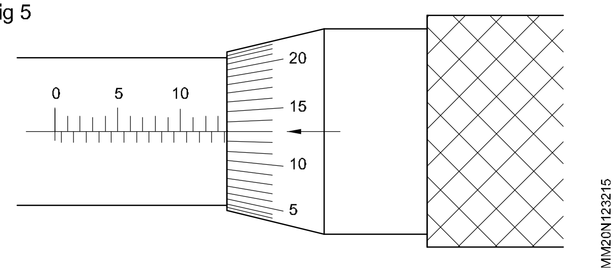
Next read the thimble graduations.

Read the thimble graduations in line with the barrel datum line, 13th div. (Fig 5)

Multiply this value with 0.01 mm (least count).

13 x 0.01 mm = 0.13 mm.

Fig 5



Add

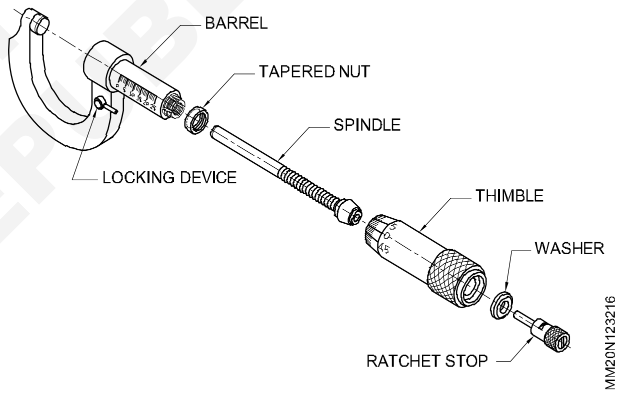
Minimum range	50.00 mm
Barrel reading	13.50 mm
Thimble reading	00.13 mm
Total	63.63 mm

The micrometer reading is 63.63 mm.

Constructional features of outside micrometer

In order to dismantle and carry out cleaning or adjustment of a micrometer, it is essential to know the functions of its various parts. (Fig 6)

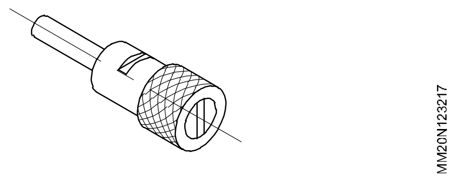
Fig 6



Ratchet stop (Fig 7)

This is a device fitted on micrometers to ensure uniform pressure between the measuring face of the micrometer while measuring.

Fig 7



The ratchet stop will slip beyond certain pressure, thus preventing further advancement of the spindle when excessive pressure is used.

This is mounted on the thimble of the micrometer, and it connects with the spindle when assembled.

A special spanner is provided along with the micrometer for fixing and removing the ratchet stop. (Fig 8)

Thimble: The thimble has a hollow taper (Fig 9) to match with the taper nose fitted on the spindle.

Fig 8

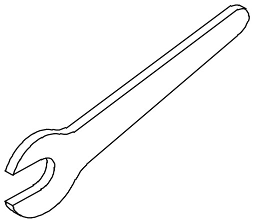
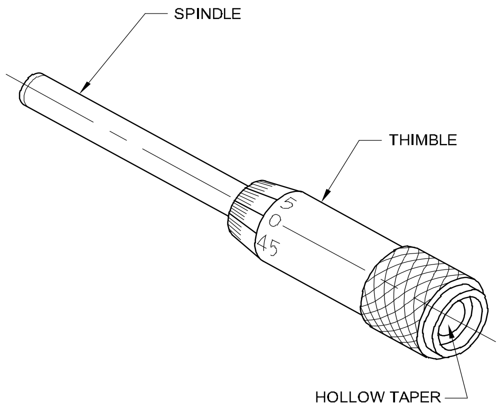


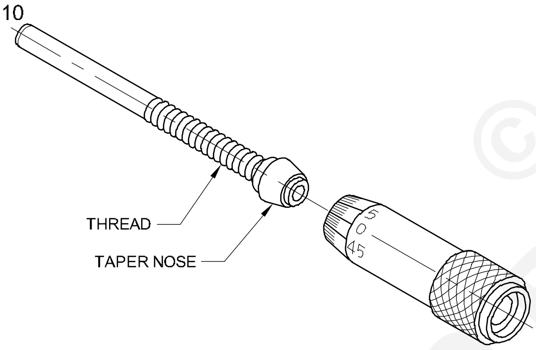
Fig 9



Spindle

One end of the spindle forms the measuring face. The other end of the spindle is threaded, the tapered nose is fitted on it. (Fig 10)

Fig 10



The taper nose is very accurately finished for axial alignment and it also permits positioning of the thimble in any required place during the adjustment of zero error.

The spindle passes through a split internal thread (Fig 11) which forms part of the barrel. The outer portion of this split internal thread has tapered external threads. A taper threaded nut is fitted on this.

Tightening and loosening of this nut enables the spilt internal thread to close or open. This permits the wear adjustment in the mating threads.

A special spanner is provided for this purpose. (Fig 12)

The locking device provided on the spindle is to arrest the movement of the spindle after taking the measurement.

Precautions while dismantling micrometers

Avoid touching the measuring faces with bare fingers as it might cause rusting.

Fig 11

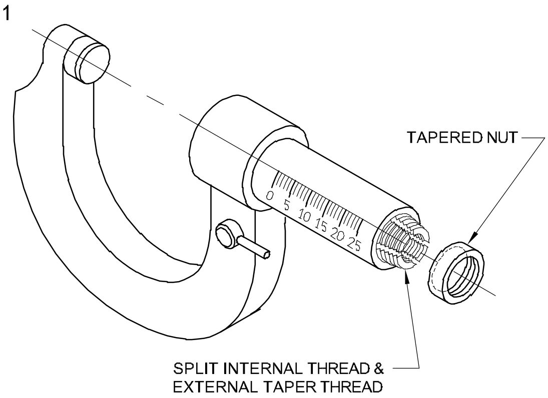
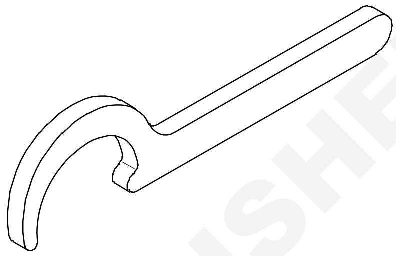


Fig 12



Protect the components of the micrometer free from dust while dismantling and assembling.

Use carbon tetrachloride for cleaning the parts after dismantling.

While assembling - apply a few drops of thin oil.

Do not use metallic surface for placing the parts after dismantling. An enameled tray is preferable.

Apply a thin coating of oil when placing the micrometer back after the adjustment.

Avoid frequent dismantling and assembling.

Inside micrometer

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

Purpose

An inside micrometer is used to measure the diameter of holes. (Fig 13)

To measure the distance between internal parallel surfaces like slots (Fig 14)

Parts (Fig 15)

The following are the parts of an inside micrometer

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

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

Locking Screw It is used to lock the extension rods.

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

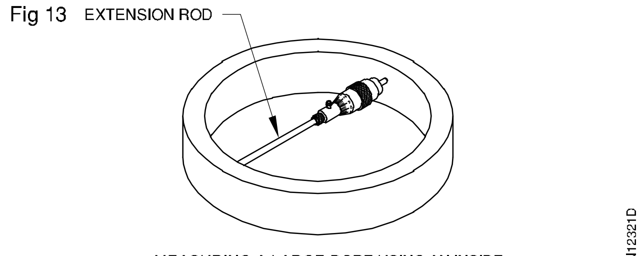


Fig 13 MEASURING A LARGE BORE USING AN INSIDE MICROMETER WITH AN EXTENSION ROD FITTED

Fig 14

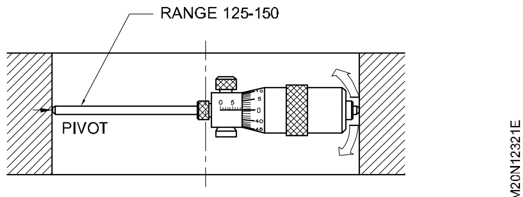
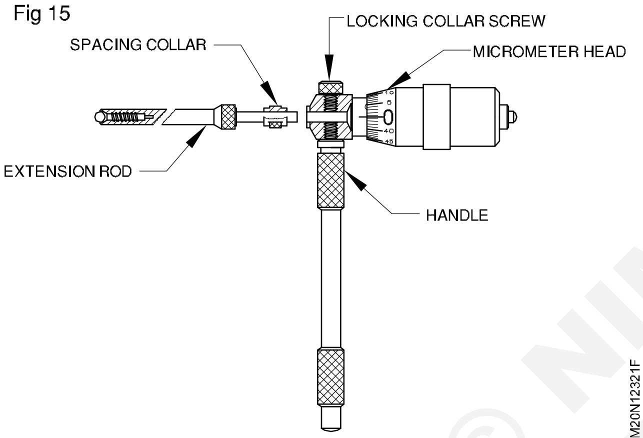


Fig 15



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

The range of inside micrometer

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

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

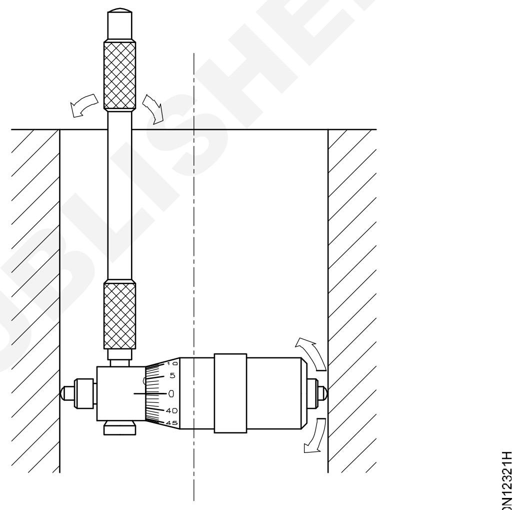
Inside micrometer

Ranges of extension rod for (50 - 200mm) Inside micrometer (Fig 16)

Checking parallelism of surfaces of deep bores

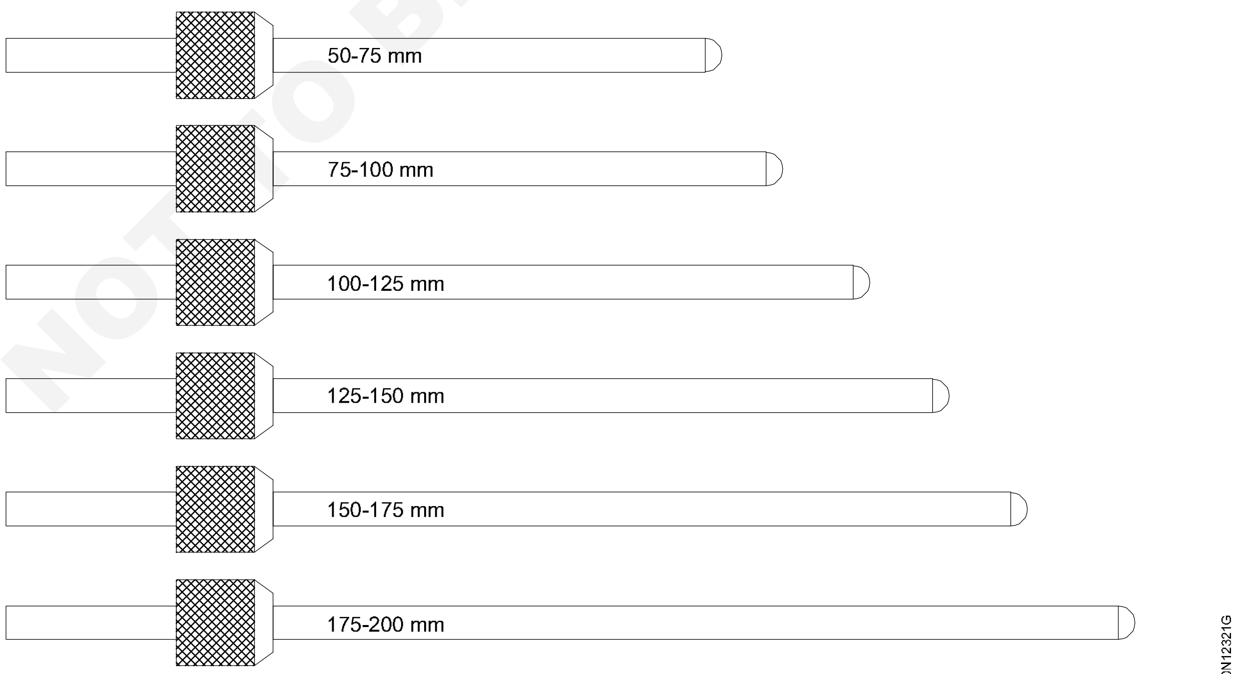
An extended handle can be used while measuring deep bores. (Fig 17) for checking the parallelism of surfaces of the bore.

Fig 17



USING AN EXTENDED HANDLE WHEN MEASURING THE BORE

Fig 16



EXTENSION RODS

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

Precautions

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

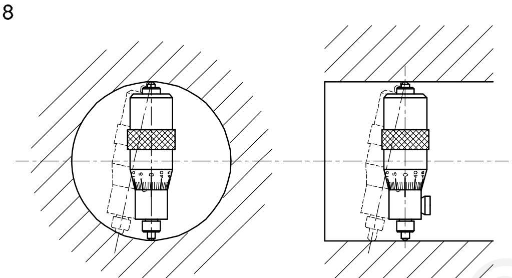
Check the ‘O” setting of the inside micrometer with an outside micrometer.

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

When measuring bores the micrometer must be set for the largest value. While measuring between flat surfaces, the micrometer should be set for the smallest value. (Fig 18)

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

Fig 18



MM20N12321I

Depth micrometer

Constructional features

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

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

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

The other end of the thimble has an external step machined and threaded to accommodate a thimble cap. (Fig 19)

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

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

The extension rods have a collar-head which helps the rod to be held firmly. (Fig 20)

Fig 19

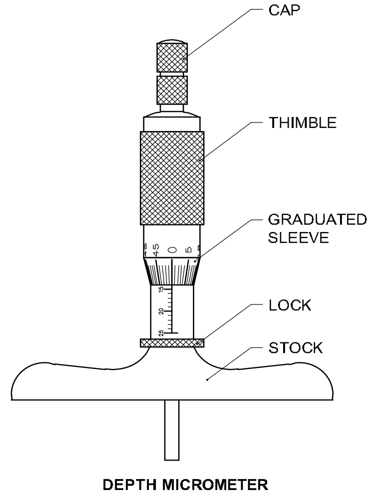
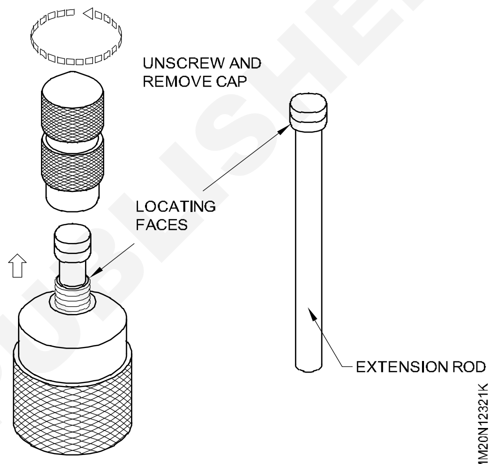


Fig 20



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

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

Graduation and least count

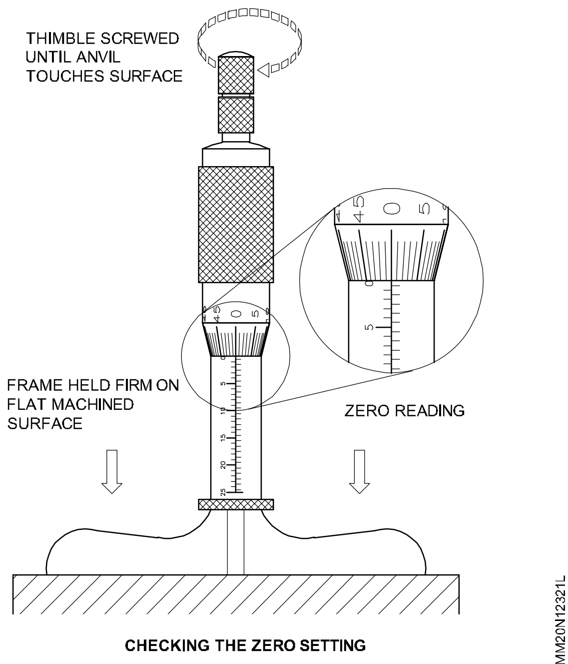
On the sleeve a datum line is marked for a length of 25 mm. This is divided into 25 equal parts and graduated, each line representing one millimetre. Each fifth line is drawn a little longer and numbered. Each line representing 1 mm is further subdivided into two equal parts. Hence each sub-division represents 0.5 mm. (Fig 21)

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

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

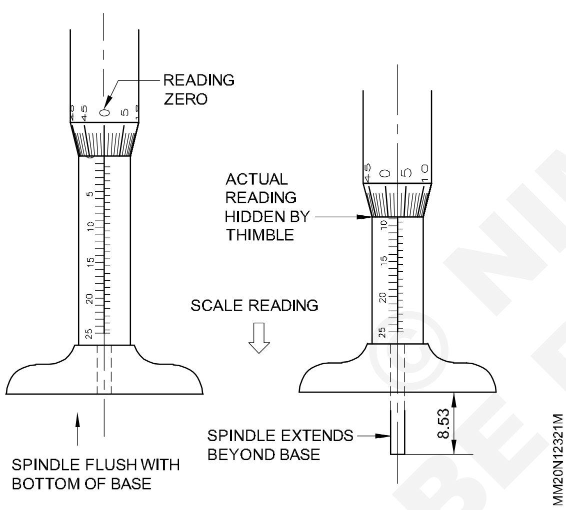
The bevel edge of the thimble is also graduated. The circumference is equally divided into 50 equal parts and every 5th division line is drawn a little longer and numbered. The numbering is in the reverse direction and increases from 0, 5,10,15, 25, 30, 35, 40,45 and 50 (0). (Fig 22)

Fig 21



CHECKING THE ZERO SETTING

Fig 22



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

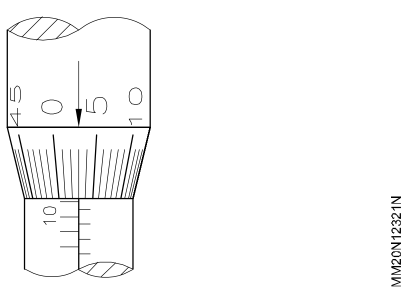
Therefore, the advancement of the extension rod for one division movement of the thimble will be equal to 0.5 / 50 = 0.01 mm.

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

Reading of depth micrometer (Fig 23)

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

Fig 23



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

Uses of depth micrometer

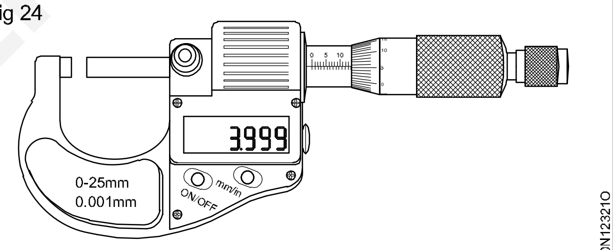
- Depth micrometers are special micrometers used to measure
- the depth of holes.
- the depth of grooves and recesses
- the heights of shoulders or projections.

Digital micrometers

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

Feature of digital micrometers (Fig 24)

Fig 24



FEATURE OF DIGITAL MICROMETERS

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

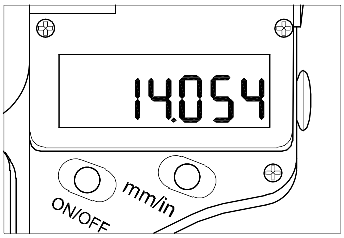
Accuracy of digital micrometers

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

Reading of the digital micrometer

The digital micrometers are provided with high precision reading with LCD display. The reading is 14.054 mm as shown in Fig 25.

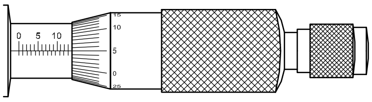
Fig 25



READING OF THE DIGITAL MICROMETERS

Reading also by reading the marks on the sleeve and the thimble. Usually, the reading from the large LCD display for the digital micrometer because the digital reading is more accurate. The reading on the sleeve and the thimble is just for reference. Read the markings on the sleeve and the thimble, firstly, read the point which the thimble stops at it on the right of the sleeve (It is 14mm here, because each line above the centre long line represents 1mm while each line below the centre long line represent 0.5mm) (Fig 26)

Fig 26



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

Maintenance of a digital micrometers

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

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

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

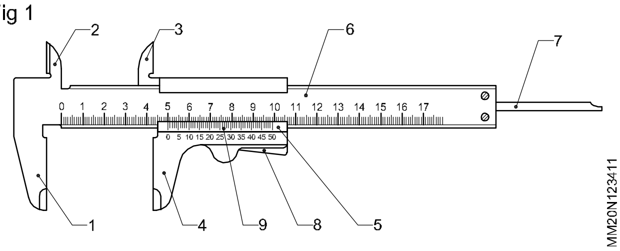
Flashing display shows dead battery. If this is the case please replace the battery at once. No displace shows poor contact of a battery or short circuit of both poles of the battery. Please check and adjust pole flakes and battery insulator cover. In case water enters the battery cover, open the cover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

Vernier calipers

Objectives : At the end of this lesson you shall be able to
- **name the parts of a vernier caliper**
- **state how the graduations made on vernier calipers**
- **state the uses of a vernier caliper**
- **parts and function of vernier height gauge.**

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

Fig 1



Parts of a vernier caliper

(Numbers as per Fig 1)

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

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

Fig 2

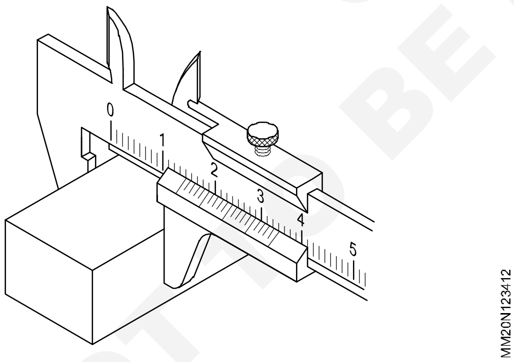
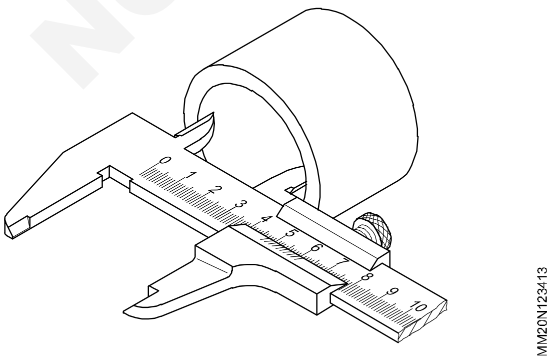


Fig 3

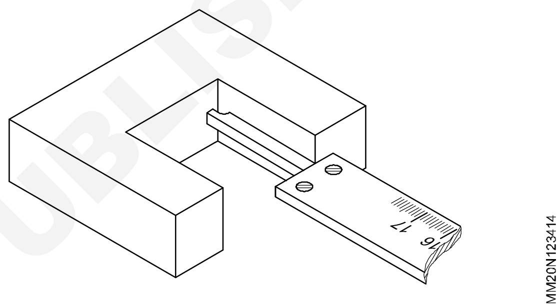


Vernier slide (5): A vernier slide moves over the beam and can be set in any position by means of a spring-loaded thumb lever.

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

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

Fig 4



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

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

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

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

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

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

They should never be mixed with any other tools.

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

Graduations and reading of vernier calipers

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

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

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

Determining the least count of vernier calipers: In the vernier caliper shown in (Fig 5) the main scale divisions (9 mm) are divided into 10 equal parts in the vernier scale.

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

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

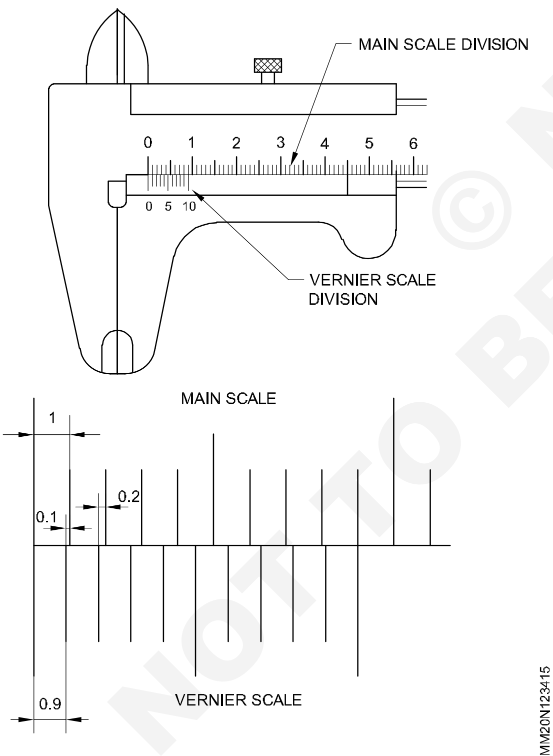
Least count = 1 MSD - 1 VSD

= 1 mm - 9/10 mm

= 0.1 mm

The difference between one MSD and one VSD = 0.1 mm

Fig 5



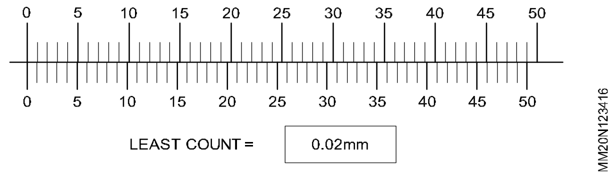
Reading vernier measurements: Vernier calipers are available with different graduations and least counts. For reading measurements with a vernier caliper, the least count should be determined first. (The least count of calipers is sometimes marked on the vernier slide)

Fig 6 shows the graduations of a common type of vernier caliper with a least count of 0.02 mm. In this, 50 divisions of the vernier scale occupy 49 divisions (49 mm) on the main scale.

Example

Calculate the least count of the vernier given in Fig 6.

Fig 6



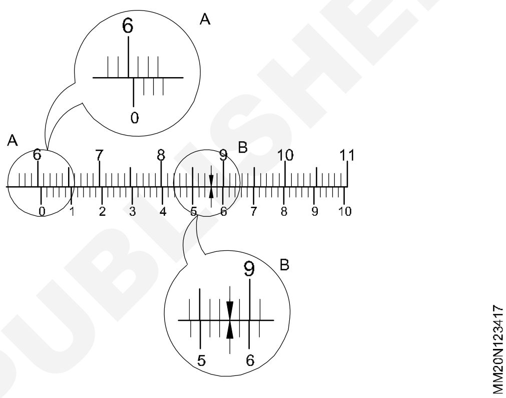
Least count = 1 mm - 49/50 mm

= 1/50 mm

= 0.02 mm.

Example for reading vernier caliper (Fig 7)

Fig 7



Main scale reading = 60 mm

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

= 0.56 mm

Reading = 60 + 0.56

Total Reading = 60.56 mm

Vernier height gauge

Specific uses of a vernier height gauge

Accurate measurements are important in layout (marking off) and inspection work. (Figs 8 & 9)

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.

Parts of a vernier height gauge and their functions

The main parts of a vernier height gauge and their functions are given here. (Fig 10)

Base (1)

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

Fig 8

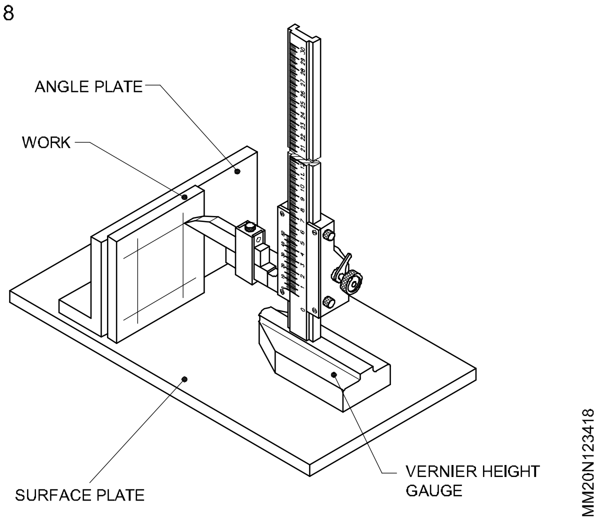


Fig 9

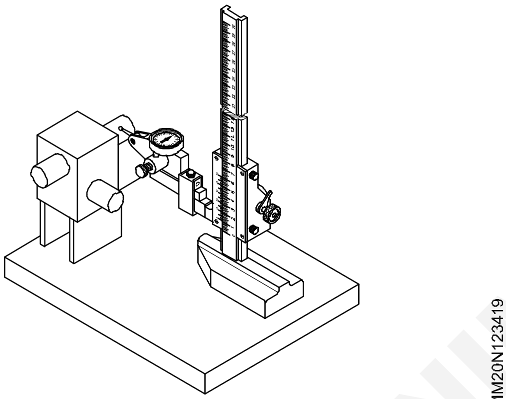
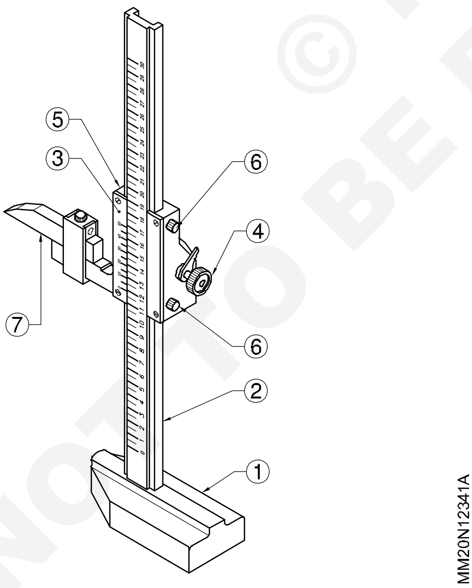


Fig 10



Beam (2)

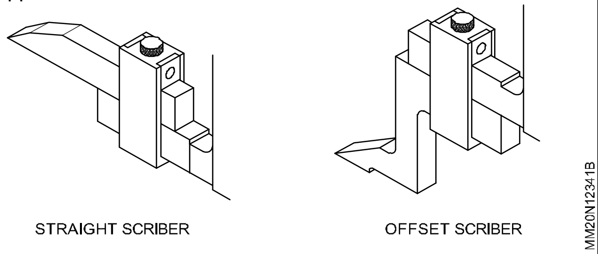
This is similar to the beam scale of a vernier caliper and is attached to the base.

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 11)

Fig 11



Zero setting of the vernier height gauge.

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

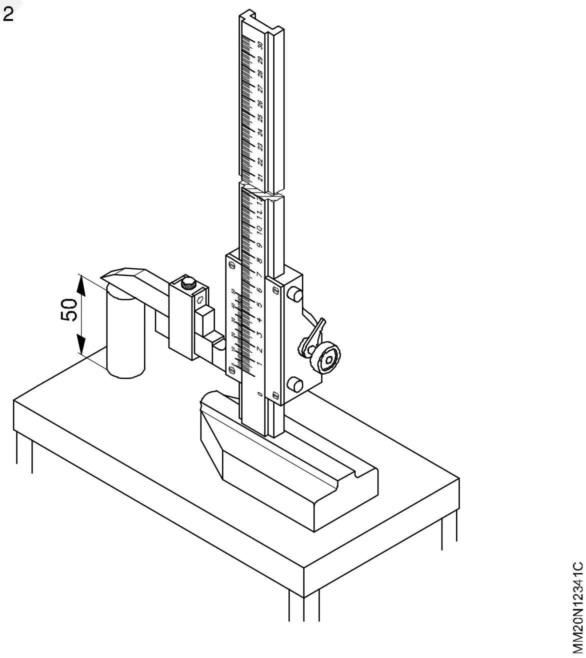
While using a straight scriber, the zero setting of the instrument is at a level above the datum surface. In this case the zero setting is to be checked using the precision round block, supplied along with the instrument.

Vernier height gauges with which we can measure from the datum surface without the special offset scribers are also available. (Fig 12)

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 12



Vernier bevel protractor

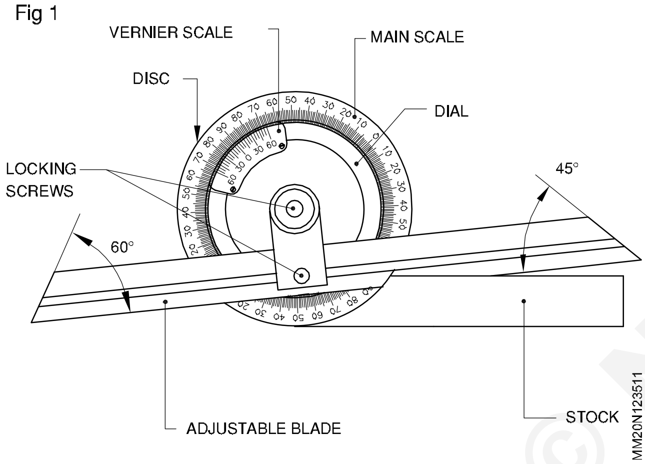
Objectives : At the end of this lesson you shall be able to
- **name the parts of a vernier bevel protractor**
- **state the Graduations on universal bevel protractor**
- **list out the uses of a vernier bevel protractor**
- **read the acute and obtuse angles in universal bevel protractor.**

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

Parts of a vernier bevel protractor

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

Fig 1



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

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

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

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

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

Uses of a vernier bevel protractor: Apart from being used for measuring angles a vernier bevel protractor is also used for setting work-holding devices on machine tools, work-tables etc.

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

Fig 2

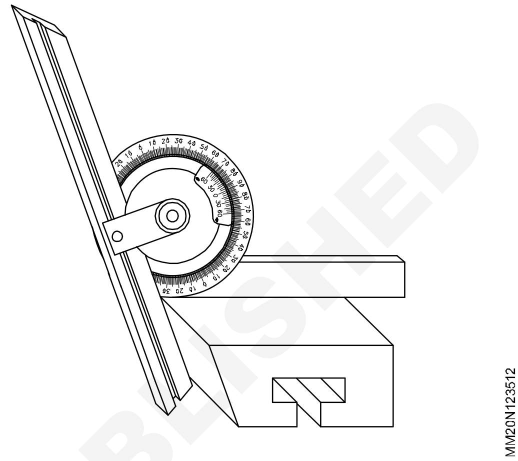
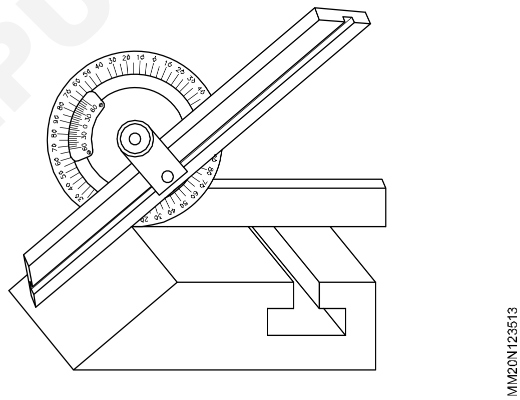


Fig 3



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

Fig 4

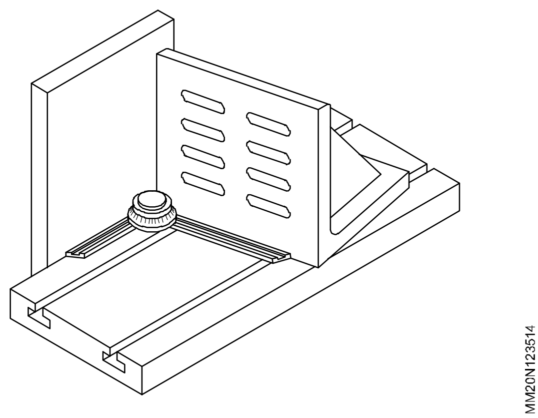
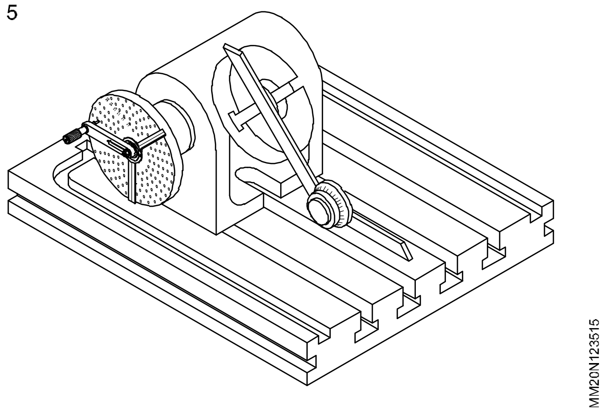


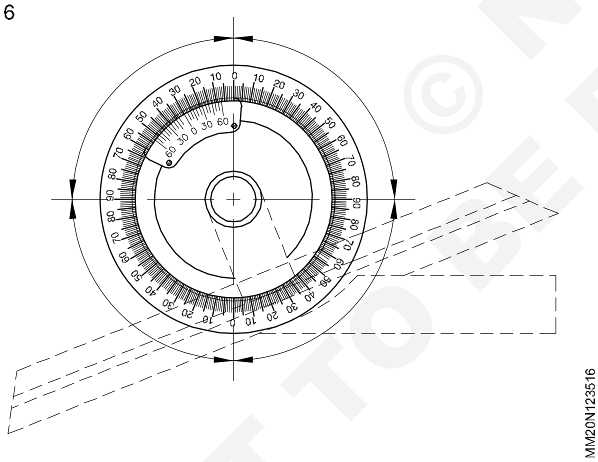
Fig 5



Graduations on universal bevel protractor

The main scale graduations (Fig 6 &7): For purposes of taking angular measurements, the full circumference of the dial is graduated in degrees. The 360° are equally divided and marked in four quadrants, from '0' degree to 90 degrees, 90 degrees to '0' degree. Every tenth division is marked longer and numbered. Each division represents 1 degree. The graduations on the dial are known as the main scale divisions. On the disc, 23 divisions spacing of the main scale is equally divided into 12 equal parts on the vernier. Each 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 6)

Fig 6



One vernier scale division VSD (Fig 7)

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 7)

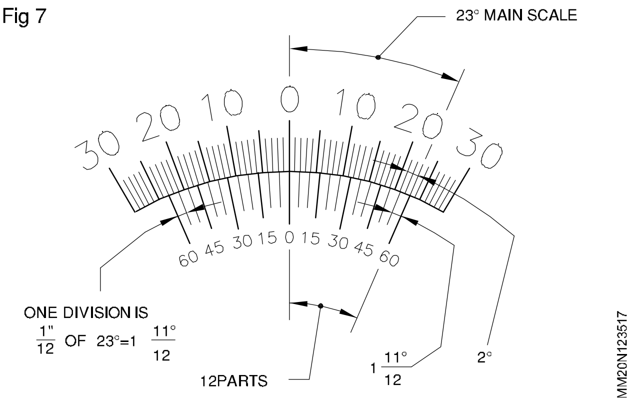
Hence the least count is

2 MSD - 1 VSD

i.e the least count = $2^\circ - \frac{23^\circ}{12}$

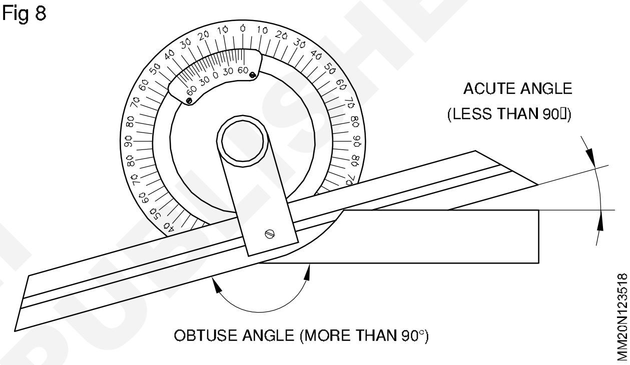
$= \frac{24}{12} - \frac{23^\circ}{12} = \frac{1^\circ}{12}$ or 5'

Fig 7



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 8)

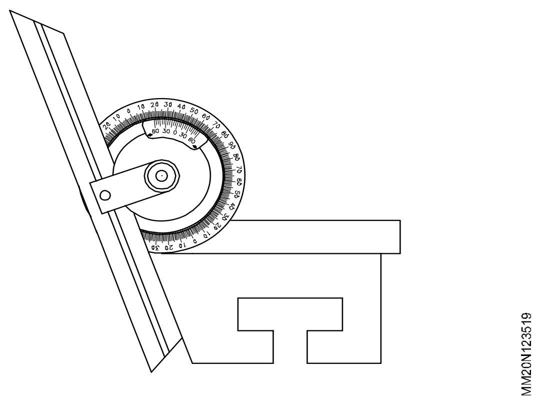
Fig 8



Reading of universal bevel protractor

For reading acute angle set up (Fig 9)**:** First read the number of whole degrees between zero of the main scale and zero of the vernier scale.

Fig 9



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 10)

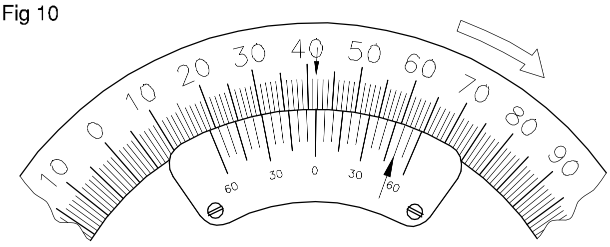
To take the vernier scale reading, multiply the coinciding divisions with the least count.

Example

10 x 5' = 50'

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

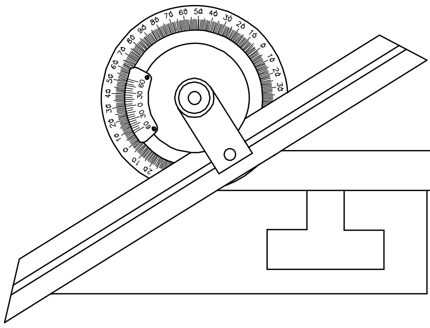
Fig 10



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

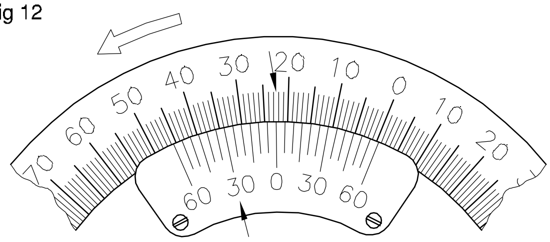
For obtuse angle set up (Fig 11**)**

Fig 11



The vernier scale reading up is taken on the left side as indicated by the arrow (Fig 12). The reading value is subtracted from 180° to get the obtuse angle value.

Fig 12



Reading 22° 30’

Measurement 180°-22°30’=157”30’

Care and maintenance of vernier bevel protractor

1 Clean the vernier bevel protractor before use.

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

3 While taking a measurement apply light pressure on vernier bevel protractor

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

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

Fig 2

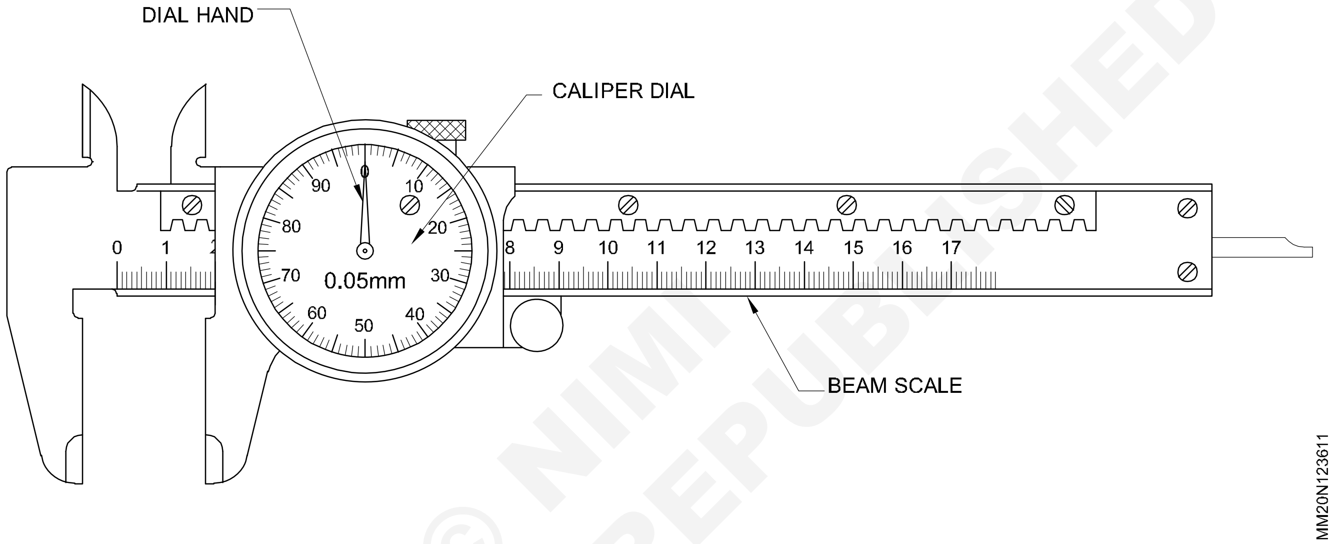
Dial Caliper

Objectives: At the end of this lesson you shall be able to
- **state the advantages of a dial caliper over a vernier caliper**
- **state the constructional features of a dial caliper**
- **read the dial caliper.**

A dial caliper is a direct reading instrument which resembles the vernier caliper. It is faster and easier to read a dial caliper than to read the traditional vernier caliper. (Fig 1)

The beam scale is graduated into 5mm increments on 0.05 mm accuracy caliper

Fig 1



Constructional features of dial caliper

The resemblance of a dial caliper is similar to normal Vernier caliper, but with additional construction of a rack mounted over the beam scale which is engaged to a pinion of the dial. The dial pointer is actuated by the movable action of vernier slide unit fixed with dial gauge.

The caliper dial on the movable jaw is graduated into 100 equal divisions. The hand of the dial makes one complete revolution for each 5 mm. Therefore, each dial graduation represents 1/100th of 5mm or 0.05 mm.

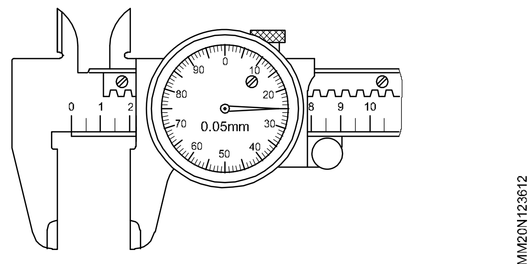
The dial hand is operated by a pinion that engages a rack on the beam.

Dial calipers are available in various sizes like vernier calipers. A dial caliper with 0.02 mm accuracy is also available.

For reading a measurement (Fig 2)

Read the beam scale reading (25 mm) and add the reading shown by the hand of the dial. 24 x 0.05 = 1.2mm

Fig 2



Reading = 25+1.2 mm = 26.2 mm.

Care and maintenance of dial caliper

1 Clean the dial caliper with a soft cloth before use.

2 Apply a small drop of oil to the beam, rack and pinion of the dial caliper to slide freely.

3 Check calibration of dial caliper, make sure that it is working correctly.

4 After using dial caliper, wipe it with a clean dry cloth, apply a thin coating of oil on sliding parts and keep it in safe place.

The digital caliper

Objectives : At the end of this lesson you shall be able to
- **state the uses of digital caliper**
- **name the parts of a digital caliper**
- **brief the zero setting of a digital caliper.**

The digital Caliper (sometime incorrectly called the digital vernier caliper) is a precision instrument that can be used to measure internal and external distance accurately to 0.01 mm, The digital vernier caliper is shown in fig 1, The distance or the measurements are read from LCD/ LED display. The parts of digital calipers are similar to the ordinary vernier caliper except the digital display and few other parts.

Part of Digital Caliper (Fig 1)

1.Internal jaws

2.External jaws

3.Power On / Off button

4.Zero Setting button

5.Depth measuring blade

6.Beam scale

7.LED/ LCD Display

8.Locking screw

9.Metric/Inch button.

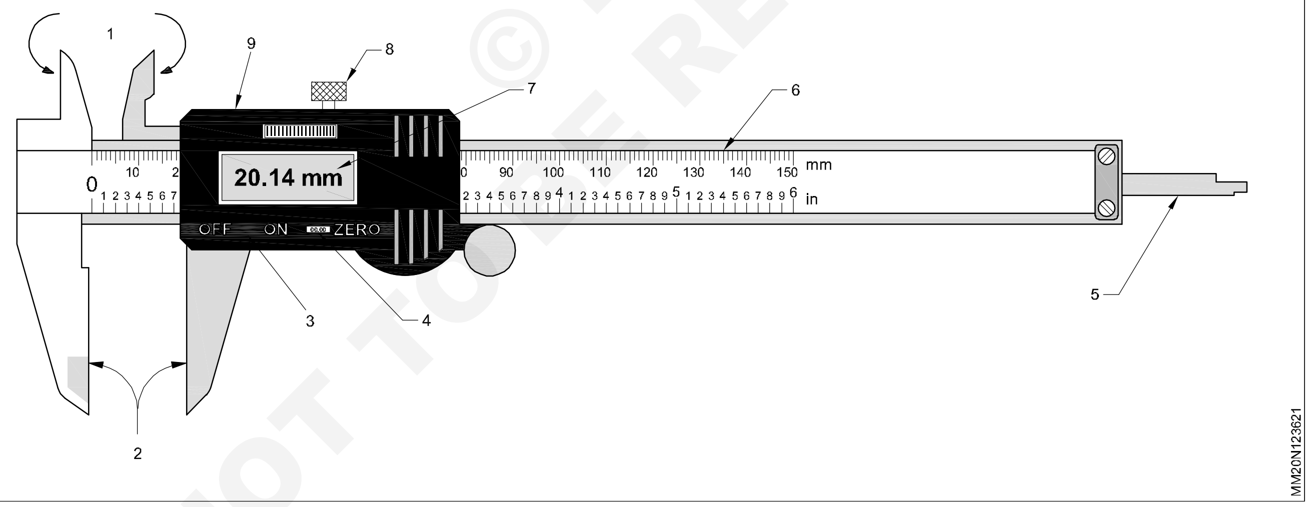
The digital caliper requires a small battery whereas the manual version does not need any power source. The digital calipers are easier to use as the measurement is clearly displayed and also, by pressing inch/mm button the distance can be read as metric or inch.

Zero setting of Digital Caliper

The display is turned on with the ON/OFF button. Before measuring, the zero setting to be done, by bringing the external jaws together until they touch each other and then press the zero button. Now the digital caliper is ready to use.

> **Caution**
>
> **Always set zero position when turning on the display for the first time.**

Fig 1



Pedestal grinder

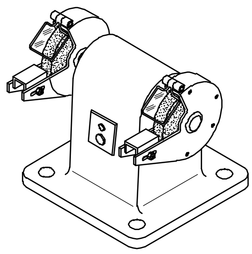
Objectives: At the end of this lesson you shall be able to
- **state the purposes of off-hand grinding**
- **name the machines with which off-hand grinding is done**
- **state the features of bench and pedestal grinders.**

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 rotating 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 grinders are fitted to a bench and pedestal (Figs 1 and 2)

Fig 1

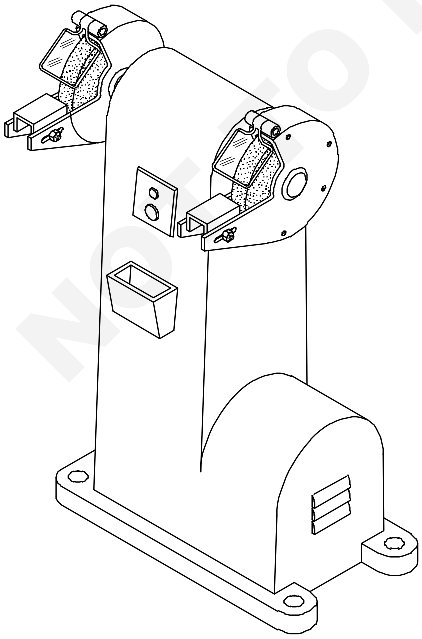


BENCH GRINDER

Bench grinders: Bench grinders are fitted on 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.

Fig 2

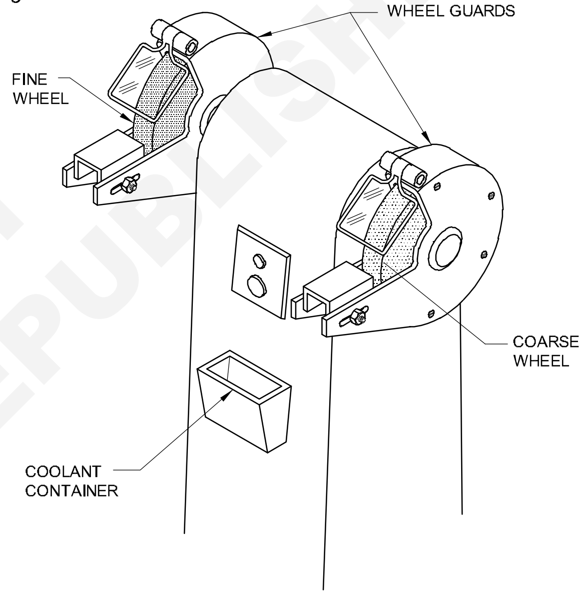


PEDESTAL GRINDER

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

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

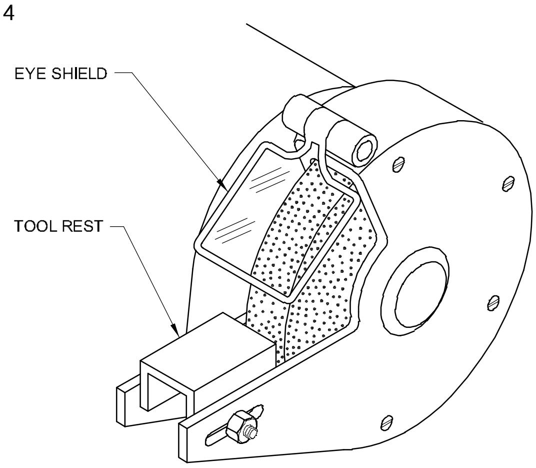
Fig 3



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

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

Fig 4



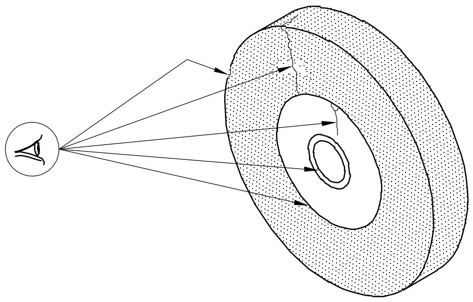
Wheel inspection and wheel mounting

Objectives: At the end of this lesson you shall be able to
- **brief steps involved in grinding wheel inspection and mounting**
- **state the Grinding wheel dressing and dressers.**

Wheel inspection: The wheel selected may have been damaged during transport or storage and must be carefully inspected before use.

Visual inspection (Fig 1)

Fig 1



CHECK FOR FAULTS

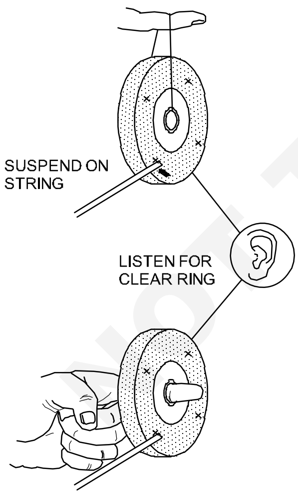
MM20N123811

Look for

- Broken or chipped edges.
- Cracks
- Damaged mounting bushing
- Damaged paper washers

Testing for cracks (Fig 2)

Fig 2



TAP GENTLY WITH WOODEN HANDLE AT SEVERAL POINTS

MM20N123812

Test a wheel for cracks by the following method

- Suspend the wheel on a piece of string or support it with one finger through the bushing.
- Allow the wheel to hang free.
- Tap the wheel with a non-metallic object such as a small wooden mallet or tool handle.
- A clear ringing sound indicates that the wheel is not cracked.
- A dull sound means that the wheel is cracked and must not be used.

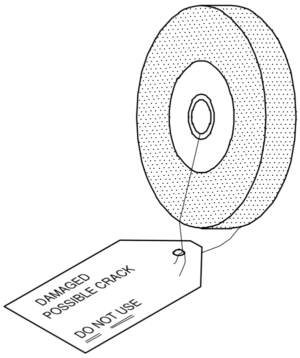
Warning

Discard any wheel that:

- **Shows any sign of damage.**
- **Does not ring clearly when struck.**

If you are in doubt, do not use the wheel. Clearly mark it and seek advice from your supervisor. (Fig 3)

Fig 3



MM20N123813

Mounting the grinding wheel (Fig 4)**:** For correct and safe operation of a grinding machine it is essential to mount the grinding wheel correctly on the spindle.

Before fitting a new wheel, make sure that the spindle is completely clean and free from surface irregularities.

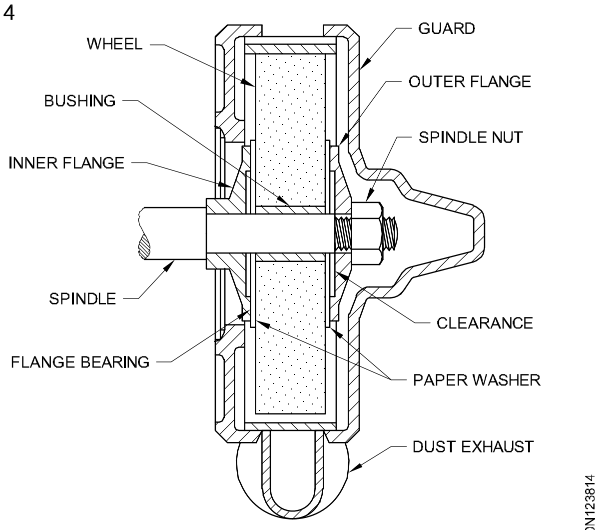
The spindle of the grinding machine includes an inner flange, an outer flange and a nut threaded on the spindle to hold the grinding wheel in position.

The inner flange must be fixed to rotate with the spindle.

Each flange has a dished face towards the surface of the wheel and has a true bearing surface at its area of contact.

Suitable paper discs are normally fitted to the wheel by the manufacturer.

Fig 4



GRINDING WHEEL CORRECTLY MOUNTED

Mounting procedure (Fig 5)

Mount the wheel on the spindle of the grinding machine as follows:

Check that the spindle surface is clean and free of irregularities. Clean with a dry cloth, if necessary.

Check that the inner flange is fixed to the spindle and that its bearing surface is clean and true.

Check that the wheel bush surface is clean and that it can fits easily, but not loosely, onto the spindle. Clean the bush before fitting the wheel on the spindle, if necessary.

Check that each side of the grinding wheel is fitted with a soft paper disc of slightly larger diameter than the spindle flanges.

Check that the diameter of each spindle flange is at least one third the diameter of the grinding wheel.

Fit the grinding wheel to the spindle and place the outer spindle flange in position.

Tighten the spindle nut against the outer spindle flange with a spanner of the correct size.

Replace the wheel guard correctly

Caution

The nut should only be tightened sufficiently to hold the wheel firmly. If it is tightened excessively, the wheel may break.

The nut is threaded onto the spindle in a direction opposite to the direction of rotation of the spindle.

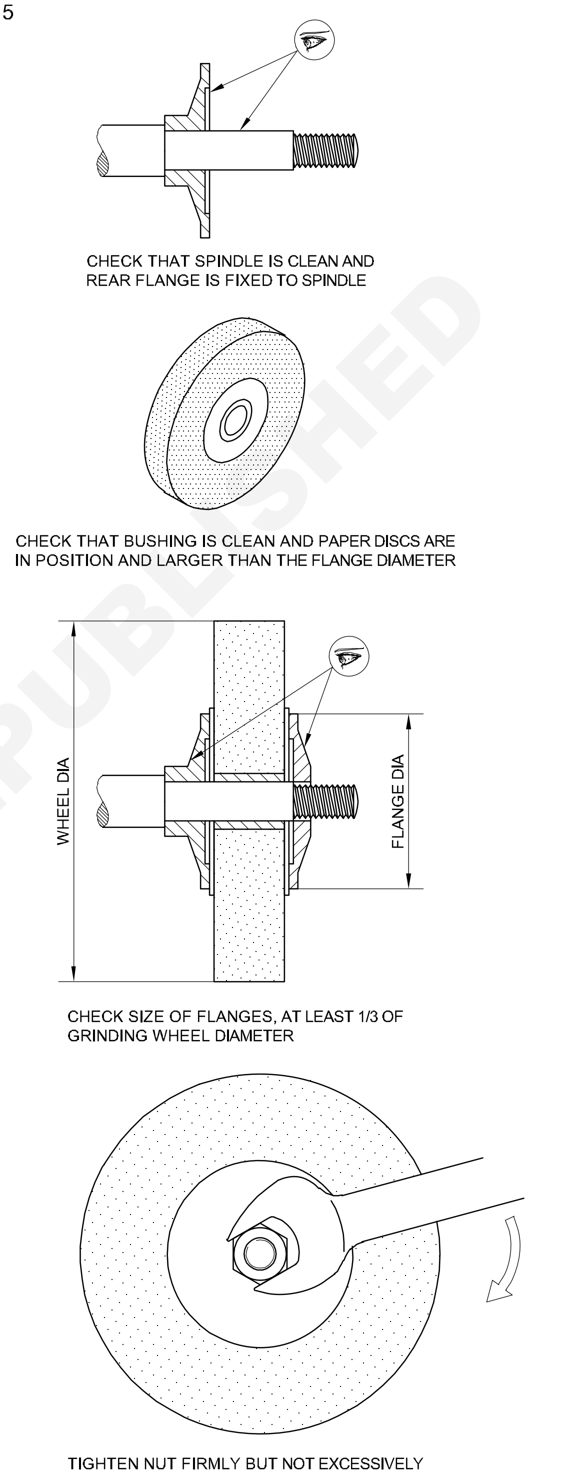
- Run the wheel at its recommended speed in the grinding machine for at least a minute. Do not use the wheel during this period.

Points to note

Study these illustrations carefully and note the points to watch when mounting grinding wheels. (Fig 6)

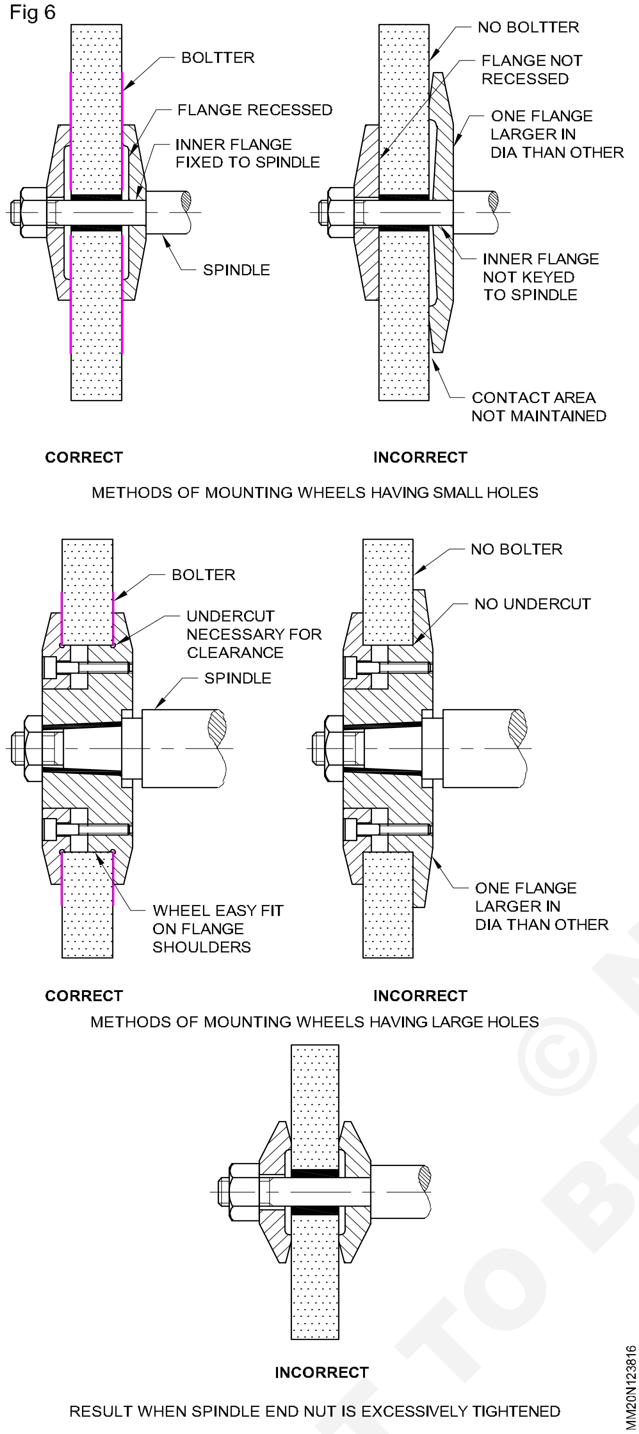
Washer of compressible material such as card board, leather, rubber etc, not more than 1.5mm thick should be fitted between the wheel and flanges. This prevents any unevenness of the wheel surface is balanced and the tight joint is obtained.

Fig 5



MOUNTING A GRINDING WHEEL ON A GRINDING MACHINE SPINDLE

Fig 6

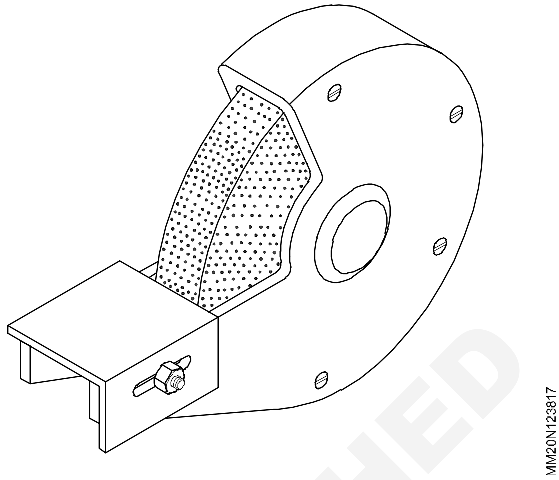


Grinding wheel dressing

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 7)

Fig 7



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 dried 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, also can run out of true, due to uneven loading while grinding.

Dressing and truing are done at the same time.

Grinding wheel dressers

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

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

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.

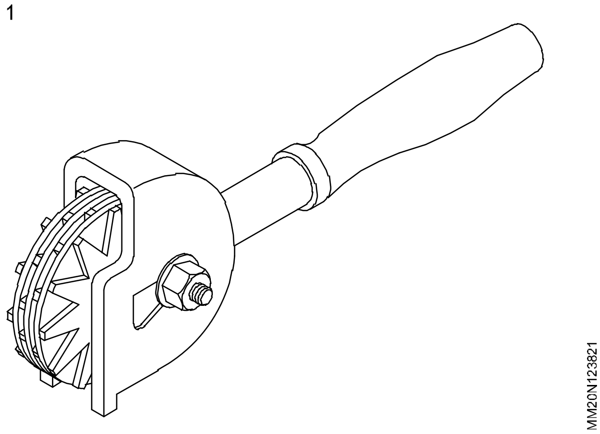


Fig 1

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.

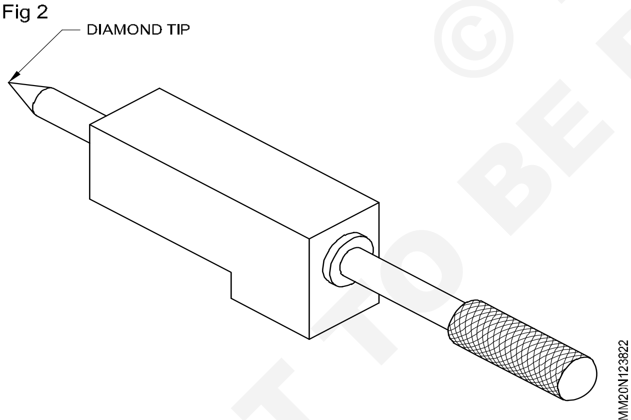
Star wheels are useful for pedestal grinders in which a precision finish is not expected.

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



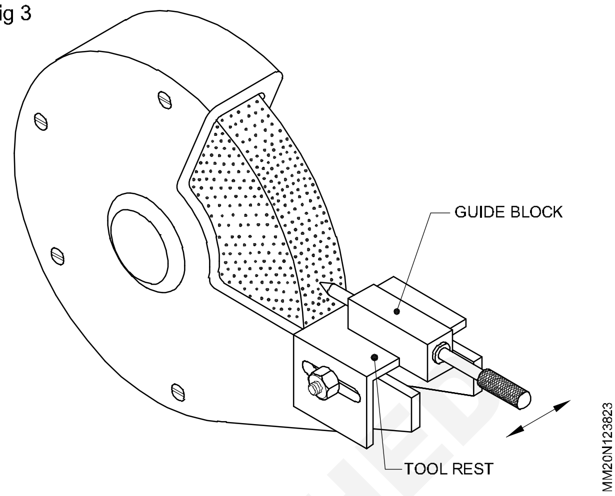
These wheels are dressed and trued with diamond dressers.

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 to contact with the wheel face and moved across.

Fig 3



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

For roughing, the dresser is moved faster.

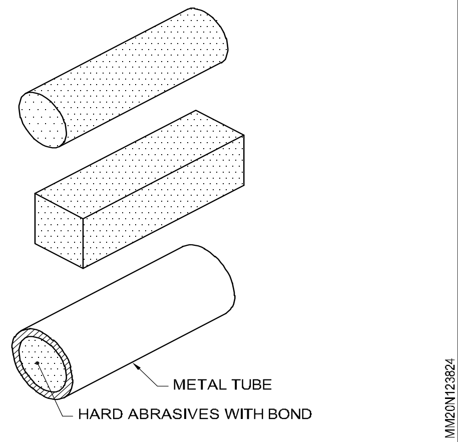
For fine finish, the dresser is moved slowly.

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

Abrasive stick (Fig 4): 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.

Fig 4



Drilling processes - Drilling Machines, Types, Use and Care

Objectives: At the end of this lesson you shall be able to
- **name the various types of drilling machines**
- **name the parts of the bench and pillar type drilling machines**
- **compare the features of the bench and pillar type drilling machines.**

The principle types of drilling machines are

– the sensitive bench drilling machine

– the pillar drilling machine

– the column drilling machine

– the radial arm drilling machine (radial drilling machine).

(You are not likely to use the column and radial type of drilling machines now. Therefore, only the sensitive and pillar type machines are explained here)

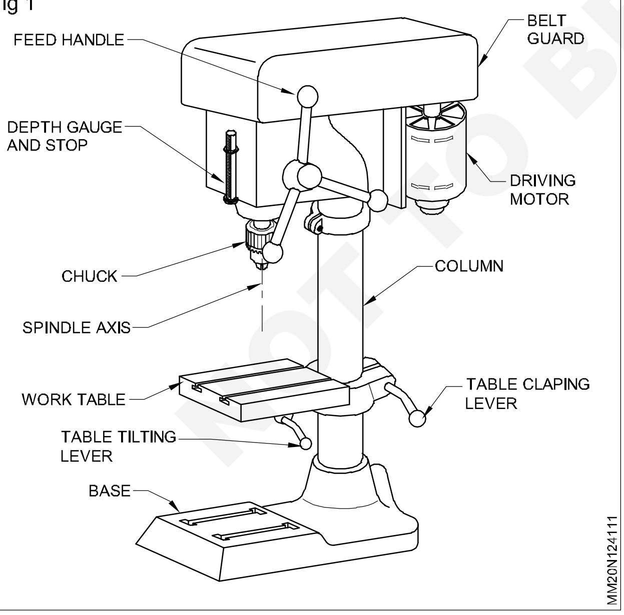
The sensitive bench drilling machine (Fig 1)

The simplest type of the sensitive drilling machine is shown in the figure with its various parts marked. This is used for light duty work.

This machine is capable of drilling holes up to 12.5 mm diameter. The drills are fitted in the chuck or directly in the tapered hole of the machine spindle.

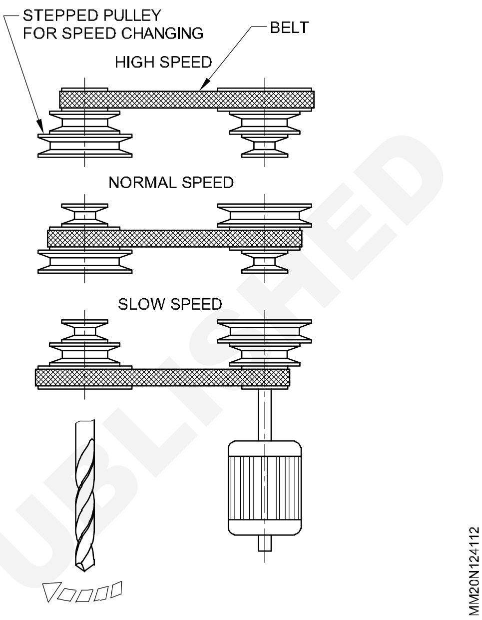
For normal drilling, the work-surface is kept horizontal. If the holes are to be drilled at an angle, the table can be tilted. (Tilting arrangement is shown in Fig.1)

Fig 1



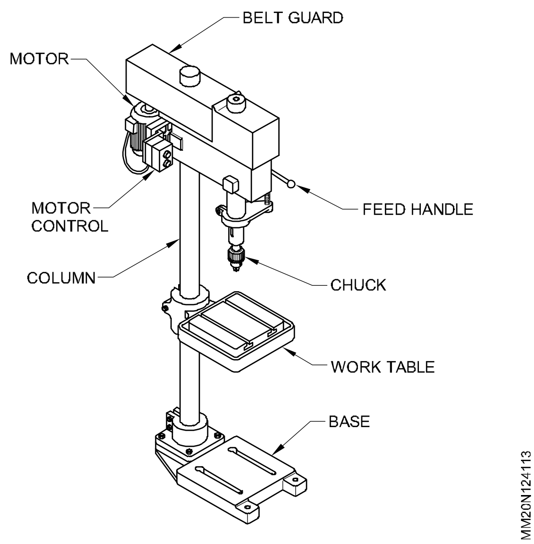
Different spindle speeds are achieved by changing the belt position in the stepped pulleys. (Fig 2)

Fig 2



The pillar drilling machine (Fig 3)**:** This is an enlarged version of the sensitive bench drilling machine. These drilling machines are mounted on the floor and driven by more powerful electric motors.

Fig 3



They are also used for light duty work. Pillar drilling machines are available in different sizes. The larger machines are provided with a rack and pinion mechanism to raise the table for setting the work.

Radial drilling machines

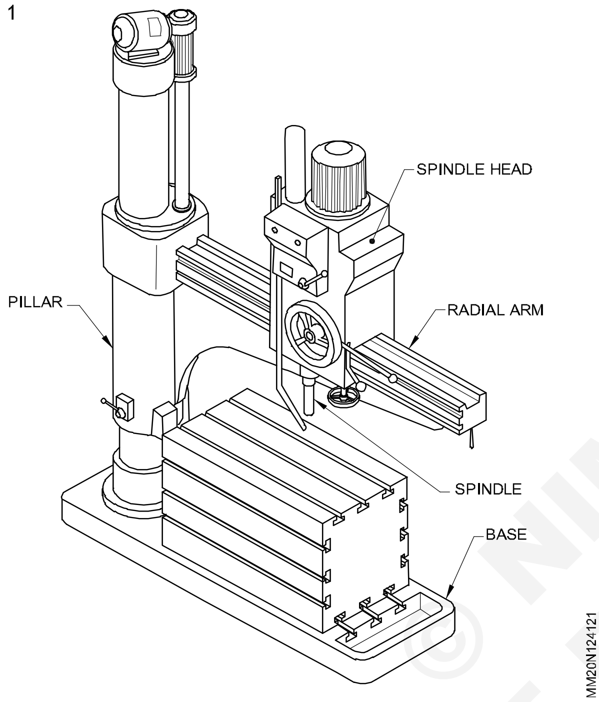
Objectives : At the end of this lesson you shall be able to
- **state the uses of a radial drilling machine**
- **state the features of radial drilling machine.**

Radial drilling machines are used to drill

- large diameter holes
- multiple holes in one setting of the work
- heavy and large workpieces.

Features (Fig 1)

Fig 1



The radial drilling machine has a radial arm on which the spindle head is mounted

The spindle head can be moved along the radial arm and can be locked in any position

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

The motor mounted on the spindle head rotates the spindle.

The variable-speed gear box provides a large range of R.P.M.

The spindle can be rotated in both clockwise and anticlockwise directions.

Angular holes can be drilled on machines having tilting tables.

A coolant tank is mounted on the base.

Precautions

Ensure that the spindle-head and the arms are locked properly to avoid vibration.

The workpiece and the drill should be rigidly held.

Bring back the spindle head nearer to the pillar after use.

Switch off power when not in use.

Use the drill drift for removing the drills, chucks or sockets.

Use a minimum number of sockets and sleeves to make for the spindle bore size.

Clean and oil the machine after use.

Stop the machine to remove the swarf.

Use a brush to clean the chips and swarf.

Gang drilling machine and multiple spindle head drilling machine

Objectives: At the end of this lesson you shall be able to
- **state the uses of a gang drilling machine**
- **state the construction of a gang drilling machine**
- **state the uses and construction of a multiple spindle head drilling machine.**

Gang drilling machine (Fig 1)

It consists of a large base supporting a long table. The top of the table is designed in such a way that several units may be mounted on it. Each spindle is driven by its individual directly connected motor.

The table has a groove around the outside for the return of the cutting lubricant, and may have 'T'-slots on its surface for ease in clamping the work to the table.

This type of machine is generally preferred when the work is to be moved from spindle to spindle for successive operations.

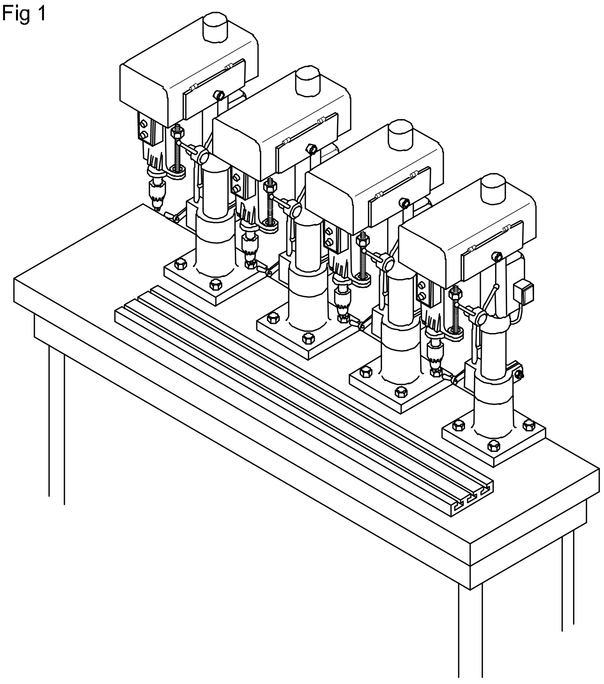
Multiple spindle head drilling machine (Fig 2)

The multiple spindle head drilling machine may have any number of spindles - from 4 to 48 or more, all driven from the one-spindle drive gear in one head.

The multiple spindle head drilling machine is specially designed for mass production operations such as drilling, reaming or tapping many holes at one time in a specific unit of work such as an automobile engine block.

There may be two or more drill heads on one machine, each with many spindles. This is necessary when holes are drilled from more than one direction - for example, on

Fig 1

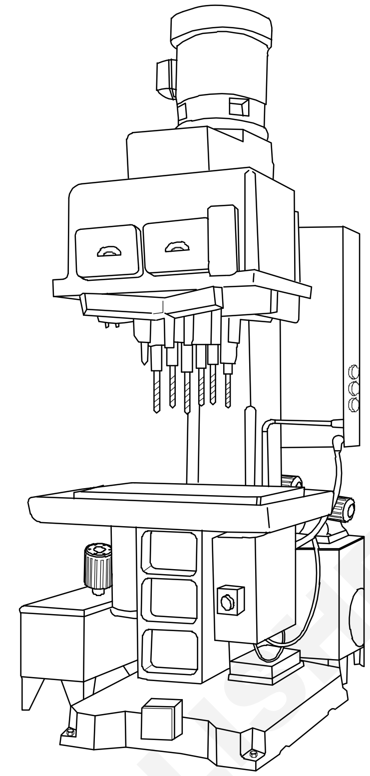


GANG OF FOUR DRILLING MACHINES

EACH MACHINE IS FITTED WITH A DIFFERENT CUTTING TOOL. AS THE WORK MOVES FROM POSITION TO POSITION A DIFFERENT OPERATION IS PERFORMED

the top side, and the end of a piece of work. Production units of this type are seldom used in a tool room that usually does highly skilled work.

Fig 2



THE DRILLING HEADS CAN BE POSITIONED TO MEET VARIOUS SPECIFICATIONS

Counter sinking

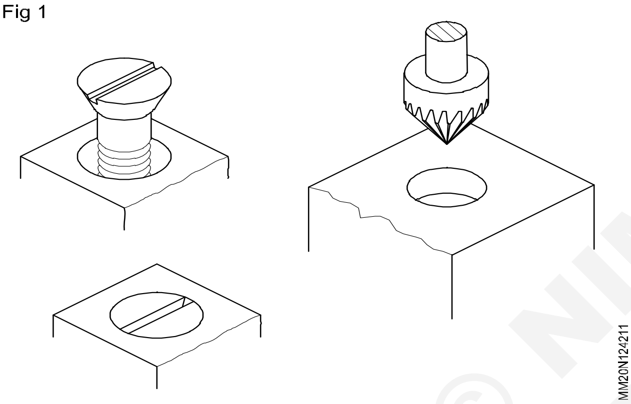
Objectives: At the end of this lesson you shall be able to
- **What is countersinking**
- **list the purposes of countersinking**
- **state the angles of countersinking for the different applications**
- **name the different types of countersinks**
- **distinguish between Type A and Type B counter sink holes.**

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

Countersinking is carried out for the following purposes:

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

Fig 1



- To deburr a hole after drilling
- For accommodating countersink rivet heads
- To chamfer the ends of holes for thread cutting and other machining processes.

Angles for countersinking

Countersinks are available in different angles for different uses.

75° countersink riveting

80° countersink self tapping screws

90° countersink head screws and deburring

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

Countersinks: Countersinks of different types are available.

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

For countersinking small diameter holes special countersinks with two or one flute are available. This will reduce the vibration while cutting.

Countersinks with Pilot (Fig 3)

For precision countersinking, needed for machine tool assembling and after machining process, countersinks with pilots are used.

Fig 2

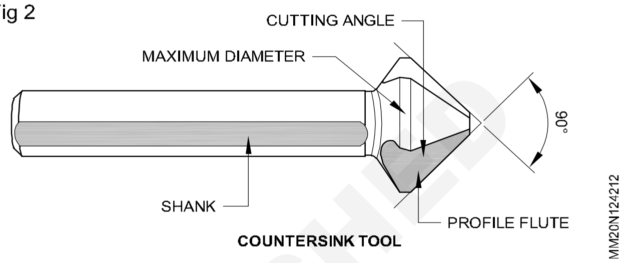
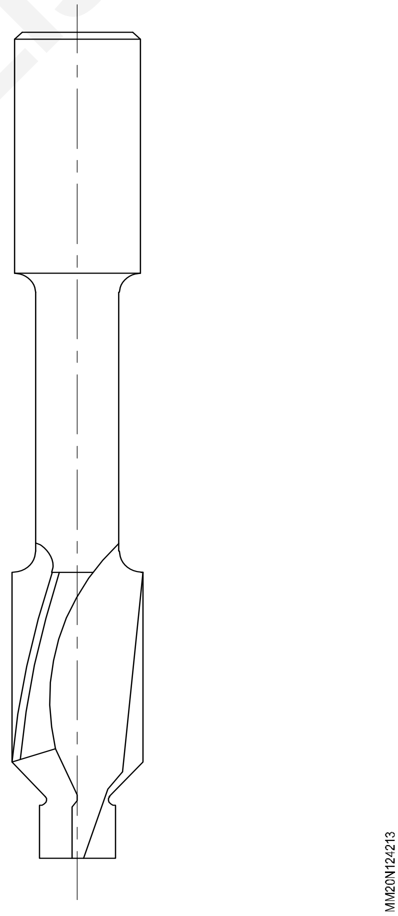


Fig 3



They are particularly useful for heavy duty work.

The pilot is provided at the end for guiding the countersink concentric to the hole.

Countersinks with pilots are available with interchangeable and solid pilots.

Countersink hole sizes: The countersink holes according to Indian Standard IS 3406 (Part 1) 1986 are of four types: Type A, Type B, Type C and Type E.

Type A is suitable for slotted countersink head screws, cross recessed and slotted raised countersink head screws.

These screws are available in two grades i.e. medium and fine.

The dimensions of various features of the Type 'A' countersink holes, and the method of designation are given in Table 1. (Fig 4 & 5)

Type 'B' countersink holes are suitable for countersink head screws with hexagon socket.

The dimensions of the various features and the method of designation are given in Table II. (Fig 6)

Type 'C' countersink holes are suitable for slotted raised countersink (oval) head tapping screws and for slotted countersink (flat) head tapping screws.

The dimension of the various features and the method of designation are given in Table III. (Fig 7)

Type 'E' countersinks are used for slotted countersink bolts used for steel structures.

The dimensions of the various features and the method of designation are given in Table IV. (Fig 8)

Dimensions and designation of countersink - Type A according to IS 3406 (Part 1) 1986

Fig 4

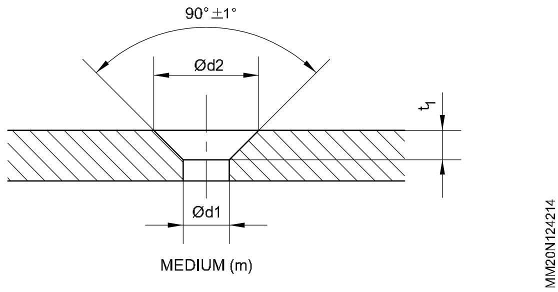


Fig 5

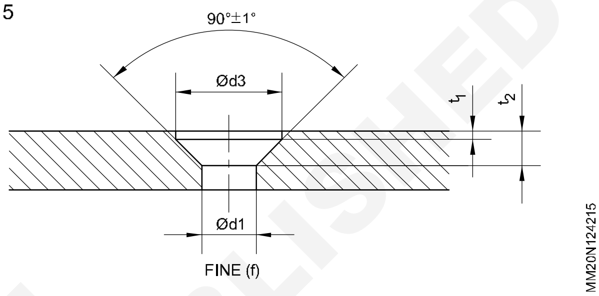


Table I

For Nominal Size		1	1.2	(1.4)	1.6	(1.8)	2	2.5	3	3.5	4	(4.5)
Medium	d_1 H13	1.2	1.4	1.6	1.8	2.1	2.4	2.9	3.4	3.9	4.5	5
Series	d_2 H13	2.4	2.8	3.3	3.7	4.1	4.6	5.7	6.5	7.6	8.6	9.5
(m)	$t_1\ ^{3}$	0.6	0.7	0.8	0.9	1	1.1	1.4	1.6	1.9	2.1	2.3
Fine	d_1 H12	1.1	1.3	1.5	1.7	2	2.2	2.7	3.2	3.7	4.3	4.8
Series	d_3 H12	2	2.5	2.8	3.3	3.8	4.3	5	6	7	8	9
(f)	$t_1\ ^{3}$	0.7	0.8	0.9	1	1.2	1.2	1.5	1.7	2	2.2	2.4
	$t_2 {}^{+0.1}_{0}$	0.2	0.15	0.15	0.2	0.2	0.15	0.35	0.25	0.3	0.3	0.3

For Nominal Size		5	6	8	10	12	(14)	16	(18)	20
Medium	d_1 H13	5.5	6.6	9	11	13.5	15.5	17.5	20	22
Series	d_2 H13	10.4	12.4	16.4	20.4	23.9	26.9	31.9	36.4	40.4
(m)	$t_1\ ^{3}$	2.5	2.9	3.7	4.7	5.2	5.7	7.2	8.2	9.2
Fine	d_1 H12	5.3	6.4	8.4	10.5	13	15	17	19	21
Series	d_3 H12	10	11.5	15	19	23	26	30	34	37
(f)	$t_1\ ^{3}$	2.6	3	4	5	5.7	6.2	7.7	8.7	9.7
	$t_2 {}^{+0.1}_{0}$	0.2	0.45	0.7	0.7	0.7	0.7	1.2	1.2	1.7

Note 1 : **Size shown in brackets are of second preference.**

Note 2 : Clearance hole d_1 according to medium and fine series of IS : 1821 ' Dimensions for clearance holes for bolts and screws (second revision)'

Designation : A countersink Type A with clearance hole of fine (f) series and having nominal size 10 shall be designated as – Countersink A f 10 - IS : 3406.

Table II

Dimensions and designation of countersink - Type B according to IS 3406 (Part 1) 1986

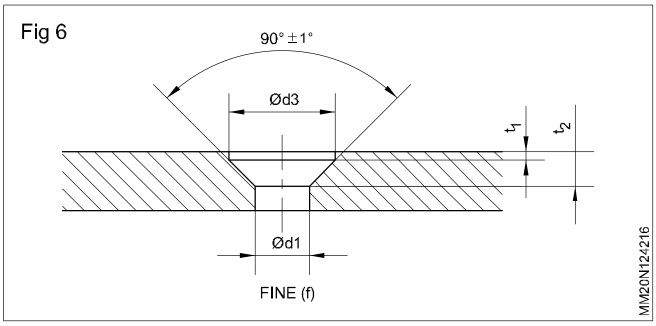


Fig 6

For Nominal Size		3	4	5	6	8	10	12	(14)	16	(18)	20	22	24
Fine	d1 H12	3.2	4.3	5.3	6.4	8.4	10.5	13	15	17	19	21	23	25
Series	d2 H12	6.3	8.3	10.4	12.4	16.5	20.5	25	28	31	34	37	48.2	52
(F)	t1 ³	1.7	2.4	2.9	3.3	4.4	5.5	6.5	7	7.5	8	8.5	13.1	14
	t2 + 0.1	0.2	0.3			0.4	0.5						1	

Note 1: **Sizes shown in brackets are of second preference.**

Note 2: Clearance hole d1 according to medium and fine series of IS : 1821- 1982.

Designation : A countersink Type A with clearance hole of fine (f) series and having nominal size 10 shall be designated as – Countersink A f 10 - IS : 3406.

Table III

Dimensions and designation of countersink - Type C according to IS 3406 (Part 1) 1986

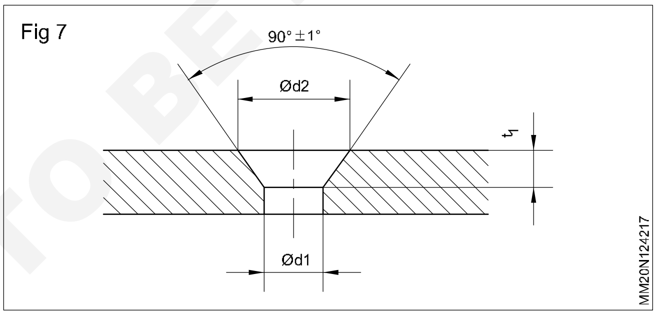


Fig 7

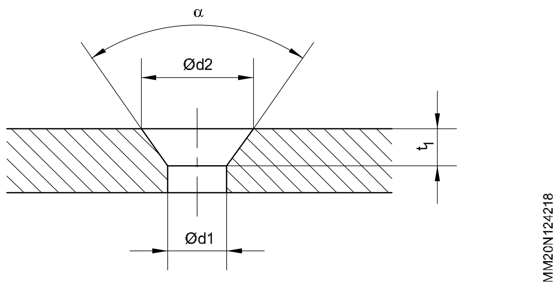
For Screw Size No.	(0)	(1)	2	(3)	4	(5)	6	(7)	8	10	(12)	14	(16)
d1 H12	1.6	2	2.4	2.8	3.1	3.5	3.7	4.2	4.5	5.1	5.8	6.7	8.4
d2 H12	3.1	3.8	4.6	5.2	5.9	6.6	7.2	8.1	8.7	10.1	11.4	13.2	16.6
t1 ³	0.9	1.1	1.3	1.5	1.7	1.9	2.1	2.3	2.6	3	3.4	3.9	4.9

Note : Sizes given in brackets are of second preference.

Designation : A countersink Type C for screw size 2 shall be designated as – Countersink C 2 - IS : 3406.

Table IV

Fig 8



Dimension and designation of countersink - Type E according to IS 3406 (Part 1) 1986

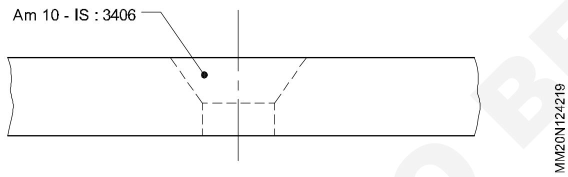
For Nominal No.	10	12	16	20	22	24
d_1 H12	10.5	13	17	21	23	25
d_2 H12	19	24	31	34	37	40
t_1 ³	5.5	7	9	11.5	12	13
α ± 1°	75°			60°		
Note: Clearance hole d_1 according to fine series of IS : 1821 - 1982						

Designation : A countersink Type E for nominal size 10 shall be designated as – Countersink E 10 - IS : 3406.

Methods of representing countersink holes in drawings

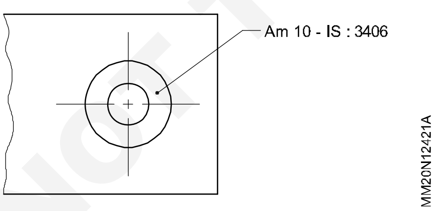
Countersink hole sizes are identified by code designation or using dimension.(Fig 9 - 12)

Fig 9



Use of code designation

Fig 10



Use of dimension

The dimension of the countersink can be expressed by the diameter of the countersink and the depth of the countersink.

Fig 11

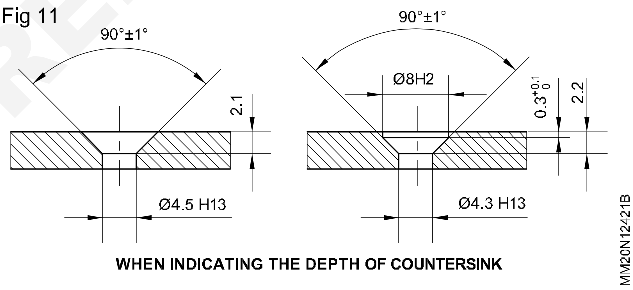
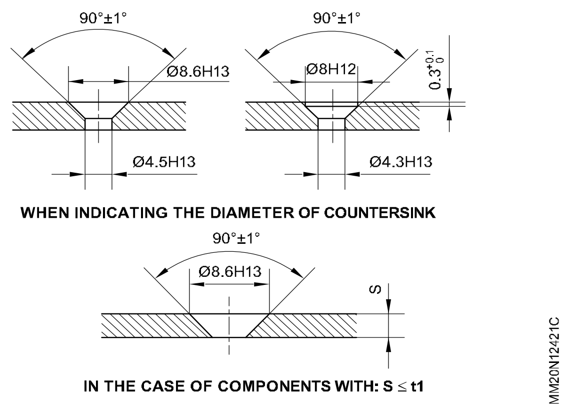


Fig 12



Counterboring and spot facing

Objectives: At the end of this lesson you shall be able to
- **differentiate counterboring and spot facing**
- **state the types of counterbores and their uses**
- **determine the correct counterbore sizes for different holes.**

Counterboring

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

Fig 1

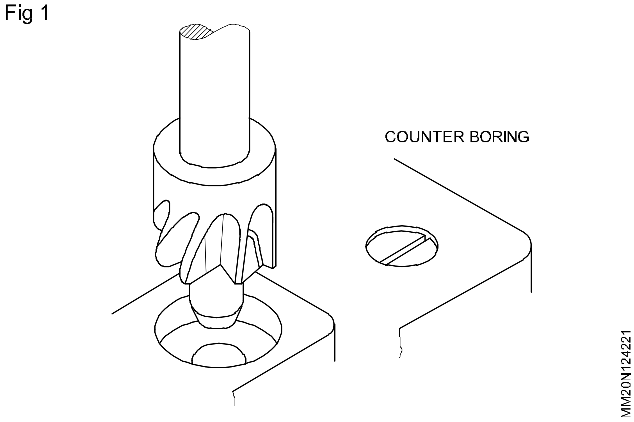
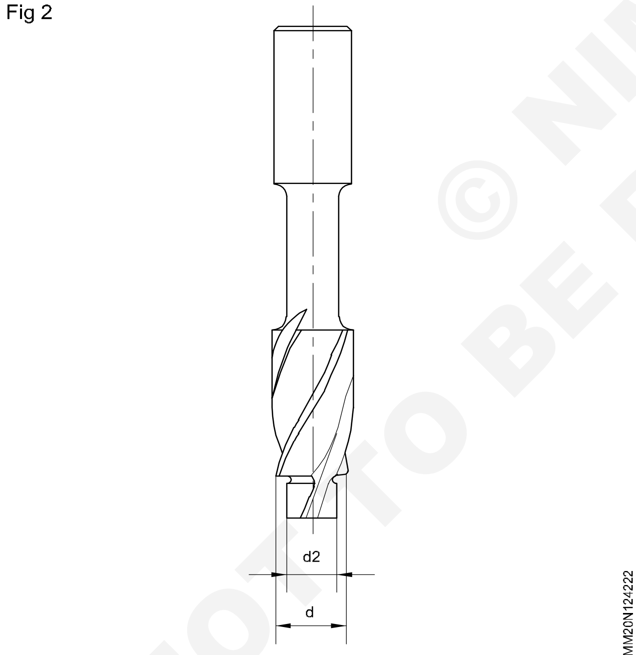


Fig 2



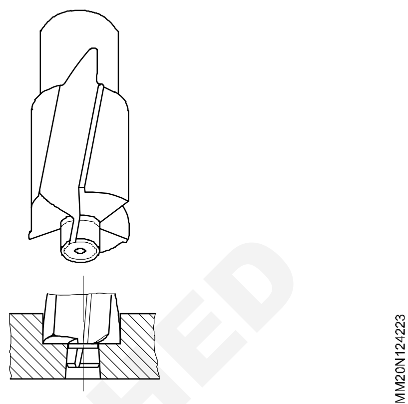
Counterbore (Tool)

The tool used for counterboring is called a counterbore. (Fig 2) Counterbores will have two or more cutting edges.

At the cutting end, a pilot is provided to guide the tool concentric to the previously drilled hole. The pilot also helps to avoid chattering while counterboring. (Fig 3)

Counterbores are available with solid pilots or with interchangeable pilots. The interchangeable pilot provides flexibility of counterboring on different diameters of holes.

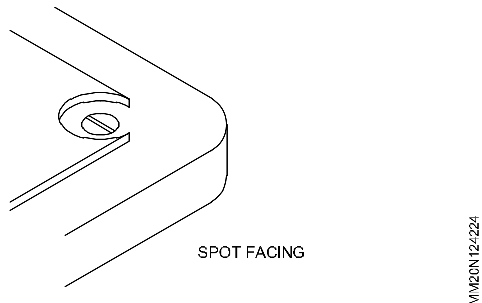
Fig 3



Spot facing

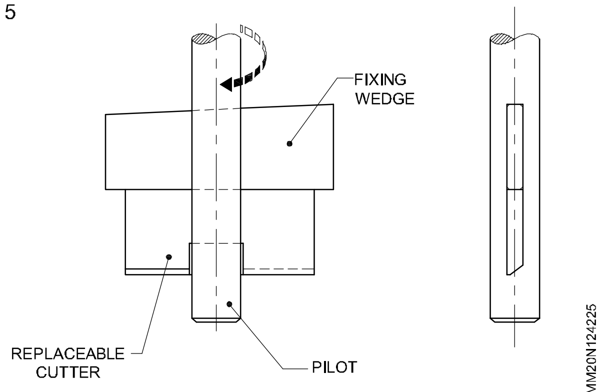
Spot facing is a machining operation for producing a flat seat for bolt head, washer or nut at the opening of a drilled hole. The tool is called a spot facer or a spot facing tool. Spot facing is similar to counterboring, except that it is shallower. Tools that are used for counterboring can be used for spot facing as well. (Fig 4)

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 5



Counterbore sizes and specification

Counterbore sizes are standardised for each diameter of screws as per BIS.

There are two main types of counterbores. Type H and Type K.

The type H counterbores are used for assemblies with slotted cheese head, slotted pan head and cross recessed pan head screws. The type K counterbores are used in assemblies with hexagonal socket head capscrews.

For fitting different types of washers the counterbore standards are different in Type H and Type K.

The clearance hole d1 are of two different grades i.e. medium (m) and fine (f) and are finished to H13 and H12 dimensions.

The table given below is a portion from IS 3406 (Part 2) 1986. This gives dimensions for Type H and Type K counterbores.

Counterbore and Clearance Hole Sizes for Different Sizes of Screws

Dimensions for H and K Type counter bores

While representing counterbores in drawings, counterbores can be indicated either by code designation or using the dimensions.

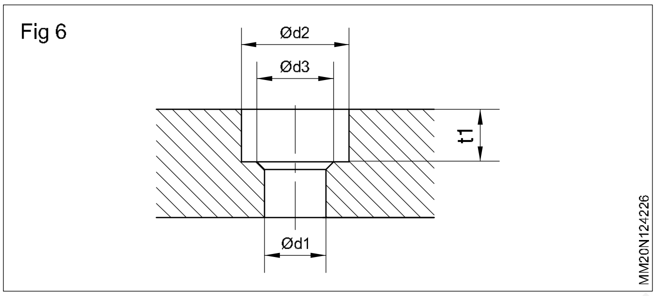
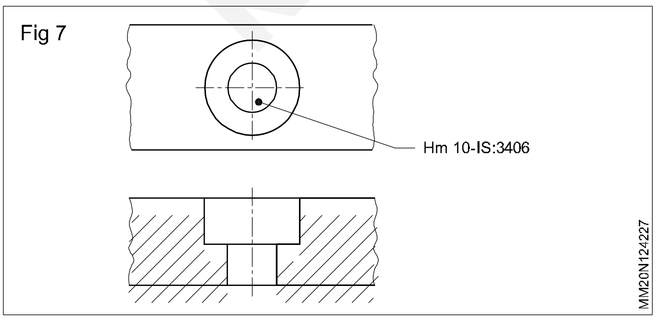


Table - 1

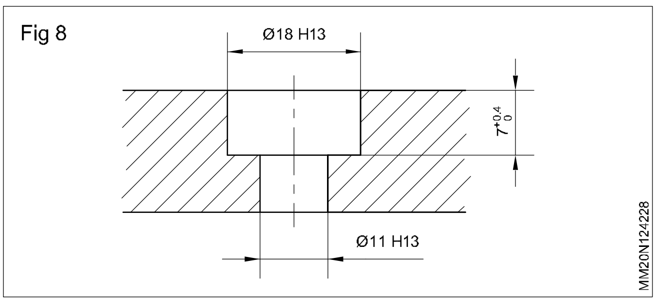
For Nominal size	1	1.2	1.4	1.6	1.8	2	2.5	3	(3.5)	4	5	6	8	10	12	(14)	16	18	20	22	24	27	30	33	36
d1 Medium (m) H13	1.2	1.4	1.6	1.8	2.1	2.4	2.9	3.4	3.9	4.5	5.5	6.6	9	11	13.5	15.5	17.5	20	22	24	26	30	33	36	39
d1 fine (f) H12	1.1	1.3	1.5	1.7	2	2.2	2.7	3.2	3.7	4.3	5.3	6.4	8.4	10.5	13	15	17	19	21	23	25	-	-	-	-
d2 H13	2.2	2.5	2.8	3.3	3.8	4.3	5	6	6.5	8	10	11	15	18	20	24	26	30	33	36	40	43	48	53	57
d3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15.5	17.5	19.5	22	24	26	28	33	36	39	42
t1 Type H	0.8	0.9	1	1.2	1.5	1.6	2	2.4	2.9	3.2	4	4.7	6	7	8	9	10.5	11.5	12.5	13.5	14.5	-	-	-	-
t1 Type K	-	-	1.6	1.8	-	2.3	2.9	3.4	-	4.6	5.7	6.8	9	11	13	15	17.5	19.5	21.5	23.5	25.5	28.5	32	35	38
Tolerances		+0.1 0					+0.2 0								+0.4 0						+0.6 0				

Note : Sizes given in brackets are of second preference. For details refer IS : 3406 (Part2) 1986.

Using code designation (Fig 7)



Using dimensions (Fig 8)



Drilling - Cutting speed, feed and r.p.m , drilling time calculation

Objectives: At the end of this lesson you shall be able to
- **define cutting speed**
- **state the factors for determining the cutting speed**
- **determine r.p.m/spindle speed.**

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 1. Based on the cutting speed recommended, the r.p.m, at which a drill has to be driven is determined.

TABLE 1

Recommended cutting speeds

Materials being drilled (HSS Tool)	
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

Cutting speed calculation

Cutting speed (V) $= \frac{\pi \times d \times n}{1000}$

$\text{r.p.m}(n) = \frac{V \times 1000}{d \times \pi}$

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 ∅ 24 to cut mild steel.

The cutting speed for mild steel 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 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 experiment.

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 a drill advances into the work in one complete rotation. (Fig 1)

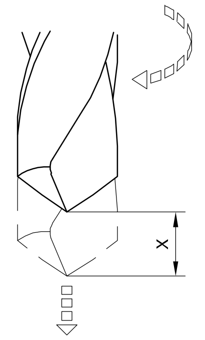
Feed is expressed in hundredths of a millimeter.

Example - 0.040mm/ rev

The rate of feed is dependent up on a number of factors.

- The finish required
- Type of drill (drill material)
- Material to be drilled

Fig 1



Factors like rigidity of the machine, holding of the work-piece and the drill, will also have to be considered while determining 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 taking all the factors into account.

The table gives the feed rate which is based on the average feed values suggested by the different manufacturers of drills. (Table 1)

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.

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 - 15.0	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

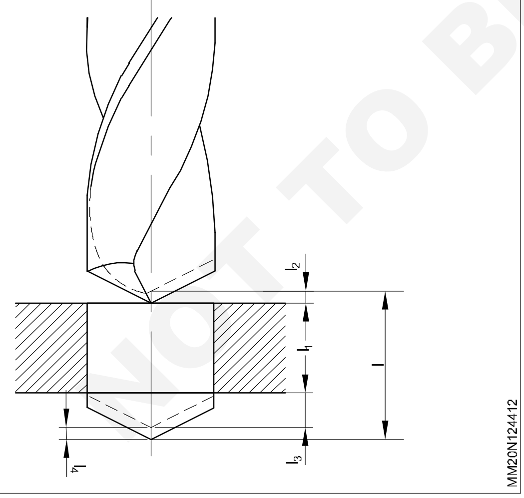
Cutting Tool	**Mild Steel**	**Carbon steel**	**Aluminium**	**Brass**	**Cast iron**	**Stainless steel**
HSS	100	80	250 to 350	175	100	80 to 100
Carbide	300	200	750 to 1000	500	250	200 to 250

Machining time in drilling (Fig 2)

Machining time in drilling is determind by the formula:

$$T = \frac{L}{nxs_r} \text{min}$$

Fig 2



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

S_r = Length of travel of the drill in mm

and T = Machining time in min.

$L = l_1 + l_2 + l_3 + l_4$

Where l_1 = length of the workpiece

l_2 = approach of the drill,

l_3 = length of the drill point (0.29d)

l_4 = over travel

Example:

Calculate the drilling time to drill 12mm dia hole in a plate of thickness 62mm, cutting speed 30m/min and feed rate is 0.05mm/rev

Formulae for drilling time $= T = \frac{L}{nxs_r}$

$L = l_1 + l_2 + l_3 + l_4$

= 62 + 5 + 4 + 2

= 73mm

$$n = \frac{1000x30}{3.143x12}$$

S_r - 0.05mm

$$T = \frac{73}{0.5x795} = 1.84 \text{ minutes}$$

= 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.

Necessity of Interchangeability in engineering field

Objectives: At the end of this lesson you shall be able to
- **state the advantages and disadvantages of mass production**
- **outline the meaning of the term, 'interchangeability'**
- **state the necessity for the limit system**
- **name the different standards of system of limits and fits.**

Mass production

Mass production means production of a unit, component or part in large numbers.

Advantages of mass production

Time for the manufacture of components is reduced.

The cost of a piece is reduced.

Spare parts can be quickly made available.

Disadvantages of mass production

Special purpose machines are necessary.

Jigs and fixtures are needed.

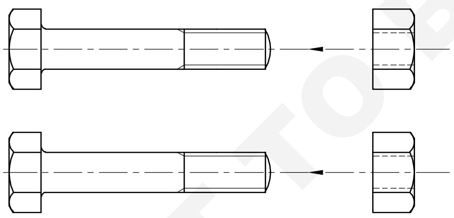
Gauges are to be used instead of conventional precision instruments.

Initial expenditure will be very high.

Selective assembly

The figures 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



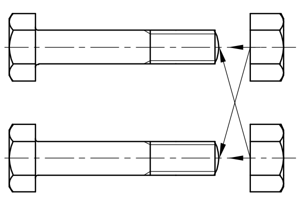
SELECTIVE ASSEMBLY

MM20N124511

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)

Fig 2



NON-SELECTIVE ASSEMBLY INTERCHANGEAB ILITY

MM20N124512

Non-selective assembly provides interchange-ability between the components.

In modern engineering production, i.e. mass production, there is no room for selective assembly. However, under some 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 further rectification during the assembly stage, 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 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 stipulated by the BIS. (Bureau of Indian Standards)

Other systems of limits and fits

International Standards Organisation (ISO)

British Standard System (BSS)

German Standard (DIN)

The Indian standard system of limits & fits - terminology

Objectives: At the end of this lesson you shall be able to
- **state the terms under the BIS system of limits and fits**
- **define each term under the BIS system of limits and fits**.

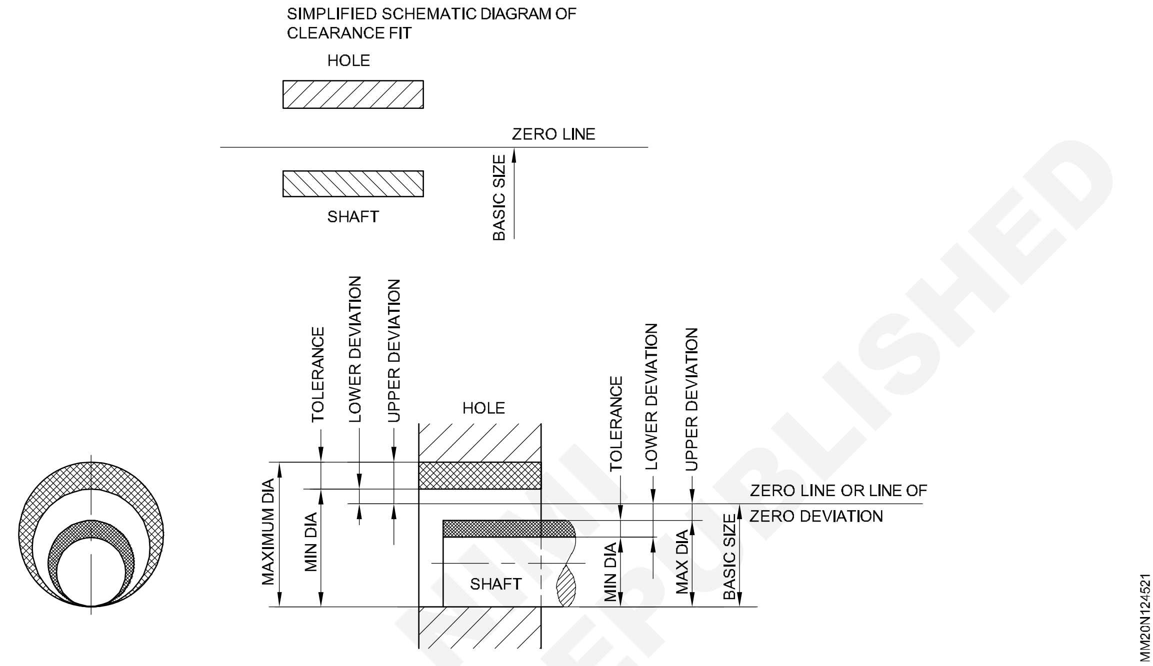
Size

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



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. (Fig 2) (Maximum and minimum limits)

Maximum limit of size

It is the greater of the two limit 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 & fits, all internal features of a component including those which are not cylindrical are designated as ` hole'. (Fig 3)

Shaft

In the BIS system of limits & fits, all external features of a component including those which are not cylindrical are designated as shaft. (Fig 3)

Fig 2

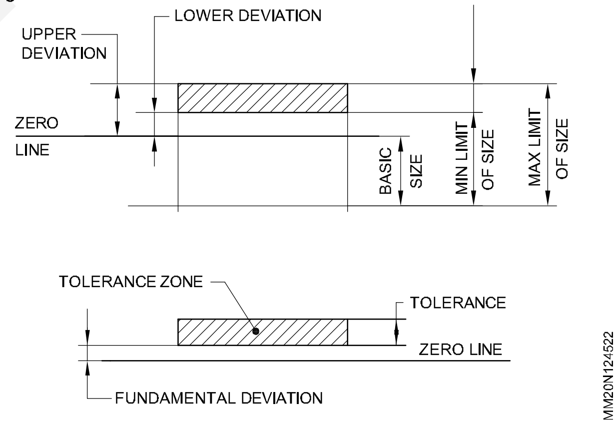


Fig 3

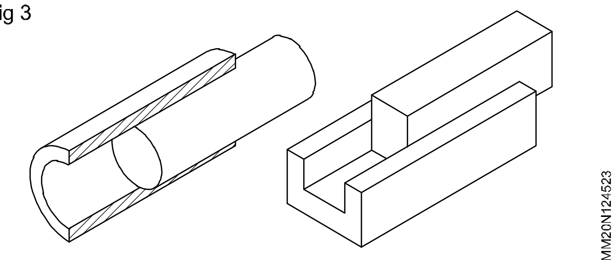


Table 1 (Examples)

SL. NO.	SIZE OF COMPONENT	UPPER DEVIATION	LOWER DEVIATION	MAX-LIMIT OF SIZE	MIN-LIMIT OF SIZE
1	$20^{+.008}_{-.005}$	+ 0.008	- 0.005	20.008	19.995
2	$20^{+.028}_{+.007}$	+ 0.028	+ 0.007	20.028	20.007
3	$20^{-.012}_{-.021}$	- 0.012	- 0.021	19.988	19.979

Deviation

It is the algebraic difference between a size, to 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 graphical representation of the above terms, the zero line represents the basic size. This line is also called as 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 & W. (Fig 4)

In addition to the above, four sets of letters JS, ZA, ZB & ZC are included. For fine mechanisms CD, EF and FG are added. (Ref.IS:919 Part II - 1979)

For shafts, the same 25 letter symbols but in small letters are used. (Fig 5)

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

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

Fig 4

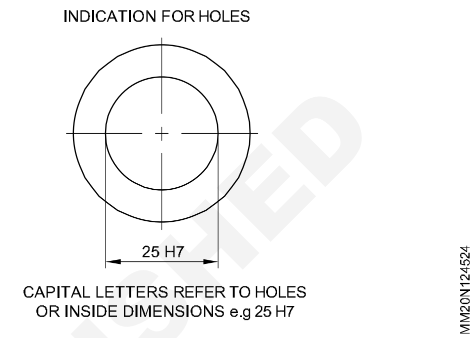


Fig 5

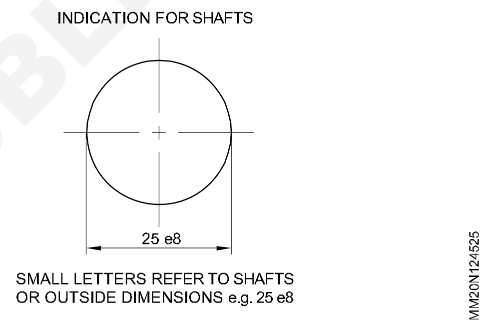


Fig 6

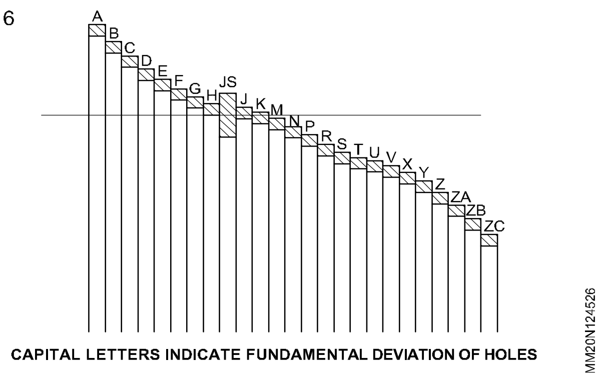


Fig 7

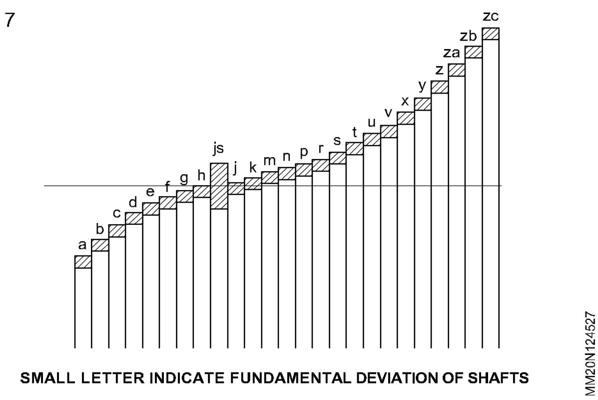


Fig 8

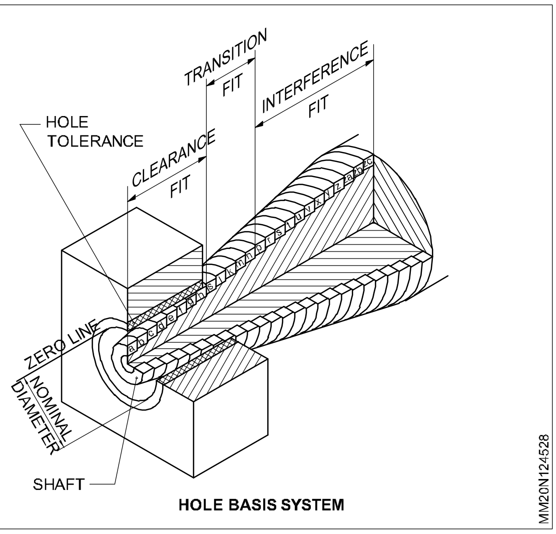
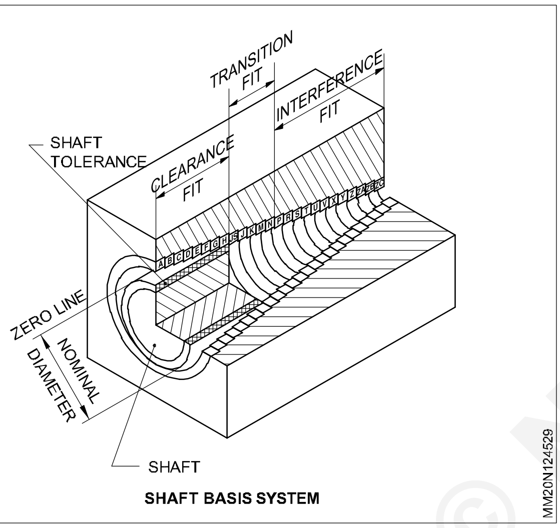


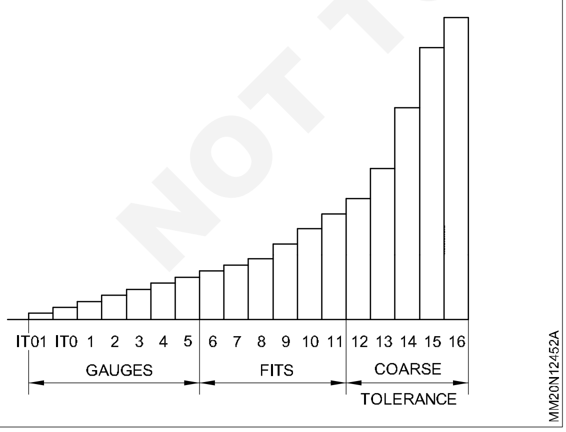
Fig 9



Fundamental tolerance

This is also called as 'grade of tolerance'. In the Indian Standard System, there are 18 grades of tolerances represented by number symbols, both for hole and shaft, denoted as IT01, IT0, IT1....to IT16. (Fig 10) A high number gives a large tolerance zone.

Fig 10



The 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)

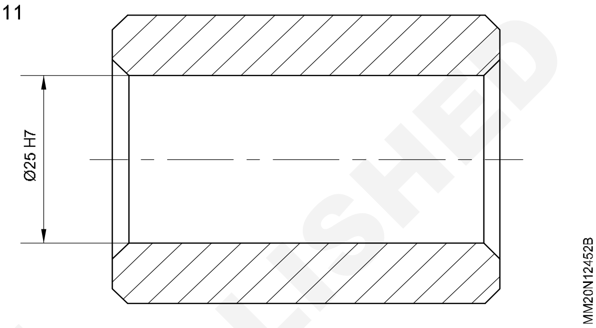
Tolerance size

This includes the basic size, the fundamental deviation and the grade of tolerance.

Example

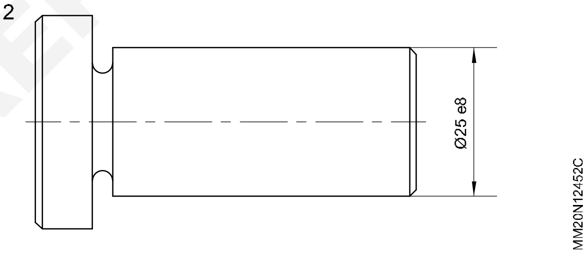
25 H7 - tolerance size of a hole whose basic size is 25. The fundamental deviation is represented by the letter symbol H and the grade of tolerance is represented by the number symbol 7. (Fig 11)

Fig 11



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

Fig 12



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

Example

In figure 13, a hole is shown as 25 ± 0.2 which means that 25 mm is the basic dimension and ± 0.2 is the deviation.

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

The deviation is mostly given on the drawing with the 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.

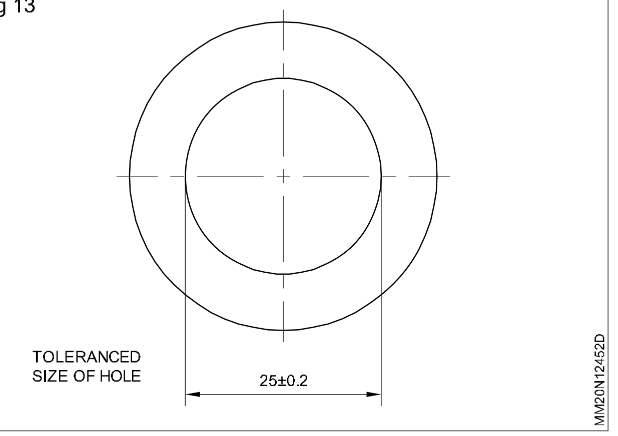


Fig 13

25.2 mm is known as the maximum limit. (Fig 14)

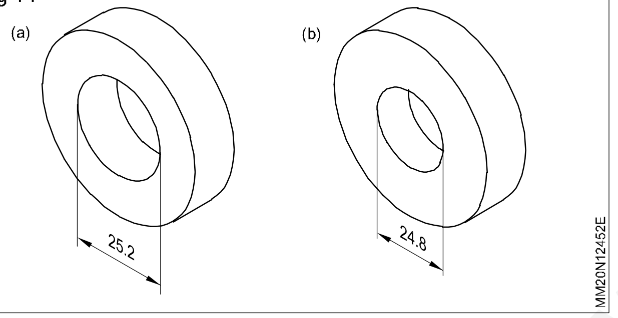


Fig 14

24.8 mm is known as the minimum limit. (Fig 15)

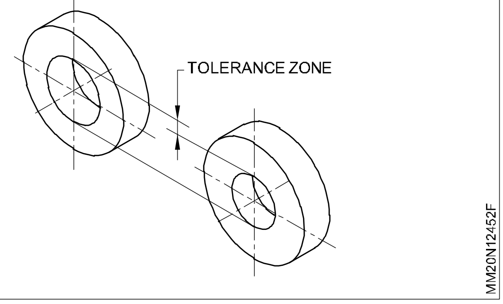


Fig 15

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

All dimensions of the hole within the tolerance zone are of acceptable size.

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

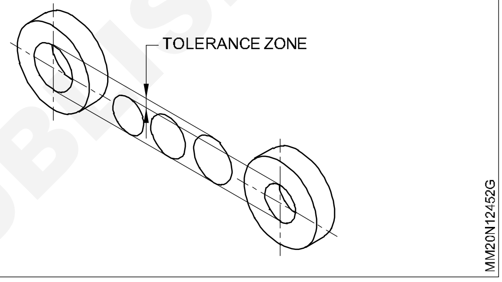


Fig 16

Constructional features and applications of a shaper

Objectives: At the end of this lesson you shall be able to
- **list the various operations performed using a shaping machine**
- **state the functions of the main parts of a shaper**
- **state the specification of a shape.**

A shaping machine is a machine tool used for the following operations done with the help of a single point cutting tool of appropriate size and shape.

Producing horizontal, vertical and angular surfaces.

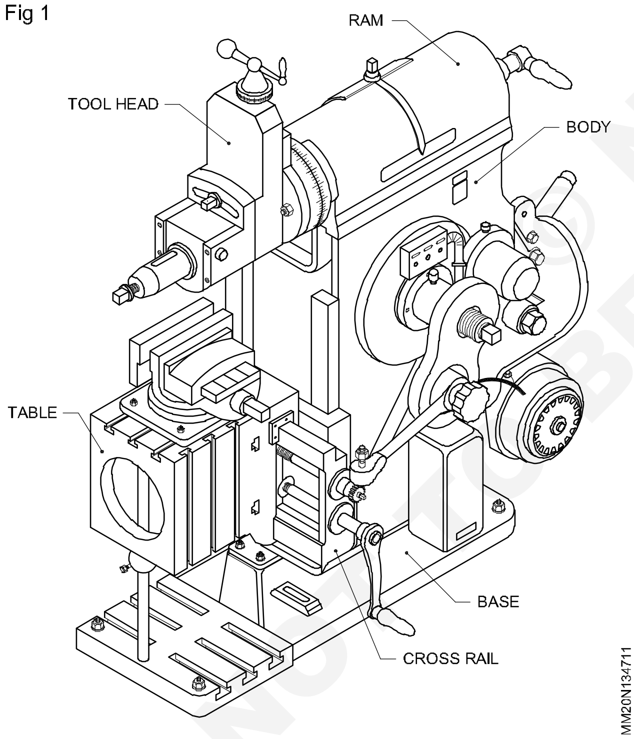
For cutting slots, grooves and keyways. Machining contour to be concave, convex and a combination of both.

Machining splines, ratchets and gears using an indexing device.

Due to the availability of sophisticated machine tools, a shaper is now used only for machining jobs with wider dimensional limits in small and medium industries,

Main parts of a shaping machine (Fig 1)

Fig 1



Body

The body of a shaper is made of cast iron, because it absorbs vibration. It houses the main drives, the gear-box, and also the quick return reciprocating mechanism for the ram.

Base

It supports the body casting and the entire load of the machine. It is made out of cast iron to withstand the vibration and the other forces set up by the cutting tool during working.

Cross-rail

This is a hollow casting which has a cross-feed screw and table elevating screw. The cross-rail body is provided with guideways which slide over the body of the machine vertically. The table is mounted to the cross-rail which can be moved with the cross-feed screw.

Table

It is box-shaped and has 'T' slots on its top and sides to hold the workpieces on the vice. The table can be moved up and down using a table lifting drive spindle. It can also be moved horizontally using a cross-feed screw.

Ram

It is fitted at the top of the body and moves to and fro through the quick return mechanism. It carries the tool head at one end. The to and fro movement of the ram, which is known as stroke length, is set according to the length of the workpiece to be machined. The position of the stroke length is set using the ram lead screw.

Tool head

It holds the tool-holder and clapper box. The tool head can be raised or lowered to give the depth of cut, using the feed-screw handle. It can also be swiveled using a calibrated adapter plate for machining angular surfaces. The cutting tool is fixed in the tool-holder.

Specification of shaper

The size of a shaper is determined by the maximum length of stroke of the ram. Generally it ranges from 175 to 900 mm. The length of stroke indicates, in addition to the general size of the shaper, the size of a cube that can be held and machined.

To specify a shaper the following information is also at times necessary.

Type of drive

Power input

Floor space required

Weight of the machine

Cutting to return stroke ratio

Number and amount of feed

Working of crank and slotted link mechanism of shaping machine (Quick return mechanism)

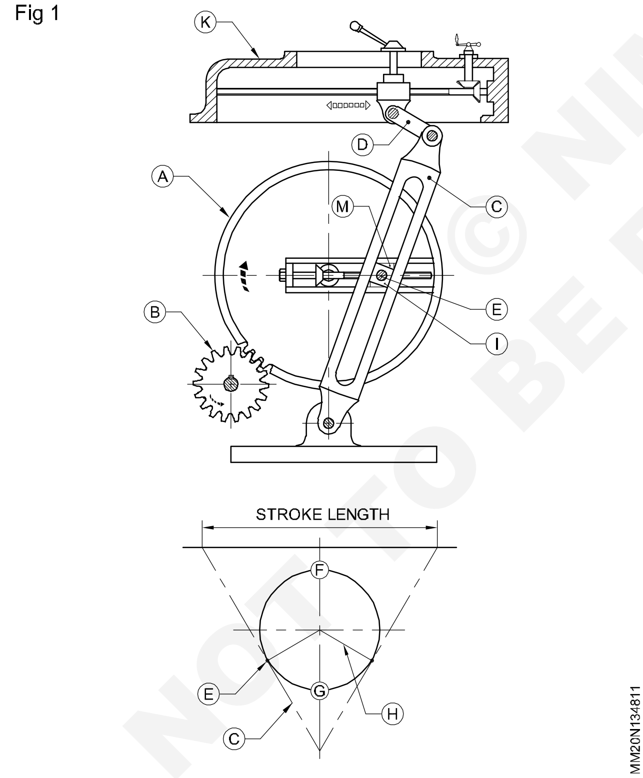
Objectives: At the end of this lesson you shall be able to
- **state the purpose of the quick return mechanism**
- **explain the operating principle of the quick return mechanism**
- **explain how idling time is reduced with respect to the speed of the ram**
- **compare the speed of the ram when returning to cutting time.**

In a shaping machine the metal cutting action takes place while the tool is moving in the forward direction. It goes back without the cutting action. This is an idle stroke and the time spent during the return of the idle stroke is called the idle time. This time shall be reduced if the tool is made to return quickly.

The mechanism used for this purpose is called quick return mechanism, and this reduces the idle time. This helps to increase the rate of production.

The operating principle of the quick return mechanism is as stated below. (Fig 1)

Fig 1



A bull gear (A) receives power from the pinion (B). The driving pin (E) rotates with the bull gear. The driving pin

is fixed to the sliding block (1). The sliding block slides in the slotted link (C). The slotted link (C) is pivoted at the bottom, and at the top it is connected with the ram (K) by the compensating link (D). As the bull gear rotates, the slotted link (C) oscillates about its pivot. This oscillating motion is converted into reciprocating motion of the ram (K) through the compensating link (D).

How is the idle stroke time reduced?

During the cutting stroke the driving pin covers a lengthier arc (F), and during the return stroke it covers a smaller arc (G). The path (G) (Fig 1) for the return stroke is shorter than the path (F) for the forward stroke.

Stroke length

The slotted link (C) swivels faster during the return stroke, and at the same time, the ram (K) has equal stroke length during the return and forward strokes. The average values of angles (F) and (G) are 216" and 144" respectively. As such the ram travels faster during the return stroke than during the cutting stroke. Consequently the idle time is reduced.

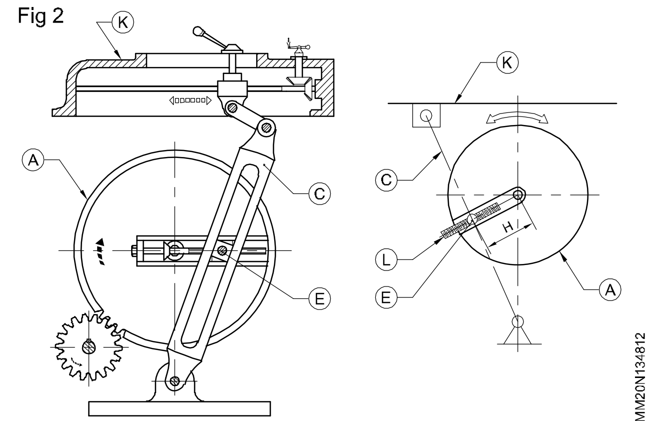
Usually the quick return mechanism provides the return stroke to be 1 1/2 times faster than the cutting stroke. In other words the ratio of the time taken for the cutting stroke to the return stroke is 3:2. This ratio may vary from machine to machine. In some machines this ratio is 2:1

The stroke length remains equal during the cutting and

return strokes. The stroke length is adjusted by adjusting the radius (H). The radius (H) is adjusted by shifting the position of the crank slide (M), which rotates with the bull gear Bigger the radius (H) lengthier the stroke

Stroke length adjustment (Fig 2)

Fig 2



The length of the stroke of the ram (K) is increased the swivelling range of the slotted link (C) is bigger (Fig 2)

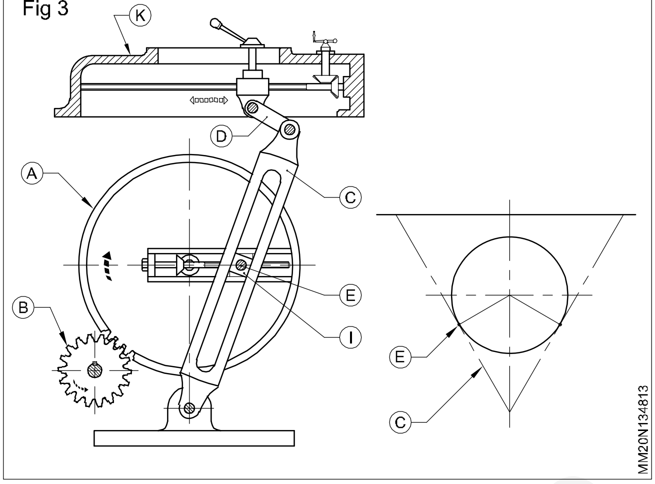
This swiveling depends on the eccentricity/actual radius (H) between the driving pin (E) and the centre of the bull gear (A). The radius (H) is increased or decreased by turning the radial lead screw (L) outwards and inwards respectively. The stroke length is set depending on the length of the workpiece to be machined.

No ram movement (though motor rotates) (Fig 3)

Even though the motor rotates, the ram (K) will not move either due to the breakage of the compensating link (D) or due to the non-movement of the slotted link (C).Non-movement of the slotted link (C) may be due to the breakage/shearing of the key between the driving pinion (B) and the shaft the breakage of either the sliding block (1) or the crank pin (E) or both

the coincidence of the axis of the sliding block (1) with the axis of the bull gear (A)

Fig 3



Calculation of cutting speed feed & depth of cut

Objectives: At the end of this lesson you shall be able to
- **define cutting speed**
- **state the factors for determining the cutting speed**
- **differentiate between cutting speed and number of strokes**
- **determine the number of strokes/min**
- **elect the number of strokes**.

Cutting speed

The cutting speed is the distance travelled by a tool point over the job in one minute. It is always expressed in metres/min. Cutting speed is also sometimes stated as surface speed or peripheral speed.

The selection of the cutting speed for a shaper depends upon the material to be shaped, and the material of the tool and the depth of cut.

Tool manufacturers usually provide a table for the cutting speeds required for different materials.

The recommended cutting speeds for different materials are given in Table 1.

Table 1

Sl. No.	Material to be shaped by HSS	Cutting speed m/min
1	Aluminium	70-100
2	Brass	35-60
3	Bronze	30-35
4	Cast iron grey	25-40
5	Mild steed	
	carbon steel	27-30
6	Plastic	20-30

The formula for cutting speed in a shaper depends on the ratio of the ram speed for the cutting stroke and the return stroke.

Let this ratio be equal to m.

Then,

$$\text{Cutting speed (V)} = \frac{NL(1+m)}{1000}$$

$$\text{where } m = \frac{\text{ram speed for return stroke}}{\text{ram speed for cutting stroke}}$$

N = No. of cutting strokes per min or number of cycles per min

L = stroke length

$$N = \frac{1000V}{L(1+m)}$$

Since every cutting stroke is followed by a return stroke,and one revolution of the bull wheel produces one cutting as well as one return stroke, N is also the number of revolutions of the bull wheel per minute.

One cutting stroke together with the return stroke is called one cycle. The time taken for one cycle is important, as the time required to shape a given surface depends very much on the cycle time.

Time required for one cycle (t) = $\frac{1}{4}$ min

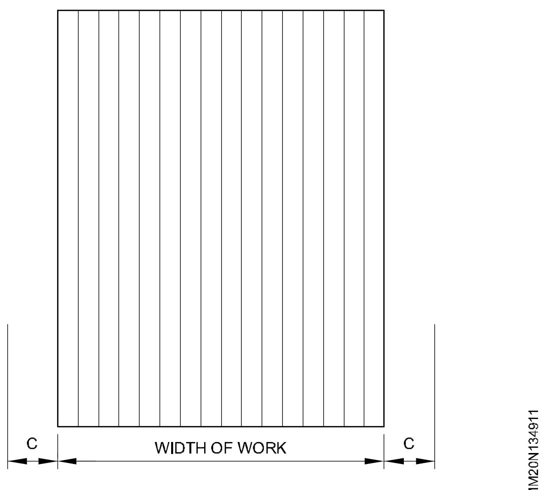
Cutting time

The time taken to shape a given surface depends on the feed (f) and cycle time (t). Larger the feed lesser the machining time and vice versa. (Refer to the chart in the reference book for recommended feeds.)

For calculating the cutting time, first determine the total number of cycles 'C' needed to shape the width "W", and then multiply it by the cycle time (t). (Fig 1)

Total No.of cycles =

Fig 1



where W is the width of the workpiece in mm including the clearance on both sides and ‘t’ is the feed per stroke.

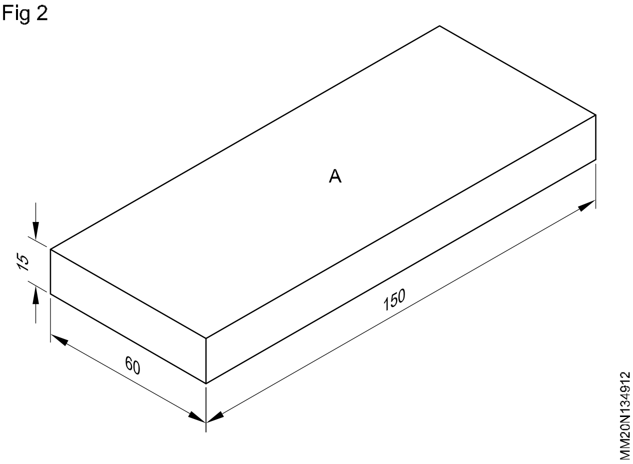
Since every cycle takes ‘t’ minutes, total machining time = 1 x C min..

Sample problem for determination of strokes and cutting time

Calculate the time required to shape the surface A shown in Fig 2 using a shaping machine having a speed ratio of 2:3. The available strokes in the machine are 28, 52 and 80 per minute.

Length of the stroke =150+30=180mm.

Fig 2



V = 20m/min and f = 0.2 mm/stroke.

Now N $= \dfrac{1000\,V}{L\,(1+M)}$ $\dfrac{1000 \times 20}{180\,(1 + 2/3)}$

$= \dfrac{1000 \times 20 \times 3}{180 \times 5}$

= 66 stroke per min.

The nearest available stroke in the machine setting is 52, and hence N must be taken as 52 stroken per min.

Cutting time for one cycle $= \dfrac{1}{52}$ min.

= 60 + 3 0 =90

Total cutting time $= \dfrac{90}{0.2} \times \dfrac{1}{52} = 8.65$min.

If the same work is done on a machine with a speed ratio 1:2

No. of strokes per min. will be $= \dfrac{1000 \times 20}{180\,(1+\frac{1}{2})} = 74$

and since the nearest speed available is 80, N will be taken as 80.

Therefore, cutting time $= \dfrac{90}{0.2} \times \dfrac{1}{80} = 5.625$min.

Specification of wheels

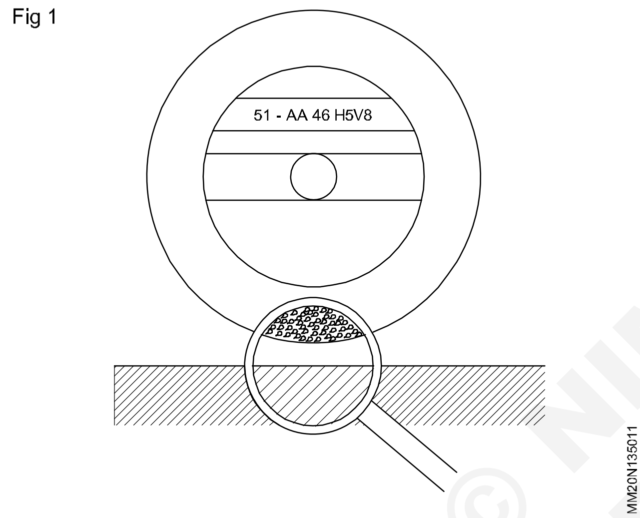
Objectives: At the end of this lesson you shall be able to
- **interpret the marking on a grinding wheel**
- **specify a grinding wheel.**

Introduction

Standard wheel - markings specify all the important wheel characteristics. The marking system comprises of seven symbols which are arranged in the following order. (Fig 1)

Example (Marking system)

Fig 1



51 - A 46 H5 V8

Specification of grinding wheels

A grinding wheel is specified by the standard wheel markings like diameter of the wheel, bore diameter of the wheel, thickness of the wheel type (Shape) of the wheel.

Example

32 A 46 H8V

250X20X32-

Straight wheel

Table 1 shows the relative position measuring of the marking system

Table 1

Position 0	**Position 1**	**Position 2**	**Position 3**	**Position 4**	**Position 5**	**Position 6**
Manufac-turer's symbol for abrasive (Optional)	Type of abra-sive grit size	Grain size	Grade	Structure (Optional)	Type of bond	Manufac-turer's own mark (Optional)
51	A	46	H	5	V	8

Chart illustrating the standard marking system is : 551-1966 (Table - 2)

Table 2

ORDER OF MARKING

0	1	2	3	4	5	6
Nature of Wheel	Type of Abrasive	Grain Size	Grade	Structure	Type of bond	Manufacturer's Reference
51	A	36	L	5	V	23

51 – Manufacturer's symbol indicating the exact nature of Abrasive (optional)

23 – Manufacturer's own identification mark for the wheel (optional)

A – Type of abrasive:

ALUMINIUM OXIDE – A
SILICON CARBIDES – C

V – Type of bond:

V – VITRIFIED
S – SILICATE
R – RUBBER
RF – RUBBER REINFORCED
B – RESINOID (SYNTHETIC RESINS)
BF – RESINOID REINFORCED
E – SHELLAC
Mg – MAGNESIA

36 – Grain size:

COARSE	MEDIUM	FINE	VERY FINE
10	30		220
12	36	80	240
14	46		280
16	54	100	320
20	60	120	400
24		150	500
		180	600

5 – Structure:

SPACING FROM THE CLOSEST TO THE MOST OPEN

	0	8
1	9	
2	10	
3	11	
4	12	
5	13	
6	14	
7		

L – Grade:

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

SOFT (A – F) | MEDIUM (G – V) | HARD (W – Z)

CHART ILLUSTRATING STANDARD MARKING SYSTEM IS : 551 – 1966

Construction of the grinding wheel

Objectives: At the end of this lesson you shall be able to
- **state the different types of abrasives and their uses**
- **state the different grain sizes and their uses**
- **state the different grades of grinding wheels**
- **state the structure of a grinding wheel**
- **name the bonding materials used for grinding wheels.**

In order to suit the grinding wheel for different work situations, the features such as abrasive, grainsize, grade, structure and bonding materials can be varied.

A grinding wheel consists of the abrasive that does the cutting, and the bond that holds the abrasive particles together.

Abrasives

There are two types of abrasives.

- Natural abrasive
- Artificial abrasive

The natural abrasives are emery and corrundum, These are impure forms of aluminium oxide.

Artificial abrasives are silicon carbide and aluminium oxide.

The abrasives are selected depending upon the material being ground.

'Brown' aluminium oxide is used for general purpose grinding of tough materials.

'White aluminium oxide is used for grinding ferrous and ferrous alloys.

'Green' silicon carbide is used for very hard materials with low tensile strength such as cemented carbides.

Grain size (Grit size): The number indicating the size of the grit represents the number of openings in the sieve used to size the grain. The larger the grit size number, the finer the grit.

Grade: Grade indicates the strength of the bond and, therefore, the 'hardness' of the wheel. In a hard wheel the bond is strong, and securely anchors the grit in place and, therefore, reduces 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.

Structure: This indicates the amount of bond present between the individual abrasive grains and the closeness of the individual grains to each other. An open structure 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 closely structured wheel.

Bond: The bond is the substance which, when mixed with abrasive grains, hold them together, enabling the mixture to be shaped to the form of the wheel, and after suitale treatment to take on the necessary mechanical strength for its work. The degree of hardness possessed by the bond is called the 'grade' of the wheel, and indicates the ability of the bond to hold the abrasive grains in the wheel. There are several types of bonding materials used for making wheels.

Vitrified bond: 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 or ordinary temperature conditions.

Silicate bond: 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, cutters etc.

Shellac bond: This is used for heavy duty, large diameter wheels where a fine finish is required. For example, the grinding of mill rolls.

Rubber bond: This is used where a small degree of flexibility is required on the wheel as in the cutting off wheels.

Resinoid bond: This is used for speed wheels. Such wheels are used in foundries for dressing castings. Retinoid bond wheels are also used for cutting off. They are strong enough to withstand considerable abuse.

Radius / fillet gauge

Objectives: At the end of this lesson you shall be able to
- **define radius/fillet gauge**
- **state the use of radius fillet gauge.**

Radius and fillet gauges: Components are machined to have curved formation on the edges or at the junction of two steps. Accordingly they are called radius and fillets. The size of the radius and radius is normally provided on a drawing. The gauges used to check the radius formed on the edges of diameters are fillet and the gauges used to check the fillets are called fillets gauges.

They are made of hardened sheet metal each to a precise radius. They are used to check the radii by comparing the radius on a part with the radius of the gauges.

Fig 1 shows the application of radius gauge to check the radius formed externally. Fig 2 shows the application of a fillet gauge to check the fillet formed on a turned component. The other typical applications are:

Fig 1

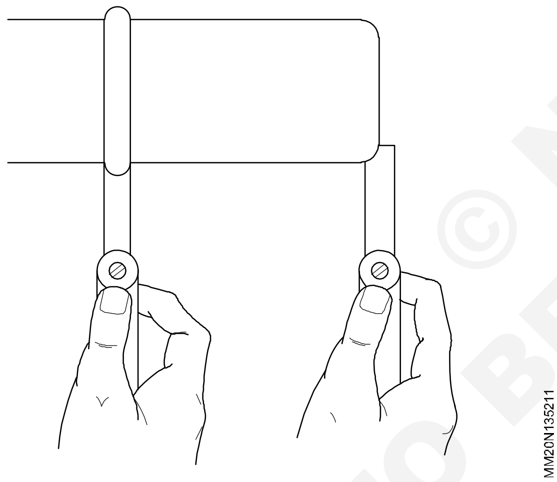
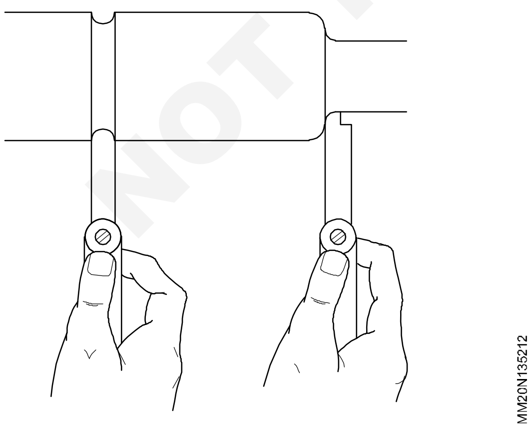
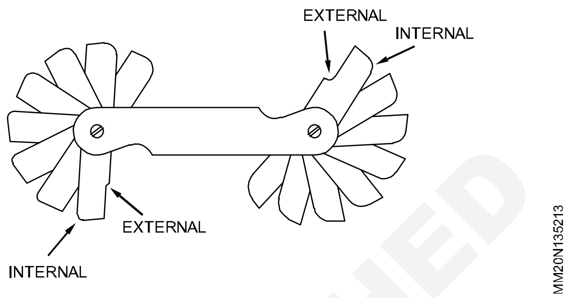


Fig 2



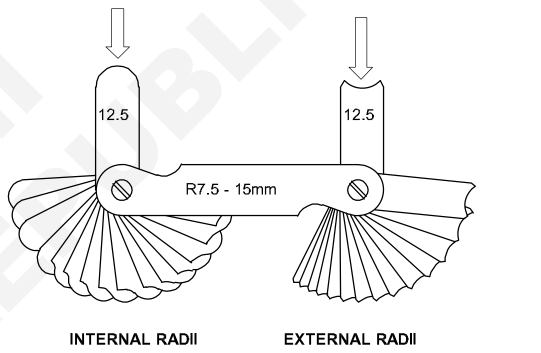
Some sets have provisions to check the radius and fillet on each blade. (Fig 3)

Fig 3



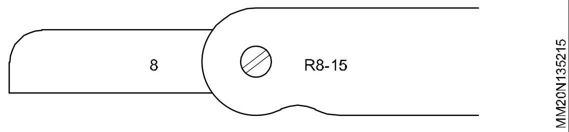
And some sets have separate sets of blades to check the radius and fillet. (Fig 4)

Fig 4



Each blade can be swung out of the holder separately, and has its size engraved on it. (Fig 5)

Fig 5



Fillet gauges are available in sets to check the radii and fillets from:

1 to 7 mm in steps of 0.5 mm

7.5 to 15 mm in steps of 0.5 mm

15.5 to 25 mm in steps 0.5 mm.

Individual gauges are also available. They usually have internal and external radii on each gauge and are made in sizes from 1 to 100 mm in steps of 1 mm. (Fig 6)

Before using the radius gauge, check that it is clean and undamaged.

Remove burrs from the workpiece.

Select the leaf of the gauge from the set corresponding to the radius to be checked.

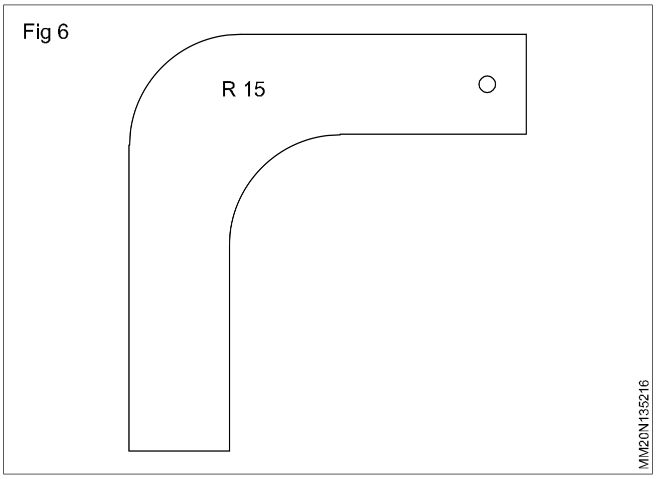


Fig 6

Fig 7 shows that the radius of the fillet and that of the external radius are smaller than the gauge.

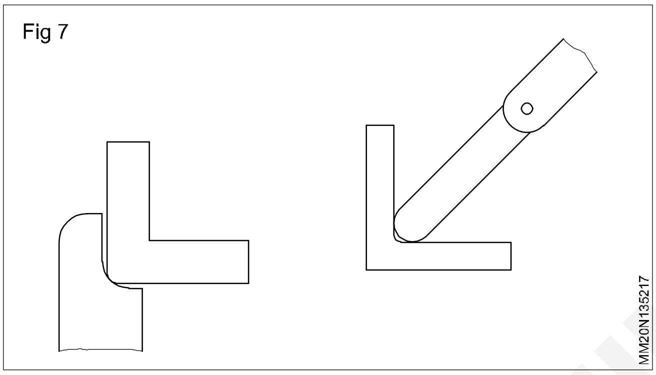


Fig 7

Feeler gauge and uses

Features: A feeler gauge consists of a number of hardened and tempered steel blades of various thicknesses mounted in a steel case. (Fig 8)

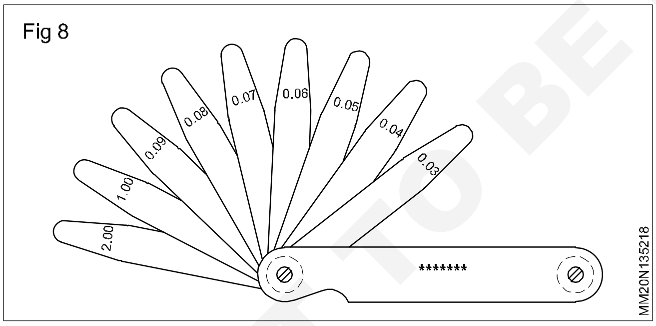


Fig 8

The thickness of individual leaves is marked on it.

B.I.S. Set: The Indian Standard establishes four sets of feeler gauges Nos.1,2,3 and 4 which differ by the number of blades in each and by the range of thickness (minimum is 0.03 mm to 1 mm in steps of 0.01 mm). The length of the blade is usually 100 mm.

Example

Set No.4 of Indian Standard consist of 13 blades of different thicknesses.

0.03, 0.04, 0.05, 0.06, 0.07, 0.08, 0.09, 0.10, 0.15, 0.20, 0.30, 0.40, 0.50.

The sizes of the feeler gauges in a set are carefully chosen in order that a maximum number of dimensions can be formed by building up from a minimum number of leaves.

The dimension being tested is judged to be equal to the thickness of the leaves used, when a slight pull is felt while withdrawing them. Accuracy in using these gauge requires a good sense of feel.

Feeler gauges are used:

- To check the gap between the mating parts
- To check and set the spark plug gaps
- To set the clearance between the fixture (setting block) and the cutter/tool for machining the jobs
- To check and measure the bearing clearance, and for many other purposes where a specified clearance must be maintained. (Fig 9)

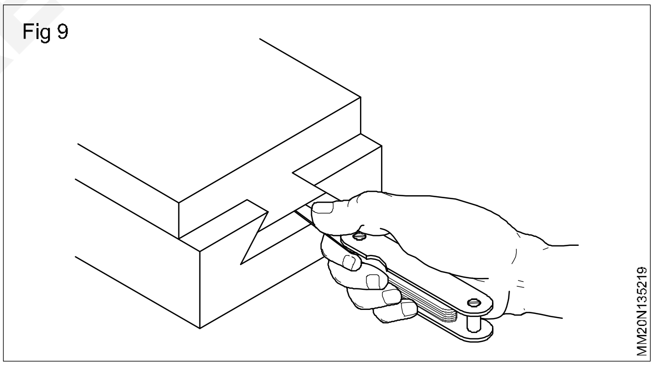


Fig 9

Small hole gauges

Objectives: At the end of this lesson you shall be able to
- **identify the parts of a small hole gauge**
- **state the construction of a small hole gauge**
- **state the ranges of small hole gauges.**

Construction (Fig 1)

A small hole gauge consists of a tube having holes on the opposite sides at one end where hardened balls are fixed. The other end of the tube has an external thread. A screwed thimble is fixed with the threaded tube. A plunger with a tapered end, and spring-loaded, is inserted in the tube and tightened with the screwed thimble.

At the end of the thimble a knurled handle is fitted. While rotating the knurled handle in a clockwise direction the plunger moves forward up, and pushes the balls out to contact the surfaces.

A small hole gauge is an instrument used for indirect measurement, while a micrometer is usually used for measuring the sizes directly.

Small hole gauges are available in a set of 4 numbers to measure holes from 3 mm to 13 mm. (as per MITUTOYO -Series 154)

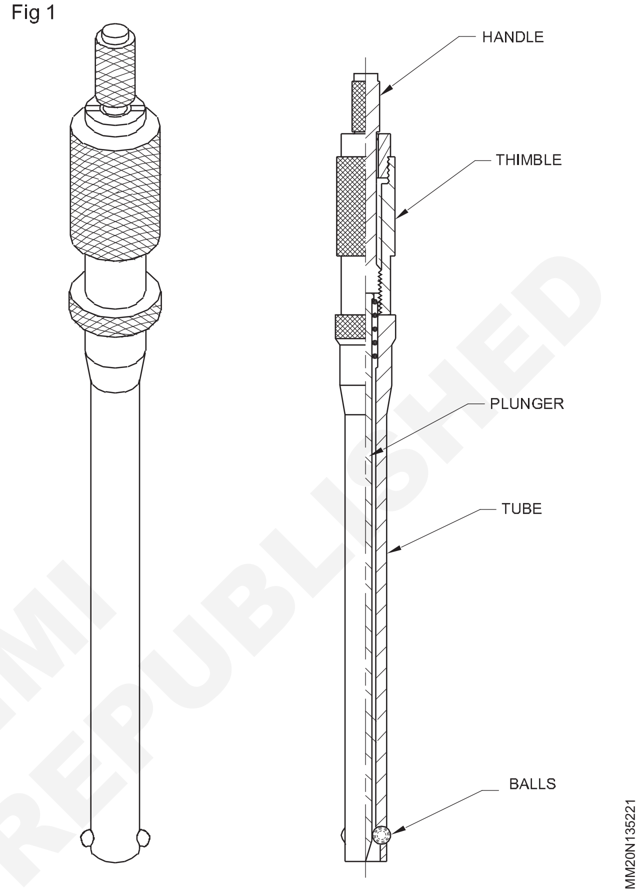
No.1 - 3 mm to 5 mm

No.2 - 5 mm to 7.5 mm

No.3 - 7.5 mm to 10 mm

No.4 - 10 mm to 13 mm

Fig 1



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

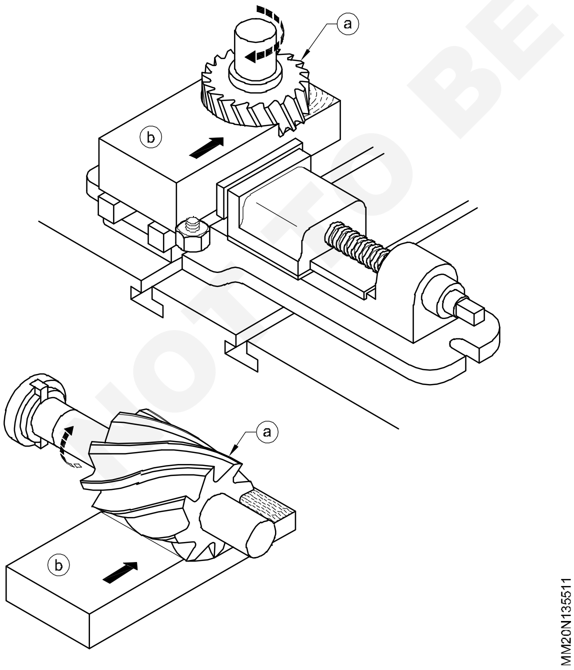
A milling machine is a machine tool that removes metal as the work is fed against a rotating multipoint cutter. The cutter rotates at a high speed and because of the multiple cutting edges it removes metal at a very fast. The machine can also holds one or more number of cutters at a time. This is why 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 comparison with other machine tools. (Fig1)

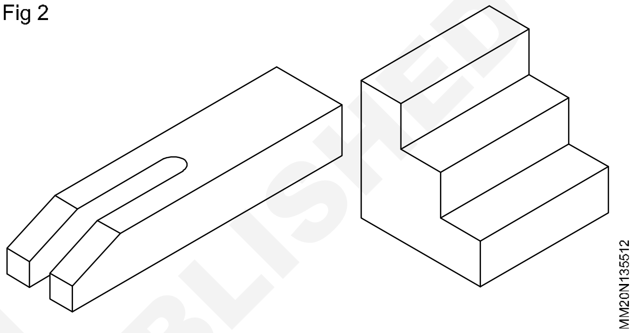
Fig 1



Job (b) can be machined manually or automatically.

By milling we can produce flat (horizontal, vertical, angular) and formed surfaces. (Fig 2)

Fig 2



A milling machine finds wide application in production work as the machine can hold one or more number of cutters at a time, and is good in accuracy, surface finish etc.

Classification

The classification according to the general design of the milling machine is:

- column and knee type
- fixed bed type
- planer type
- special type

But out of these types the one that is used most in general workshop is the column and knee type machine.

In the column and knee type category the following machines are covered.

¨ Plain/horizontal milling machine (Fig 3)

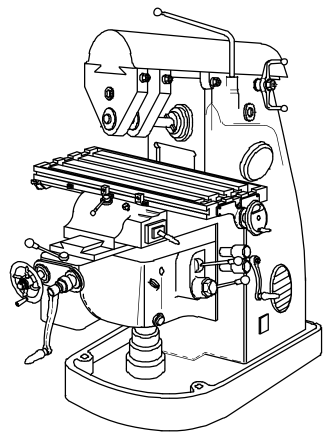
¨ Vertical milling machine (Fig 4)

¨ Universal milling machine (Fig 5)

1 Plain milling machine (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.

Fig 3

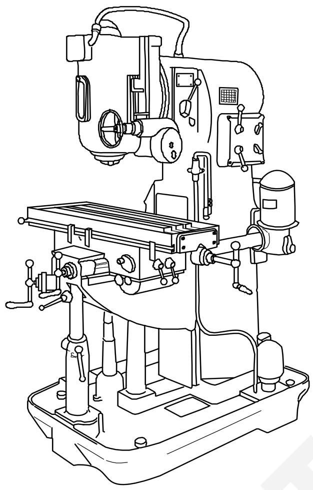


MM20N135513

2 Vertical milling machine (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 filted or swiveled.
- Most suitable for boring, pocket milling, profile milling and for making keyways.

Fig 4



MM20N135514

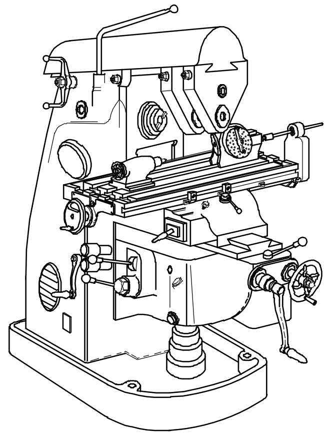
3 Universal milling machine (Fig 5)

- Table apart from having movements in 3 directions and also can be swiveled about its horizontal axis.
- Maximum swiveling 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 milling machine is similar in construction to the plain machine. But its table, apart from having movements in 3 directions, can also be swiveled about the horizontal axis. The maximum swiveling is 45° both the clockwise and anticlockwise directions. (Fig 6)

The swiveling of the table permits angular feeding. Because of this, the universal milling machine is suitable for milling helical gears, helical grooves, etc,.

Fig 5



MM20N135515

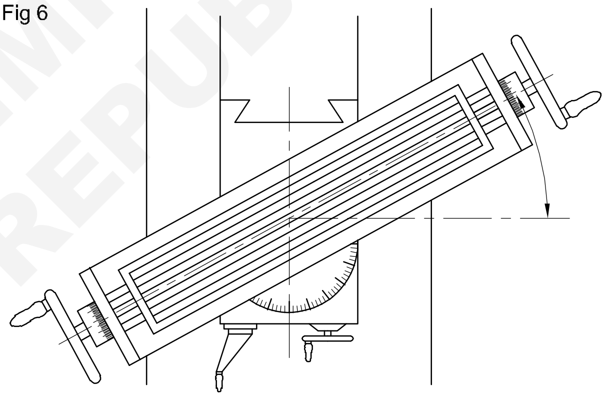
This machine is supported with different attachments like vertical head, slotting head, rack-milling attachment.

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

Fig 6



MM20N135516

- number of spindle speeds
- spindle nose taper
- number of feeds
- floor space area, etc.

Safety precaution followed during, milling opreration

- Work must be clamped securely in a vise and vise clamped tightly to the table, or, work must be clamped securely to the table.
- Do not take climb milling cuts on the shop's mills unless instructed to do so.
- Make sure cutter is rotating in the proper direction before cutting material.
- Before running machine the spindle should be rotated by hand to make sure it is clear for cutting
- Make sure the power is off before changing cutters.
- Always use the proper cutting fluid for the material being cut.

- Never run the machine faster than the correct cutting speed.
- Make sure that the machine is fully stopped before taking any measurements.
- Always use cutters which are sharp and in good condition.
- Don't place anything on the milling machine table such as wrenches, hammers, or tools.
- Always stay at the machine while it is running.
- Don't take to heavy a cut or use too rapid a feed.
- Remove the collect tightening wrench immediately after using it.
- if at all feasible rig a guard or shield to prevent chips from hitting other people.
- Use the milling machine spindle brake to stop the spindle after the power has been turned off.
- Before cleaning the mill remove cutting tools from the spindle to avoid cutting yourself.

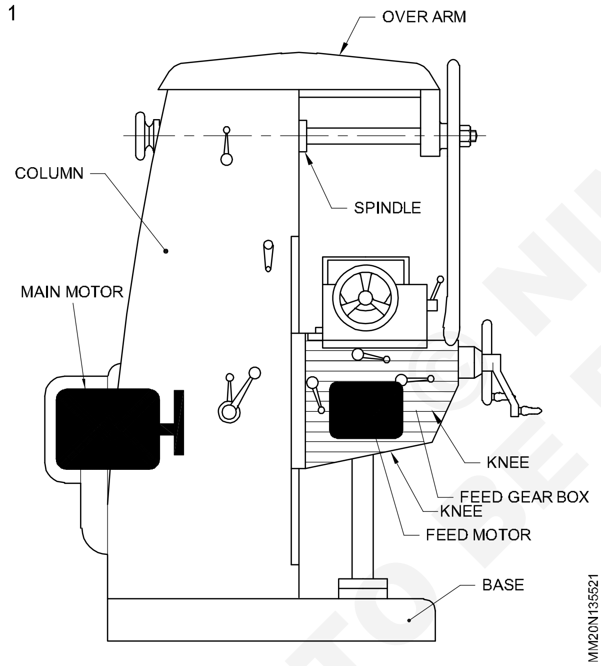
Parts and construction of milling machine

Objectives: At the end of this lesson you shall be able to
- **state the main parts of a milling machine and its functions.**

Part 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.

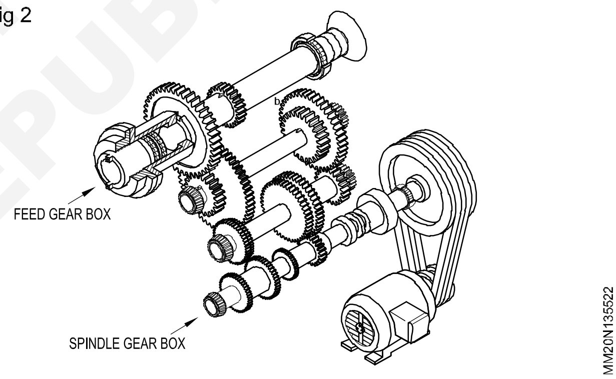
Knee

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.

Fig 2



Spindle

The spindle is housed in the upper part of the column and receives power from the motor and transmits it to the arbor.

The front end of the spindle projects from the column face and is provided with a tapered hole into which various cutting tools and arbors may be mounted. The accuracy in 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)

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 3

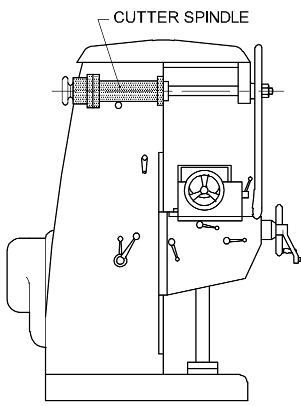
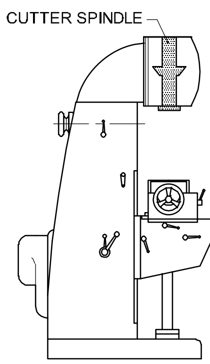


Fig 4



Overarm and brace (Fig 5)

The overarm is mounted on the top of the column above the spindle, and is intended as a support when milling with an arbor. The arm is adjustable so that the bearing support may be provided nearest to the cutter.

Fig 5

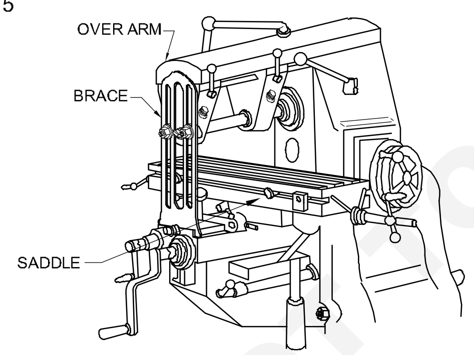
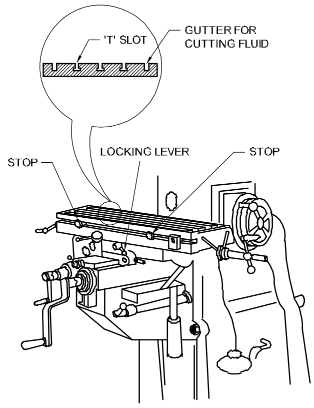


Table (Fig 6)

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.

The brace provides extra stability to the machine. It must be loosened before the table elevation setting is altered.

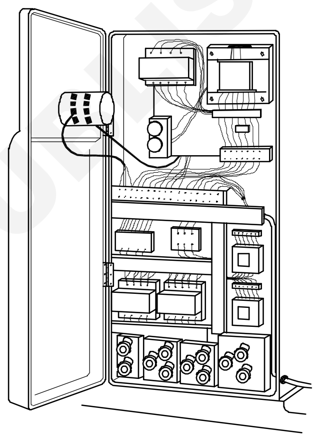
Fig 6



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.

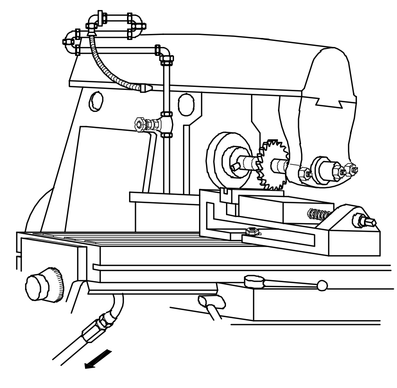
Fig 7



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



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.

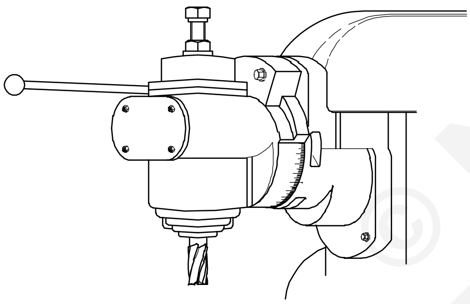
Vertical milling attachment (Fig 1)

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.

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.

Fig 1



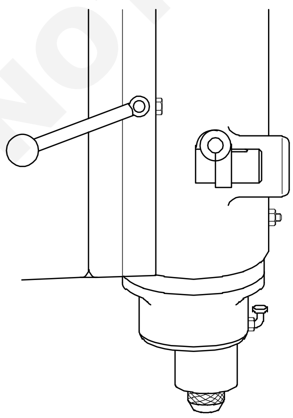
HEAVY DUTY VERTICAL ATTACHMENT

MM20N135531

High speed attachment (Fig 2)

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.

Fig 2



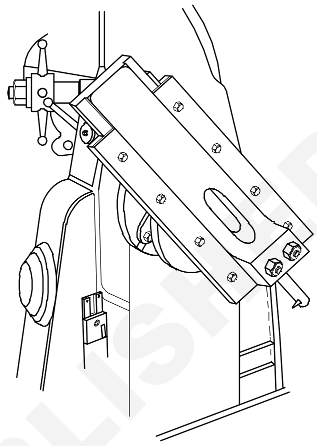
HIGH SPEED ATTACHMENT

MM20N135532

It may be fitted to the vertical or horizontal machine as required.

Slotting attached (Fig 3)

Fig 3



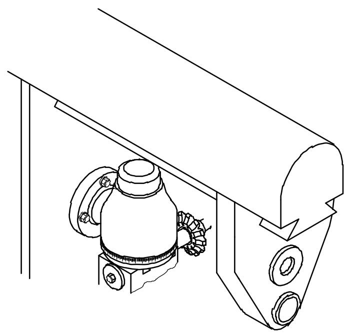
SLOTTING ATTACHMENT

MM20N135533

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

MM20N135534

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 swiveled 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 swiveling with respect to the housing.

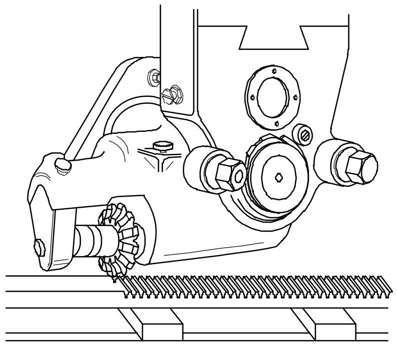
The combination of the two swiveling actions permits the small spindle to be set at any compound angle with respect to the column of the milling machine.

This attachment is particularly useful for cutting helical threads, gears, worms and racks.

Rack milling attachment

The rack milling attachment is mounted between the face of the column and the outer support on a plain or universal milling machine. It consists of a fixed housing fitted with an angle drive and a spindle. The spindle axis is fixed parallel to the table. (Fig 5)

Fig 5

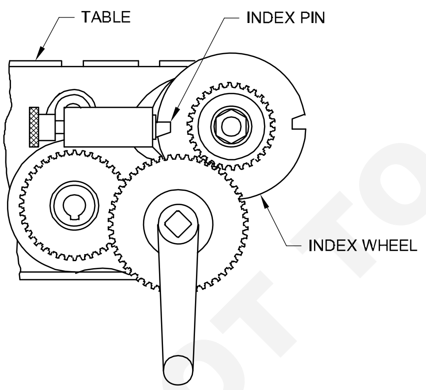


RACK MILLING ATTACHMENT

In rack milling, the cross-feed is used to move the cutter into the workpiece, and the longitudinal feed is used to index the cutter to produce the rack teeth.

A special rack indexing attachment (Fig 6) is used to move the work longitudinally, the exact amount needed for accurate spacing of the teeth.

Fig 6



RACK INDEXING ATTACHMENT

At one end of the table is fastened a bracket which carries a locking indexing wheel together with change gears for gearing to the table feed screw.

To index any required spacing, change gears are selected which will produce one or more complete turns of the indexing wheel. For each indexing operation, the index pin is withdrawn and the table advanced by turning the table feed screw until the pin drops into the slot again, and locks the wheel.

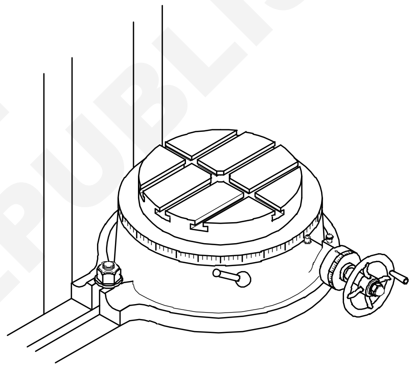
This method is positive and much more reliable than setting the table to a graduated dial directly fitted to the table feed screw.

Circular table attachment

This attachment is used for profile milling, surfacing quantities of small pieces in the one set up, and for many other circular operations in the horizontal plane such as slotting and dovetailing.

It consists of a base, a worm gear drive mechanism and a small circular work table. (Fig 7)

Fig 7



The base is bolted to the table and the drive mechanism connected with the feed mechanism of the milling machine. A crank for manual feed is also provided.

The workpiece is secured to the circular table and the table is rotated by the feed mechanism for circular cuts.

By combining the rotary motion with one or more of the other feeds of the machine, profiles of almost any shape can be milled. The hand crank can be replaced by an indexing device for requiring accurately spaced slots, holes or grooves.

Different types of milling cutter and their uses - cutter nomenclature

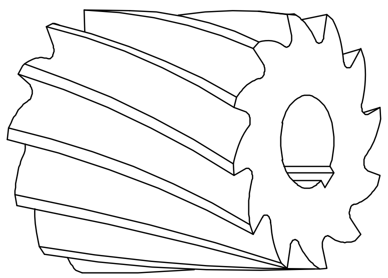
Objectives: At the end of this lesson you shall be able to
- **state the two main categories of milling cutters**
- **state the different types of plain milling cutters**
- **state the uses of plain milling cutters.**

Milling cutters

Milling cutters generally fall into two categories, solid cutters and inserted tool cutters.

Solid cutters (Fig 1)

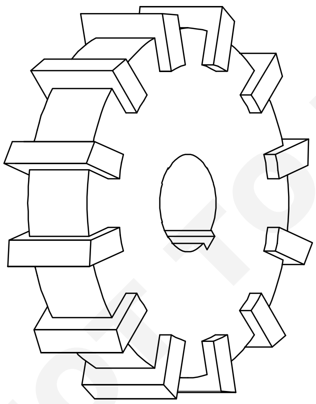
Fig 1



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

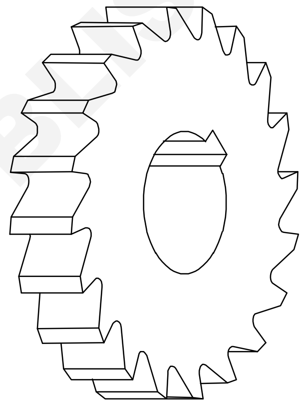
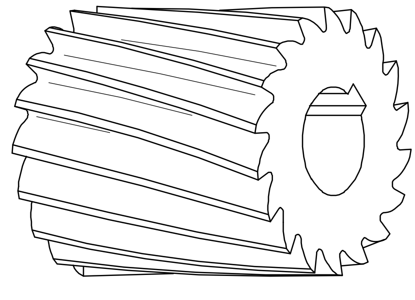


Fig 4



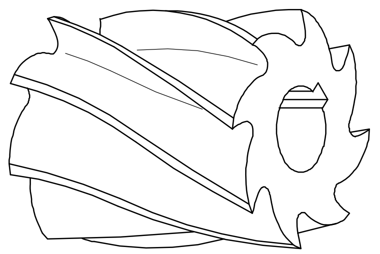
This type of cutter is used only for light milling operations since it has too many teeth to permit the chip clearance required for heavier cuts.

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°.

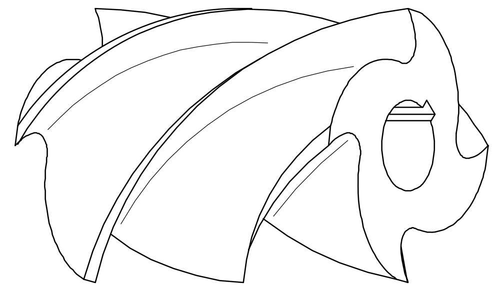
The greater helix angle on the teeth produces a smoother surface due to shearing action and reduces chatter. Less power is required for the cutter than what the straight tooth and small helix angle cutters require.

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

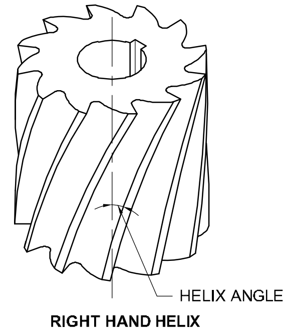


Fig 8

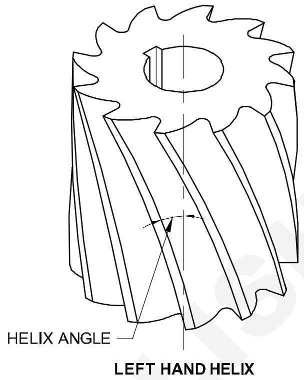


Fig 9

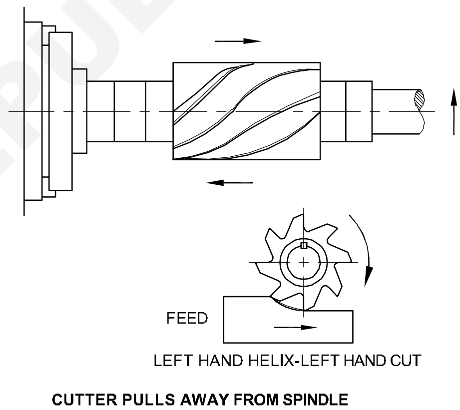
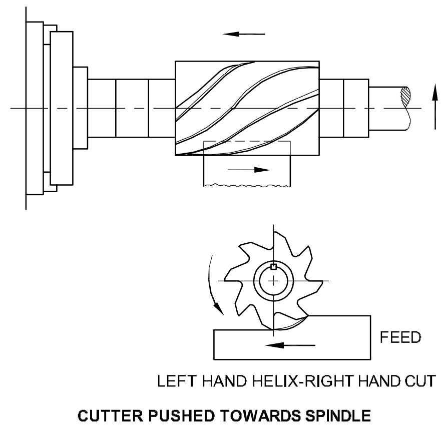


Fig 10



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

Objectives: At the end of this lesson you shall be able to
- **state the different types of side and face milling cutters and their uses.**

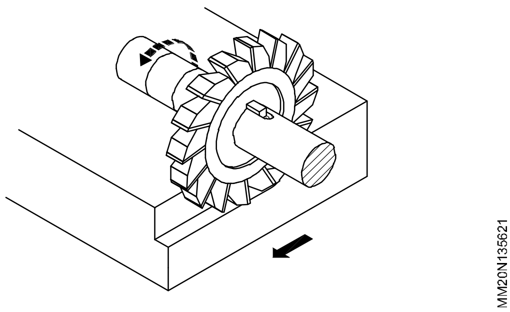
These cutters differ from plain milling cutters due to the fact that they have teeth on the periphery and face.

These cutters are mainly used for step milling, slot milling and straddle milling. These cutters are available from 50 to 100 mm in diameter and the width of the cutters ranges from 5 to 32 mm.

Types of side and face milling cutters

Half side milling cutter (Fig 1)

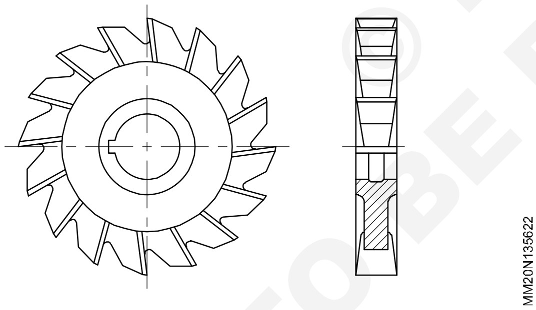
Fig 1



Cutters with teeth on one side only are called half side milling cutters and are used for heavy straddle milling, and for machining one side only.

Plain side and face milling cutter (Fig 2)

Fig 2



Inside and face milling cutters with teeth on both the sides are known as plain side and face milling cutters and are used for slot cutting (Fig 3) and face milling. These cutters are also used for straddle milling. (Fig 4).

Fig 3

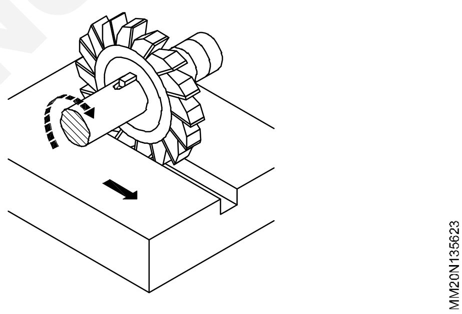
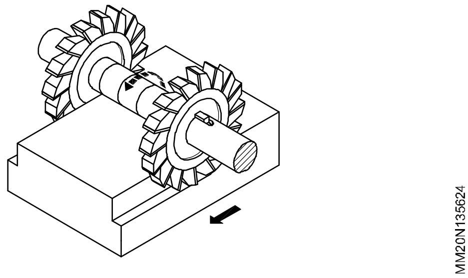


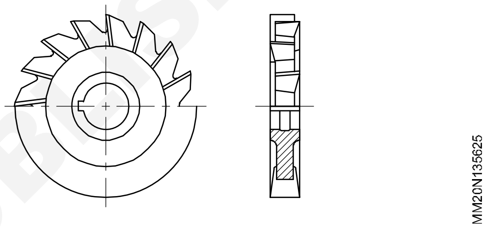
Fig 4



Staggered teeth side milling cutter (Fig 5)

These cutters have alternate teeth with opposite helix angles. Due to this design, the chip space increases to a great extent. These cutters are used for milling deep and narrow slots or keyways.

Fig 5

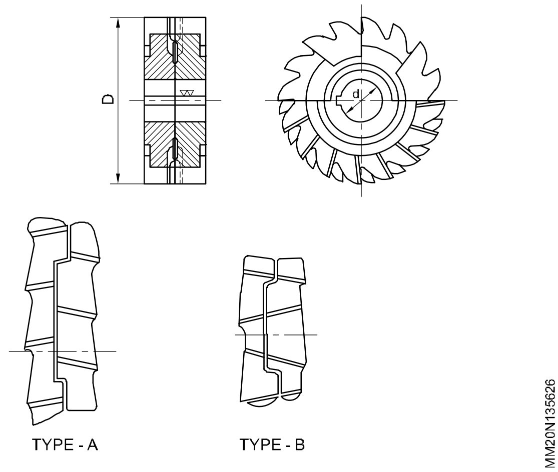


Interlocking side milling cutter (Fig 6)

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 the 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 filted 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 index able inserts which can be replaced when worn out. (Fig 4)

Fig 1

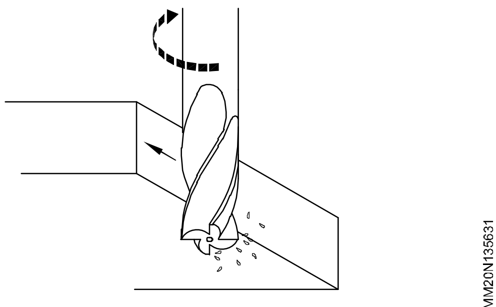


Fig 2

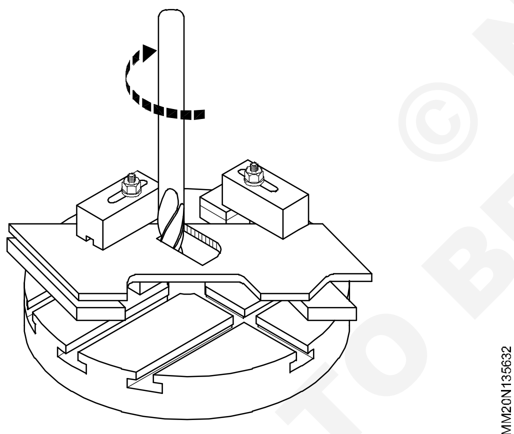


Fig 3

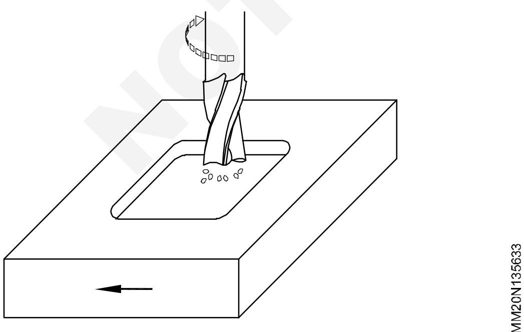
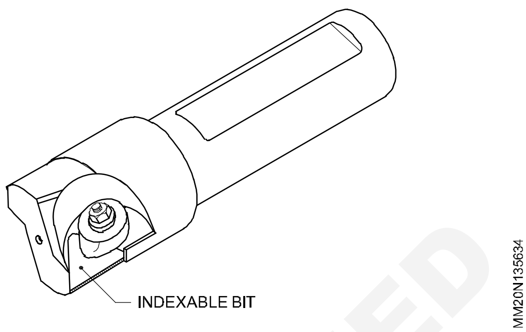
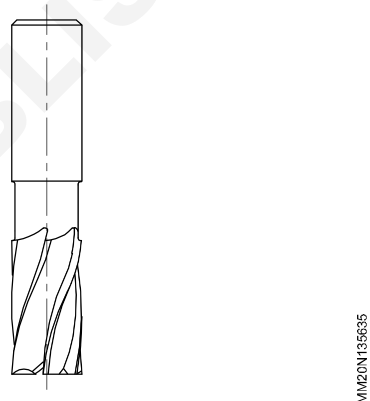


Fig 4



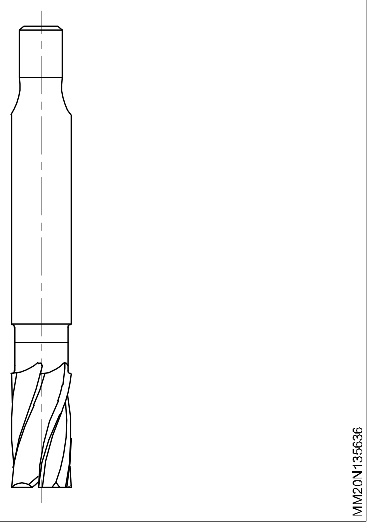
End mill cutters are solid type of cutters in which the shank and the cutters are integral. (Fig 5)

Fig 5



End mill cutters have straight shank (Fig 5) or taper shank (Fig 6).

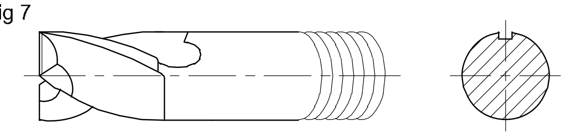
Fig 6



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.**

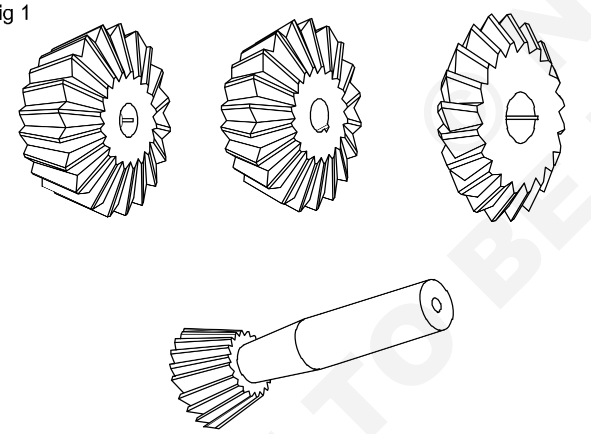
Angular milling cutters

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

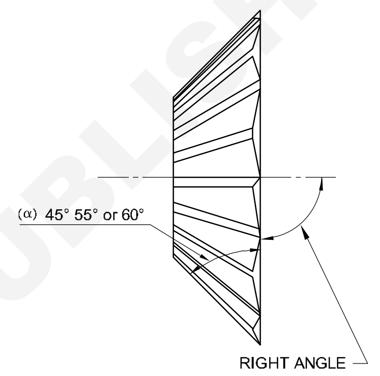
These cutters have teeth on the angular surface, and may or may not have teeth on the flat side. The included angle between the flat face and the angular face designates the cutters, such as 45° or 60° angular cutter. (Fig 2) They may be of the shell or shank type.

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



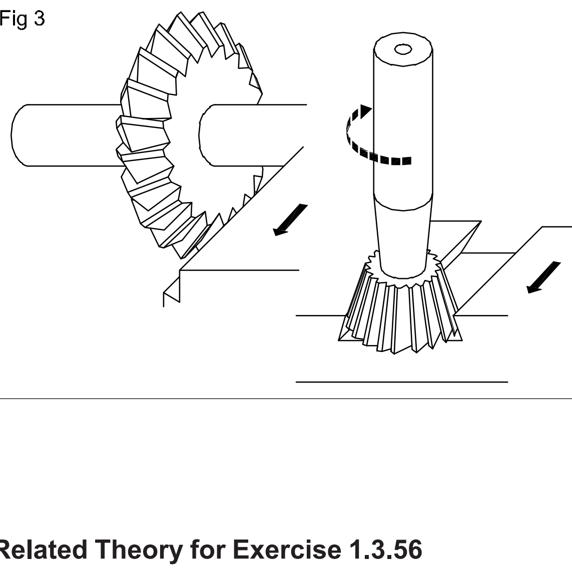
A dovetail milling cutter type A having diameter D = 20 mm, angle μ = 60° of tool type 'N' for right hand cutting shall be specified as

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)

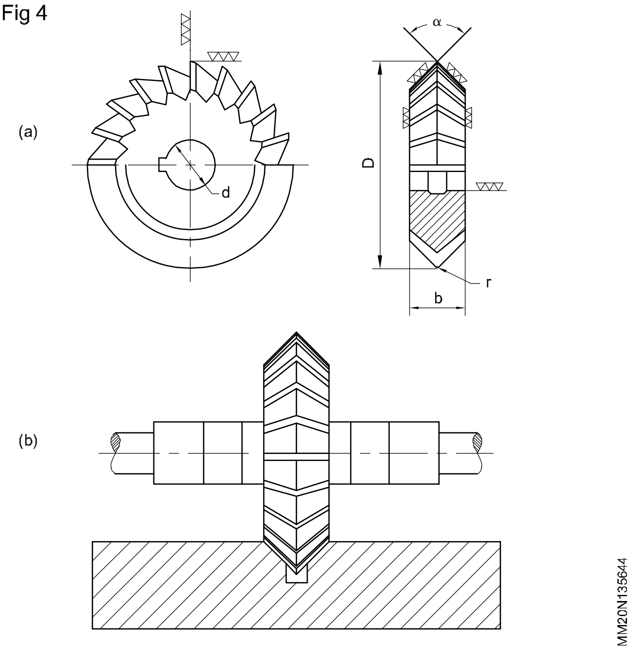
Fig 3



Equal angle milling cutters

These cutters have two intersecting angular surfaces with cutting teeth on both. 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

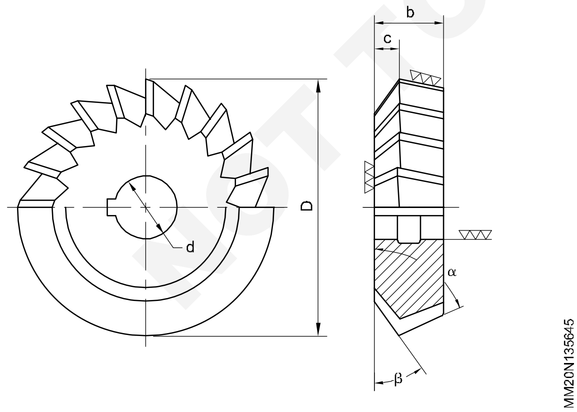
An equal angle milling cutter of diameter D = 56 mm for angle 60° of 'tool type' N shall be specified as Equal angle milling cutter 56 x 60° N IS 6326.

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

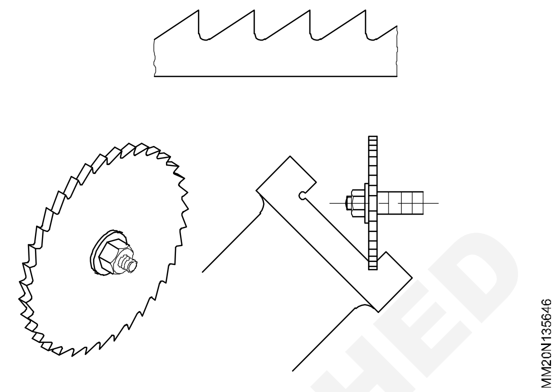
A double angle milling cutter of diameter D = 50 mm, b = 12 mm and angle 75° of 'tool type H and for right hand cutting shall be specification as

Double angle milling cutter 50 x 12 x 75°H IS 6325.

Slitting saw

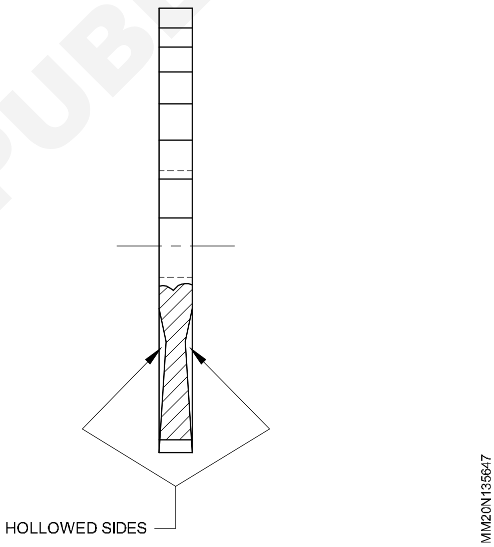
It is basically a thin plain milling cutter. It has a large number of teeth. (Fig 6)

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

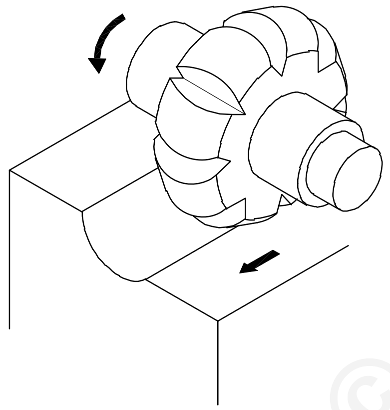
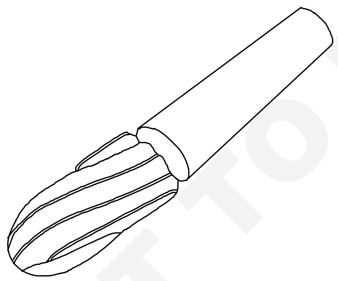


Fig 2

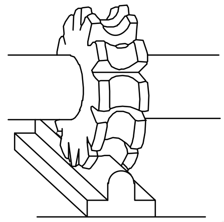


Concave milling cutter

These cutters have their teeth curved inwards on the circumferential surface to form the contour of a semi circle. Convex semicircular surfaces are produced with this cutter. (Fig 3).

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



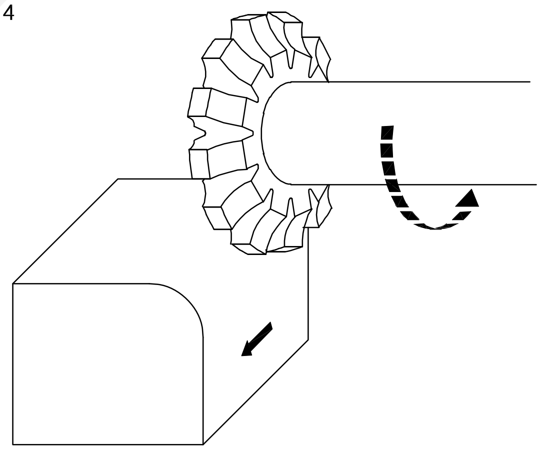
Corner rounding milling cutter

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



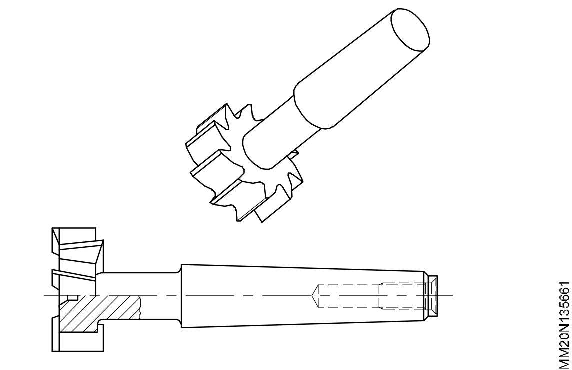
‘T’ slots cutters

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

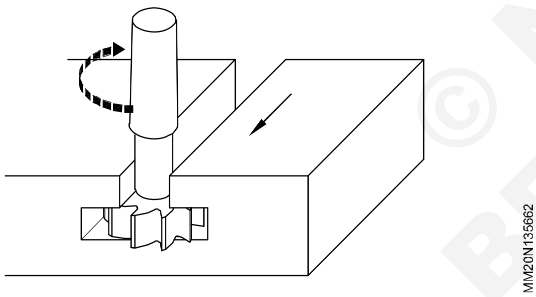
These cutters are profile-sharpened side milling cutters with a straight or taper shank. (Fig 1) They have staggered teeth and are either solid or tipped in construction. Due to the staggered teeth the chips are cleared without clogging.

Fig 1



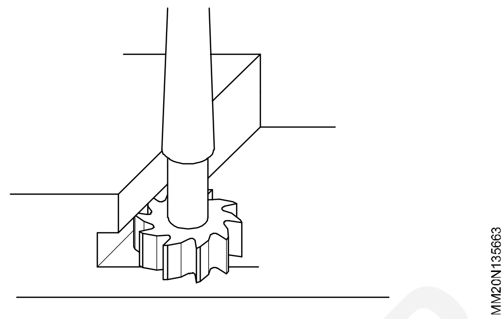
The ‘T’ slot cutter is used to cut ‘T’ shaped slots in machine tool work tables. (Fig 2) Before cutting the ‘T’ slot, a narrow vertical groove is machined with an end mill or a slot milling cutter.

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.

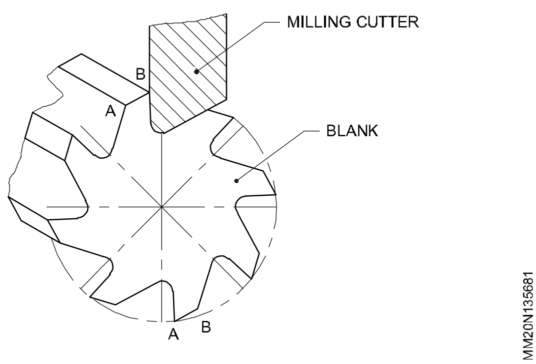
Example : 16 N BIS 2668

Cutter nomenclature

Objectives: At the end of this lesson you shall be able to
- **state the elements of a milling cutter**
- **state the influence of rake angles in machining.**

Milling cutter are multiple point cutting tools. They are made from cylindrical blanks with the teeth formed by milling the chip space. (Fig 1) The number of teeth so milled depends on the diameter of the cutter as well as on the type of operation, namely roughing and finishing. A roughing cutter will have less number of teeth as compared to a finishing cutter of the same diameter.

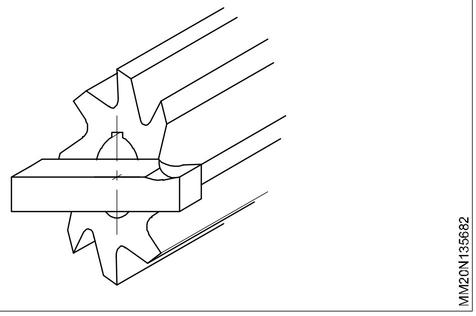
Fig 1



Angle of a milling cutter

A milling cutter tooth is more or less identical to that of a single point tool. (Fig 2)

Fig 2



The rake angle (a) of a milling cutter is the inclination of the tooth face F, and it is measured from a line joining the centre of the cutter 'O' and the tip of the tooth 'T'. (Fig 3)

The **clearance angle** of a milling cutter is the relief given to the portion AB of the cutter. (Fig 1) This clearance relief is given to form the cutting edge, and it avoids rubbing the work piece while machining. It is given in two stages. First it is ground to a small angle θ. (Fig 3) and this angle is called relief angle. This angle should be very small (about 6°) as any increase in this angle would reduce the strength of the tooth. The portion TP of the tooth up to which the relief angle extends is called the land.

After the land, the tooth is further relieved to an angle θ1 (Fig 3) and this angle is called the **primary clearance** angle which is about 15°. The angle θ2 (Fig 3) is called the **secondary clearance** angle and this defines the shape of the chip space which is also called gash. The tooth of the chip space is reduced to help curling of the chips. (Fig 4) This round portion of the chip space is called **fillet**.

It may be noted that the relief angle θ, primary clearance angle θ1 and secondary clearance θ2 are all measured from a tangent drawn at the tool tip T. (Fig 3)

Fig 3

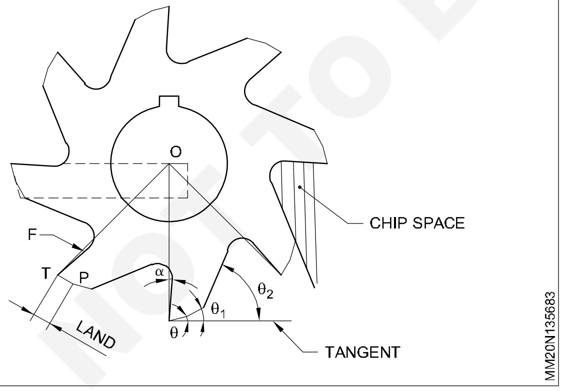
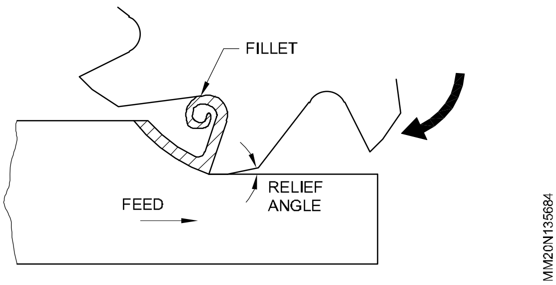


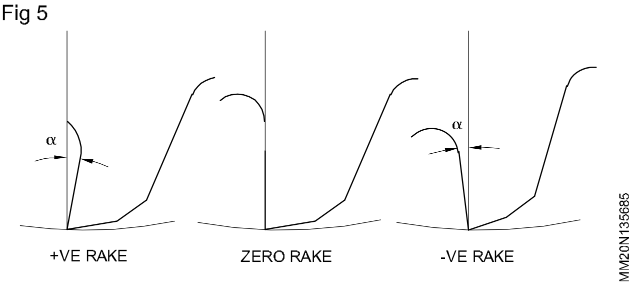
Fig 4



Positive, zero and negative rake

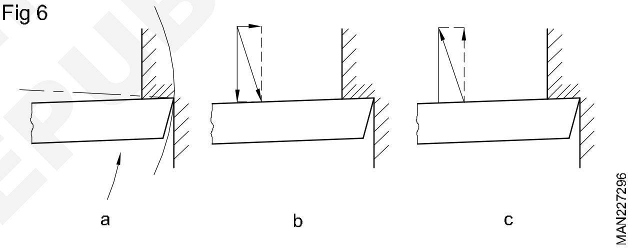
The rake angle may be positive, zero or negative as shown in fig 5.

Fig 5



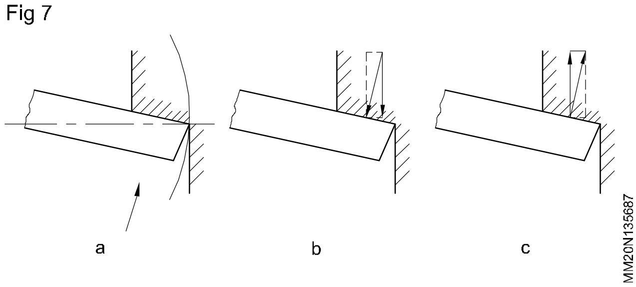
The positive rake is used for general purpose, and is used specially for milling materials which produce continuous chips. In the positive rake, the weakest point is presented to cut first. (Fig 6a) The reaction forces tend to pull the cutter into the work (Fig 6b) and the cutter forces tend to lift 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.

Milling cutter holding devices

Objectives : At the end of this lesson you shall be able to
- **state the different types of arbors**
- **state the uses of arbors**
- **name the parts of an arbor**
- **specify the arbor**
- **brief the different methods of holding end mills.**

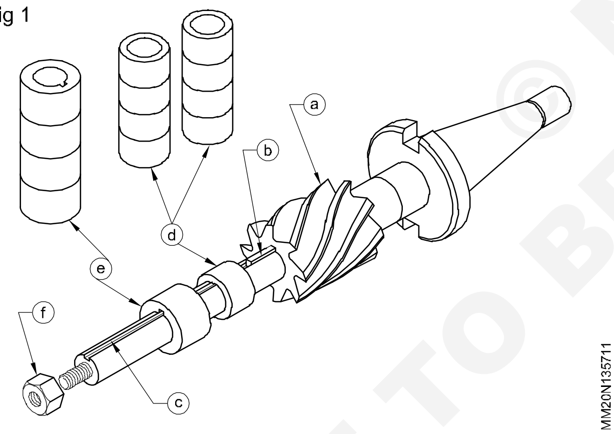
Types of arbors and their uses

An arbor is considered as an extension of the machine spindle on which milling cutters are mounted. Arbors are provided with quick-release taper shanks for proper alignment with the spindle. There are two types of arbors, normally used for holding the cutters. They are (1) long arbor and (2) short or stub arbor.

Long arbor (Fig 1)

Long arbors are used for holding cutters in both horizontal and universal milling machines. The milling cutter (a) is driven by a key (b) which fits into the keyway (c) on the arbor and cutter. This prevents the cutter from turning on the arbor. The spacer (d) and bearing bushings (e) hold the cutter in position on the arbor after the nut (f) has been tightened.

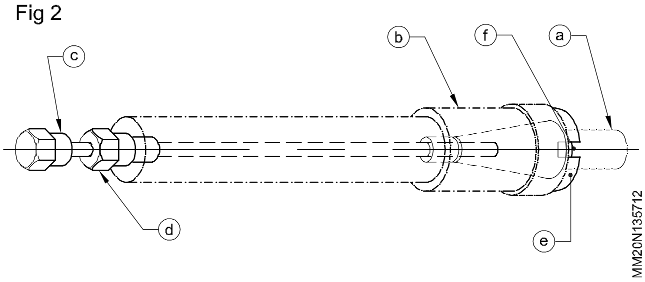
Fig 1



The tapered end of the arbor (a) is held securely with the machine spindle (b) by a draw-in bar (c) and lock-nut (d). (Fig 2) The flange (e) has two notches (f) to engage with the spindle tennon for transmitting the power.

The outer end of the arbor assembly is supported by the bushing and the arbor support.

Fig 2



Long arbors with I.S.O.taper shanks are available in different diameters. The normal diameters used commonly are Ø16, Ø22,Ø27, Ø32, Ø40 and the taper is ISO40/50.

The arbor is designated by the taper number, diameter and length.

Example ISO40 x Ø 22 x 500 mm.

ISO40 = Type of taper

Ø 22 = diameter of the arbor in 'mm'

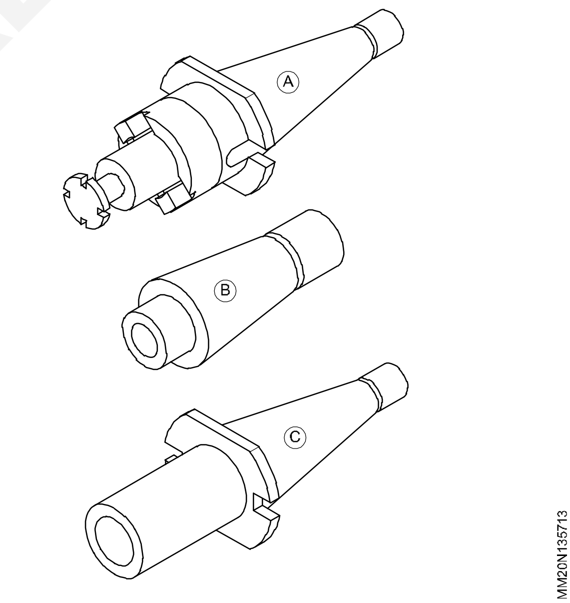
500mm = length of the arbor

Stub arbor

Stub arbors are used to mount various tapers of cutters in the spindle of horizontal and vertical milling machines.

The arbors are held with the machine spindle by a taper and a draw-in bar. The arbors are of three types (A), (B) & (C) as shown in Fig 3.

Fig 3

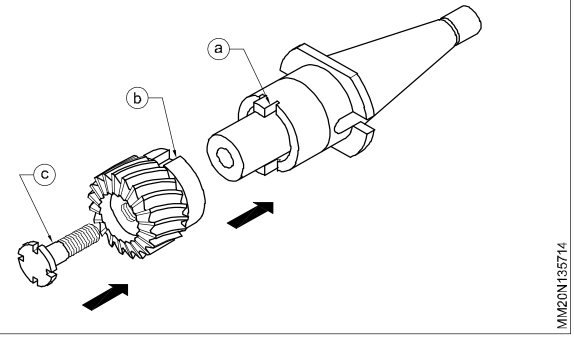


Types

Type A (Fig 4) is used to mount the shell end mills and similar cutters.

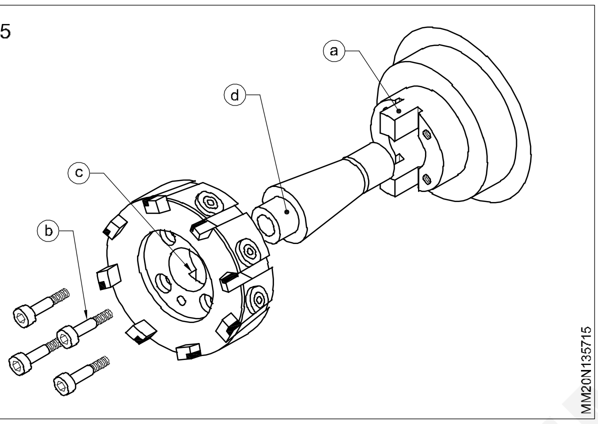
The cutter is pushed on the arbor so that the arbor key (a) fits with the slot (b) on the cutter. The cutter is tightened on the arbor using the screw (c).

Fig 4



Type B (Fig 5) is used to mount large face milling cutters. It is made with a centralizing spigot (a) to ensure that the cutter is centralized with the cutter spindle.

Fig 5



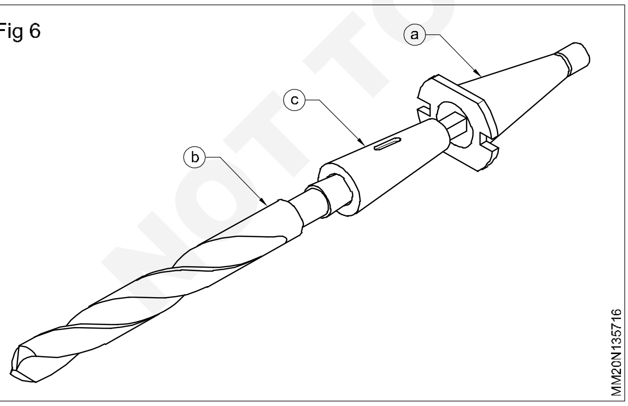
The cutter is held on the arbor by four screws (b). It has a slot (c) which fits over the spindle (d) to provide the drive.

Type C (Fig 6) is a Morse taper adapter arbor (a). It is used to hold drills, reamers, chucks (b), etc. which have taper shanks and also Morse taper sleeves (c) which are used to adapt a Morse taper to a larger taper.

According to B.I.S. specifications stub arbors with Morse taper shanks are available from 13 to 27 mm in diameters.

The stub arbor is designated by the taper number, diameter and length.

Fig 6



Collet chuck (Fig 7)

The chuck is supplied with a set of spring collets (Fig 8) in various sizes to suit the shanks of standard parallel shank cutters.

The chuck body Fig 9(a) is mounted in the machine spindle nose in the same way as the horizontal milling arbor.

Fig 7

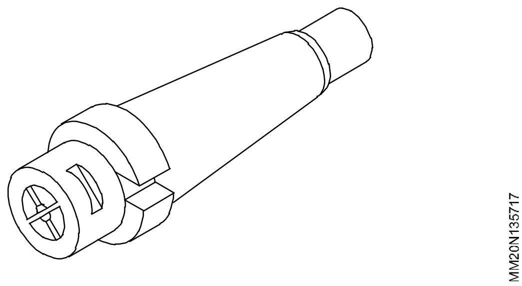


Fig 8

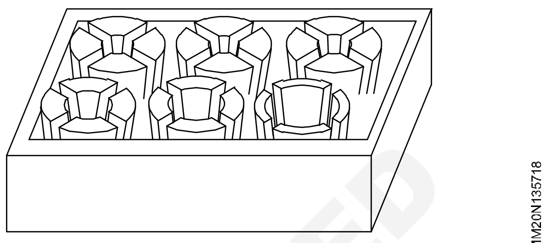
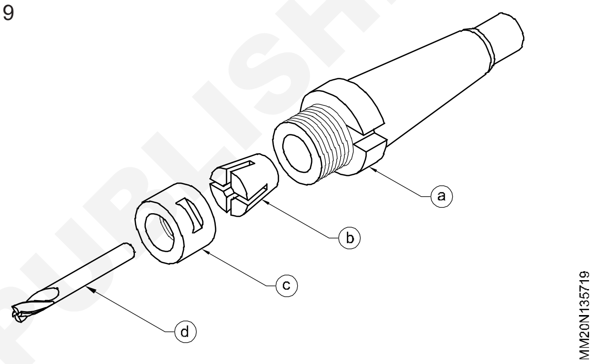


Fig 9



The collet (b) (of the same size as that of the cutter shank) is pushed in to the chuck body. The nut (c) is screwed on until it just grips the collet.

The cutter (d) is inserted into the collet and then the nut is tightened using the special spanner supplied with the chuck.

Adapters

These are used to reduce the internal taper in the work spindle, so that it fits on required arbor or cutter. (Fig 10) This type is used for holding the cutters with internal thread. Another type of adapters (shown in Fig 11) with Morse taper and flat tongs is used for holding taper shank end mills with tongs.

Fig 10

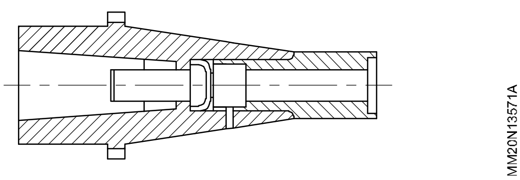
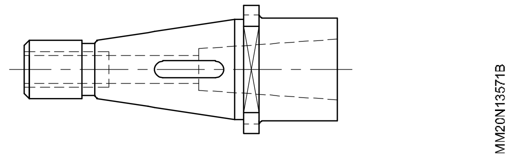


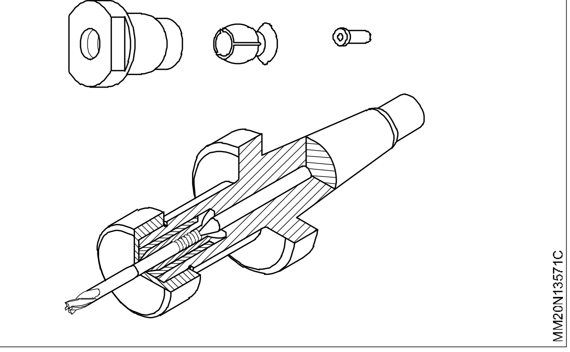
Fig 11



Self-locking chucks (Heavy duty chucks)

The cutter is provided with fine pitch thread at the end of the cutter shank. The cutter is mounted by turning with the thread provided into the chuck body and clamping. (Fig 12)

Fig 12



The common methods used to mount end mills in vertical milling machine are shown in Figs 13 to 16.

Fig 13

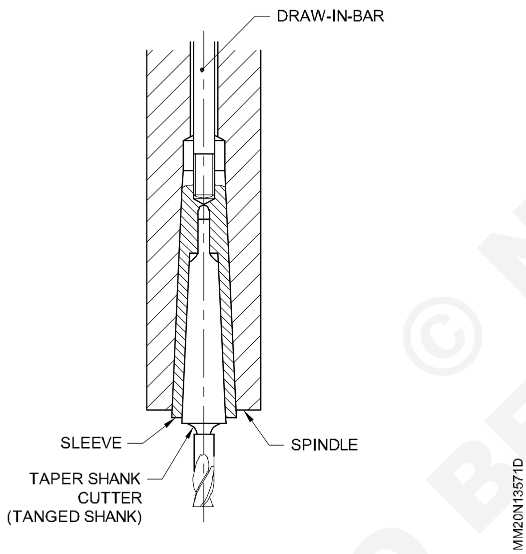


Fig 14

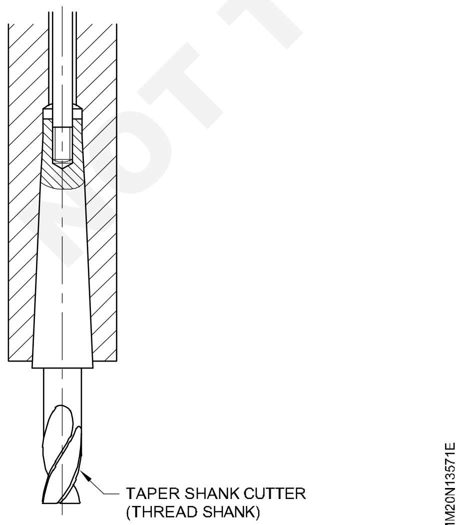


Fig 15

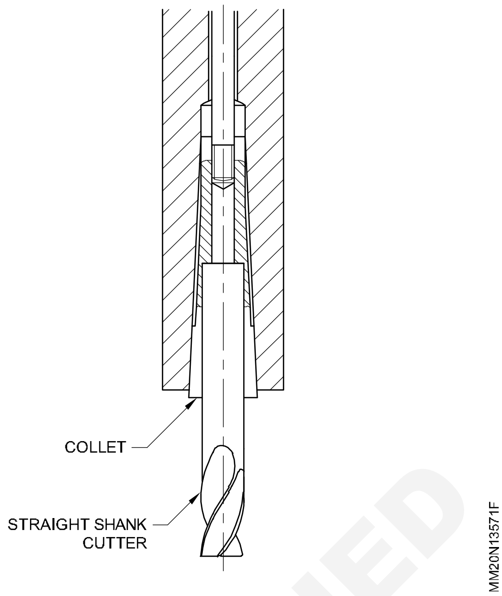
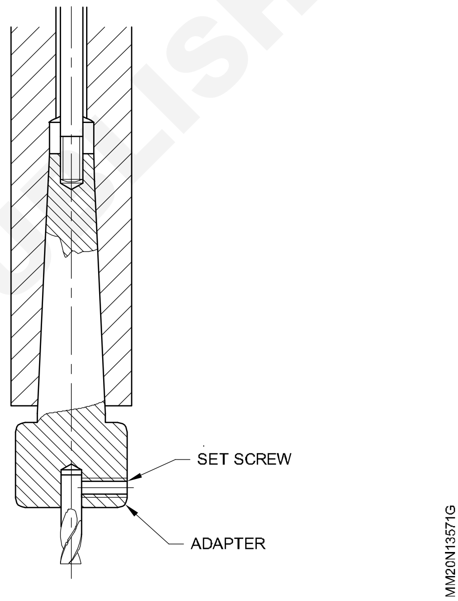


Fig 16



Work holding devices

Objectives: At the end of this lesson you shall be able to
- **explain vices, clamps, v-block, parallel block**
- **list the type of Work holding devices.**

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.

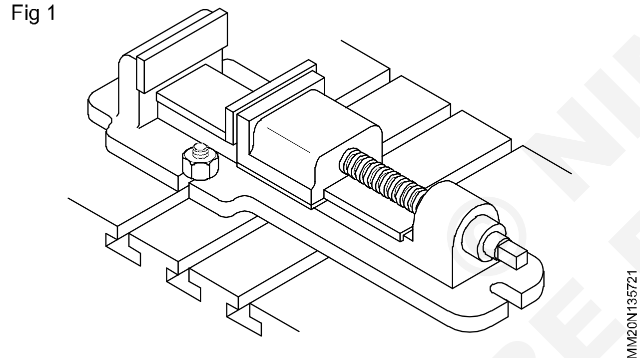
Machine vices and clamps

There are two main types of machine vices used or milling machine.

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.

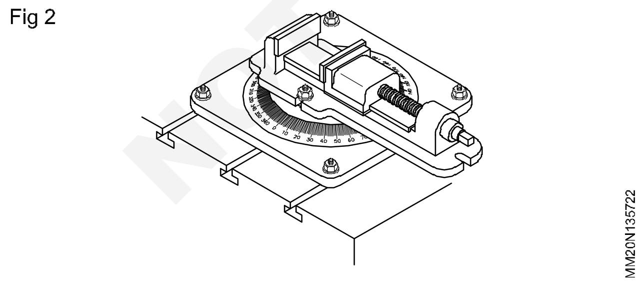
Fig 1



Swivel base vice (Fig 2)

It is the most commonly used on milling machine. The base can be swiveled to the desired angle to machine angular jobs.

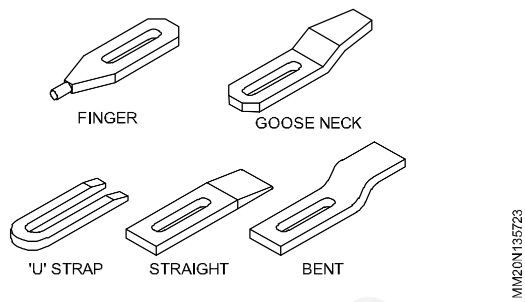
Fig 2



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.

Fig 3



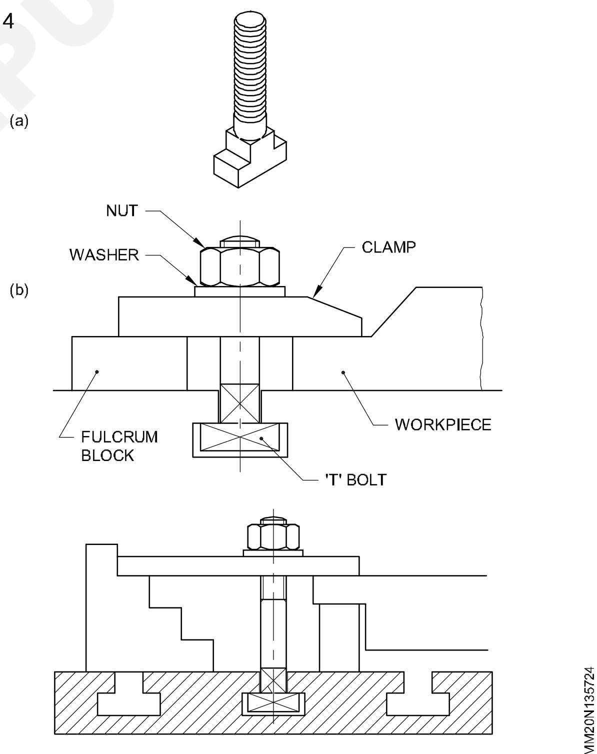
Tee bolts (Fig 4a)

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.

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

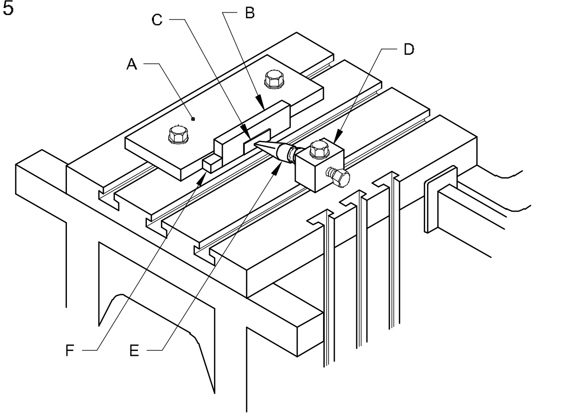
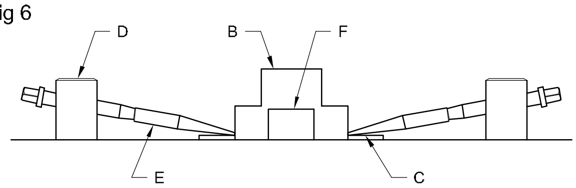


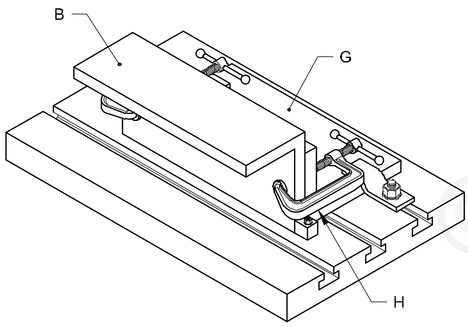
Fig 6



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.

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 8

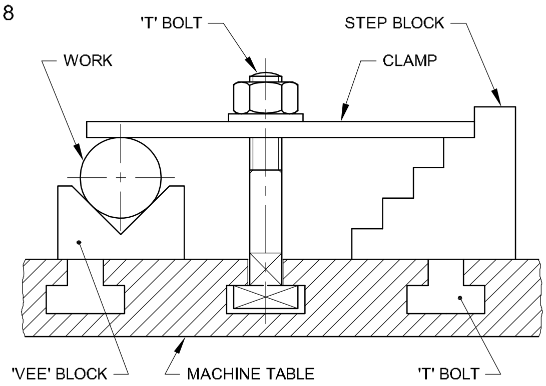
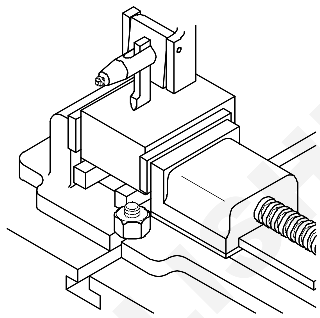


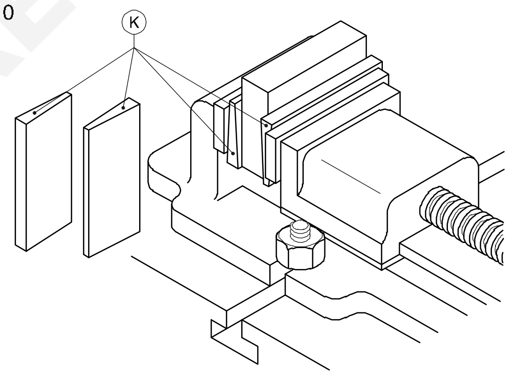
Fig 9



Degree parallels (K in 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



Milling machine operations

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.**

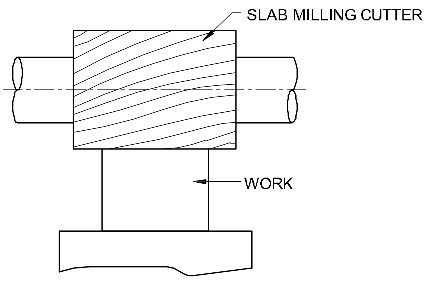
Plain milling

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.

Face milling

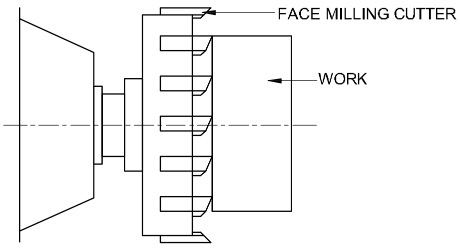
The face milling is the operation performed by the face milling cutter rotated about an axis at right angles to the work surface. End mills and side & face milling cutter are also used at times to perform this operation. Fig 2 shows face milling operation.

Fig 1



PLAIN MILLING OPERATION

Fig 2

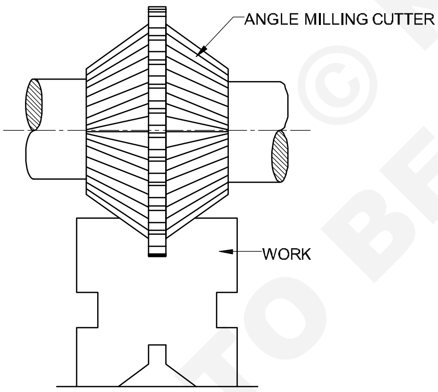


FACE MILLING OPERATION

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.

Fig 3



ANGULAR MILLING OPERATION

Form milling (Fig 4)

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.

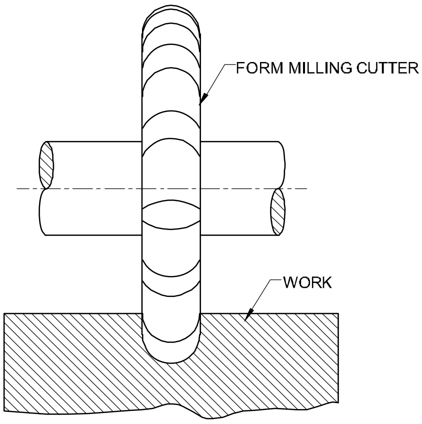
Slot milling (Fig 5)

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.

Gang milling

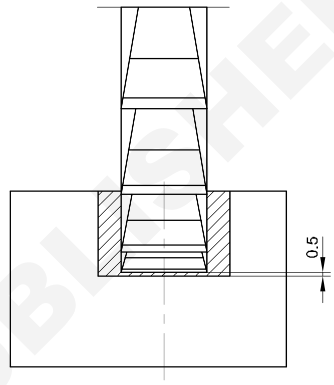
It is the operation of machining several surfaces of work simultaneously by feeding the table against a number of cutters (either of same type or different type) mounted on

Fig 4



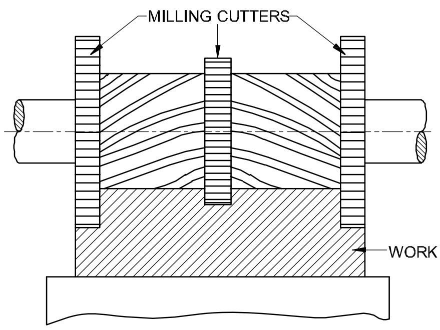
FORM MILLING OPERATION

Fig 5



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)

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.

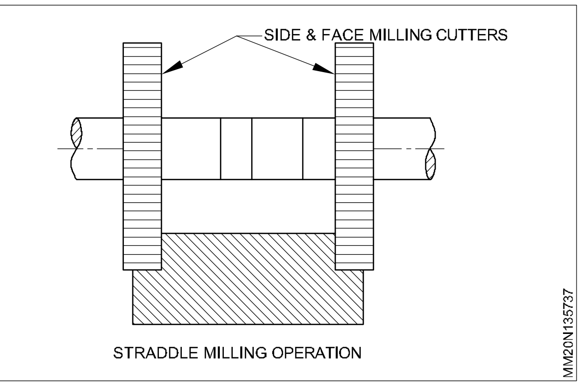


Fig 7

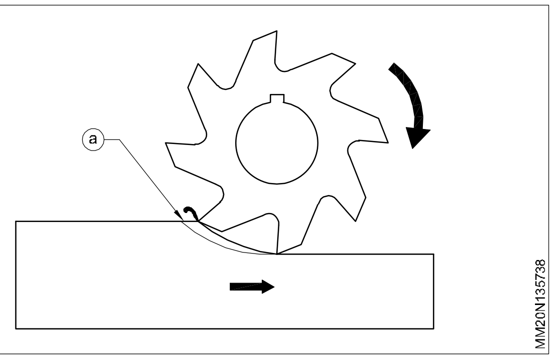


Fig 8

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 climb-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.

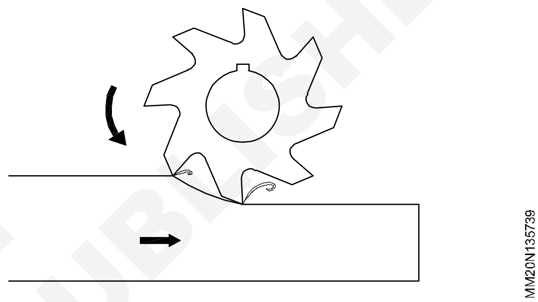


Fig 9

Cutting speed, feed and machining time calculation

Objectives: At the end of this lesson you shall be able to
- **calculate the revolution per minute for various cutters and materials**
- **select and calculate proper feeds for various cutters and materials**
- **explain the correct procedure for taking roughing and finishing cuts.**

Cutting speeds, feeds and depth of cut

The efficiency of a milling operation depends upon the cutting speed, feed, and depth of cut.

If the cutter is run too slowly valuable time will be wasted, while excessive speed results in loss of time in replacing and regrinding cutters. Somewhere between these two extremes is the efficient cutting speed for the material being machined.

The rate at which the work is fed into the revolving cutters is important. If the work is fed too slowly time will be wasted and chatter may occur which shortens the tool life of the cutter. If the work is fed too fast, the cutter teeth can be broken. Much time will be wasted if several shallow cuts are taken instead of one deep or roughing cut. Therefore speed, feed and depth of cut are the three important factors in any milling operation.

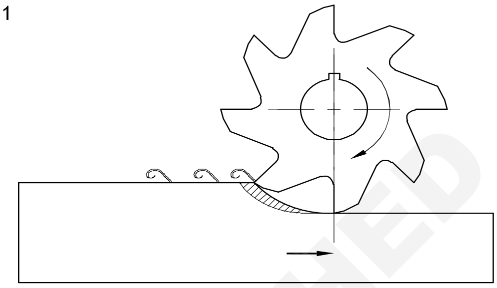
Cutting speed

The cutting speed for a milling cutter is the speed at which the cutting edge or tooth cuts into the workpiece. (Fig 1)

It is expressed in metres per minute.

The following important factors must be considered when determining the proper revolutions per minute at which to machine a metal.

Fig 1



MM20N135811

- Type of work material
- Cutter material
- Diameter of the cutter
- Surface finish required
- Depth of cut being taken
- Rigidity of the machine and work set up

Since different types of metals vary in hardness, structure and machineability, different cutting speeds must be used for each type of metal and for various cutter materials.

The cutting speeds for the more common metals for HSS milling cutters are shown in Table 1.

Table 1

Table for selecting cutting speeds for high speed steel milling cutters

Material to be machined	BHN hardness	Shell and Mill	End mill	S& F cutter	Cylind. cutter	Slot's cutter	Form cutter	In.tooth face mill
Mild steel	150	20-30	20-30	15-25	15-25	15-25	30-45	20-30
Medium carbon steel	200	15-25	15-20	15-20	20-30	15-20	15-25	15-25
High carbon steel	300	10-15	10-15	10-15	12-20	10-15	13-20	13-20
Stainless steel	200	22-30	22-30	15-25	15-25	20-30	15-25	20-30
Malleable iron	160	15-22	15-22	15-20	15-20	20-30	15-20	18-25
Soft cast iron	180 max	15-20	15-25	15-20	15-20	20-30	15-20	15-25
Hard cast iron	Over 180	13-17	10-15	10-15	10-15	10-25	10-15	13-17
Hard brass & hard bronze	-	40-60	40-60	30-45	30-45	70-90	30-45	50-60
Soft brass & soft bronze	-	40-60	40-60	25-35	25-35	70-90	25-35	40-50
Copper	-	30-45	30-45	30-45	30-45	70-90	25-35	50-60
Aluminium alloy	-	200-300	200-300	150-300	150-300	200-300	150-250	200-400

Carbide cutters are able to cut at a much higher speed than HSS cutters and they are made in a variety of grades. If you are going to use a carbide cutter, ask your instructor what cutting speed you should select, as he will have the values for the particular grade of carbide used in the cutter in your workshop.

Calculation

$$\text{Cutting speed (V)} = \frac{\pi DN}{1000} \text{ m/min}$$

$$N(r.p.m) = \frac{V \times 1000}{3.1416 \times D}$$

Since only a few machines are equipped with a variable speed drive which allows them to be set to the exact calculated speed, a simplified formula can be used to calculate the revolution per minute.

The π(3.1416) on the bottom line of the formula will divide the 1000 of the top line approximately 320 times. This results in a simplified formula which is close enough for most milling operations.

$$N(r.p.m) = \frac{V\,(m) \times 320}{D\,(mm)}$$

where 'D' is diameter of the cutter.

Example

Calculate the revolution per minute required for ϕ75 mm high speed steel cutter when cutting machine steel. (V = 30 m/min.)

$$r.p.m = \frac{30 \times 320}{75} = \frac{9600}{75} = 128$$

From the Table 2 the intersection of $\varnothing$ 75mm and cutter speed of 30 m/min. is in between 115 and 140 r.p.m. This can be taken as 128 r.p.m. as calculated.

Too fast a speed will shorten the cutter tool life; too slow a speed will waste time.

Milling feeds and depth of cut

The two other factors which affect the efficiency of a milling operation are the milling FEED or the rate at which the work is fed into the milling cutter and the DEPTH of CUT taken at each pass.

Feed

Feed is the rate at which the work moves into the revolving cutter. It is measured in millimetres per minute (mm/min.)

Feed rate is specified in mm/min.

The feed is expressed in milling machines by following three different methods.

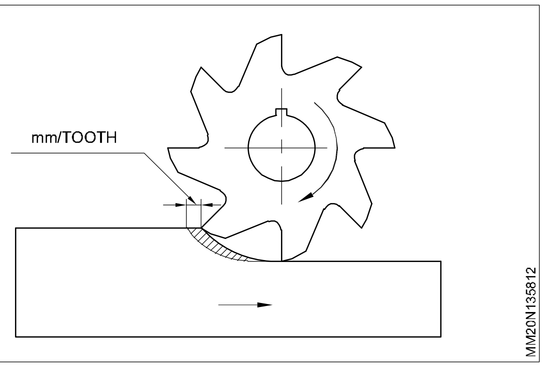
Feed per tooth

Feed per tooth is defined by the distance the work advances and the time between engagement by two successive teeth. It is expressed in mm/tooth of the cutter.(Fig 2)

Feed per cutter revolution

Feed per cutter revolution is the distance the work advances in the time when the cutter runs through one complete revolution. It is expressed in mm/revolution of the cutter.

Fig 2



Feed per minute

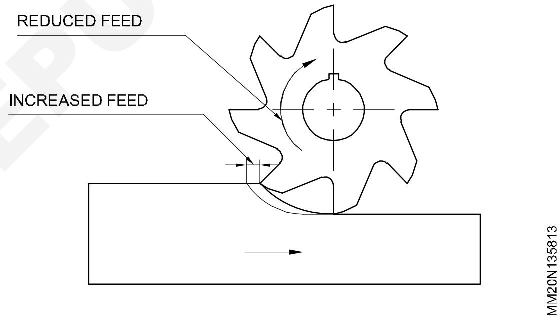
Feed per minute is defined by the distance the work advances in one minute. It is expressed in mm/ minute.

The rate of feed has an effect on the life of the cutter. An increase in feed, using the same cutting speed and depth of cut will reduce the amount of wear of the cutter.

In general we can say that the

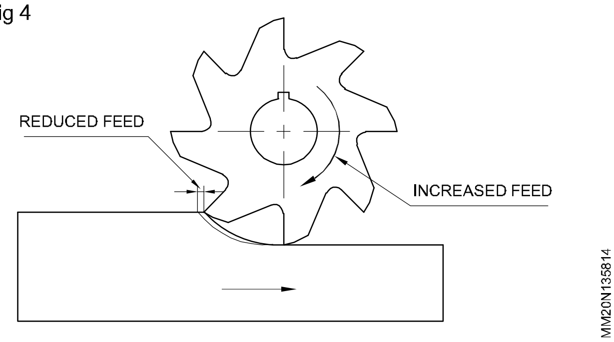
- cutting speed should be reduced when feed is increased (Fig 3)

Fig 3



- cutting speed should be increased when feed is reduced. (Fig 4)

Fig 4



The feed rate on a milling machine depends on a variety of factors such as

- width and depth of cut
- type of cutter
- sharpness of the cutter
- workpiece material

- strength and uniformity of the workpiece
- type of finish and accuracy required
- power and rigidity of the machine.

Calculation

The formula used to find the work feed is

feed mm/min.(S) = N x Cpt x r.p.m.

where N = number of teeth in milling cutter

Cpt = chip per tooth for a particular cutter

r.p.m. = revolution per minute of the milling cutter.

Example 1

Calculate the feed in mm/min. for a ∅75, six-teeth helical carbide milling cutter when machining a cast iron workpiece (V = 60 and Cpt = 0.18).

First calculate the r.p.m. of the cutter

$$\text{rev/ min.} = \frac{60 \times 320}{75} = 256$$

Feed (mm/min.) = N x C.p.t x r.p.m.

= 6 x 0.18 x 256

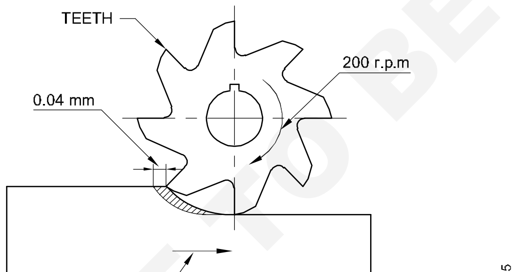
= 276.4

= 276 mm/min.

> **The spindle speed (revolution per minute) must always be calculated before the feed rate can be calculated.**

Example 2 (Fig 5)

Fig 5



A cutter having 8 teeth is to have a feed of 0.04 mm/tooth. The spindle speed is to be 200 r.p.m. What feed, in mm/min. should be set on the machine?

While rough milling, where the purpose is to remove surplus metal as quickly as possible and finish is not important, a heavy feed and low cutting speed are used. (Fig 6) However, the cutting speed should not be reduced too much as the cutter would then be operating under very heavy cutting forces.

For finish milling, the quality of the surface finish is, ofcourse, important. Therefore, a light feed and a high cutting speed are used. (Fig 7)

Fig 6

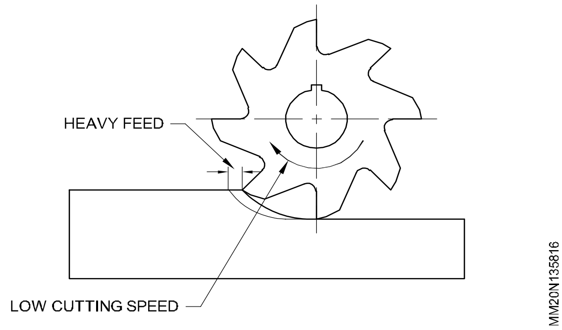
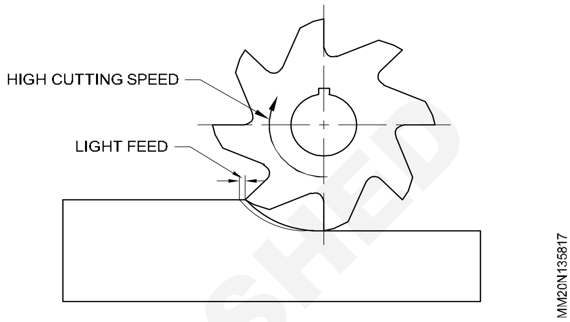


Fig 7

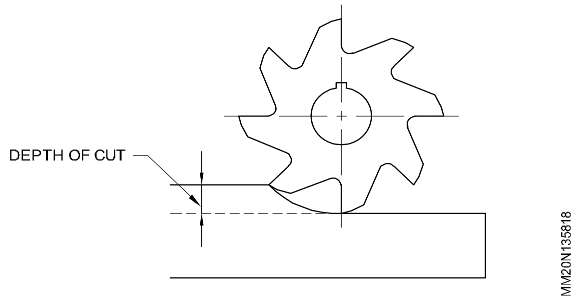


> **Cutting speed should be reduced when the feed is increased.**
>
> **Cutting speed should be increased when the feed is reduced.**

Depth of cut

The depth of cut is the depth to which the cutter penetrates the workpiece surface during a given cut. It is the perpendicular distance (Fig 8) measured between the original and the final surface of the workpiece.

Fig 8



Where a smooth and accurate finish is needed, it is a good practice to take roughing and finishing cuts. Roughing cuts should be deep with a feed as heavy as the work and machine will permit with low cutting speed. (Fig 9) Heavier cuts may be taken with helical cutters having fewer teeth than with those having many teeth. Cutters with fewer teeth are stronger and have greater chip clearance than cutters with more teeth.

Finishing cuts should be light with a fewer and finer feed than is used in roughing cuts. (Fig 10) The depth of cut should be atleast 0.4 mm. Light cuts and extremely fine feeds are not advisable, since the chip taken by each tooth will be thin and the cutter will often rub the surface of the work. When a fine finish is required, the feed should be reduced rather than the cutter speed; more cutters are dulled by high speeds than by high feeds.

The table 1 shows the cutting speed (V) in metres per minute (m/min) for various materials, using high speed (HSS) milling cutters of various types. They must be considered as average values which may vary according to actual working conditions.

Fig 9

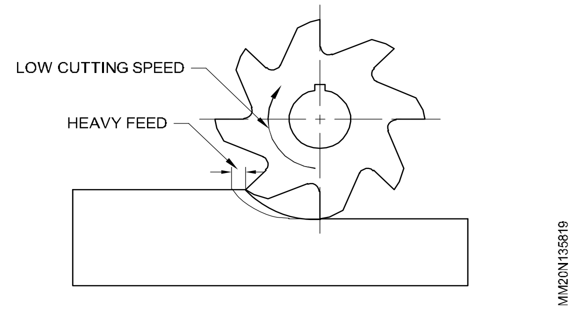
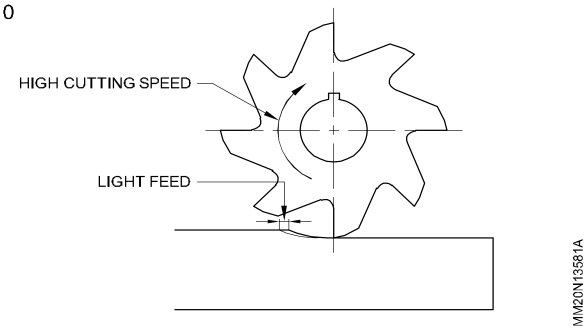


Fig 10



Machining time for milling

Objectives: At the end of this lesson you shall be able to
- **state the importance of machining time**
- **calculate the machining time.**

Importance of machining time

Time means money. Any engineering product should be manufactured at the shortest time possible to the required accuracy and quality. Machining time is one of the main factors for cost estimation of a product.

It is always good to plan how much time is needed for a particular milling operation. This will also enable you to plan for the appropriate machine, the right type of cutters, selection of speed, feed etc. In order to save time and increase productivity.

The total machining time depends on

- the length of the workpiece to be machined
- the method of milling employed i.e. rough or finish milling
- the size of the cutter.

Selection of a milling cutter should be such that the width of the job is covered by the cutter in one pass. If the width of the workpiece is more than the width of the cutter, machining has to be done by more than one pass. The total time therefore depends on the number of passes also.

The total time required to mill a surface for any milling operation is calculated from the formula

Total time for milling (th)

$$= \frac{\text{total travel of the cutter (L)}}{\text{feed per revolution (S)}}$$

The total travel of the cutter 'L' is equal to l + la +lx

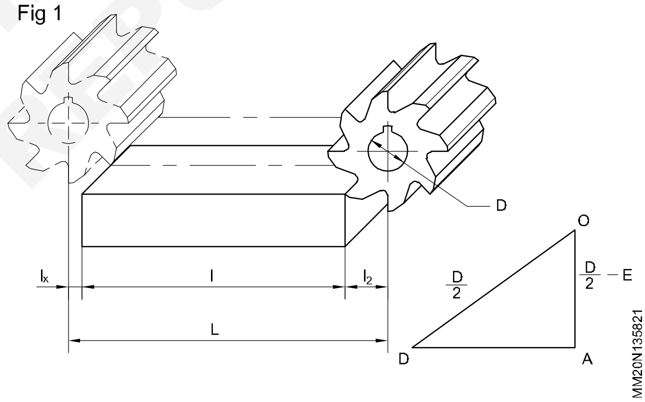
where l = length of workpiece to be milled

la = run up travel of the cutter from start of cut to go to the full given depth.

lx = run over the minimum distance the cutter has to move away from the work after the cut is taken.

Calculation of la (Fig 1)

Fig 1



By Pythogoras Theorem, we have

$$\left(\frac{d}{2}\right)^2 = (la)^2 + \left(\frac{d}{2} - a\right)^2$$

$$(la)^2 = \left(\frac{d}{2}\right)^2 - \left(\frac{d}{2} - a\right)^2$$

la = $d.a - a^2 = a(d-a)$

la = $\sqrt{a(d-a)}$

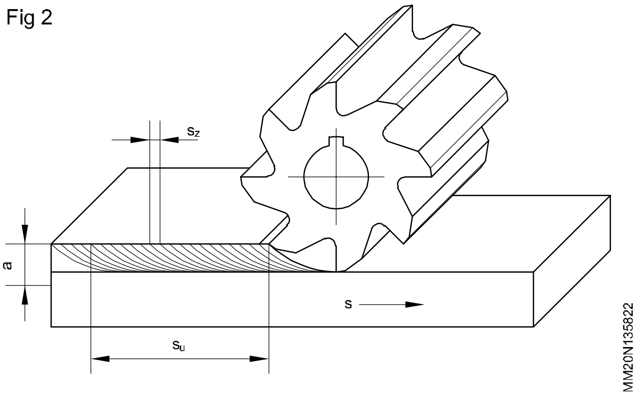
Where

d = cutter diameter

a = cutting depth.

Calculation of 'U' (Fig 2)

Fig 2



Feed per tooth = Sz in mm

Feed per revolution S = Sz x Z m

Feed for 'n' revolutions 'u' = Sz x Z x N mm/min.

Where

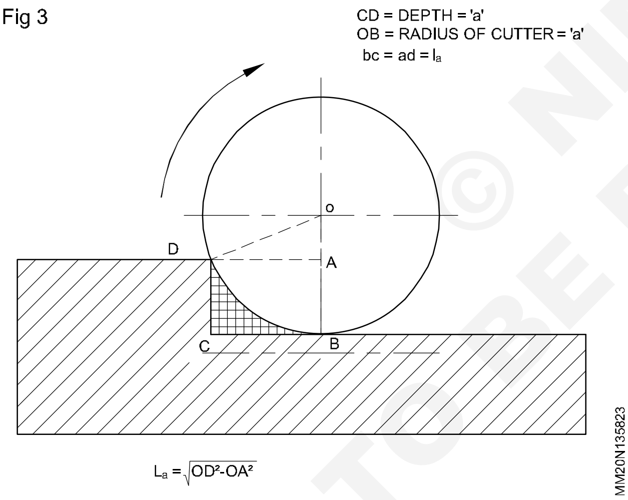
'U' = total feed per minute

Z = number of teeth of cutter

n = r.p.m. of the cutter

Calculation of 'the' (Fig 3)

Fig 3



$$\text{The milling time} = \frac{\text{Cutter travel x number of travels(i)}}{\text{feed per minute}}$$

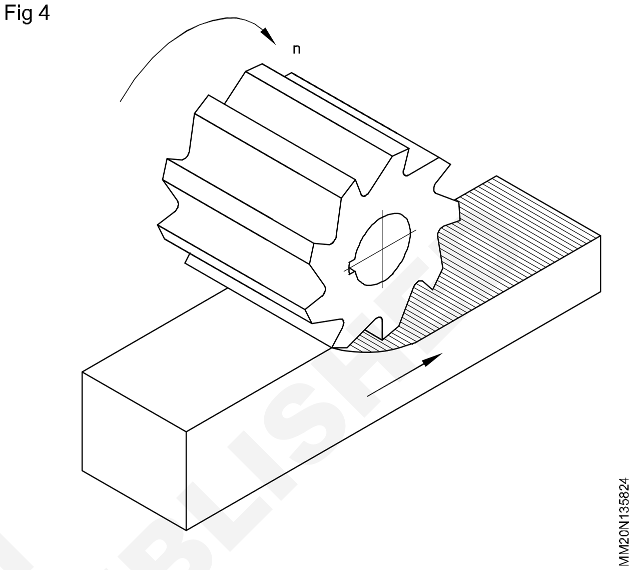
$$= \frac{L \times i}{u} = \frac{L \times i}{Sz \times Z \times n}$$

$$= \frac{\text{Cutter travel x number of travels}}{\text{feed per tooth x no. of teeth of the cutter x r.p.m.}}$$

To determine the milling time, the total travel of the cutter L is calculated and it is equal to l + la + lx where l is the length of work, la is the run up to be calculated as equal to $\sqrt{a(d-a)}$ and lx will be the known value.

Example (Fig 4)

Fig 4



A milling cutter of 80 mm diameter has nine teeth. It is to mill a 240 mm long workpiece. The run over is 4 mm and the depth of cut is 5 mm. A cutting speed of 12 metres/ min. and feed per tooth of 0.15 mm have been selected.

Determine the milling time.

$$n = \frac{V \times 1000}{d \times \pi} = \frac{12 \times 1000}{80 \times \pi} = 48 \text{ r.p.m}$$

$$\text{Total milling time} = \frac{L \times i}{Sz \times Z \times n}$$

(L = l + la + lx)

$$la = \sqrt{a(d-a)} = \sqrt{5(80-5)}$$

$$= \sqrt{5 \times 75 \text{ mm}} = 19.4 \text{ mm}$$

la = 4 mm

L = l + la + lx = 240 + 19.4 + 4 mm = 263.4 mm

$$\text{Total milling time} \quad \frac{263.4 \times 1}{0.15 \times 9 \times 48}$$

Total milling time = 4.07 min.

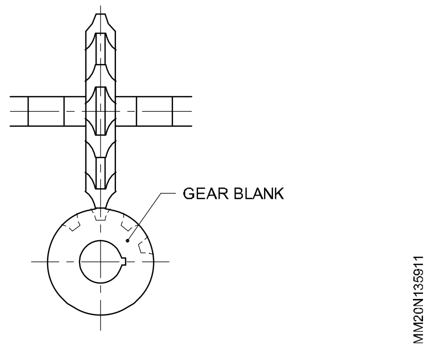
Indexing or dividing head

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.**

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.

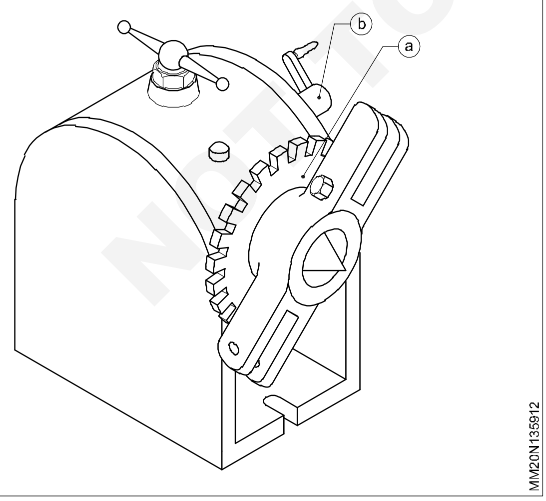
This operation is performed on a milling machine by means of an indexing attachment which is called as indexing head or the dividing head.

Types of indexing heads

The most common types of indexing heads or dividing heads are

- direct indexing head (Fig 2)

Fig 2



- simple indexing head (Fig 3)
- universal indexing head. (Fig 4)

Fig 3

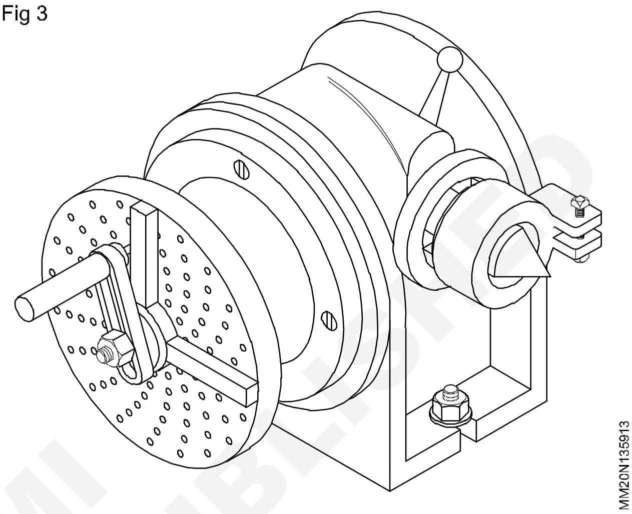
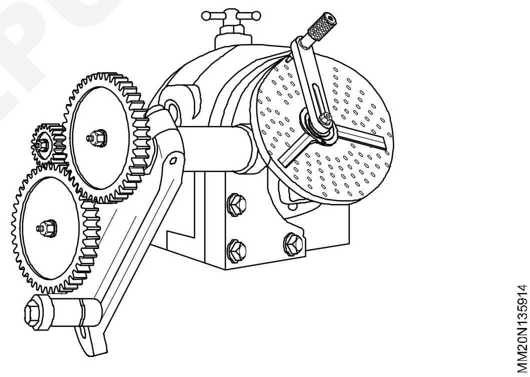


Fig 4



Direct indexing

Purpose of direct indexing

Direct indexing is a rapid method of indexing. It is used where a large number of identical pieces are indexed by very small number of divisions. Usually, this type of indexing can be performed on a direct indexing head.

Principle of direct indexing

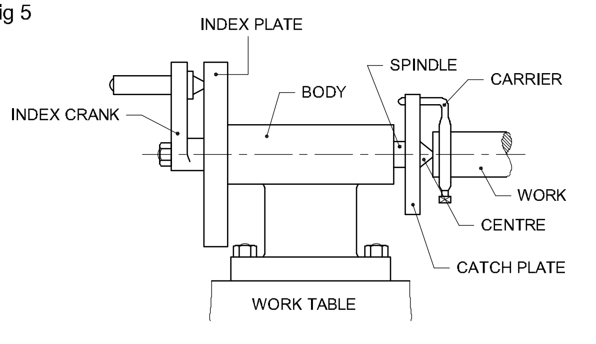
Direct indexing may be employed whenever the number of divisions required can be divisible without remainder into the number of holes or slots in the direct index plate.

Direct indexing mechanism (Fig 5)

It consists of a housing, a spindle with a driving lug and an indexing crank. The rear of the housing is fitted with a flat index plate which has a number of holes spaced around the circumference of the circles of different radii.

The number of holes varies from circle to circle. The index plate usually has three circles of holes with 24, 30, 36 holes respectively.

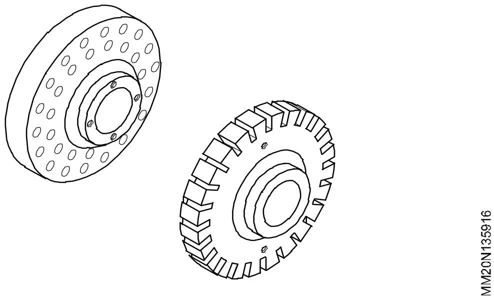
Fig 5



Another type of index plate (Fig 6) which is having a number of slots (ie.24 or 30 or 36 slots) on the periphery of the index plate, is fitted to the front end of the spindle nose. (Fig 2) The spindle is rotated by hand and locked by a pin.

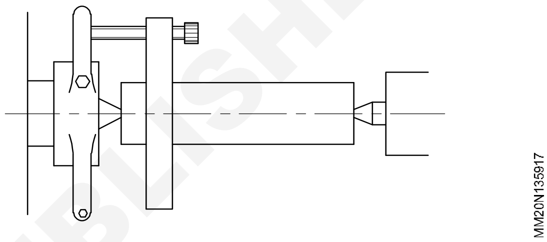
The handle of the indexing crank, which can be moved radially, is fitted with a spring-loaded index pin. The index pin engages with the holes in the indexing plate.

Fig 6



While indexing, the pin is taken out from the index plate hole. The spindle is rotated by the crank and after the required position is reached, it is again locked by the pin. The workpiece can be set up in a chuck on the indexing head spindle or between centres using the indexing head and a matching tailstock. For centre work, any suitable carrier may be used to engage the workpieces with the driving lug on the indexing head spindle. (Fig 7)

Fig 7



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)

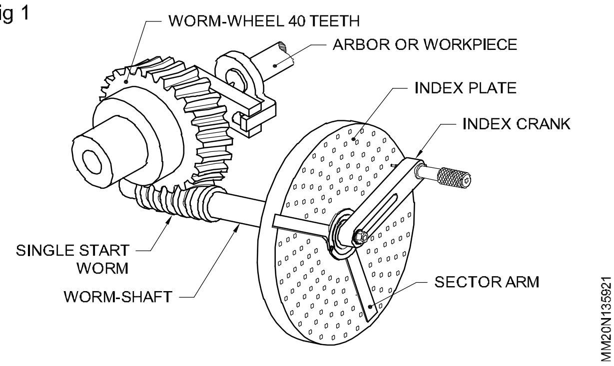
The simple indexing mechanism consists of a 40 tooth worm-wheel fastened to the spindle, a single start worm, a crank for turning the work shaft and an index plate and sector.

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

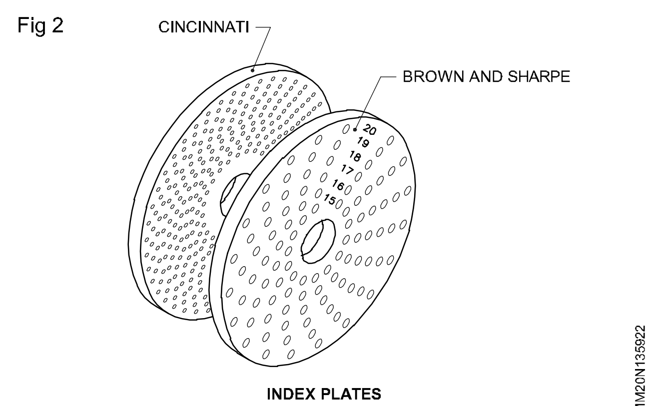
The index plate is mounted behind the index crank. It is a circular plate provided with a circle of holes representing different divisions of the circle.

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.



INDEX PLATES

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.

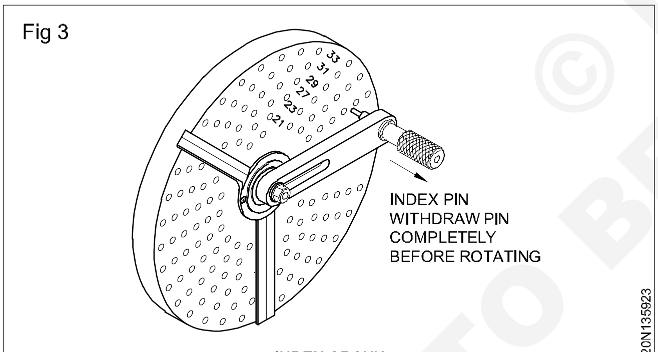
Cincinnati and parkinison index plate system

The Cincinnati and parkinson 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)



INDEX CRANK

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.

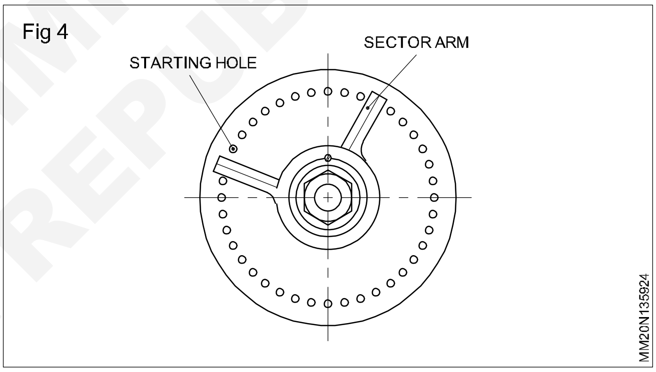
Adjustment is made by slackening the lock screws, moving the arms to the desired setting and re-tightening the screws to lock the arm in position.

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.



Angular indexing

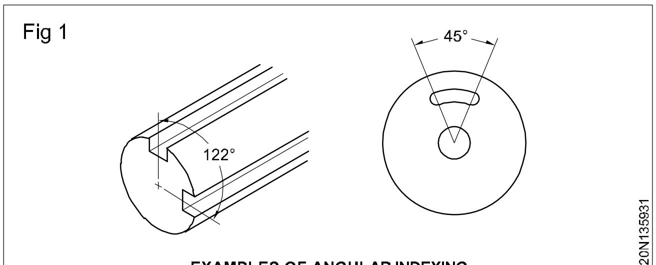
Objectives : At the end of this lesson you shall be able to
- **state the need for angular indexing**
- **state the principle of angular indexing.**

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.



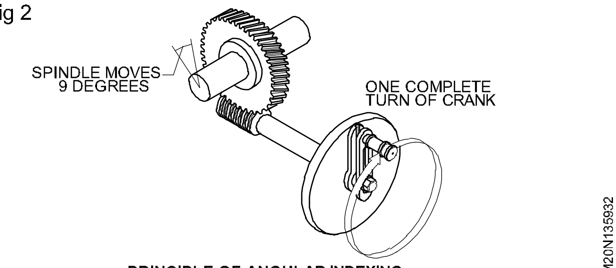
EXAMPLES OF ANGULAR INDEXING

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 2



PRINCIPLE OF ANGULAR INDEXING

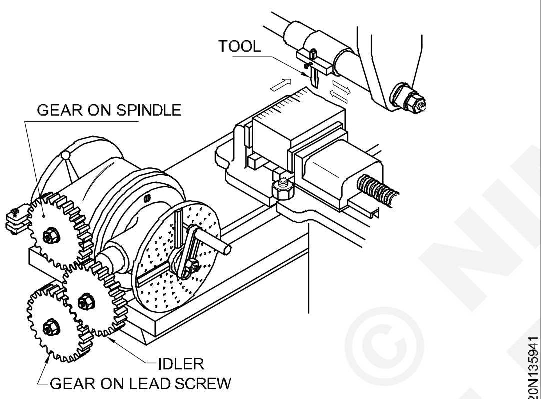
Linear Indexing

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.

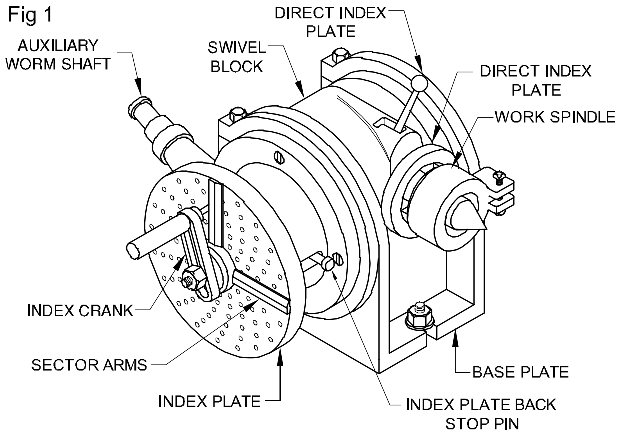
Part of its body forms a swivel block clamped in a cradle. The spindle can be tilted vertically through 90° or more, and wider range of operations can be set up.

Gear trains may be mounted on universal indexing heads to enable spiral milling.

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.

Fig 1

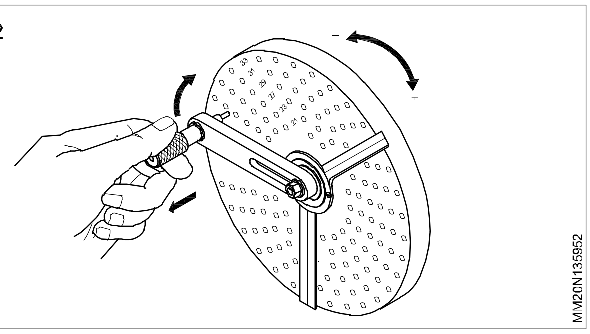


UNIVERSAL INDEXING HEAD

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



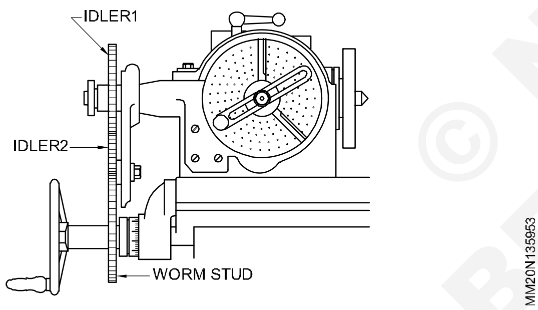
The actual movement of the crank is either smaller or greater than its movement in relation to the index plate.

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.

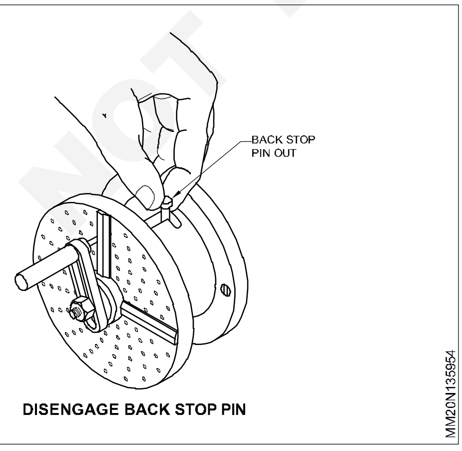
Fig 3



Gear operation

Prior to indexing the back stop pin must be disengaged to permit rotation of the index plate. (Fig 4)

Fig 4



DISENGAGE BACK STOP PIN

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.

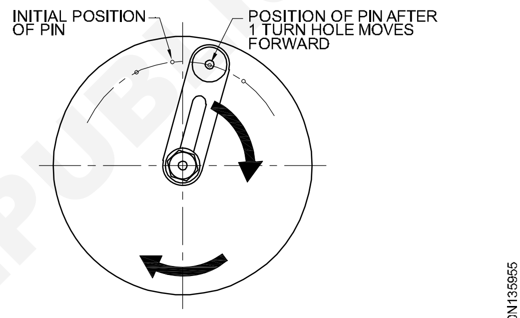
The plate moves in the same or opposite direction to the crank, depending on the number of idler gears used and the design of the indexing head.

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.

Fig 5



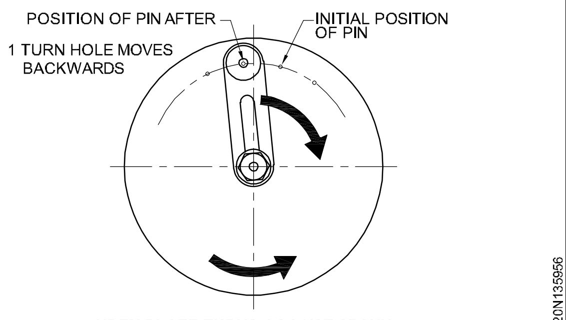
INDEX PLATE TURNS WITH CRANK

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 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.**

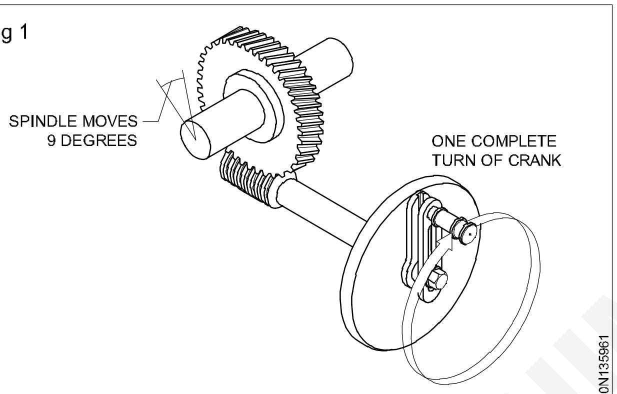
Direct indexing

If six slots are to be machined and the 30 circles located. No.of index crank movement

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)

Fig 1



PRINCIPLE OF ANGULAR INDEXING

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

$$\frac{24}{1} x \frac{1}{3} = 8 \text{ holes}$$

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°

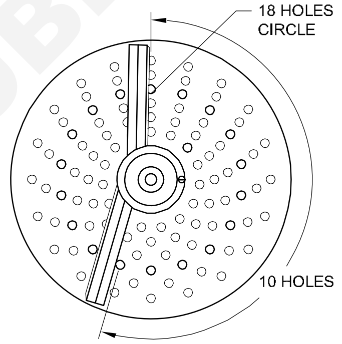
That is 13 complete turns and 5/9 of a turn. This is obtained by setting an index plate with a circle of holes divisible by 9 and setting the sector arms of 5/9 of a turn.

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



SECTOR ARMS SET FOR 5/9 TURN

Indexing in minutes

One revolution of the crank gives a spindle movement of 9° and to convert the degrees into minutes multiply by 60.

9° = 9 x 60 = 540 minutes.

The number of turns of crank is found by dividing the angle to be indexed in minutes by 540.

$$\text{No.of turns} = \frac{\text{Angles to be indexed in minutes (M)}}{540}$$

Example (Figs 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

Fig 3

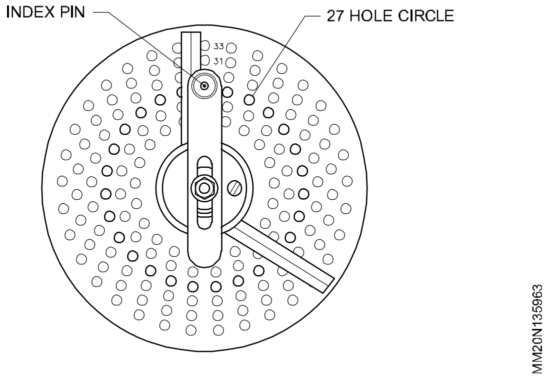
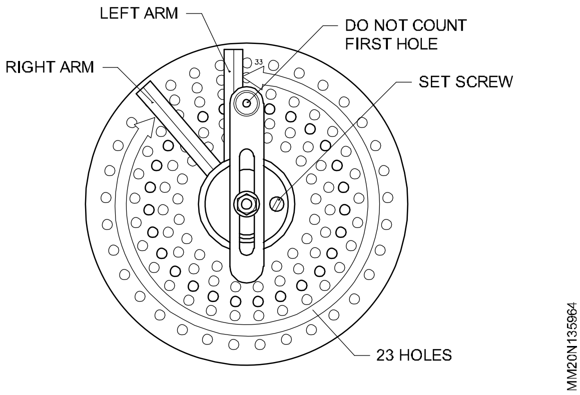


Fig 4



Indexing in seconds

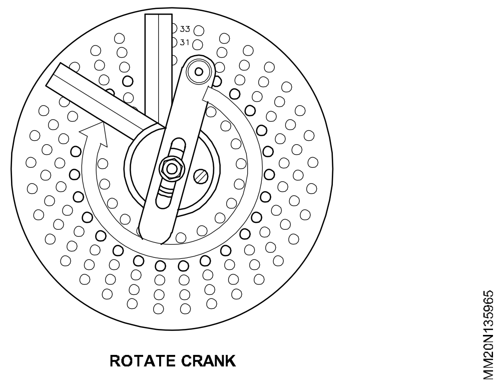
One revolution of the crank gives a spindle movement of 9° and to convert the degrees into seconds multiply by 60 x 60.

9° = 9 x 60 x 60 = 32400 seconds

Index crank movement =

$$\frac{\text{Angular displacement of work in seconds}}{32400}$$

Fig 5



Linear indexing

Calculation

The formula for calculating the indexing for linear graduations in thousands of an inch is

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

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.

Calculations for differential indexing

Objectives : At the end of this lesson you shall be able to
- **explain the gear ratio for differential indexing**
- **explain the indexing movement for differential indexing**
- **explain change gears for differential indexing.**

Calculations

Example

Calculate the index movement, the change gears required and the direction of index plate movement to cut 127 teeth on a gear blank.

The std. set of change gear supplied consists of total 12 gears 24, 24, 28, 32, 40, 44, 48, 56, 64, 72, 86 and 100.

Brown and Sharpe

15, 16,17, 18, 19, 20,

21, 23, 27, 29, 31, 33,

37, 39, 41, 43, 47 and 49.

Index crank movement

Assume a number close to the required number (within 10% variation).

For this exercise : 120

By simple indexing, turns of index crank

$$= \frac{\text{Ratio of indexing head}}{\text{Assumed number}}$$

$$= \frac{40}{120} = \frac{1}{3}$$

$$= \frac{9 \text{ spaces}}{27 \text{ circles}} \text{ or } \frac{11}{33} \text{ cincinati plates}$$

Select a circle of holes having factors contained in the index plates supplied.

The sector arms will need to be set apart 9 spaces on the 27 hole circle or 11 spaces on the 33 hole circle or any other setting 1/3 of a turn.

Change gear required

Using the formula $\frac{\text{Driver}}{\text{Driven}} = (A - N) \times \frac{40}{A}$

Where A = The assumed number which is approximately equal to N

N = Required number of divisions

40 = Index head ratio

$$= (120 - 127) \times \frac{40}{120}$$

$$= \frac{-7}{1} \times \frac{1}{3} = \frac{-7}{3} = \frac{-7 \times 8}{3 \times 8} = \frac{-56}{24}$$

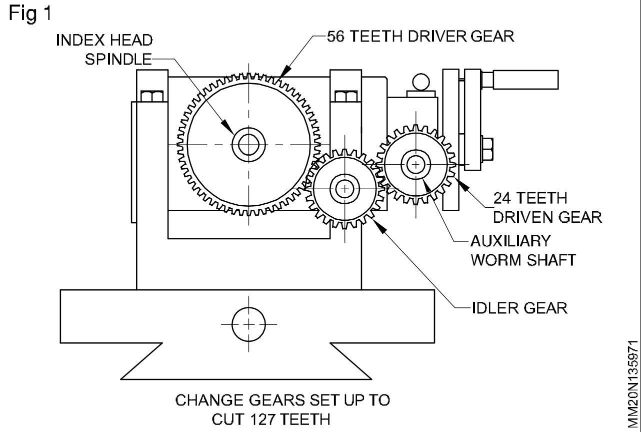
Fit a 56 gear on index head spindle and 24 gear on auxiliary worm shaft. (Fig 1)

Connect the gears together by an idler gear.

Disengage the back direction of rotation of the index plate.

Check the direction of rotation of the index plate in relation to the crank direction.

Fig 1



Direction of index plate movement

The index plate and crank should rotate in the same direction when:

– the assumed number is greater than the required number

– the calculated gear ratio has a plus sign.

The index plate and crank should rotate in opposite directions when:

– the assumed number is less than the required number

– the calculated gear ratio has a minus sign.

In the above example there is a minus sign in the ratio; therefore, the index plate must turn against the direction of rotation of the crank. This can be obtained by adding or removing the idler gears from the gear train, depending on the design of the indexing head used.

Heat treatment of steel

Objectives: At the end of this lesson you shall be able to
- **Describe the iron carbon equilibrium diagram**
- **Explain the time temperature transformation curve.**

The iron-carbon equilibrium diagram, also known as the iron-iron carbide equilibrium diagram or simply the iron-carbon diagram,is a graphical representation of the phases that exist in the iron-carbin system at various temperatures and compositions. This diagram is of great importance in the field of metallurgy and materials science because it helps in understanding the phase transformations that occur in iron and steel.

The iron-carbon equilibrium diagram typically looks like this (Fig 1)

Key features of the iron-carbon equilibrium diagram:

1 **Phases**

- **Austenite (Y):** The phase that exists at high temperatures. It is a solid solution of carbon in iron with a face- centered cubic (FCC) crystal structure.
- **Ferrite (α):** The phase that exists at lower temperatures. It is a solid solution of carbon in iron with a body-centered cubic (BCC) crystal structure.
- **Cementite (Fe3C):** A compound with a fixed composition of 6.7% carbon. It has an orthorhombic crystal structure.

2 **Phase Boundaries:**

- The curved line separating the austenite and ferrite regions called the

  Austenite-Ferrite Boundary.
- The vertical line at around 0.022% carbon represents the Eutectoid

  Composition, where the transformation from austenite to a mixture of ferrite and cementite occurs.
- The horizontal line at approximately 727°C (1341°F) is the Eutectoid Temperature, which is the temperature at which the eutectoid transformation takes place.

3 **Phases at Specific Compositions:**

- Hypoeutectoid Alloys: Alloys with less than 0.022% carbon, located to the left of the eutectoid composition line, primarily consist of ferrite with some cernentite.
- Hypereutectoid Alloys: Alloys with more than 0.022% carbon, located to the right of the eutectoid composition line, primarily consist of cementite with some ferrite.

4 **Eutectoid Transformation:** This is a critical point in the diagram, where austenite transforms into a mixture of ferrite and cementite. This transformation occurs at the eutectoid composition and temperature.

The iron-carbon equilibrium diagram provides valuable information for the heat treatment and alloying of steels. It helps engineers and metallurgists in designing and controlling the microstructures and properties of steel products by adjusting the composition and heat treatment conditions. For example, it's crucial for determining the cooling rate needed to achieve specific steel properties, such as hardness and toughness, through processes like quenching and tempering.

Time Temperature Transformation curve (TTT curve)

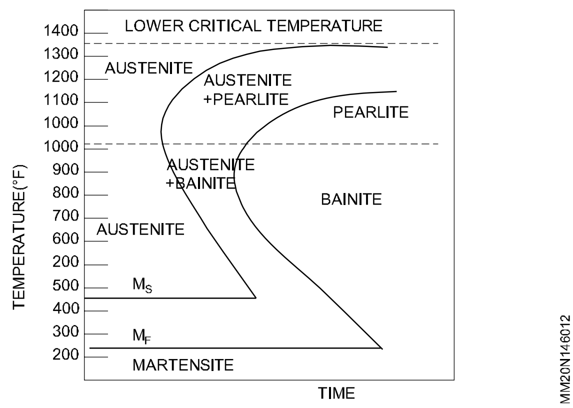
The TTT curve" typically refers to the Time-Temperature-Transformation curve in materials science and metallurgy. It is also known as the Isothermal Transformation Diagram. The TTT curve is a graphical representation that shows how a material undergoes phase transformations over time at a constant temperature.

TTT Diagram (Fig 2)

- Area on the left is austenite region.
- Austenite stable above LCT but unstable below LCT
- Left curve start of transformation
- Right curve finish of transformation

Area between the two curves indicates the transformation of austenite to different types of crystal structures (Pearlite, Martensite, Bainite)

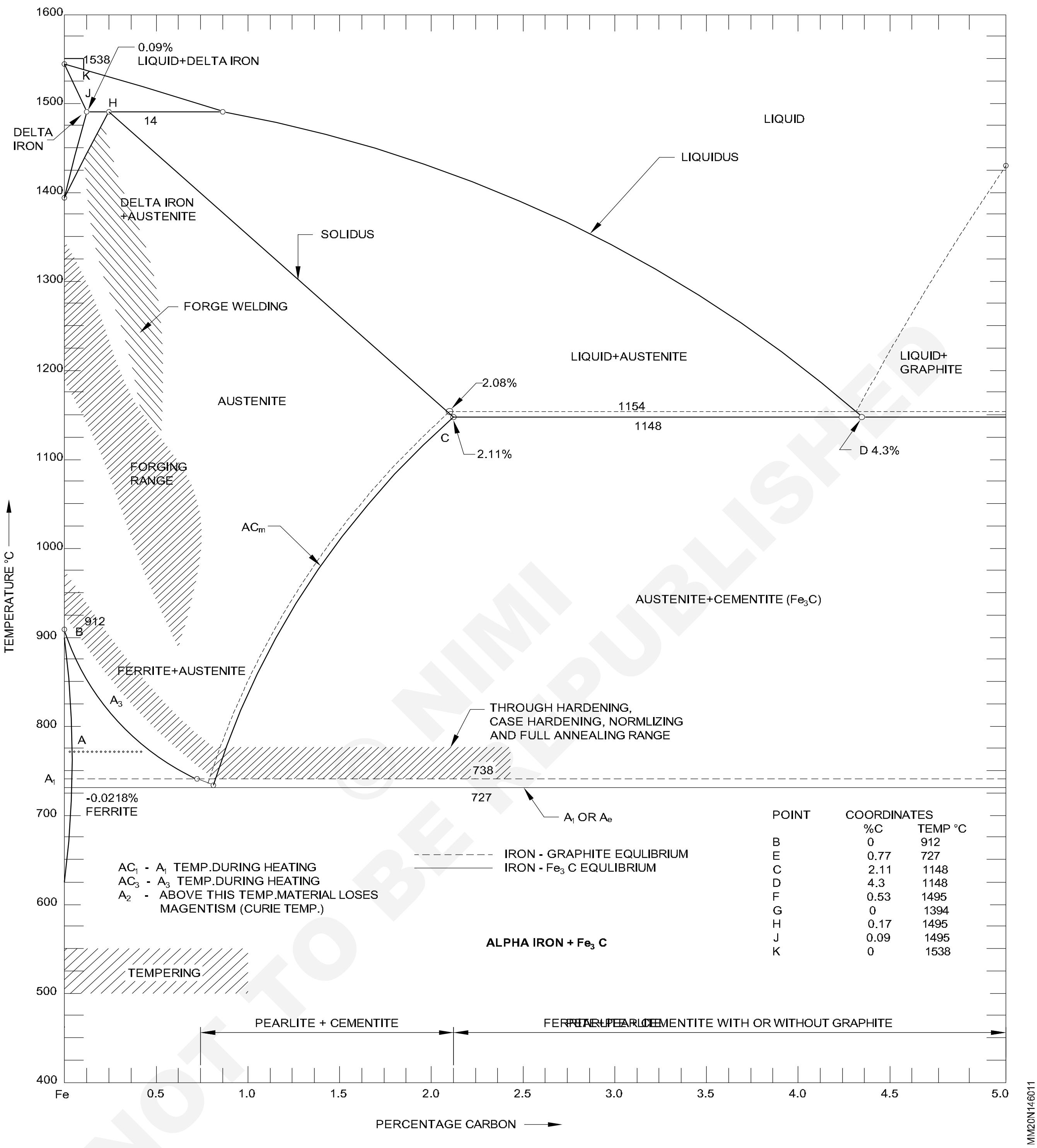
Fig 2



Key features of a TTT curve include:

1 **Time (t):** The x-axis represents time in the transformation process.

Fig 1



2 **Temperature (T):** The y-axis represents temperature. The curve is specific particular temperature. a

3 **Phases:** Different phases of a material, such as austenite, ferrite, pearlite, martensite, and others, are shown on the curve. These phases change over time at the constant temperature.

4 **Nose:** The point on the curve where the transformation begins is called the "nose." This is where the phase transformation initiates.

The TTT curve provides valuable information about the transformation kinetics and microstructure development in materials. It is commonly used in heat treatment processes for materials like steel to determine the best conditions for achieving desired properties, such as hardness, toughness, or strength.

The exact shape of the TTT curve depends on the material's composition and is often used to design heat treatment processes for optimizing material properties. Different materials will have different TTT curves, and understanding these curves is crucial in materials engineering and manufacturing.

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.**

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

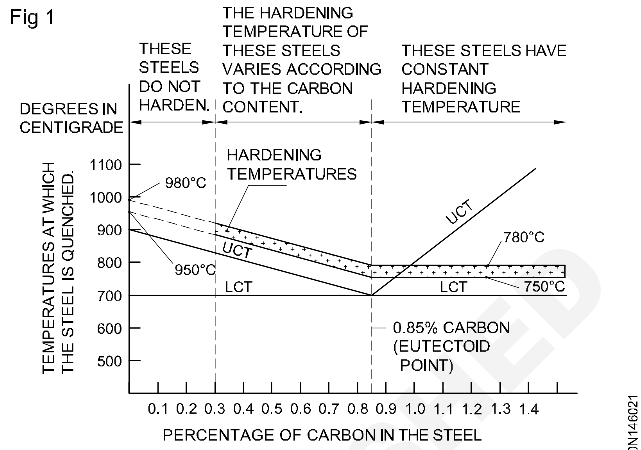
Hardening affects the mechanical properties of steel like strength, toughness, ductility etc.

Hardening adds cutting ability.

Process of hardening

Steel with a carbon content above 0.4% is heated to 30-500°C above the upper critical temperature (Fig 1). A soaking time of 5mts./ 10 mm thickness of steel is allowed. (Fig 1)

Fig 1



HARDENING OF PLAIN CARBON STEELS

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.**

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.

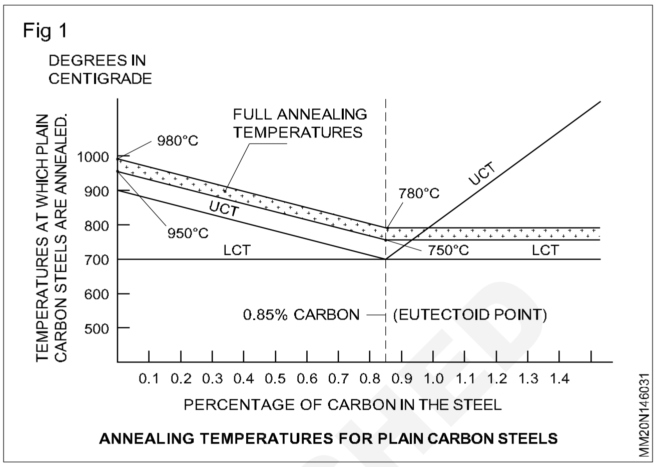
Table - 1

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

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 hypoeutectoid 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.

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.

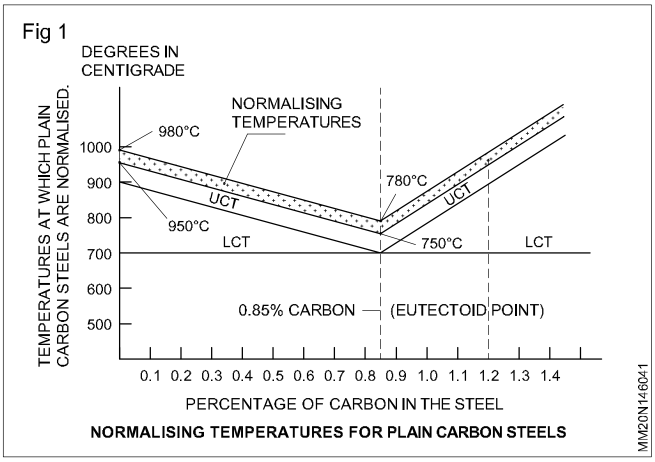
To remove stresses and strains formed in the internal structure due to repeated heating and uneven cooling or hammering.

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

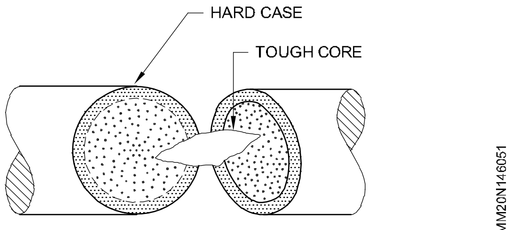
Avoid placing the component in a wet place or wet air, thereby restricting the natural circulation of air around the component. Avoid placing the component on a surface that will chill it.

Surface hardening of steel

Objectives: At the end of this lesson you shall be able to
- **name four different types of surface hardening processes**
- **state the purpose of case hardening**
- **state the purpose of carburising**
- **state the purpose of liquid carburising**
- **state the process of gas carburising.**

Most of the components must have a hard, wear-resisting surface supported by a tough, shock-resisting core for better service condition and longer life. This combination of different properties can be obtained in a single piece of steel by surface hardening. (Fig 1)

Fig 1



Types of surface hardening

- Case hardening
- Nitriding
- Flame hardening
- Induction hardening

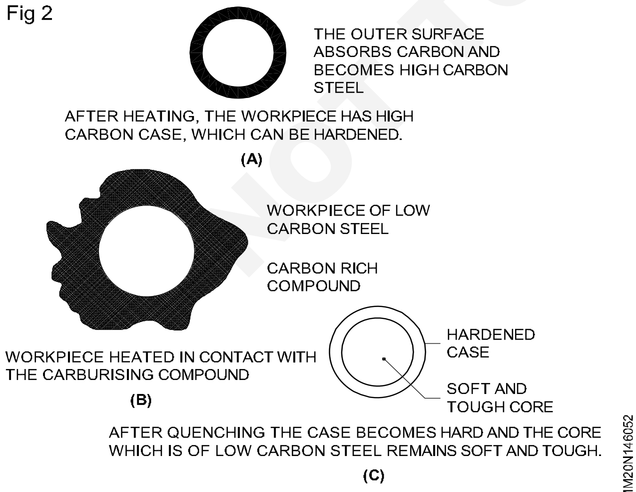
Case hardening

Parts to be hardened by this process are made from a steel with a carbon content of 0.15% so that they will not respond to direct hardening.

The steel is subjected to treatment in which the carbon content of the surface layer is increased to about 0.9%.

When the carburised steel is heated and quenched, only the surface layer will respond, and the core will remain soft and tough as required. (Fig 2)

Fig 2



The surface which must remain soft can be insulated against carburising by coating it with suitable paste or by plating it with copper.

Case hardening takes place in two stages.

- Carburising in which the carbon content of the surface is increased.
- Heat treatment in which the core is refined and the surface hardened.

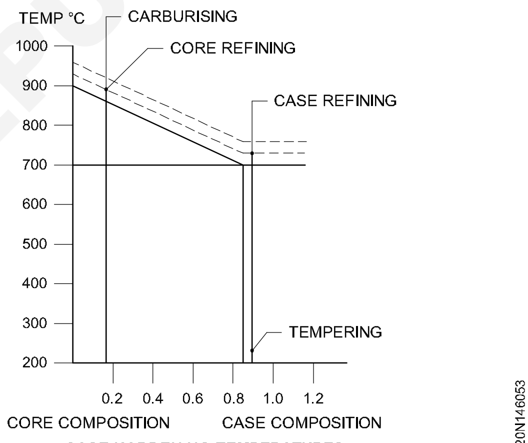
Carburising

In this operation, the steel is heated to a suitable temperature in a carbonaceous atmosphere, and kept at that temperature until the carbon has penetrated to the depth required.

The carbon can be supplied as a solid, liquid or gas.

In all cases, the carbonaceous gases coming from these materials penetrate (diffuse) into the surface of the workpiece at a temperature between 880° and 930°C. (Fig 3)

Fig 3



CASE HARDENING TEMPERATURES

Pack carburising (Fig 4)

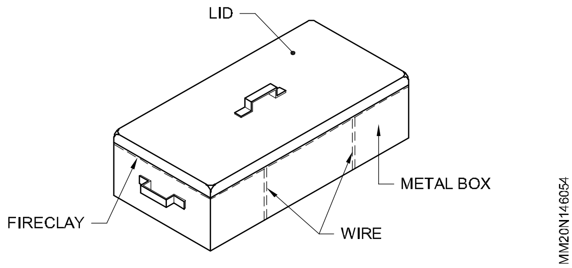
The parts are packed in a suitable metal box in which they are surrounded by the carburising medium, such as wood, bone, leather or charcoal, with barium carbonate as an energiser.

The lid is fitted to the box and sealed with fireclay and tied with a piece of wire so that no carbon gas can escape and no air can enter the box to cause de-carburisation.

Liquid carburising

Carburising can be done in a heated salt bath. (Sodium carbonate, sodium cyanide and barium chloride are typical carburising salts.) For a constant time and temperature of carburising, the depth of the case depends on the cyanide content.

Fig 4



This is suitable for a thin case, about 0.25 mm deep. Its advantage is that heating is rapid and distortion is minimised, and it is suitable for batch production.

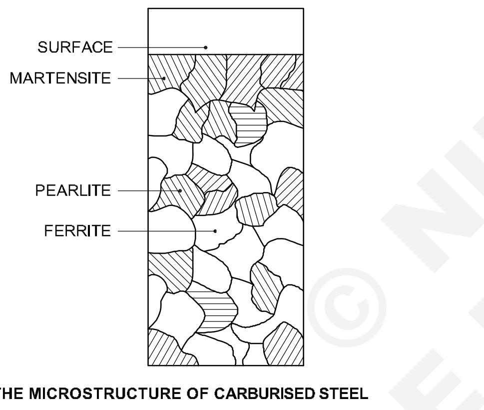
Gas carburising

The work is placed in a gas-tight container which can be heated in a suitable furnace, or the furnace itself may be the container.

The carburising gas 'methane or propane' is admitted to the container, and the exit gas is vented.

Fig 5 illustrates the appearance of the structure across its section produced by carburising.

Fig 5



THE MICROSTRUCTURE OF CARBURISED STEEL

Heat treatment

After carburising has been done, the case will contain about 0.9% carbon, and the core will still contain about 0.15% carbon. There will be a gradual transition of the carbon content between the case and the core. (Fig 2)

Owing to the prolonged heating, the core will be coarse, and in order to produce a reasonable toughness, it must be refined.

To refine the core, the carburised steel is reheated to about 870°C and held at that temperature long enough to produce a uniformity of structure, and is then cooled rapidly to prevent grain growth during cooling.

The temperature of this heating is much higher than that suitable for the case, (Fig 2) and, therefore, an extremely brittle martensite will be produced.

The case and the outer layers of the core must now be refined.

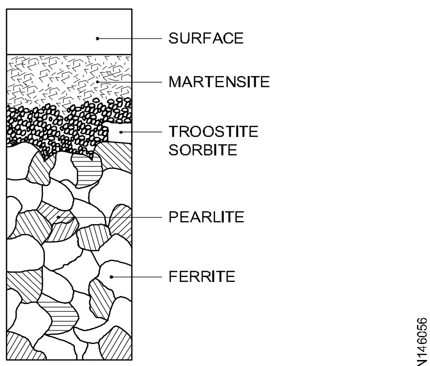
The refining is done by reheating the steel to about 760°C, to suit the case, and quenching it.

Tempering

Finally the case is tempered at about 200°C to relieve the quenching stresses.

Fig 6 illustrates the appearance of the structure across its section produced by case hardening.

Fig 6



THE MICROSTRUCTURE OF CASE HARDENED STEEL

Nitriding

Objectives: At the end of this lesson you shall be able to
- **state the process of case hardening by gas nitriding**
- **state the process of case hardening by nitriding in a salt bath.**

In the nitriding process, the surface is enriched not with carbon, but with nitrogen. There are two systems in common use, gas nitriding and salt bath nitriding.

Gas nitriding

The gas nitriding process consists of heating the parts at 500°C in a constant circulation of ammonia gas for up to 100 hours and cooling them in air.

Nitriding in salt bath

Special nitriding baths are used for salt-bath nitriding. This process is suitable for all alloyed and unalloyed types of steel, annealed or not annealed, and also for cast iron.

Process

The completely stress-relieved workpieces are preheated (about 400°C) before being put in the salt bath (about 520 - 570°C). A layer 0.01 to 0.02 mm thick is formed on the surface which consists of a carbon and nitrogen compound. The duration of nitriding depends on the cross-section of the workpieces (half an hour to three hours). It is much shorter than for gas nitriding. After being taken out of the bath, the workpieces are quenched and washed in water and dried.

Advantages

The parts can be finish-machined before nitriding because no quenching is done after nitriding, and, therefore, they will not suffer from quenching distortion.

In this process, the parts are not heated above the critical temperature, and, hence warping or distortion does not occur.

The hardness and wear-resistance are exceptional. There is a slight improvement in corrosion resistance as well.

Since the alloy steels used are inherently strong when properly heat-treated, remarkable combinations of strength and wear-resistance are obtained.

Flame hardening

Objectives: At the end of this lesson you shall be able to
- **state the process of surface hardening using a flame**
- **state the advantages and disadvantages of flame hardening.**

Flame hardening

In this type of hardening, the heat is applied to the surface of the workpiece by specially constructed burners. The heat is applied to the surface very rapidly and the work is quenched immediately by spraying it with water. (Figs 1 & 2) The hardening temperature is generally about 50°C higher than that for full hardening.

The workpiece is maintained at the hardening temperature for a very short period only, so that the heat is not conducted more than necessary into the workpiece.

Steels used for surface hardening will have a carbon content of 0.35% to 0.7%.

The following are the advantages of this type of hardening.

- The hardening devices are brought to the workpiece.
- It is advantageous for large workpieces.
- Short hardening time.
- Great depth of hardening.
- Easily controlled.
- Small distortion.
- Low fuel consumption.

The following are the disadvantages.

- Not suitable for small workpieces because of the danger of hardening through.
- The workpieces must be stress-relieved before hardening.

Fig 1

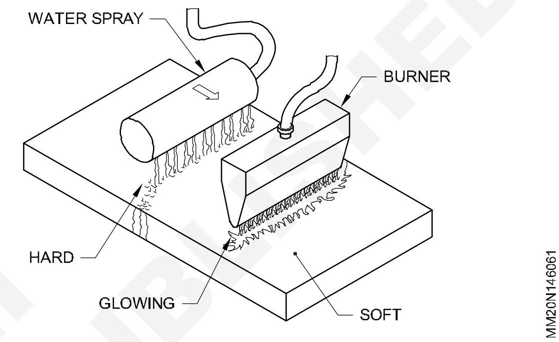
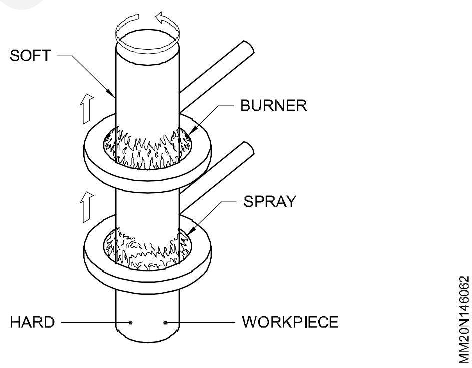


Fig 2



Induction hardening

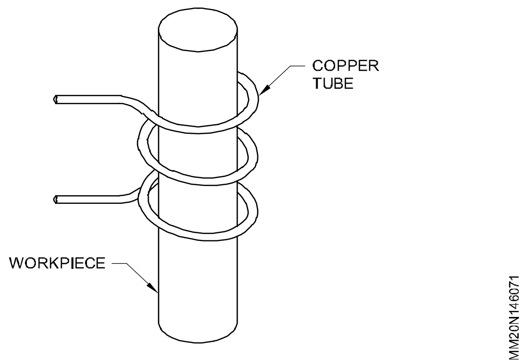
Objectives: At the end of this lesson you shall be able to
- **state the process of the induction hardening method**
- **state the advantages of the induction hardening process.**

Induction hardening

This is a production method of surface-hardening in which the part to be surface-hardened is placed within an inductor coil through which a high frequency current is passed. (Fig 1) The depth of penetration of the heating becomes less, as the frequency increases.

The depth of hardening for high frequency current is 0.7 to 1.0 mm. The depth of hardening for medium frequency current is 1.5 to 2.0 mm. Special steels and unalloyed steels with a carbon content of 0.35 to 0.7% are used.

Fig 1



After induction-hardening of the workpieces, stress relieving is necessary.

The following are the advantages of this type of hardening.

- The depth of hardening, distribution in width and the temperature are easily controllable.
- The time required and distortion due to hardening are very small.
- The surface remains free from scales.
- This type of hardening can easily be incorporated in mass production.

Heating/Quenching steel for heat treatment

Objectives: At the end of this lesson you shall be able to
- **distinguish between the lower critical and the upper critical temperatures**
- **state the three stages in the heat treatment process**
- **determine the upper critical temperature for different plain carbon steels from the diagram.**

Critical temperatures

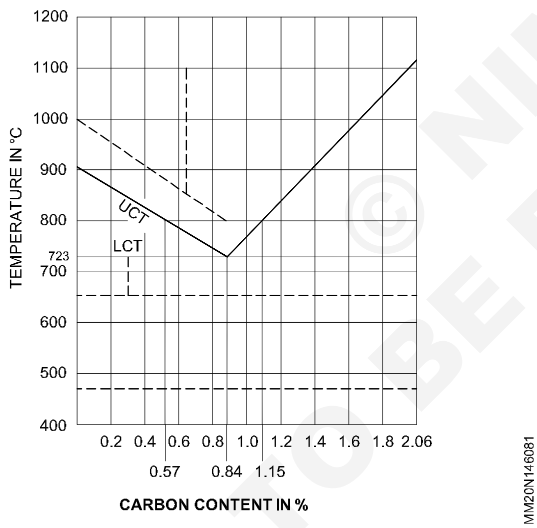
Lower critical temperatures

The temperature, at which the change of structure to austenite starts - 723°C, is called the lower critical temperature for all plain carbon steels.

Upper critical temperature

The temperature at which the structure of steel completely changes to AUSTENITE is called the upper critical temperature. This varies depending on the percentage of carbon in the steel. (Fig 1)

Fig 1



Example

0.57% and 1.15% carbon steel: In these cases the lower critical temperature is 723°C and the upper critical temperature is 800°C.

For 0.84% carbon steel, both LCT and UCT are 723°C. This steel is called eutectoid steel.

Three stages of heat treatment.

- Heating
- Soaking
- Quenching

When the steel on being heated reaches the required temperature, it is held in the same temperature for a period of time. This allows the heating to take place throughout the section uniformly. This process is called soaking.

Soaking time

The depends upon the cross-section of the steel, its chemical composition, the volume of the charge in the furnace and the arrangement of the charge in the furnace. A good general guide for soaking time in normal conditions is five minutes per 10 mm of thickness for carbon and low alloy steels, and 10 minutes per 10 mm of thickness for high alloy steels.

Heating steel

This depends on the selection of the furnace, the fuel used for heating, the time interval and the regulation in bringing the part up to the required temperature. The heating rate and the heating time also depend on the composition of the steel, its structure, the shape and size of the part to be heat-treated etc.

Preheating

Steel should be preheated at low temperature up to 600°C as slowly as possible.

Quenching

Depending on the severity of the cooling required, different quenching media are used.

The most widely used quenching media are:

- brine solution - water
- oil - air

Brine solution gives a faster rate of cooling while air cooling has the slowest rate of cooling.

Brine solution (Sodium chloride) gives severe quenching because it has a higher boiling point that pure water, and the salt content removes the scales formed on the metal surfaces due to heating. This provides a better contact with the quenching medium and the metal being heat teated.

Water is very commonly used for plain carbon steels. While using water as a quenching medium, the work should be agitated. This can increase the rate of cooling.

The quenching oil used should be of a low viscosity. Ordinary lubricating oils should not be used for this purpose. Special quenching oils, which can give rapid and uniform cooling with less forming and reduced fire risks, are commercially available. Oil is widely used for alloy steels where the cooling rate is slower than plain carbon steels.

Cold air is used for hardening some special alloy steels.

Scrapers

Objectives: At the end of this lesson you shall be able to
- **name the different types of scrapers**
- **state the features and uses of scrapers**
- **state the precautions to be observed in the use of scrapers.**

Scraping is used to produce a high degree of fit between two flat or two curved surfaces particularly where the surfaces can rub together in use.

After a surface is filed or machined as accurately as possible, it can be further improved by rough scraping. after which finish scraping is employed. Accurate scrap ing is used only to remove minute amounts of material.

It is essential that the cutting edge of a scraper be carefully tempered, uniform and free from defects. In ddition, the cutting edge must be sharp, hard and durable. This requires careful grinding followed by hon- ing on a suitable abrasive stone.

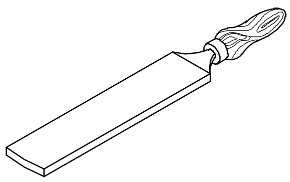
Common types of scrapers

There are five common types of scrapers which can bedivided into two main groups.

For scraping flat surfaces there are:

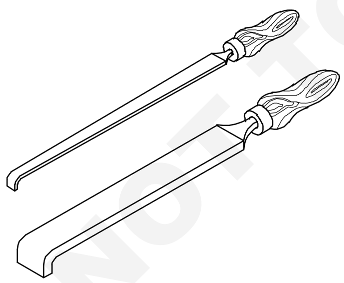
flat scrapers with straight rectangular blades. (Fig 1)

Fig 1



hook scrapers with rectangular blades bent at right angles. (Fig 2)

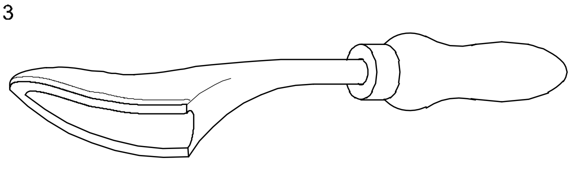
Fig 2



For scraping curved surfaces there are:

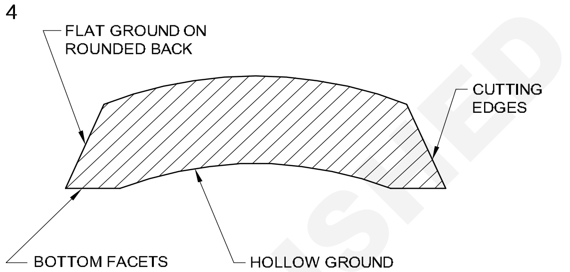
- half-round scrapers of segmental section which may be curved slightly toward the curved surface (Fig 3)

Fig 3



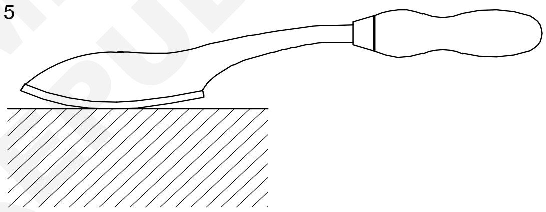
- three square or three cornered scrapers of triangular section often with each of the three faces hollow ground (Fig 4)

Fig 4



- bull-nose scrapers in which the rectangular blade is forged to a disc-like and (Fig 5)

Fig 5



Scrapers are made of forged blades, either of high grade tool steel or of special alloy steel and provided with handles, either of wood or of knurled steel tube. The overall length of blade and handle may range from 150 to about 500 millimetres. A good scraper blade should have a slight amount of spring.

Flat scrapers are made of flat rectangular blades which may range in width from 10 to 35 millimetres or more. The working portion of the blade is thinned to a thickness of about 2 mm to facilitate honing. Often this tapered portion of the blade is made with both wide faces slightly convex. The end of the blade is also slightly curved. This allows a very narrow portion of the centre of the curved cutting edge to scrape a very small area and it eliminates the danger of the corners scratching the work.

Hook scrapers are formed in a similar fashion to flat scrapers, but a short portion of the blade is bent at right angles. Hook scrapers are used for scraping the centre portions of large flat surfaces where it is not convenient to use a flat scraper. Also hook scrapers are used for finishing work where a light touch is required.

Never touch the surface being scraped because:

Fine metal particles may penetrate your skin.Perspiration on the surface makes the scraper slip, especially on cast iron.

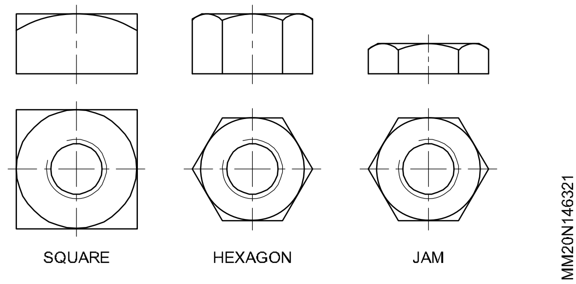
Types of nuts

Objectives: At the end of this lesson you shall be able to
- **name the different types of nuts**
- **state use of each nut.**

Nuts: Nut utilise a hexagonal or square head and are used with bolts with the some head shapes. They are available in various finish.

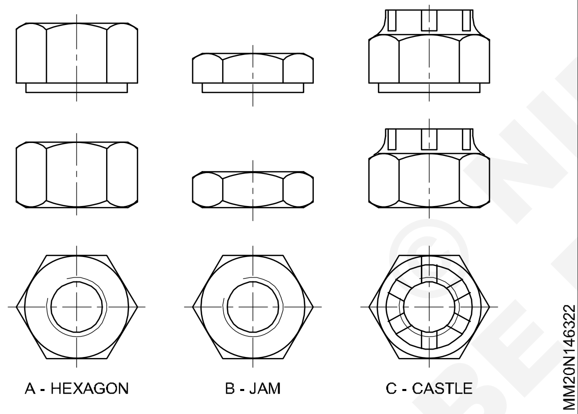
Regular is unfinished (not machined) except on the thread. (Fig 1)

Fig 1



Regular semifinished is machined on the bearing face to provide a truer surface for the washers. (Fig 2)

Fig 2

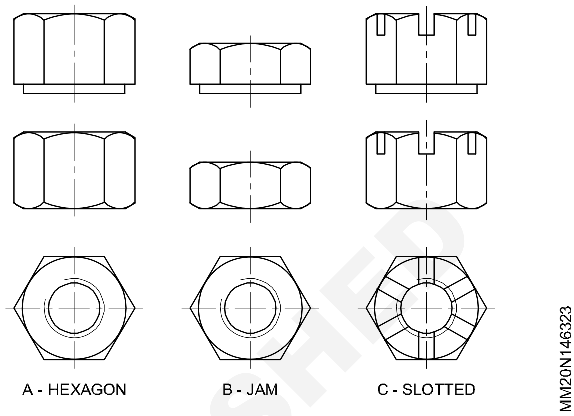


Heavy semi-finished are identical in finish to the regular semi-finished nut, however, the body is thicker for additional strength. (Fig 3)

The jam check nut is used where the strength of the full nut is not needed. They are frequently used in pairs with standard nuts for locking action (Fig 2B 3B)

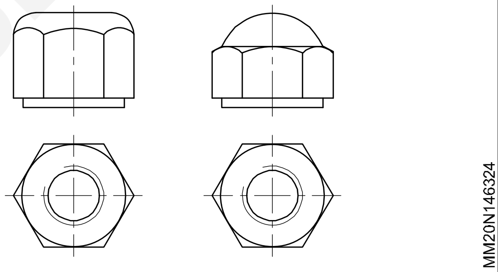
Castle and slotted nut have milled slots across the flats So that can be locked with a cotter pin/spilt pin or safety. wite that is inserted through the slot and a hole drilled in the bolts prevent the nut from tuming loose (Fig 2C 3C)

Fig 3



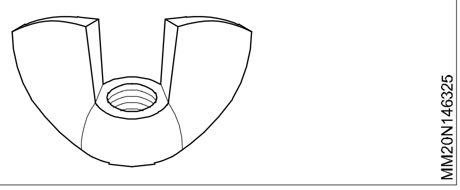
A jam nut Cap nut are used when appearance is primary importance or where projecting threads must be protected. They are available in low or high crown styles (Fig 4)

Fig 4



The wing nut is used where frequent adjustment or removal is necessary it can be loosened or tightened rapidly without the need of a wrench Nut are manufactured in the same material as the bolts (Fig 5)

Fig 5



Bolts and studs

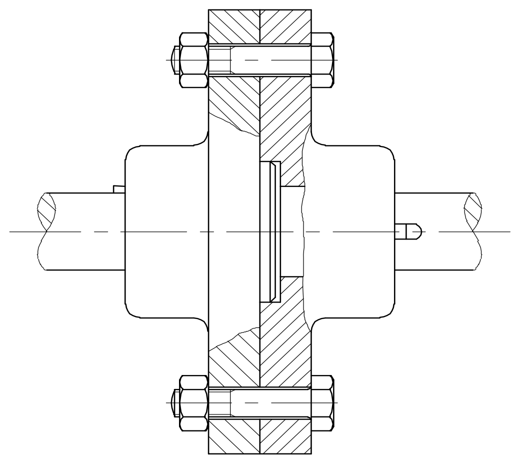
Objectives: At the end of this lesson you shall be able to
state the situations in which bolts and nuts are used
state the advantages of using bolts and nuts
identify the different types of bolts
state the applications of the different types of bolts
state the situations in which studs are used
state the reason for having different pitches of threads on stud ends.

Bolts and nuts (Fig 1)

These are generally used to clamp two parts together When bolts and nuts are used thread as stripped a bolt and nut can be used But in the case of a screw directly timed in the component when threads are damaged the component may need extensive repair or replacement

Depending on the type of application, different types of bolts are used

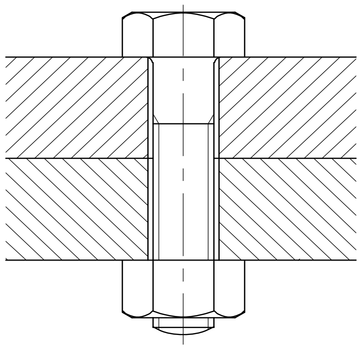
Fig 1



Bolts with clearance hole (Fig 2)

This is the most common type of fastening arrangement bolts. The size of the hole is slightly larger than the bolt (clearance hole)

Fig 2

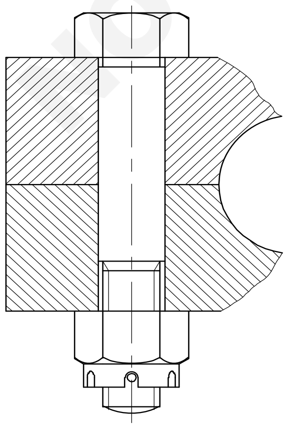


Slight misalignment in the matching hole will not affect the assembly.

Body fit bold (Fig 3)

This type of bolt assembly is used when the relative movement between the workpieces has to be prevented The diameter of the threaded portion is slightly smaller than the shank diameter of the bolt The bolt shank and the hole are accurately machined for achieving perfect mating.

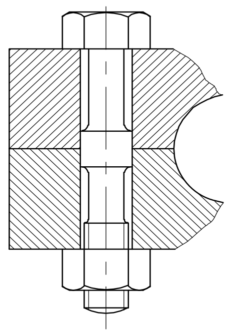
Fig 3



BODY FIT BOLT

Anti-fatigue bolt (Fig 4)

Fig 4



ANTI-FATIGUE BOLT

This type of bolt is used when the assembly is subjected to alternating load conditions continuously. Connecting rod big ends in engine assembly are examples of this application

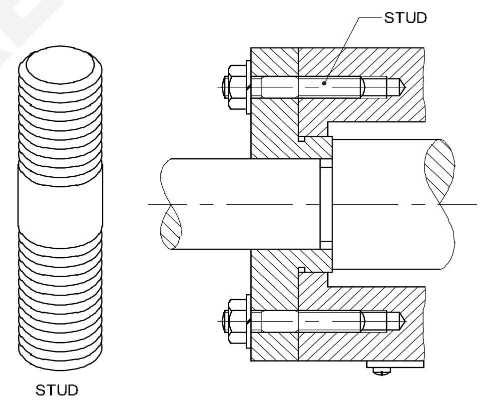
The shank diameter is in contact with the hole in a few places and other portions are relieved to give clearances,

Studs (Fig 5)

Studs are used in assemblies which are to be separated frequently

When excessively tightened, the variation in the thread pitch allows the fine thread or nut end to slip. This prevents damage to the casting.

Fig 5



Designation of bolts as per B.I.S. specifications

Hexagon head bolts shall be designated by name, thread size, nominal length, property class and number of the Indian Standard.

Example

A hexagon head bolt of size M10, nominal length 60 mm and property class 4.8 shall be designated as:Hexagon head bolt M10 x 60-4.8-IS:1363 (Part 1).

Explanation about property class

The part of the specification 4.8 indicates the property class (mechanical properties). In this case it is made of steel with minimum tensile strength = 40 kgf/mm² and having a ratio of minimum yield stress to minimum tensile strength = 0.8.

NOTE

Indian standard bolts and screws are made of three product grades A, B, & C, 'A' being precision and the others of lesser grades of accuracy and finish.

While there are many parameters given in the B.I.S. specification, the designation need not cover all the aspects and it actually depends on the functional requirement of the bolt or other threaded fasteners.

For more details on the designation system, refer to IS:1367, Part XVI 1979.

Locking devices - Types of lock nut

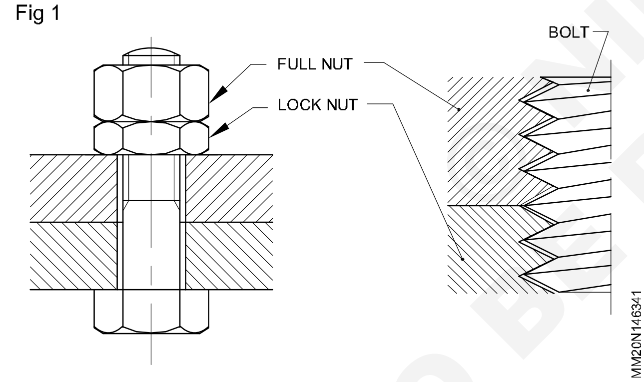
Objectives : At the end of this lesson you shall be able to
- **state the different types of locking devices**
- **state the uses of locking devices.**

Nuts used along with bolts in assembly may loosen due to vibration. Different types of nut-locking devices are used depending on the severity of the condition in which the fastener is used. The following are the most commonly used types.

Lock-nut

A thin nut with both faces machined is placed below a nut in the assembly. (Fig 1) Both nuts are tightened over the bolt one after the other. Then using two spanners pressure is exerted on both nuts by turning in opposite directions. Both nuts are held together by friction.

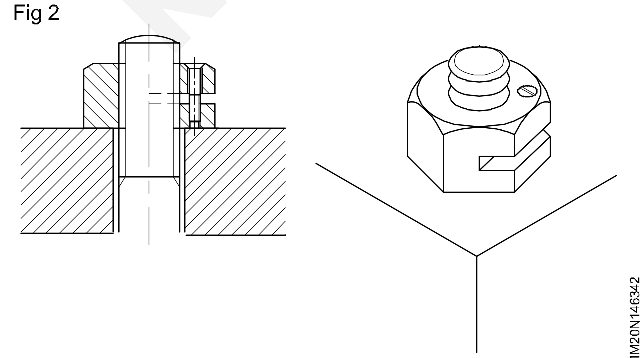
Fig 1



Sawn nut (Wiles nut)

In this type of locking, a slot is cut half way across the nut. A screw is fitted with a clearance hole on the top part and matching thread on the lower part of the nut. (Fig 2) Tightening of the nut provides positive locking for the nut.

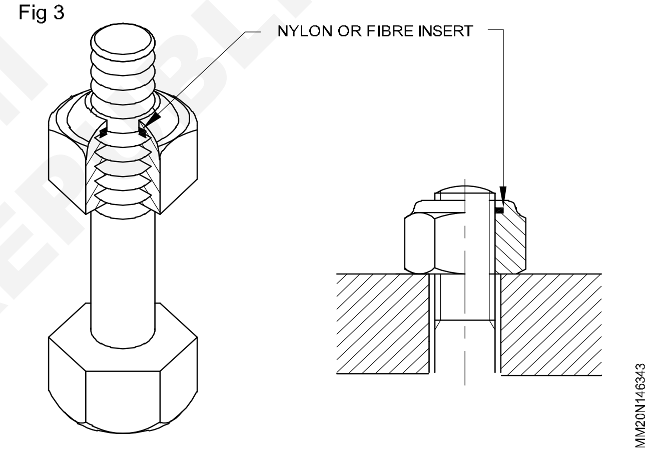
Fig 2



Self-locking nut (Simmonds nut)

This is a special nut with a nylon or fibre ring insert placed in the upper part of the nut. The internal diameter of the ring is smaller than the core diameter of the bolt thread. The nut while tightening cuts its own thread on the nylon insert. This provides a positive grip and prevents the nut from loosening due to vibration. (Fig 3)

Fig 3



Slotted and castle nuts

These nuts have special provision in the form of slots for fixing split pins for locking the nuts.

Slotted nuts are hexagonal shaped throughout. (Fig 4) in the case of castle nuts, the top part of the nut is cylindrical in shape.

Slotted and castle nut with split pin

The position of the nut can be locked using a split pin.

Split pins are designated by the nominal size, nominal length, the number of the Indian Standard and the materials (for materials other than steel only).

The nominal size is the diameter of the hole for receiving the split pins.

The nominal length is the distance from the underside of the eye to the end of the short leg. (Fig 5)

Split pins are used for locking slotted nuts, castle nuts, hexagonal nuts, clevis pins etc. and are used in different ways. (Fig 6)

Fig 4

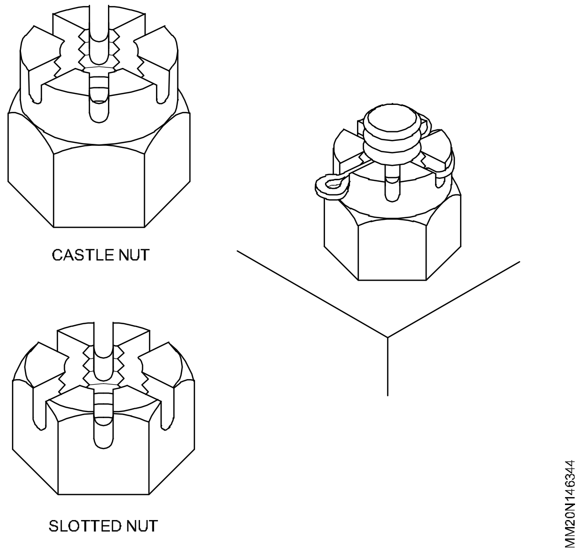


Fig 5

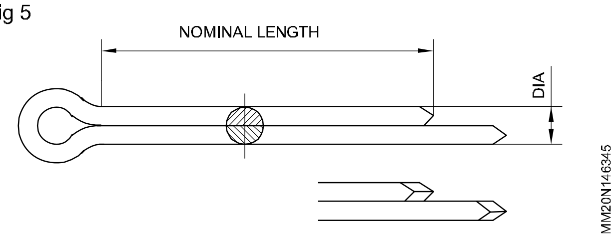
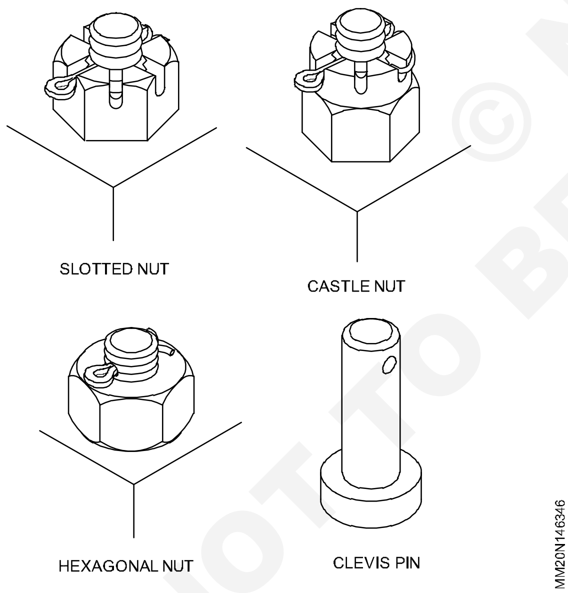


Fig 6



Grooved nut (Penning nut)

This is a hexagonal nut with the lower part made cylindrical on the cylindrical surface. There is a recessed groove in which a set screw is used to lock the nut. (Fig 7)

Locking plate

For preventing the nut from loosening locking plates are fixed on the outside of the hexagon nut. (Fig 8)

Fig 7

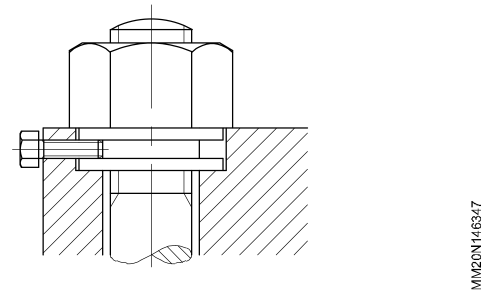
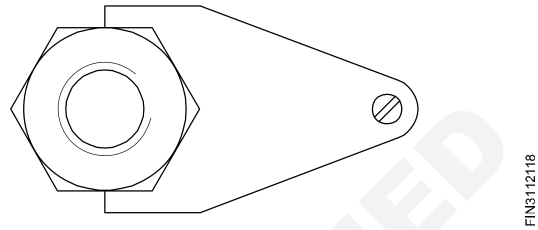


Fig 8

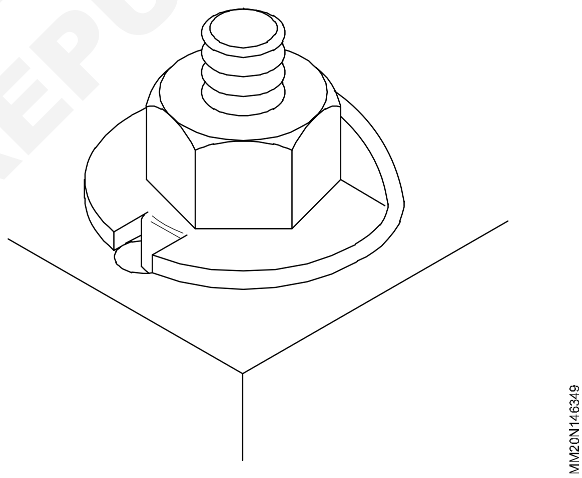


Lock-washers with lug

In this arrangement of locking a hole is drilled for accommodating the lug. (Fig 9)

The movement of the nut is prevented by folding the washer against the nut.

Fig 9



Tab washers (Fig 10)

Tab washers can be used for locking the nuts which are located near an edge or corner.

Spring washers (Fig 11)

Spring washers are available with a single or a double coil. These are placed under a nut in the assembly as washers. The stiff resistance offered by the washer against the surface of the nuts serves to prevent loosening.

Fig 10

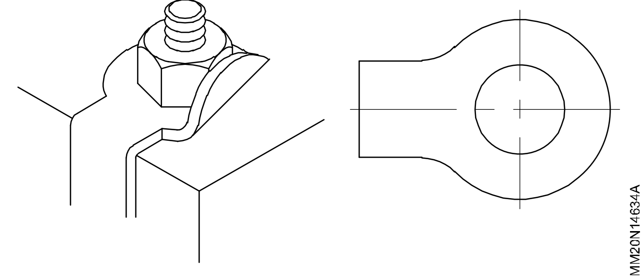
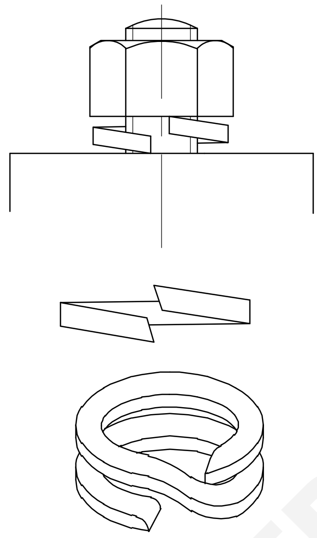


Fig 11



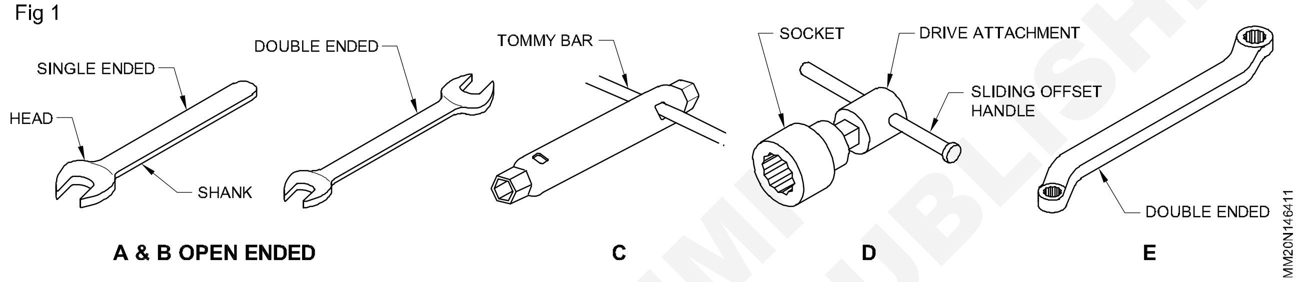
Spanners and their uses

Objectives : At the end of this lesson you shall be able to
- **state the necessity of spanners**
- **identify the different types of spanners**
- **specify the spanners**
- **identify the parts of adjustable spanners**
- **state the features of 'C' spanners and their uses.**

Spanners are used for operating threaded fasteners, bolts and nuts. They are made with jaws or openings that fit square on hexagonal nuts and bolts and screw heads. They are made of high tensile or alloy steel. They are drop forged and heat treated for strength. Finally they are given a smooth surface finish for ease of gripping.

Spanners vary considerably in shape to provide ease of operation under different conditions (Fig 1).

Fig 1



The five basic types of spanners are open end spanners

single ended (A)

double ended (B)

tube or tubular box spanners(C)

socket spanners(D)

ring spanners (E).

The correct spanner to use is the one that fits exactly and allows room for use. They should also permit the job to be done in a shorter time.

The following are the points to be noted for using spanners in a safe way.

Use open end and ring spanners by pulling on the shank. It is safest to pull as there is less chance of hitting your knuckles if the spanner or nut slips suddenly. If you are forced to push the spanner, use the base of your hand and keep your hand open.

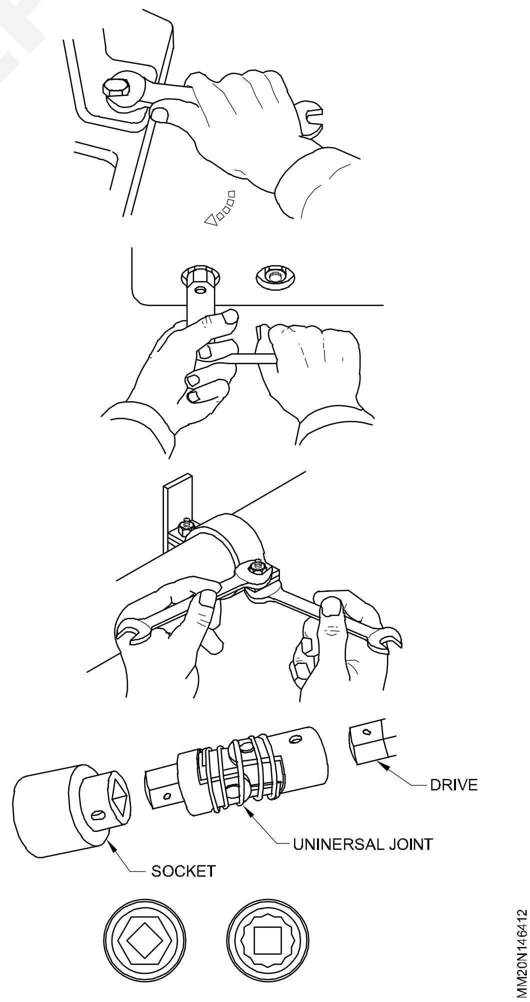
Use both hands for large spanners.

Keep yourself balanced and firm to avoid slipping your-self, if the spanner slips suddenly. Hold on to some support, if there is any chance of falling.

Use both hands as shown in Fig 2, when using tubular box spanners.

Use two spanners as shown in the figure to stop the head of the bolt rotating as the nut is operated: (Fig 2)

Fig 2



Socket spanners may be turned by accessories which have square driving ends.

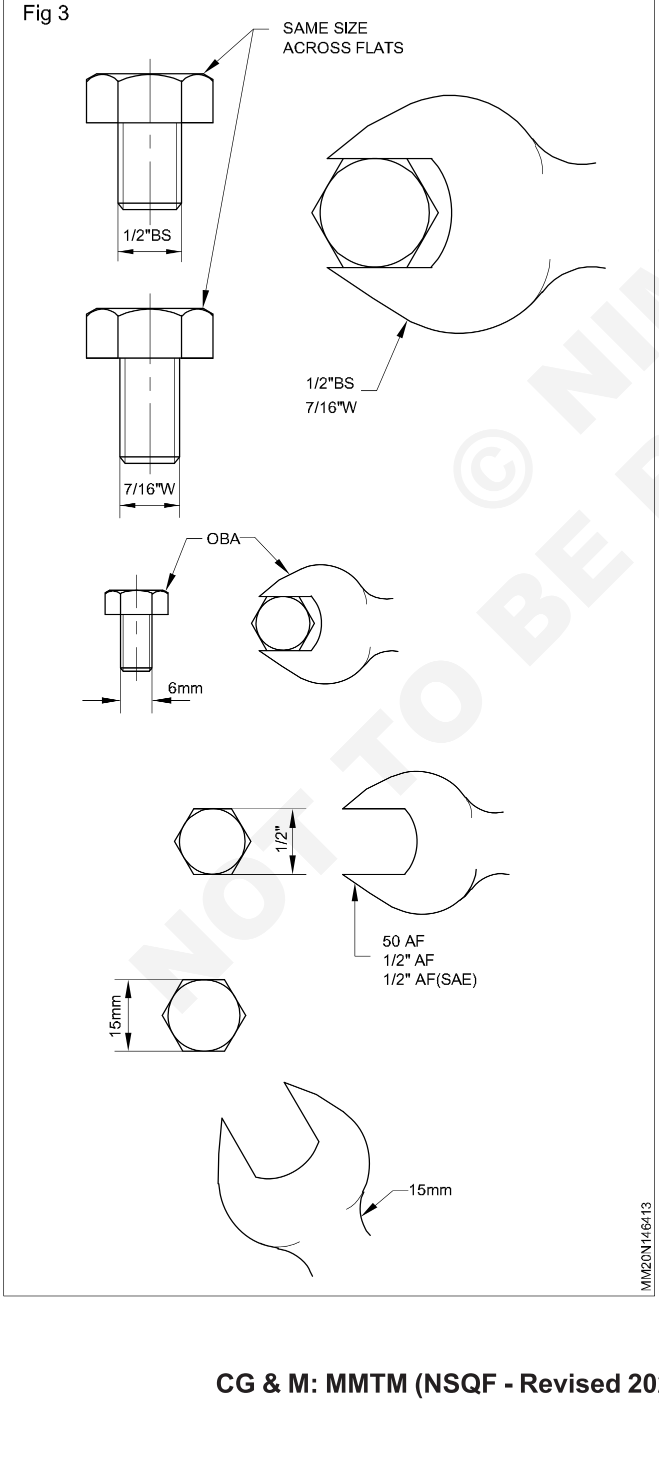
Size and identification of spanners

The size of a spanner is determined by the nut or bolt it fits The distance across the flats of a nut or bolt varies both with the size and the thread system.

In the British system the nominal size of the bolt is used to identify the spanner.

In the unified standard system, the spanners are marked with a number based on the decimal equivalent of the nominal fractional size across the flats of the hexagon, following the sign A/F or with the fractional size across the flats. In the metric system, spanners are marked with the size across the jaw opening followed by the abbreviation 'mm'. (Fig 3)

Fig 3



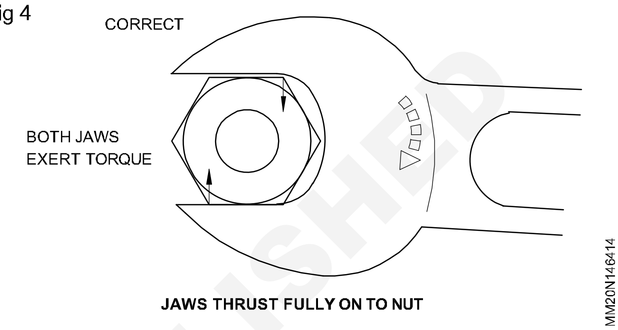
To fit exactly, a spanner must be

- of the correct size
- placed correctly on the nut
- in good condition

Spanners have their jaws slightly wider than the width of the nut so that they can be placed into position easily. Any excess more than a few hundredths of a millimeter clearance could cause the spanner to slip under pressure

Place the spanner so that its jaws bear fully on the flats of the nut. (Fig 4)

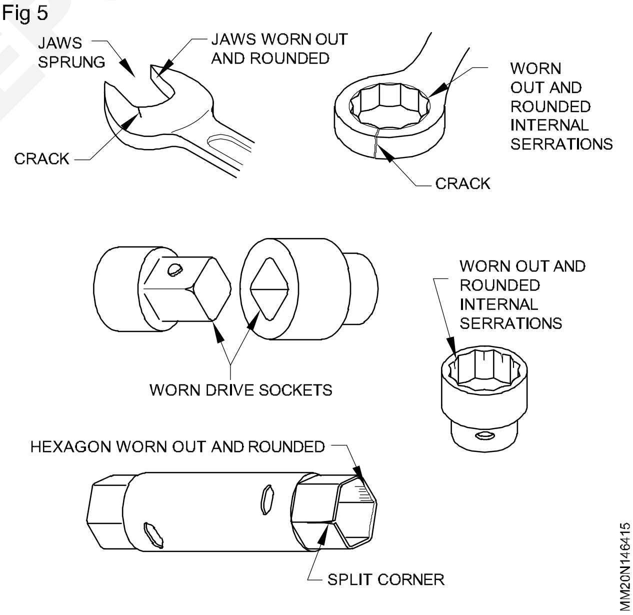
Fig 4



incorrect use damages the spanners

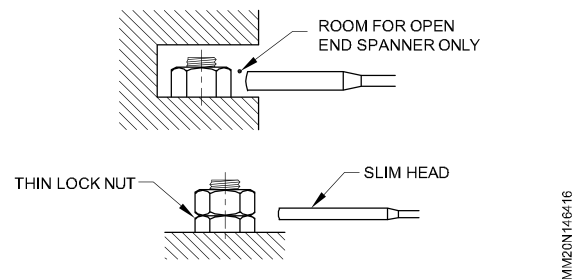
Discard any defective spanners. The spanners illustrated here are dangerous for use (Fig 5)

Fig 5



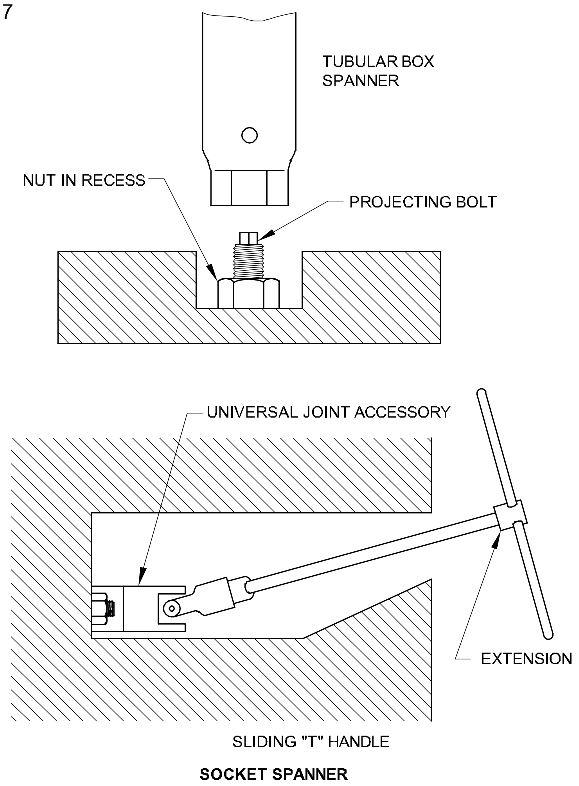
Choose spanners that allow room for use (Fig 6)

Fig 6



Nuts in inaccessible positions may be reached with socket spanners, with special drawing accessories (Fig 7)

Fig 7



SOCKET SPANNER

Length of spanners

Normally spanners have a length that is about ten times the width of the jaw opening.

Never exert excessive pull on a spanner, particularly by using a pipe to extend the length of a spanner.

Excess turning effect of the spanner could result in:

striping the thread

- shearing the bolt

straining the jaws of the spanner

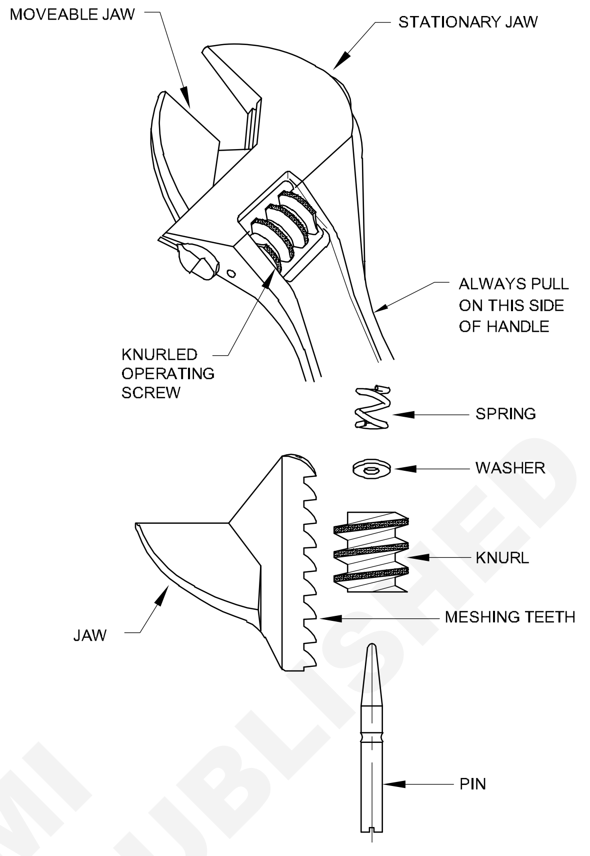
making the spanner slip and cause an accident.

Adjustable spanners (Fig 8)

Most common types of adjustable spanners are similar to open end spanners, but they have one movable jaw. The opening between the jaws of a typical 250 mm spanner can be adjusted from zero to 28.5 mm. Adjustable spanners may range in length from 100 mm to 760 mm. The type illustrated has its jaws set at an angle of 22 1/2" to the handle Adjustable spanners are convenient for use where a full kit of spanners cannot be carried about. They are not intended to replace fixed spanners which are more suitable for heavy service. If the movable jaw. or knurled screw is cracked or worn out, replace them with spare ones.

When using the adjustable spanner follow the steps given below.

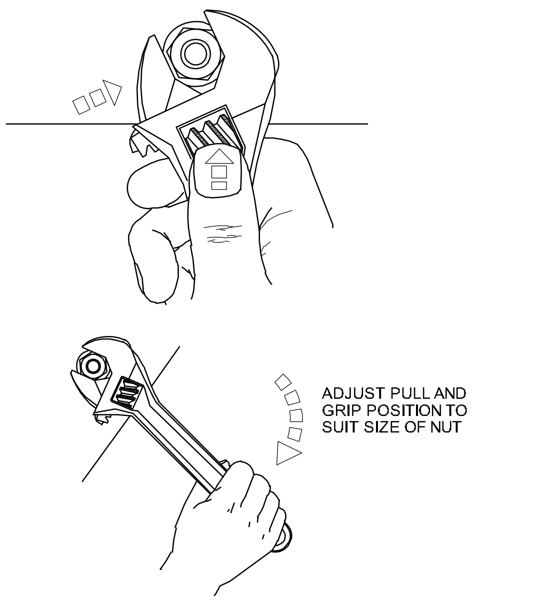
Fig 8



Place it on the nut so that the jaw opening points in the same general direction as the handle is to be pulled. In this position the spanners are less liable to slip and the required turning force can be exerted without damage to the moving jaw and knurl.

Push the jaws into full contact with the nut. (Fig 9)

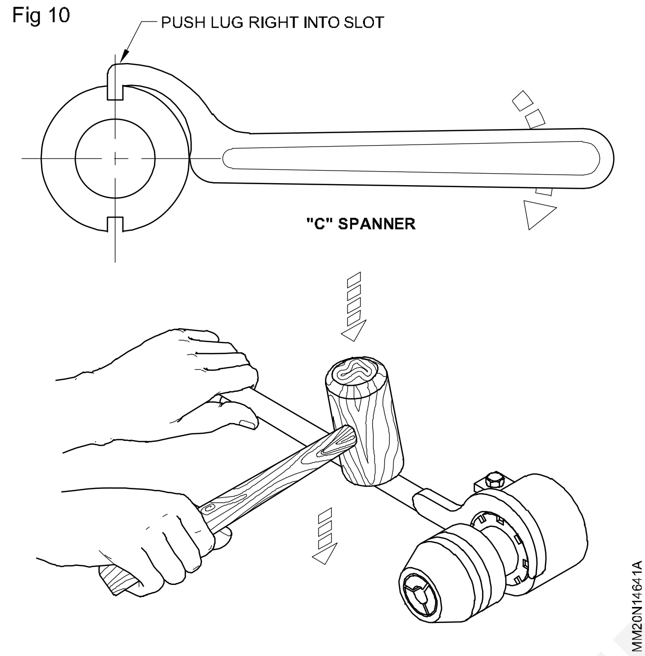
Fig 9



Use the thumb to tighten the adjusting knurl so that rotate continuously. The length of the handle is designed The maximum opening of the jaws. With small nuts, a very small pull on the handle will produce the required torque (Fig 10)

'C'spanners (Hook spanners)

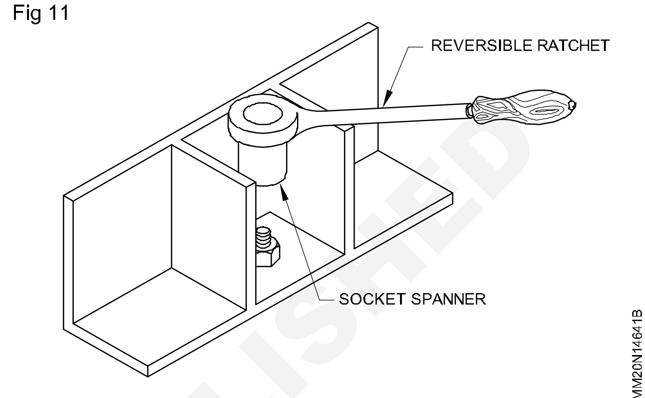
Fig 10



It has a lug that fits in a notch, cut in the outer edge of a round nut. The 'C' section is placed around the nut in the direction in which it is to be turned. In adjustable hook wrenches, part of the 'C' section pivots to fit nuts with a range of diameters. A set of three spanners is needed to cover diameters from 19 mm to 120 mm..

The applications of 'C' spanners are shown in figure 10. With socket spanners, use the reversible ratchet handle for doing fast work, where turning space is restricted. (Fig 11)

Fig 11

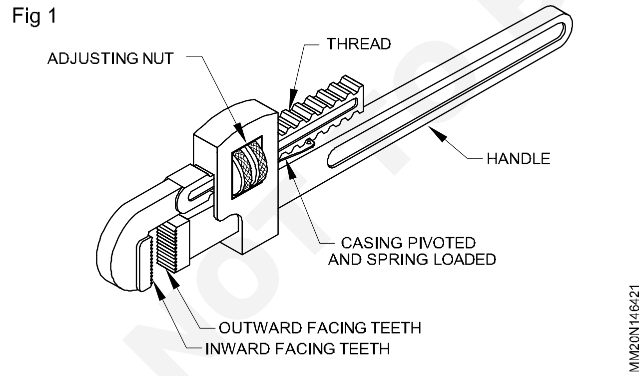


Pipe wrenches

Objectives : At the end of this lesson you shall be able to
- **state the different types of pipe wrenches**
- **state the uses of each type of wrench.**

Stillson pipe wrench (Fig 1)

Fig 1

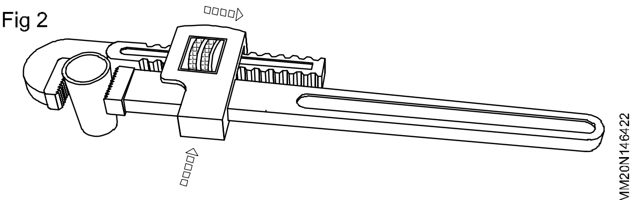


This pipe wrench is used for gripping and turning pipes, tubes and cylindrical rods of different diameters (Fig 2)

This is made of high tensile steel, drop-forged, hardened and tempered. Stillson pipe wrenches are available in sizes from 6" to 24" inches (150 to 600 mm). The size refers to the overall length of the wrench when the jaws are opened to the maximum width.

These wrenches have sharp serrated teeth and will damage polished or plated surfaces.

Fig 2



Chain wrench (Figs 3 & 4)

The chain wrench is used for holding or gripping large diameter pipes (Fig 4) where the Stillson wrench cannot be used.

This wrench is made out of high tensile steel with hardened and tempered double-ended reversible jaws. A long tapered handle is bolted with the jaws.

The capacity of the chain wrench is approximately from 50 mm to 150 mm.

This can also be used for gripping irregular surfaces.

Strap wrench (Fig 5)

Strap wrenches are used on finished tubular surfaces to avoid marking or damaging. These wrenches have metallic straps by which the surfaces can be tightly gripped

Fig 3

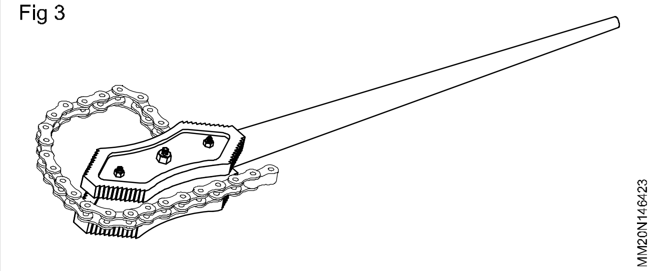


Fig 4

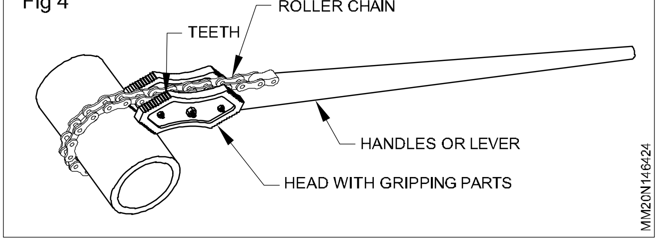
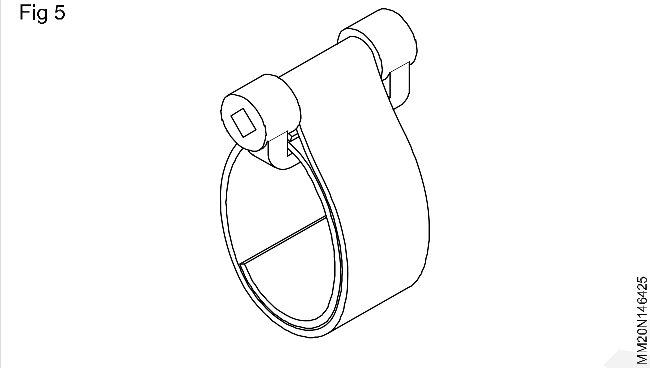


Fig 5

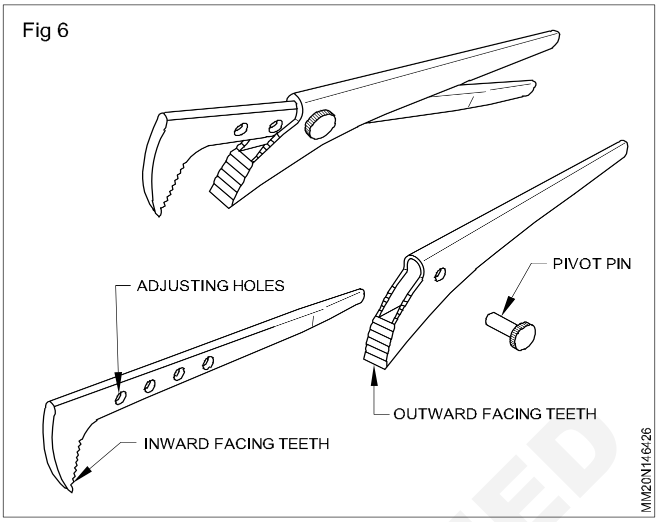


Footprint wrench (Figs 6)

These are used for gripping and turning pipes and round stocks in confined places.

The required size is adjusted by placing the pivot pin in the different holes of the solid handle.

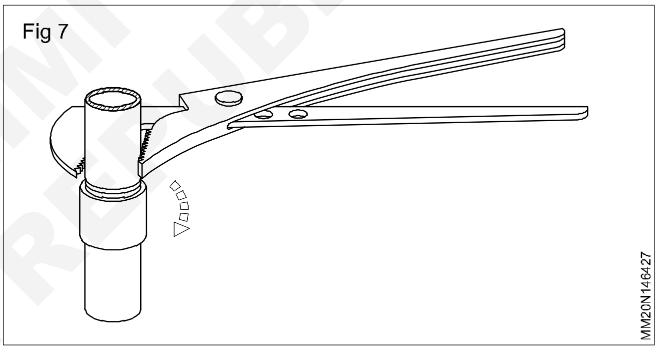
Fig 6



The grip is obtained by squeezing both the solid handles together. (Fig 7)

The selection of hole should be such that the handles are not too far as this may result in uncomfortable holding of the handles.

Fig 7



Pliers

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

Features

Pliers have a pair of legs joined by a pivot, hinge or fulcrum pin. Each leg consists of a long handle and a short jaw.

Elements of pliers with two joint cutters (Fig 1) (Combination pliers)

- Flat jaw
- Pipe grip
- Side cutters
- Joint cutters
- Handles

Features (Fig 1)

Flat jaw tips are serrated for general gripping.

Pipe grip is serrated for gripping cylindrical objects. (Fig 2)

Side cutters are provided for cutting off soft wires. (Fig 3)

Two joint cutters are provided for cutting or shearing off steel wires. (Fig 4)

Handles are used for applying pressure by hand.

Pliers are available in sizes from 150 mm to 230 mm. (Size = Overall length)

Other types of pliers

Flat nose pliers

It has tapered wedge jaws with flat gripping surfaces which may be either smooth or serrated. (Fig 5)

Fig 1

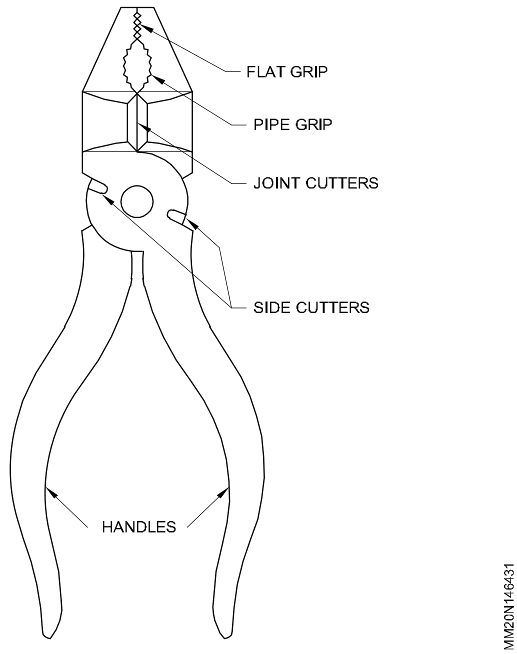


Fig 2

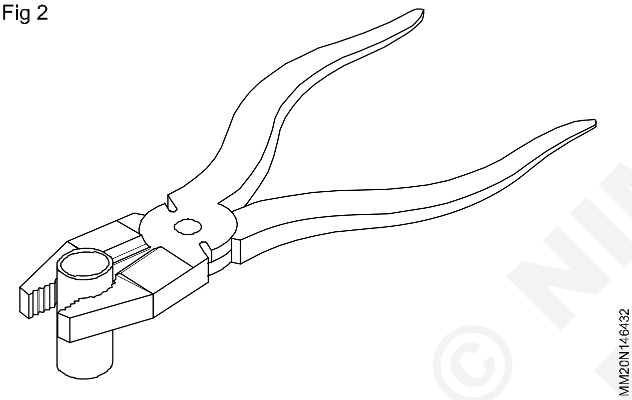


Fig 3

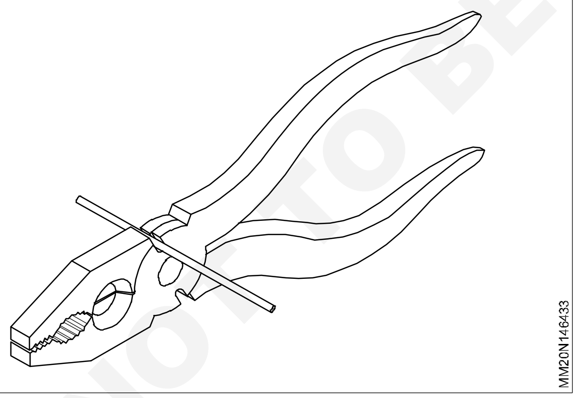


Fig 4

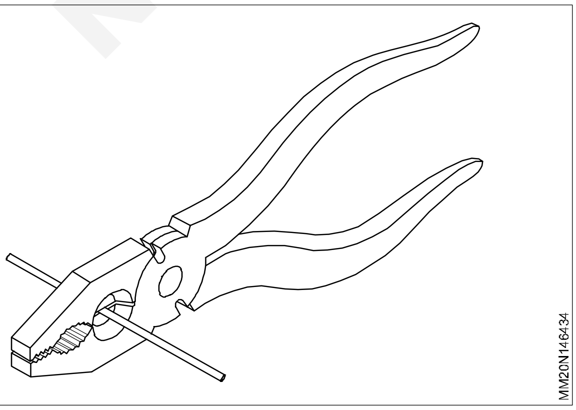
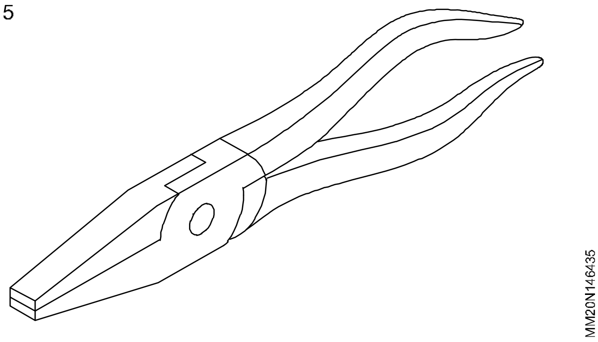
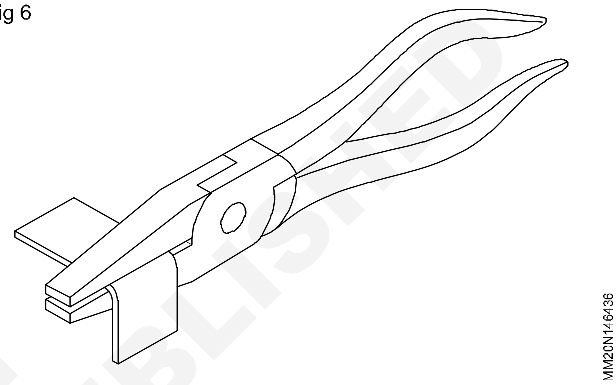


Fig 5



It is used for bending and folding narrow strips of thin sheet metal. (Fig 6)

Fig 6



Round nose pliers

This type of pliers is made with tapered round shaped jaws. (Fig 7) They are used to shape loops in wires and to form curves in light metal strips. (Fig 8)

Fig 7

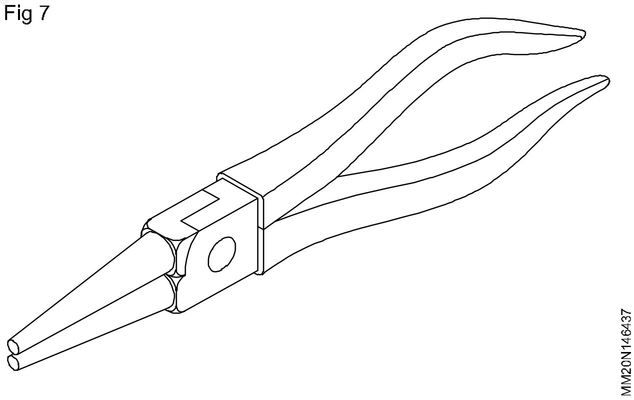
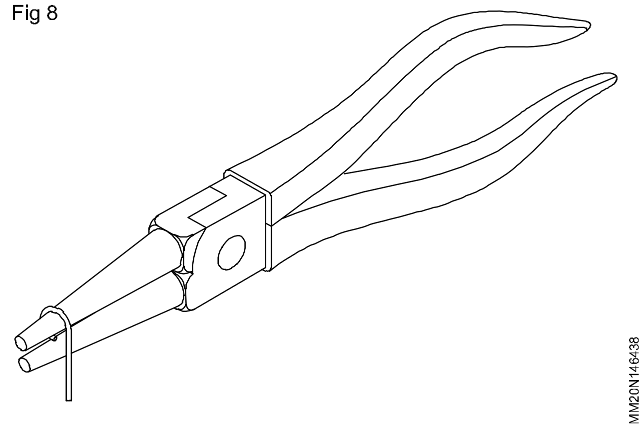


Fig 8

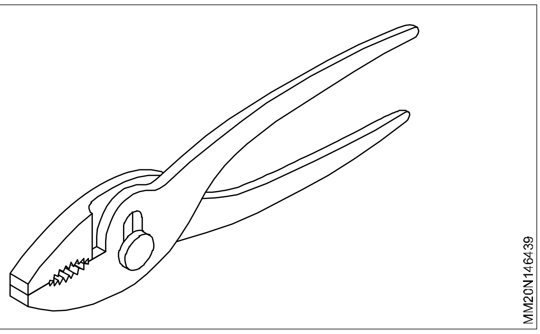


Slip-joint pliers

These pliers are available in various ranges of position with different shapes of pivot pins so that they have various ranges of jaw openings.

Mainly used for gripping. (Fig 9)

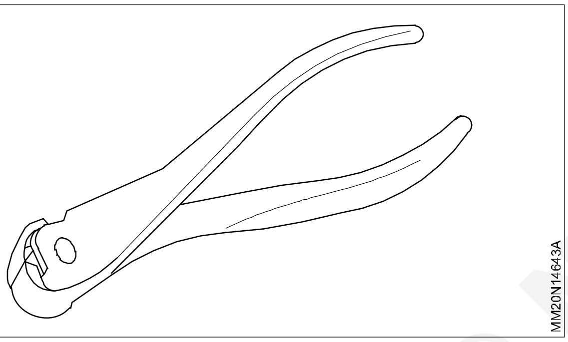
Fig 9



End cutting pliers

These pliers have the same uses as the side cutting pliers. (Fig 10)

Fig 10



Circlip pliers

Circlip pliers are used for fitting and removing circlips in assembly works.

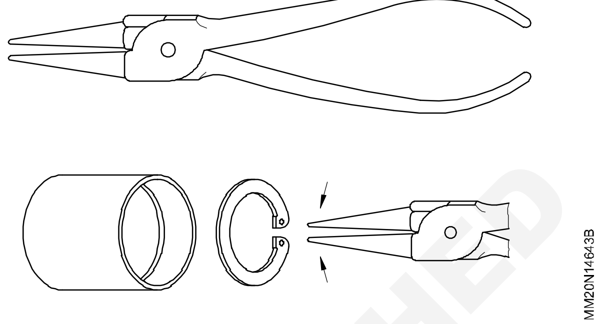
External circlip pliers

External circlip pliers are used to fit and remove the external circlip in the grooves of the shafts

Internal circlip plier

It is used to fit and remove the internal circlip in the groove of the bore. (Fig 11)

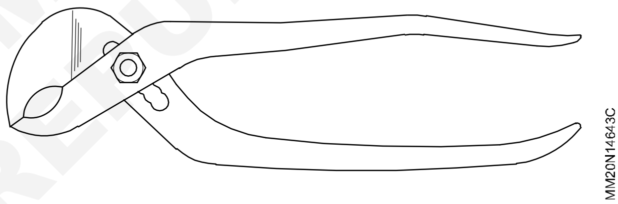
Fig 11



Slip-joint, multi-grip pliers

It is similar to the grip pliers but has more openings in the legs. It gives a range of jaw openings. It allows parallel gripping by the jaws in a number of positions. (Fig 12)

Fig 12



Screw drivers

Objectives : At the end of this lesson you shall be able to
- **state different types of screw drivers and their uses**
- **specify a screw driver**
- **list the precautions to the observed while using screw driver.**

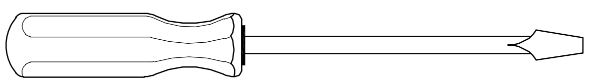
Screwdrivers are used to tighten or loosen screws and are available in various lengths.

Hand-held screwdrivers are of the following types.

Standard screwdriver (Light duty) (Fig 1)

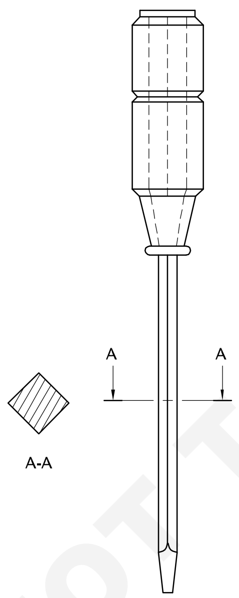
It is of round shank/blade with metal, wood or moulded, insulated material handle.

Fig 1



Standard screwdriver (Heavy duty) (Fig 2)

Fig 2



It has a square blade. The shank is also of square section for applying extra twisting force with the end of a spanner. (Fig 3)

Heavy duty screwdriver (London pattern) (Fig 4)

It has a flat blade and is mostly used by carpenters for fixing and removing wood screws.

Fig 3

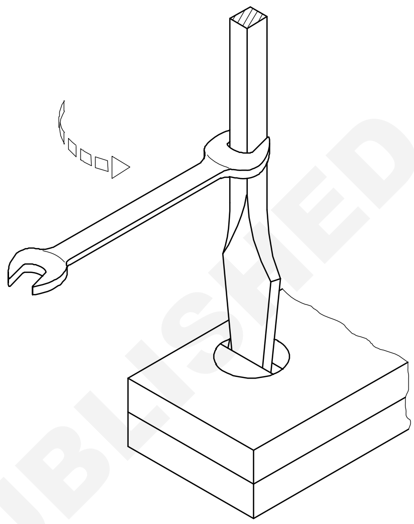
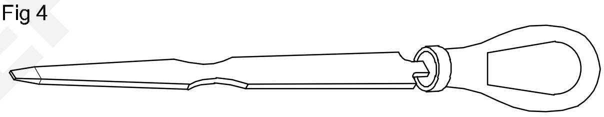
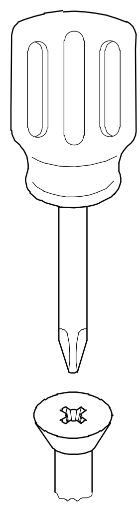


Fig 4



Philips screwdriver (Fig 5)

Fig 5



These are made with cruciform (Fig 6) tips that are unlikely to slip from the matching slots. (Fig 7) Philips recess head screws are shown in Fig 8.

Fig 6

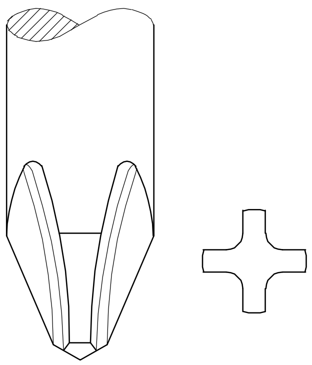


Fig 7

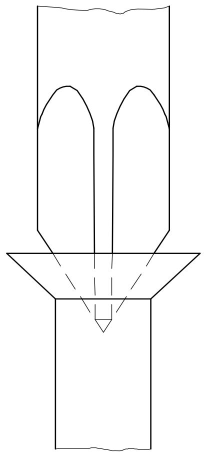
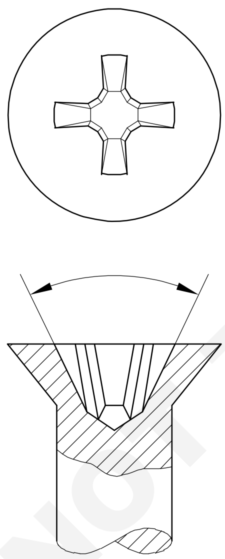


Fig 8



The sizes of Philips screwdrivers are specified by point size 1, 2, 3 and 4.

Offset screwdrivers (Fig 9)

These are useful in some situations (Fig 10) where the normal screwdriver cannot be used because of the length of the handle. They are also useful for applying greater turning force.

Fig 9

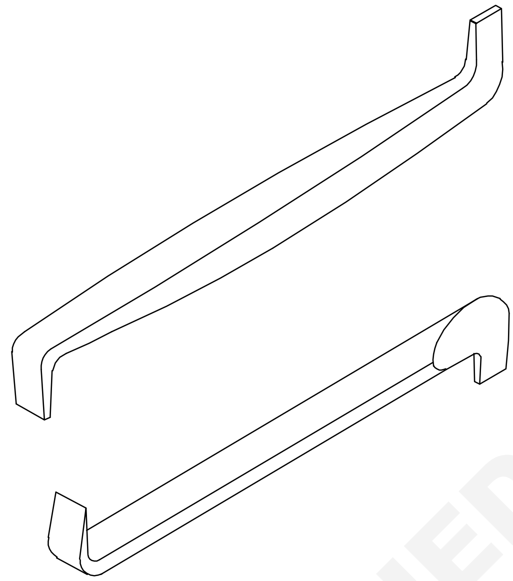
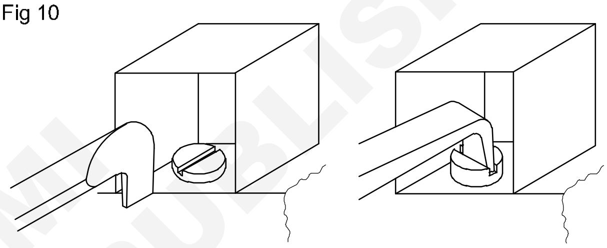
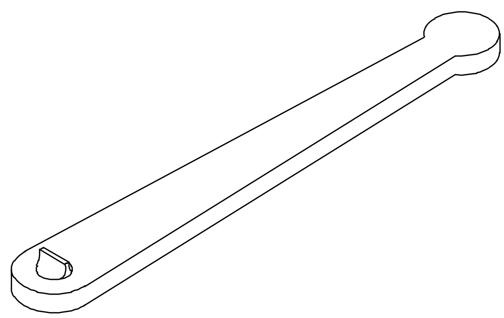


Fig 10



For quicker application ratchet offset screwdrivers are also available with renewable tips. (Fig 11)

Fig 11



Specification

Screwdrivers (Fig 12) are specified according to the

- length of the blade
- width of the tip.

Normal blade length: 45 to 300mm. Width of blade : 3 to 10mm.

The blades of screwdrivers are made of carbon steel or alloy steel, hardened and tempered.

Screwdrivers for special uses

Small sturdy screwdrivers are available for use where there is limited space. (Fig 13)

Fig 12

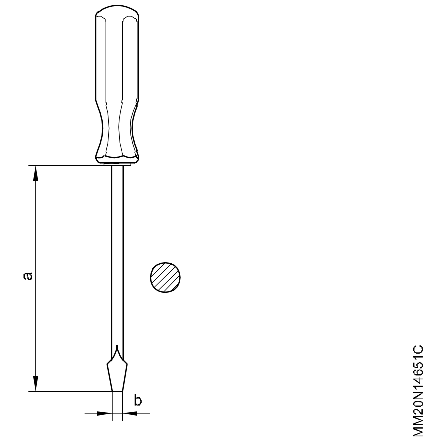
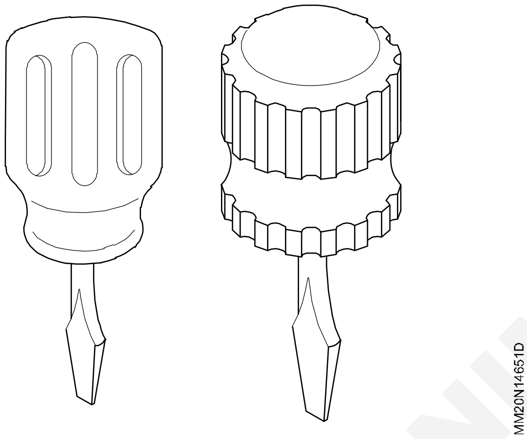
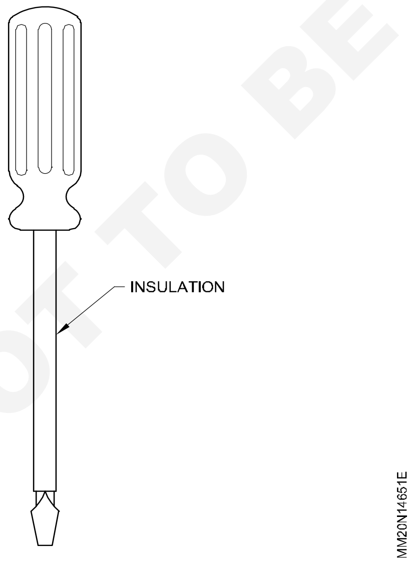


Fig 13



Screwdrivers with blades sheathed in insulation are available for the use of electricians. (Fig 14)

Fig 14

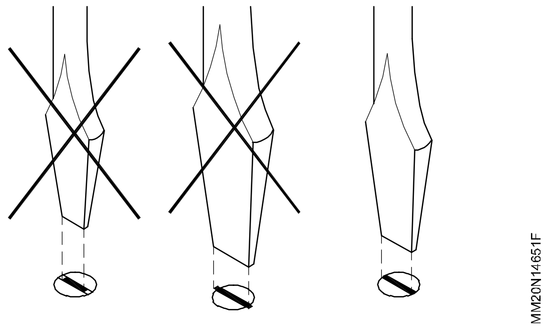


Precautions

Use screwdrivers with tips correctly fitting into the screw slot. (Fig 15)

Make sure your hand and the handle are dry.

Fig 15

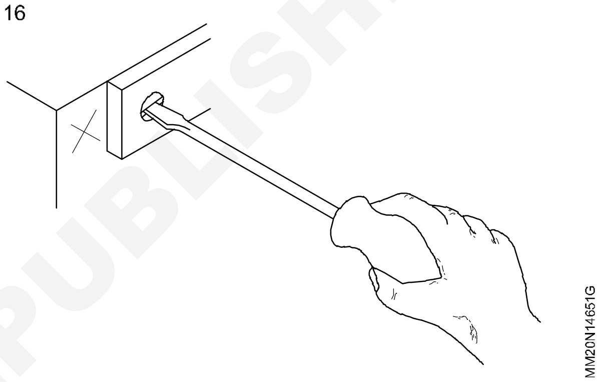


Hold the screwdriver with its axis in line with the axis of the screw.

While using a Philips screwdriver apply more downward pressure.

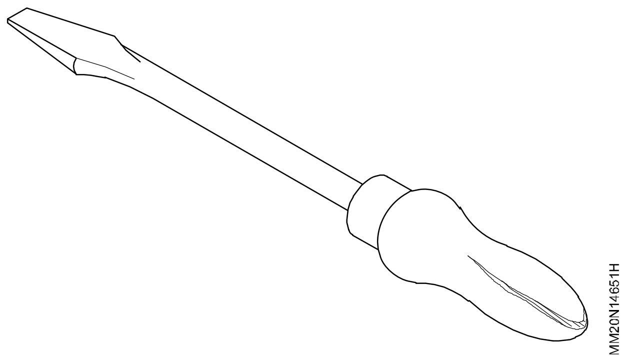
Keep your hand away to avoid injury due to slipping of screwdriver. (Fig 16)

Fig 16



Do not use screwdrivers with split or defective handles. (Fig 17)

Fig 17



In the case of damaged screwdrivers, the blades can be ground (the faces will be parallel with the sides of the screw slot) and used. While grinding ensure the end of the tip is as thick as the slot of the screw.

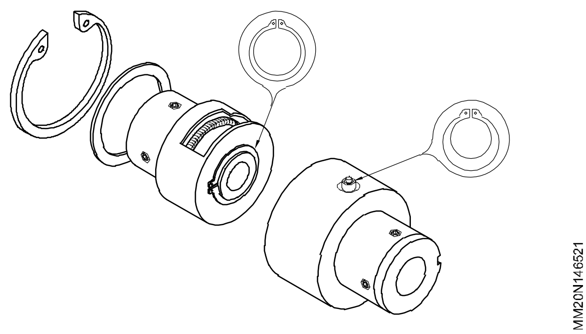
While using screwdrivers on small jobs, place the jobs on the bench or hold them in a vice.

Circlips

Objectives : At the end of this lesson you shall be able to
- **state the functions of circlips**
- **state the different types of circlips**
- **state the advantages of circlips over other fastening devices**
- **state the material used for circlips.**

Circlips are fastening devices used to provide shoulders for positioning or limiting the movement of parts in an assembly. (Fig 1) Circlips are also called 'Retaining rings

Fig 1



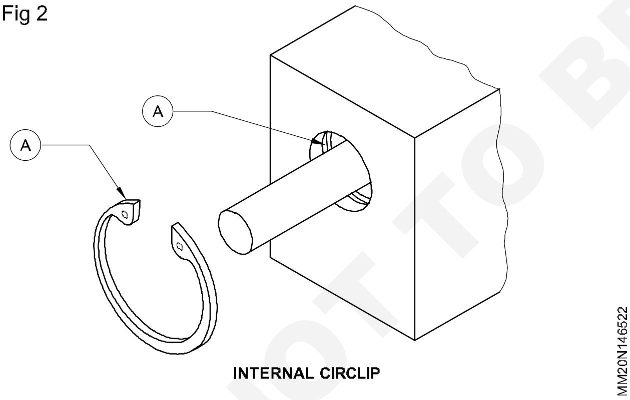
The rings are generally made of materials having good spring properties so that the fastener may be deformed elastically to a considerable degree and still spring back to its original shape. This permits the circlips to spring back into a groove or other recess in a part or they may be seated on a part in a deformed condition so that they grip the part by functional means. Circlips are manufac- tured from spring steel with high tensile and yield strength.

Types

There are two types.

Internal circlips (Fig 2)

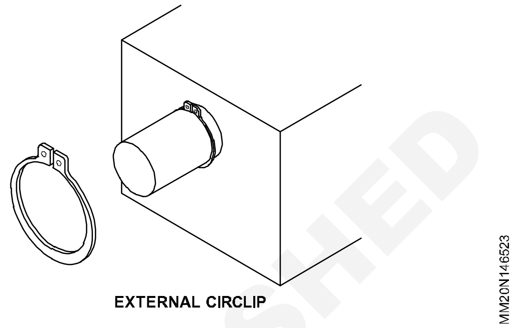
Fig 2



This type of rings are assembled in holes, bores or housing.

External circlip (Fig 3)

Fig 3



This type of rings are installed on shafts, pins, studs and similar parts

Both types offer a number of advantages over other fastening methods.

- Their cost is relatively low when compared with other types of fasteners
- Their use often results in savings in raw material and simplified machining operations for other parts in the assembly.
- One circlip often can replace two or more parts.
- Assembly toolings developed for circlips usually permit very rapid assembly of the fasteners, even by unskilled workers.

Material

Because retaining rings depend for their function largely on their ability to be deformed elastically during assembly and disassembly, the materials must have good spring properties Circlips are manufactured from spring steel with high tensile and yield strength.

Split pin

Objectives: At the end of this lesson you shall be able to
- **state the functions of split pin**
- **state the material used for split pin**
- **explain the construction of split pin.**

Split pins are frequently used to secure other fasteners, e.g clevis pins, or to secure a castellated nut, or, infrequently, as a low-tech shear pin. Split pins are cheaper but less reusable than linchpins, and provide less strength but easier to install/remove than spring pins.

Split pins are typically made of soft metal, making them easy to install and remove, but also making it inadvisable to use them to resist strong shear forces. common materials include mild steel, brass, bronze, stainless steel, and aluminium. (Fig 1)

Fig 1

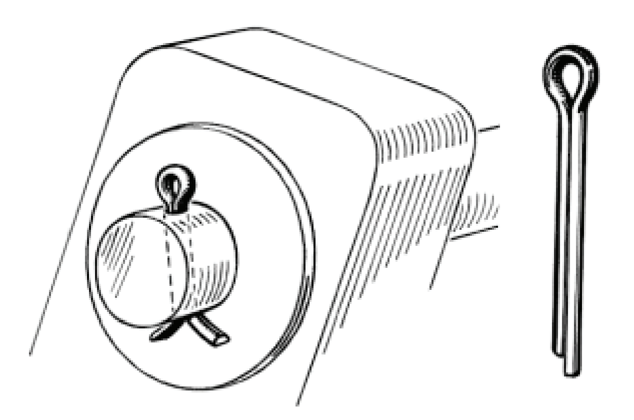
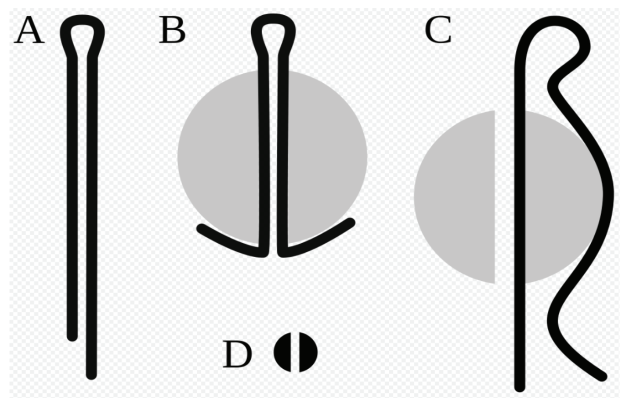


Fig 2



Split pins are measured along the shortest length of the pin. The nominal diameter of the pin is the size of hole it is designed to pass through. This means the pin will be fractionally smaller than its nominal diameter.

Split pins have two tines (or prongs) with an eyelet at the bend. Split pins need to be strong enough to hold components in place, but flexible enough to be bent to secure the fastening.

A New split pin

B Installed split pin

C R-clip

D Cross-section of a new split pin

A new split pin (see figure A) has its flat inner surfaces touching for most of its length so that it appears to be a split cylinder (figure D). Once inserted, the two ends of the pin are bent apart, locking it in place (Figure B). When they are removed they are supposed to be discarded and replaced, because of fatigue from bending. (Fig 2)

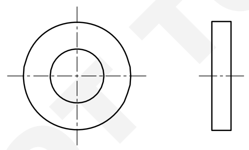
Split pins are typically made of soft metal, making them easy to install and remove, but also making it inadvisable to use them to resist strong shear forces. common materials include mild steel, brass, bronze, stainless steel, and aluminium.

Washers

Objectives : At the end of this lesson you shall be able to
- **state the various types of washer and their specifications.**

Washers are used to distribute the clamping pressure over a larger area, and prevent the surface damaged (marking). They are also provide an increased bearing surface for bolt heads and nuts. Washers are manufactured in light, medium, heavy and extra heavy series. (Fig 1)

Fig 1



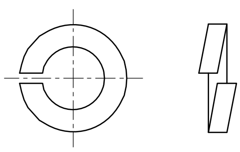
MM20N146531

Lock washers: A lock washer is used to prevent a bolt or nut from loosening under vibration.

The split ring lock washer is being rapidly replaced by lock washers designed for specific applications. (Fig 2)

Tooth type lock washers: These washers have teeth that bite deep into both screw head and work surface Their design is such that they actually lock lighter as vibrations increase.

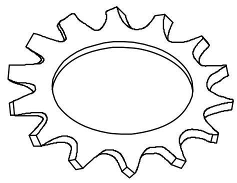
Fig 2



MM20N146532

External type: Should be used where possible as it provides the greatest resistance. (Fig 3)

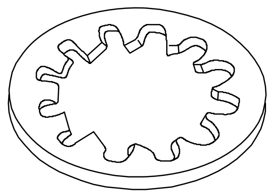
Fig 3



MM20N146533

Internal type: Used with small head screws and where it is desirable to hide the teeth either for appearance or to prevent snagging (Fig 4)

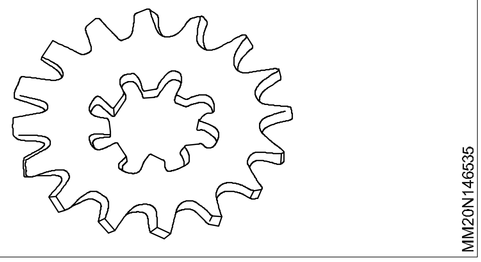
Fig 4



MM20N146534

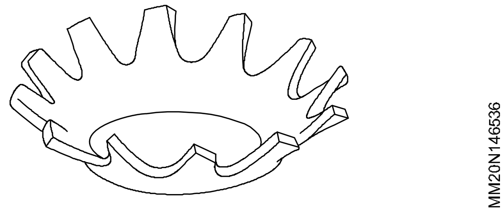
Internal and external type: Used when the mounting holes are over size. (Fig 5)

Fig 5



Countersunk type: For use with fat or oval type head screws (Fig 6)

Fig 6



Power tools

Objectives: At the end of this lesson you shall be able to
- **define power tool, torque and torque wrench**
- **state care and maintenance of power tools.**

Definition

A power tool is a tool actuated by power source and mechanism other than manual labour used with hand tools for fastening bolts and nuts.

Power wrench

A power wrench is type of wrench that is powered by other means than human force. A typical power source is compressed air. There are two main types of power wrenches:

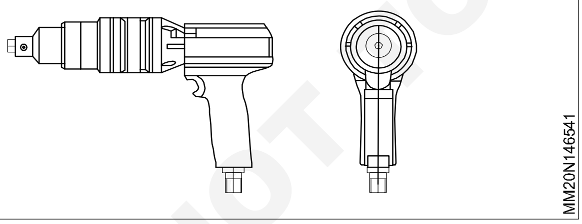
1 Impact wrenches and

2 Air ratchet or pneumatic ratchet wrenches

Air ratchet wrench

An air ratchet wrench is very similar to hand powered ratchet wrenches in that it has the same square drive, but an air motor is attached to turn the socket drive. Pulling the trigger activates the motor which turns the socket drive. A switch is provided to change the direction of socket drive. (Fig 1)

Fig 1



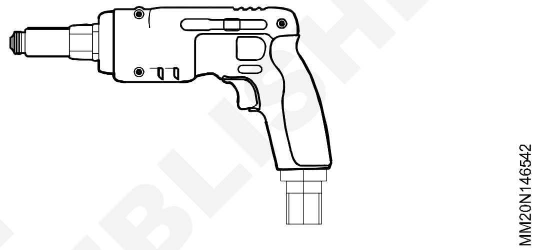
This type of power wrench is designed more for speed and less for torque. If high levels of torque are desired an impact wrench should be used.

Pneumatic torque wrench

Pneumatic torque wrench setting torque on bolts.

A pneumatic torque wrench is a primary torque multiplier or a gear box that is mated to a pneumatic air motor. At the end of the gear box is a reaction device that is used to absorb the torque and allows the tool operator to use it with very little effort. The torque output is adjusted by controlling the air pressure. (Fig 2)

Fig 2



These planetary torque multiplier gearboxes have multiplication ratios up to 125:1 and are primarily used anywhere accurate torque is required on a nut and bolt, or where a stubborn nut needs to be removed.

The pneumatic torque wrench is sometimes confused with a standard impact wrench due to their similar appearance. A pneumatic torque wrench is driven by continuous gearing and not by the hammers of an impacting wrench. A pneumatic torque wrench has very little vibration and excellent repeatability and accuracy.

The pneumatic torque wrench was first invented in germany in the early 1980's.

Torque capabilities of pneumatic torque wrenches range from 118Nm, up to a maximum of 47,600Nm.

Air requirements

A pneumatic motor using compressed air is the most common source of power for pneumatic torque wrenches. CFM requirements are usually 20-25 CFM of air consumption per tool.

CFM - Cubic feet/minute (or) PSI - Pounds/square inch.

Torque wrenches

Screwdrivers are available - manual, electric and pneumatic with a clutch that slips at a preset torque. This helps the user tighten screws to a screws to a specified torque without damage or over - tightening. Cordless drills designed to use as screwdrivers often have such a clutch.

Torque

- Torque is the application of a force acting at a radial distance and tending to cause rotation
- Torque is used to create tension in thread fasteners
- When the nut and bolt are tightened the two plates are clamped together. The thread converts the applied torque into tension in the bolt shank. This turn is converted into clamping force. The amount of tension created in the bolt is critical.

Torque wrench

A tool for setting and adjusting the tightness of nuts and bolts to a desired value is called torque wrench. (Figs 3 & 4)

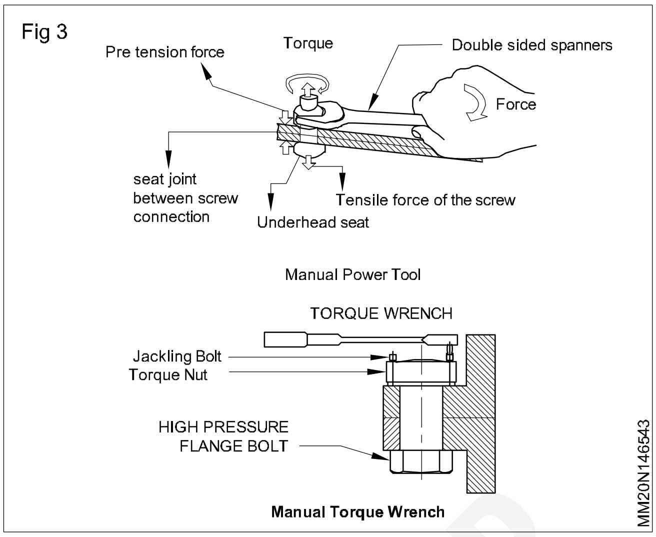
Fastener tightening

- Always use a torque wrench to tighten fasteners, and use a slow, smooth, even pull on the wrench.
- When reading a bar type torque wrench, look straight down at the scale.
  - Viewing from an angle can give a false reading.
- Only pull on the handle of the torque wrench.
  - Do not allow the beam of the wrench to touch any thing.
- Tighten bolts and nuts incrementally
  - Typically, this should be to one-half specified torque, to three-fourth torque, to full torque, and then to full torque a second time.

Maximum Tightening Torque

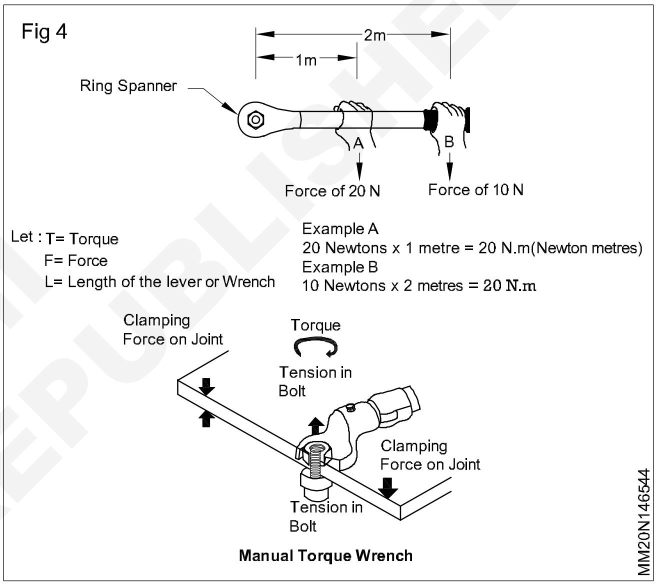
M4	270 Nm
M5	5.40 Nm
M6	9.50 Nm
M8	22.0 NM
M10	44.0 NM

Fig 3



Manual Torque Wrench

Fig 4



Manual Torque Wrench

Rivet and riveting

Objectives: At the end of this lesson you shall be able to
- **state what is rivet and riveting**
- **list the part of rivet**
- **explain the type of rivet.**

Rivet

A rivet is a permanent mechanical fastener consisting of a head at one end and a cylindrical stem at the other end (called the tail) which has the appearance of a metal pin.

Rivets are used to in structures, bridges, sheet metal operations, ships, and in many industries.

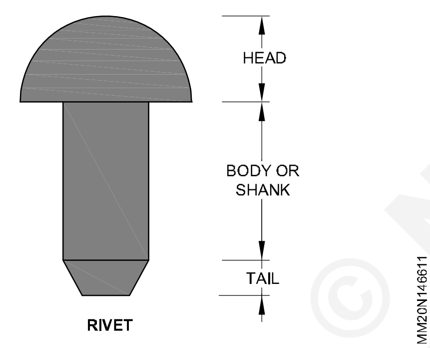
Riveting

Riveting is one of the methods of making permanent joint

Parts of a Rivet

Following are the parts of a Rivet (Fig 1)

Fig 1



1 Head 2 Shank or Body 3 Tail

Head : The upper-most part of rivet is called "head". These are made of different type according to different jobs.

Shank or Body: The part below rivet is called shank or body. This is round in shape.

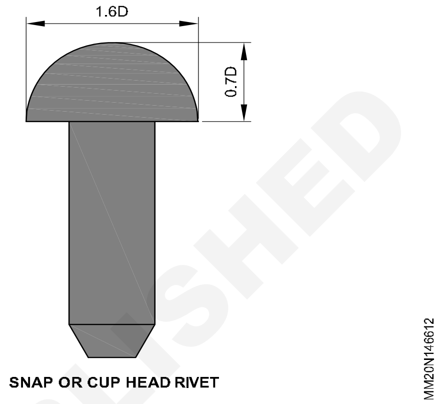
Tail: Part below its centre is called tail. It is somewhat tapered. It is inserted into holes of two plates and head is made by beating their tail. The length of tail is ¼ D. A rivet is known by its roundness, length and shape of head.

Type of rivet

1 Snap head or cup head rivets
2 Pan head rivets
3 Conical head rivets
4 Countersunk head rivets
5 Flat head rivets
6 Bifurcated head rivet
7 Hollow head rivets.
8 Tinman's rivet
9 Flush rivet

Snap head or cup head rivets (Fig 2)

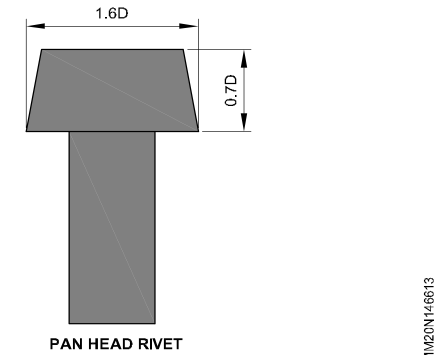
Fig 2



The head is of a semi-circle in shape.. The joints of this rivet are very strong. It is widely used in bridges made of iron material.

Pan head rivets (Fig 3)

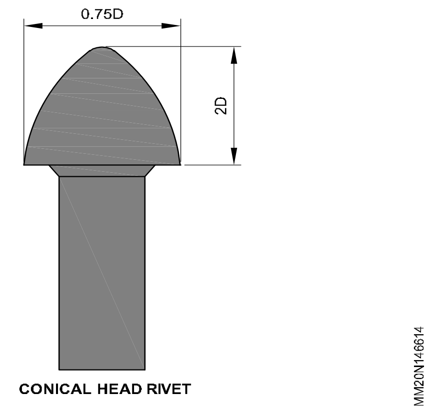
Fig 3



The upper portion of the rivet head is flat and taper. Small diameter of the head is equal to the diameter of the rivet. In heavy engineering, pan head rivets are used.

Conical Head Rivet (Fig 4)

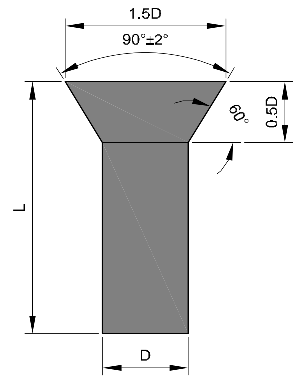
Fig 4



The conical shape is given is used for light jobs. A conical shape is given to the head by a hammer.

Counter Sunk Head Rivet (Fig 5)

Fig 5

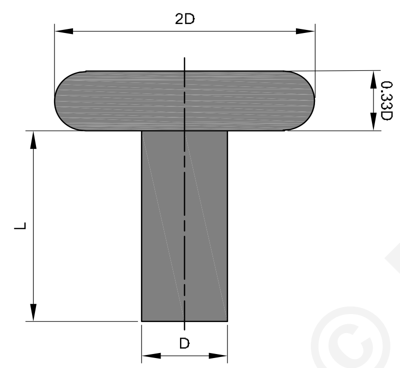


COUNTER SUNK HEAD RIVET

At places where it is necessary to keep the surface plane even after fixing a rivet, this type of rivets is used.

Flat Head Rivet (Fig 6)

Fig 6

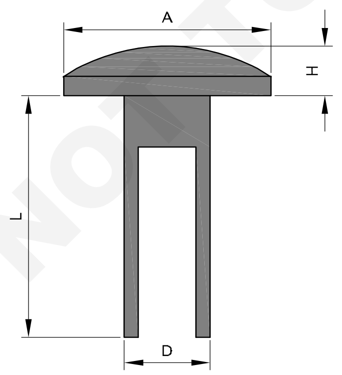


FLAT HEAD RIVET

For small and light jobs of sheet metal, flat head rivets are used. These are generally used in non-ferrous metals and thin sheets. Its head is flat.

Bifurcated rivet (Fig 7)

Fig 7

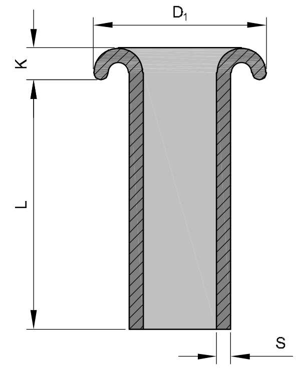


BIFURCATED RIVET

These types of rivets are different from other rivets. These are used for joining chains etc. in place of pins.

Hollow Rivet (Fig 8)

Fig 8

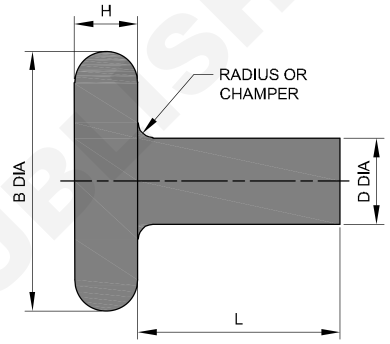


HOLLOW RIVET

Hollow rivets used where a part of the machine moves and it is also necessary to keep this part attached to the machine.

Tinman's Rivets (Fig 9)

Fig 9



TINMAN'S RIVET

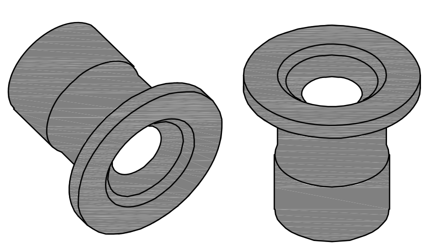
They are small flat headed rivets with relatively short lengths. The size number of tin man's rivets are determined

by the approximate weight per thousand rivets. Each weight of rivet has a definite diameter and length. (Table 1)

Tinmen's rivets are commonly used in light sheet metal work, such as the manufacture of buckets, steel trunks and fabrication of air-conditioning ducts.

Flush rivet (Fig 10)

Fig 10



TINMAN'S RIVET

Flush riveting is a method of connecting two pieces of sheet metal together, using rivets whose heads do not protrude above the surface of the metal. In aircraft construction, a flush rivet reduces drag, thus increasing aircraft performance

A flush rivet takes advantage of a countersink hole; they are also commonly referred to as countersunk rivets

Table 1 Dimensions of tinmen's riverts (Clause 4.1 and Fig 1)						
Rivet	Length	Shank	Head Dia		Head Thickness	
Size	(L)	Dia	(B)		(H)	
Designating Number			max	min	max	min
(1)	(2) mm	(3) mm	(4) mm	(5) mm	(6) mm	(7) mm
2	4-0	2-1	4-2	4-0	0-6	0-5
4	4-8	2-4	4-8	4-6	0-6	0-5
6	5-2	2-7	5-6	5-3	0-8	0-6
8	6-0	3-1	6-4	6-0	0-9	0-7
10	6-8	3-8	7-8	7-4	1-1	0-9
12	8-3	4-2	8-5	8-1	1-1	0-9
14	9-1	5-2	10-7	10-2	1-4	1-1
16	11-5	5-6	11-4	10-8	1-5	1-2
18	12-7	6-4	13-0	12-3	1-7	1-4
20	14-3	7-0	14-3	13-6	1-9	1-6

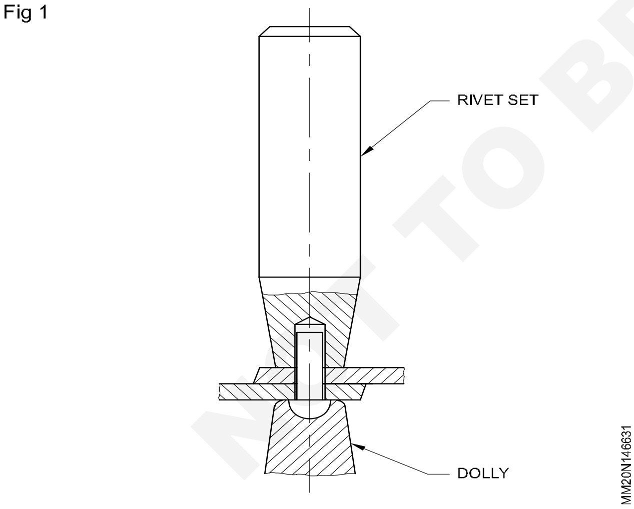
Hand-riveting tools

Objectives: At the end of this exercise you shall be able to
- **name the different hand-riveting tools**
- **state the uses of different hand -riveting tools**

Rivet set: It is used for bringing the sheet metal closely together after inserting the rivet in the hole

This is required while riveting thin plates or sheet with small rivets (Fig 1)

Fig 1



Dolly: It is used to support the head of the rivet which is already formed and also to prevent damage to the shape of the rivet head (Fig 1)

Rivet snap: It is used to form the final shape of the rivet during riveting. Rivet snaps are available to match the different shapes of rivet heads (Fig 2)

Combined rivet set: This is a tool which can be used for setting and forming the head (Fig 3)

Fig 2

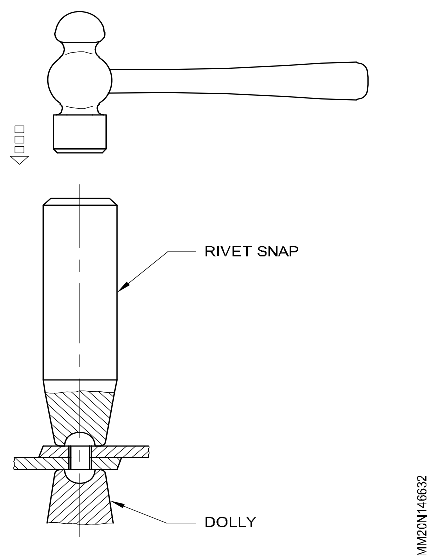
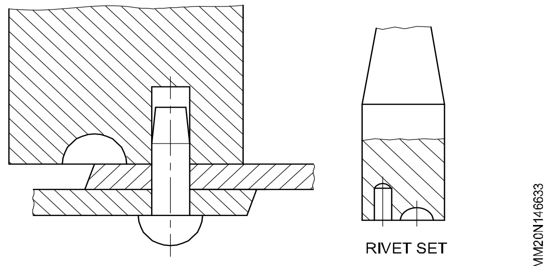


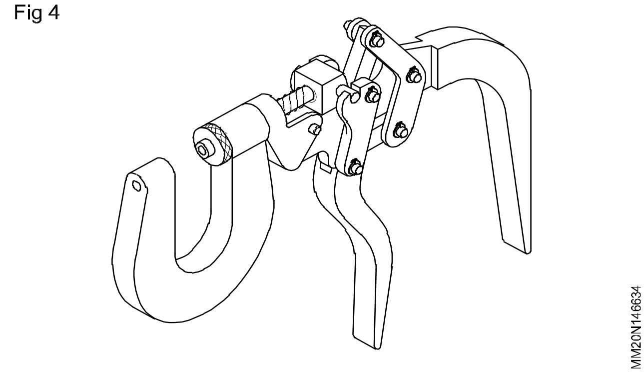
Fig 3



Hand riveter: This has a lever mechanism which exerts pressure between the jaws when the handle is pressed.

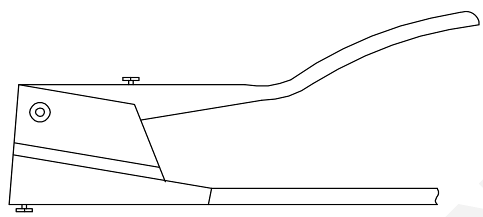
This is useful for riveting copper or aluminium rivets. Interchangeable anvils can be provided.(Fig 4)

Fig 4



Pop riveter: This is used for riveting pop rivets by hand. The trigger mechanism squeezes the rivet and separates the mandrel of the rivet. In this method as the mandrel is being separated from the rivet, the head is formed on the other end (Fig 5)

Fig 5



Drift: It is used to align the holes to be riveted. (Fig 6)

Caulking tool: It is used for closing down the edges of the plates and heads of the rivets to form a metal-to-metal joint (Fig 7)

Fig 6

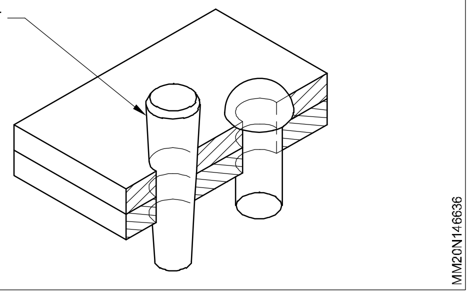
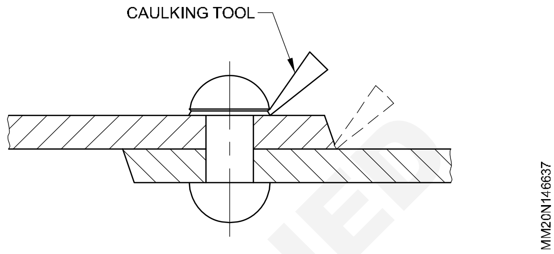
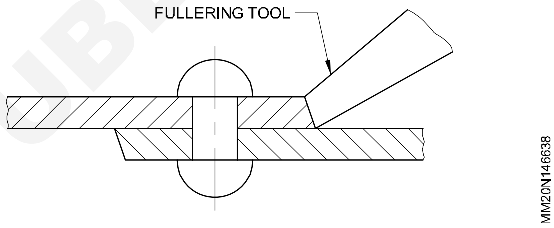


Fig 7



Fullering tool: It is used for pressing the surface of the edge of the plate (Fig 8) Fullering helps to make fluid-tight joints.

Fig 8

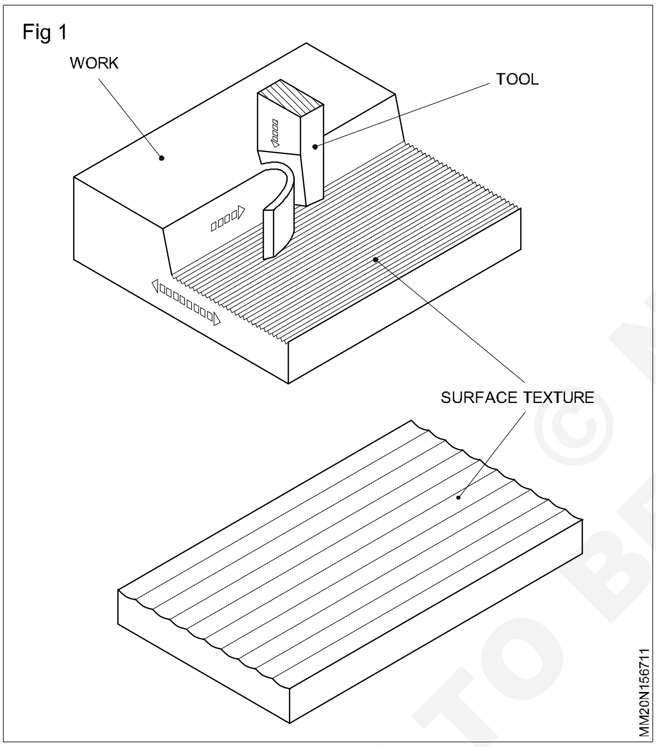


Surface finish importance

Objectives : At the end of this lesson you shall be able to
- **state the meaning of surface texture**
- **distinguish between roughness and waviness**
- **state the need for different quality surface textures**
- **state the meaning of 'Ra' valve**
- **interpret 'Ra' and roughness grade number in drawings.**

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)

Fig 1



The components of surface texture

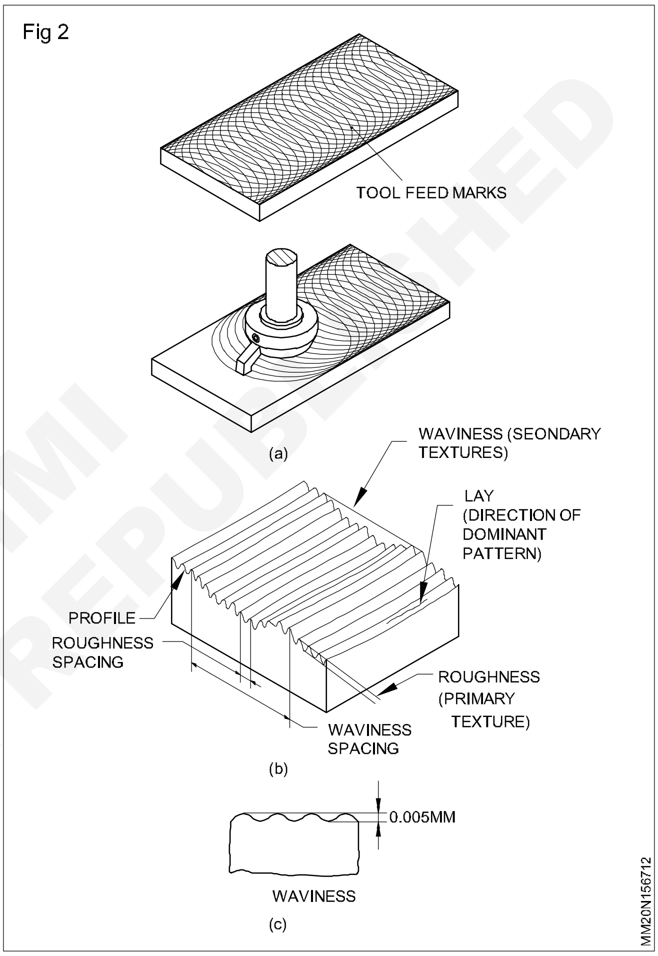
Roughness (Primary texture)

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 (Fig 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.

Fig 2



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 wrung together.

The cylinder bore of an engine (Fig 4) may require a certain degree of roughness for assisting lubrication needed for the movement of the piston.

For sliding surfaces the quality of surface texture is very important.

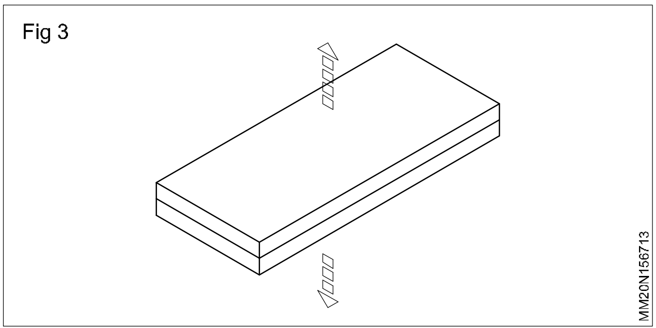


Fig 3

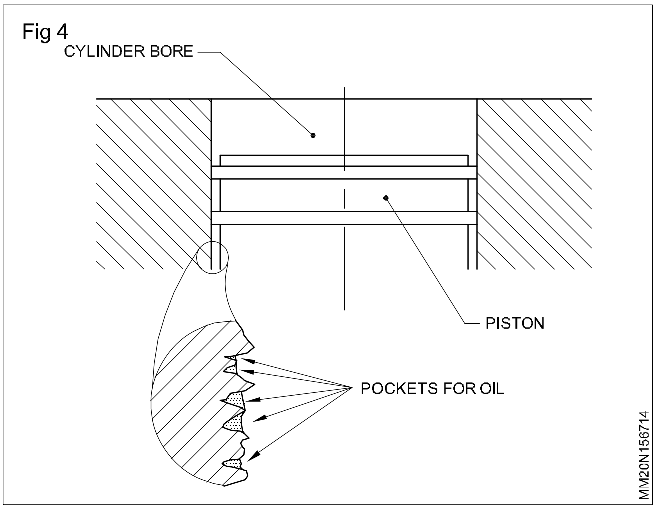


Fig 4

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.

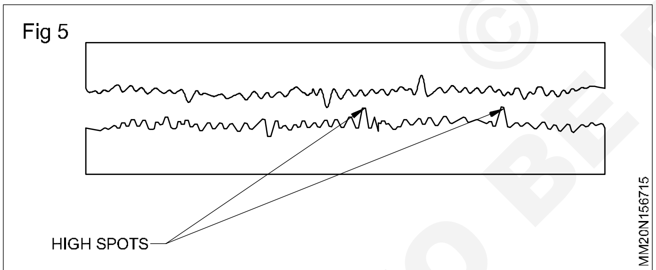


Fig 5

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.

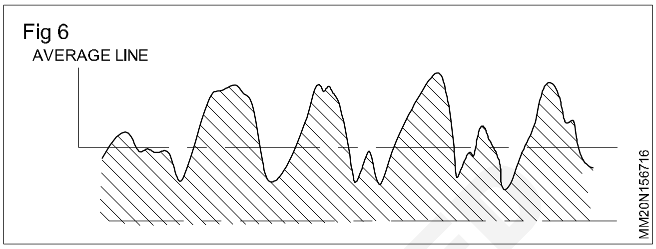


Fig 6

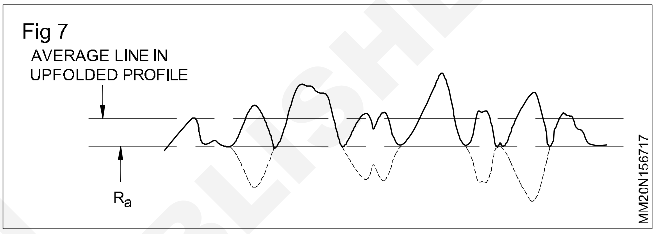


Fig 7

The profile curve is then drawn along the average line so that the profile below this is brought above.

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.

Surface texture measuring instruments

Objective: At the end of this lesson you shall be able to
- **distinguish the features of mechanical and electronic surface indicators**
- **name the parts of a mechanical surface indicator**
- **identify the features of electronic surface indicators (taly-surf)**
- **state the functions of the different features of electronic surface indicators.**

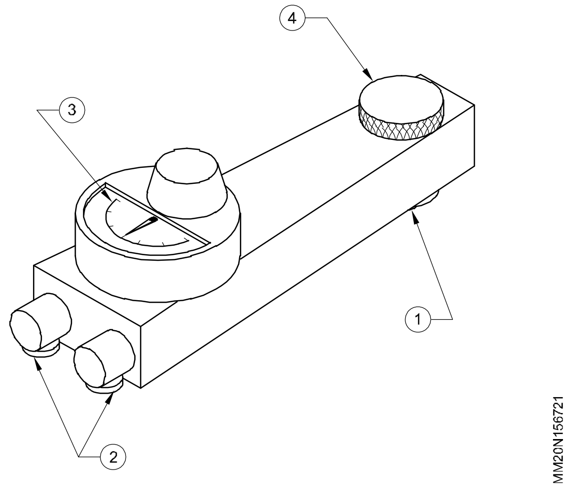
The use of surface finish standards which we have seen earlier is only a method of comparing and determining the quality of surface. The result of such measurement very much depends on the sense of touch and cannot be used when a higher degree of accuracy is needed.

The instruments used for measuring the surface texture can be of a mechanical type or with electronic sensing device.

Mechanical surface indicator

This instrument consists of the following features. (Fig 1)

Fig 1



1 Measuring stylus

2 Skids

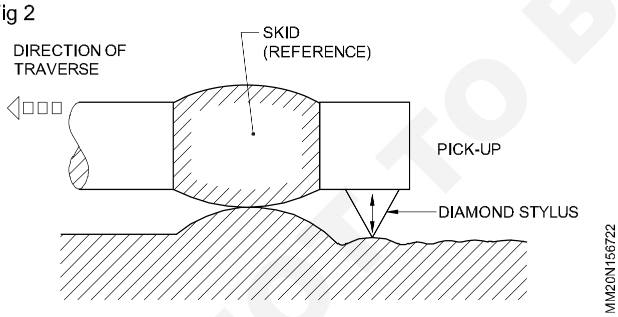
3 Indicator scale

4 Adjustment screw

The stylus is made of diamond, and its contact point will have a light radius.

When the stylus is slowly traversed across the test surface the stylus moves upward or downward depending on the profile of the surface. (Fig 2) This movement is amplified and transferred to the dial of the surface indicator. The pointer movement indicates the surface irregularities.

Fig 2



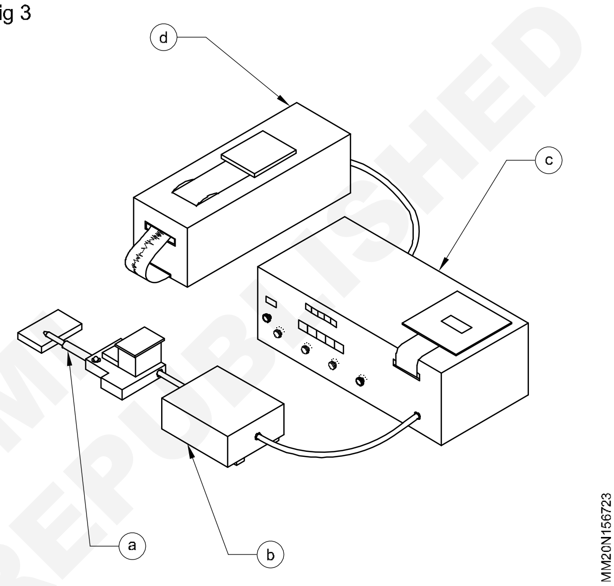
When using a mechanical surface indicator, measurement must be read as it is moved over the surface, and then a profile curve is drawn manually to compute the mean value.

There are different types of electronic surface measuring devices; one type of such an instrument used in workshops is the taly-surf.

Taly-surf (Electronic surface indicator)

This is an electronic instrument for measuring surface texture. This instrument can be used for factory and laboratory use. (Fig 3)

Fig 3

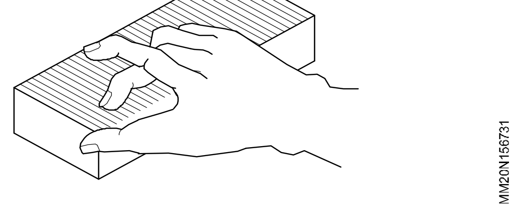


The measuring head of this unit consists of a stylus (a) and a motor race (b) which controls the movement of the instrument head across the surface. The movement of the stylus is converted to electrical signals. These signals are amplified in the surface analyser/amplifier (c) which calculates the surface parameter and presents the result on a digital display or in the form of a diagram through a recorder (d).

Surface quality

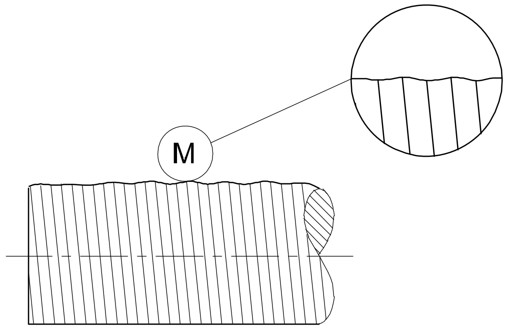
Various components are manufactured by different machining processes. The surfaces of the components differ in their appearance as well as `feel' when we move our hand over the surface. (Fig 1)

Fig 1



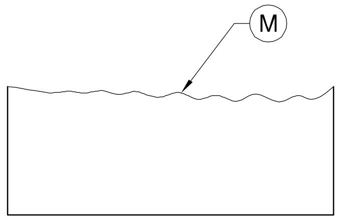
The surface will have ups and downs. These ups and downs are due to the tool marks. The pattern of these tool marks depends on the machining processes. The irregular patterns of tool marks depend on the feed, speed, tool angles, depth of cut etc. So all the machined surfaces are rough due to the inherent tool marks left in the machining processes. The surface appearance of components is shown in Figs 2 to 4.

Fig 2



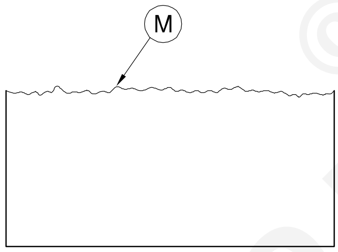
TOOL MARKS IN TURNING

Fig 3



TOOL MARKS IN MILLING

Fig 4



TOOL MARKS IN SHAPING. PLANING, SLOTTING

In other words, the selection process and setting of machining parameters are dictated by the type of surfaces quality demanded in the drawing of the part.

Surface roughness measurement

To control the roughness of a surface precisely, we need to define and establish a measuring system for it.

Roughness is defined as the average height or depth from the hill to the valley of a surface pattern (Fig 5) and it is possible to measure this by instruments specially designed for this purpose.

This instrument has a very sharp stylus. (Fig 6) This stylus is moved across the surface to be measured mechanically over a short distance and during this time the instrument calculates the average depth and displays the value as a roughness number.

Fig 5

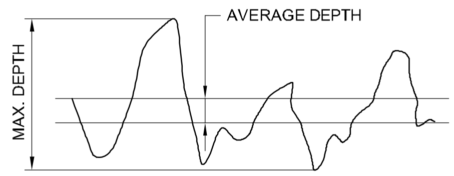
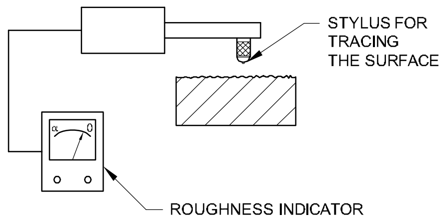


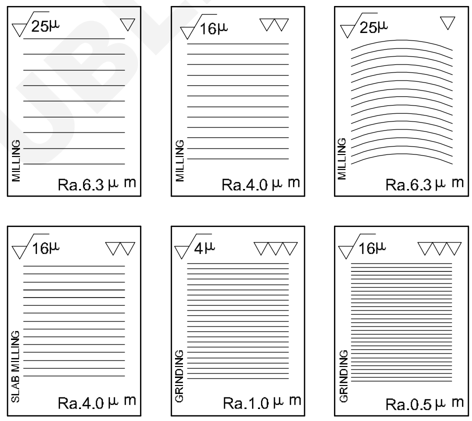
Fig 6



Surface finish standard

One method of determining the surface roughness is by using a surface finish standard. (Fig 7) This is a box which consists of 20 blocks of a specific surface finish obtained by a specific machining operation.

Fig 7



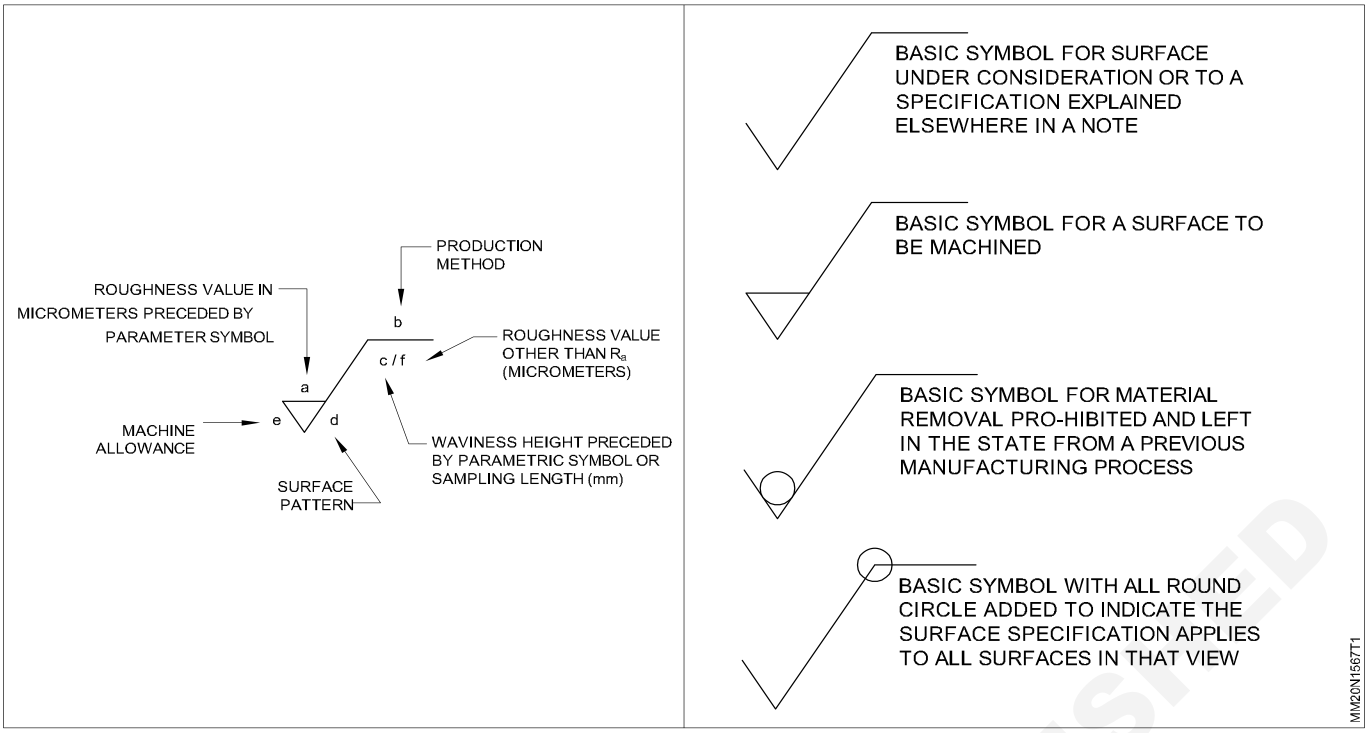
The type of machining operation is marked on each block together with the surface roughness number for height and width. Using the surface finish standard, we can make comparisons between the machined surface and the standard surface using our sense of touch.

However, this method is sometimes not accurate enough and the individual must be very sensitive to the different surface roughness.

If the degree of accuracy of checking is high, then the application of a sensitive instrument is inevitable.

In order to obtain the required surface quality, it is necessary to choose the appropriate manufacturing process. Table-1 appended here gives an idea about the different processes and range of surface quality attainable.

For more detailed information on surface texture, symbols and their representations refer to IS:10719.



Honing

Objectives: At the end of this lesson you shall be able to
- **define honing**
- **state the principle of honing**
- **name the various applications of honing**
- **state the methods of honing**
- **compare the features of the honing tools used in manual and power stroking**
- **name the different honing stones(abrasive) and state their uses**
- **list the cutting fluid used in honing.**

Honing

Honing is a super finishing process carried out using abrasive sticks for the removal of stock from metallic and non-metallic surfaces.

This process:

- produces high surface finish
- corrects the profiles of cylindrical surfaces
- removes taper.

Working principle

The honing tool with abrasives mounted on it is held on the spindle of a machine which can be rotated in its axis.

As the spindle rotates, a reciprocating motion is also given to the tool. The surface produced will have a cross hatched pattern. (Figs 1 & 2) This pattern of the surface texture provides better lubrication in cylindrical bores.

Application

Honing is used for finishing of bores in ferrous and non-ferrous materials.

Honing can be done in hardened or un-hardened state.

Bores of any size, length, blind or through, tandem or interrupted surfaces can also be honed.

Fig 1

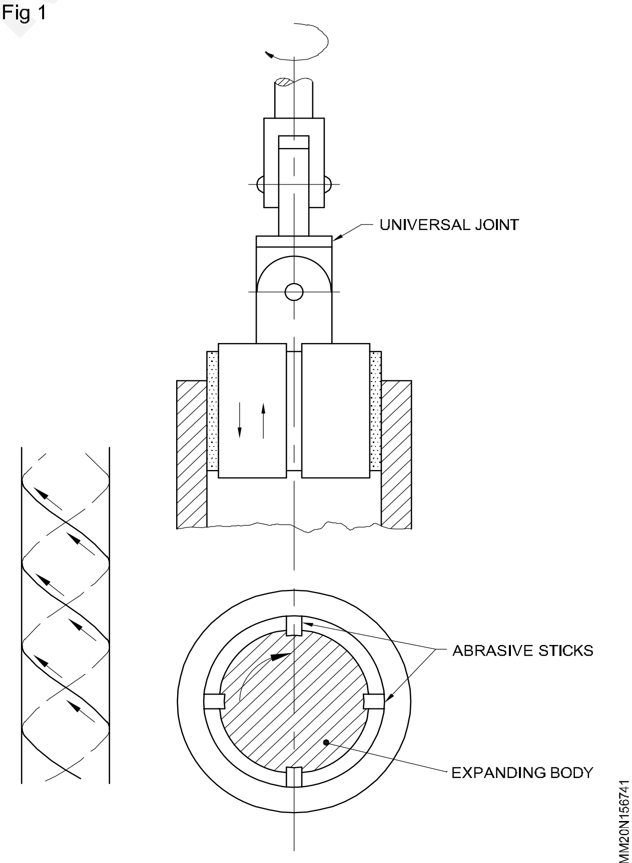
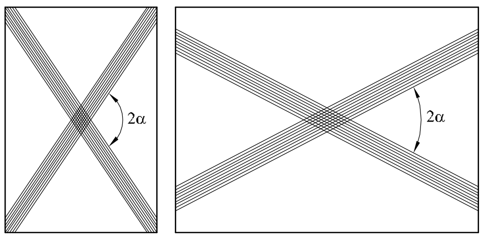


Fig 2



Honing can be carried out on drilling or other machines which have arrangement for rotary and reciprocating motion simultaneously.

A rotary motion can be given by the spindle and the reciprocating motion can be either manual or by power depending on the type of machine used.

For mass production special honing machines are used.

Methods of honing

Manual stroking/Power stroking

Manual stroking is preferred for large quantities when tolerances are extremely close.

Many operators prefer this because of the flexibility in operation.

This eliminates the use of expensive fixtures to hold the work.

Jobs can be quickly changed from one type to another.

Jobs can be reversed from end to end for accurate honing and correction. The stroke length can be altered depending on the actual requirement of the individual workpiece.

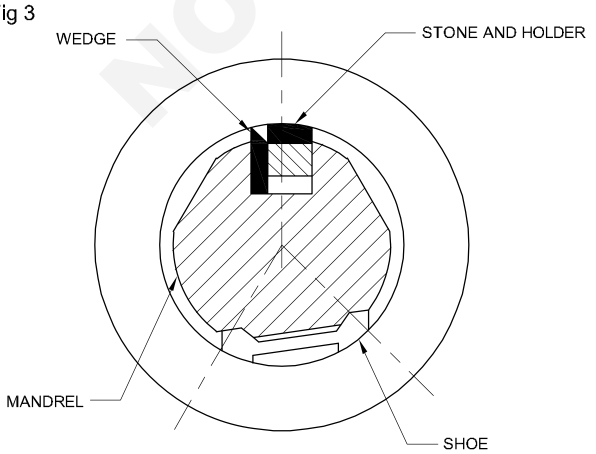
Power stroking is used for honing all types of workpieces. Power stroking may prove to be economical particularly in the case of small parts.

Note

Sometimes for final finishing, manual stroking is employed after power stroking.

The tools used for manual stroking consist of a mandrel, an abrasive stone with holder and a pair of shoes made of wear resistant material with respect to workpiece materials. (Fig 3)

Fig 3



The wedge controls the feeding of the abrasive stone. The shoes stabilize and guide the tool in the workpiece.

Power stroke tools will have abrasive stones at equal distance all around the circumference of the tool. For feeding the abrasive stones, expanding cones are provided. The tools are usually of a self-aligning type with a double universal joint.

Honing stones

Honing stones consist of particles of aluminium oxide, silicon carbide or diamond bonded together with vitrified clay, cork, carbon or metal. The honing stones have a porous structure and this helps for chip clearance.

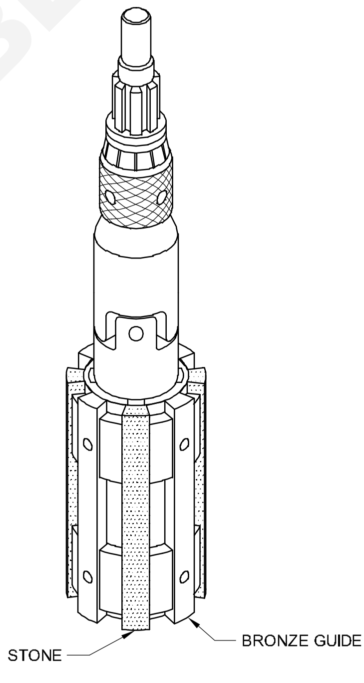
The grit size of abrasives used ranges from 36 to 600 but the most commonly used sizes are 120 to 320.

Uses of different abrasives

Aluminium oxide	**Steel**
Silicon carbide	Cast iron & non-ferrous metals
Diamond	Tungsten, ceramics etc.

Power stroke honing tool shown in Fig 4.

Fig 4



POWER STROKE HONING TOOL

Cutting fluids: Cutting fluids are used while honing. The mineral oil commonly used in machining operations is diluted in proportion of one part of oil with four parts of kerosene before it is used for honing.

Lapping

Objectives: At the end of this lesson you shall be able to
- **state the purpose of lapping**
- **state the features of a flat lapping plate**
- **state the use of charging a flat lapping plate**
- **state the method of charging a cast iron plate**
- **distinguish between wet lapping and dry lapping.**

Lapping is a precision finishing operation carried out using fine abrasive materials.

Purpose: This process:

– improves geometrical accuracy

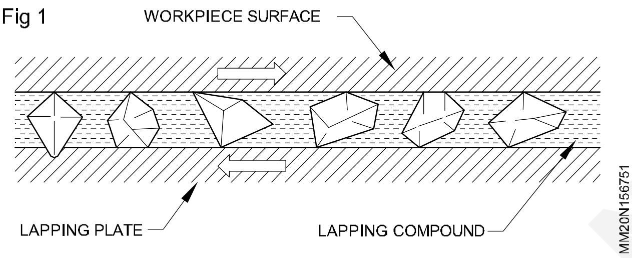
– refines surface finish

– assists in achieving a high degree of dimensional accuracy

– improve the quality of fit between the mating components.

Lapping process: In the lapping process small amount of material are removed by rubbing the work against a lap charged with a lapping compound. (Fig 1)

Fig 1

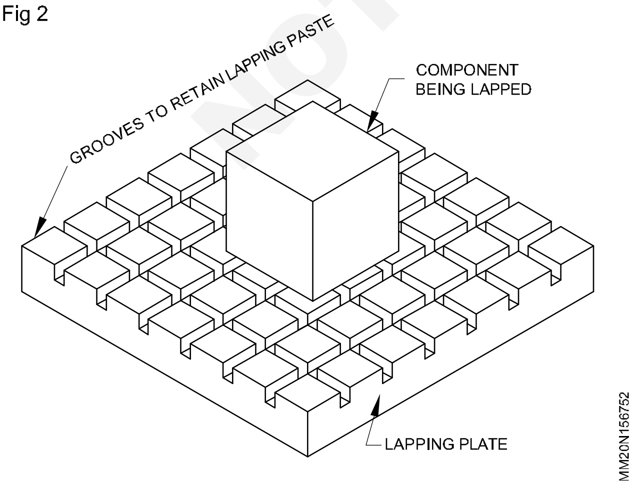


The lapping compound consists of fine abrasive particles suspended in a 'vehicle' such as oil, paraffin, grease etc.

The lapping compound which is introduced between the workpiece and the lap chips away the material from the workpiece. Light pressure is applied when both are moved against each other. The lapping can be carried out manually or by machine.

Hand lapping of flat surfaces: Flat surfaces are hand-lapped using lapping plate made out of close grained cast iron. (Fig 2) The surface of the plate should be in a true plane for accurate results in lapping.

Fig 2



The lapping plate generally used in tool rooms will have narrow grooves cut on its surface both lengthwise and crosswise forming a series of squares.

While lapping, the lapping compound collects in the serrations and rolls in and out as the work is moved.

Before commencing lapping of the component, the cast iron plate should be CHARGED with abrasive particles.

This is a process by which the abrasive particles are embedded on to the surfaces of the laps which are comparatively softer than the component being lapped. For charging the cast iron lap, apply a thin coating of the abrasive compound over the surface of the lapping plate.

Use a finished hard steel block and press the cutting particles into the lap. While doing so, rubbing should be kept to the minimum. When the entire surface of the lapping plate is charged, the surface will have a uniform gray appearance. If the surface is not fully charged, bright spots will be visible here and there.

Excessive application of the abrasive compound will result in the rolling action of the abrasive between the work and the plate developing inaccuracies.

The surface of the flat lap should be finished true by scraping before charging. After charging the plate, wash off all the loose abrasive using kerosene.

Then place the workpiece on the plate and move along and across, covering the entire surface area of the plate. When carrying out fine lapping, the surface should be kept moist with the help of kerosene.

Wet and dry lapping: Lapping can be carried out either wet or dry.

In wet lapping there is surplus oil and abrasives on the surface of the lap. As the workpiece, which is being lapped, is moved on the lap, there is movement of the abrasive particles also.

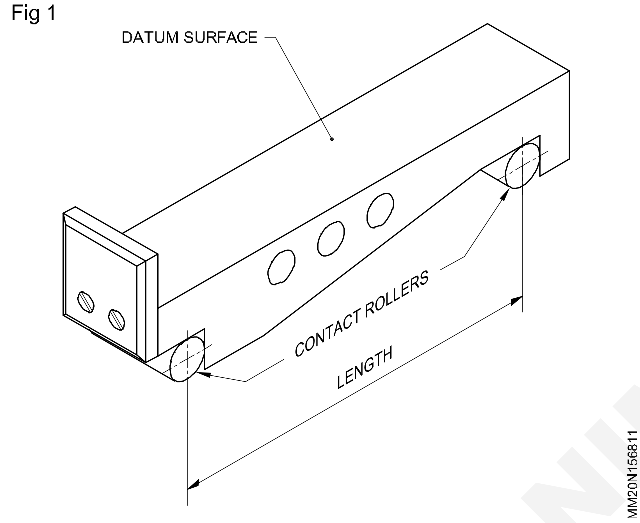
In dry method the lap is first charged by rubbing the abrasives on the surface of the lap. The surplus oil and abrasives are then washed off. The abrasives embedded on the surface of the lap will only be remaining. The embedded abrasives act like a fine oilstone when metal pins to be lapped are moved over the surface with light pressure. However, while lapping, the surface being lapped is kept moistened with kerosene or petrol. Surfaces finished by the dry method will have better finish and appearance. Some prefer to do rough lapping by wet method and finish by dry lapping.

Sine bar principle application and specification

Objectives : At the end of this lesson you shall be able to
- **state the principle of a sine bar**
- **specify the sizes of sine bar**
- **state the features of sine bars**
- **state the different uses of sine bar using slip gauges.**

A sine bar is a precision measuring instrument for checking and setting of angles. (Fig 1)

Fig 1

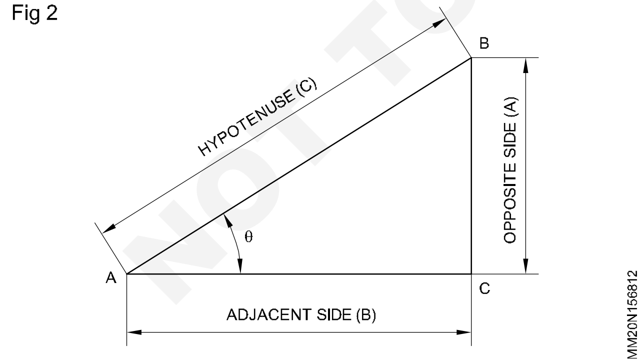


The principle of a sine bar

The principle of a sine bar is based on the trigonometrical function.

In a right angled triangle the function known as Sine of the angles is the relationship existing between the opposite side to the angle and the hypotenuse. (Fig 2)

Fig 2

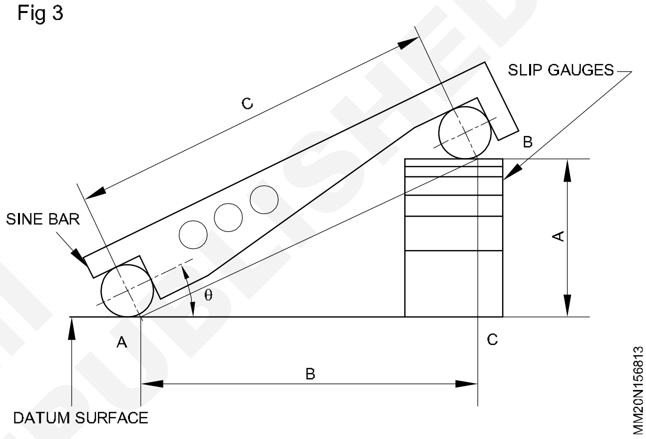


It may be noted that for setting the sine bar to different angles, slip gauges are used.

A surface plate or marking table provides the datum surface for the set up.

The sine bar, the slip gauges and the datum surface upon which they are set form a right angled triangle. (Fig 3) The sine bar forms the hypotenuse (c) and the slip gauge stack forms the side opposite (a).

Fig 3



$$\text{Sine of the angle } \theta = \frac{\text{Opposite side}}{\text{Hypotenuse}}$$

$$\text{Sine } \theta = \frac{A}{C}$$

Features

This is a rectangular bar made of stabilized chromium steel.

The surfaces are accurately finished by grinding and lapping.

Two precision rollers of the same diameter are mounted on either end of the bar. The centre line of the rollers is parallel to the top face of the sine bar.

There are holes drilled across the bar. This helps in reducing the weight, and also it facilitates clamping of sine bar on angle plate.

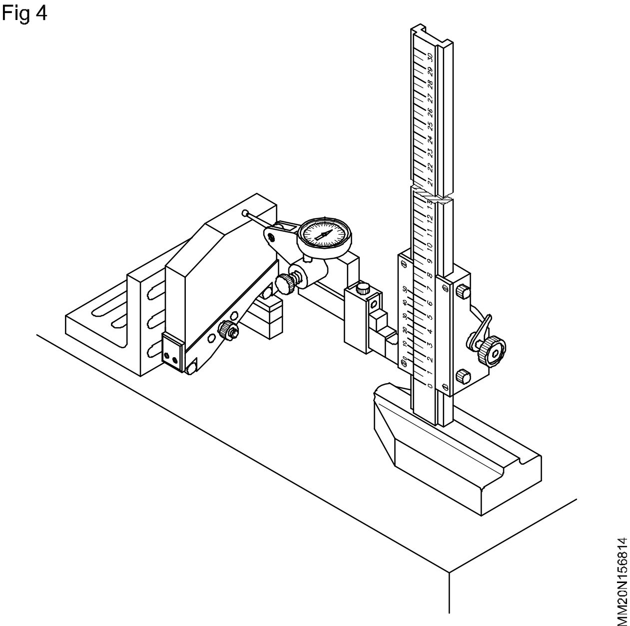
The length of the sine bar is the distance between the centres of the rollers. The commonly available sizes are 100 mm, 200 mm, 250 mm and 500 mm. The size of a sine bar is specified by its length.

Uses

Sine bars are used when a high degree of accuracy to less than one minute is needed for

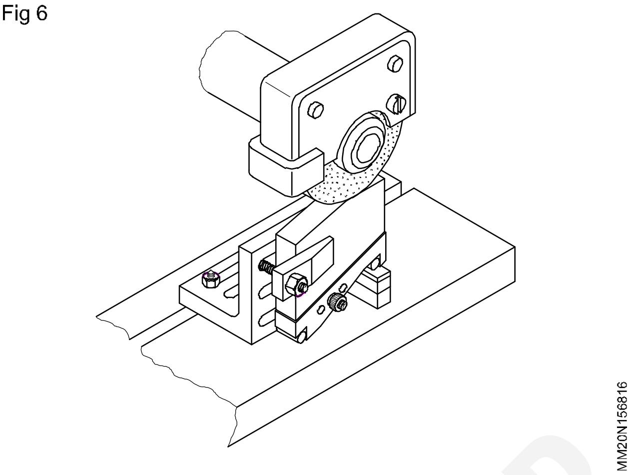
– measuring angles (Fig 4)

Fig 4



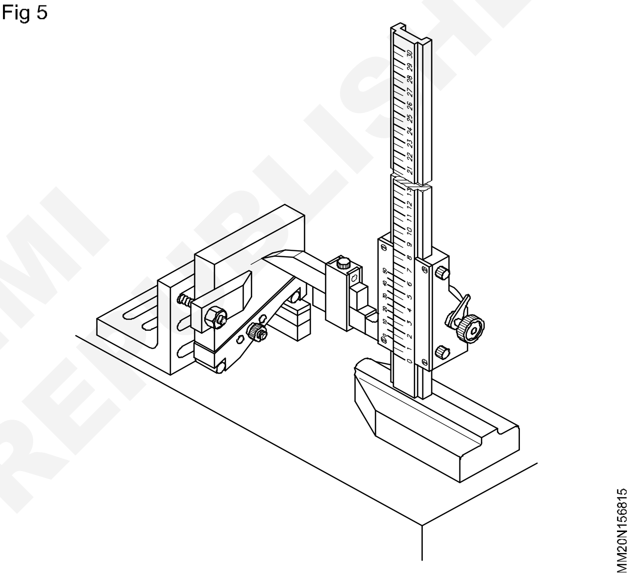
– marking out (Fig 5)

Fig 6



– setting up for machining. (Fig 6)

Fig 5



Determining taper using sine bar and slip gauges

Objectives: At the end of this lesson you shall be able to
- **determine correctness of a known angle**
- **calculate the height of slip gauges to a known angle.**

Sine bars provide a simple means of checking angles to a high degree of accuracy of not less than one minute upto 45^0.

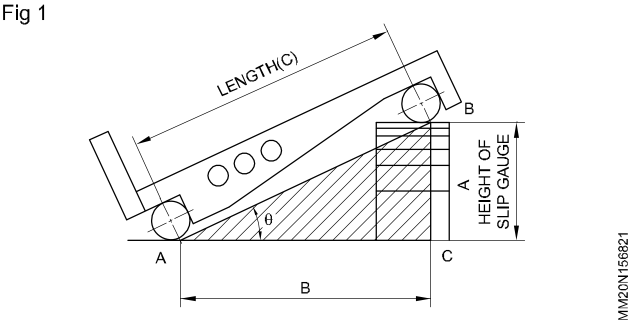
The use of a sine bar is based on trigonometric function. The sine bar forms the hypotenuse of the triangle and the slip gauges the opposite side. (Fig 1)

Checking the correctness of a known angle

For this purpose first choose the correct slip gauge combination for the angle to be checked.

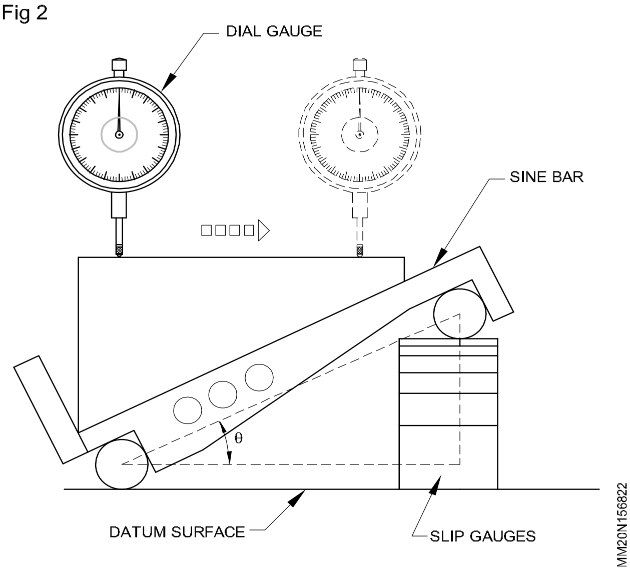
The component to be checked should be mounted on the sine bar after placing the selected slip gauges under the roller. (Fig 1)

Fig 1



A dial test indicator is mounted on a suitable stand or vernier height gauge. (Fig 2) The dial test indicator is then set in first position as in the figure and the dial is set to zero.

Fig 2

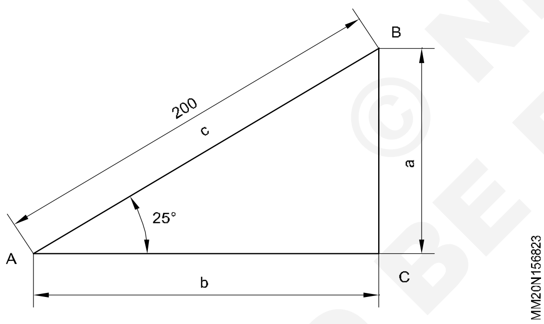


Move the dial to the other end of the component (second position). If there is any difference then the angle is incorrect. The height of the slip gauge pack can be adjusted until the dial test indicator reads zero on both ends. The actual angle can then be calculated and the deviation, if any, will be the error.

Method of calculating the slip gauge height

Example (Fig 3)

Fig 3



Exercise 1

To determine the height of slip gauges for an angle of 25^o using a sine bar of 200 mm long.

$$\text{Sine } \theta = \frac{a}{c}$$

q = 25^0

a = C Sine q

= 200 x 0.4226

a = 84.52 mm

The height of the slip gauge required is 84.52 mm.

The value of sine q 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.

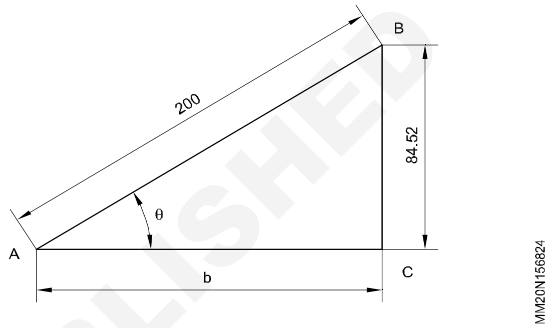
Calculating the angle for tapered components

Exercise 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



$$\text{Sine}\theta = \frac{a}{c}$$

$$= \frac{84.52}{200}$$

$$\text{sine } \theta = 0.4226$$

The angle whose sine value is 0.4226 is 25^0. Hence the angle of tapered component is 25^0.

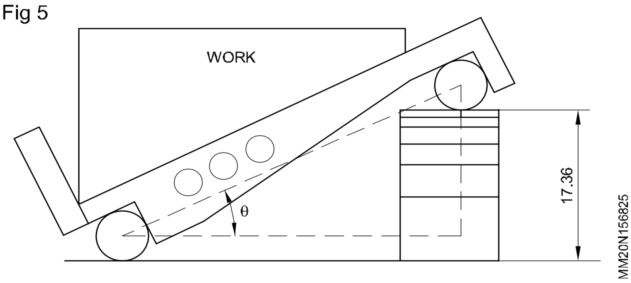
Classroom Assignment

1 What will be the angle of the workpiece if the slip gauge pack height is 17.36 mm and the size of the sine bar used is 100 mm? (Fig 5)

Answer ________________________

2 Calculate the height of the slip gauge pack to raise a 100 mm sine bar to an angle of 3^0 35'

Fig 5



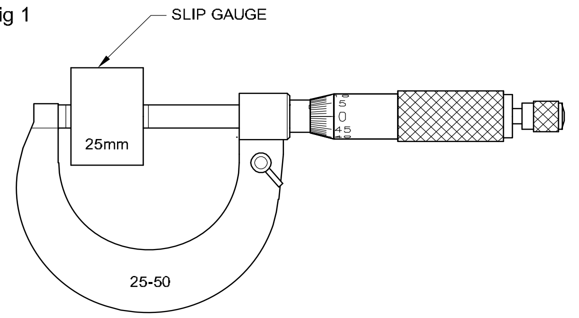
Slip Gauges

Objectives : At the end of this lesson you shall be able to
- **define the features of slip gauges**
- **state the different grades of slip gauges**
- **state the number of slips in standard**
- **state the precautions and application of slip gauges.**

Slip gauges

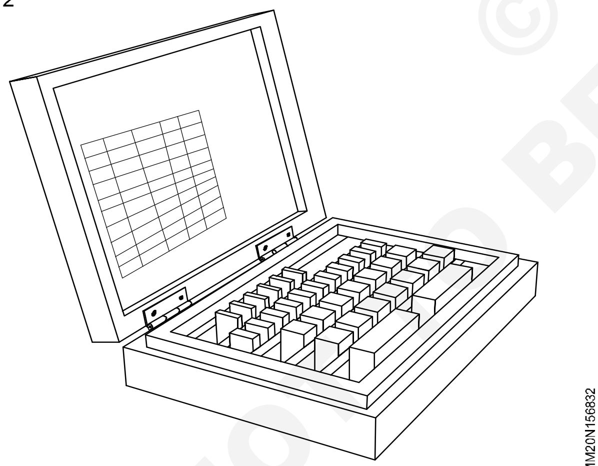
Slip gauges are gauge blocks used as standards for precision length measurement. (Fig 1) These are made in sets and consist of a number of hardened blocks, made of high grade steel with low thermal expansion. They are hardened throughout, and heat treated further for stabilization. The two opposite measuring 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.

Some sets of slip gauges also contain protector slips of some standard thickness made from higher wear-resistant steel or tungsten carbide. These are used for protecting the exposed faces of the slip gauge pack from damage.

Fig 3

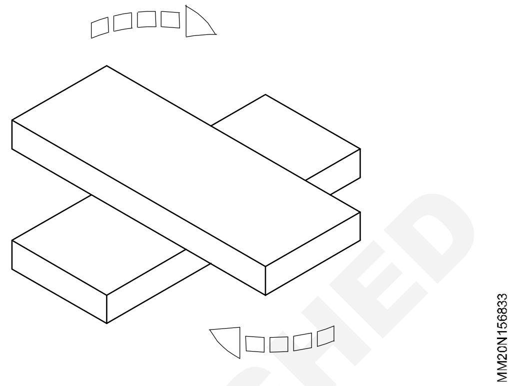
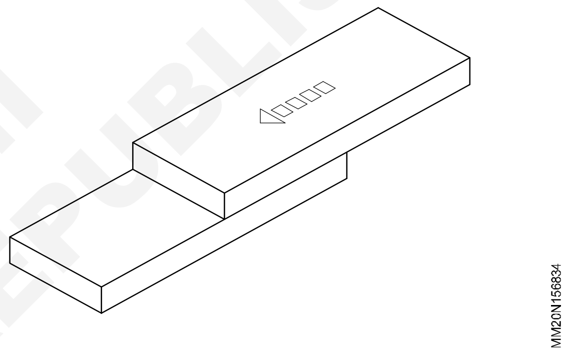


Fig 4



Grades

Grade '00' accuracy

It is a calibration grade used as a standard for reference to test all the other grades.

Grade '0' accuracy

It is an inspection grade meant for inspection purposes.

Grade I accuracy

Workshop grade for precision tool room applications.

Grade II accuracy

For general workshop applications.

B.I.S. recommendations

Three grades of slip gauges are recommended as per IS 2984. They are:

- Grade '0'
- Grade I
- Grade II.

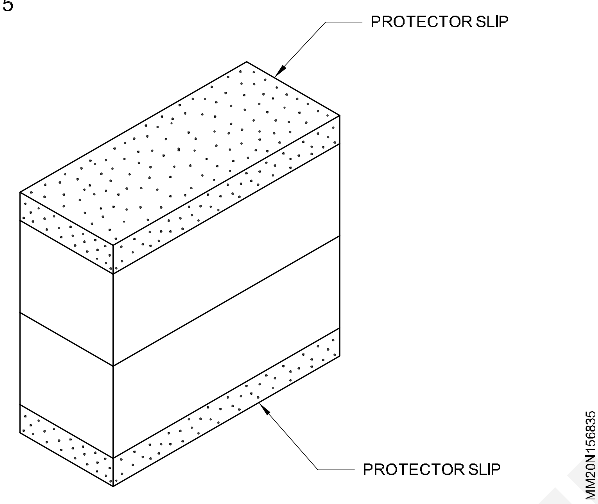
Care and maintenance points to be remembered while using slip gauges.

- 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) After use, clean the slips with carbon tetrachloride and apply petroleum jelly for protection against rust.

Fig 5



Before use, remove petroleum jelly with carbon tetrachloride. Use chamois leather to wipe the surfaces.

TABLE 1

Different sets of slip gauges

Set of 112 pieces (M112)

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 (M103)

Table 2

Range (mm)	Steps (mm)	No.of pieces
1st series 1.005	-	1
2nd series 1.01 to 1.49	0.01	49
3rd series 0.5 to 24.5	0.5	49
4th series 25 to 100	25.0	4
Total pieces		103

Table 3

Set of 46 pieces (M46)

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 1.10 to 1.90	0.10	9
4th series 1.00 to 9.00	1.00	9
5th series 10.00 to 100.00	10.00	10
Total pieces		46

Selection and determination of slip gauges for different sizes

Objective: At the end of this lesson you shall be able to
- **determine slip gauges for different sizes.**

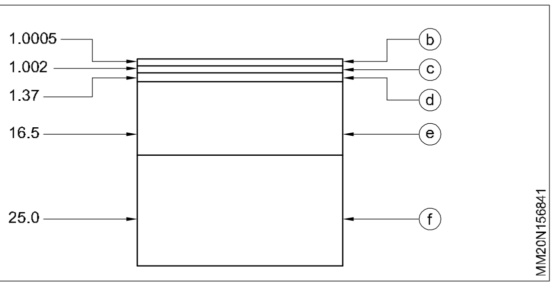
For determining a particular size, in most cases a number of slip gauges are to be selected and stacked one over the other by wringing the slip gauges.

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. (Fig 1)

Example (Without using protector slips)

Building up a size of 44.8725mm with the help of 112 piece set. (Table 1)

Fig 1



Set of 112 pieces (M112)

Range (mm)	Steps (mm)	No.of pieces
1.005	--	1
1.001 to1.009	0.001	9
1.01 to 1.49	0.01	49
0.5 to 24.5	0.5	49
25.0 to 100.0	25.5	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	1.005subtract	1.0005
		43.872
c Select 1st series slip that has the same last figure	1.002 subtract	1.002
		42.870
d Select the 2nd series slip that has the same last figure and that will leave 0.0 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	16.5 subtract	16.5
	(41.5 - 25 = 16.5)	25.00
f Select a slip that eliminates the final figure Add	25.0 subtract	25.00
	44.8725	0

Gauges and types of gauges

Objectives : At the end of this lesson you shall be able to
- **define template with its uses and advantages**
- **define gauges their necessity and types.**

Gauge

Gauge is an inspection tool used to check product dimension with reference to its maximum and minimum acceptable limits. It is, generally, used to segregate acceptable and non-acceptable products in mass production, without the exact dimensions. It is made of tool steel and is heat treated.

Advantages of gauging

Faster checking of the product is within the specified limits.

Less dependence on operator skill and getting affected by operator judgement.

Gauges are economical when compared to measuring instruments.

Instrument used for gauging

1 Snap and ring gauge

2 Combined gauge

3 Plug gauge

4 Screw pitch gauge

5 Template and form gauge

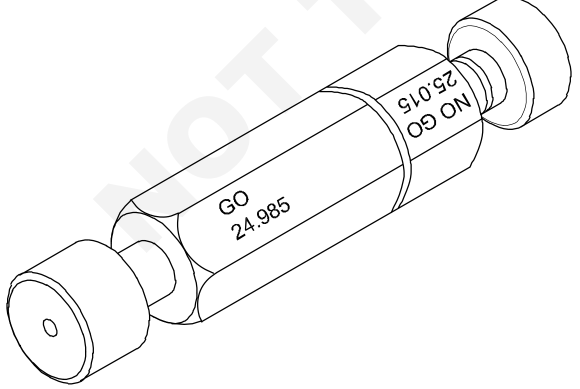
6 Taper gauge

Types of cylindrical plug gauges

Double-ended plug gauge (Fig 1 and 2)

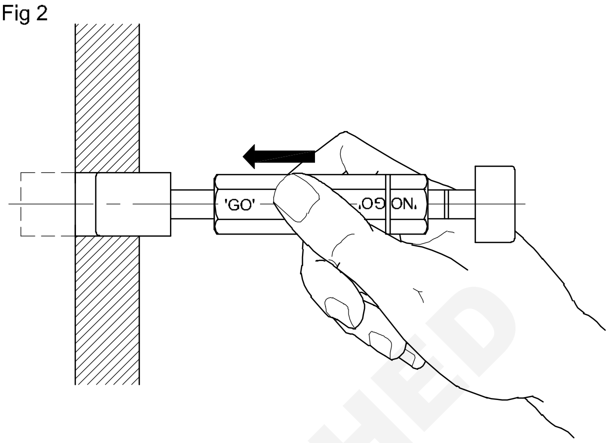
Plain cylindrical gauges are used for checking the inside diameter of a straight hole. The 'Go' gauge checks the lower limit of the hole and the 'No- Go' gauge checks the upper limit. The plugs are ground and lapped. (Fig 3)

Fig 1



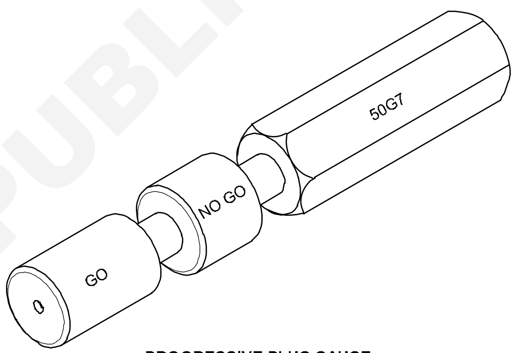
DOUBLE ENDED PLUG GAUGE

Fig 2



Progressive plug gauge (Fig 3)

Fig 3

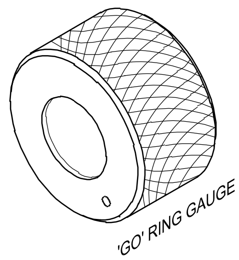


PROGRESSIVE PLUG GAUGE

Plain ring gauge (Fig 4)

Plain ring gauges are used to check the outside diameter of pieces. Separate gauges are used for checking 'Go' and 'No- Go' sizes. A `No-Go' gauge is identified by an annular groove on the knurled surface.

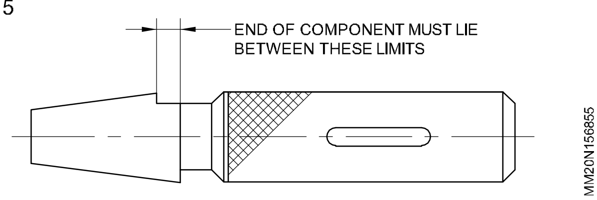
Fig 4



Taper plug gauges (Fig 5)

These gauges made with standard or special tapers are used to check the size of the hole and the accuracy of the taper. The gauge must slide into the hole for a prescribed depth and fit perfectly. An incorrect taper is evidenced by a wobble between the plug gauge and the hole.

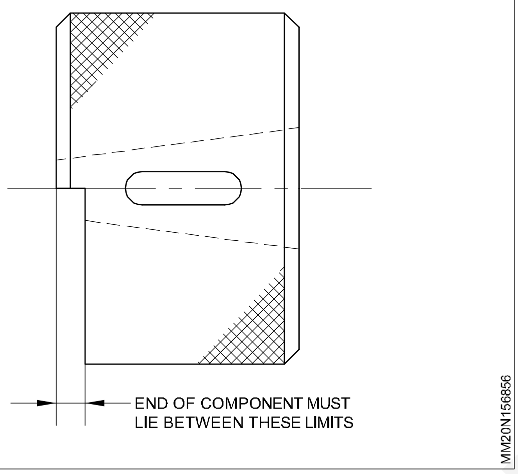
Fig 5



Taper ring gauges (Fig 6)

They are used to check both the accuracy and the outside diameter of a taper. Ring gauges often have scribed lines or a step ground on the small end to indicate the 'Go' and 'No-Go' dimensions.

Fig 6



Thread plug gauges (Figs 7 and 8)

Fig 7

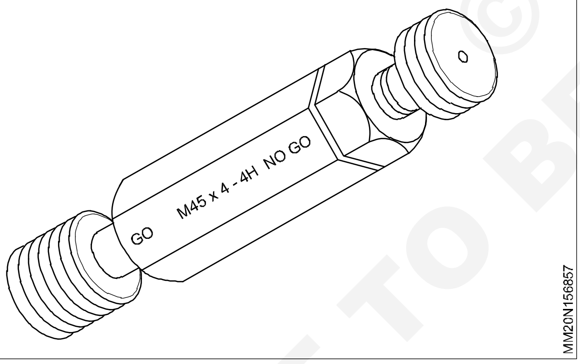
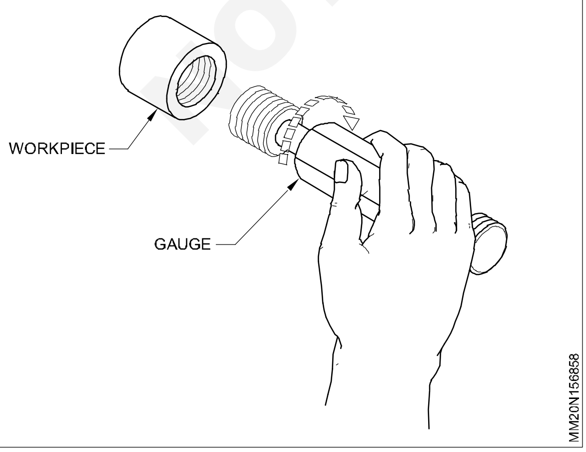


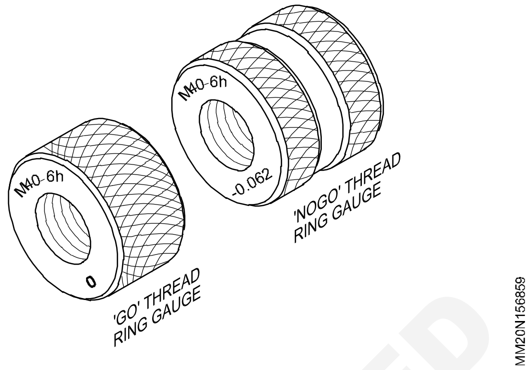
Fig 8



Internal threads are checked with thread plug gauges of 'Go' and `No-Go' variety which employ the same principle as cylindrical plug gauges.

Thread ring gauges (Fig 9)

Fig 9



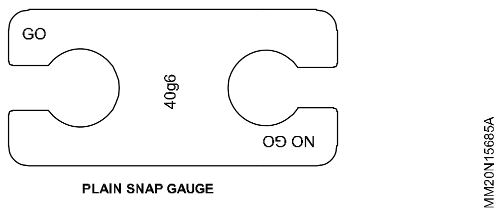
These gauges are used to check the accuracy of an external thread. They have a threaded hole in the centre with three radial slots and a set screw to permit small adjustments.

Snap gauges (Figs 10, 11, 12 and 13)

Snap gauges are a quick means of checking diameters and threads to within certain limits by comparing the part's size to the present dimension of the snap gauge.

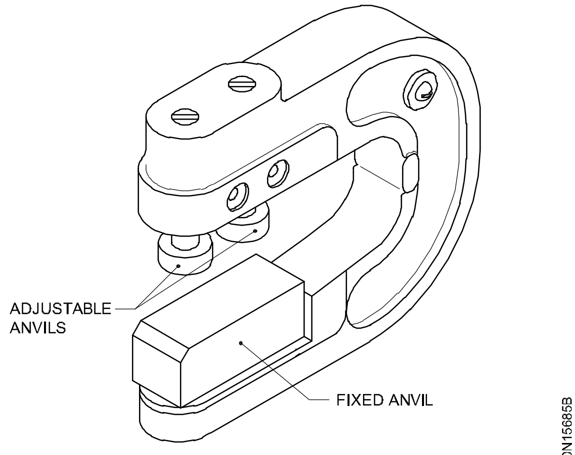
Snap gauges are generally C-shaped and are adjustable to the maximum and minimum limits of the part being checked. When in use, the work should slide into the 'Go' gauge but not into the 'No-Go' gauging end.

Fig 10



PLAIN SNAP GAUGE

Fig 11



ADJUSTABLE SNAP GAUGE

Fig 12

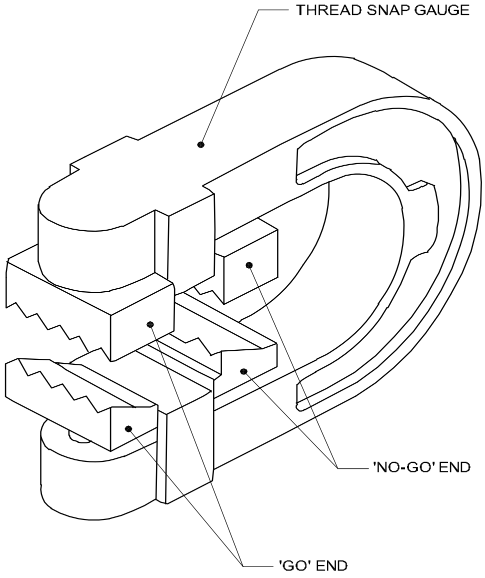
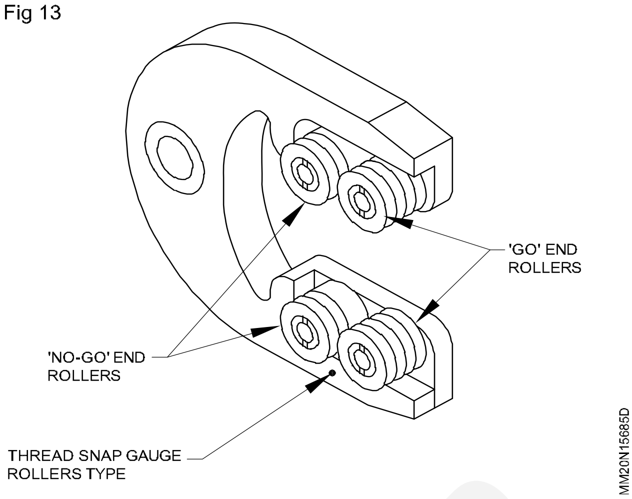


Fig 13



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 features 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.

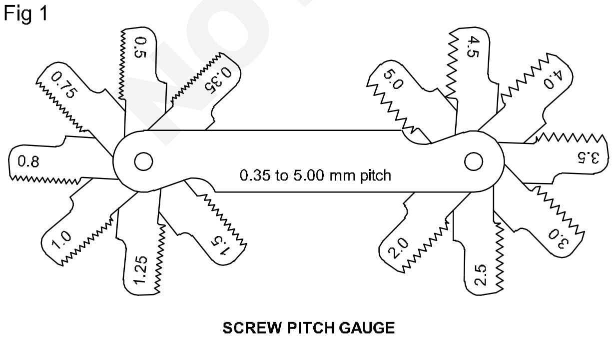
Constructional features

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)

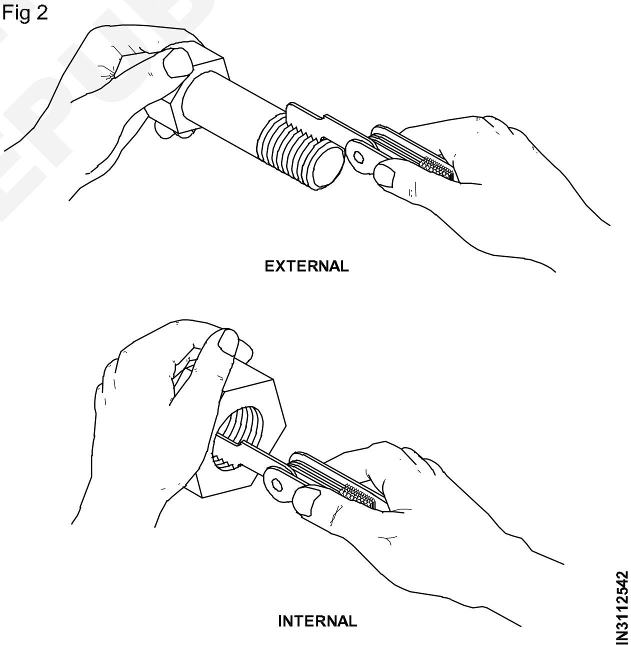
Fig 1



SCREW PITCH GAUGE

For obtaining accurate results while using the screw pitch gauge, the full length of the blade should be placed on the threads. (Fig 2)

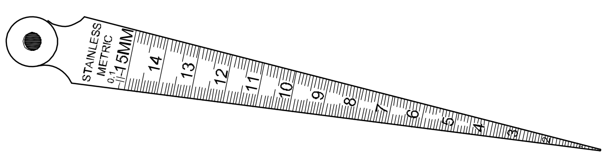
Fig 2



Taper gauge

A taper gauge is a measuring tool that measures sizes such as the width of gaps and grooves, hole diameter, and pipe inner diameter. (Fig 3)

Fig 3



Fits and their classification as per the Indian Standard

Objectives: At the end of this lesson you shall be able to
- **define 'Fit' as per the Indian Standard**
- **list out the terms used in limits and fits as per the Indian Standard**
- **state examples for each class of fit**
- **interpret the graphical representation of different classes of fits.**

Fit

It is the relationship that exists between two mating parts, a hole and a shaft, with respect to their dimensional differences before assembly.

Expression of a fit

A fit is expressed by writing the basic size of the fit first, (the basic size which is common to both the hole and the shaft,) followed by the symbol for the hole, and by the symbol for the shaft.

Example

30 H7/g6 or 30 H7 - g6 or 30 $\frac{H7}{g6}$

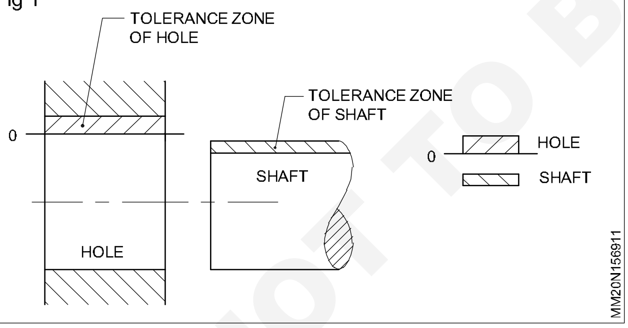
Clearance

In a fit the clearance is the difference between the size of the hole and the size of the shaft which is always positive.

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.

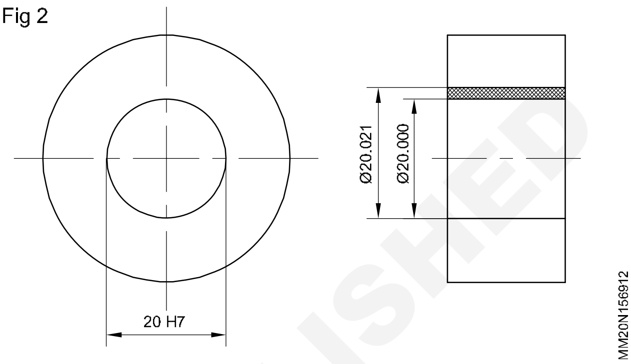
For a hole 20 H7 we find in the table + 21.

These numbers indicate the deviations in microns.

(1 micrometre = 0.001 mm)

The limits of the hole are 20 + 0.021 = 20.021 mm and 20 + 0 = 20.000mm. (Fig.2)

Fig 2



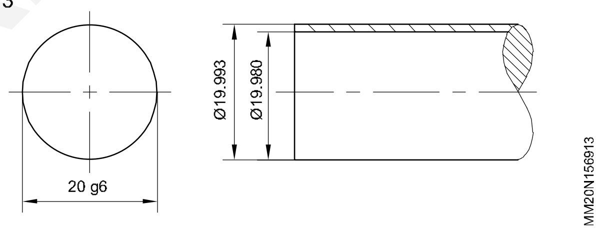
For a shaft 20 g6 we find in the table – 7
– 20.

So the limits of the shaft are

20 – 0.007 =19.993 mm

and 20 – 0.020 =19.980mm.(Fig .3)

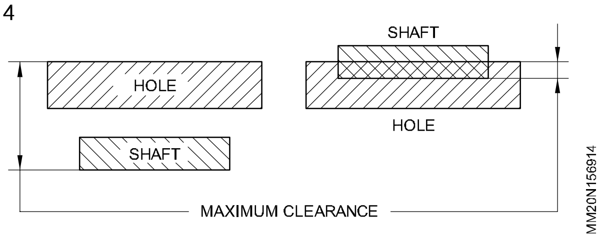
Fig 3



Maximum clearance

In a clearance fit or transition fit, it is the difference between the maximum hole and minimum shaft. (Fig 4)

Fig 4



Minimum Clearance

In a clearance fit, it is the difference between the minimum hole and the maximum shaft. (Fig 5)

The minimum clearance is 20.000 - 19.993 = 0.007mm. (Fig 6)

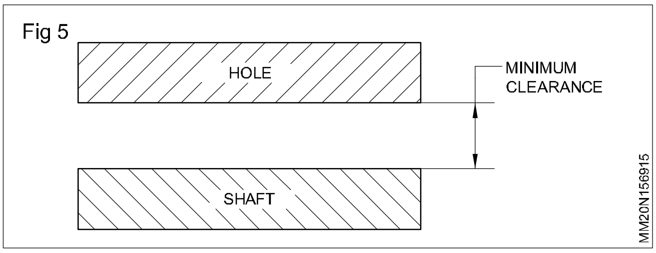


Fig 5

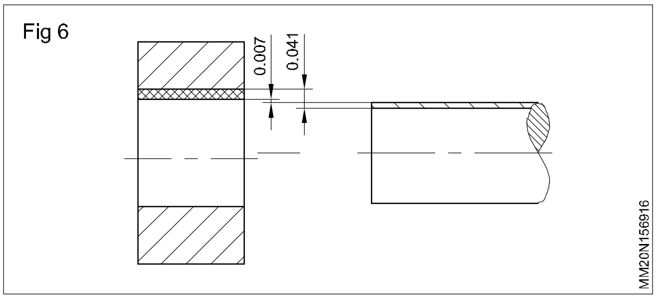


Fig 6

The maximum clearance is 20.021 - 19.980 = 0.041 mm. (Fig 7)

There is always a clearance between the hole and the shaft. This is the clearance fit.

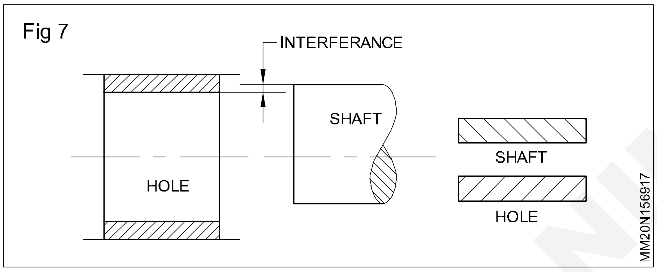


Fig 7

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 8)

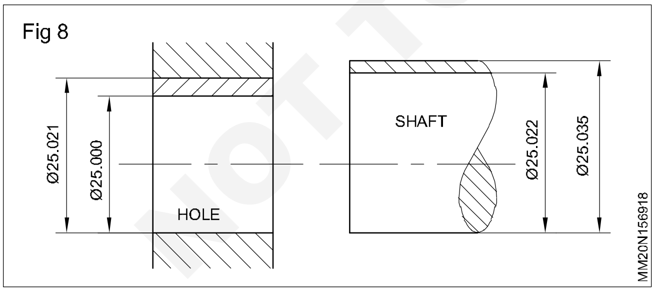


Fig 8

Example: Fit 25 H7/p6 (Fig 9)

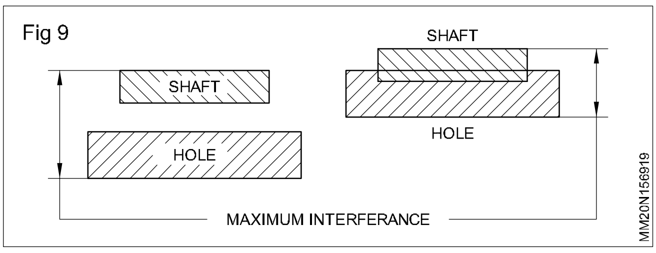


Fig 9

The limits of hole are 25.000 and 25.021 mm and the limits of the shaft 25.022 and 25.035 mm. The shaft is always bigger than the hole. This is an interference fit.

Maximum interference

In an interference fit, it is the algebraic difference between the minimum hole and the maximum shaft. (Fig 10)

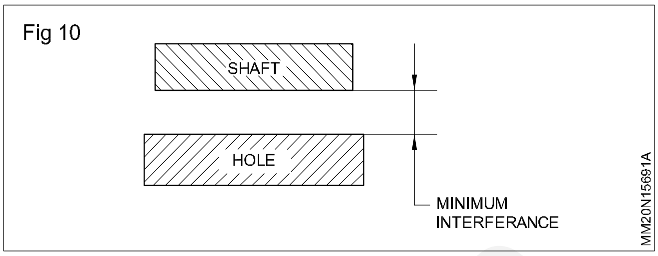


Fig 10

Minimum interference

In an interference fit, it is the algebraic difference between the maximum hole and the minimum shaft. (Fig 11)

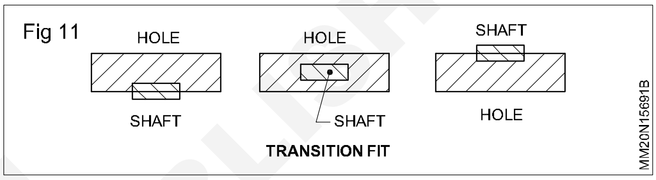


Fig 11

In the example shown in figure 9

The maximum interference is	=	25.035 – 25.000
	=	**0.035**
The minimum interference is	=	25.022 – 25.021
	=	0.001

Transition fit

It is a fit which may sometimes provide clearance, and sometimes interference. When this class of fit is represented graphically, the tolerance zones of the hole and shaft will overlap each other. (Fig 12)

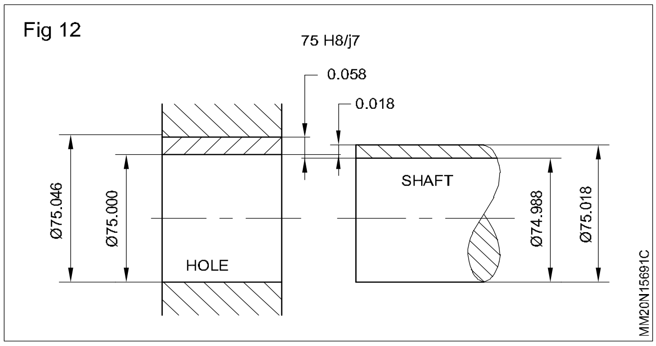


Fig 12

Example Fit 75 H8/j7 (Fig 13)

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 Clearance = 75.046 - 74.988 = 0.058 mm.

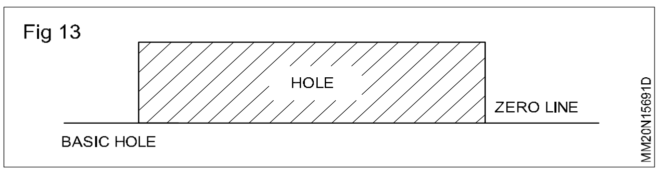


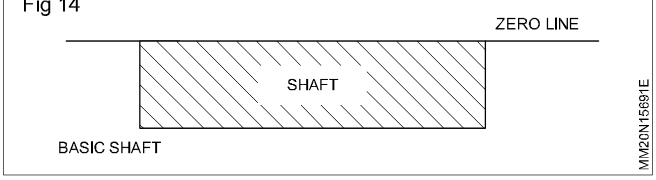
Fig 13

If the hole is 75.000 and the shaft 75.018 mm, the shaft is 0.018 mm, bigger than the hole. This results in interference. This is a transition fit because it can result in a clearance fit or an interference fit.

Hole basis system :In a standard system of limits and fits, where the size of the hole is kept constant and the size of the shaft is varied to get the different class of fits, then 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 hole `H' is zero. It is known as `basic hole'. (Fig 14)

Fig 14



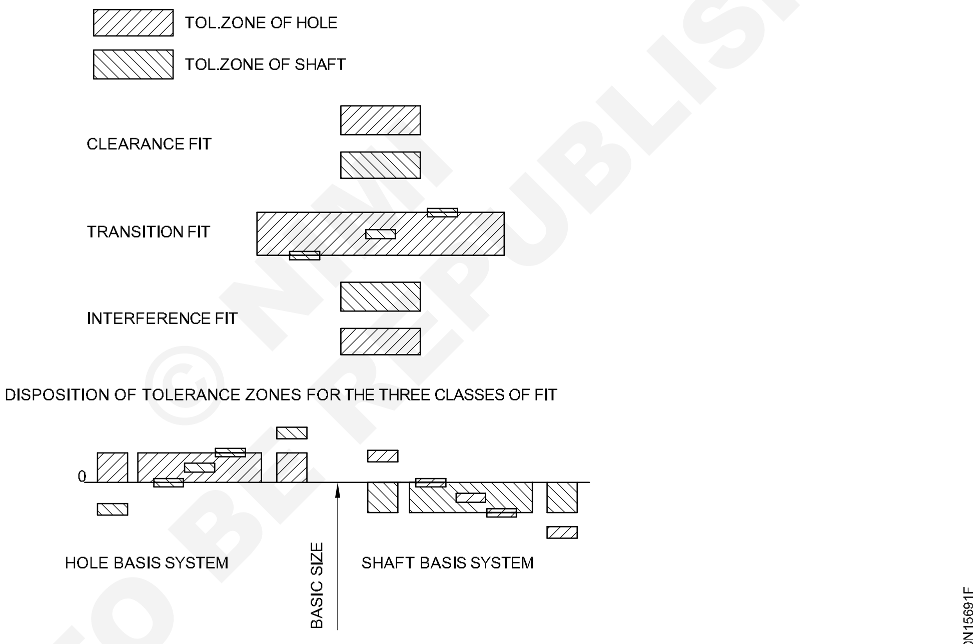
Shaft basis system

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 class of fits, then it is known as shaft basis. The fundamental deviation symbol `h' is chosen for the shaft when the shaft basis is followed. This is because the upper deviation of the shaft `h' is zero. It is known as `basic shaft'. (Fig 15)

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 because it is external, but it is difficult to do minor alterations to a hole. Moreover the hole can be produced by using standard tooling's.

The three classes of fits, both under hole basis and shaft basis, are illustrated in (Fig 15).

Fig 15



EXAMPLES ILLUSTRATING THE HOLE BASIS AND SHAFT BASIS SYSTEM

Screw thread and elements

Objectives: At the end of this lesson you shall be able to
- **Define the fasteners**
- **state the terminology of screw threads**
- **state the types of screw threads.**

A fastener is a non- permanent or permanent mechanical tool that rigidly connects or affixes two surfaces or objects together.

Non permanent fastener can easily be removed without damaging the joined materials the removal of permanent fasteners might damage the connected surface

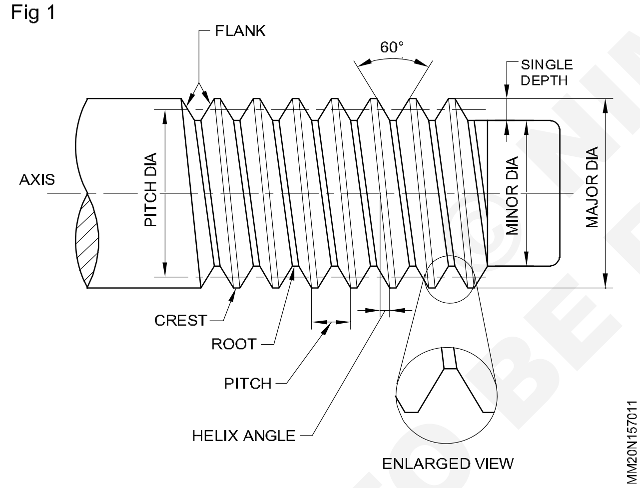
Types of non permanent faster. They are bolts. screws nut, washers and studs.

Bolts, screws, nuts and studs all are have threading, of different types

Screw thread terminology

Parts of screw thread (Fig 1)

Fig 1



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.

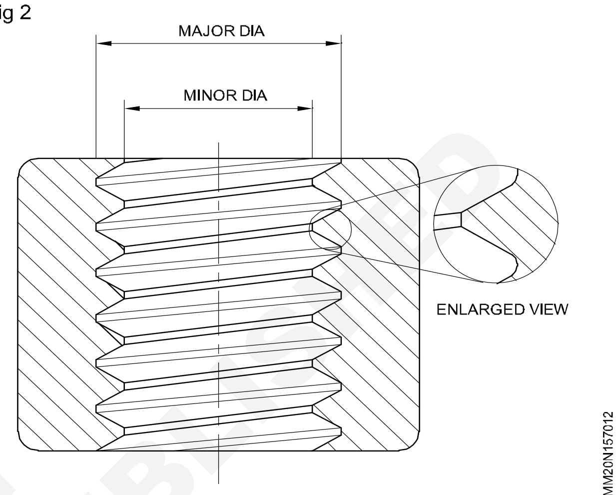
Thread angle: The included angle between the flanks of adjacent threads.

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 2)

This is the diameter by which the sizes of screws are stated.

Fig 2



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.

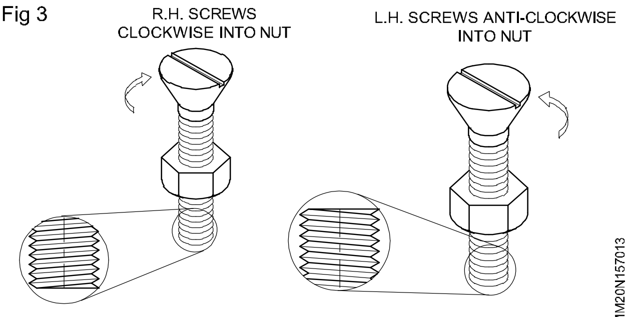
Pitch: It is the distance from a point on one thread to a correspond ing point on the adjacent thread measured parallel to the axis.

Lead: Lead is the distance of 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 3)

Fig 3



Screw threads - types of V threads and their uses

Objectives: At the end of this lesson you shall be able to
- **state the different standards of V threads**
- **indicate the angle and the relation between the pitch with the other elements of the thread**
- **state the uses of the different standards of V threads.**

The different standards of V threads are:

- BSW thread: British Standard Whitworth thread
- BSF thread: British Standard fine thread
- BSP thread: British Standard pipe thread
- B.A thread: British Association thread
- I.S.O Metric thread: International Standard Organisation metric thread
- ANS: American National or sellers' thread
- BIS Metric thread: Bureau of Indian Standard metric thread.

BSW thread (Fig 1): It has an included angle of 55° and

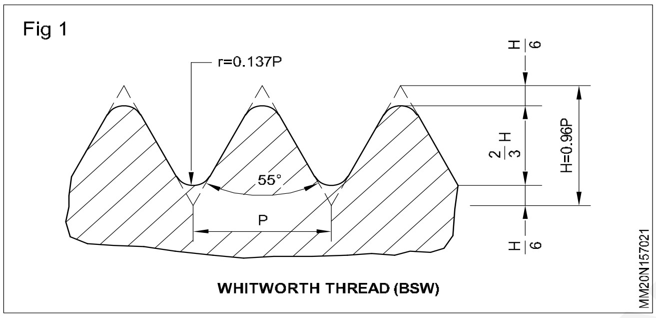


Fig 1
WHITWORTH THREAD (BSW)

the depth of the thread is 0.6403 x P. The crest and root are rounded off to a definite radius . The Fig 1 shows the relationship between the pitch and the other elements of the thread.

BSW thread is represented in a drawing by giving the major diameter. For example : 1/2" BSW, 1/4" BSW. The table indicates the standard number of TPI for different diameters. BSW thread is used for general purpose fastening threads.

BSF thread: This thread is similar to BSW thread except the number of TPI for a particular diameter. The number of threads per inch is more than that for the BSW thread for a particular diameter. For Example, 1" BSW has 8 TPI and 1 "BSF has 10 TPI. The table indicates the standard number of TPI for different dia. of BSF threads. It is used in automobile industries.

BSP thread: This thread is recommended for pipe and pipe fittings. The table shows the pitch for different diameters. It is also similar to BSW thread. The thread is cut externally with a small taper for the threaded length. This avoids the leakage in the assembly and provides for further adjustment when slackness is felt.

BA thread (Fig 2): This thread has an included angle of 47 1/2°. Depth and other elements are as shown in the figure. It is used in small screws of electrical appliances, watch screws, screws of scientific apparatus.

Unified thread (Fig 3): For both the metric and inch series, ISO has developed this thread. Its angle is 60°. The crest and root are flat and the other dimensions are

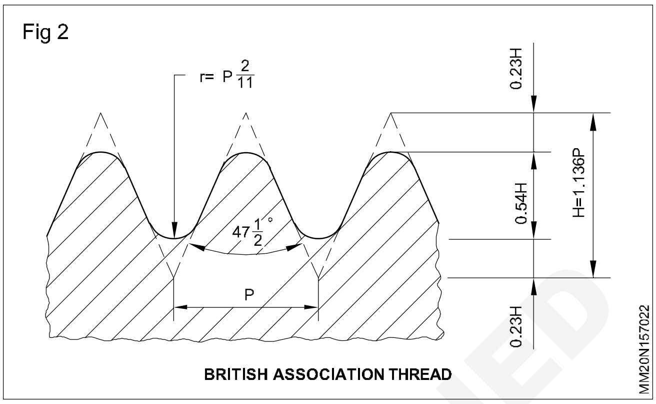


Fig 2
BRITISH ASSOCIATION THREAD

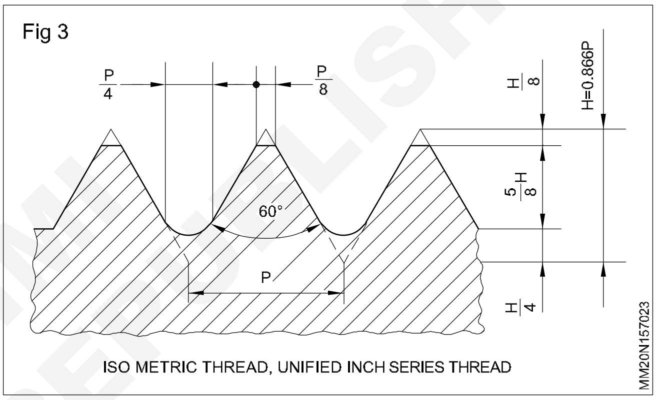


Fig 3
ISO METRIC THREAD, UNIFIED INCH SERIES THREAD

as shown in the Fig 3. This thread is used for general fastening purposes.

This thread of metric standard is represented in a drawing by the letter 'M' followed by the major diameter for the coarse series.

Ex : M14, M12 etc.

For the fine series, the letter 'M' is followed by the major diameter and pitch.

Ex : M14 x 1.5

M24 x 2

American National Thread (Fig 4)**:** These threads are also called as seller's threads. It was more commonly used prior to the introduction of the ISO unified thread.

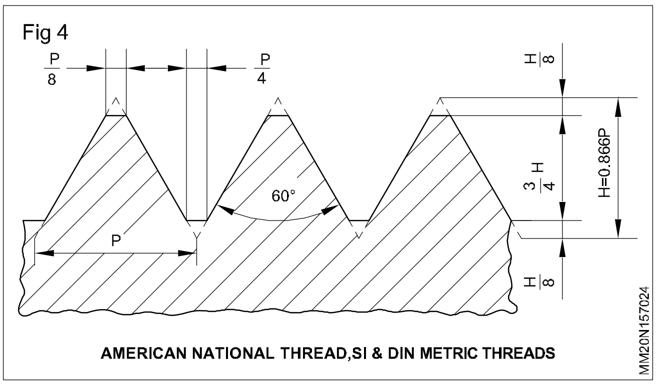


Fig 4
AMERICAN NATIONAL THREAD,SI & DIN METRIC THREADS

Various types of keys

Objectives : At the end of this lesson you shall be able to
- **list the types of keys**
- **state the specification of keys**
- **state the standard taper of key**
- **state the uses of key pullers.**

Key

Key is a metallic piece of wedge inserted between a shaft and hub, parallel to the axis of shaft. It is proportionate to the shaft dia.

Purpose

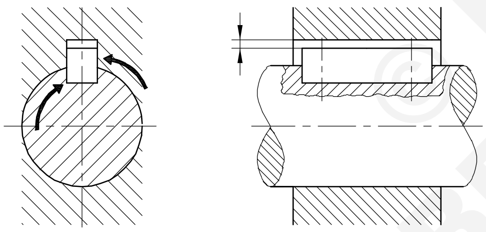
A key is an insert which is housed in the keyway to fit together a hub or a pulley to transmit torque. A keyway is provided on the shaft and also on the hub or on a pulley to connect together the conjugate parts by inserting the key in between. The key can be withdrawn at will to disengage the mating components.

Common types

Parallel key or feather key (Fig 1)

This is the most commonly used key, used for transmitting unidirectional torque. A hub or a pulley is engaged to the shaft by a key which prevents relative motion. The functioning of the feather key assembly is shown in Fig 1.

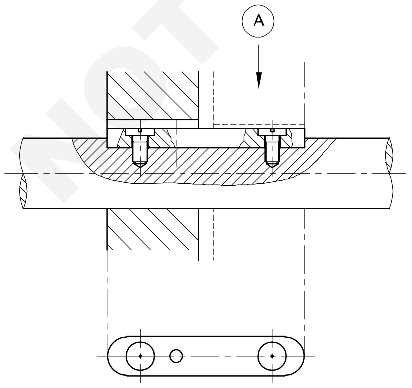
Fig 1



FUNCTIONING OF A FEATHER-KEYED JOINT

In many cases the key is screwed to the shaft keyway. (Fig 2)

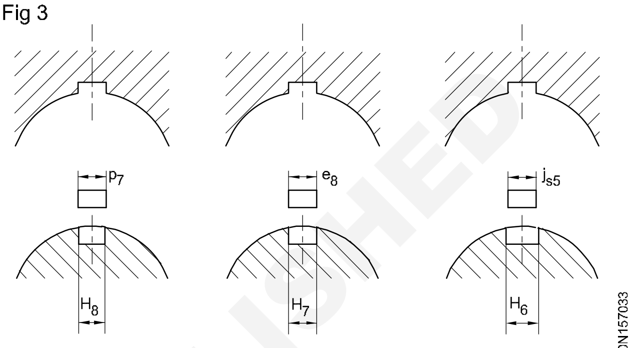
Fig 2



HUB IS MOVABLE

Where axial movement of the hub is required, a clearance fit is provided between the hub and the shaft and the hub and the key. Three types of fits are shown for feather key in Fig 3.

Fig 3



TIGHT SEAT　LOOSE SEAT　SLIDING SEAT

Approximate proportion of parallel or taper keys.

If D is the dia. of the shaft, width of the key W = 1/4D+ 2 mm.

Nominal thickness T = 2/3 w.

Example

Diameter of shaft = 40 mm

Width = $\frac{1}{4}$ x 40+2 = 12 mm

Thickness = $\frac{2}{3}$ x 12 = 8 mm

Thickness at the large end is the nominal thickness of the taper key.

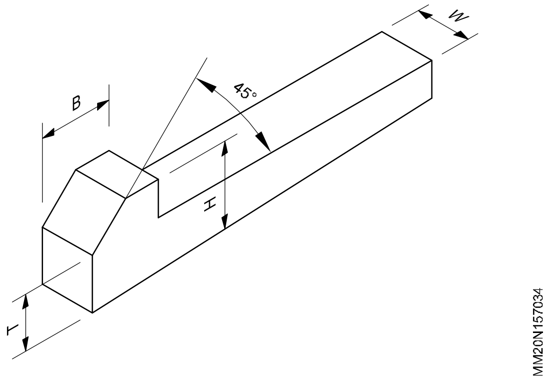
Taper is 1 in 100 on the top face only.

Taper and jib-headed key (Fig 4 & 5)

The key is having a jib-head with a taper (1 in 100) on the top face. It is driven on to the keyway by hammering on the jib to have a tight fit. The taper rectangular key without a jib-head is also in use. A jib-headed key can be widthdrawn easily and used for transmitting more torque. It is not good for high speed applications.

Approximate proportion of jib-headed key (Fig 4)

Fig 4



$$H = 1.75T$$
$$B = 1.5\,T$$
$$W = \frac{1}{4}D+2$$

Nominal thickness $T = \frac{2}{3}W$

Angle of chamfer = 45°

Example

Diameter shaft = 46 mm

$$\text{Width(w)} = \frac{1}{4} \times 46+2 = 11.5+2$$

= 13.5 rounded off to 14 mm.

$$\text{Thickness(T)} = \frac{2}{3} \times 13.5 = 9 \text{ mm}$$

$H = 1.75 \times 9 = 15.75$

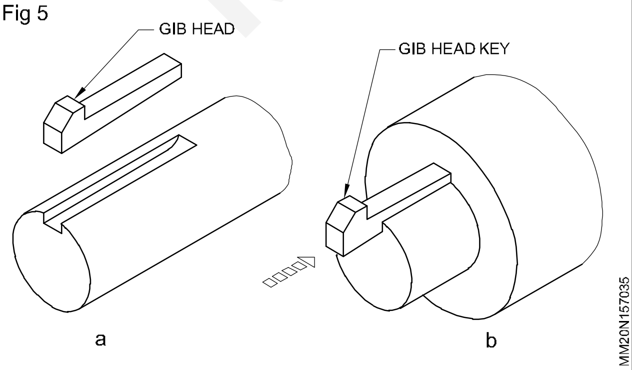
say 16 mm

$B = 1.5 \times 9 = 13.5$ mm.

Woodruff key key (Fig 6)

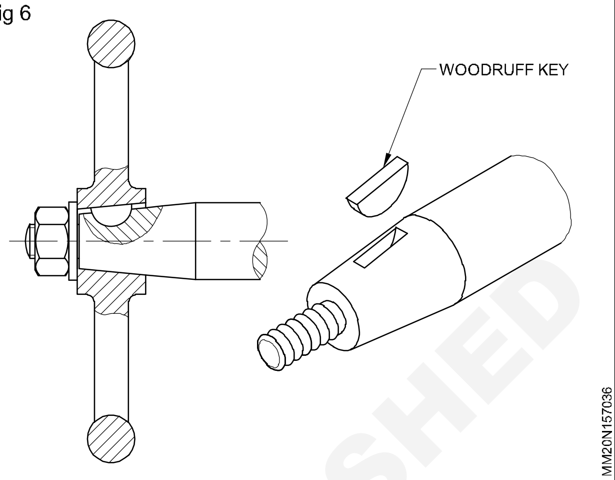
It is a semicircular key used for transmitting light torque. It fits on to the shaft on which matching recesses are cut. The top portion of the key projects out and fits in the keyway cut on the hub. (Fig 6)

Fig 5



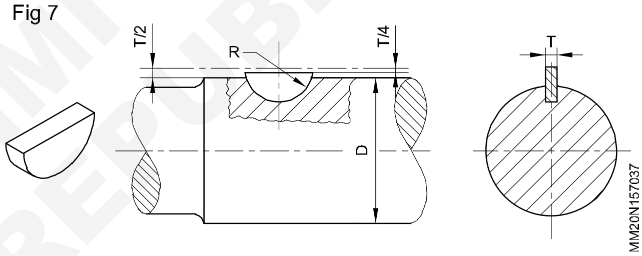
This key is particularly useful on tapered fittings or shafts. Its key way is milled to the profile of the key on the shaft which tends to weaken the shaft. This type of key positions itself in the keyway to accommodate the hub to have an easy assembly.

Fig 6



Approximate proportion of woodruff key (Fig 7)

Fig 7



$$\text{Radius of the key (R)} = \frac{D}{3}$$

$$\text{Thickness(T)} = \frac{D}{6}$$

Example

For shaft ø 30.

R = 30/3 = 10 mm

T = 30/6 = 5 mm

Keys and splines: Keys and splines are used for transmitting torque from a rotating shaft to a hub/wheel or from a hub/wheel to the shaft. (Fig 8)

Keys of different types and splines are used depending on the requirements of transmission.

Hollow saddle key: One face of this key has a curvature to match with that of the shaft surface. It has a taper of 1 in 100 and is driven in through the keyway. (Fig 9)

Fig 8

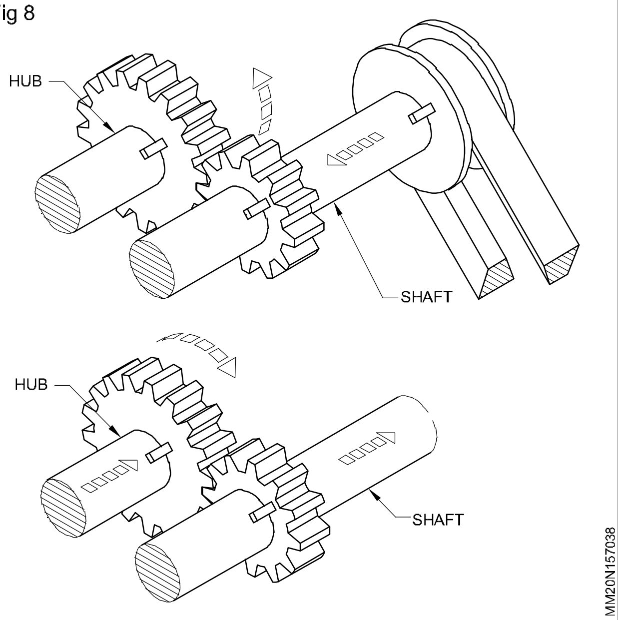
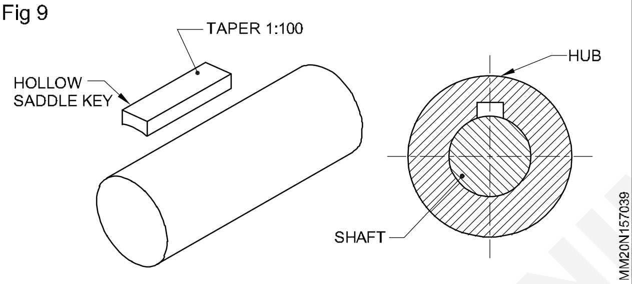


Fig 9

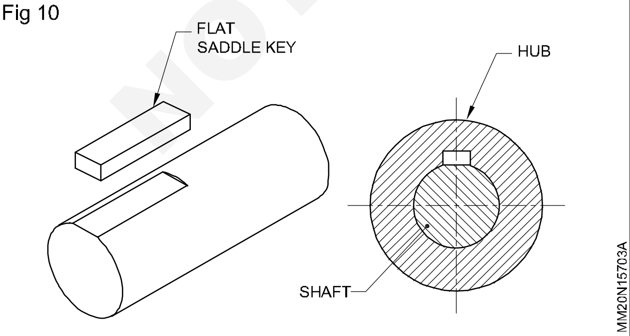


The hub is held on the shaft due to friction. This key is useful only for light duty transmission.

Flat saddle key: This key has a rectangular cross-section.

For fitting this key in the assembly a flat surface is machined on the shaft. (Fig 10) The key is placed between the flat surface of the shaft and the keyway on the hub. This is considered to be stronger than the hollow saddle key. This is not suitable for heavy duty transmission.

Fig 10



Approximate proportion

If D is the diameter of the shaft,

width of the key (W) = $\frac{1}{4}$D+2 mm

nominal thickness (T) = $\frac{1}{3}$W.

Example

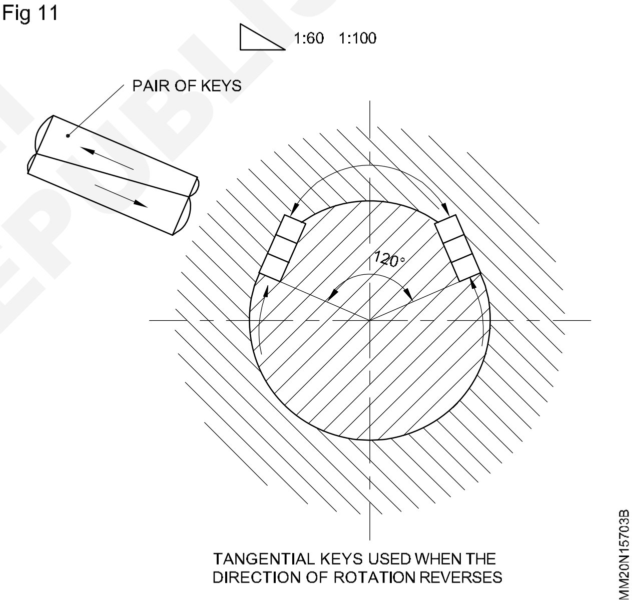
diameter of the shaft = 24 mm

W = $\frac{1}{4}$x 24+2 = 8 mm

T = $\frac{1}{3}$x 8 = 2.7 or 3 mm.

Tangential key (Fig 11)

Fig 11

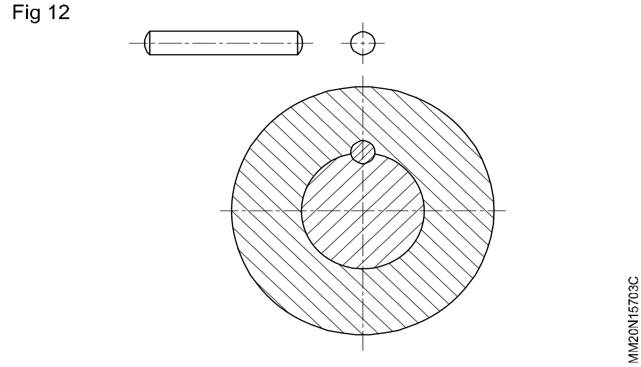


These keys are used when very high torque of impact type is to be transmitted in both directions of rotation. Common applications are found in flywheels, rolling mills etc. A tangential key consists of two taper rectangular wedges, positioned one over the other in opposite directions. Two sets of keys are fixed at 120° angle as shown in Fig 11 and should be such that the broad side is directed along a tangent to the shaft circle while the narrow side sits along the radius of the shaft.

Round key (Fig 12)

It is of cylindrical cross-section and is used in assemblies to secure the mating components where the torque is light. The key is fitted parallel to the shaft into the drilled hole made partly on to the shaft and partly on to the mating part.

Fig 12



Approximate proportion of round key

If dia. of the shaft = D

Dia. of the key (d) = $\frac{1}{6}$D

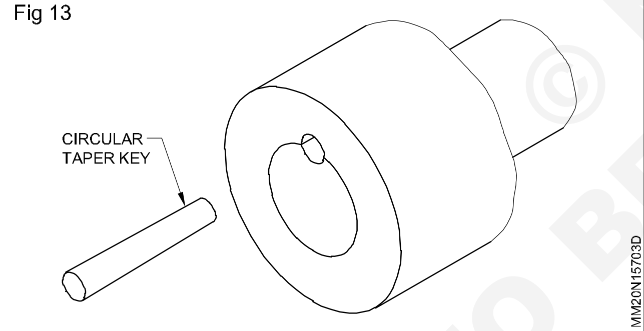
Example

Dia. of shaft = 30 mm

Dia of key = $\frac{1}{6}$ x 30 = 5 mm

Circular taper key: In this case both the shaft and the hub have semicircular keyways cut on them. (Fig 13) The taper key is driven in while assembling. This key is suitable only for light transmission.

Fig 13



Sunk key: This key has a rectangular cross-section and it fits into the keyway cut on both the shaft and the hub. Sunk keys are either parallel or tapered. (Figs 14 and 15)

Fig 14

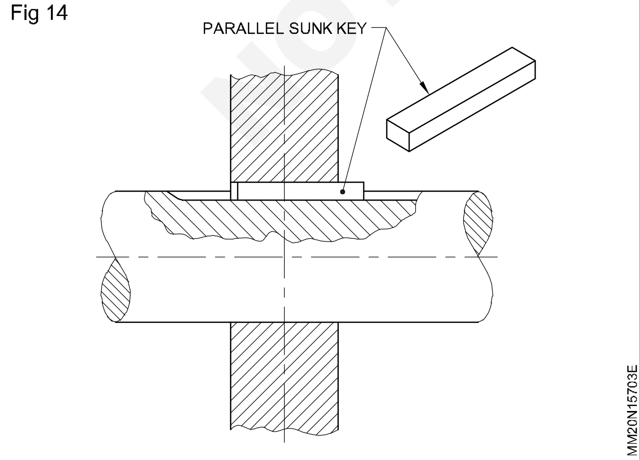
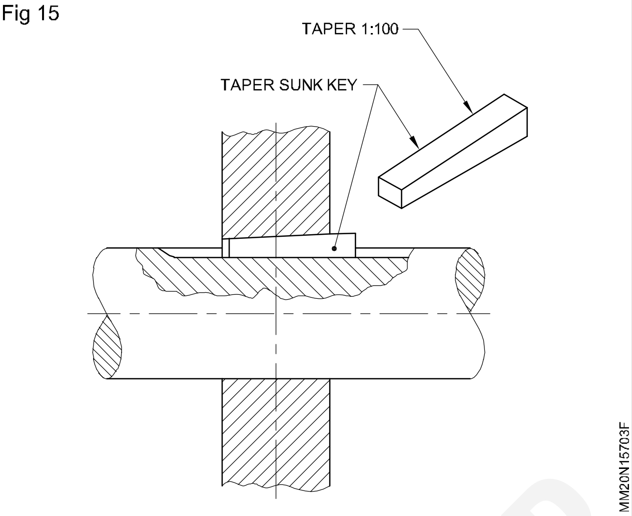
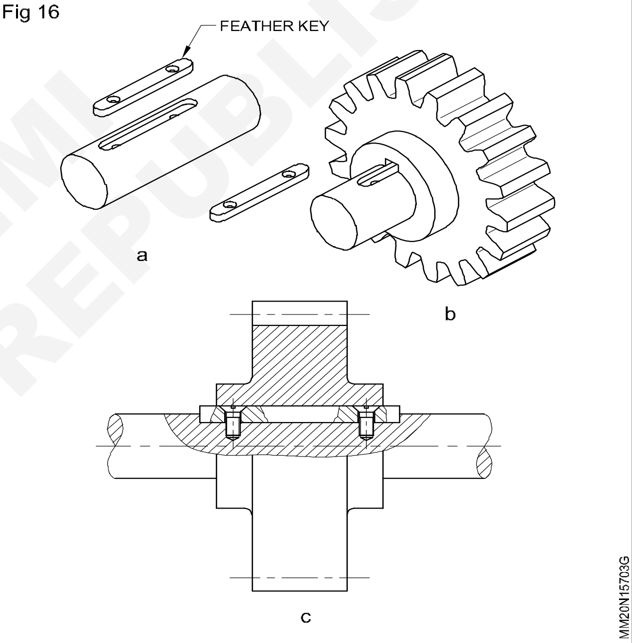


Fig 15



Feather key: This is parallel key with rounded ends. This is useful when the hub/pulley has to slide axially on the shaft to some distance. (Figs 16a, b and c) This key may be either tightly fitted in the keyway or screwed in.

Fig 16



Splines: Splines are ridges (or) teeth on a drive shaft that mesh with grooves in a mating piece and transfer torque to it, maintaining the angular correspondence between them.

An alternative to spline is a key way and key

Splined shaft and serrated shaft: Splined shafts along with splined hubs are used particularly in the motor industry. The splined hub can also slide along the shaft, wherever necessary (Figs 17a and b) used while fixing change gears in a lathe and heavy duty drilling machine.

In certain assemblies, serrated shafts are also used for transmission. (Fig 18)

Peg feather key: It is a parallel rectangular key having a round peg at the centre or one edge of the key face. (Fig 19)

Fig 17

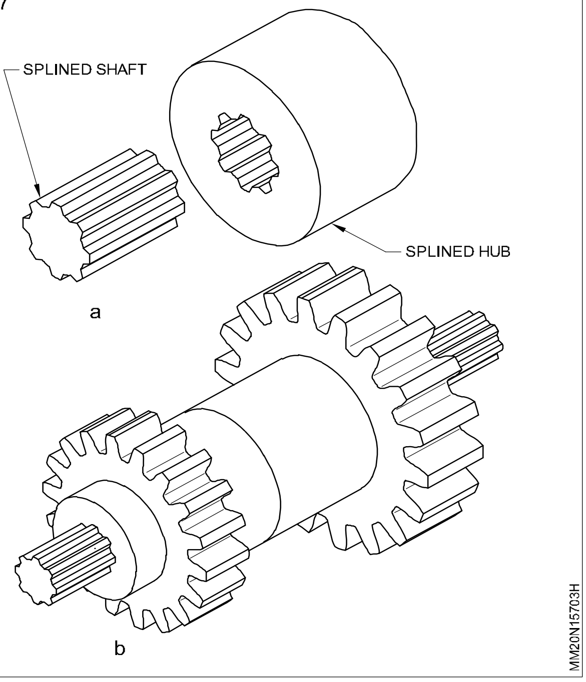


Fig 18

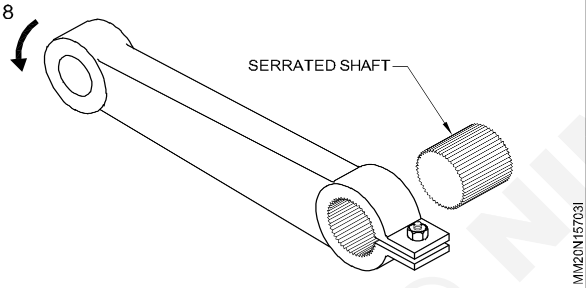
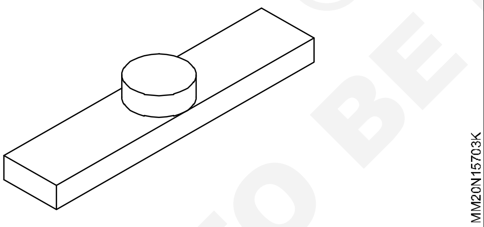


Fig 19



The peg will fits into the hole of the shaft or stationary member of a unit assembly to prevent the sliding of the key.

A peg feather key is used at the bottom of the tail stock barrel to prevent the barrel from rotation. It is also used in a drilling machine spindle while moves along with quill when the spindle in rotation.

Some of the key dimensions as per IS is given in table 1, 2, 3 & 4.

Key puller (Fig 20)

Key puller is used for the safe removal of keys from the shaft of any type of machine, motor, blower, compressor, etc.

It is generally used for the keys from 5mm to 35mm width.

Advantages

- Safe and fast removal
- Perpendicular removal
- No damage to shafts & keys
- Saves time & labour costs & costs

Easy-to-use

1 Turn wheel (A) to move the jaws (1) up or down so that they are aligned with housing (2)

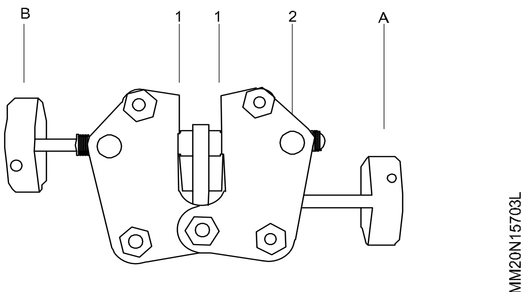
2 Turn wheel (B) to fit the size of the key allowing ± 1 mm space.

3 Turn wheel (B) hand tight to secure the key with the jaws.

4 Then turn wheel (A) to extract the key perpendicularly.

5 Turn wheel (A) to move the jaws down, turn wheel (B) to open the jaws and free

Fig 20



Types of maintenance

Objectives: At the end of this lesson you shall be able to
- **state maintenance and its types**
- **state the function of each maintenance**
- **distinguish between breakdown maintenance and preventive maintenance**
- **state the importance of breakdown and preventive maintenance in productivity.**

Maintenance is a process adapted to extent the life as well as the performance of machines, equipments, tools, etc.

Types of maintenance

- Scheduled maintenance
- Preventive maintenance
- Breakdown maintenance
- Predictive maintenance

Scheduled maintenance

- This is called as routine maintenance.
- In order to get trouble free service from productive equipments.
- Following activites is necessary to carry out.
  i) Lubrication
  ii) Periodic inspection
  iii) Adjustments of various parts
  iv) Cleaning
  v) Periodic overhaul
  vi) Repair and replacement, etc.

All the above maintenance operations are carried out while the machine is running or during pre-planned shutdowns.

This type of maintenance may prevent breakdown of equipments.

Routine maintenance should not interfere with production schedules.

Preventive maintenance

- Preventive maintenance is the maintenance undertaken to prevent breakdown.
- Weak spots as bearings, parts under excessive vibration and heat etc., are located by regular inspection.
- The parts of equipments are changed before the end of its lifetime to reduce danger of breakdown.
- The underlying principle of preventive maintenance is that "Prevention is better than cure".
- Preventive maintenance is a definite programme of periodic cleaning, servicing, inspection and replacement of worn out and damage parts for vital plant facilities.

Importance of Preventive maintenance

Preventive maintenance is important because of the following advantages.

- Prevention of accidents.
- Prevention of damage to material and equipment.
- Reduce downtime and lower unit cost.
- Prevention of economic losses resulting from machinery breakdown.
- Decrease maintenance and repair cost.
- Increased efficiency in machinery performance.
- Improve quantity and quality of product.
- Reduced major and repetitive repairs of machines.
- Finds small problems before they become big ones.

Breakdown maintenance

This is called corrective maintenance or emergency maintenance. A machine is permitted to run without much attention till it breaks down. When it actually breaks down, it will be attended, since no attempt is made to prevent the occurrence of breakdown.

Breakdown maintenance is harmful. It is unpredictable and results in production loss. Hence any breakdown has to be given more priority and the equipment shall be got back into service as quickly as possible. In addition to repairing, causes of breakdown shall be investigated in order to avoid breakdowns in future.

Cause of equipment breakdown

- Failure to replace worn-out parts.
- Lack of proper lubrication and cooling system.
- External factors such as voltage fluctuations, poor quality oils, etc.
- Not caring for equipments vibrations, unusual sounds, excessive heat on equipments and other minor faults.

Disadvantages of breakdown maintenance

- Production delays and stoppage.
- Inefficient use of maintenance manpower.
- Production and maintenance overtime.
- Not suitable for items regulated by statutory provisions. Eg., Cranes, Lifts, Pressure vessels, etc.

Difference between breakdown maintenance and preventive maintenance

Sl. No.	Breakdown maintenance	Preventive maintenance
1	Maintenance is undertaken only after breakdown	Maintenance is undertaken only before breakdown
2	No attempt is made to prevent breakdown	Maintenance is made to prevent breakdown
3	This is unpredictable activity.	Predictable activity.
4	Maintenance cost less.	Cost of maintenance is high.
5	Not suitable for equipments like cranes, hoists, pressure vessels.	Can be applied to all types of equipments.
6	Results in production loss and more "Down time"	Such disadvantages are eliminated.

Predictive maintenance

Scheduled programme of maintenance and preventive maintenance need careful planning. Hence it is necessary to know what is happening to different parts of machine tool equipment under actual working conditions. This will useful to estimate the lifetime of different parts of machine-tool equipments and to access the frequency of periodically maintenance.

In predictive maintenance, condition of equipment are checked periodically making use of human senses such as hearing, smell, sight, etc.

There are sensitive instruments to predict troubles in machines.

- Audio gauges
- Vibration analyzers
- Amplitude meters
- Pyrometers
- Strain gauges etc.

The above sensitive instrument are useful for the maintenance men to take timely action such as equipment adjustment, recondition or overhauling.

Upnormal sound coming out of a running machine predicts a trouble. Overheat a bearing predicts a trouble. Simple hand touch can point out many upnormal conditions and thus predict trouble.

Predictive maintenance increases the service life of machine tool and equipment without fear of failure.

Effect of maintenance on machine tool equipments life output and quality

- Life of machine tool equipment increases with increase in the performance of machine tool equipment.
- The products will be of good quality. The quality of goods produced may be consistent.
- Output of goods from the machine increases. This also results in lower unit cost.

Proactive maintenance

Proactive maintenance is a preventive maintenance strategy for maintaining the reliability of machines or equipment. The purpose of proactive maintenance is to view machine failure and similar problems as something that can be anticipated and dealt with before they occur.

Proactive maintenance focuses primarily on determining the root causes of machine failure, and dealing with those issues before problems occure. It is often seen as a cost-effective practice since it allows a company to avoid machine failure and solves issues before they become problems.

Reactive maintenance

The oldest maintenance approach is reactive. Equipment is not repaired or replaced until it breaks. In this maintenance equipment fails with little or no warning so this could be down until replacement parts arrive, resulting in income loss. In this maintenance cost and down time increased and also create safety issues. Reactive maintenance can be suitable in some situation such as for non critical and low cost equipment with little or no risk of capital loss or production loss.

Importance of breakdown maintenance and preventive maintenance in productivity

The importance of an effective maintenance program cannot be overlooked because it plays such an important role in the effectiveness of lean manufacturing. As in personal health care insurance, maintenance may be considered the health care of our manufacturing machines and equipment. It is required to effectively decrease waste and run an efficient, continuous manufacturing operation, business, or service operation. The cost of routine maintenance is very small when it is compared to the cost of a major breakdown at which time there is no production.

Purpose of maintenance

The importance use of routine maintenance is to ensure that all equipment required for production is operating at 100% efficiency at all times. Through short daily inspections, cleaning, lubricating and making small adjustment, small problems can be detected and corrected before they become a major problem that can shut down a production line. A good maintenance program requires company wide participation and support by everyone ranging from the top executive to the shop floor personnel.

Maintenance organization

Objectives: At the end of this lesson you shall be able to
- **state what is organizing and organization structure**
- **brief the duties of maintenance manager**
- **describe the organization structure.**

Organizing and organization

- Organizing is the process of arranging resources (people, materials, technologies.) together to achieve the organization's strategies and goals.
- The way in which the various parts of an organization are formally arranged is referred to as the organization structure.
- It is a system involving the interaction of inputs and outputs.
- However, there is no universally accepted methodology for designing maintenance systems, i.e., no fully structured approach leading to an optimal maintenance system (i.e., organizational structure with a defined hierarchy of authority and span of control; defined maintenance procedures and policies, etc.). Identical product organizations, but different in technology advancement and production size, may apply different maintenance systems and the different systems may run successfully.
- So, maintenance systems are designed using experience and judgment supported by a number of formal decision tools and techniques.

Maintenance managers

- Maintenance managers must have the capabilities to create a division of labour for maintenance tasks to be performed and then coordinate results to achieve a common purpose.
- Solving performance problems and capitalizing on opportunities could be attained through selection of the right persons, with the appropriate capabilities, supported by continuous training and good incentive schemes, in order to achieve organization success in terms of performance effectiveness and efficiency.

Maintenance Organization role and Responsibility

A maintenance organization and its position in the plant/ whole organization is heavily impacted by the following elements or factors:

- Type of business, e.g., whether it is high tech, labour intensive, production or service;
- Size and structure of the organization;
- Culture of the organization; and
- Range of responsibility assigned to maintenance.

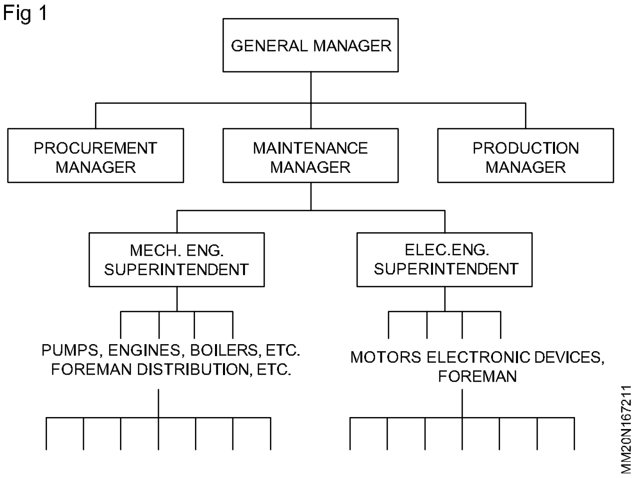
The principal responsibility of maintenance is to provide a service to enable an organization to achieve its objectives.

- Keeping assets and equipment in good condition, well configured and safe to perform their intended functions;
- Perform all maintenance activities including preventive, predictive; corrective, overhauls, design modification and emergency maintenance in an efficient and effective manner;
- Conserve and control the use of spare parts and material;
- Commission new plants and plant expansions; and
- Operate utilities and conserve energy. The above responsibilities and objectives impact the organization structure for maintenance as will be shown in the coming sections.

Basic Types of Organizational Model

Centralized maintenance. All crafts and related maintenance functions report to a central maintenance manager as shown in Figure 1. The strengths of this structure are: allows economies of scale; enables in-depth skill development; and enables departments (i.e., a maintenance department) to accomplish their functional goals (not the overall organizational goals). This structure is best suited for small to medium- size organizations.

Fig 1



Concept of TPM & OEE

Objectives: At the end of this lesson you shall be able to
- **explain the concept of TPM**
- **state advantage of TPM**
- **explain the concept of OEE**
- **describe the components of OEE and their effects.**

Total Productive Maintenance(TPM) concepts

TPM aims to maximize overall equipment effectiveness. Establishes a complete system of productive maintenance for the machines/equipments entire lifespan is implemented by various departments. [Engineering, Operations, Maintenance, Quality and Administration]

TPM can be considered as the medical science of machines.

TPM involves every single employee, from top management to all the operators on the shop floor. TPM raises and implements productive maintenance based on autonomous small group activities.

TPM is a maintenance program which involves a newly defined concept for maintaining plants and equipment.

The goal of TPM is to an extent increase production while, at the same time, increasing employee morale and job satisfaction.

TPM brings maintenance into focus as a necessary and vitally important part of the business. It is no longer regarded as a non-profit activity.

Downtime for maintenance is scheduled as a part of the manufacturing day. In some cases as an integral part of the production process.

The goal of TPM is to stop the emergency and unscheduled maintenance.

Form different teams to reduce defects and self maintenance.

Advantages of TPM

- Avoids wastage in quickly changing economic environment.
- Produces goods without reducing product quality.
- Reduces maintenance cost.
- Produces a low batch quantity at the earliest possible time.
- Ensures the non defective goods to the customers.
- Reduce customers complaints.
- Reduce accidents.
- Follow pollution control measures.
- Favourable change in the attitude of the operator.

Overall equipment effectiveness (OEE)

Overall equipment effectiveness (OEE) is a concept utilized in a lean manufacturing implementation. OEE is described as one such performance measurement tool that measures different types of production loses and indicate areas of process development. The OEE concept normally measures the effectiveness of a machine center or process line, but can be utilized in non-manufacturing operation also.

The high level formula for the lean manufacturing OEE is

OEE = Availability x Productivity x Quality

Availability

The availability is part of the above equation measures the percentage of time the machine/equipment of operation was running compared to the available time. For example if the machine was available to run 20 hours but was only run for 15, then the availability is 75 percent 15/20. The five hours when the machine didn't run would be set up time, breakdown or other downtime. The 4 hours the company did not plan to run the machine is rarely used in the calculation.

Performance

The performance part of the equation measures the running speed of the operation compared to its maximum capability often called the rated speed. For example, if a machine produced 80 pieces per hour while running, but the capability of the machine is 100, then the performance is 80% (80/100). The concept can be used multiple ways depending on the capability number. For example, the machine might be capable of producing 100 pieces per hour with the perfect part, but only 85 on that particular order. When the capability of 100 is used for the calculation, the result is more a measure of facility OEE.

Quality

The third portion of the equation measures the number of good parts produced compared to the total number of parts made. For example if 100 parts are made and 95 of them are good, the quality is 95% (95/100).

Combining the above example into the OEE equation the

OEE is

OEE = 75% x 80% x 95% = 57%

Elements of Mechanical Transmission

Objectives: At the end of this lesson you shall be able to
- **state what is mechanical power transmission**
- **list the benefit of power transmission**
- **classify the mechanical power transmission**
- **list the elements used in mechanical power transmission.**

Mechanical power transmission is used to transfer power and rotation from one place to another. Following are the benefits of power transmission

- Transmit power efficiently
- The elements help to split and distribute the power source to run several mechanisms such as a single motor running multiple conveyor belts.
- To change rotational speeds
- Reverse the rotational direction from the motor
- Converts rotational movement into linear reciprocating motion

The mechanical drives may be classified as positive drive, negative drives

Positive drive:

A drive-in which slip does not occur is known as a positive drive. In any Flat, Round, or Crossed belt drive, the belt can slip on the surface of the pulley, since there is no projection or tooth-like structure to lock it in place.

The negative drive is an informal expression to describe 'friction drive'. The belt drive is based on friction between the disc and the belt, however positive drive is based on movements without slipping

Friction drive: mechanical drives where motion and power transmission occur by means of friction are called friction drive. For example, friction force between the pulley and the belt helps driving one shaft by retrieving power from another shaft. Apart from belt drive, rope drive also falls under this category.

Mechanical power transmission elements

- Shafts
- Rope drive
- Belt drive
- Chain drive
- Gears drive

A "universal spindle" in the context of machines typically refers to a type of spindle that can be used for a variety of machining operations. Spindles are components in machines like lathes, milling machines, and drills that rotate and hold cutting tools or workpieces. ""A universal spindle is versatile and can accommodate different types of tooling or attachments, making it suitable for various machining tasks. It's designed to provide flexibility and adaptability in a machine, reducing the need for changing or swapping spindles when switching between different machining operations. ""Universal spindles are commonly found in multi-purpose or multi-axis machining centers where the machine needs to perform different operations, such as drilling, milling, and turning, without the need for extensive tool changes. These spindles can often be adjusted to various angles and orientations to enable a wide range of machining capabilities.

Shaft

Shaft is basically the rotating component of any machine, which is round in the cross section and is used for passing the power from one part to another or from the power producing machine to the power absorbing machine. For the transmission of power, one end of the shaft is connected with power source and the other end of the shaft are connected with the machine. There are different types of shafts are available

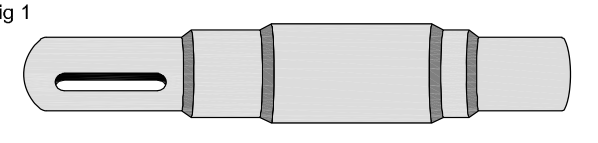
They are:

- Plain shaft
- Hollow shaft
- Crank shaft and
- cam shaft

Plain shaft / solid shaft

Solid shaft drivers are used to drive pumps with relatively short shafts. They are used to drive almost all process pumps and circulators. They provide more positive shaft alignment which is especially important when the pumps have mechanical seals rather than packing. (Fig1)

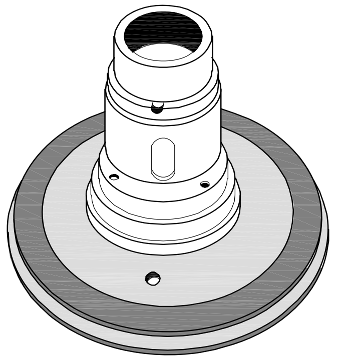
Fig 1



Hollow shaft

Hollow shafts are significantly lighter than solid shafts and can transmit the same torque as solid shafts of equal diameters. Furthermore, hollow shafts require less energy to accelerate and decelerate. As a result, hollow shafts have a lot of potential in the automotive industry for power transmission. (fig 2)

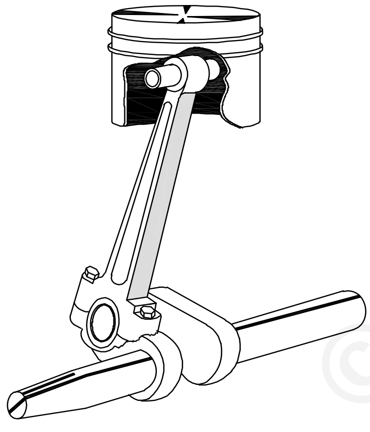
Fig 2



Crank shaft

A crankshaft is a rotating shaft that converts reciprocating motion of a piston into a rotational motion. It's commonly used in internal combustion engines to perform such operation. Crankshafts consist of series of cranks and crankpins to which the connecting rods are attached. (Fig 3)

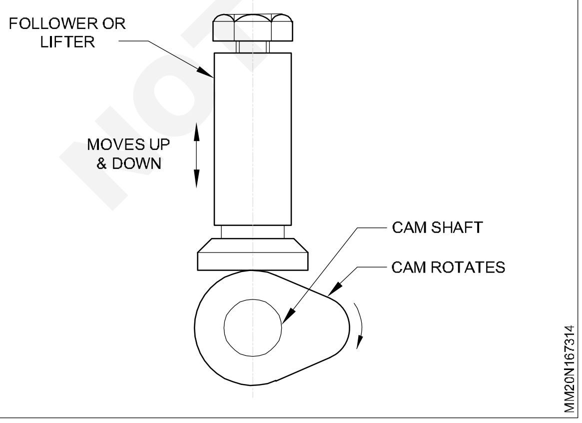
Fig 3



Cam shaft

A camshaft is a mechanical device used in an IC engine to perform the opening and closing action of the inlet and exhaust valve at the right time. The basic function is to convert rotatory motion into linear motion. Fig 4)

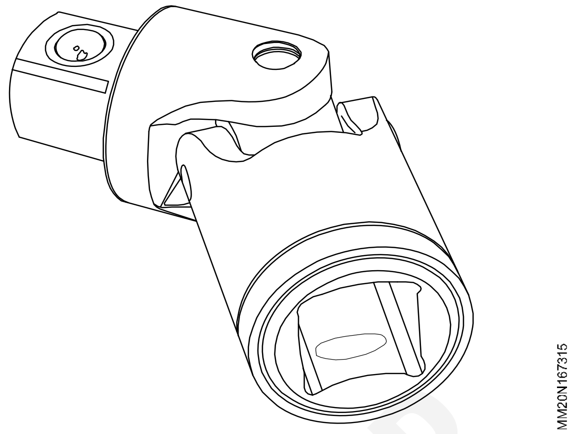
Fig 4



Universal shaft

A universal joint is a connection between two objects, typically shafts, that allows relative rotation in two axes. It is made up of two revolute joints with perpendicular and intersecting axes. (Fig 5)

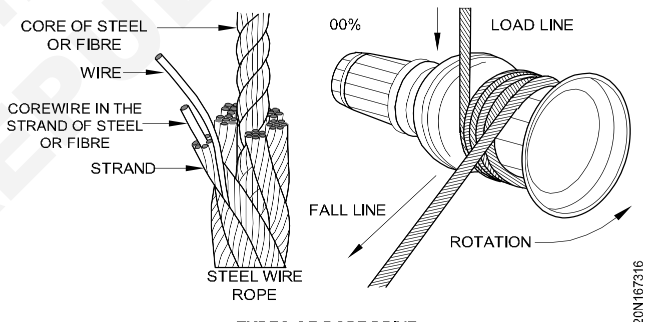
Fig 5



Rope drive

Rope drive is a form of belt drive, which is used for mechanical power transmission. Rope drives use multiple circular section ropes instead of single flats or V-belts. The rope drives are widely used where a large amount of power is to be transmitted, from one pulley to another, over a considerable distance. (fig 6)

Fig 6



TYPES OF ROPE DRIVE

Types of Rope Drive

The ropes drive is found using these two types of ropes:

1 Wire ropes.

2 Fibre ropes.

The fibre ropes are referred to as those ropes which are usually found being operated successfully when the pulleys are found being approximately 60 meters apart from each other, whereas the wire ropes are found being used at the time when the pulleys are separated by 150 meters.

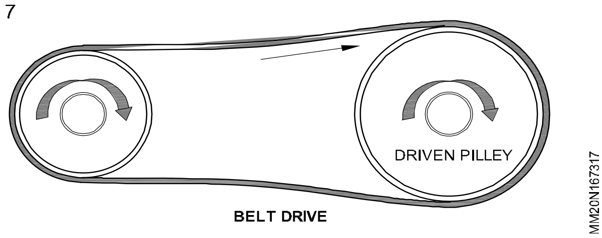
Belt Drives

Belt Drives are a type of frictional drives used for transmitting powers from one shaft to another by means of pulleys which rotate at the same speed or at the different speed. (fig 7)

Chain drive

Chain drive is a type of mechanical power transmission system that uses chains to transfer power from one place to another. A conventional chain drive consists of two or more sprockets and the chain itself. The holes in the chain links fit over the sprocket teeth.

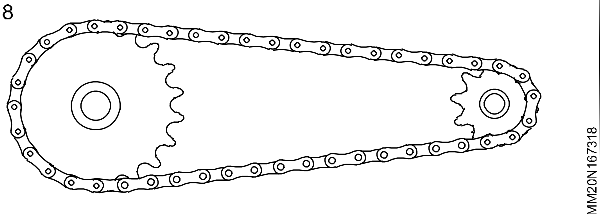
Fig 7



When the prime mover rotates, the chain wrapped on the shaft's sprocket rotates with it. This applies mechanical force onto the driven shaft, transmitting mechanical power in the process.

Chain drives are used apart from transmitting mechanical power but also for conveying goods, as well as lifting and dragging objects. However, the power is said to be output when the chain is rotating. (Fg 8)

Fig 8

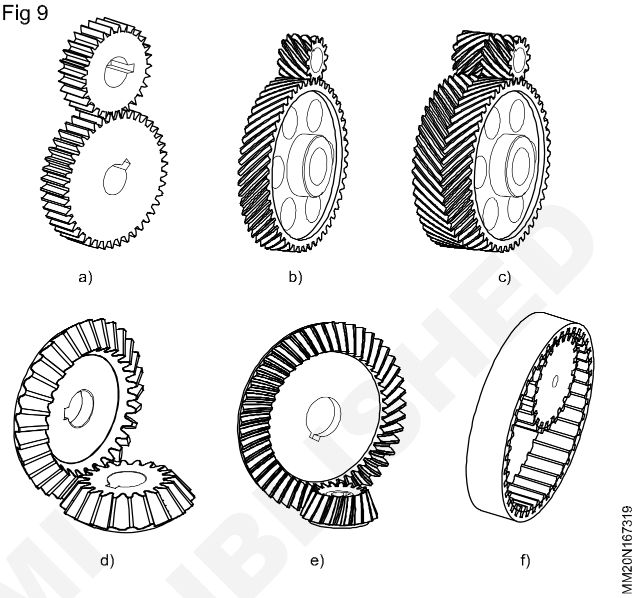


Gear drive

Transmission of motion or torque from one shaft to another by means of direct contact between gears

Gear drives are classified according to the relationship of the axes to the drives (Fig 9) spur gearing, with parallel axes; bevel gearing, (worm gears, hypoid gears, and screws), with overlapping axes. Rack and pinion gear are used to transmit rotary motion into linear motion Fig 1. Gear drive with spur gears: (a) straight-cut, (b) helical, (c) herringbone, (d) bevel, (e) with spiral teeth, (f) with internal gearing

Fig 9



Clutches

Objectives: At the end of this lesson you shall be able to
- **state the function of clutches**
- **name the different types of clutches**
- **state the application of the different types of clutches.**

Power transmission by clutches

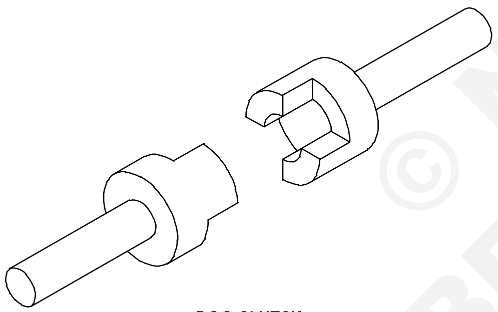
The purpose of the clutch is to connect or disconnect the various mechanisms to the power source. Various types of clutches are incorporated in machine tools.

Types of clutches

- Dog clutch
- Cone clutch
- Multi-plate clutch
- Electromagnetic multiple disc clutch.
- Overriding clutch
- Air clutch
- Centrifugal clutch
- Single plate clutch

Dog clutch (Fig 1)

Fig 1

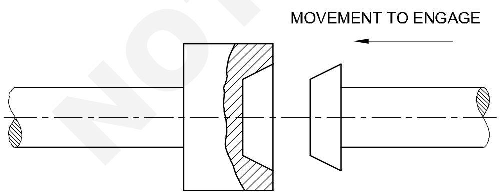


DOG CLUTCH

The dog clutch provides a positive drive but can only be engaged when two elements of the clutch are stationary or are being gently mood by hand.

Cone clutch (Fig 2)

Fig 2

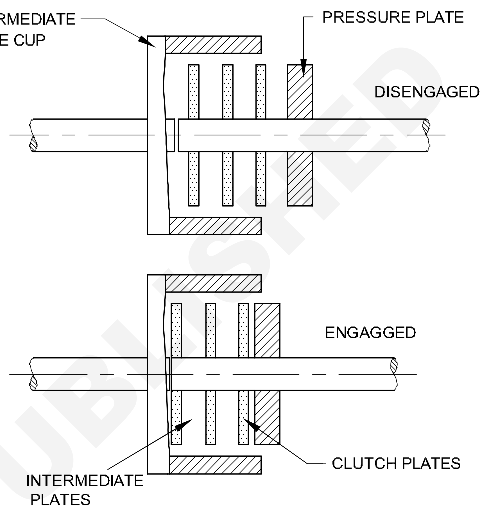


THE CONE CLUTCH

The cone clutch can be engaged progressively whilst one or both of the elements are rotating. It can transmit low power.

Multi-plate clutch (Fig 3)

Fig 3

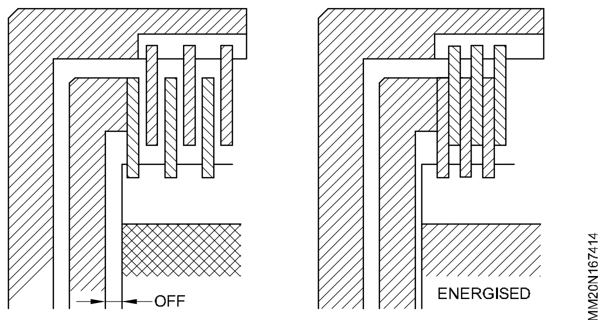


TRANSMISSION CLUTCHES

The multi-plate clutch is widely used in machine tools to connect the transmission gearbox to the driving motor. It is compact, smooth in operation and very powerful. A brake is frequently built into the clutch so that the transmission gearbox is rapidly brought to rest when the clutch is disengaged.

Electromagnetic multiple disc clutch (Fig 4)

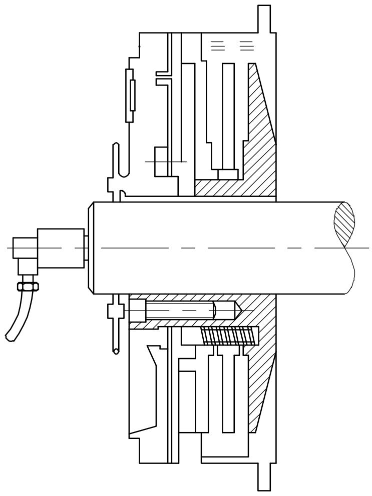
Fig 4



This clutch joins the shaft and the gear. It can be operated through a cable from a distance. If direct current is applied, it builds a magnetic field on a magnetic coil. It flows through the discs and firmly pulls and attracts the armature disc. The armature clamps the plates together so that they transmit the drive.

Air clutch (Fig 5)

Fig 5

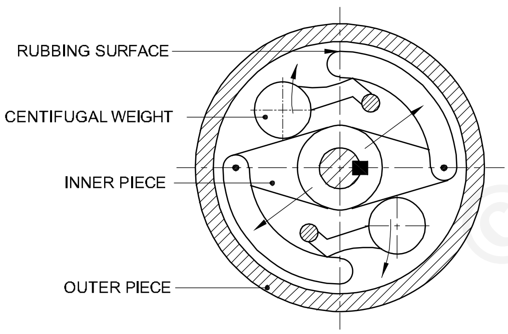


AIR -CLUTCH MECHANISM

An air clutch requires no mechanical adjustment since the moving parts automatically take up any wear on the friction surface. Air pressure must be maintained continuously while the clutch is engaged.

Centrifugal clutch (Fig 6)

Fig 6

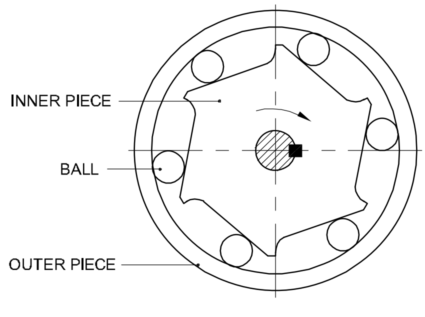


CENTRIFUGAL CLUTCH

When the inner piece has achieved a sufficiently high speed, the centrifugal weights swivel towards the outside, press the jaws on the outer piece with the friction lining and the clutch is closed. When the speed is reduced, the clutch opens by itself. Eg. moped.

Overriding clutch (Fig 7)

Fig 7

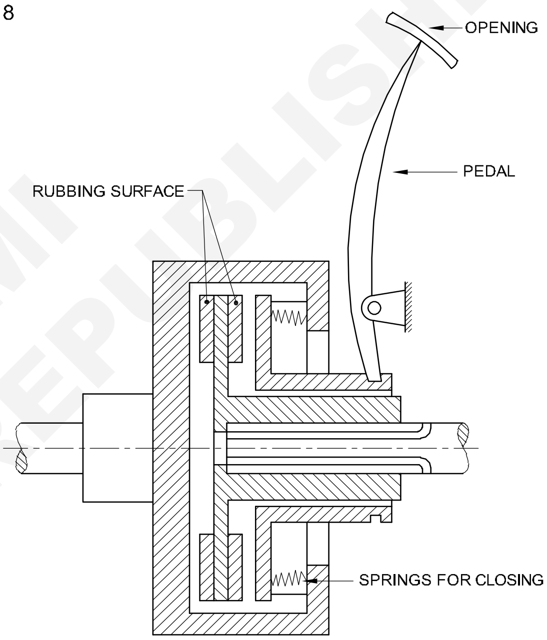


OVER -RIDING CLUTCH

When the inner piece has to be faster the overriding clutch transfers the turning moment by the climbing of balls or the cylindrical rollers. It opens in the opposite case.

Single plate clutch (Fig 8)

Fig 8



SINGLE PLATE CLUTCH

This is used in automobile vehicles. The rubbing surface is covered with friction lining of asbestos/plastic/cotton, with steel wires. The contact force is produced by springs which effect the continuous closing of the clutch. The pedal force acts against the spring force and opens the clutch.

Electro magnetic clutch

Objectives: At the end of this lesson you shall be able to
- **brief construction of electro magnetic clutch**
- **identify the different parts**
- **state the working principle of electro magnetic clutch**
- **purpose and use of electro magnetic clutch.**

General Description

These clutches use a single plate friction surface to engage the input and output members of the clutch. This style of clutch is used in applications ranging from copy machines to conveyor drives. They are the most common type of electromechanical clutches. Other applications for these clutches could include packaging machinery, printing machinery, food processing machinery and factory automation.

Engagement (Fig 1)

Electromechanical clutches operate via an electrical actuation, but transmit torque mechanically. when the clutch is required to actuate, voltage/current is applied to the clutch coil. The coil becomes an electromagnet and produces magnetic lines of flux. This flux is then transferred through the small air gap between the field and the rotor. The rotor portion of the clutch becomes magnetized and sets up a magnetic loop that attracts the armature. The armature is pulled against the rotor and a frictional force is applied at contact. Within a relatively short time the load is accelerated to match the speed of the rotor, thereby engaging the armature and the output hub of the clutch. In most instances, the rotor is constantly rotating with the input all the time.

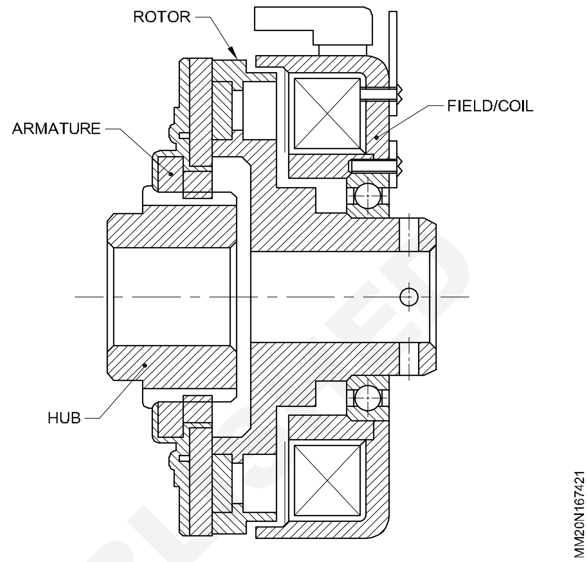
Disengagement

When current/voltage is removed from the clutch, the armature is free to turn with the shaft. In most designs, spring hold the armature away from the rotor surface when power is released, creating a small air gap.

Cycling

Cycling is achieved by turning the voltage/current to the coil on and off. Slippage should occur only during acceleration. When the clutch is fully engaged, there is no relative slip (if the clutch is sized properly). Torque transfer is 100% efficient.

Fig 1



Couplings - Types of couplings

Objectives: At the end of this lesson you shall be able to
- **state the types of couplings**
- **state the purpose of couplings.**

Introduction

- Power is transmitted from one end to the other commonly by means of shafts.
- If the distance between the two ends is large (say 8 - 10 m), it would be inconvenient and expensive to have one such long length of shaft both from manufacturing and transport point of views.
- Hence, it is recommended to connect a number of pieces by means of suitable couplings to transmit power from one end to the other.

Types

Shaft couplings may be broadly classified as :

1 Rigid or fast coupling
2 Muff coupling
3 Flange coupling
4 Flexible coupling
5 Pin bush coupling
6 Chain coupling
7 Gear coupling
8 Spider coupling
9 Tyre coupling
10 Grid coupling
11 Old ham coupling
12 Fluid coupling
13 Universal coupling

1 Rigid or fast couplings

This type of couplings provide rigid connection between the two shafts without permitting any relative motion between them.

The important types of rigid couplings are

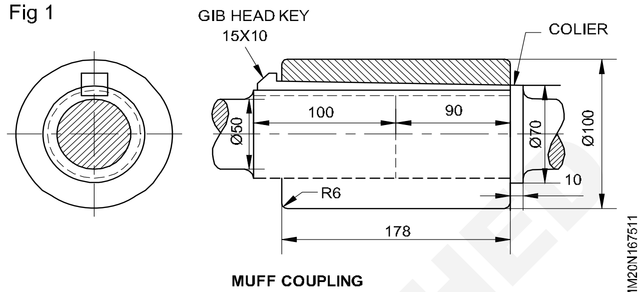
- Unprotected type flanged coupling
- Protected type flanged coupling
- Solid or forged flanged coupling
- Muff couplings
- Compression coupling

2 Muff Coupling

In muff or sleeve coupling shown in fig 1, the ends of the two shafts to be coupled butt against each other and a cast iron muff or sleeve envelops them.

A gib - headed sunk key is provided to hold the sleeve and the shafts together, thus forming a rigid coupling.

Fig 1



MUFF COUPLING

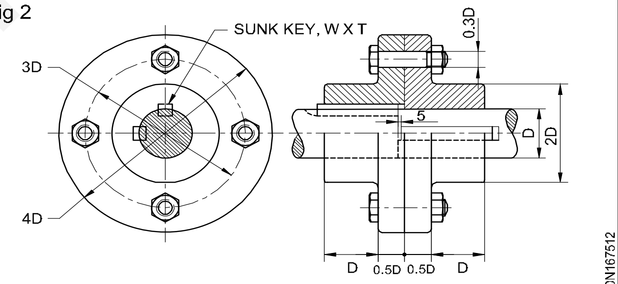
3 Flanged couplings

These are the standard forms of couplings, most extensively used. In a flanged coupling, flanges are either fitted or provided at the ends of shafts. The flanges are fastened together by means of a number of bolts and nuts. The number and size of the bolts depend upon the power to be transmitted and hence, the shaft diameter.

3.1 Flanged coupling with datachable flanges

In this, two flanges are keyed, one at the end of each shaft, by means of sunk keys (Fig 2). For ensuring correct alignment, a cylindrical projection may be provided on one flange which fits into the corresponding recess in the other.

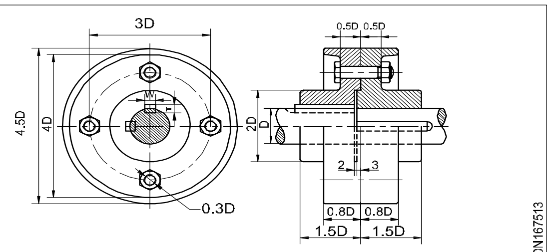
Fig 2



FLANGED COUPLING

In the design shown in figure, the bolt heads and nuts are exposed and liable to cause injury to the workman. Hence, as a protection, the bolt heads and nuts may be covered by providing an annular projection on each flange. A flanged coupling, using these flanges is called a protected flanged coupling (Fig 3).

Fig 3

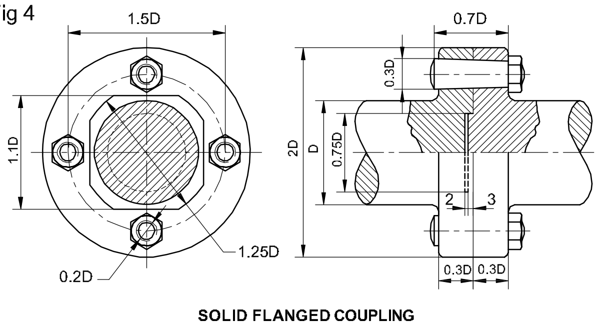


PROJECTIVE FLANGED COUPLING

3.2 Solid flanged coupling

Couplings for marine or automotive propeller shafts demand greater strength and reliability. For these applications, flanges are forged integral with the shafts. The flanges are joined together by means of a number of headless taper bolts (Fig 4).

Fig 4

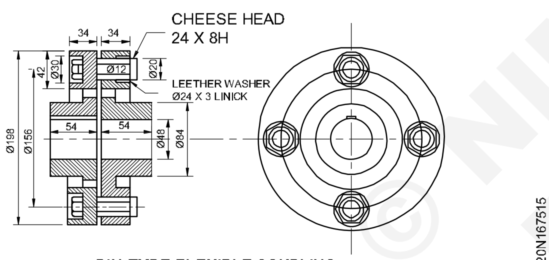


SOLID FLANGED COUPLING

4 Flexible Coupling

- Flexible couplings are used where slight relative movement is required or the axis of shafts run slightly out of line.
- Pin-type coupling shown in Fig 5 is the most commonly used flexible coupling.

Fig 5



PIN-TYPE FLEXIBLE COUPLING

- Here the motion from one half of the coupling to the other half is imparted with the help of driving pins rigidly bolted to one flange and loosely fitting corresponding holes in the other.
- Brass bush and rubber covering is provided on the driving pins for absorbing shocks and as insulators.

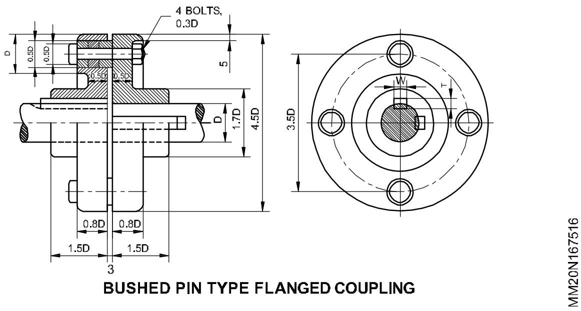
5 Bushed Pin type Flanged Coupling (Fig 6)

It is the modified version of a protected flanged coupling. In this, bolts are replaced by bushed pins. The smaller ends of the pins are rigidly fastened by nuts to one of the flanges, while the enlarged ends are covered with flexible material like leather or rubber bushes, in the other flange. The flexible medium takes care of mis-alignment, if any, and acts as a shock absorber. These couplings are used to connect prime mover or an electric motor and a centrifugal pump.

6 Chain Coupling (Fig 7)

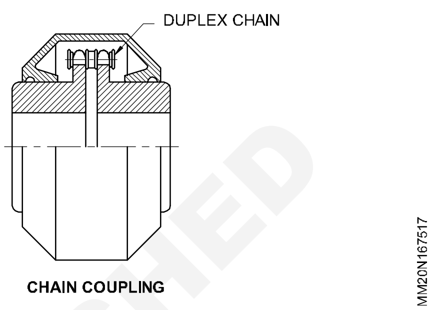
Flanges replaced a sprocket on each shaft. The coupling is by a duplex chain wrapped over both adjacent coupling.

Fig 6



BUSHED PIN TYPE FLANGED COUPLING

Fig 7

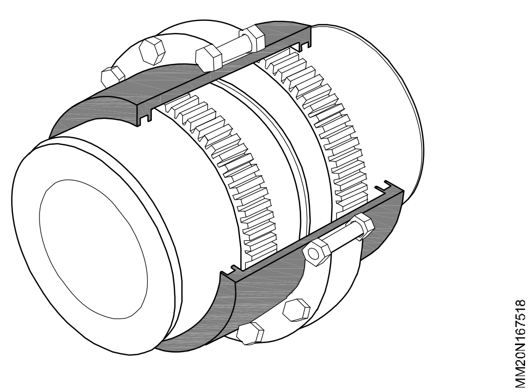


CHAIN COUPLING

7 Gear Coupling (Fig 8)

Both coupling halves have a raised rim machined as an external gear. The sleeve which couples the two shafts comprises two halves bolted together, each half having a machine internal gear. This coupling requires lubrication. The coupling is capable of high speeds and high power capacity.

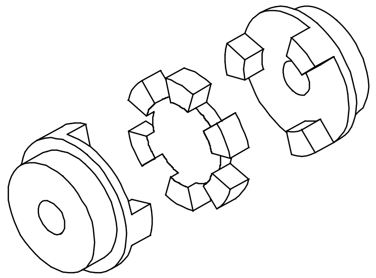
Fig 8



8 Spider (Fig 9)

Both half of the couplings have three shaped lugs. When the coupling halves are fitted together the lugs on one half fit inside the spaces between the lugs on the other side. A rubber insert with six legs fits within the spaces between the lugs. The drive is by the lugs transmitting the torque through the rubber spider spacer. This coupling is only used for low power drives.

Fig 9

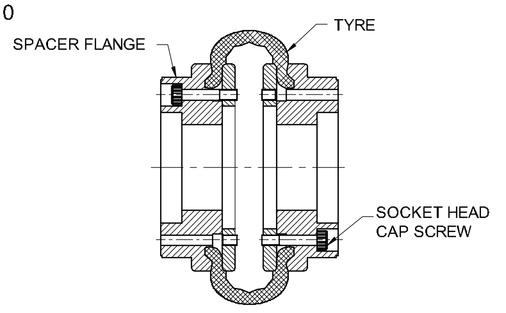


SPIDER COUPLING

9 Tyre Coupling (Fig 10)

Tyre coupling device is used to reduce vibration in engines and also reduces the torque oscillation. It is available in different versions such as F or H type. And customers can find tyre coupling in various dimensions and in taper lock fitting models. It is applicable in compressors, pumps, blowers, etc.,

Fig 10

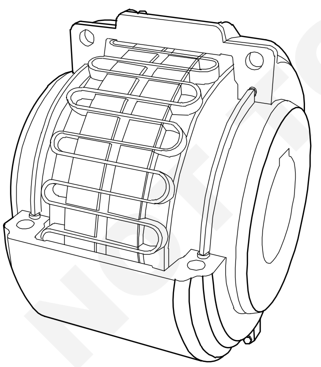


TYRE COUPLING

10 Grid Couplings (Fig 11)

Metal coupling that provides positive protection against the damaging effects of shock loads and vibration. Both horizontal cover, and vertical cover designs are available. Grid couplings are an excellent choice where torsional flexibility/vibration damping are primary concerns.

Fig 11



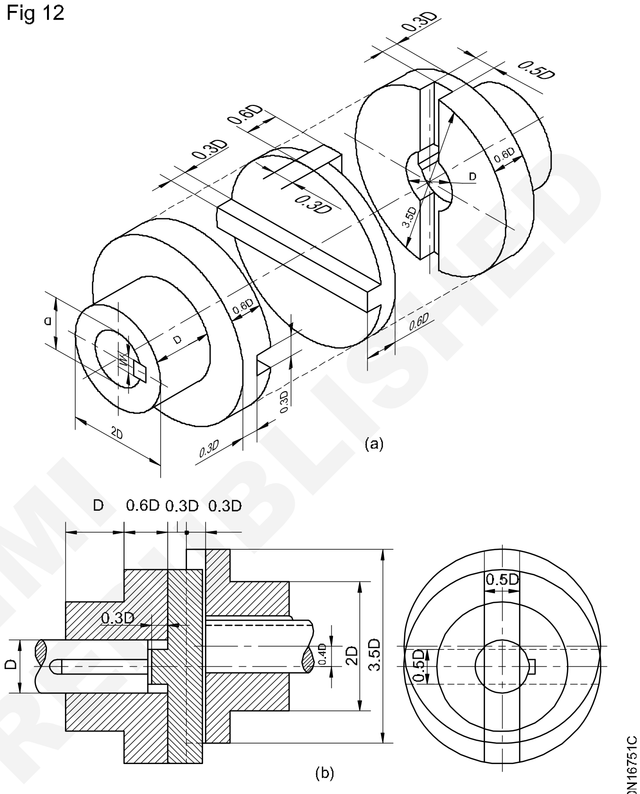
- Easy to assemble/replace
- Part-for-part interchangeable with industry standard grid coupling designs.
- Coupling sizes 2020 through 2140 in-stock in a range of standard bore sizes.
- Shot-peened tapered grid flex element for long life.

Typical Applications :

- Pumps
- Gear Boxes
- Electric Motors
- Fans/Blowers
- Conveyors
- Compressors

11 Oldham Coupling (Fig 12)

Fig 12



OLDHAM COUPLING

It is used to connect two parallel shafts whose axes are at a small distance apart. Two flanges, each having a rectangular slot, are keyed, one on each shaft. The two flanges are positioned such that, the slot in one is at right angle to the slot in the other.

To make the coupling, a circular disc with two rectangular projections on either side and at right angle to each other, is placed between the two flanges. During motion, the central disc, while turning, slides in the slots of the flanges. Power transmission takes place between the shafts, because of the positive connection between the flanges and the central disc.

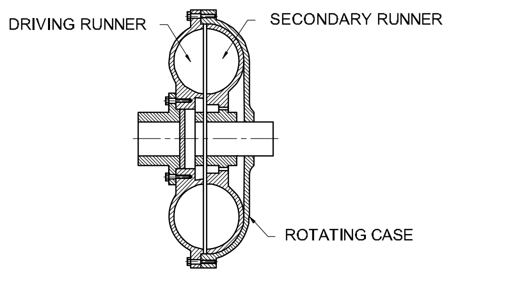
12 Fluid Coupling (Fig 13)

Based on both coupling halves having vanes within a housing (case) containing viscous fluid which rotates with the driving shaft. The rotation is transmitted from one side (Driving) to the other (Secondary) via the viscous fluid. The coupling provides a soft start.

13 Universal Coupling (Fig 14)

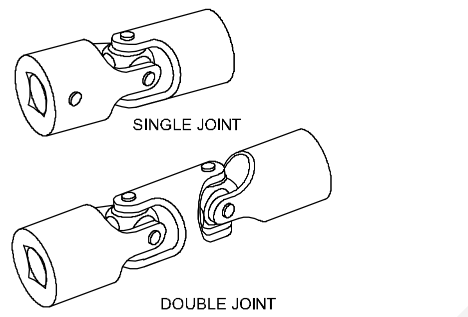
Coupling which allows large angle between drive halves (20 - 30^0). Generally based on a yoke mounted on each shaft. Between to yokes is mounted a trunnion cross. Needle bearings are used at the bearing points between the cross and the yokes. These type or units are used in pairs on carden shafts. Uses widely on rear wheel drive vehicle prop shafts.

Fig 13



FLUID OUPLING

Fig 14

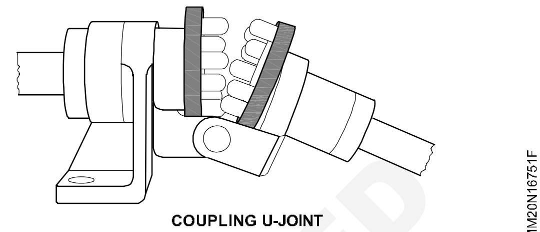


UNIVERSAL COUPLING

14 Universal Coupling-Uni-Joint (Fig 15)

Simplest type of coupling which allows large angle between drive halves. Each side of coupling includes protruding pins. The halves of the coupling are fastened in a pivoting assembly. At all angles up to about 40^0 the pins interlock with each other and rotation on one half forces the other half to rotate. Low power use only. Not smooth. Not reliable. Really only suitable for remote manual operations.

Fig 15



COUPLING U-JOINT

Brakes and braking mechanism

Objectives: At the end of this lesson you shall be able to
- **state the purpose of brakes**
- **state the types of brakes**
- **state brake liner materials.**

Purpose of brakes

The brake is a frictional device whose primary function is to control the motion of a machine or a machine member. In doing so, it is called upon to bring to rest a body which is in motion or to slow it down or to hold it in state of rest or of uniform motion against the action of external forces or couples. Other uses of brakes are to release a load and control its speed or to prevent an unwanted reversal of the direction of rotation. In the process of performing this primary function, it is required to absorb kinetic energy of the moving parts or the potential energy of the objects being lowered by hoists, elevators, etc. and convert these energies into internal energy of the brake components and dissipate it in the form of heat. This heat is dissipated by means of convection heat transfer to the surrounding air or by means of water which is circulated through the passages in the former both the members to be engaged are in motion, a brake connects a moving member to a stationary member.

Two factors are of paramount importance in the design of a brake:

- Determination of the torque it must provide.
- Amount of energy which the brake must dissipate repeatedly.

Types of brakes

The brakes are usually classified according to the means for transforming energy by the braking element. The common types of brakes are :

Hydralic Brakes

a) Pump or Hydrodynamic b) Agitator

Electric Brakes

a) Generator b) Eddy Current

Mechanical Brakes

a) Block b) External and internal shoe

c) Band d) Disk e) Slipper

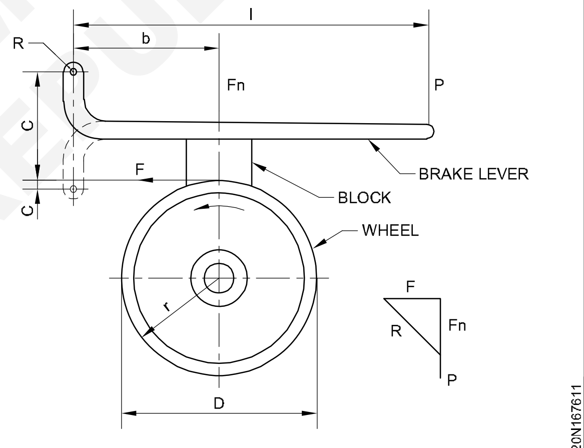
Both hydralic and electric brakes are mostly used where large amounts of energy are to be transformed while retarding the load e.g. laboratory dynamometer, highway trucks and electric locomotive. They also find application in the rectardation of moving loads is also limited. The most important consideration in the use of these brakes is that these should not be dependent upon to hold a load stationary since the braking torque is a function of the speed of rotation of the brake rotor.

In this chapter, only the mechanical brakes shall be discussed. The mechanical brakes may be divided into two groups according to the direction of the acting force : (a) Radial brakes, (b) Axial Brakes.

Axial brakes may be further classified as ”Disc brakes” and “Cone Brakes”.

Block or Shoe Brakes : In these brakes, relatively rigid blocks or shoes press against the inside or outside surfaces of the brake drum. The brake drum is keyed on to the shaft. A single block brake is shown in fig 1. P is the force which is applied at the end of the brake arm or lever to press the block against the brake drum. Fn is the normal reaction between the block and the drum. The brake arm is pivoted about the pin A.

Fig 1



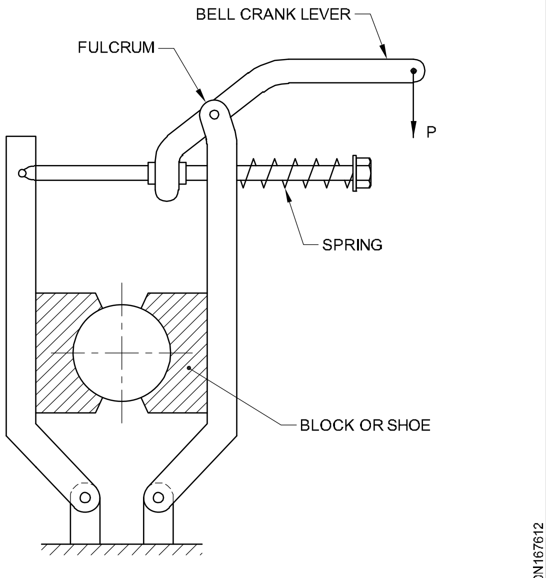
BLOCK BRAKE

Double Block or Shoe Brake

When a single block brake is applied to a rolling wheel, an additional load is thrown on the shaft bearings due to the normal force (R_N). This produces bending of the shaft. In order to over come this drawback, a double block or shoe brake, as shown in fig 2, is used. It consists of two brake blocks applied at the opposite ends of a diameter of the wheel which eliminate or reduces the unbalanced force on the shaft. The brake is set by a spring which pulls the upper ends of the brake arms together. When a force P is applied to the bell crank lever, the spring is compressed and the brake is released. This type of brake is often used on electric cranes and the force P is produced by an electromagnet or solenoid. When the current is switched off, there is no force on the bell crank lever and the brake is engaged automatically due to the spring force and thus there will be no downward movement of the load.

In a double block brake, the braking action is doubled by the use of two blocks and these blocks may be operated practically by the same force which will operate one.

Fig 2



DOUBLE BLOCK OR SHOE BRAKE

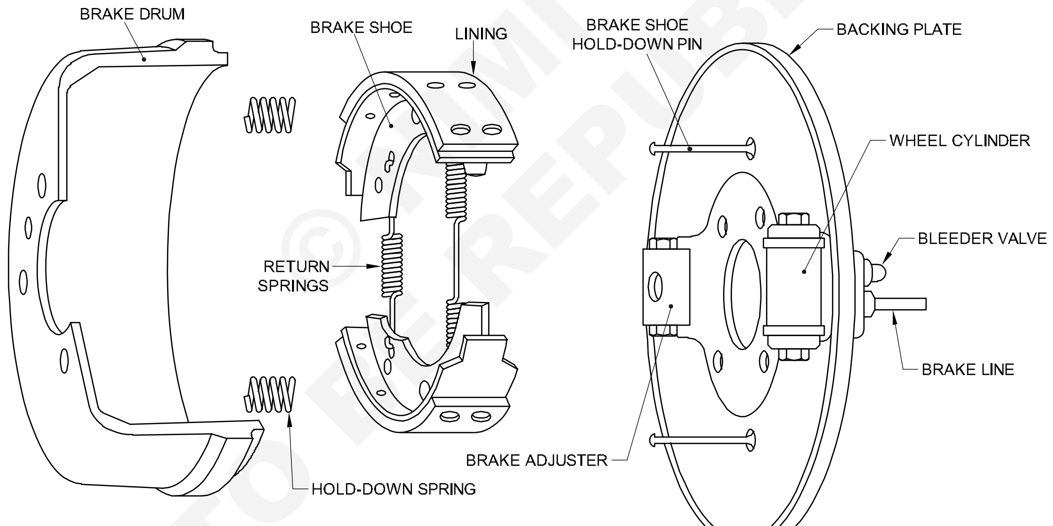
Internal Expanding Brake (Fig 3)

An Internal expanding brake consists of two shoes S_1 and S_2 as shown in Fig 4. The outer surface of the shoes are lined with some friction material (usually with Ferodo) to increase the coefficient of friction and to prevent wearing away of the metal. Each shoe is pivoted at one end about a fixed fulcrum O_1 and O_2 and made to contact a cam at the other end. When the cam rotates, the shoes are pushed outwards against the rim of the drum. The friction between the shoes and the drum produces the braking torque and hence reduces the speed of the drum. The shoes are normally held in off position by a spring as shown in Fig 4. The drum encloses the entire mechanism to keep out dust and moisture. This type of brake is commonly used in motor cars and light trucks.

Band Brakes

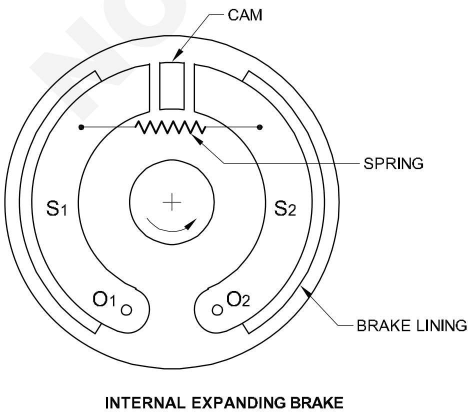
The general arrangement of a band brake is shown in Fig 5. It consists of a steel band or strap lined on one side with leather, wooden blocks or an asbestos composition material. The actuating force is applied so that it tightens the band around the brake drum.

Fig 3



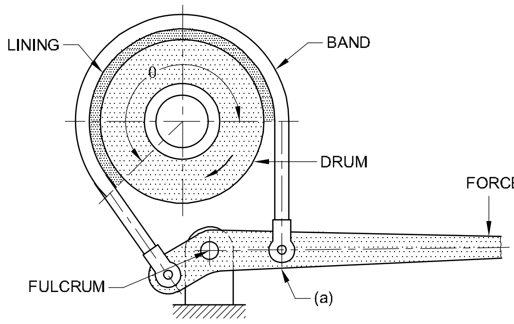
A TYPICAL AUTOMOTIVE LONG-SHOE, INTERNAL, EXPANDING RIM BRAKE, COMMONLY CALLED A DRUM BRAKE

Fig 4



INTERNAL EXPANDING BRAKE

Fig 5



BAND BRAKE

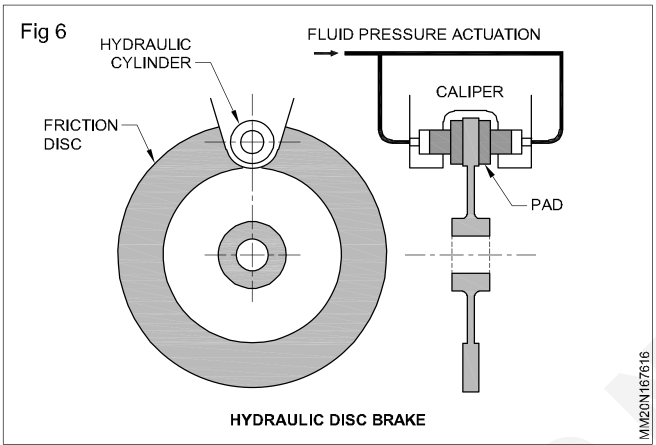
It consists of flexible band of lined with friction material, which embraces a part of the circumference of the drum.

Here one end of band attached to the fixed pin or fulcrum of the lever while other end is attached to the lever at (a) as shown in the fig (5).

When a force is applied to the lever at (p) the lever turn about the fulcrum pin at (o) and tightends the band on the drum and hence brakes are applied.

Hydraulic disc brake (fig 6)

A hydraulically activated disc brake comprises two opposing pistons each faced with a pad of lining material. When the hydraulic pressure is increased the pads are forced against the rotating metal friction disc, exerting a normal force at each contact. The two normal forces cancel one another axially but cause additive tangential friction forces which oppose the disc's motion and decelerate it.



Advantages of Disc Brake:

- Disc brake requires less effort (brake torque) to stop the vehicle compare to drum brake.
- It generates less heat compare to drum brake for the same brake torque.
- Ease of maintenance as disc brake is outside the wheel rim.
- It cools down faster compare to drum brake.
- If worn out brake shoes are not changed at proper time it can cut the brake drum in drum brake. Disc brake does not have such problem.
- It is less likely to skid compare to drum brake in wet condition.
- It is much safer than drum brake in hard braking condition. Under such condition drum brake can lock up the rear wheel.
- It has brake pad wear indicator which is not there in drum brake.

Disadvantages of Disc Brake

- It is expensive compare to drum brake.
- More skills require to operate disc brake compare to drum brake that's the reason why some people are not comfortable with disc brake.
- If any air remains in disc brake system, it can cause accident as the brake will not work effectively.
- Disc brake assembly has more moving parts and much complex than drum brake.
- It requires lot of effort at maintenance front like brake fluid (bleeding), change of brake pads etc compare to drum brake.

Materials for brake drums and for brake linings

The most common material for brake drums is cast iron with some alloying elements added. When good heat conduction is needed stainless steel, aluminium and monel can also be used. Brake linings are usually made of some form of asbestos and binders. Most of the time, the asbestos based linings are moulded. These linings are used upto temperatures of about 200^{0}C. For temperature range of 200^{0}C to 400^{0}C, sintered metal linings are usually employed. Sinteral metal linings with ceramic particles can be used for temperature range of 400^{0}C to 540^{0}C. By increasing the ceramic content, temperatures as high as 1000^{0}C can be tolerated. Ceramic linings have high thermal conductivity, long life and very stable friction properties. However, these are expensive, have lower co-efficient of friction and must be made to shape because of their rigidity. Linings are attached to the drum usually by riveting or bonding. Riveting is cheaper, and simple, but its drawback is that the usable lining thickness depends upon the depth to which the rivet head can be counter sunk. Bonded linings have greater effective thickness and more friction area but are more expensive.

Inspection and maintenance of brakes

Objectives: At the end of this lesson you shall be able to
- **explain the steps involved in inspection and maintenance of brakes.**

Inspection and maintenance

In all of the following procedures, maintenance manuals shall be referred to for such items as torque values, voltage settings, condemning limits, clearance measurements and specific procedure methodology.

Devices must be cleaned for proper inspection. These procedures cover only the visible inspection, adjustments and functional testing.

Documentation of the inspection and maintenance process will enhance the reliability and accountability of the process.

Brake control equipment (visual/audible and operational inspection)

1 Inspect air brake operating control equipment for damage, leaks, or loose components. Correct any damage or leaks found and secure loose components.

2 Verify proper position of all cut-out valves and seals as required.

3 Inspect brake control unit for damaged or loose components and air leaks. Correct any damage found and secure loose components.

4 Inspect hydraulic pressure control unit for damaged or loose components, hydraulic leaks and fluid level. Correct any damage found, secure loose components, and refill and bleed as required.

5 Inspect mounting hardware, torque stripes and safety/ tamper proof seals. Repair or replace as required.

6 Inspect the hydraulic accumulator for damaged or loose components. Pressure-test the accumulator.

7 Clean or replace filters/breathers as recommended

8 Verify operation of trip valve/trip switch, if equipped, and lubricate as recommended.

9 Verify proper pressure with a test gauge in all modes of brake and release conditions.

10 Perform self-tests and verify proper brake operation.

11 Review on-board recording equipment for recorded faults.

Hand brake equipment/parking brake equipment (visual/audible and operational inspection)

1 Inspect hand brake equipment/parking brake equipment for damage, leaks, or loose components. Correct any damage or leaks found and secure loose components.

2 Apply and release the hand brake equipment/parking brake equipment; verify proper operation and inspect for interference and damage.

3 Lubricate the hand brake equipment/parking brake equipment as recommended.

4 Verify manual quick-release mechanism.

Disc brake equipment (visual/audible and operational inspection)

1 Inspect disc brake units for damage, leaks, lose or missing components. Correct any damage or leaks found and secure loose and replace missing components.

2 Visually inspect brake lines and hoses for leaks, longitudinal cracks, mounting and chafing; repair as required.

3 Apply and release the brakes and verify operation for:

- proper operation of the disc brake unit
- proper piston travel
- no indication of binding or fouling of the disc brake unit's levers and/or pins.

4 Lubricate the disc brake unit as recommended

5 Inspect the brake disc faces for damage, cracks or nicks along the outer periphery of the brake disc. Some radial and thermal checks and cracks occur during operation.

6 Inspect the hub for lateral movement on axle seat, cracks, broken or missing tangs, or damage.

7 Inspect brake disc mounting hardware, such as bolts, nuts, washers and retaining mechanisms, for proper attachment

8 Measure the brake disc at the greatest wear locations for proper thickness and improper wear patterns such as scoring or excessive dishing.

9 Inspect the brake disc for any fin obstructions or damage. Refer to the OEM for condemning and inspection recommendations

10 Inspect for missing disc brake pads. Replace missing disc brake pads and ensure that the disc brake pad is properly secured.

11 Inspect the thickness of the disc brake pads. Replace the disc brake pad if remaining wear material is less than the condemning limit

12 Inspect disc brake pad for broken or missing friction braking material.

13 During disc brake pad replacement, the disc brake ad securing mechanism shall be visually inspected and replaced if broken, worn, or damaged.

14 Inspect disc brake unit for worn bushings and pins. Refer to OEM for condemning and inspection recom mendations

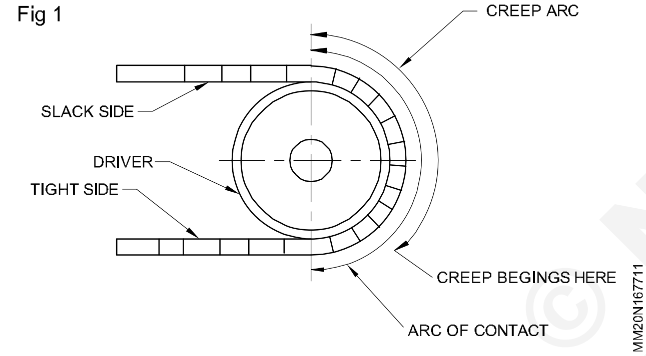
Belts - types - belt fasterners

Objectives: At the end of this lesson you shall be able to
- **distinguish between creep and slip**
- **define belt dressing**
- **name the different types of belts**
- **state the effect of creep and slip**
- **state the advantage, classification and designation of 'V' belt**
- **calculate flat belt length**
- **state the different types of belt fasteners.**

Creep and slip of belt (Fig 1)

As the belt turns on a pulley it tends to stretch on the contact area of the driving pulley and shorten on the driven pulley. This localised movement of the belt is a direct result of the elastic stretch and is known as creep. Greater the load more will be the creep. The figure shows the condition of belt as a result of creep.

Fig 1



Slip is the actual difference caused between the surface speed of the belt and pulley. The effect of slip may be reduced by decreasing the pulley ratio and maintaining proper alignment. Creep, being the physical characteristic of the belt, cannot itself be controlled. Slip and creep jointly cause power loss.

Belt dressing

Due to the continuous rubbing of the belt on the surface of the pulley the belt gets dried up due to friction, and heat is generated. This causes the belt to slip.

To keep the belt supple and free from cracks, belt dressing is appliled. Tallow or powdered resin are good dressing materials which are applied on the inner face of the belt. This improves the gripping property of the belt.

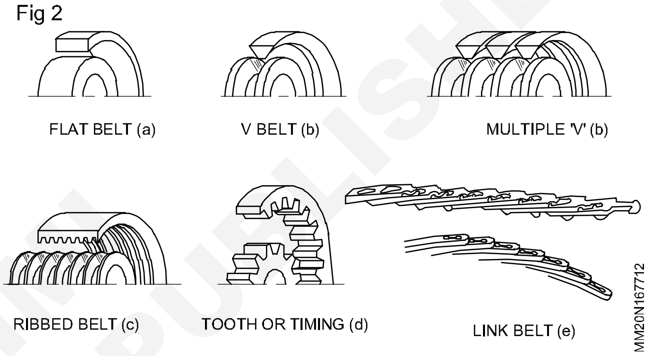
Types of belts

Basically five types of belts are used for the transmission of power.

- Flat belt (Fig 2a)
- V-belt and multiple V-belt (Fig 2b)
- Ribbed belt (Fig 2c)
- Toothed or timing belt (Fig 2d)
- Link belt (Fig 2e)

The choice of a particular belt depends upon speed ratio, centre distance, flexibility, strength, economy and maintenance consideration of the driving system.

Fig 2



V-belts

'V'belt drives are generally used when the distance between the shafts is too short for flat belt drives. Owing to the wedge action between the belt and the sides of the groove in the pulley, the V belt is less likely to slip, hence more power can be transmitted.

The endless V belt is shaped roughly like a trapezium in cross-section, and is made of cord and fabric, and is treated with rubber and moulded together in a uniform manner and shape. The cross-sectional symbol of a V-belt is shown in Fig 3.

Advantages of V-belt drive

- It is compact, so installation is possible in limited space.
- It is used when the centre distance between the driver and the driven pulleys is short.
- Less vibration and noise.
- Cushions the motor and bearing against load fluctuation.
- Easy replacement and maintenance.

Classification of 'V'belts

The 'V' belts are classified into 5 groups as per IS.2494-1974 namely A,B,C,D and E. The nominal included angle of the V-belt shall be 40^{o}.

Table 1 given below lists the standard sizes of V-belts from Section A to E.

Fig 3

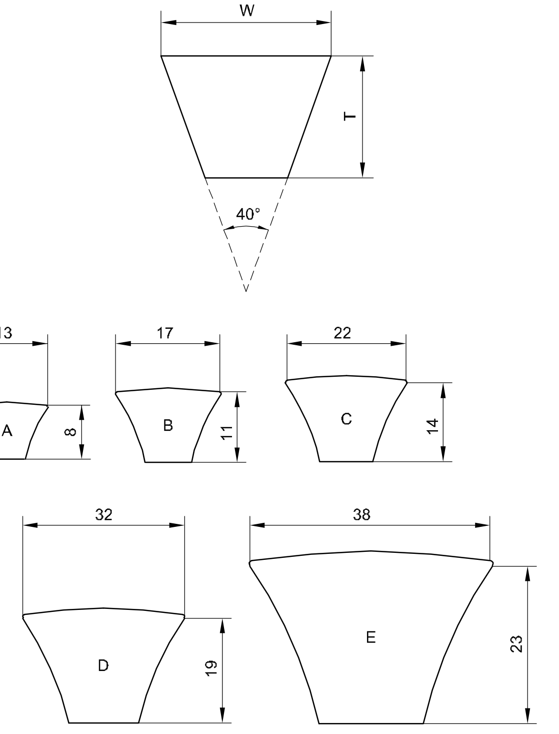


TABLE - 1

Cross-section Symbol	Nominal Top Width W (mm)	Nominal Thickness (T)
A	13	8
B	17	11
C	22	14
D	32	19
E	38	23

Individual manufacturer's belts may deviate slightly from these dimensions for various constructional reasons. Crowning, if any, in belts should be disregarded for the measurement of thickness.

Designation of V-belt as per IS.2494

The V belts conforming to this standard shall be designated by the cross-section symbol, nominal inside length and the number of IS: standard.

Example

C 3048 IS: 2494

C = V-belt cross-section

3048 = Nominal inside length in mm. in untensioned state.

Belt length calculation - (flat belts)

The best way to determine the correct length of a belt is by wrapping a steel tape around the pulleys and recording the measurement. If the belts are to be spliced and cemented, an additional amount of belt length must be provided for making the lap. The formula to determine the belt length is given below.

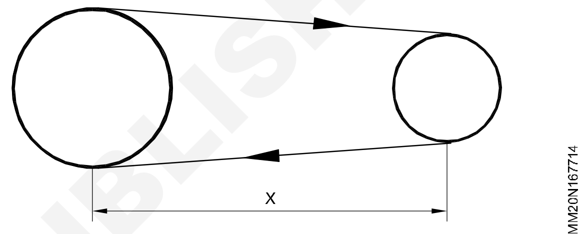
CALCULATION

Open belting (Fig 4)

If L = length of open belting
D = dia. of larger pulley
d = diameter of smaller pulley
x = centre distance between the pulleys

then, $L = \frac{D + d}{2} \times 3\frac{1}{7} + 2x$

Fig 4

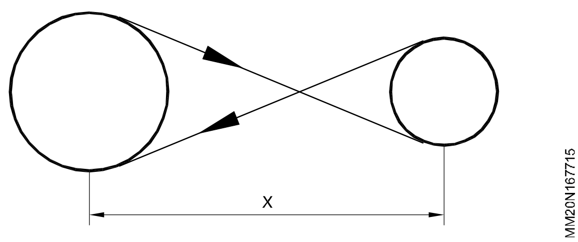


Cross-belting (Fig 5)

If L_C = length of cross-belting
C = circumference of larger pulley
c = circumference of smaller pulley
R = Radius of larger pulley
r = radius of smaller pulley
x = centre distance between the pulleys

then, $L_c = \frac{C}{2} + \frac{c}{2} + \sqrt[2]{x^2 + (R + r)^2}$

Fig 5



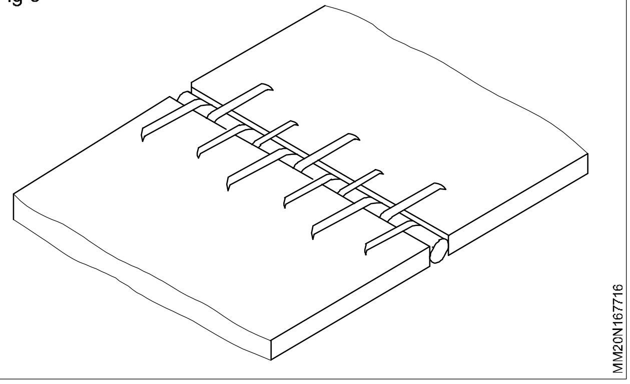
Types of fasteners

The belt fasteners commonly used in addition to the alligator type are as follows.

Wire type belt fastener

Fig 6 shows the wire type fastener generally used on light duty machines.

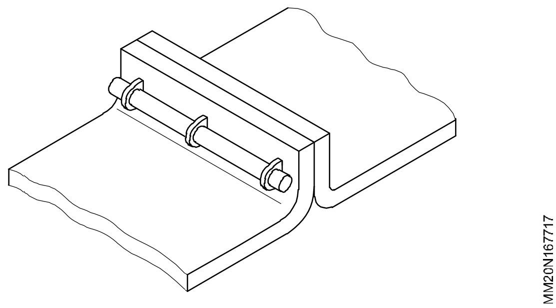
Fig 6



'Lagrelle' type belt fastener

Fig 7 shows a lagrelle type fastener used on heavy duty machines.

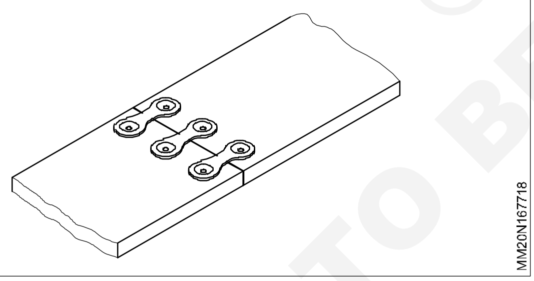
Fig 7



Jackson-type belt fastener

The Jackson-type fastener illustrated in Fig 8 is used on medium duty machines.

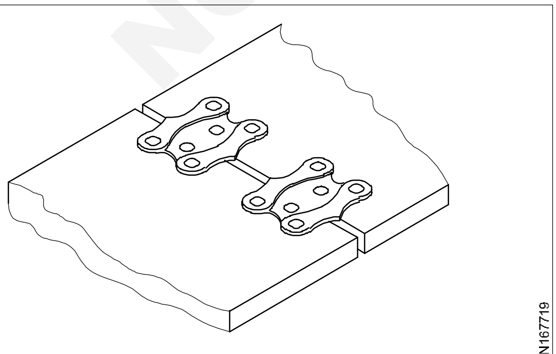
Fig 8



Crescent plate belt fastener

Fig 9 shows a mechanical type belt fastner which is used on medium duty machines.

Fig 9

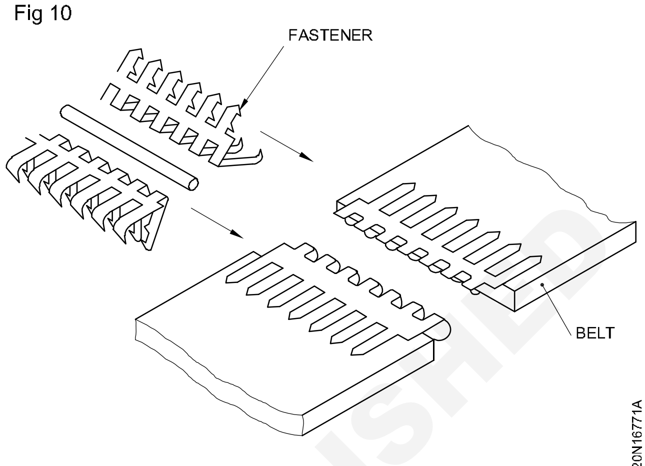


"CRESCENT" - PLATE BELT FASTENER

Belt fasteners (Alligator type)

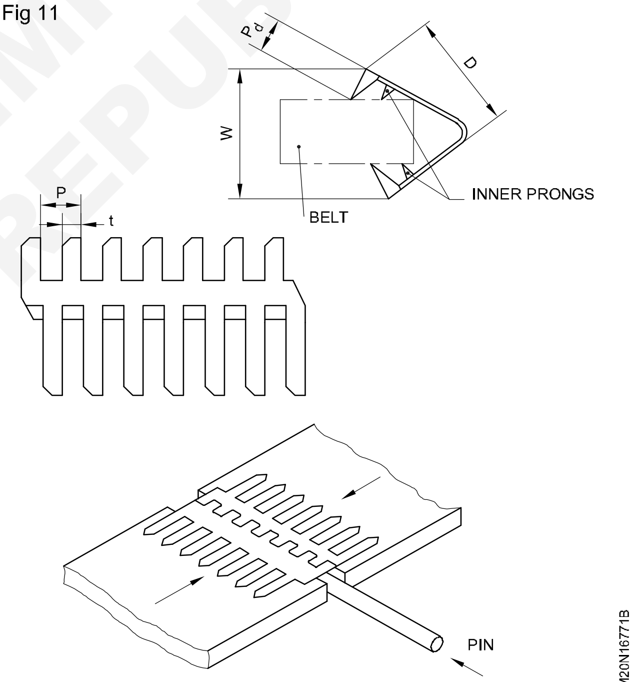
Alligator type fasteners are used in joining belting for industrial purposes. The belt fastener is made of steel sheets conforming to IS:513-1973. The pins shall be made from mild steel wire conforming to IS: 280-1972. Belt fastners are shown in Fig 10 and the position of the pin in a joint is illustrated in Fig 11.

Fig 10



ALLIGATOR TYPE BELT FASTENER

Fig 11



WEAR ADJUSTMENT BY PARALLEL GIB

Specification

The fastener designation and pin size, thickness of belt and other dimensions are given in the table -1 as per IS: 5593-1980.

Table - 1

Fastener Designa-tion	Thickness of belt	Metal thick-ness (Sheet)	Point depth P_d	Approx overall width W	Approx overall depth t_1 Min D	Width of bar prong P	Pitch of prong
15	3 to 4	1.0	5.0	18	13	2.5	6
20	4 to 5	1.1	6.5	22	17	3	8
25	5 to 5.5	1.2	7.0	25	21	3	8
27	5.5 to 7	1.2	8.0	29	24	3	8
35	7 to 8	1.8	9.5	32	30	4	10
45	8 to 9.5	1.8	11.0	38	31	5	12
55	9.5 to 11	2.0	14.0	48	40	6.5	16
65	11 to 13	2.0	16.0	54	41	6.5	16

Pin Size

Fastener designation	Pin size mm
15,20,25	2.64
27,35	3.25
45,55,65	4.06

Pulleys - types - uses

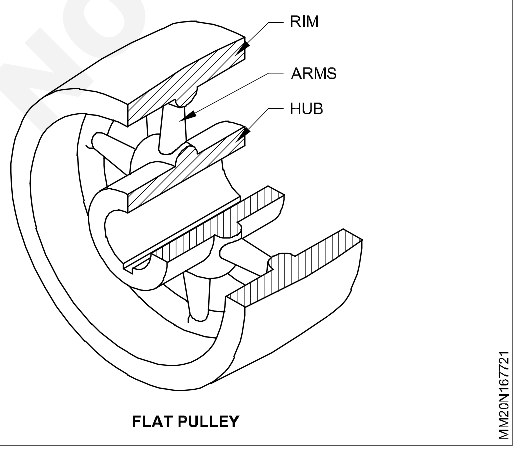
Objectives: At the end of this lesson you shall be able to
- **state the different types of pulleys and their uses**
- **state the purpose of crowning of a pulley.**

Pulley for flat belt

Pulleys for flat belts are made from cast iron or mild steel and are available in solid or split form.

The flat pulleys have a wide rim with a crowned surface for retention of the belt. The hub is strongly designed and provides the means of securing the pulley to the shaft. The arms unite the hub and rim into a rigid assembly. The arms of a pulley may be of circular or elliptical cross-section, but larger at the hub than at the rim. (Fig 1)

Fig 1



FLAT PULLEY

Crowned face of pulley

The rim of a pulley for flat belt is generally made convex and this is called the crowned face of the pulley. The crown faced pulley will keep the belt centralised even if there is any slight tendency to run off. Shifting the belt from the fast pulley to the 'loose' pulley will be quick and easy. Excessive crowning will be injurious to belting.

'V' groove pulley

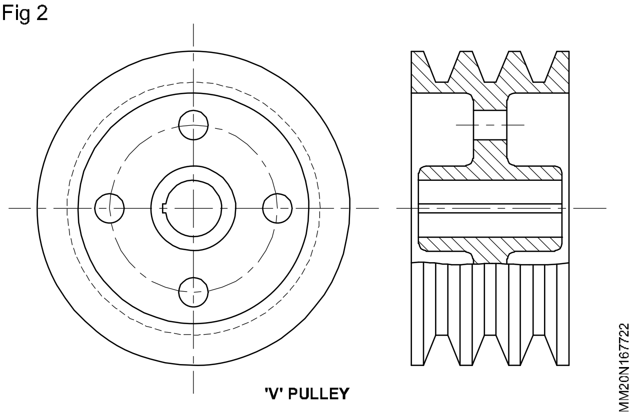
These pulleys have one or more 'V' grooves to carry the V belts. Fig 2 shows a V belt pulley having three V grooves. These pulleys are widely used in transmission of motion in machine tools and are made from cast iron, wrought iron, mild steel or wood.

Fast and loose pulley

Pulleys are usually secured to their shafts by means of a key or grub screw. The function of the pulley keyed to the shaft is to convey rotation from the driving to the driven pulley by means of a belt. This is called a fast pulley.

The loose pulley is not keyed to the shaft and is free to rotate on the shaft.

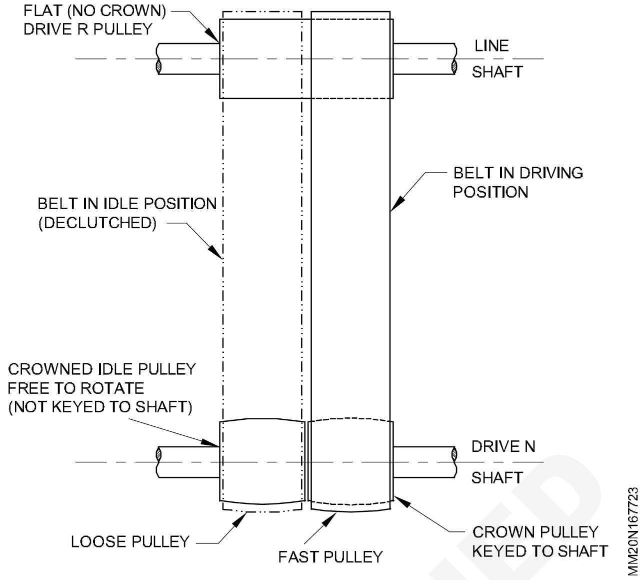
Fig 2



Function

A machine can be easily stopped or started whenever required by the use of a pair of fast and loose pulleys. This pair is mounted on a counter- shaft near the machine to be operated. When the driving belt from the main shaft is on the fast pulley, the countershaft is in motion. If the belt is shifted from the fast pulley on to the loose pulley, the countershaft will stop rotation. Fig 3 shows the position of the fast and loose pulleys in a driving system.

Fig 3



Rope pulleys

Rope pulleys are grooved to carry one or more ropes by means of which power is transmitted to shafts at different heights and at varying distances.

Belt installation

Objectives: At the end of this lesson you shall be able to
- **describe the belt drive alignment**
- **explain the method of belt alignment**
- **brief the steps in installation of belt and checking the belt tension.**

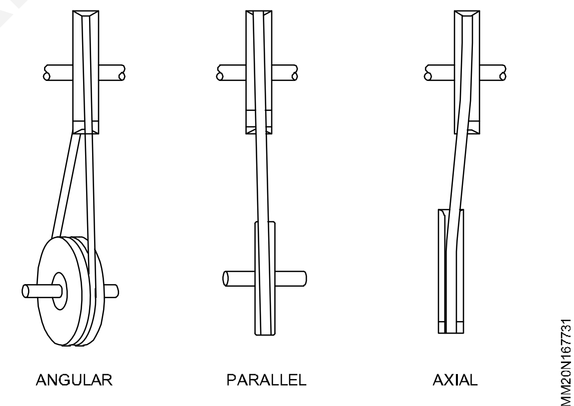
"V" Belt Drive Alignment

The life of a "V" belt is dependent on: first the quality of materials and manufacture; and second on installation and maintenance. One of the most important installation factors influencing operating life is belt alignment. In fact, misalignment is probably the most frequent cause of shortened belt life. While "V" belts because of their inherent flexibility can accommodate themselves to a degree of misalignment not tolerated by other types of power transmission, they still must be held within reasonable limits. Maximum life can be attained only with true alignment and as misalignment increases belt life is proportionally reduced. If misalignment is greater than 1.5m for each 300mm of centre distance, very rapid wear will result.

Misalignment of belt drives results from shafts being out of angular or parallel alignment, or from the sheave grooves being out of axial alignment. These three types of misalignment are illustrated in Fig. 1.

Because the shafts of most "V" belt drives are in a horizontal plane, angular shaft alignment is easily obtained by levelling the shafts. In those cases, where shafts are not horizontal, a careful check must be made to ensure the angle of inclination of both shafts is the same. Before any check is made for parallel-shaft and axial-groove alignment, the shaft and sheaves must be checked for run-

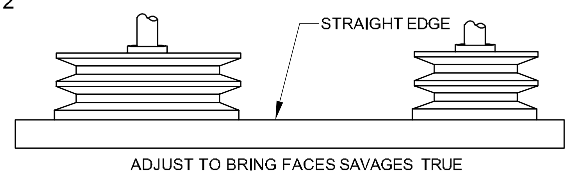
Fig 1



"V" Belt Alignment

The most satisfactory method of checking parallel-shaft and axial-groove alignment is with a straightedge. It may also be done with a taut line, however, when using this method care must be exercised as the line is easily distorted. The straightedge checking method is illustrated in Fig 2, with arrows indicating the four check points. When sheaves are properly aligned no light should be visible at these four points.

Fig 2



"V" Belt installation

"V" belts should never be 'run-on" to sheaves. To do so places excessive stress on the cords, usually straining or breaking sane of them. A belt damaged in this manner will flop under load and turn over in the sheave groove. The proper installation method is to loosen the adjustable mount, reduce the centre distance, and slip the belts loosely into the sheave grooves.

The following six general rules should be followed when installing "V" belts:

1 Reduce centres so belts can be slipped on sheaves

2 Have all belts slack on the same side (top of drive)

3 Tighten belts to approximately correct tension

4 Start unit and allow belts to seat in grooves.

5 Stop - retighten to correct tension

6 Recheck belt tension after 24 to 48 hours of operation.

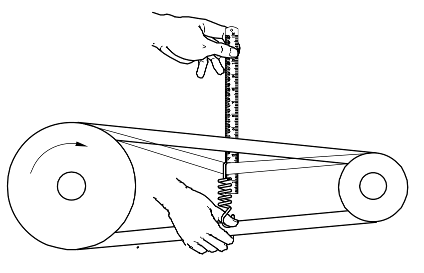
Checking Belt Tension

Belt tension is a vital factor in operating efficiency and service life. Too low a tension results in slippage and rapid wear of both belts and sheave grooves. Too high a tension stresses the belts excessively and unnecessarily increase bearing loads.

The tensioning of fractional horsepower and standard multiple belts may be done satisfactorily by tightening until the proper "feel" is attained. The proper "feel" is when the belt has a live springy action when struck with the hand. If there is insufficient tension the belt will feel loose or dead when struck. Too much tension will cause the belts to feel taut, as there will be no give to them.

Wedge Belt Tension The 3V, 5V and 8V wedge belts operate under very high tension since there are fewer belts and/or smaller belts per horsepower. When properly tightened they are taut and have little give, therefore, tightening by "feel" is not dependable. A better method is to use the belt tension measuring tool shown in Fig 3

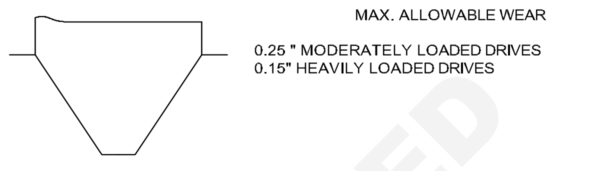
Fig 3



Sheave Grooves: When sheave groove wear becomes excessive, shoulders will develop on the groove side walls. If the sheave is not repaired or replaced these shoulders will quickly chew the bottom corners off new belts and ruin them.

The more heavily loaded a drive, the greater the effect of groove wear on its operation. Light to moderately loaded drives may tolerate as much as 1/32" wear, whereas, heavily loaded drives will be adversely affected by .010" to .015" of wear. Wear should be checked with the appropriate gauge at the point illustrated in Fig. 4.

Fig 4



"V" Belt Replacement

When replacing "V" belts care must be exercised that the correct type is selected. Errors in choice might be made since the top width of sane of the sizes in the three types are essentially the same. Also belts from different manufacturers should not be mixed on the same drive because of variations from nominal dimensions. When determining the length belt required for most drives it is not necessary to be exact. First, because of the adjustment built into most drives and second because belt selection is limited to the standard lengths available. Since the standard lengths vary in steps of several inches, an approximate length calculation is usually adequate. For these reasons the following easy method of belt calculation can be used for most "V" belt drives:

1 Add the pitch diameters of the sheaves and multiply by 11/2.

2 To this add twice the distance between centres.

3 Select the nearest longer standard belt.

4 This method should not be used when centres are fixed or if there are extreme pitch-diameter differences on short centres. Sheave Groove Wear All "V' belts and sheaves will wear to some degree with use. As wear occurs the belts will ride lower in the grooves. Generally, a new belt should not seat more than 1/6 inch below the top of the groove. While belt wear is usually noticed, sheave-groove wear is often overlooked. As wear occurs at the contact surfaces on the sides of the grooves, a dished condition develops. This results in reduced wedging action, loss of gripping power, and accelerated wear as slippage occurs. Installing new belts in worn grooves will give temporary improvement in operation but belt wear will be rapid. When changing belts, therefore, sheave-groove wear should be checked with gauges or templates. Care must be taken when checking grooves that the correct gauge or template in respect to type, size and pitch diameter is used. As sheave grooves are designed to conform to the belt cross-section change as it bends, small diameter sheaves have less angle than larger diameter sheaves. The variation in sheave-groove included angles range from 34 degrees for small diameter sheaves up to 42 degrees for the largest diameter sheaves.

Chains and sprockets

Objectives: At the end of this lesson you shall be able to
- **state the advantages of chains drives**
- **state the use of a jockey sprocket**
- **state the types and specifications of chains**
- **brief the maintenance features of the chain drive.**

Chain drive (Fig 1)

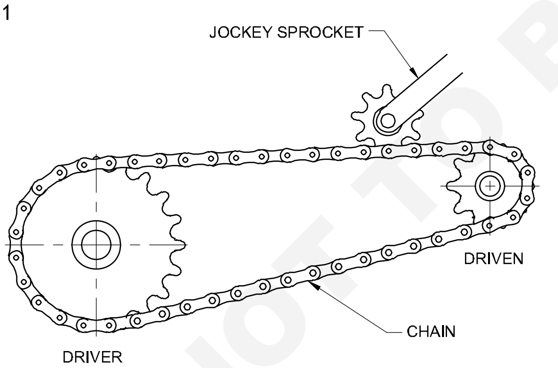
Chain drives are used for transmission of motion at constant velocity ratio without creep and slippage. Chains are used in conjunction with sprocket pinions and sprocket wheels. Chains and sprockets are available in both British and metric standards. The sprockets are generally keyed to the shafts.

Advantages of a chain drive

- Positive contact between the chain and the drive sprockets eliminates the possibility of slips.
- Has a wide range of driving power.
- Can be used where there is a large distance between the driving and driven shafts.
- Useful for low speed and high torque transmissions.
- Can absorb shocks.
- Chain drives are compact.
- Chain drives withstand heat, dirt and weather exposure when properly lubricated.

Jockey sprocket (Fig 1)

Fig 1



A spring-loaded jockey sprocket can be used to tension a chain which transmits the drive between the sprockets with fixed centres.

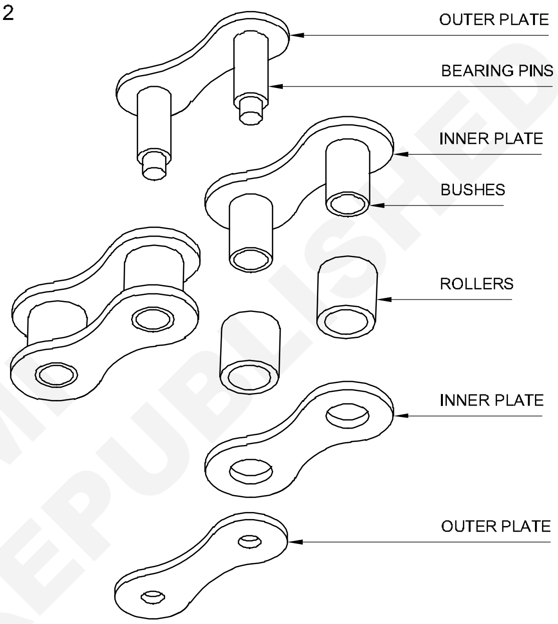
Types of chains

There are many types of chains but follow two types are commonly used.

- Roller chain
- Toothed chain

Roller chain (Fig 2)

Fig 2



COMPONENT PARTS OF A SIMPLE ROLLER CHAIN

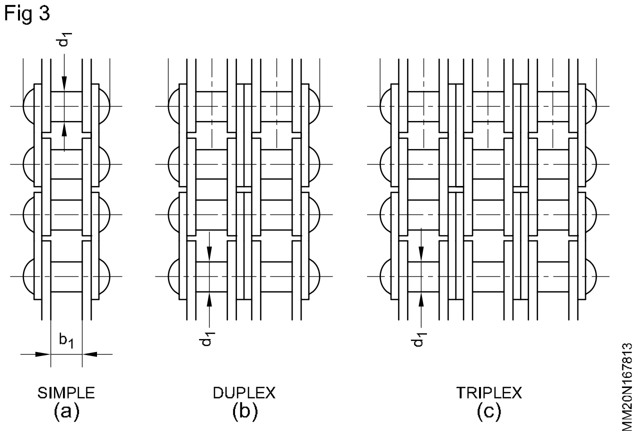
Rollers are housed between the connecting links and rotate freely on the bush. The bush is pressed in the holes of internal link and can rotate about the pin.

a) Single roller type chain is called a Simplex chain. (Fig 3a)

b) Double roller type chain is called a Duplex chain (Fig 3b)

c) Triple roller type called a Triplex chain. (Fig 3c)

Fig 3



Toothed chain or silent chain

These chains are provided for noiseless and uniform drive. It consist of a row of toothed links connected through bushes.

Chain specification

Chains are specified by the pitch. For roller chains pitch is the distance between the centre-to-centre of adjacent pins. Width refers to normal width of the link measured within the side of the plates. Diameter means the actual outside diameter of the roller. (Fig 4)

ISI 2403-1975 gives the specifies dimensions for standard chains of different diameters.

Maintenance features for chain drive

- Check alignment periodically and rectify if necessary.
- Inspect the chain for elongation. Excess clearance at point signifies elongation as shown in fig 5. The chain should be replaced as excess elongation spoils the sprocket.

Fig 4

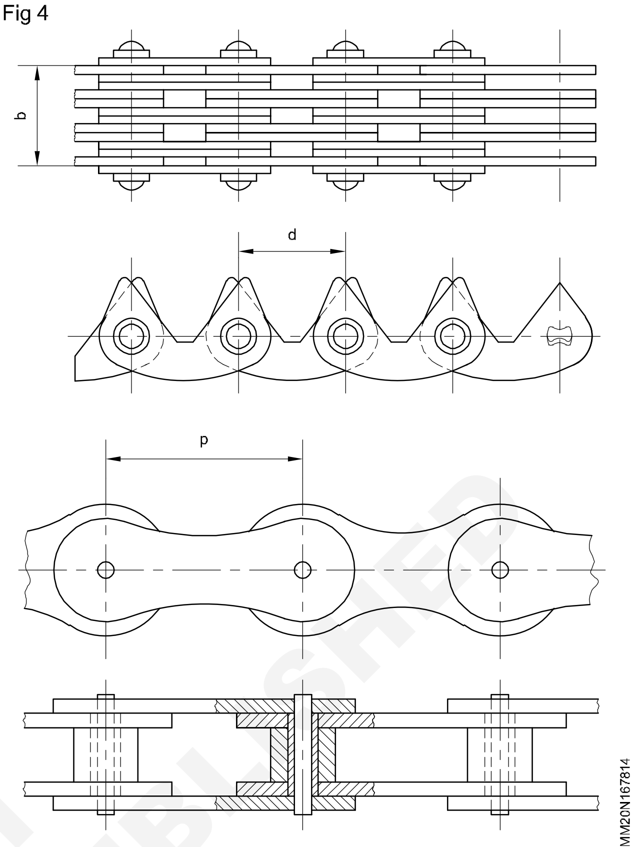
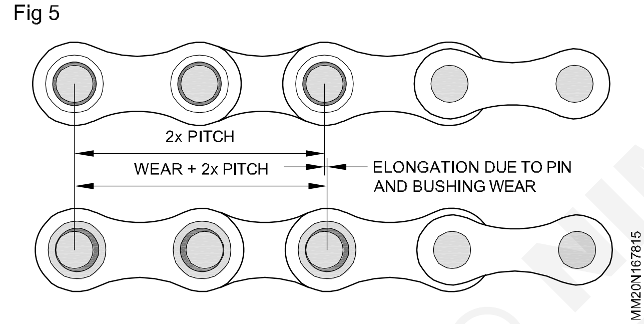


Fig 5



Roller Chain Installation

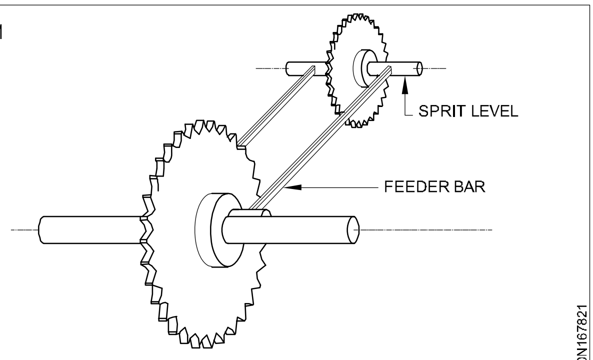
Objective: At the end of this lesson you shall be able to
- **describe the method of installing the chain.**

Correct installation of a roller chain drive requires that the shafts and the sprockets be accurately aligned. Shafts must be set level, or if inclined from a level position, both shafts must be at exactly the, same angle. The shafts must also be positioned parallel within very close limits. The sprockets must be in true axial alignment for correct sprocket tooth and chain alignment

Horizontal shafts may be aligned with the aid of a spirit level. The bubble in the level will tell when they are both in exact horizontal position. Shafts may be adjusted for parallel alignment as shown in Fig. 1. Any suitable measuring device such as callipers, feeder bars, etc. may be used. The distance between shafts on both sides of the sprockets should be equal. For an adjustable shaft drive make the distance less than final operating distance for easier chain installation. For drives with fixed shafts, the centre distance must be set at the exact dimension specified.

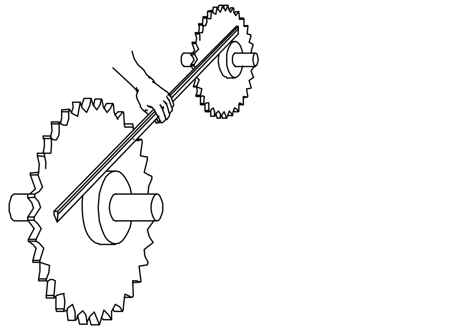
To set axial alignment of the sprockets, apply a straight-edge to the machined side surfaces as shown in Fig. 2. Tighten the set screws in the hubs to hold the sprockets and keys in position. If one of the sprockets is subject to end float, locate the sprocket so that it will be aligned when the shaft is in its normal running position. If the centre distance is too great for the available straightedge, a taut piano wire may be used.

Fig 1



MEASURING TWO SHAFTS FOR BOTH HORIZONTAL &PARALLEL ALIGNMENT

Fig 2



MM20N167822

To install roller chain, fit it on both sprockets, bringing the free chain ends together on one sprocket. Insert the pins of the connecting link in the two end links of the chain as shown in Fig.3; then install the free plate of the connecting link. Fasten the plate with the cotters or spring clip depending on type used. When fastened, tap back the ends of the connecting link pins so the outside of the free plate of the connecting link. Fasten the plate with the cotters or spring clip depending on the type used. When fastened, tap back the ends of the connecting link pins so the outside of the free plate comes snugly against the fastener. This will prevent the connecting link squeezing the sprocket teeth which might interfere with free flexing of the joint and proper lubrication.

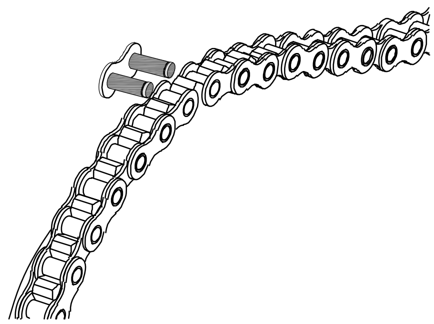
Adjustable drives must be positioned to provide proper chain tension. Horizontal and inclined drives should have an initial sag equal to 2% of the shaft centres.

Measurements are made as shown in Fig.3. The measurements for various centre distances to obtain approximately the recommended 2% sag. To measure the amount of sag, pull the bottom side of the chain taut so that all of the excess chain will be in the top span. Pull the top side of the chain down at its centre and measure the sag as shown in Fig. 4 then adjust the centres until the proper amount is obtained. Make sure the shafts are rigidly supported and securely anchored to prevent deflection or movement which would destroy alignment.

Chain Replacement During operation

Chain pins and bushings slide against each other as the chain engages, wraps and disengages from the sprockets. Even when parts are well lubricated, some metal-to-metal contact does occur, and these parts eventually wear. This progressive joint wear elongates chain pitch, causing the chain to lengthen and ride higher on the sprocket teeth. The number of teeth in the large sprocket determines the amount of joint wear that can be tolerated before the chain jumps or rides over the ends of the sprocket teeth. When this critical degree of elongation is reached, the chain must be replaced.

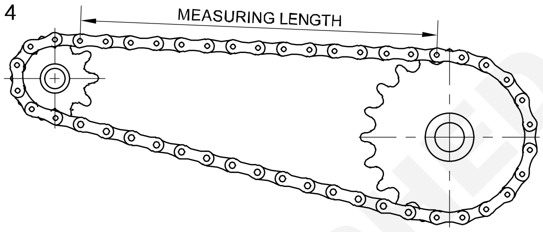
Fig 3



ROLLER CHAIN INSTALLATION

MM20N167823

Fig 4



MM20N167824

Chain manufacturers have established tables of maximum elongation to aid in the determination of when wear has reached a critical point and replacement should be made. By placing a certain number of pitches under tension, elongation can be measured. When elongation reaches more than the limits recommended by the manufacturer the chain should be replaced.

The recommended measuring procedure is to remove the chain and suspend it vertically with a weight attached to the bottom. When the chain must be measured while on sprockets, remove all slack and apply sufficient tension to keep the chain section that is being measured taut.

Types of bearing and function

Objectives: At the end of this lesson you shall be able to
- **state what is a bearing**
- **state the classification of bearing**
- **name different types of plain bearings with their uses**
- **state the types of bushes and their applications.**

Bearing

Bearing is a component which is having the same configuration to that of its counterpart. It supports, aligns and bears the load of the supported member which are in relative motion.

Classification of bearing

Plain bearing

Rolling contact bearing

Plain bearing

Radial load

Thrust load

Guide way bearing

Rolling contact bearing

Radial load

Thrust load

Linear bearing

Plain bearing has more friction comparing to rolling contact bearing

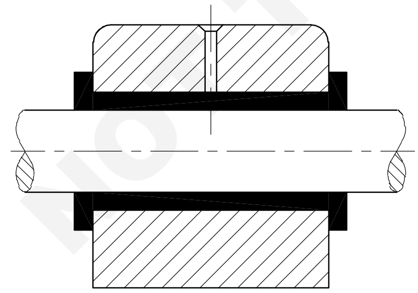
Types of plain bearing

Radial or journal bearing

In this bearing, load is acting at right angle to the axis. (Fig. 1)

The portion of the shaft which is supported by the bearing is known as journal.

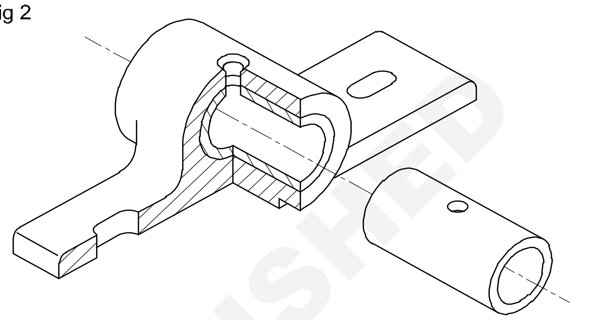
Fig 1



Solid bush bearing (Fig. 2)

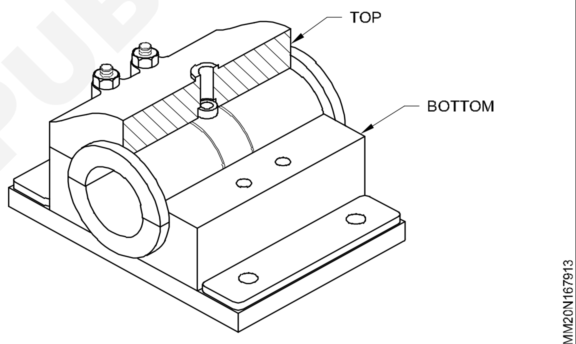
In this journal bearing a solid bush is press fitted in a cast iron housing or pedestal (Fig. 2) an oil hole is provided on the top of the bearing for lubrication. This bearing is used for slow speed radial load application only. These bearings are made in halves and assembled in plummer blocks

Fig 2



Split bush bearing (Fig. 3)

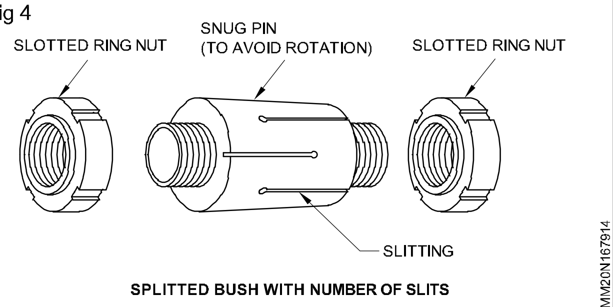
Fig 3



This journal bearing is built up of a bush and a housing of two halves as 'top' and 'bottom', are housed in a pedestal block or plumber with an oil hole at the top. Bush can be adjusted to compensate the wear. This is used for slow and medium speed applications.

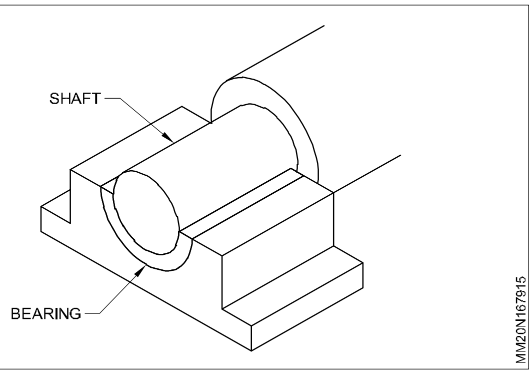
Another type of split bush bearing (Fig 4), which can be adjusted radically the internal clearance by slotted ring nuts at its both end.

Fig 4



Another type of journal bearing is known as partial or half bearing which embraces the shaft less than 180^o portion. This is also used for very slow speed application where continuous motion is not desired (Fig. 5)

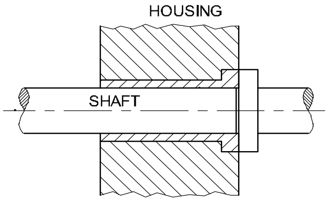
Fig 5



Thrust bearing (Fig. 6)

In this bearing load is acting axially. To withstand or counteract the thrust load, thrust pad, linear or collar is provided. This is used for slow, medium and high speed applications with axial load.

Fig 6

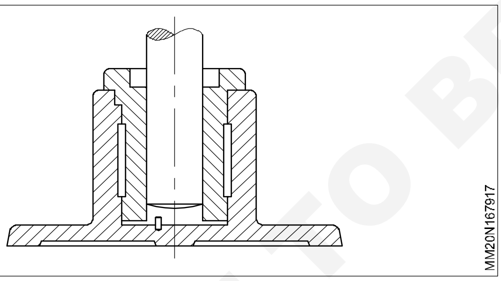


PLAIN BEARING

Foot step bearing (Fig. 7)

This is also known as pivot bearing with axial load where the shaft is supported by a concave plate at its bottom, named as breast plate which counteracts the axial thrust. This bearing is used for slow and medium speed vertical shaft applications.

Fig 7



Bush and liner

Bushes are cylindrical in form and generally made of bronze. They are fitted into the housing to form a plain bearing. Liners are either cylindrical or rectangular flat pieces, made of cast iron, brass and bronze. They are either fitted inside the bore or fixed over the flat surface to form a lining.

Common types

Plain bush

Collar bush

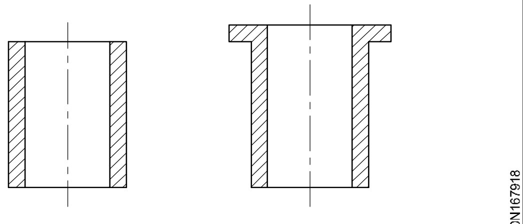
Flanged bush

Floating bush

Split bush

Plain bushes are made in sizes between 10 to 58 mm and used in small bearings, links, oil engine's connecting rod etc. collar bushes are also made in smaller sizes and fixed into the housing where radial and axial load is in one direction. (Fig. 8a, b)

Fig 8

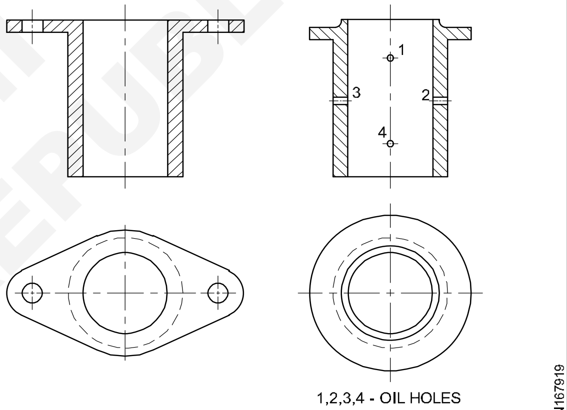


(a) PLAIN BUSH (b) COLLAR BUSH

Example - pillar drill machine's pulley guard through which the spindle passes and also used in links, coupling rods etc.

Flanged bushes are fixed into the valves loosely on studs and lightened with nuts. Floating bush is fitted into the big end of locomotive connecting rod wherein translator motion is converted into rotary motion. (Fig. 9)

Fig 9

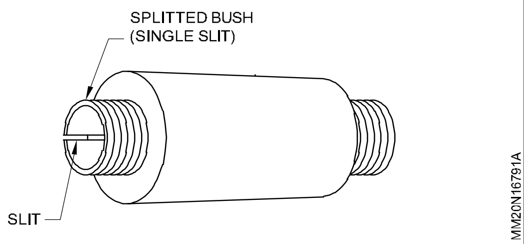


(a) FLANGED BUSH (b) FLOATING BUSH

Split bush is fitted into the main spindle bearing of high speed grinding machine.

It has a taper on its outer diameter and housed into the corresponding taper bore. For compensating the wear big end nut is tightened while the other end nut is loosened. For locking in a particular adjustment a mild steel insert is set into the slit. (Fig. 10)

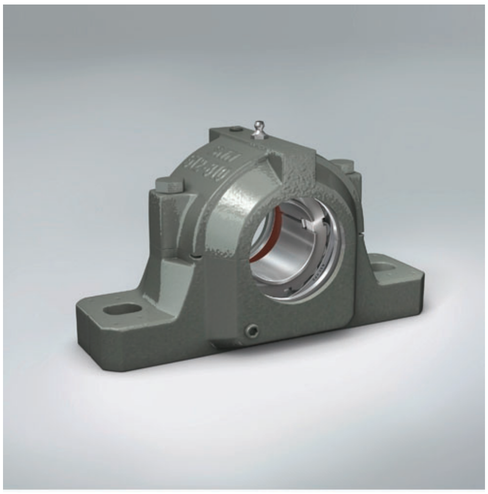
Fig 10



plumber block bearing

A plummer block is a type of-bearing used in various machinery applications. The purpose of the plummer block is to support a shaft and allow it to rotate freely. There are two types of plummer blocks: solid and split . solid plummer blocks are made from one piece of material, while, split plummer blocks are made from two pieces that are bolted together. pillow blocks are similar to plummer blocks, but they have a square or rectangular base instead of a round base. (Fig 11)

Fig 11



Pivot bearing

It consists of an outer ring and several balls and supports a conical section (usually 60 degree pivots) at the tip of the rotating shaft, friction torque is small due to the small pitch diameter of the ball and the shape of the pivot part of the shaft. (Fig 12)

Fig 12

Types of bearing fit

Objectives: At the end of this lesson you shall be able to
- **state the importance of proper bearing fit**
- **brief the methods of mounting and dismounting the bearing from the shafts.**

Importance of proper fit

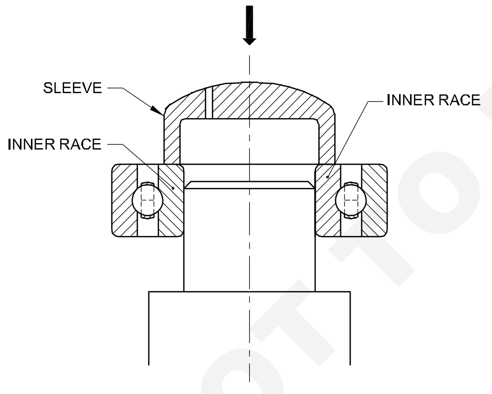
Proper fit in rolling contact bearing ensures long service life. If the bearing is fitted too tight, the internal radial clearance will be reduced and thereby the rolling elements will get jammed. Consequently it will have premature failure. If the bearing is too loose, it will not take the load. So, a proper fit is very much essential.

In general applications, when the journal (spindle) is rotating, the inner race will have an interference fit with the journal and the outer race will have a close push fit. In the case of a stationary spindle, when the outer race is the rotating member, the interference fit will be with the outer race, and the hub and close push fit with the inner race and spindle. The degree of tightness and looseness depends upon the load, speed, temperature and the type of the bearing.

Bearing mounting

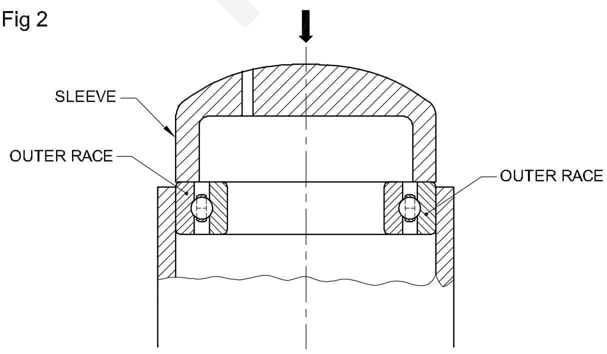
Bearing mounting deserves great care. When the bearing is fitted tight into the spindle, pressure should be applied on to the inner race. (Fig. 1) If the bearing is pressed into the housing, pressure must be applied on to the outer race. (Fig. 2)

Fig 1



BEARING BEING FITTED ON SPINDLE

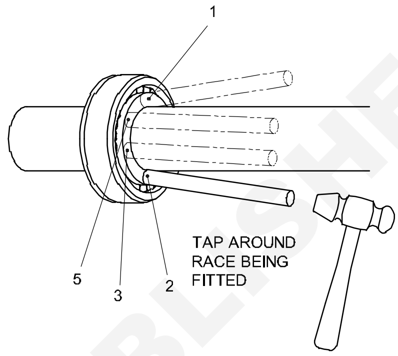
Fig 2



Smear thin lubricating oil on the shaft or housing where the bearing is to be fitted.

Small bearings can be fitted by using mounting sleeves and hammer (Fig 3) or using a copper drift and hammer.

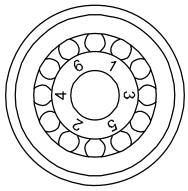
Fig 3



The mounting sleeve should have its faces parallel and flat.

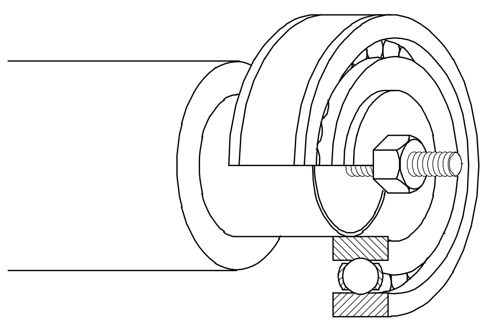
Check frequently that the bearing is driven parallel to the axis of the housing or at right angle to the axis of the shafts. When a suitable bearing puller is not available, a soft metal drift may be used to drive the bearing into position. While striking the bearing on the inner race, it should be struck progressively on the opposite point of the race as shown in (Fig. 4).

Fig 4



If a shaft is having internal threads at the centre (Fig. 5) or external threads, they can be utilised for mounting the bearings.

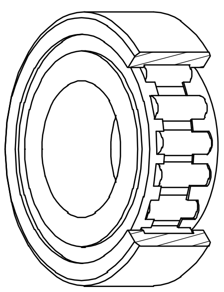
Fig 5



SHAFT WITH INTERNAL THREAD FACILITATES MOUNTING

Separable parts of cylindrical roller bearing are mounted independently. Mount the inner ring first and then the outer race with the roller and cage assembly after a little bit oiling or greasing. (Fig. 6)

Fig 6

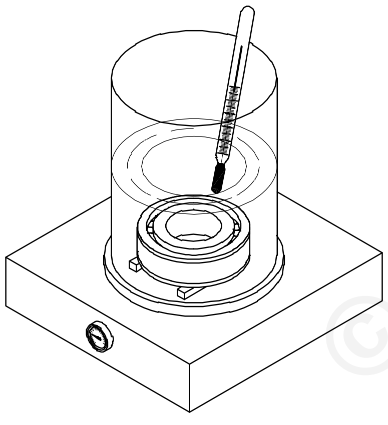


MM20N168016

Mounting and dismounting rolling contact bearings

When the shaft fit has more interference, one should adopt shrinkage fit. For such a fit the inner race should be heated up in an oil bath as shown in (Fig. 7) or by induction heating process between 90° to 120°C depending upon the expansion requirement. (Fig. 8)

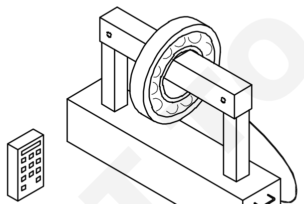
Fig 7



MM20N168017

OIL HEATING OF BEARING

Fig 8



MM20N168018

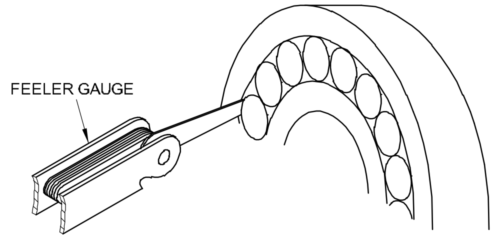
INDUCTION HEATING OF BEARING

In no case should the rolling contact bearing be heated more than 140°C

Check the internal clearance of the bearing (Fig. 9) after the bearing attains room temperature. When the bearing is having more interference in the housing, the bearing should be cooled in a freezing chamber (-5 to -20°C) and pushed inside the housing easily.

The inner ring of bearings with the tapered bore is always mounted with an interference fit, usually on a taper adopter sleeve or a withdrawal sleeve. When the bearing is driven up the original radial, the internal clearance is reduced. The reduction in clearance required can be referred in the table provided by the bearing manufacture. The clearance is measured as shown in (Fig. 9).

Fig 9



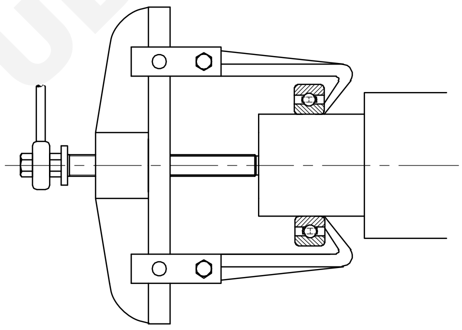
MM20N168019

Bearing dismounting

Dismounting of bearing should be done with proper care using proper tools. If proper tools are not used and right techniques are not adopted, the bearing is likely to be damaged and may lead to premature failure.

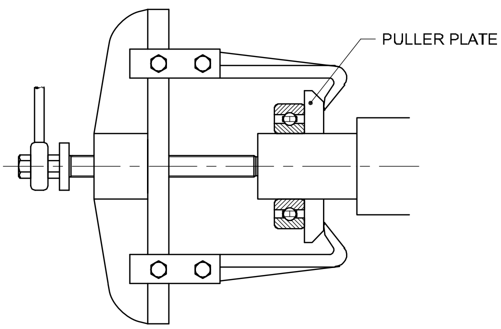
While using a puller, the pulling legs of the puller should be placed with the inner race. (Fig. 10) In certain cases, we use a puller plate (Fig. 11) to facilitate the placing of the pulling legs in position so that force is applied on the inner race. Special puller plates (Fig. 12) are used along with a two-legged puller so that the pull is applied on the inner race alone.

Fig 10



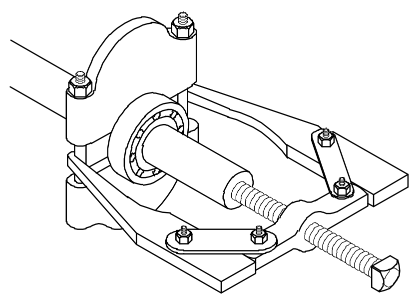
MM20N16801A

Fig 11



MM20N16801B

Fig 12



MM20N16801C

For detachable inner ring type bearing, the puller legs can be placed with the outer ring as shown in (Fig 13) for dismounting the bearing when the outer ring is having an interference fit in the housing.

A self-aligning ball-bearing can be swiveled as shown in (Fig 14) for fixing the bearing puller to facilitate the dismounting process.

Fig 13

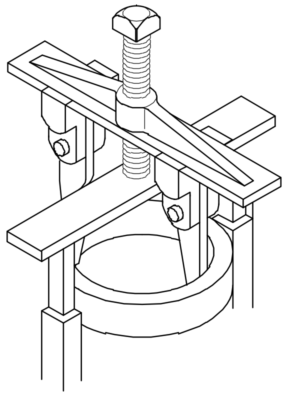
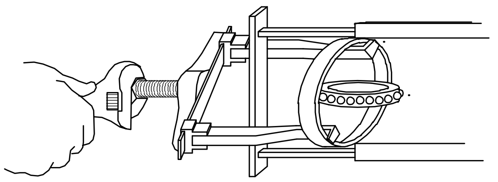


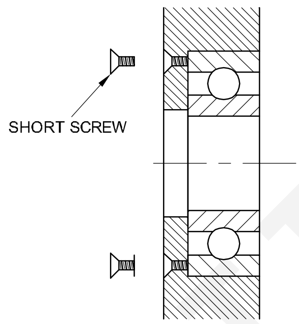
Fig 14



Dismount bearing assembled in blind bore housing

Some bearing housings have tapped and counter sunk holes behind the bearing. These holes are normally fitted with short screws to prevent the threads blocked with dirt. To remove the bearing Fig. 15.

Fig 15

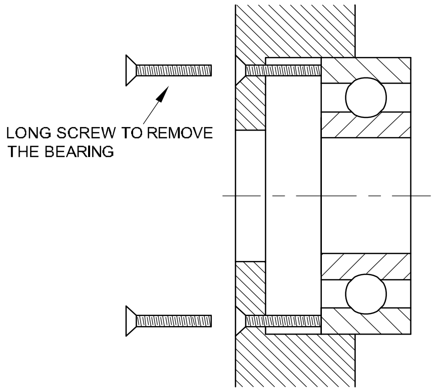


- Remove the screws from the holes.

- Select the same number of screws that will fit the holes and are long enough to remove the bearing.

- Tighten both the screws gradually by applying small amounts of pressure to remove the bearing slowly from its housing. Make sure the bearing maintain square to its housing still its removed completely from housing (Fig 16).

Fig 16



Care and maintenance

A good bearing should not be dismantled unless otherwise it is absolutely necessary.

Bearings should be handled in a dirt/dust free environment. Bearing housing on the shaft should be free from burns or scratches.

Proper mounting and dismount tools, and correct techniques should be adopted. Provide proper support for the bearing and shaft during disassembly.

Direct blows should not be given to the bearing.

Bearing should not be heated with a naked flame. Before heating ensure that any grease or lubricant does not start a fire.

Use only the recommended grade and quantity of lubricant for the lubrication of bearing.

Lubrication of rolling contact bearing

- Lubrication of such bearings is depending upon where it is fixed.
- Cases where gravity feed, force feed and splash lubrication is incorporated, suitable oil should be used.
- Cases where bearings are isolated and inaccessible grease lubrication is preferred.
- For slow speed bearings grease is preferred while for high speed applications oil is preferred.
- For machine tools oil lubricated bearing servo system 32, 68 (IOC) is commonly used and for grease lubricated bearings servo gam grease - (IOC) is preferred.
- For lubrication always follow the recommendation of the machine manufacture.

Failure of rolling contact bearing

- Improper fit, generally more interference.
- Improper mounting and misalignment
- Improper selection of lubricant, lack of lubrication and failure of lubrication
- Excessive load condition.
- Dust, dirt and foreign particles inclusion in the bearing
- Excessive temperature generation
- Too much vibratory condition.

Rolling contact bearing

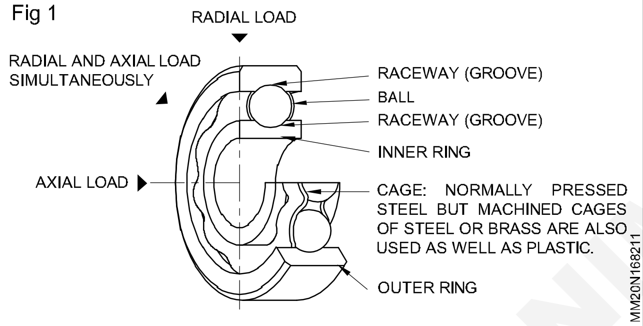
Objectives: At the end of this lesson you shall be able to
- **state the main features of rolling contact bearing**
- **state the classification of rolling contact bearing**
- **state the application of rolling contact bearings.**

Main features of rolling contact bearing

In this type of bearing rolling elements constitutes the friction. Rolling friction is very less while in plain bearing friction is more. In rolling contact bearing shaft is not coming in contact with the rolling elements in most cases, hence shaft does not wear out.

The bearing consists of outer race, rolling elements, cage or retainer and the inner race (Fig 1)

Fig 1



The bearing is made of high carbon steel, high carbon nickel, Chromium steel, high carbon high chromium refined grade steel and stainless steel. Generally, high carbon nickel chromium steel is used for high speed application bearings. Cage or retainer is made of pressed steel, brass, bronze, nylon, fibre and special engineering plastics.

Rolling element and raceways are hardened, tempered, ground and honed to give high degree of surface finish and accuracy.

Rolling elements

They are available in different shapes such as balls, parallel rollers, taper rollers, barrels and needles (Fig 2). They are made of chromium (or) chrome-nickel steel with a ground or polished surface. The load of the rotating member is carried by the rolling elements.

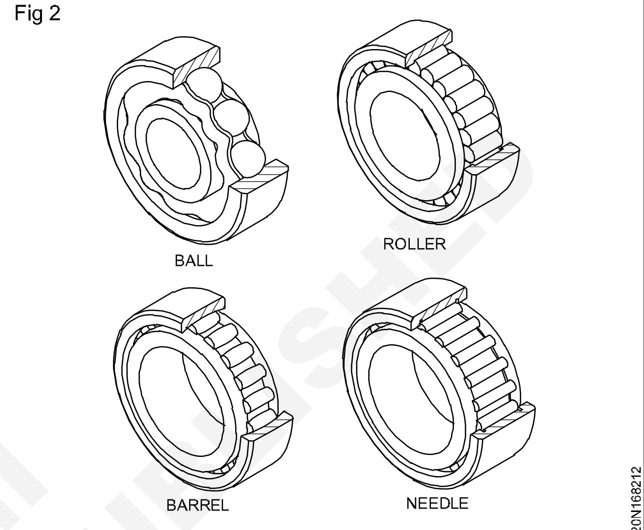
Races

The inner and outer races are provided with grooves or race-ways which guide the rolling elements. They are made of high grade chromium steel or chrome-nickel steel. They are hardened, ground and polished.

Cage

Each rolling element is separated from the other by means of a 'cage' and it keeps the rolling elements from bunching up. The rolling element and the cage are retained between the inner and outer races. The rolling elements are retained in the cages to ensure proper fits and equal spacing between the rolling elements. They are made out of brass, steel or plastics.

Fig 2



TYPES OF ROLLING ELEMENTS

Classification of rolling contact bearings

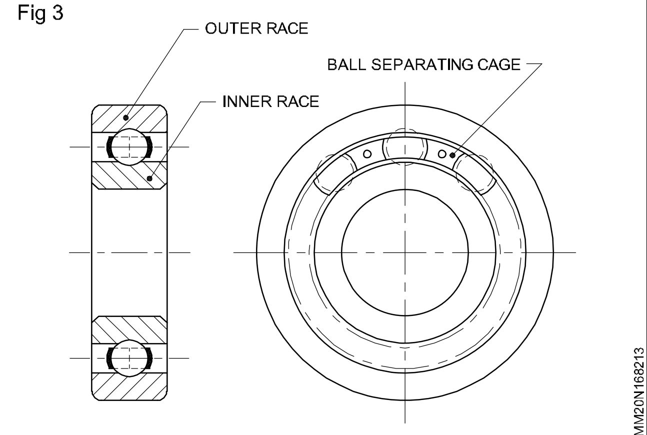
Rolling contact bearings
- Ball bearing
  - Radial Ball Bearing
  - Thrust ball bearing
- Roller bearing
  - Radial roller bearing
  - Thrust roller bearing

Commonly used rolling contact bearings

Ball- bearings

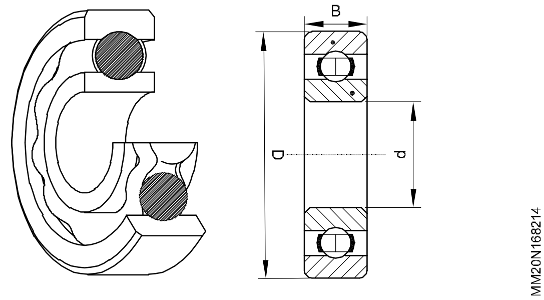
Ball-bearings are the most widely used of all the bearings. (Fig 3)

Fig 3



Deep groove ball bearing (Fig 4)

Fig 4

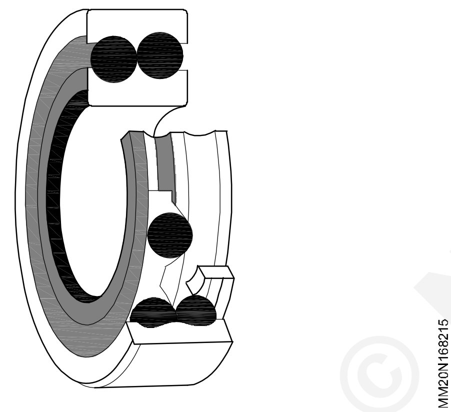


Deep groove ball bearing may be single row or double rows type. Double rows type is wider in width to allow two rows of ball with the objective of increasing load capacity

Deep groove double row ball bearing (Fig 5)

Double row deep groove ball bearing are very suitable for bearing arrangements where the load carrying capacity of a single row bearing is inadequate.

Fig 5

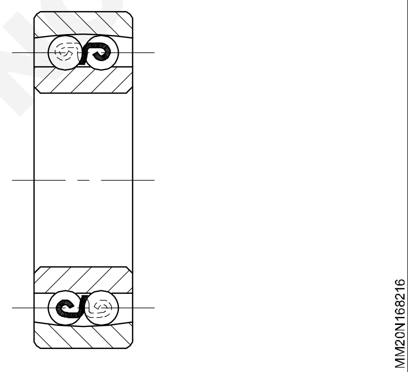


For any given bore diameter, there are usually two or three sizes of outside diameter width, and the load-carrying capacity. The width of these bearings is smaller than the bore diameter. The width (or length) to diameter ratio is much smaller than that of plain bearings. Although principally they are to carry journal loads,

Self-aligning ball-bearings (Fig 6)

This type of bearings has a spherical bore on the outer race. This bearing can carry journal loads which are slightly inclined due to shaft mis-alignment.

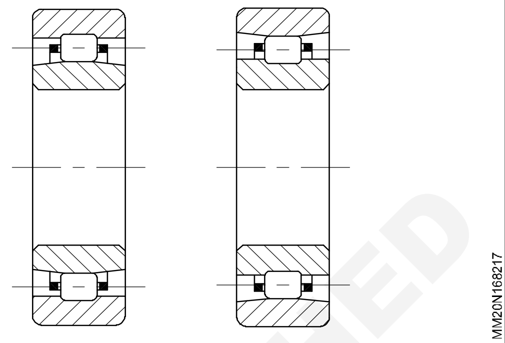
Fig 6



Roller bearings (Fig 7)

Roller bearings are available with the grooved race in the outer and inner members. Selection of this depends upon which race is required to be locked. Roller bearings are intended to carry radial (journal) loads and can carry greater radial loads than ball-bearings of the same size. They are also available in double rows to carry greater radial load.

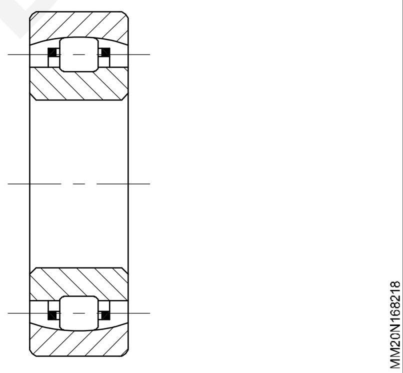
Fig 7



Spherical roller bearing or self aligning roller bearing (Fig 8)

Self aligning roller bearings have barrel-shaped rollers and spherical bores in the outer race. For very heavy radial loads double row spherical roller bearing are also available.

Fig 8



Needle - bearings

Rollers of very small diameter, called needle rollers, are shown in (Fig 9). This type of bearing is used where the outside diameter of the bearing is severely restricted because of the limited bearing space in the housing. (Fig 10) shows the needles fitted in a circular cage which is push fit in the housing.

In this design the needles are in contact with the shaft journal.

Fig 9

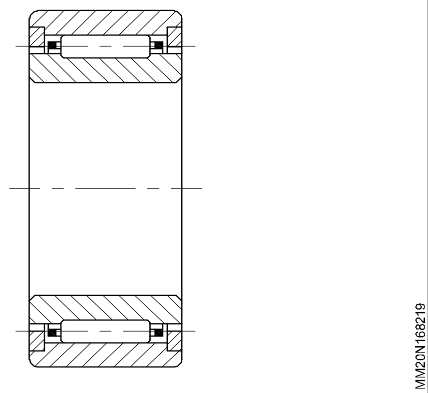
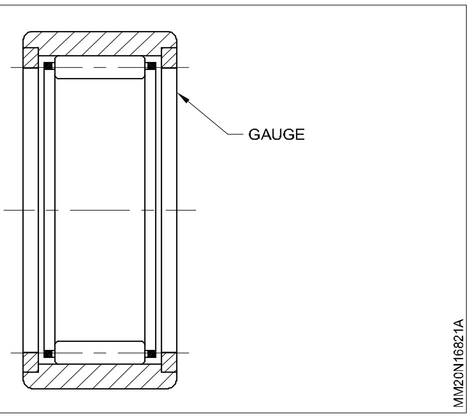


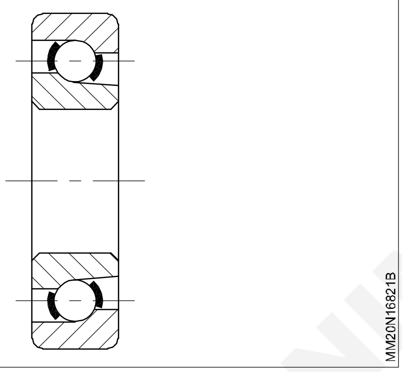
Fig 10



Angular contact ball - bearing

These bearings are designed to take an axial thrust as well as radial loads. (Fig 11) shows an angular contact ball-bearing (single row).

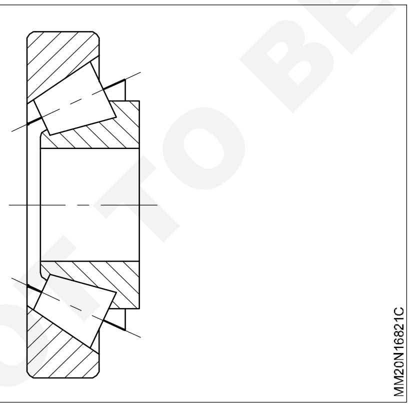
Fig 11



Tapered roller-bearings (Fig 12)

These are used for taking high axial thrust loads. Tapered roller bearings with slow tapered cones are used where the axial thrust is more than the radial load.

Fig 12

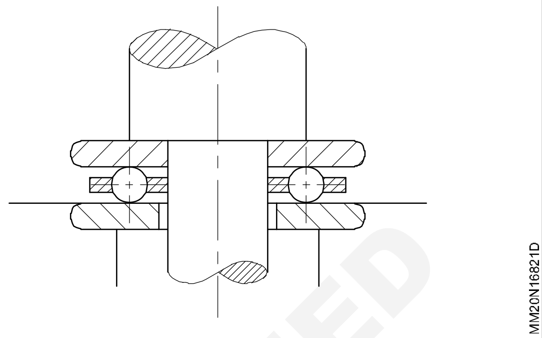


These bearings are made to take thrust from one direction only. Where there is opposing thrust then the bearings must be mounted as pairs in opposition.

Thrust ball-bearing

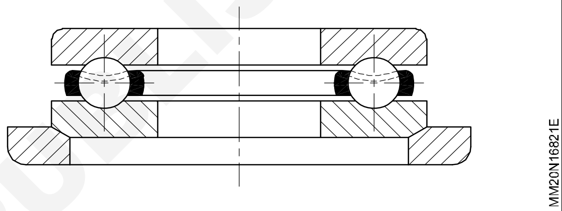
These bearings are useful for taking vertical thrust load (Fig 13) but cannot take any radial load.

Fig 13



Special thrust bearings (Fig 14) are available which can also take horizontal end thrusts.

Fig 14



Bearing designation (ISO system)

Objectives: At the end of this lesson you shall be able to
- **describe the ISO bearing designation.**

Each antifriction standard bearing has a specific designation which indicates the type of bearings, sizes of different elements of the bearing and other constructional features.

These designations consists of either 3, 4, or 5 numbers or combination of number and letters which in turn indicate, the type of bearing, dimension series, and bore diameter.

3 0 2 0 5

Where, 3 Bearing type Code

0 = Width Code

2 = Diameter Code

05 = Inner diameter code

Type code First digit indicates type of bearing. Type codes are:

0____ Double row angular contact bearing.

1____ Double row Self Aligning ball bearing

2____ Spherical Roller Bearing

3____ Taper Roller bearing

4____ Double row Deep Groove ball bearing

5____ Thrust ball bearing

6____ Single row Deep Groove ball bearing

7____ Single row angular contact ball bearing

8____ Cylindrical roller thrust bearing

N____ Cylindrical roller bearing

QJ___ 4-point contact ball bearings

T____ Taper roller bearings.

The prefix T is followed by 3 symbols designated the bearing series and a 3-digit code indicating the bore dia. In

Codes for identifying width and external diameters are sometimes as dimension series of a bearing increases as the no. of rows of the rolling element. External diameter increases also as the load increases. These are generally indicated by 0, 1, 2, 3 and 4.

When width and diameter codes are shown together by a single digit, total no. of bearing designation comes to 4 only.

Bearing

The last two digits indicate the diameter of bore between 20 to 490 mm. The bore diameter is obtained by multiplying two digits by 5.

For bearings with bore diameter greater than 490 mm, the bore diameter is directly indicated after an oblique (e.g.511/500).

Special coding applies for the bearings with bore diameter less than 20mm.

00__ __10 mm

01__ __12 mm

02__ __15 mm

03__ __17 mm

For the bore diameter less than 10 mm, the bore diameter is indicated by a single digit which gives the value of bore diameter directly.

Some prefixes and suffixes are indicated on the bearings, like

7205 B-Single row angular contact ball bearing with a contact angle of 40°

J__Pressed Steel Cage.

RS LS__Synthetic rubber seal fitted at one side““bearing.

2RS 2LS-Synthetic rubber seal fitted on both side of the bearing.

Z-Shield fitted at both sides of the bearing.

ZZ-Shield fitted in one side of the bearing

K-Tapered bore, taper 1:12 on diameter.

K-30-Tapered bore, taper 1:30 on diameter.

NR-Srap ring groove in outer ring with a snap ring.

C1/C2/C3/C4/C5-Manufacturers clearances.

Mounting/dismounting tapered bore roller bearings

Objectives: At the end of this lesson you shall be able to
- **describe the methods of mounting the taper bore bearing**
- **explain the method of dismounting the taper bore bearing**
- **state the arrangement of taper bore bearing**
- **brief the method of dismounting bearing on sleeves.**

Mounting

Roller bearings with a tapered bore are either fitted directly onto a tapered shaft or onto a cylindrical shaft with an adapter sleeve or a withdrawal sleeve. By driving up the inner ring on the shaft or sleeve, the tight fit required is obtained and is measured by checking the radial clearance reduction due to the expansion of the inner ring or by measuring the axial drive distance. Check the drive up distance for spherical roller bearings with feeler gauge.

Small bearings up to approximately 80mm bore can be pressed with a locknut onto the taper seat of the shaft or the adapter sleeve. A hook spanner should be used to tighten the nut. Small withdrawal sleeves are also pressed with a locknut into the gap between the shaft and the inner ring bore.

It is advisable to use a hydraulic press for driving-up larger bearings or pressing them onto the sleeve. Hydraulic nuts are available for all popular sleeve and shaft threads. For bearings with a bore of 160mm and upwards mounting and dismounting are greatly facilitated by the hydraulic method.

Dismounting

When bearings are directly on the tapered seat or an adapter sleeve, the locking device of the shaft or sleeve is loosened first. The nut is then turned back by the amount corresponding to the drive up distance. The inner ring is then driven off the sleeve or the shaft by means of a hammer and a piece of tubing. When a press is used the adapter sleeve is supported and the bearing pressed off.

Withdrawal sleeve mounted bearings are removed by means of an extraction nut. High forces are required for large sized bearings. Extraction nuts with additional thrust bolts are then used. A washer should be inserted between the bearing inner ring and the thrust bolts.

The dismounting of withdrawal sleeves is much easier and cost effective with hydraulic nuts. The hydraulic method is applied to facilitate the dismounting of large size bearings. Oil is injected between the mating surfaces and enables the mating parts to be moved separately without risking surface damage. Tapered shafts must be provided with oil grooves and supply bores. The required oil pressure has to be created with a pump. When dismounting, an oil with a viscosity of about 150mm2/s at 20 degrees C is used (nominal viscosity 46mm2/s at 40 degrees C. Fretting corrosion can be dissolved by adding rust removing additives to the oil. For tapered bore bearings, oil is pressed between the mating surfaces. Since the press fit is released abruptly, a stop such as a nut should be provided to control the movement of the bearing.

Bearing mounting and bearing arrangements

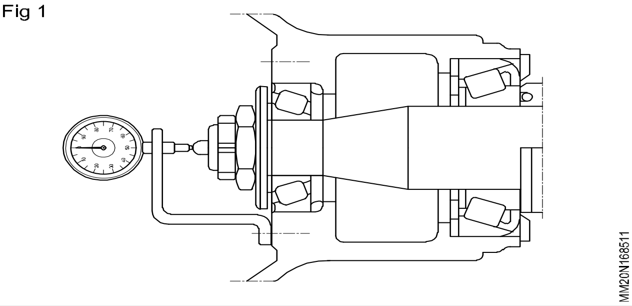
The following recommendations refer only to the adjustment of the mounted clearance for bearing arrangements with single row angular contact ball bearings or tapered roller bearings.

The mounted clearance of single row angular contact ball bearings and single row tapered roller bearings is only established when the bearing is adjusted against a second bearing. Usually, they are arranged back-to-back or face-to-face, and one bearing ring is axially displaced until a given clearance or preload is obtained. For information about bearing preload, refer to relevant product table.

The appropriate value for the clearance to be obtained when mounting depends on the bearing size and arrangement, and operating conditions such as load and temperature. Since there is a definite relationship between the radial and axial clearance of angular contact ball bearings and tapered roller bearings, it is sufficient to specify one value, generally the axial clearance for the arrangement. This specified value is then obtained by measuring the clearance during adjustment and by loosening or tightening a nut on the shaft or a threaded ring in the housing bore or by inserting calibrated washers or shims between one of the bearing rings and its abutment. The actual method used to adjust and measure the clearance depends on whether this is an occasional or repetitive process.

One way to check the axial clearance in a bearing arrangement is to use a dial indicator attached to the hub. When adjusting tapered roller bearings and measuring clearance, the shaft or housing should be turned through several revolutions in both directions to be sure that there is proper contact of the roller ends with the guide flange on the inner ring. Without proper contact, the measured result will not be correct (Fig 1)

Fig 1



Duplex bearings are a set of two bearings that attain greater radial and axial rigidity when arranged on a shaft with the inner and outer rings clamped together with preload. Single-row angular contact ball bearings and tapered roller bearings are generally preloaded axially by mounting them against a second bearing of the same type and size in a back-to-back (load lines diverge) or face-to-face (load lines converge) arrangement.

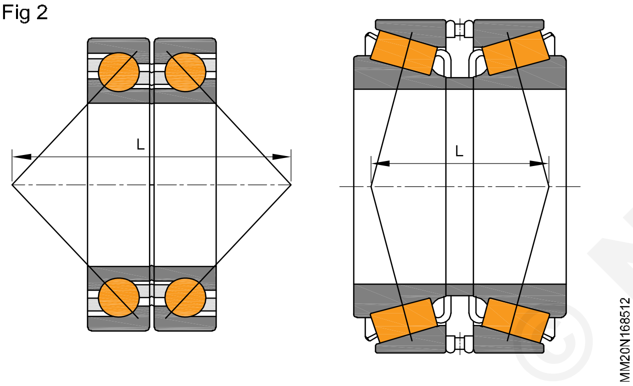
The bearings are matched pair bearings and the faces of the bearings are precisely machined and grounded to provide preload when installed. As mentioned above, these different types call for the different faces of the bearings to come in contact, causing preload. These arrangements are typically used in connection with angular contact ball bearings and tapered roller bearings. The preloading is achieved either by closing the gap between outer-race faces or inner-race faces, depending on the type of arrangement.

Types of Arrangements

The descriptions for the arrangements include:

Back - to - Back (Fig 2)

Fig 2



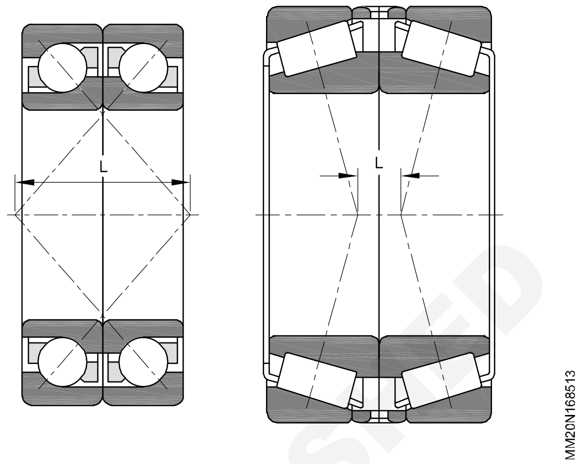
Back to back arrangement is also known as O arrangement. The important thing is to understand why this arrangement gives more rigidity and stability. Looking closely, what actually happens is that outer races are radially and axially restricted completely. So now, the internal clearance of the bearing will be closed when the inner races of the two bearings touch. That is called preloading. When preloading, the inner races of the bearings are being pushed toward one another.

The inner races obviously have a rolling element with a cage above them, and pushing inner races will in turn push these rolling elements in the direction of the force. Now the rolling elements are restricted by the outer races. Hence, the outer race will exert the reaction to the applied load, which will be toward the shaft centreline. Now, as per the contact angle, the reactions from both the bearings will be diverging, with distance L between the two reactions.

Because of this constant reaction force from an outside stationary body (ground) acting on the shaft and with L being more than the width of the bearings, the shaft will be tightly held in the position covering length L at the bearing location. This tightness is realized in terms of higher rigidity and the stability of the shaft. That is why back-to-back arrangements have better resistance to moments in the shaft.

Face-to-face arrangement: Also known as an X arrangement, this is known to tolerate misalignments and cannot support moment loads as effectively as back-to-back arrangements. If misalignment cannot be avoided between the bearing positions, face-to-face bearing arrangements are recommended (Fig 3).

Fig 3



Here in this arrangement, one can see the reaction load lines are converging inside reducing the distance L, as compared with back-to-back arrangements. However, the noteworthy point here is that the inner races are touching each other at the face and the gap is initially present at the outer races. Hence, the preload is achieved by closing the gap between the outer races. In the same way as described for back-to-back arrangements, one can imagine that while pushing the outer races closer, it will move the rolling elements with the cage along.

Since the movement of the inner races is completely confined, there will be a reaction force arising inside out, i.e., the reaction will be given by the inner races against the applied force. This is due to the load lines will come closer to reducing the length L. The reaction force coming from the shaft (inner races) reduces the stiffness of the arrangement and then it can tolerate some misalignments.

After understanding these arrangements, it makes clear the advantages that are normally outlined in the manufacturer's catalogues.

The primary benefits resulting from preload include, but are not limited to:

- enhanced stiffness
- reduced noise levels
- improved shaft guidance
- compensation for wear and settling
- extended bearing service life

Axial play checking of face to face fitting: Following is the way of

Checking axial play of the bearing:

Open cover plate of the bearing from one side. Push the shaft with suitable device towards other end. Insert feeler gauge leaf of suitable size on the top gap of the bearing.

If feeler gauge method is not applicable, DTI is used to check.

Place DTI plunger on front face of the shaft with base at some firm place. Give pre load and set the reading to zero. Move the shaft axially with some suitable device. To and fro reading on DTI will show the axial play in the bearing.

AXIAL PLAY ADJUSTMENT OF FACE TO FACE FITTING: Following is the way of adjusting axial play of the bearing:

Check axial play of the bearing. Compare measured axial play of bearing with its required value. If measured play is less than the required value, insert shims or liners equal to the difference of value between cover plate and housing. Place cover plate on its position and tighten it fully. Check the play. If measured play is more than the required value, remove shims or liners from the position between cover plate and housing equal to the difference of value. Tighten the cover plate and check axial play.

Checking and adjustment of axial play of back to back fitting:

Following is the way of checking and adjustment of axial play of taper roller bearing

Check axial play in the bearing as explained earlier. It clearance is more than the requirement, tighten the nut to move inner race against the outer race to minimize clearance. If clearance is less than the requirement, loosen the nut and hit the inner race to give more clearance between them.

MOUNTING OF TAPER BORE BEARING

Taper bore bearing is generally mounted on the shaft without shoulder. It helps in positioning the bearing in plummer block without any stress on it. Taper bore bearing is mounted on the shaft either on adopter sleeve or withdrawal sleeve.

Adopter sleeve helps the bearing while mounting, where as withdrawal sleeve helps in dismount bearing from shaft.

Standard taper (1:12) or steep taper (1:30) is generally given in bearing bore. A taper bore bearing has an indication K written along with bearing number.

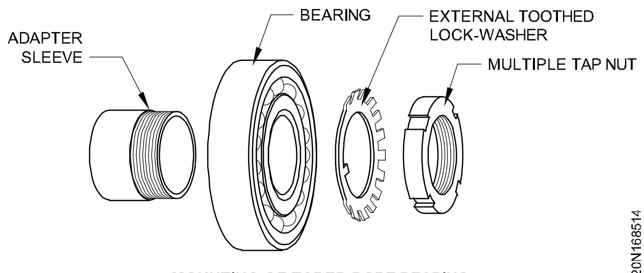
Mounting of taper bore bearing with adoter sleeve:

Mount adopter sleeve on the shaft by expanding the hole and place it in position. Mount taper bore bearing on adopter sleeve and tighten it with the help of multiple tab nut. Tighten the nut till the bearing clearance becomes zero, or bearing refuses to rotate. Loosen the nut equal to axial play and hit the bearing in opposite direction. Check the clearance and lock the nut on its position by tab washer.

Dismounting bearing on an adapter sleeve

Small and medium-sized bearings on adapter sleeve and smooth shafts can be dismounted by hammer blows directed to a drift (Fig 4) until the bearing becomes free. But first the sleeve nut has to be loosened a few turns.

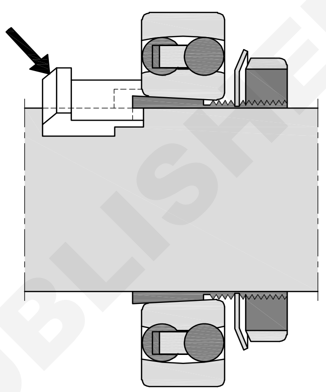
Fig 4



MOUNTING OF TABER BORE BEARING

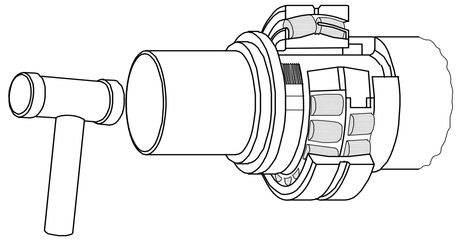
Small and medium-sized bearings on adapter sleeve and stepped shafts can be dismounted by using a dolly abutting the sleeve nut, which has been released by a few turns (Fig 5)

Fig 5



Dismounting large bearings from an adapter sleeve with a hydraulic nut has proved easy to do. To use this technique however, the bearing must be mounted against a shoulder (Fig 6). If the sleeves are pro- vided with oil supply ducts and distributor grooves the dismounting becomes easier because the oil injection method can be employed.

Fig 6



Dismounting bearing on a withdrawal sleeve

When dismounting bearings on withdrawal sleeves, the axial locking device: a locking nut, end cover etc., has to be removed. Small and medium-sized bearings can be dismounted using a lock nut and a hook or impact spanner to free the bearing (Fig 7).

The preferred means of dismounting large bearings is by using a hydraulic nut (Fig 8). If the threaded section of the sleeve protrudes beyond the shaft end or shaft shoulder, a support ring having the greatest possible wall thickness should be inserted in the sleeve bore to prevent distortion and damage to the thread when the nut is tightened.

Fig 7

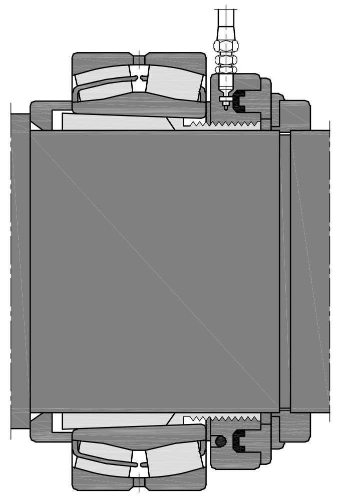


Fig 9

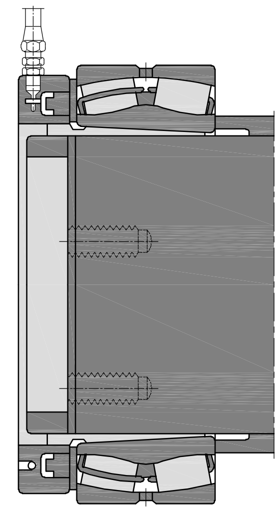


Fig 8

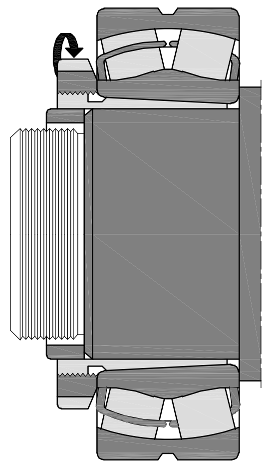
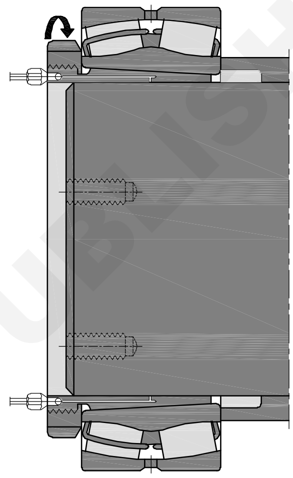


Fig 10



Withdrawal sleeves for large bearings are generally provided with distributor ducts and grooves for the oil injection method to save considerable time when mounting as well as dismounting large bearings.

Handling of bearings

One of the universal facts about bearings is that they constantly deal with a lot of load. Being constantly exposed to pressure will directly affect its longevity and performance if not maintained well. Certain recommendations as to how it should be properly handled are to be followed as its quality is vital for machines to run efficiently. But it's also important to note that certain automotive and industrial bearings do not need much maintenance as some such as DGBB, Pillow Block Bearings and more are relatively maintenance-free. However, it's crucial to handle them correctly because there are certain common practices that can shorten their functional lifespan. ""Bearings should never be handled with bare hands. Tac-free finger cots or talc-free surgical gloves should be worn. Work areas must be clean, (no food or smoking should be allowed). Bearings should be kept in original packaging until the moment they are ready to be installed."

Bearing storage

The conditions in which bearings are stored can have adverse effects on operational performance. Inventory control also exerts an important role on bearing performance, particularly sealed bearings. Premature damage to bearings is mainly caused by contaminants, corrosive agents and inadequate handling, but this can be avoided by following the correct storage conditions. Provided below we present a brief guide on how bearings should be protected.

If bearings are to be stored for a long time, it is advisable that the bearings be stored on shelves set higher than 30cm from the floor, at a humidity less than 65%, and at a temperature around 20°C. Avoid storage in places exposed directly to the sun's rays or placing boxes of bearings against cold walls.

Rigging (material handling)

Objectives: At the end of this lesson you shall be able to
- **state what is rigging**
- **list the tools and tackles used in rigging**
- **brief the tools used in rigging.**

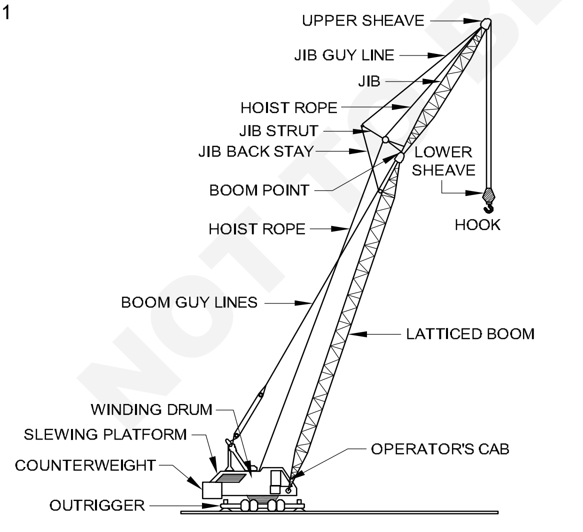
Rigging is the action of designing and installing the equipment, in the preparation to move objects. A team of riggers design and install the lifting or rolling equipment needed to raise, roll, slide or lift objects such as with a crane, hoist or block and tackle.

Rigging comes from rig, to set up or prepare. Rigging is the equipment such as wire rope, turnbuckles, clevis, jacks used with cranes and other lifting equipment in material handling and structure relocation. Rigging systems commonly include shackles, master links and slings, and lifting bags in underwater lifting.

Crane

A crane is a type of machine, generally equipped with a hoist rope, wire ropes or chains, and sheaves, that can be used both to lift and lower materials and to move them horizontally. It is mainly used for lifting heavy objects and transporting them to other places. The device uses one or more simple machines to create mechanical advantage and thus move loads beyond the normal capability of a human. Cranes are commonly employed in transportation for the loading and unloading of freight, in construction for the movement of materials, and in manufacturing for the assembling of heavy equipment.(Fig 1)

Fig 1



There are many different types of cranes, each tailored to a specific use. Sizes range from the smallest jib cranes, used inside workshops, to the tallest tower cranes, used for constructing high buildings. Mini-cranes are also used for constructing high buildings, to facilitate constructions by reaching tight spaces. Large floating cranes are generally used to build oil rigs and salvage sunken ships.

Jack

A jack is a mechanical lifting device used to apply great forces or lift heavy loads. A mechanical jack employs a screw thread for lifting heavy equipment. A hydraulic jack uses hydraulic power. The most common form is a car jack, floor jack or garage jack, which lifts vehicles so that maintenance can be performed. Jacks are usually rated for a maximum lifting capacity (for example, 1.5 tons or 3 tons). Industrial jacks can be rated for many tons of load.(Fig 2&3)

Fig 2

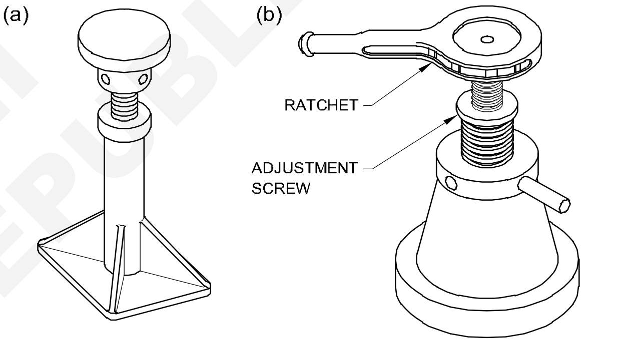
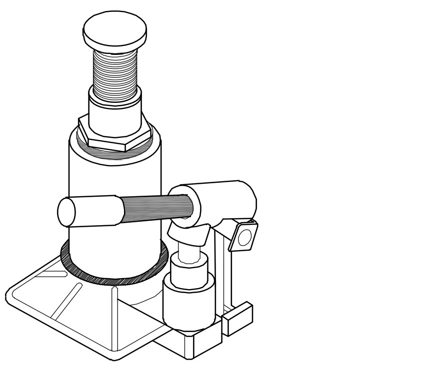


Fig 3



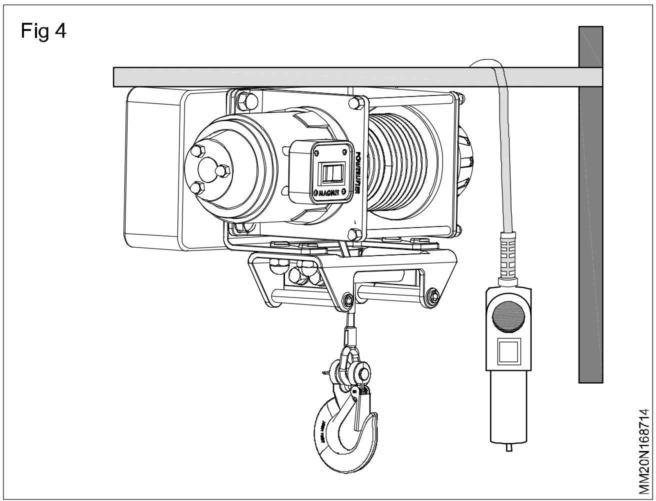
HYDRAULIC JACK

Hoist

A hoist is a device used for lifting or lowering a load by means of a drum or lift-wheel around which rope or chain wraps. It may be manually operated, electrically or pneumatically driven and may use chain, fibber or wire rope as its lifting medium. (Fig 4)

Block and tackle

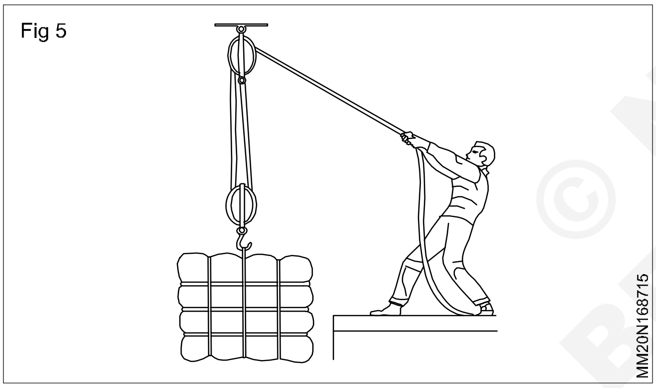
A block and tackle or only tackle is a system of two or more pulleys with a rope or cable threaded between them, usually used to lift heavy loads.



The pulleys are assembled to form blocks and then blocks are paired so that one is fixed and one moves with the load. The rope is threaded through the pulleys to provide mechanical advantage that amplifies the force applied to the rope.(Fig 5)

Winch

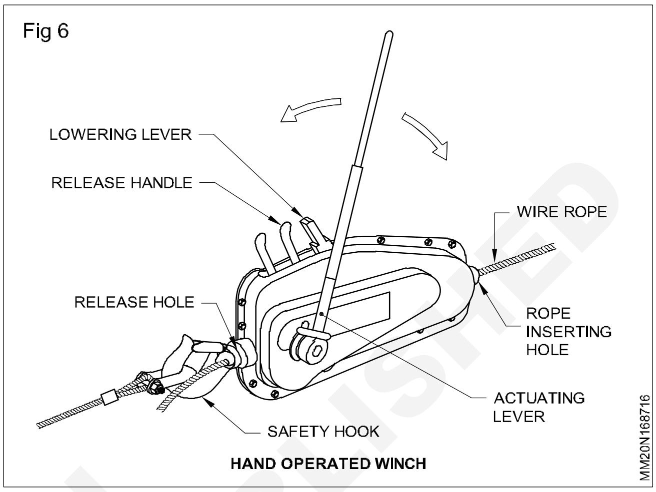
A winch is used to draw loads along the ground. It may also be used for hoisting purpose in some special cases. Two major classification of winches are



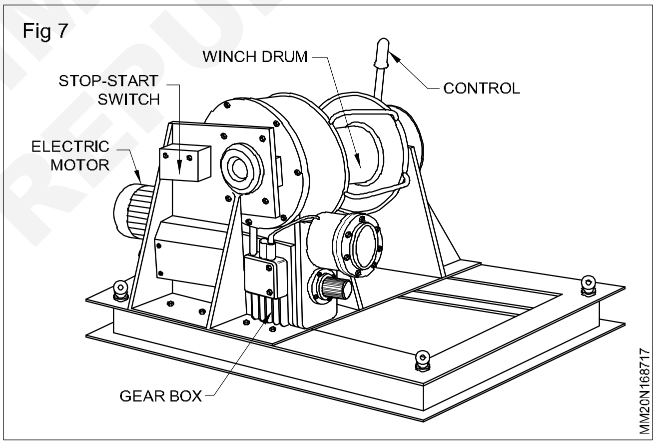
1 Hand operated winches

2 Power operated winches

Working principle of hand operated winch (Fig 6) These are most correctly used and simple in design, construction and operation. The pulling and lifting operation is achieved by two pairs of steel jaws operated by a hand lever. The grip is actuated by the movement of cams through operation of hand lever and mechanism is such that heavier the load firmer is the grip.



Power operated winch (fig 7)



Connect wire ropes using bulldog grips

Objectives: At the end of this lesson you shall be able to
- **state components and material and properties of wire rope**
- **state construction and lay of wire rope**
- **state specification of wire rope**
- **state inspection of wire rope**
- **state joining of wire rope**
- **state maintenance of wire rope.**

Components of wire rope

The three basic components of a rope are (Fig 1)

i steel wire

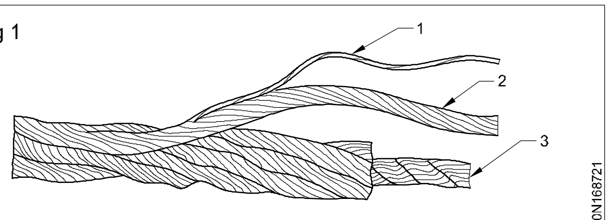
ii strand

iii core.

Wire rope material

Wire rope is made of iron, traction steel, galvanised steel, plow steel, bridge rope steel, stainless steel and phosphor bronze. For general application bright or high tensile steel wire having a tensile strength of 120 to 180 kgf/mm^2 are used.

Fig 1



COMPONENTS OF A ROPE

Properties of steel wire rope

i) strength

ii) flexibility

iii) resistance to wear

iv) resistance to crushing and distortion.

Rope construction

There are three types of wire rope constructions (Fig 2). They are:

- Seale
- Filler
- Warrington

In seale types of construciton, there are nine bigger diameter wires on the outer layer with nine smaller diameter wires in the next layer and with a bigger wire at the center to make a strand . Such six strands with a core makes a wire rope.(Fig 2a)

In filler type, twelve wires are on the outside with six in the next layer and one at the centre to make a strand. Six such strands with a core makes a rope. (Fig 2b)

In warrington type six wire ropes of big diameter with six smaller diameter ropes on the outside with six big dia. ropes in the next layer and one at the centre. Such six strands, with six smaller dia strands and a small dia wire at the centre forms core make a rope (Fig 2c)

Common lay of ropes

i) Right hand 'regular lay'

ii) Left hand 'regular lay'

iii) Right hand 'lang's lay'

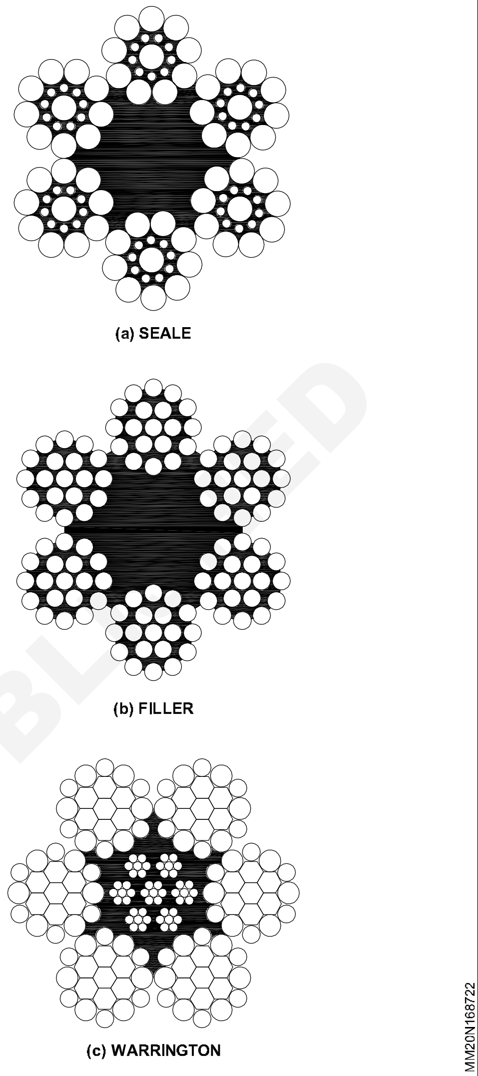
iv) Left hand 'lang's lay'

i) Regular lay ropes are so constructed that the direction of twist of the wires in the strand is opposite to that of twist in strands. There are two types as right hand and left and in one strands as shown in Fig 3a and b. These are commonly used in workshop applications.

ii) Long lay or parallel lay ropes Fig 3c and d are so constructed that the direction of twist of the wires in one strand is same to that of the strands in rope. There are also right hand and lefthand types. (Fig 3c and d). These ropes are more wear resisting in their characteristics but they tend to spin. These are generally used in lifts and other hoists and also as haulage ropes.

iii) Reverse lay ropes: In this construction the wire in the too adjacent strands are twisted in the opposite direction. Theses are generally used for heavy applications.

Fig 2

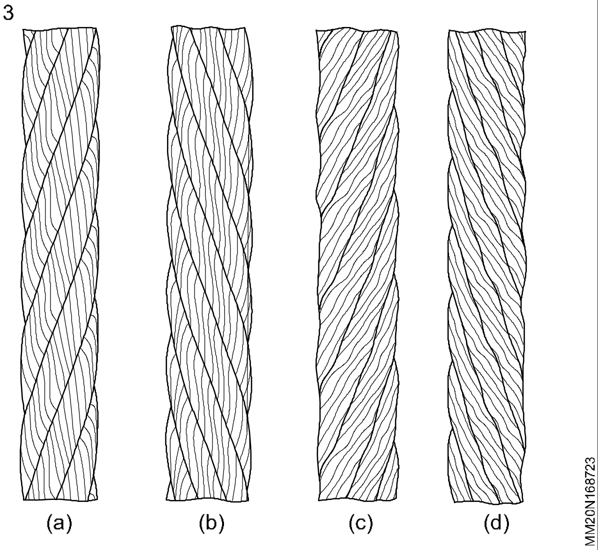


(a) SEALE

(b) FILLER

(c) WARRINGTON

Fig 3



Specification of wire rope

For specification of a wire rope, the following informations are to be furnished.

i) Length

ii) Diameter

iii) Number of strands

iv) Number of wire in each strand

v) Type of rope construction

vi) Type of core and type of lay.

Example (Ref. Fig No.2a,b and c)

6 x 19 sealed (9/9/1) nine large outer wires, nine smaller inner wires and one core wire.

6 x 19 filler (12/6+6F/1) 12 outer wires, 6 inner pins 6 filler wire over a core wire.

6 x 10 warington (6and 6/6/1) 12 wires alternatively small and large over 6 wires over a core or king wire.

Inspection of wire rope

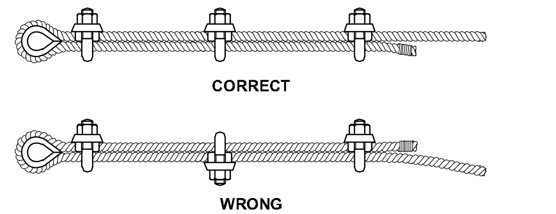
Every 3 cm of rope should be inspected for wear, wire breakage, corrosion, reduction in diameter (stretched due to load) etc. As a statutory regulation, ropes certified by the authority for the factor of safety. Normally, factor of safety is between 3 to 4 times the load tends to carry and 5 to 12 times for severe operating condition.

Joining of wire ropes

Wire ropes are joined by bulldog clamps. The method is very simple and capable of taking applied load on the rope (75 to 80% efficiency).

The process is to form a loop and eyelet is put on it. Now put one grip close to eyelet, the second one at the short end of the rope and the third one should be in between as a minimum of three clamps are to be put (as mentioned in the chart below). Distance between the grip should be 6 times the diameter of the rope. 'U' side of the grip must be on the short end side of the ropes as shown in Fig 4, clamps are evenly tightened to take load with 80% efficiency.

Fig 4



METHODS OF ATTACHING CLIPS TO WIRE ROPE

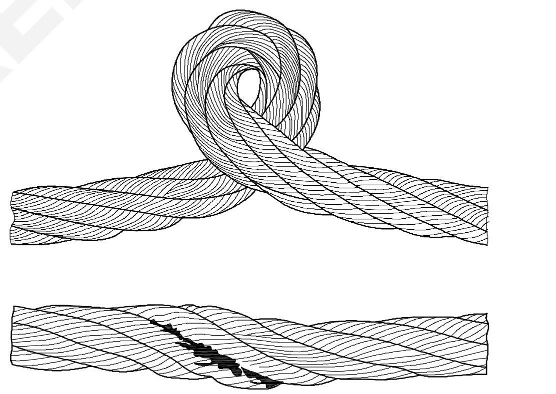
Number of grips for rope joining

Diameter of rope	Min.Nos.of grips
Upto and including 19 mm	3
Over 19 mm to 32 mm	4
Over 32 mm to 38 mm	5
Over 38 mm to 44 mm	6

Maintenance of wire rope

- Wire rope should be stored in cool dry place.
- Rope should not be allowed to form kink (Fig 5) which leads to damage and failure.
- Dust, dirt and mud should be brushed off and steam washed and dried whenever necessary.
- After drying oil lubrication should be done.
- Periodically, rope should be tensile tested to ensure its factor of safety.

Fig 5



Terminology related to rope binding and knots

Objectives: At the end of this lesson you shall be able to
- **state the meaning of terms used in rope binding.**

Hoist (Fig 1)

It is an equipment used for raising or lowering.

Laying and re-laying (Fig 2)

The process of building up a rope to form strands is called laying, and the untwisting of the strands is called re-laying.

Crowning (Fig 3)

This is a neat, secure and permanent method of fastening of strands of a rope with slight enlargement at the end of the rope.

Whipping (Fig 4)

It is the process of binding the end of a rope with twine or soft wire to prevent it from untwisting.

Knot (Fig 5)

Fastening of one part of a rope to another part of the rope is known as a knot.

Bight (Fig 6)

Bending of a rope is called a bight.

Fig 1

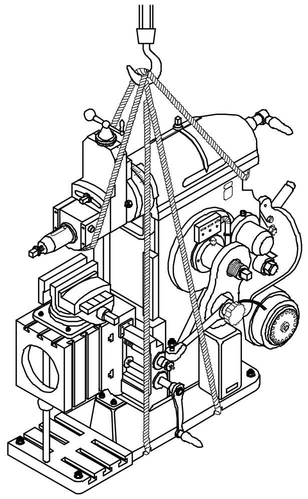


Fig 2

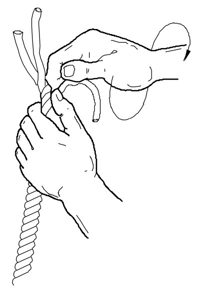


Fig 3

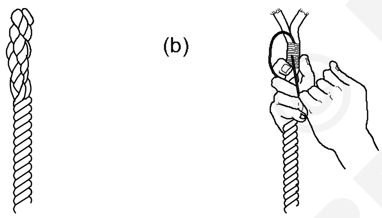


Fig 4

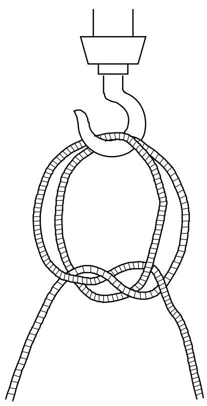
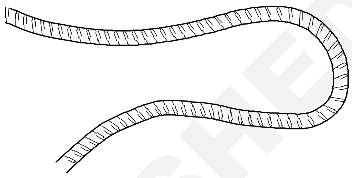


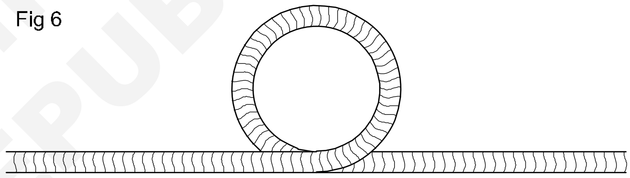
Fig 5



Loop (Fig 6)

Loop or turn is made by crossing the sides of a bight.

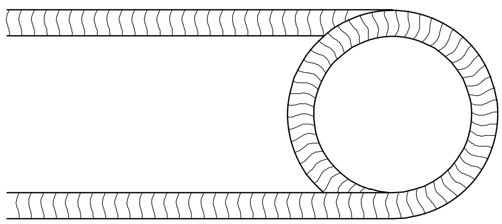
Fig 6



Round turn (Fig 7)

It is produced by further bending of one side of a loop.

Fig 7



Ropes

Objectives: At the end of this lesson you shall be able to
- **name the different types of ropes and their uses**
- **state the precautions to be observed while using ropes**
- **state the general inspection points for using ropes.**

Ropes are made from individual fibres, spun together like string or yarn. Hemp, cotton, Manila, steel and synthetic wire are used in the manufacture of rope. Manila and hemp ropes are manufactured from the fibre of wild banana plants.

Ropes are manufactured in three or four strands. Manila and hemp ropes are used for light duty hoisting with a rope pulley block.

The following precautions should be observed while using the ropes.

- Avoid running the rope over sharp edges.
- Ropes should be kept dry because moisture hastens their decay.
- Hang wet rope loosely in an area where it can dry before it is used.

- Avoid dragging of rope over concrete, gravel and other rough surfaces.
- Frozen rope should not be used until it is thawed.

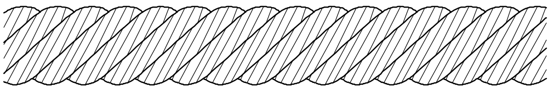
Wire ropes

Wire ropes or cables are built up of strands of wire laid together in the direction of opposite twists which form the rope. Standard wire rope is made from strands encompassing a single core.

Wire ropes are used for heavy duty hoisting.

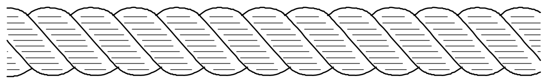
When the wires and strands are twisted in the same direction the rope is known as 'Lang lay rope' (Fig 1) and when twisted in the opposite direction it is known as regular lay rope. (Fig 2) The combined lay rope is shown in Fig 3.

Fig 1



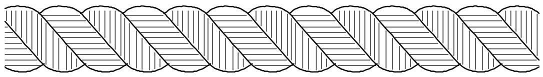
MM20N168741

Fig 2



MM20N168742

Fig 3



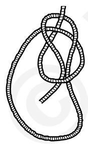
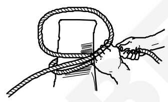
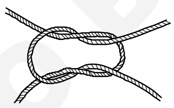
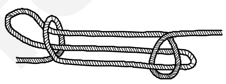
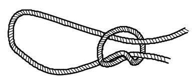
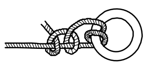
MM20N168743

Rope inspection

- Inspect ropes frequently for damage.
- Surface inspection will reveal broken or worn out strands.
- For interior inspection twist the rope in the opposite direction to the way it was spun.

This will open up and separate the strands so that the interior fibres can be examined.

Different types knots used is described in Table 1 with diagram

Name of the knot	Sketch	Uses
Bowline knot		Non-slipping eye, easy to untie.
Clove-hitch knot		Secures rope to pipe or post.
Square knot		Joins two pieces of rope of equal diameter. Slips, if rope is wet.
Sheep shank knot		For shortening a rope without cutting.
Slip knot		Used for lifting light loads
Double hitch knot		Secures rope to small pipe or ring.

Gears - types - description and function

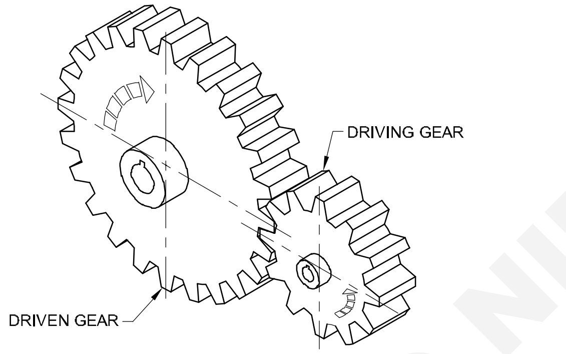
Objectives: At the end of this lesson you shall be able to
- **state the purpose of gears**
- **name the most common forms of gears and state their applications**
- **determine the velocity ratio of a gear train**
- **state the care and maintenance of gears.**

Purpose of gears

Gears are used to transmit torque/motion from the driving shaft to the driven/follower shaft:

- to change the velocity ratio
- to change the direction of rotation. (Fig 1)
- to get a positive drive.

Fig 1



Gears are made from cast iron, steel, non-ferrous, plastic or fibre material.

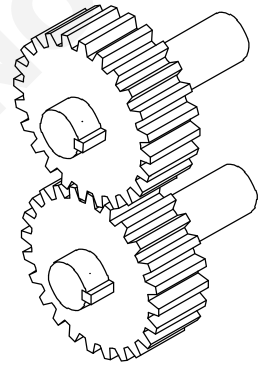
Types

Spur gear

The teeth are cut parallel to the axis of rotation. The spur gears are used to transmit power between two parallel shafts.

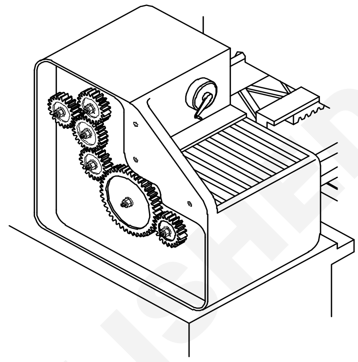
Fig 2 shows two spur gears mating each other and Fig 3 illustrates the application of gears in the centre lathe to transmit motion from the main spindle to the lead screw.

Fig 2



SPUR GEAR

Fig 3



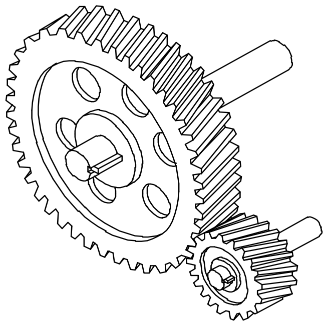
SPUR GEARS

Helical gear

In a helical gear, the teeth are cut at an angle to the axis of rotation. It may be used to transmit power between two parallel shafts. Helical gears run more silently than a spur gear.

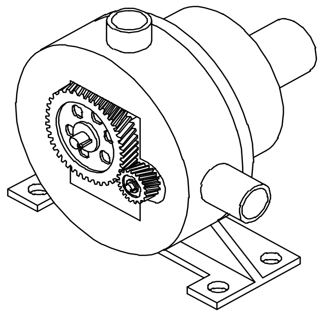
Fig 4 shows a set of helical gears mounted on two parallel shafts. These are widely used in automobile vehicles. The application of helical gears in an oil pump is illustrated in Fig 5.

Fig 4



HELICAL GEARS

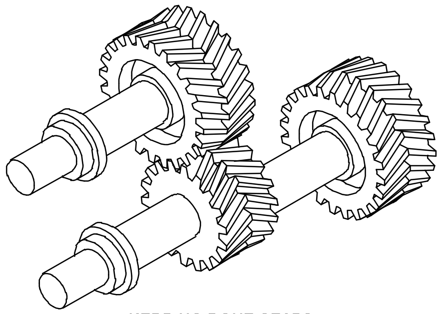
Fig 5



HELICAL GEARS

The end thrust is exerted by the driving and driven gears in the case of helical gears and the thrust may be eliminated by using double helical gears. These gears are called herring-bone gears. (Fig 6)

Fig 6



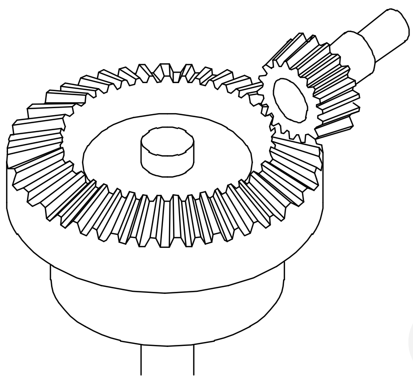
HERRING BONE GEARS

MM20N168816

Bevel gear

The bevel gears shown in Fig 7 are used to transmit motion between shafts at various angles to each other. The teeth profile may be straight or spiral.

Fig 7

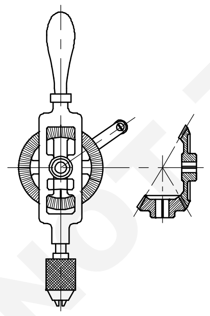


BEVEL GEAR

MM20N168817

In a hand driller, the bevel gears transmit motion when the shafts are at right angles to each other. (Fig 8)

Fig 8



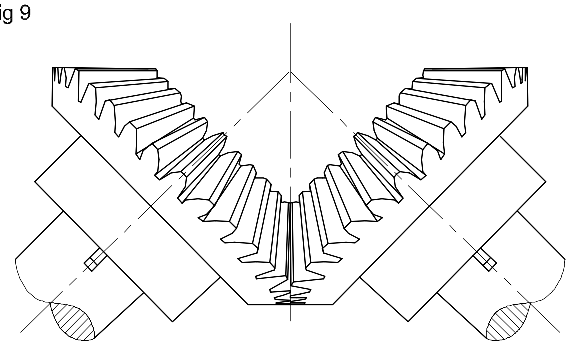
BEVEL GEAR

MM20N168818

Mitre gears

If two bevel gears are symmetrical to each other and transmit motion at right angles, such gears may be called 'mitre gears'. (Fig 9)

Fig 9



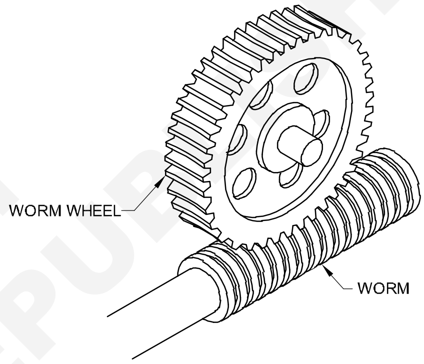
MITRE GEARING

MM20N168819

Worm shaft and worm gear

The worm shaft has spiral teeth cut on the shaft and the worm wheel is a special form of gear teeth cut to mesh with the worm shaft. (Fig 10)

Fig 10

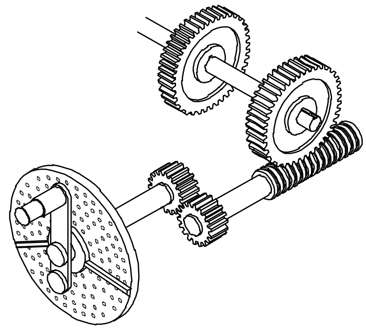


MM20N16881A

These are widely used for speed reduction purpose.

The application of worm and worm gear in the index-head gear mechanism is shown in Fig 11.

Fig 11



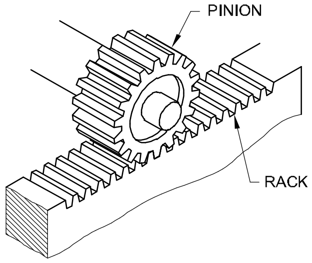
MM20N16881B

This system transmits motion at right angles to the axis of motion at different planes.

Rack and pinion

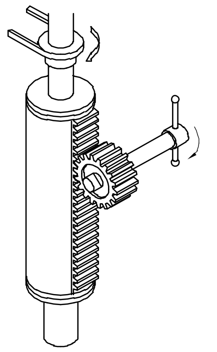
The rack and pinion can change rotary into linear movement and vice versa. (Fig 12)

Fig 12



This mechanism is used in drilling machines as illustrated in Fig 13.

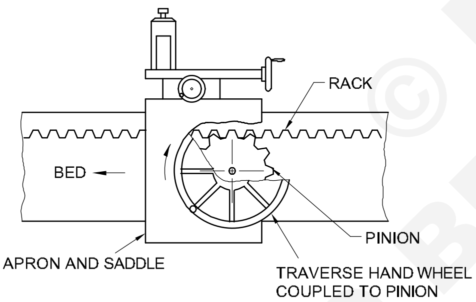
Fig 13



DRILLER

Fig 14 shows the application of the rack and pinion in lathe traverse mechanism.

Fig 14

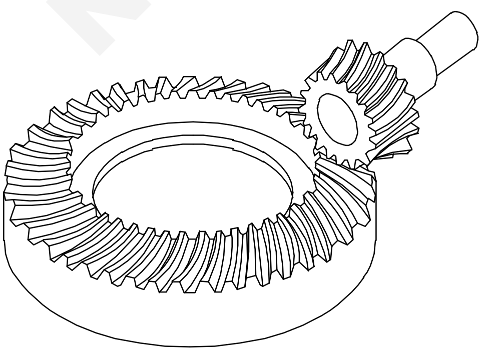


RACK AND PINION (LATHE TRAVERSE MECHANISM)

Hypoid gears

The hypoid gears are used in automotive differential gear-boxes. A pair of hypoid gears (illustrated in Fig 15) is similar to the spiral bevel gear but with the shafts offset.

Fig 15



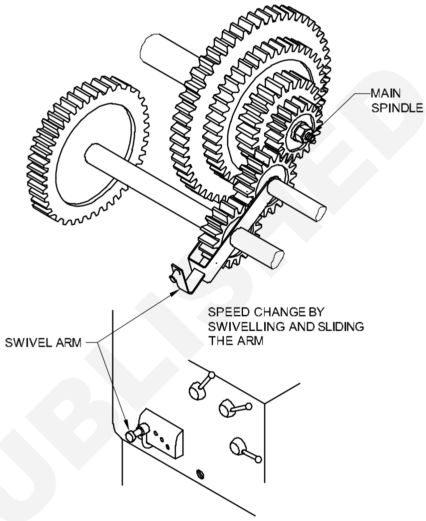
The tooth action between each gear is a combination of rolling and sliding action along a straight line. The pitch surfaces are hyperboloids of revolution; as such the gears are called hypoid gears.

Velocity ratio of gear train

The gear train transmits motion without slip.

Different speeds can be obtained by shifting gear position in the gear- box. (Fig 16) shows the feed change by swivelling and sliding the swivel arm in the Norton gearbox of lathes.

Fig 16



Formula for velocity ratio of gear train

$N_1 T_1 = N_2 T_2$

where

N_1 = RPM of driver gear

T_1 = number of teeth in the driver gear

N_2 = rpm of the follower/driven gear

T_2 = number of teeth in the driven gear.

Care and maintenance of gears

The low speed gears which are visible may be lubricated with an oilcan or brush. (Fig 17) The drop oil method of lubrication is shown in (Fig 18).

Fig 17

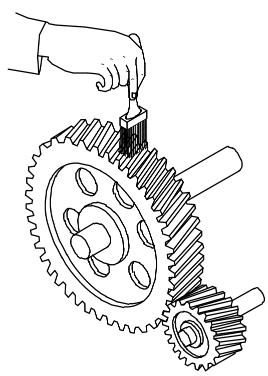
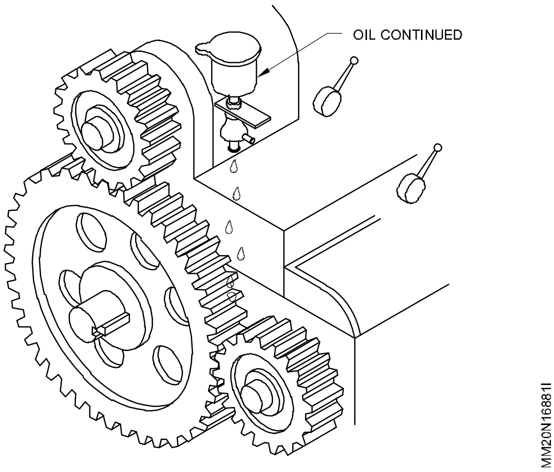
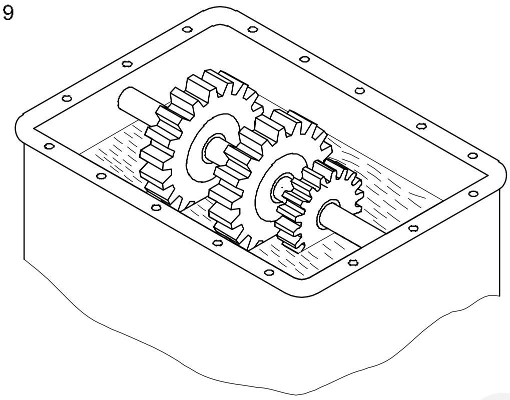


Fig 18



The enclosed gear trains should be packed in grease or run in an oil bath. (Fig 19)

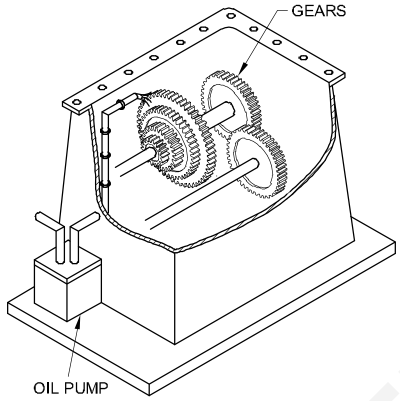
Fig 19



OIL IN GEAR BOX

In the case of big gearboxes mounted with different levels of gear sets,they are provided with oil pumps for lubrication purposes. (Fig 20)

Fig 20



To ensure proper and long life of gears they should never run dry.

Gear terminology

Objectives: At the end of this lesson you shall be able to
- **state the basic elements of spur gear**
- **calculate spur gear tooth proportions with the given data**
- **explain the backlash of gear teeth**
- **describe the measurement of gear size and run out**
- **describe the composite and pitch measurement of gears.**

Spur gear elements

A spur gear is the simplest form of gears. The tooth proportions of the spur gears are expressed in terms of modules.

Module

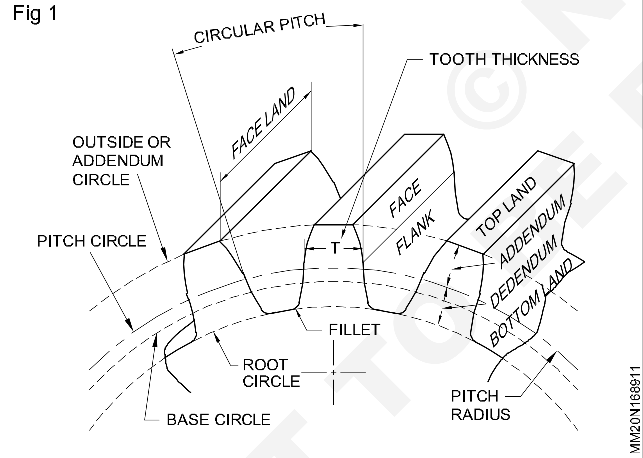
It is defined as the ratio of the pitch diameter to the number of teeth of a gear. The module is denoted by the letter 'm' and is expressed in millimetres. The module is one of the major determining parameters of a gear.

Basic elements (Fig 1)

Pitch circle

It is the imaginary circle on which two mating gears seems to be rolling.

Fig 1



The gear calculations are based on this circle.

Circular pitch: 'CP or 'P'

It is the distance from the point of one tooth to the corresponding point of the adjacent tooth measured on pitch circle.

Pitch circle diameter (PCD)

The diameter is called pitch circle diameter (PCD) or simply pitch diameter.

It is denoted by the letter 'd' with proper subscripts *eg.* d1 for pinion and d2 for the matting gear.

Addendum circle

Addendum circle or outside circle bounds the outer edges of the teeth of a gear and its diameter is denoted by 'da'.

Root circle

The root circle or dedendum circle bounds the bottom of the teeth and its diameter is denoted by 'df '.

Base circle ('db')

This is the circle from which the involute tooth profile is developed. Its diameter is denoted by 'db'.

Addendum (ha) (Fig 2)

It is the radial distance between the pitch circle and the addendum circle and is denoted by 'ha'.

Dedendum (hf) (Fig 2)

It is the radial distance between the pitch circle and the root circle, and is denoted by 'hf '.

Land (Fig 2)

The land and the bottom land are surfaces at the top of the tooth and the bottom of the tooth space respectively.

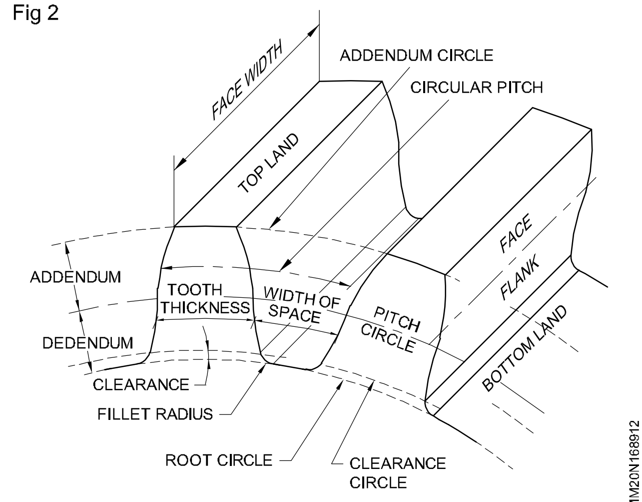
Working depth (Fig 2)

This is the distance of engagement of two mating teeth and is equal to the sum of addendums of the mating teeth of the two gears in the case of standard systems and is expressed as '2ha'.

Whole depth (Fig 2)

This is the height of a tooth and is equal to the addendum plus dedendum and is expressed as (ha+hf).

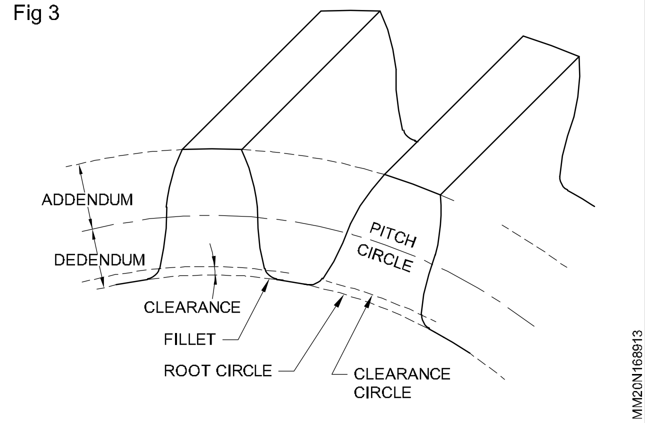
Fig 2



Clearance (Fig 3)

This is the radial distance between the top land of a tooth and the bottom land of the mating tooth.

Fig 3



Face width (Fig 2)

This the width of the gear and it is the distance from one end of a tooth to the other end.

Face of a tooth (Fig 2)

This is the surface of the tooth between the pitch circle and the outside circle.

Flank of tooth (Fig 2)

This is the surface of the tooth between the pitch circle and the root circle.

Chordal tooth thickness (Fig 4)

This is the chord referred to above. Chordal addendum (or chordal height, as it is sometimes called) as well as the chordal tooth thickness are important in the checking of gears.

Chordal addendum (Fig 4)

This is the height bound by the top of the tooth and the chord corresponding to the arc of the pitch circle representing the circular tooth thickness.

Diametral pitch (DP) (Fig 4)

This is a term used in gear technology in the F.P.S. system. It is defined as the ratio of the number of teeth to the pitch diameter in inches.

It is usually denoted as 'DP'. It is equal to the number of gear teeth per inch of the pitch diameter. The unit of DP is the reverse of inch.

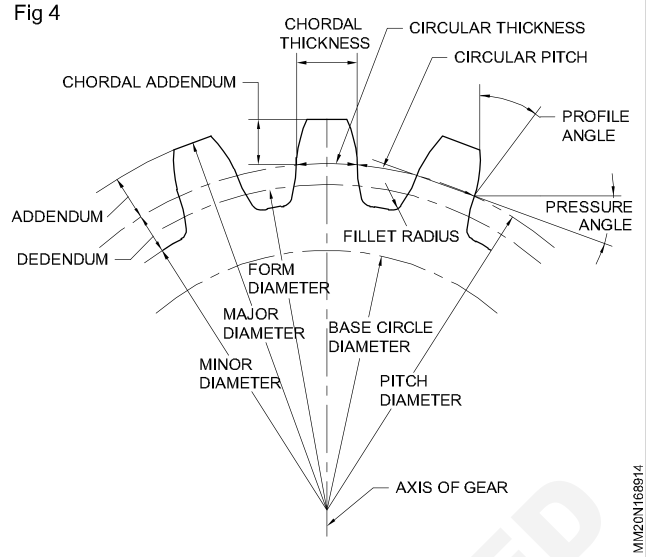
The following relation exists between DP and module.

$$M = \frac{25.4}{DP} \quad DP = \frac{25.4}{m}$$

Line of action

This is the line along which the point of contact of the two mating teeth profiles moves.

Fig 4



Pitch line

It is the line of contact of two pitch surfaces.

Pressure angle (Fig 4)

The angle which the common normal to the two teeth at the point of contact makes with the common tangent to the two pitch circles at the pitch point is known as the pressure angle.

Spur gear tooth proportions

Symbols

Pd	=	Pitch diameter
da	=	Outside diameter
df	=	Root diameter
P	=	Circular pitch
Z	=	Number of teeth
m	=	Module
h	=	Height of tooth (ha + hf)
ha	=	Tooth addendum
hf	=	Tooth dedendum

Tooth proportions for 14 1/2° pressure angle

Pitch diameter Pd = Zm

Outside diameter da = m(Z + 2)

Root diameter df = $m\left(Z - \frac{7}{3}\right)$

Circular pitch P = $\frac{\pi \times pd}{Z}$

Module m = $\frac{pd}{Z}$

Height of tooth h = ha + hf = m(1 + 7/6)

Tooth addendum ha = m

Tooth dedendum = $\frac{7}{6}$ m

Example

Determine P, ha, hf, h, Pd, da and df for a gear wheel with a module of 3 mm 20 teeth.

Given m = 3 mm

Z = 20.

Pd (Pitch diameter) = Zm

= 20 x 3 = 60mm.

da (Outside diamater) = m (Z+2)

= 3 (20 + 2a)

= 3 x 22 = 66mm.

(or)

da = Pd + 2 addendum

da = 60 + 2 x ha

da = 60 + 2 x 3 (because ha = m)

60 + 6 = 66 mm.

df (Root diameter) = m ($Z - \frac{7}{3}$)

df = $3(20 - \frac{7}{3}) = 3\frac{60-7}{3} = 3\frac{53}{3}$

= 3 x $\frac{53}{3}$ = 53mm.

ha (Tooth addendum) ha = m, ha = 3mm.

hf (Tooth dedendum) = $\frac{7}{3}$ m

$\frac{7}{6}$ x 3 = $\frac{7}{2}$ = 3.5 mm.

h = (height of tooth) = (ha + hf) = 3 + 3.5 = 6.5 mm.

P = (Circular pitch) = $\frac{\pi \times pd}{Z} = \frac{22}{7} \times \frac{66}{7}$

= 9.43 mm.

Ans. P = 9.43 mm. ha = 3 mm. hf = 3.5 mm.

h = 6.5 mm. Pd = 60 mm. da = 66 mm.

df = 53 mm.

Types of gear train

Objectives: At the end of this lesson you shall be able to
- **state gear train and its types**
- **explain simple gear train & compound gear train**
- **describe reverted gear train & epicyclical gear train**
- **list and brief the types of gear boxes used in machine shop.**

Introduction

Sometimes, two or more gears are made to mesh with each other to transmit power from one shaft to another. Such a combination is called gear train or train of toothed wheels. The nature of the train used depends upon the velocity ratio required and the relative position of the axes of shafts. A gear train may consist of spur, bevel or spiral gears.

Types of gear trains

Following are the different types of gear trains, depending upon the arrangement of wheels:

Simple gear train	Reversed gear train and
Compound gear train	Epicyclic gear train.

In the first three types of gear trains, the axes of the shafts over which the gears are mounted are fixed relative to each other. But in case of epicyclic gear trains, the axes of the shafts on which the gears are mounted may move relative to a fixed axis.

Change gear train

Change gear train is a train of gears serving the purpose of connecting the fixed stud gear to the quick change gear- box. 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 cut- ting. The gears which are utilized for this purpose comprise the change gear train.

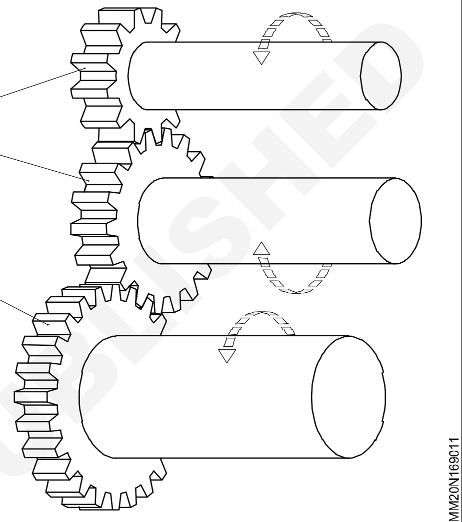
The change gear train consists of driver and driven gears and idler gears.

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

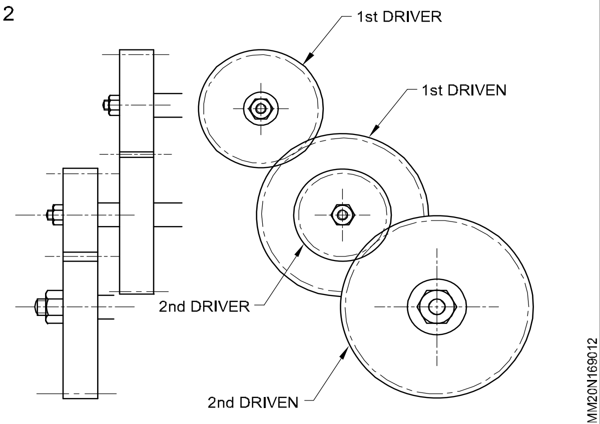


Compound gear train

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 2 shows the arrangement of a compound gear train

Fig 2

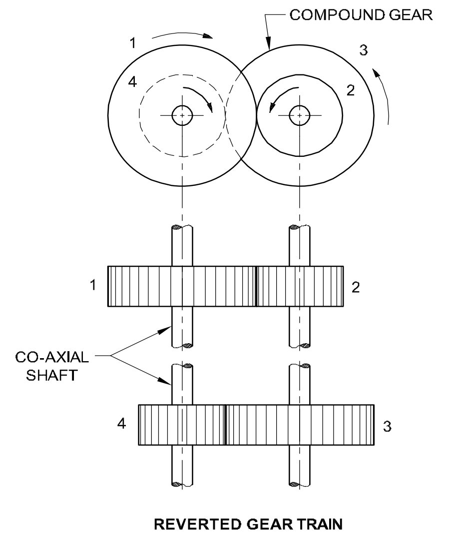


Reverted gear train

When the axes of the first gear (i.e. first driver) and the last gear (i.e. last driven or follower) are co-axial, then the gear train is known as reverted gear train as shown in Fig. 3

We see that gear 1 (i.e., first driver) drives the gear 2 (i.e. first driven or follower) in the opposite direction. Since the gears 2 and 3 are mounted on the same shaft, therefore they form a compound gear and the gear 3 will rotate in the same direction as that of gear 2. The gear 3 (which is now the second driver) drives the gear 4 (i.e. the last driven or follower) in the same direction as that of gear 1. Thus we see that in a reverted gear train, the motion of the first gear and the last gear is like.

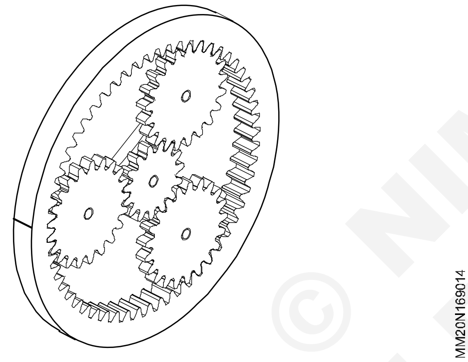
Fig 3



REVERTED GEAR TRAIN

Epicyclic gear train (Fig 4)

Fig 4



Like a compound gear train, planetary trains are used when a large change in speed or power is needed across a small distance. There are four different ways that a planetary train can be hooked up.

A planetary gear train is a little more complex than other types of gear trains. In a planetary train at least one of the gears must revolve around another gear in the gear train. A planetary gear train is very much like our own solar system, and that's how it gets its name. In the solar system the planets revolve around the sun. Gravity holds them all together. In a planetary gear train the sun gear is at the center. A planet gear revolves around the sun gear. The system is held together by the planet carrier. In some planetary trains, more than one planet gear rotates around the sun gear. The system is then held together by an arm connecting the planet gears in combination with a ring gear.

The planetary gear set is the device that produces different gear ratios through the same set of gears. Any planetary gear set has three main components:

Gear boxes

The spindle of various operations in a machine tool requires different velocity ratios or speeds. This can be full filled by a number of gear or gear transmission system.

Generally this gears are enclosed in a metallic box to get the required power transmission is called gear box.

The purpose of gear box is to support the gears as well as to withstand the thrust force and vibration of gears while power transmission.

Types of gear boxes

According to the arrangement of engaging and disengaging the gears enclosed in a gearbox, can be classified as,

Constant mesh gear box (Fig 5&6)

Sliding mesh gear box (Fig 7)

Synchromesh gear box (Fig 8)

Epicyclical gear box (Fig 9)

Worm and worm wheel (Fig 10)

Constant mesh gear box

In these types of gear boxes all the gears on the counter shaft are fixed and gears on main shaft are free to rotate.

Fig 5

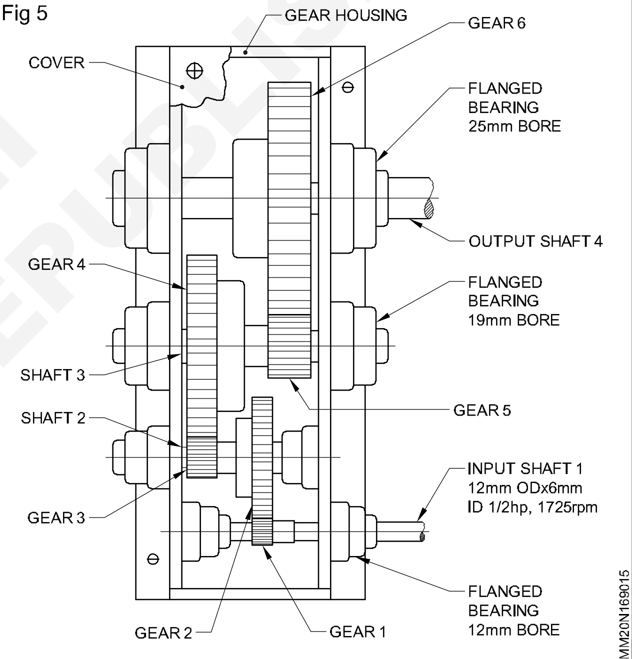
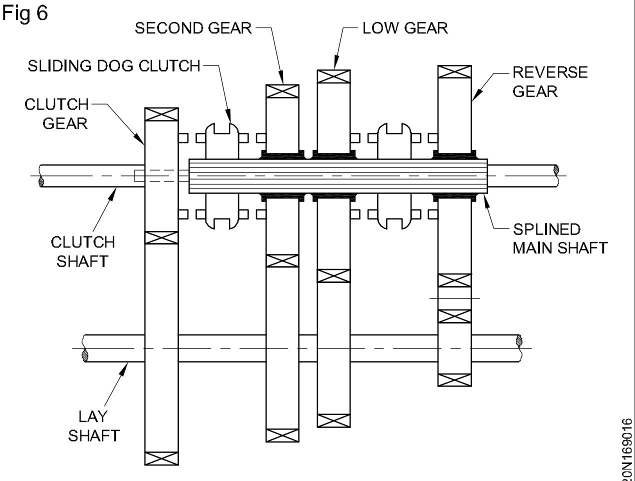


Fig 6



CONSTANT MESH GEARBOX

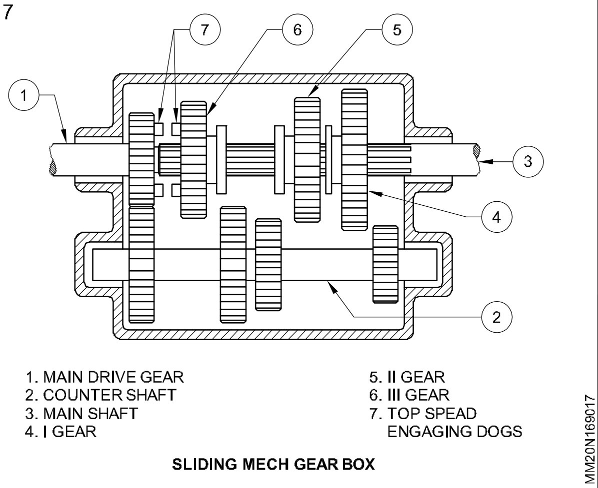
Dog clutches can slide on the main shaft and rotate with it. Dog clutches engage with gears on main shaft to obtain desired speed. (Fig 6)

Helical and herring bone gear can be used in these gear boxes and therefore, constant mesh gearboxes are quieter. Since the gears are engaged by dog clutches, if any damage occurs while engaging the gears, the dog omit members get damaged but not the gear wheels.

2 Sliding mesh gear box (Fig 7)

This gearbox consists of normally three forward and one

Fig 7



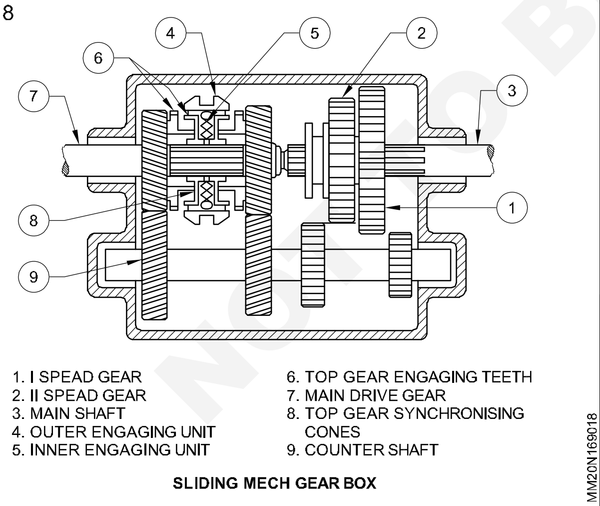
SLIDING MECH GEAR BOX

reverse gear ratios as shown in fig 7 spur gears are used for power transmission. Gear wheels on the main shaft are engaging with gear wheels on the lay shaft (Counter shaft) by sliding themselves.

3 Synchromesh gear box (Fig 8)

This type of gear box is similar to the constant mesh type

Fig 8



SLIDING MECH GEAR BOX

in that all gears on the main shaft are in constant mesh with the corresponding gears on the lay shaft. (Fig 8)

The gears on the lay shaft are fixed to it while those on the main shaft are free to rotate on the same.

Worm and Worm wheel (Fig 9)

These are basically a form of spiral gearing in which the axes of teh driving and driven shafts are usually, at right angles and velocity ratio is high, the driving wheel being of a small diameter. These gear box mostly used for speed reduction purpose. since a worm drive can reduce rotational speed or allow higher torque to be transmitted.

4 Epicyclic gearbox (Fig 10)

Epicyclic gear trains are used to get the various gear ratios. Atleast one wheel not only rotates about its own axis but also rotates about some other axis.

Automatic gearboxes typically use one or more compound planetary gear sets having two sun gears and two sets of inter meshing planet gears. There is still only one ring gear.

Fig 9

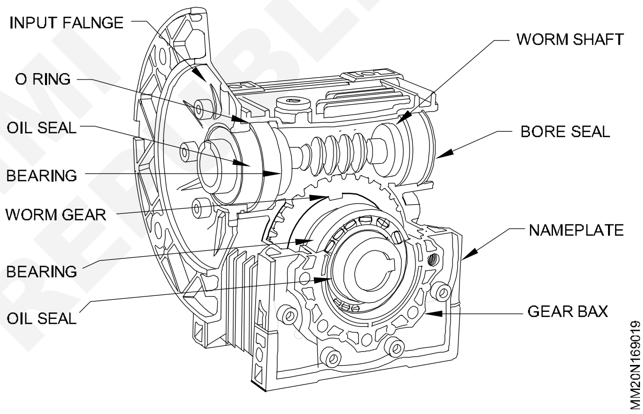
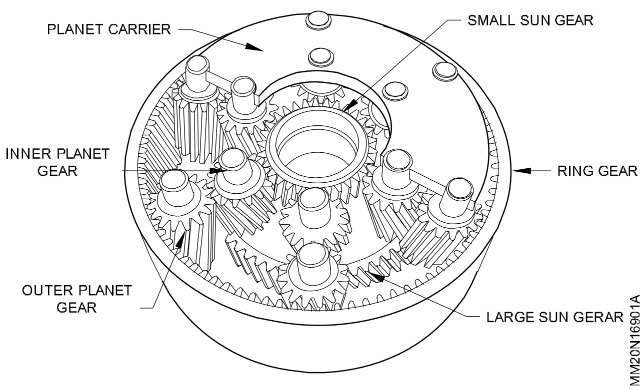


Fig 10



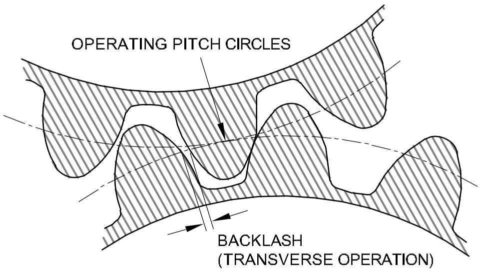
Checking back lash, root clearance and gear mesh in gear

Objectives: At the end of this lesson you shall be able to
- **state what is back lash in gear**
- **brief the methods of measuring back lash in gear**
- **state what is root clearance in gear**
- **describe the method of checking the gear mesh.**

Back lash

Backlash, sometimes called lash or play is clearance between mating components, sometimes described as the amount of lost motion due to clearance or slackness when movement is reversed and contact is re-established. For example, in a pair of gears, backlash is the amount of clearance between mated gear teeth.(Fig1)

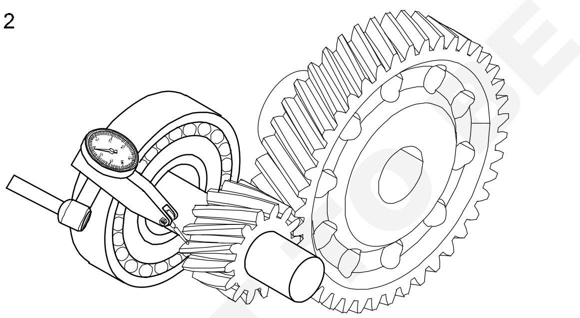
Fig 1



The backlash can be measured with dial gauge, feeler gauge and lead wire.

Dial gauge method (Fig 2)

Fig 2

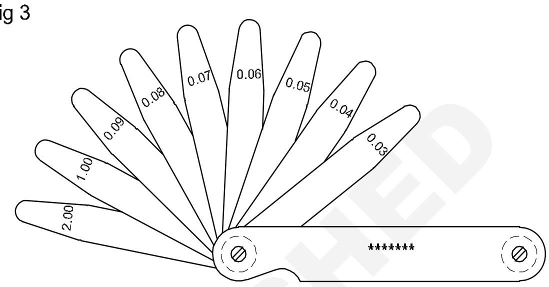


The backlash of a pair of cylindrical gears is measured by restricting the rotation of one shaft and measuring the rotational motion of the other shaft with an indicator stand with magnetic base with the tip positioned near the diameter of reference. When measuring the Backlash in cylindrical gears we can measure either on the input shaft or output shaft.

Feeler gauge

Backlash measurement method Backlash static off-line measurement Feeler gauge is a tool to measure the meshing-teeth side clearance directly. The feeler gauge can directly measure it by inserting the different thickness combination of the feeler into the two gears, and then the backlash can be calculated. The feeler gauge used in this is shown in Fig 3.

Fig 3



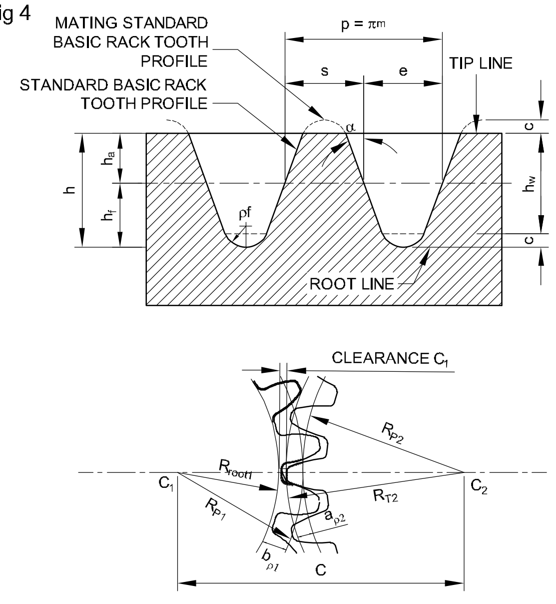
The thickness of the plug in the feeler gauge is 0.05mm, 0.06mm, 0.07mm, 0.08mm, 0.10 mm, 0.15mm, 0.20mm. 0.25mm, 0.30mm, 0.40mm, 0.50 mm, and 0.75 mm respectively. The meshing-teeth side clearance can be mea- sured by combining different thickness plug into the back- lash to be measured. Because of its high measurement accuracy, this chooses the backlash calculated by static measurement of backlash with feeler gauge as the evaluation standard of dynamic online measurement of backlash accuracy.

Lead wire impression testing

in this method is keeping the lead wire in between the two face of the mating gear and allowed to mesh after the lead wire compressed, it is measured with the micrometer which show the backlash reading.

Root clearance (Fig 4)

Fig 4



The distance between the outside circle of a gear and the root circle of its mating gear (the gap) is the root clearance. This distance (the gap) is also called the root clearance, top clearance, bottom clearance or simply the clearance

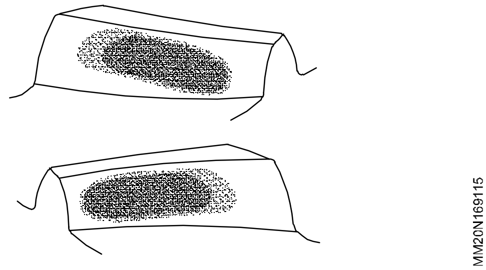
Method for setting and checking of gear mesh

Proper setting of gears usually involves checking backlash and tooth contact pattern.

Contact pattern checks require painting some or all of the teeth of at least one member with gear marking com- pound and rotating the gears to see how they contact in the marking compound.

Desirable pattern of contact (fig 5)

Fig 5



Running maintenance related hazards, risk and precautions

Objectives: At the end of this lesson you shall be able to
- **state the importance of running maintenance.**
- **brief the relationship between running maintenance and preventive maintenance**
- **explain the hazards and risks of maintain power transmission system**
- **list about the precautions to eliminate failures.**

When equipment fails the biggest concern is how to get it running again. An equal important thing is discovering the cause for the failure. Through preventive maintenance, future gear box failures can be minimised.

Steps for preventive maintenance of gear box

Analysing the problem : Lubrication

Effective lubrication is extremely critical to all gear boxes and will help prevent gear and bearing failures. Lubricant selection is based on many independent factors including gear type, load type, speed, operating temperatures, input power and reduction ratio.

If a gear continues to operate without adequate lubrication, the gear's tooth profiles will degrade to the point where replacement is the only remedy.

Analysing the problem : Vibration

Vibration is another hazard in the case of gear box maintenance. Each machine fault generates a specific vibration hazard. By analysing shaft vibration, engineers can determine whether the cause of the machine fault is due to imbalance, misalignment, general looseness or wear, bearing defects, gear defects or some other unforeseen problem.

Imbalance is the force created by a rotating body when its center of mass is offset from its centre of rotation.

Misalignment is the deviation from a common centreline during operation and can occur as offset (shafts meeting square, but not on a centreline), angular (shafts meeting at an angle from one another).

Misalignment is the common cause of broken teeth on helical and bevel gears. Wear is another hazard developed from vibration.

A broader range of gear damage can be prevented in future by vibration analysis.

Establishing a preventive maintenance program

Trouble shooting is a significant component of a comprehensive preventive maintenance program. The information gathered while analysing the problem will ultimately serve as the foundation for planning future preventive maintenance.

Gear oil selection

It is easy to accept the machine manufacturer's recommendation but they can never anticipate all the conditions under which the gear box may operate. The manufacturer's recommendation, therefore, must be a guideline and not necessarily the final word. Operating conditions must also be determined in order to make the best possible recommendation.

Failure / Wear analysis

During the first inspection of a set of gears that are properly installed and lubricated, the combined action of roling and sliding will smooth the working surfaces of the teeth and give them highly polished look. The main causes of failure or wear of gears are

1 Rapid fluctuations in operating temperature, high speeds and heavy loads.
2 Any operating environment that causes condensation inside the gear case.
3 Operation in moist or dirty environments.
4 Gear oil changes as needed are critical during the first few weeks or months operation of gear cases.
5 After checking for dirt, metals, water, acid number and viscosity, the operator can determine when the interior of the oil reservoir needs cleaning.
6 The careful inspection and proper cleaning of all types of gear sets are also valuable in obtaining maximum service life.

Methods to eliminate the gear box related hazards

Drain oil completely as possible, while the unit is still warm. This helps to remove contaminants and oxidised oil that can affect the performance of the new gear lubricants.

If contaminated oil remains in the gear box foaming can occur

1 Do not use a volatile, chlorinated solvent or solvent type flushing compound to wash out the gear box.
2 Properly flush the gear box, use one of the new lubricants, or a light viscosity of compressor or turbine oil, filing to one third the recommended operating oil level. Circulate under no load conditions for 15 minutes and drain.
3 Clean the vent plug and reinstall correctly.
4 When working will enclosed gear boxes or oiling systems that do not have a drain or circulating system, the used oil and flushing oil should be removed by suction. Use of pressure to force out or blow out this oil may damage seals.

5 Be careful not to overfill oil in the gear box because it can cause foaming.

6 Install an oil sight glass to the gear box drain port at the bottom of the reservoier.

Points to be remembered while doing the running maintenance of power transmission elements

1 Ensure the parallel and angular alignment of shaft and couplings.

2 In case of belts or chain drives, check the alignment made in accordance with the manufacturer's recommendations.

3 Belt and chain tensions must be kept within proper limits.

4 In case of 'U' belt adjust its tension of 1/2 inch deflection at the mid point with a given spring load or any other method.

5 In the case of chain drives, it is good practice to mount the sprockets as close to the gear shaft bearing as possible.

6 Check the tension of the chain after 100 hrs of operation, rechecked after 500 hrs and periodically thereafter.

7 Listen the sound generating by a gear box and ensure that there is no abnormal sound in the gar box.

Proper support, proper alignment and proper lubrication are the three key ingredients to ensure the running maintenance of power transmission elements.

Lubrication

Objectives: At the end of this lesson you shall be able to
- **state what is lubrication and lubricant**
- **explain the lubrication system and brief the parts of lubrication system**
- **describe the lubrication mechanism**
- **list the types of lubrication and it properties.**

1 Lubrication

Lubrication can be defined as the application of some materials between two objects moving relative to each other to allow smooth operation as much as necessary. Either oil or grease is used for rolling bearings to prevent noise, wear and tear, and heat from being generated from their rolling and sliding movements, and in some special cases, solid lubricants are occasionally used.

2 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 minimises friction.

3 Lubrication mechanism

They are

1 Boundary lubrication also known as thin film lubrication

2 Hydrodynamic lubrication also called thick film lubrication and

3 Extreme pressure lubrication.

Boundary lubrication

Boundary lubrication occurs in machine parts of low speed and high load. The film thickness of the lubricant is low as 2-3 molecule thickness with the frictional coefficient being 0.05 to 0.15. In this type it is just impossible to maintain the thick film of lubricant in between the moving surfaces.

Hydrodynamic lubrication

Hydrodynamic lubrication takes place in machine parts of high speed. The coefficient of friction is low that is it ranges from 0.01 to 0.003. Here a thick film of lubricant separates the two moving parts of machine.

Extreme pressure lubrication

The conditions under which this type of lubrication occurs are:

1 High load

2 High speed

The lubricant here either vaporizes or decomposes due to local heat. Some addictive are used to overcome this difficulty and are called extreme pressure additives. These additives at high temperature react with metal giving metallic chlorides possessing high melting point and high temperature.

Types of lubricants

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:

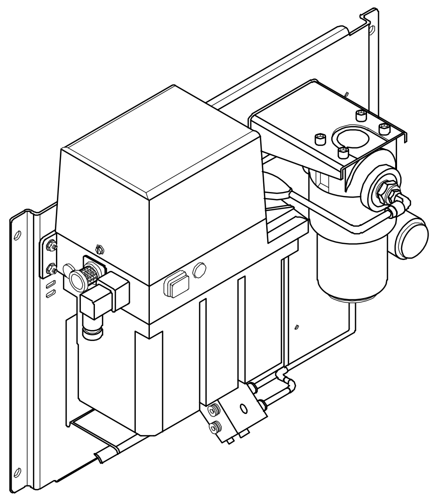
- turbine oils
- circulating and hydraulic oils (R & O Type)
- circulating and hydraulic oils (anti-wear type)
- circulating oil (anti-wear type)
- special purpose hydraulic oil (anti-wear type)
- fire-resistant hydraulic fluid
- spindle oil - machinery oils
- textile oils

- 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.

4 Lubrication system (Fig 1)

Fig 1



Lubrication systems distribute the lubricant to the moving machine parts in contact. Lubricants reduce the friction between sliding or rolling machine elements, such as gears, spindles, bearings, chains, dies, screws, cylinders, valves, and cables, in order to prevent wear, heat generation, and premature failure and prolong the service life of the machine elements. Lubricants may also function as a coolant that prevents thermal expansion, which consequently degrades the accuracy of the machine element.

Lubrication systems control the volume and pressure of the lubricant to be applied to the surfaces of the moving machine parts in contact. They promote the smooth and healthy operation of the machinery. Through lubrication systems, the lubricant is applied and distributed efficiently and regularly. These systems are widely used in the automotive, industrial manufacturing, oil and gas, power generation, and steel processing industries. Lubrication systems are also present in automotive engines. The complexity of lubrication systems ranges from manually operated grease guns to automated and centralized lubricant dispensing systems

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.

Lubricating System

Objectives: At the end of this lesson you shall be able to
- **state the methods of applying a lubricant.**

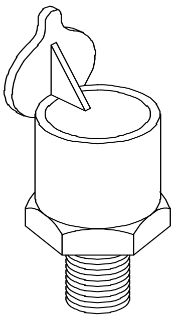
There are 3 systems of lubrication

- Gravity feed system
- Force feed system
- Splash feed system

Gravity feed

The gravity feed principle is employed in oil holes, oil cups and wick feed lubricators provided on the machines. (Figs 1 & 2)

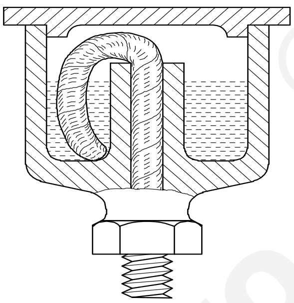
Fig 1



OIL CUP

MM20N179711

Fig 2



WICK FEED

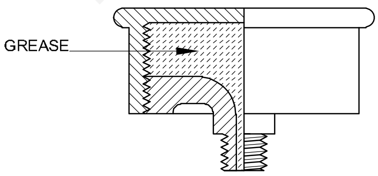
MM20N179712

Force feed/Pressure feed

Oil, grease gun and grease cups

The oil hole or grease point leading to each bearing is fitted with a nipple, and by pressing the nose of the gun against this, the lubricant is forced to the bearing. Greases are also force fed using grease cup. (Fig 3)

Fig 3

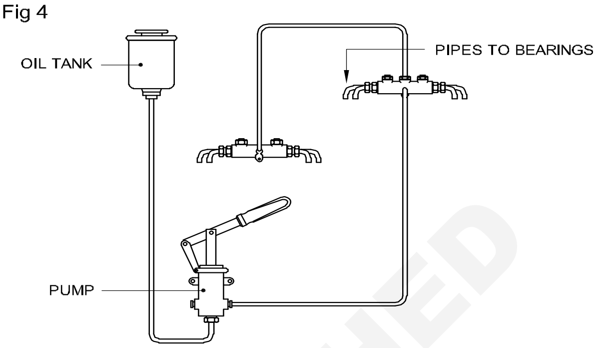


MANUAL SCREW DOWN GREASER

MM20N179713

Oil is also pressure fed by hand pump and a charge of oil is delivered to each bearing at intervals once or twice a day by operating a lever provided with some machines. (Fig 4) This is also known as shot lubricator

Fig 4



HAND PRESSURE FEED (ONE SHOT)

MM20N179714

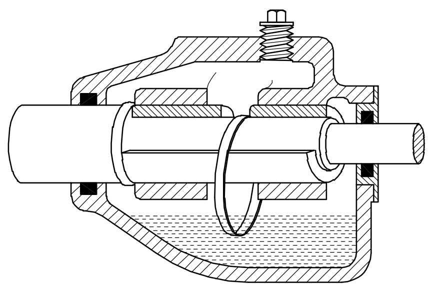
Oil pump method

In this method an oil pump driven by the machine delivers oil to the bearings continuously, and the oil afterwards drains from the bearings to a sump from which it is drawn by the pump again for lubrication.

Splash lubrication

In this method a ring oiler is attached to the shaft and it dips into the oil and a stream of lubricant continuously splashes around the parts, as the shaft rotates. The rotation of the shaft causes the ring to turn and the oil adhering to it is brought up and fed into the bearing, and the oil is then led back into the reservoir. (Fig 5) This is also known as ring oiling.

Fig 5



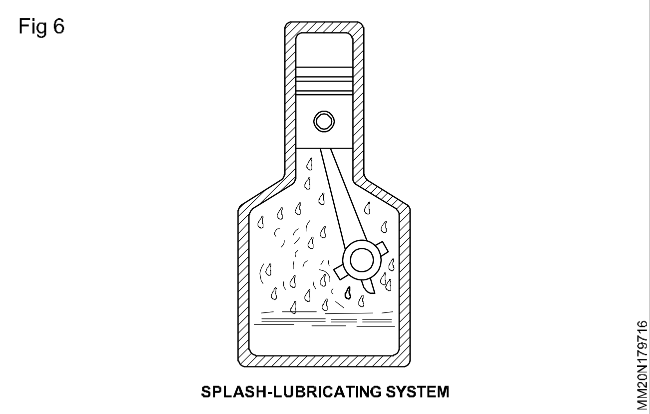
RING OILING

MM20N179715

In other systems one of the rotating elements comes in contact with that of the oil level and splash the whole system with lubricating oil while working. (Fig 6) Such systems can be found in the headstock of a lathe machine and oil engine cylinder.

Automatic lubrication system

An Automatic Lubrication System (ALS), also known as a centralized lubrication system, is a system that continuously provides a controlled amount of lubricant (either grease or oil) to many spots on a machine while it is running. This technology is more precise, and it eliminates the bearing failure-causing cycle of over-lubrication and under-lubrication.



Applications of an automatic lubrication system

The applications of automatic or centralized lubrication systems are as follows:

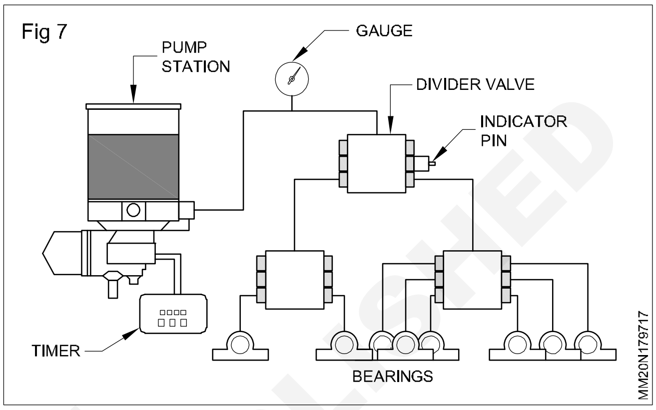
- Machine tools
- Automation
- On/Off-road machines
- Construction, agriculture, and forestry machines
- Mining and cement industry
- Food and beverage
- Railroad applications
- Steel industry
- Pulp and paper
- Wind energy and more

Parts of an automatic lubrication system

The followings are the major components of an automatic lubrication system:

- Control or timer: It triggers the system for lubrication distribution and can be linked to a POS system.
- Pump with reservoir: The lubricant is stored and delivered to the system via a pump with a reservoir.
- Injectors and metering valves: It's a part that measures and distributes lubricant to application spots.
- Supply lines: it connects the pump to the metering valves or injectors via a pipeline. These valves or injectors are where the lubricant is pumped.
- Feed lines: A feed line is a pipe that links metering valves or injectors to application sites.

Diagram of a centralized lubrication system (Fig 7)



Working Principle

When the controller/timer send a signal to the pump to start the lubrication cycle, the process begins. To build up pressure in the supply line linking the pump to the injectors dispense a predetermined amount of lubricant to the lubricarion locations through feed lines in the requisite pressure is reached. A pressure switch will transmit a signal to the controller once the entire system reaches the required pressure, signaling that oil/ grease has cycled through all distribution points. the pump is turned off. The system's pressure is released, and oil/grease in the line is redirected back to the pump reservoir until the system's normal pressure level is restored.

Grease lubrication system

Objectives: At the end of this lesson you shall be able to
- **list the types of grease gun**
- **describe the centralised grease lubrication system.**

Grease gun

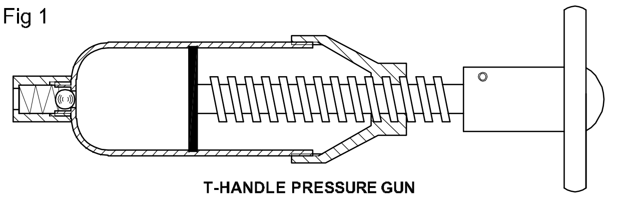
A device for used for supply grease under pressure to a particular point.

Types of grease guns

The following types of grease guns are used for lubricating machines.

'T' handle pressure gun (Fig 1)

Fig 1

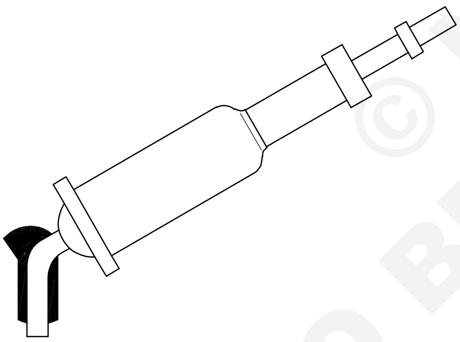


T-HANDLE PRESSURE GUN

MM20N179811

Automatic and hydraulic type pressure gun (Fig 2)

Fig 2

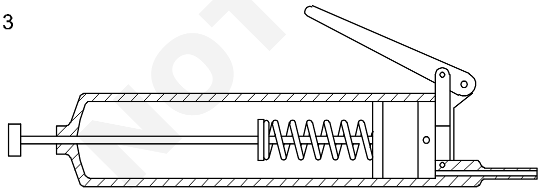


AUTOMATIC HYDRAULIC-TYPE PRESSURE GUN

MM20N179812

Lever-type pressure gun (Fig 3)

Fig 3



PRESSURE GREASE GUN

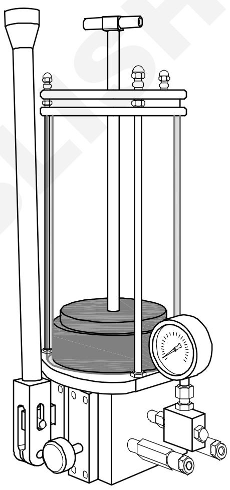
MM20N179813

Centralised Grease lubricating system

A simple Grease Lubrication system consists of a pump and a distributor blocks, pipes& fittings as shown in the diagram. The distributor block (called as progressive block) will dispense the lubricant in measured amount directly in the lube points through the feed lines. The visual indicator pin on the progressive block confirms the delivery of lubricant. The pin moves in and out in each cycle of the lubricant delivery. System can be operated by a manual, motorized or pneumatic pump. The complete system can be Automated by incorporating a controller. The pump will be activated at regular intervals for fixed number of lubrication cycles while the production machine is in operation. Progressive Block will dispense small measured amounts of lubrication each and every cycle.

Manual Grease Pump (Fig 4)

Fig 4



MANUAL GREASE PUMP

MM20N179814

Hand operated grease pumps for proper greasing to important moving parts of the machines as for bearing, bushes, chains slides, mixing machines. Rolling Mills, Furnaces etc.

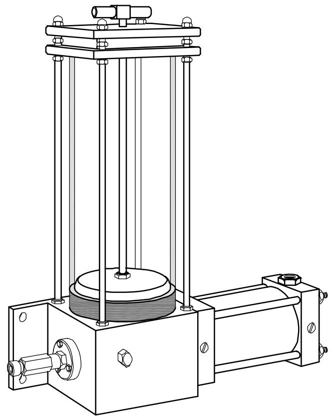
Working principle

The hand operated grease pumps provide a predetermined quantity of grease on each stroke of its operation, when we pull the hand suction part of the cylinders it gets filled with grease, spring force through follow plate on the top surface further helps to push grease into the suction part. While pushing handle this grease comes out under pressure through check valve and is supplied by the lubricating points through pipelines.

Pneumatically Operated Grease Pump (fig 5)

Pneumatic Grease pump is operated by pneumatic power or pneumatic line connected to the port of cylinder. The cylinder is built in with the pneumatic pump. During 'ON' Period of pneumatic line, piston inside the cylinder is pushed, ejects out pressurized grease from the outlet port of the pump body. During reverse flow of pneumatic line, grease is sucked through the suction port in the pump

Fig 5

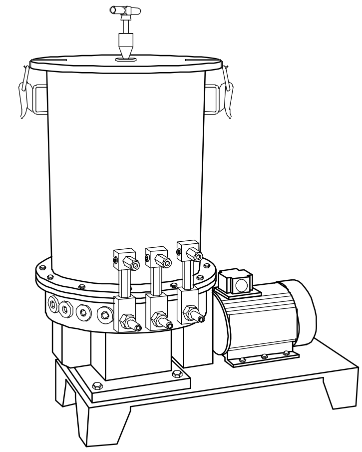


PNEUMATICALLY OPERATED GREASE PUMP

spring force through follower plate exerted on the top surface of grease make the suction of the grease positive and easier.

Motorised Grease Pump (Fig 6)

Fig 6

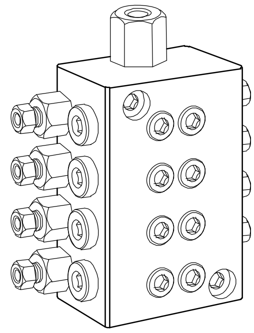


MOTORISED GREASE PUMP

Motorised Grease Pump (also called Radial Lubricator or Multipoint Lubricator) is a user friendly and cost-effective solution for centralized and automatic lubrication of a machine or equipment having multiple points. Multiline lubricator combines multiple pumps into a single entity sharing a common reservoir and common drive.

Progressive Block (Fig 7)

Fig 7



PROGRESSIVE BLOCK

Progressive Block is a positive metering device. It incorporates a series of metering spools to provide accurate dispensing from each outlet. Progressive Blocks are available for oil applications as well as grease applications.

Function of components and trouble shooting in centralised lubrication system

Objectives: At the end of this lesson you shall be able to
- **list the component used in centralised lubricating systems**
- **Brief the functions of each parts used in lubricating systems**
- **Explain the trouble shooting general problems in lubricating system**

Any rotating or sliding parts may develop certain amount of heat due to friction of the moving parts and consequently, there will be some wear and tear and loss of power. The most effective method of reducing friction to minimum and to save the metals from wear and tear is efficient lubrication and the substance used for this purpose is called lubricant.

So proper lubrication system is the most important arrangement for efficient running of engines and machine parts.

Pump

It converts the mechanical energy in to flow energy or hydraulic energy. Oil pressure is created in the lubrication system with the help of pump. It will work positively if the direction of rotation of pump will be in the correct direction. The pump used in this system is a georator type having discharge 1Lpm.

Motor

it coverts the electrical energy in to mechanical energy and provides motion to pump. the following types of motor are use with this model and can be supplied as per customer's requirement. (a) Motor -415V AC, Three phase, 1440RPM, 0.12KW,0.16HP the rating of motor has been mentioned on the motor also.

Relief valve

To maintain the oil pressure constant, an oil pressure relief valve is placed in the circuit. When the pressure of the of exceeds the normal limit the oil returns to the oil Reservoir through the relief valve, The setting of pressure relief valve can be adjusted by loosing or tightening the split screw and nut of relief valve. pulg the outlet of lubrication system at the time of adjusting the relief valve.

Pressure gauge

It indicates the pressure in kg/cm^2 which is devaloped by the system. Required pressure can be set with the help of relief valve seeing the position of pointer on the dial scale of pressure Gauge which is 0-28kg/Cm^2. The changing position of pointer confirms that the system is working

Oil fillet cum breather

Used for filling the oil in thereservoir as well filter the oil. Filter level is 300micron.

Suction strainer

The function of strainer is to prevent admission of the impurities that may pan in to the oil system, made with SS Wire mesh, 149 micron.

Metering injector

The main function of metering injector is to inject metered amount of oil to the lubrication points. It works on stroke. The oil is always stored in the metering injector. The stored oil is discharged to the end lubrication point through injector & are recharged with fresh oil for next stroke when the motor of lubrication system OFF. It also works as a N.R.V (non Return Valve). It comes With dosage of 0.01,0.03,0.05,0.10,0.16,0.25,0.40,1.00 & 1.60 cc. Made of Brass and EN - 1A leaded material. Mounting thread is M8 X1 & M10 X1. Outlet port is for 4MM O.D Tube which connects to Lubrication points.

Pressure switch

Pressure Switch to sense Low pressure of system during running to get alarm or interlock of machine. Pressure Switch Range 8-30 Kg/Cm2, or 0-20 Kg/Cm2, Set pressure is Kg/Cm2, Switch Type With 1NO + NC or NO Contact used.

Float switch

Sense Low Oil Level In Reservoir of Lubrication system electrically . It is vertical. or Horizontal type with NO or NO contact.

Temperature gauges

Oil temperature gauges are used for monitoring oil temperature. Oil subjected to too high of heat can lose it's lubrication properties that keep metal parts from touching.

The needle will indicate the current oil temperature on the application being monitored. This reading should remain fairly steady and may increase under heavy acceleration. You will need to know what to expect from your system.

If the oil temperature rises above the desired limit, you should reduce the load placed on the engine or transmission to help reduce the temperature and then determine what is causing the overheating situation and fix it.

Low oil pressure:

Low oil pressure is indicated when the oil indicator light glows, oil gauge reads low, or when the engine lifters or bearings rattle.

The most common causes of low oil pressure are as follows:

1 Low oil level (oil not high enough in pan to cover oil pickup)

2 Worn connecting rod or main bearings (pump cannot provide enough oil volume)

3 Thin or diluted oil (low viscosity or fuel in the oil)

4 Leak or broken pressure relief valve spring (valve opening too easily)

5 Cracked or loose pump pickup tube (air being pulled into the oil pump)

6 Worn oil pump (excess clearance between rotor or gears and housing)

7 Clogged oil pickup screen (reduce amount of oil entering pump) A low oil level is a common cause of low oil pressure. Always check the oil level first when troubleshooting a low oil pressure problem

High Oil Pressure:

High oil pressure is seldom a problem. When it occurs, the oil pressure gauge will read high.

The most frequent causes of high oil pressure are as follows:

1 Pressure relief valve struck (not opening at specified pressure)

2 High relief valve spring tension (strong spring or spring has been improperly shimmed)

3 High oil viscosity (excessively thick oil or use of oil additive that increase viscosity)

4 Restricted oil gallery (defective block casting or debris in oil passage)

Temperature gauge

Indicator or gauge problems:

A bad oil pressure indicator or gauge may scare the operator into believing there are major problems. The indicator light may stay on or flicker, pointing to a low oil pressure problem. The gauge may read low or high, also indicating a lubrication system problem.

Inspect the indicator or gauge circuit for problems. The wire going to the sending unit may have fallen off. The sending unit wire may also be shorted to ground (light stays on or gauge always reads high).

To check the action of the indicator or gauge, remove the wire from the sending unit. Touch it on a metal part of the engine. This should make the indicator light glow or the oil pressure gauge read maximum. If it does, the sending unit. may be defective. If it does not, then the circuit, indicator, or gauge may be faulty. Note Always check the service manual before testing an indicator or gauge circuit. Some manufacturers recommend a special gauge tester. This is especially important with some computer-controlled system

Lubricating system maintenance

There are certain lubricating system service jobs that are more or less done automatically, when an engine is repaired. For example, the oil pan is removed and cleaned during such engine overhaul jobs as replacing bearing or rings. When the crankshaft is removed, it is usual procedure to clean out the oil passages in the crankshaft. Also, the oil passages in the cylinder block should be cleaned out as part of the overhaul. As a Construction Mechanic, you will be required to maintain the lubrication system. This maintenance normally consists of changing the oil

Most centralized lubrication systems are designed with an audible or visual check mechanism incorporated into the system. These devices are also susceptible to failure and must be checked periodically. A low-level warning device on the lubricant reservoir can be beneficial to the system.

The plant personnel responsible for system inspections should be thoroughly trained and familiar with the sequence of operation. Most major system manufacturers and suppliers will train plant personnel on the selected system. The training should include operations, adjustments and maintenance of the system.

Simple manual operation of the system will determine if the power resource is operating efficiently. In the case of pneumatic or hydraulic operations, a pressure gauge on the power source will confirm operating pressure.

The next phase of the system PM inspection is to check the level of lubricant in the supply reservoir. This check should include a visual examination of the lubricant for contamination in cases where the lubricant is open to the atmosphere during transfer and handling. If the system uses filters, strainers or screens, they should be checked periodically for contamination build-up or blockage, and cleaned.

During manual operations of the system, check system pressure and compare to previously determined normal operating pressures.

Checking any lubricating system at the pump/reservoir/control panel location is a necessity, but does not assure that the lubricant is being delivered to the lubrication point. It means only that the heart of the system is in good operating condition.

The next step is to check the distribution system

The best way to assure that all lube points are being properly serviced is to visually check each header, secondary lube line, and lube line from the metering device to the lube point.

Finally, the system is not fully operational unless each metering device is individually checked to assure proper operation. Most metering devices have a visual indicator for this purpose. Those devices that do not have a visual indicator can be checked only by loosening the distribution line from the metering device, operating the system and visually checking for operation of the valve. This is a time consuming and often overlooked portion of the PM check, but is also an important aspect.

lubrication fittings

Objectives: At the end of this lesson you shall be able to
- **list the lubrication fitting used in centralised lubrication system.**

The design of complex centralized lubrication systems is often not the only challenge. The structural conditions of systems, machines and vehicles also require a high degree of flexibility in screw connections and pipes for lubrication systems, particularly with regard to sizes and shapes.

The decisive function of cutting ring fittings is the fluid-tight connection of pipes within central lubrication systems. By tightening the conical union nut, the cutting ring is cut into the tube wall, which creates a tight form fit. They are divided into different series in terms of nominal and operating pressures, as well as line cross sections.

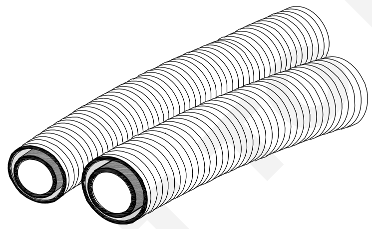
Push-in fittings offer a clear advantage in terms of assembly time compared to cutting ring fittings, but there are restrictions regarding their maximum operating pressures and piping materials. When connecting to metal pipes and pipe sockets, it is imperative to pay attention to an existing claw groove, which prevents it from "slipping out". Because of their reusability, connectors offer further great benefits.

When selecting the suitable lubrication line, the prevailing pressures, ambient temperatures, equipment regulations and lubricant compatibility also play a major role. In the case of poly pipes with a wall thickness of <1.5 mm, care should be taken, for example, to use push-in sleeves to prevent the pipe from being compressed.

Flowing are the commonly used fitting in lubrication

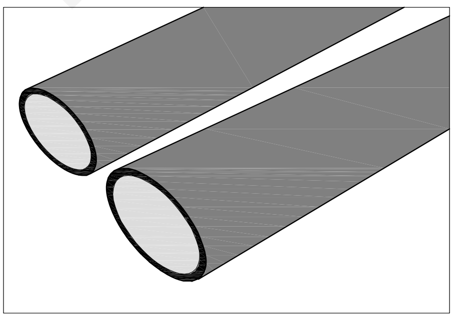
Lubrication/Grease Hose (Fig 1)

Fig 1



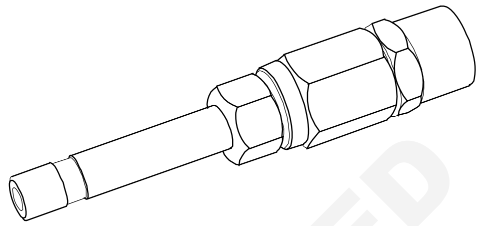
Polyurethane casing for logistics transportation TPU hose (Fig 2)

Fig 2



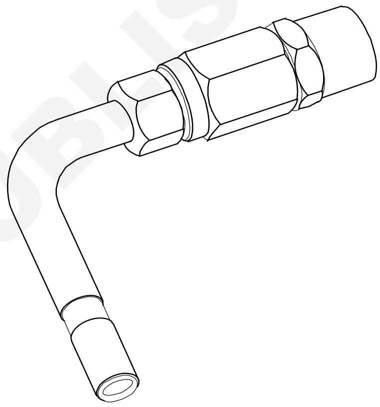
Hose stud straight (Fig 3)

Fig 3



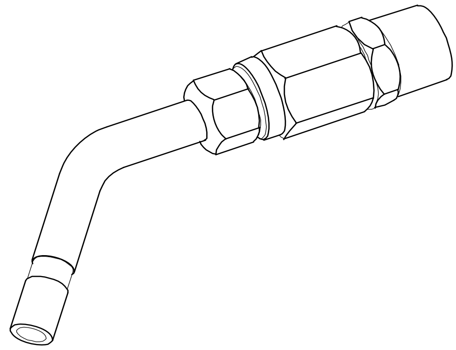
Hose stud straight 90° (Fig 4)

Fig 4



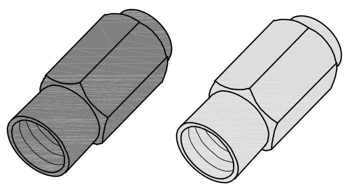
Hose stud straight 45° (Fig 5)

Fig 5



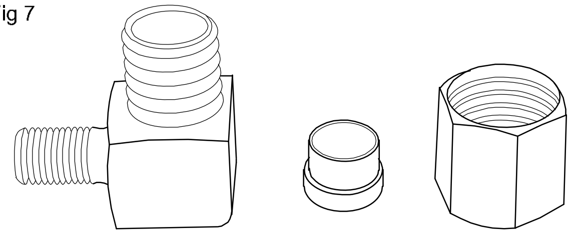
Screw sleeve (Fig 6)

Fig 6



Elbow screw fitting (Fig 7)

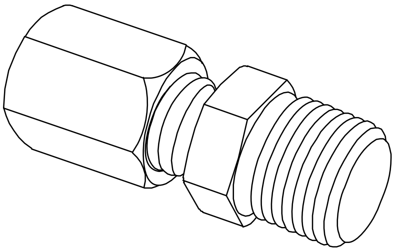
Fig 7



ELBOW SCREW FITTING

Straight screw coupling (Fig 8)

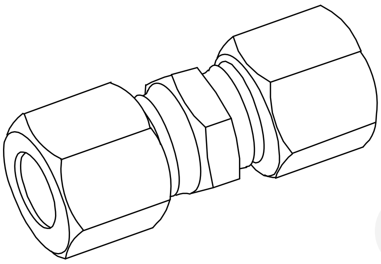
Fig 8



STRAIGHE SCREWEL COUPLING

Connector (Fig 9)

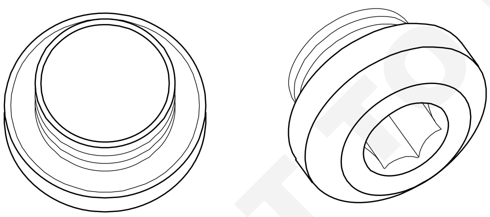
Fig 9



CONNECTOR

Oil outlet plug (Fig 10)

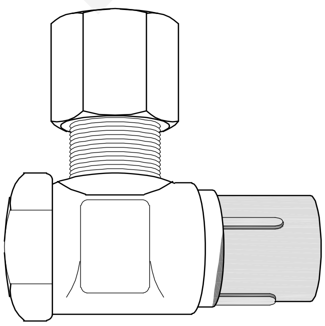
Fig 10



OIL OUTLET PLUG

Swivel union (Fig 11)

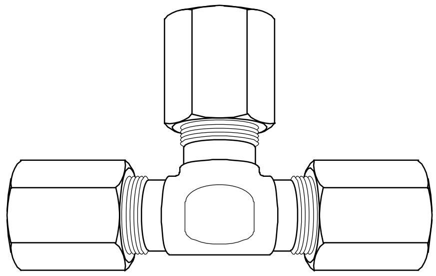
Fig 11



SWIVEL UNION

Equal tee (Fig 12)

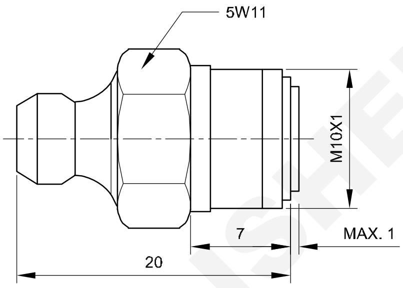
Fig 12



EQUAL TEE

Conical Lubrication Nipple with valve (Fig 13)

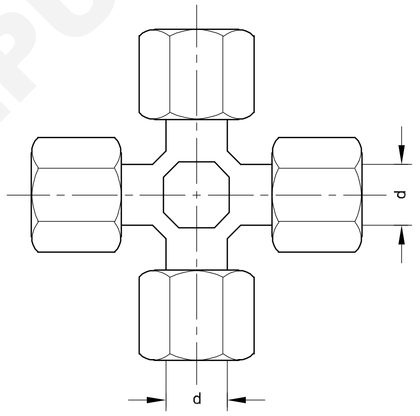
Fig 13



CONICAL LUBRICATION NIPPLE WITH VALVE

Cross Fitting (Fig 14)

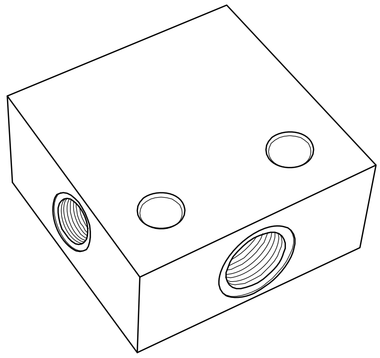
Fig 14



CROSS FITTING

Crosspiece (Fig 15)

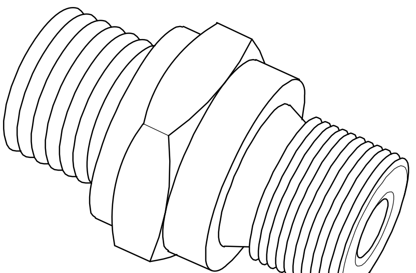
Fig 15



CROSS PIECE

Double Nipple (Fig 16)

Fig 16

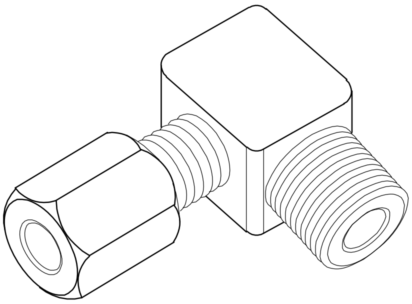


DOUBLE NIPPLE

MM20N171001G

Elbow Connector (Fig 17)

Fig 17

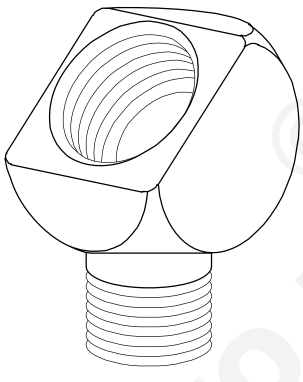


ELBOW CONNECTOR

MM20N171001H

L bow fitting with 45 and 90 degree (Fig 18)

Fig 18

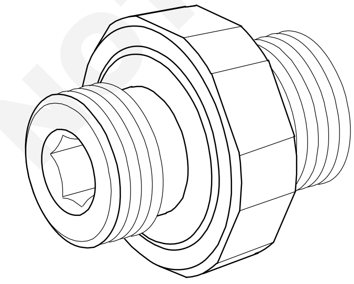


BOW FITTING WITH 45 AND 90 DEGREE

MM20N171001I

Flexible Connection Set (Fig 19)

Fig 19



FLEXIBLE CONNECTION SET

MM20N171001J

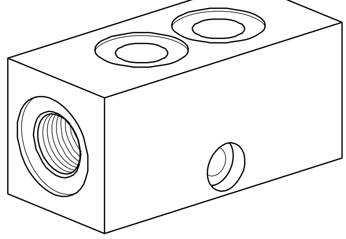
Manifolds (Fig 20)

Mounting Clip for 1x Ø 8mm + 2x Ø 4mm (Fig 21)

Quick linc Check Valves (Fig 22)

Reduction Connector (Fig 23)

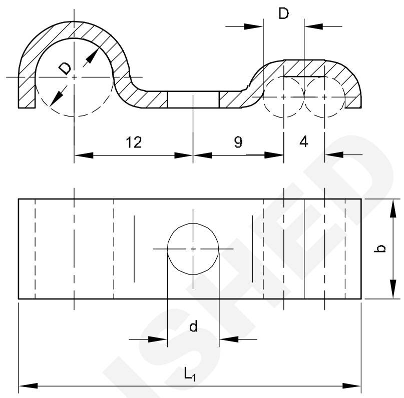
Fig 20



MANIFOLDS

MM20N171001K

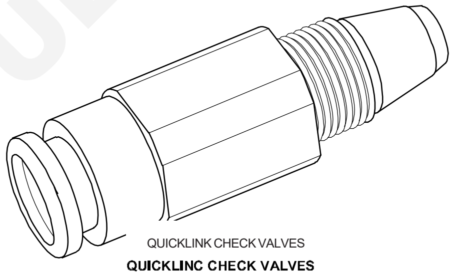
Fig 21



MOUNTING CLIP FOR 1X Ø 8MM + 2X Ø 4MM

MM20N171001L

Fig 22

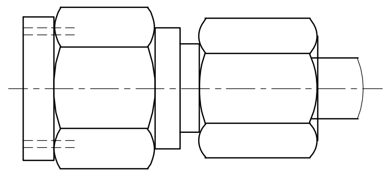


QUICKLINK CHECK VALVES

QUICKLINC CHECK VALVES

MM20N171001M

Fig 23

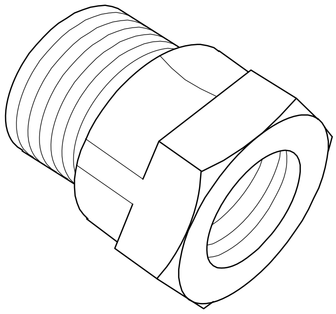


REDUCTION CONNECTOR

MM20N171001N

Reduction Fitting, cylindrical (Fig 24)

Fig 24

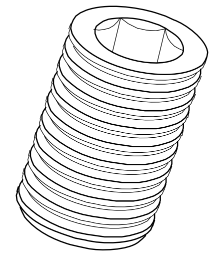


MM20N171001O

Threaded Fittings (Fig 25)

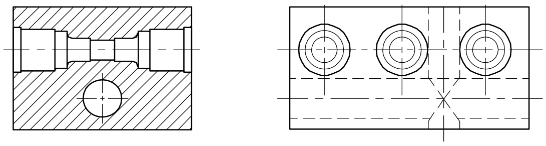
Tube Connectors, with mount (Fig 26)

Fig 25



THREADED FITTINGS

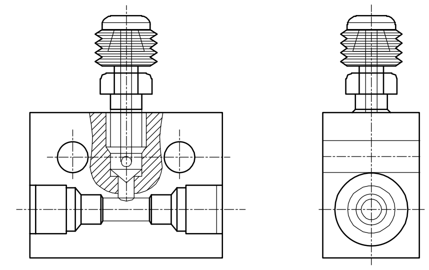
Fig 26



TUBE CONNECTORS WITH MOUNT

Tube Connectors, with vent (Fig 27)

Fig 27



TUBE CONNECTORS WITH VENT

Storage and handling of lubricants

Objectives: At the end of this lesson you shall be able to
- **state the important of proper storage of lubricant**
- **explain the outdoor, indoor and bulk storage of lubricant**
- **describe the method of handling of barrels**
- **list the point on he contamination control.**

Introduction

The storage of lubricant after delivery, several things can happen to impair quality. Careless handling, contamination, exposure to abnormal temperatures, confusion of stocks all these factors can result in wastage, damage to machinery, deterioration of lubricants, higher maintenance cost and loss of production.

In order to avoid all the points listed above, lubricants must be stored under safe covering and in a controlled, moderate temperature environment. Some instances may call for product to be stored outdoors. In general, indoor storage is preferable.

General guide lines for storage of lubricants

Good access for delivery vehicles

properly equipped unloading dock with direct access to the oil store

Clean dust free conditions for unsealing and dispensing

Easy distribution to the principal points of use

Simple inventory control, and at-a-glance check on the conditions of containers

Space for empty barrels and returnable containers

Outdoor storage

Outdoor storage should be avoided if possible. Weathering can obliterate the labels on containers, leading to possible mistakes in selecting lubricants for specific applications.

Furthermore, widely varying outdoor temperatures, with consequent expansion and contraction of steams, may lead to leakage and wastage. The likelihood of contamination is also increased. Water can leak into even tightly closed drums by being sucked in past the bung as the drum and its contents expand and contract.

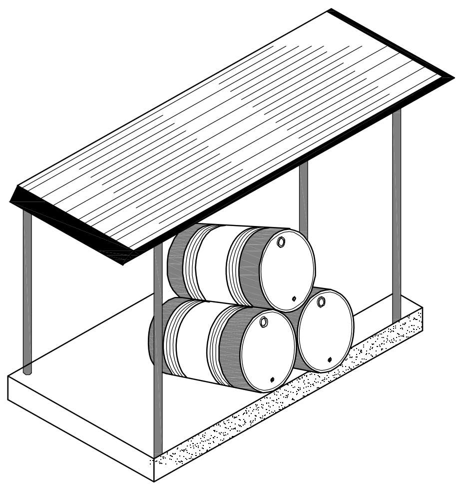
Extremely cold or hot weather can also change the nature of some pounded oils and emulsions, making them useless.

When containers must be stored outside or undercover, the following precautions are advised:

Keep bungs tight.

Lay drums on their sides. Position the drums so that the bungs are at 9 and 3 o' clock. This will ensure that they are covered by the drum contents. Thus minimizing moisture migration and drying out of the seal Fig 1)

Fig 1



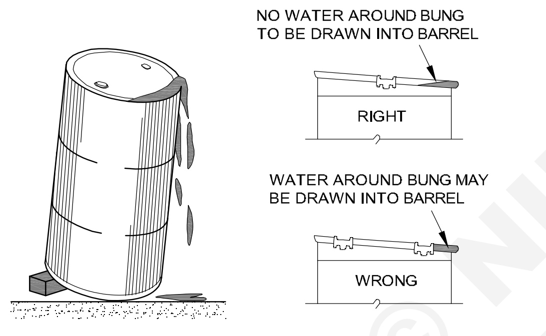
When lubricants are decanted or dispensed outdoors condensation or water ingress is more likely when a barrel is only part-full.

Oil barrels standing in the open suffer variations in temperature, and corresponding Variations in internal pressure. This leads to "breathing".

Be used to keep them clear of the ground and to prevent rusting of the undersides. In every case, barrels should be stored off the ground on still ages or in racks, well clear of surface water. They should never be stocked directly on surface containing clinker, which is particularly corrosive to metal. The drums at each end of a stack must be securely wedged to prevent movement. Regular inspection should be carried out with a view to the detection of leaks and to make sure that Identification markings remain clear and legible.

If, for any reason, drums have to be stored on their ends, they should be raised off the ground and stored upside down (i.e. With the bungs at the bottom). Failing this, they should be tilted so that rain water cannot collect round and submerge the bungs. Water contamination is undesirable, whatever the grade of lubricant, and it is not always realized that moisture can enter a drum through what appears to be a perfectly sound bung.(Fig 2)

Fig 2



Indoor Storage

Indoor storage is always preferred. With limited space, it should be reserved for small packaged lubricants which can be affected by frost, for opened packages, and for the special categories of lubricant

Rarely indoor temperatures fall so low as to affect a lubricant adversely. However, excessive local heat from steam pipes, furnaces etc. should be avoided to prevent thermal degradation or volatilization of solvent containing grades. (In many cases, insurance requirements or local fire regulations necessitate separate storage facilities for volatile products).

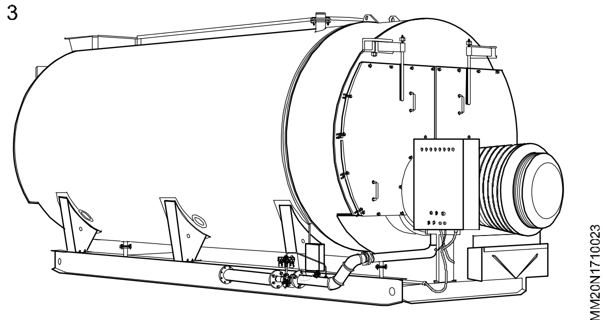
If one part of the storage site is warm, it should be reserved for high viscosity (thick) oils to make dispensing easier.

The lubricants store should be kept dry at all times, to prevent the corrosion of containers which would occur in damp conditions.

Bulk storage

Bulk lubricants storage tanks should be sited indoors, but they can be in the open if protected from driving rain and snow and from extremes of temperature. All tanks fill pipes and off take pipes must be labelled with the full grade name of the product they contain, to avoid crossovers when delivering or dispensing (fig 3)

Fig 3



Stacking barrels

If space is insufficient to allow barrels to be stored on horizontal still ages, they may be vertically stacked on pallets or stored in horizontal or sloping racks. Whichever method is adopted it should allow individual packages to be readily accessible with the minimum of disturbance to those not immediately required.

A system of stock rotation must be devised, to avoid the accumulation of old stock. "First-in, first-out" is a good principle to establish.

When other packages are free stacked on top of one another, the safe height varies according to the stability of the stack and the weight which the lower packages can support.

The use of pallets or slatted frames stabilizes the stack and helps prevent damage to the lower layers.

Steel racks offer greater convenience for loading, retrieval, inventory control and stock rotation. The sloping rack with one side for loading and the other (lower) side for retrieval is an effective means of ensuring "first-in, first-out" barrel stock movement.

Barrels containing soft grease should be stood upright.

The standard 180 kg grease barrel has a large opening, the seal of which is readily damaged by careless handling. This may lead to the leaking of soft grease from a horizontal stored barrel.

Handling barrels (Fig 4)

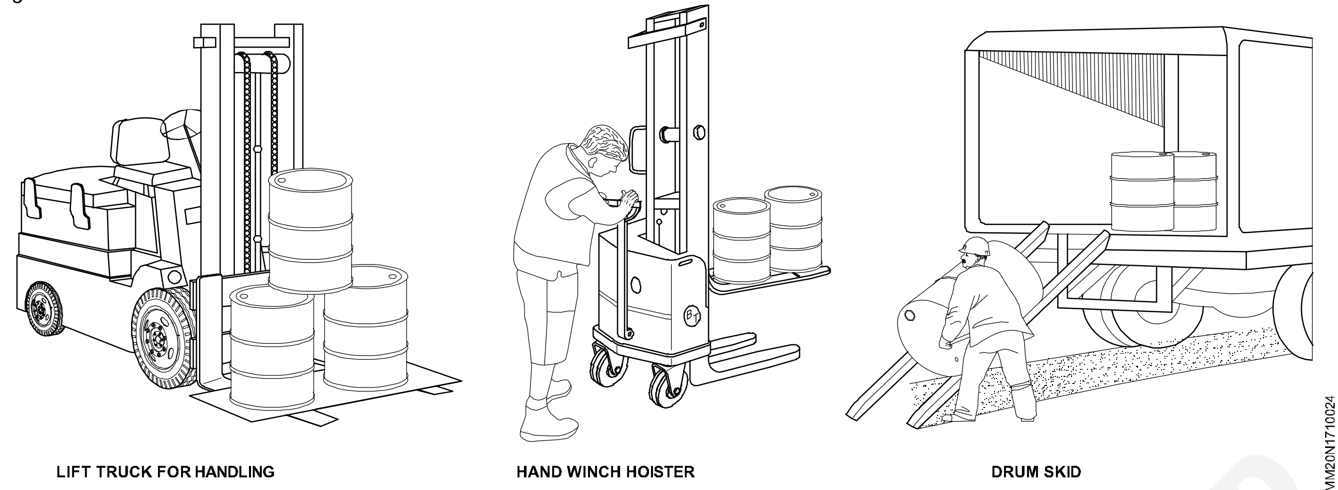
The standard 208 litter barrel weighs about 185 kg when filled with oil. It is strong, being designed to be re-used several times, but is readily damaged by bad handling.

The barrels must never be dropped when being unloaded or moved. The impact can burst the seams, causing subsequent leaking or contamination of the contents. There are many suitable methods of handling barrels, but the most widely accepted are:

Forklift truck (either horizontally on the standard fork, or vertically with a single or fourbarrel handling attachment)

- Two-wheel hand truck
- Triangular drum dolly
- Manual elevator
- Manual side-delivery stacker
- Chain hoist and trolley on 'I-Beam' bridge
- Rolling (by two workers)

Fig 4



Contamination control

Lubricants and cutting oils must periodically be drained from the machine and replaced by fresh oils or coolant. Some used oils, particularly in less arduous applications, can be reclaimed for future use by settling, centrifuging, water washing or filtration.

Your fluid Manager will advise on the appropriate treatment. Cutting oils are especially liable to contamination in use. For example, oil films on the surface of an emulsion may indicate from a leaking gearbox or hydraulic system.

When soluble oil is prepared for use, the oil must be added to the water in the recommended amount, with consistent stirring to form a stable added to the oil, as an unstable emulsion may result. The water must be clean, and mixing should take place in a clean separate tank rather than in the machine sump.

It should be noted that a new emulsion rapidly deteriorates if added to one already contaminated, bacteria-infected or unstable.

Unpleasant odours or rusting are indicators of bacteriological or chemical degradation. Clean coolant must be used in a clean sump for efficient operation.

About greases, if you open a container of unused lubricating grease and observe dirt or water, what should you do? Can the grease still be used? If it is a new container of the product, contact the supplier. If the package is being reopened, and a small amount of free water is present, then remove the water with a clean paper towel or similar absorbent material and dispose of it properly.

Gross contamination with water may render the grease unsuitable for use. Small amounts of particulate matter (dirt/dust) can be removed from the grease surface with a clean spatula or putty knife and the removed material disposed of properly. It may be necessary to remove the entire top layer of the grease. For this reason, it is important to keep the lid securely on partially used containers of grease.

Waste lubricant disposal

Waste oils are subject to re-use or destruction largely according to economic factors. Re-use may follow re-fining, laundering (e.g. by filtering or centrifuging) or downgrading (e.g. for use as a bitumen flux oil); or maybe as a fuel oil.

When waste oil is too heavily contaminated to allow re-use, the only courses are incineration after suitable pre-treatment or disposal by controlled dumping on an approved site in accordance with environmental legislation.

Used cutting oils, both neat and soluble, are affected by additional disposal factors, and special procedures should be followed after consultation with marketing technical services.

Unused lubricating grease should be disposed of in accordance with all federal, state and local environmental regulations. Used lubricating grease should be disposed of in accordance with national and local environmental regulations. In some cases, used oil recyclers will accept used grease.

Depending on the service the grease has been in and contaminants to which it may have been exposed, used grease may be contaminated and considered to be a hazardous waste and may require special handling for disposal. Used grease should not be re-used.

Safety

Dispensing equipment is not left unattended. This prevents personnel tripping and falling over it. B. Spilled or leaking lubricants are removed from floors to prevent slipping.

Drum slings are used instead of rope slings for lifting.

Lubricant and solvent containers are not left in direct sunlight, in very hot areas, or where there are sparks because of possible spontaneous combustion.

High-pressure grease guns are used with care to prevent accidents.

Oily rags are put in tightly closed safety containers and disposed of regularly.

Storage tank vents are kept open.

Smoking in lubricant and solvent storage areas is prohibited.

Where necessary, machines are properly shut down before lubricating.

Secure ladders are used to reach high lubrication points.

Light oils and solvents are properly vented to prevent excessive inhaling of fumes by personnel.

Types of Seals used in lubricating system

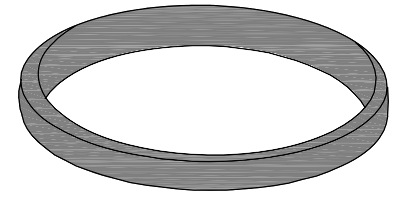
Objectives: At the end of this lesson you shall be able to
- **explain the different types of seal used in fluid system**
- **list out the different material used in seal.**

The seals can be divided into two large categories: Static and dynamic.

Static seals are used in situations in which the component parts aren't designed to experience relative movement. These seals include O-rings, D-rings, backup seals, and other seals that are intended to remain in a fixed relative location.

O ring seal (Fig 1)

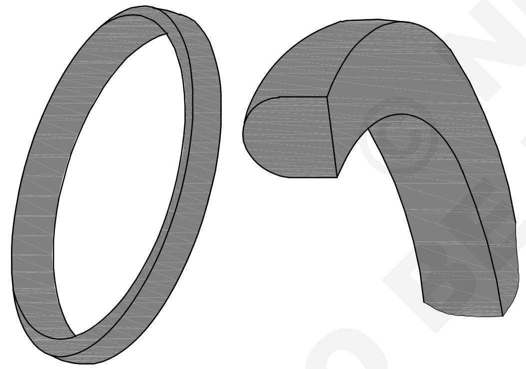
Fig 1



O RING SEAL

D ring seal (Fig 2)

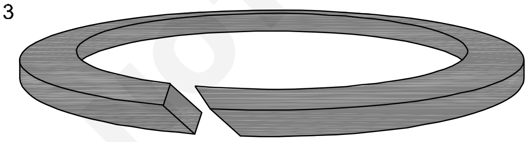
Fig 2



D RING SEAL

Backup up ring seal (Fig 3)

Fig 3



BACKUP UP RING SEAL

These are the most common types of seal in use and have many applications. When requires to seal against pressure, they are fitted with backup rings. (Fig 4&5) There are many similar seals made of special purposes that do not have a circular cross - section

Dynamic seals, are intended for areas in which there is relative motion between two components. Because there are a number of different functions performed by dynamic seals within cylinder,

Fig 4

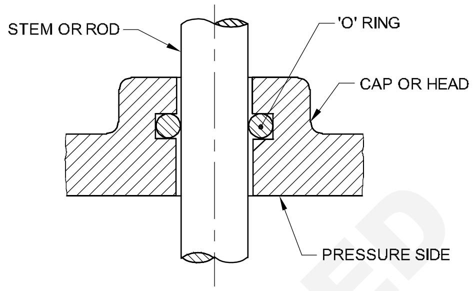
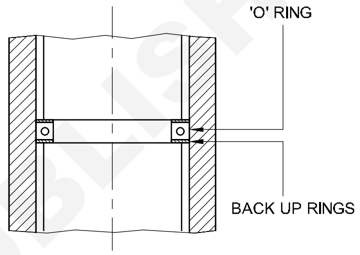


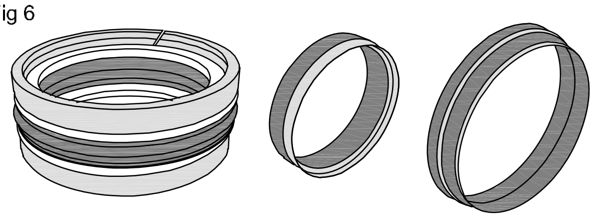
Fig 5



Piston Seals (fig 6)

Piston seals or piston rings are used in cylinders for fluid sealing and are designed to ensure that pressurised fluid does not leak across the piston as the system pressure pushes the piston down the cylinder bore.

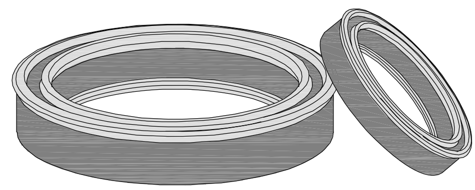
Fig 6



PISTON SEAL

Rod seal (Fig 7)

Fig 7



ROD SEAL

Wiper Seals (Fig 8-15)

Sometimes referred to as dust seals, excluders, or scrapers, wiper seals protect your equipment by preventing contaminants from entering your cylinder as the piston rod retracts.

Since the piston rod is coated with a thin layer of fluid to prevent corrosion, it can also pick up dirt and other contaminants, which could quickly damage the interior components of your cylinder. Wiper seals keep these contaminants outside of your system.

Fig 8

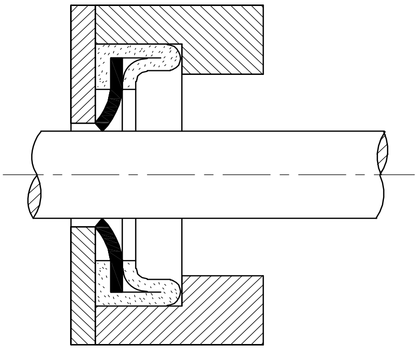


Fig 9

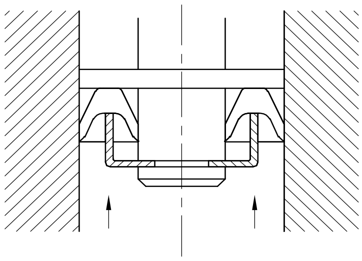


Fig 10

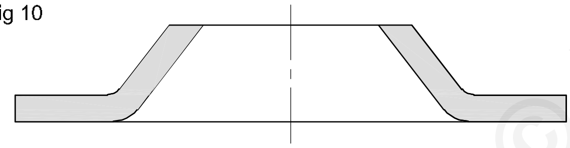


Fig 11

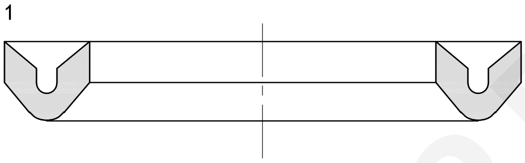


Fig 12

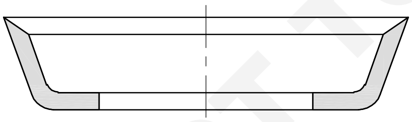


Fig 13

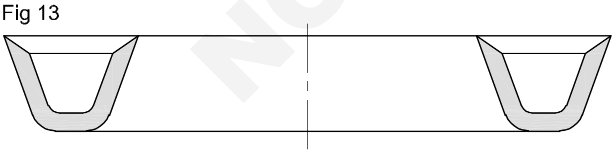
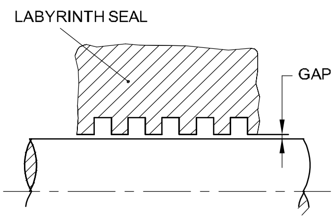


Fig 14



Guide Rings

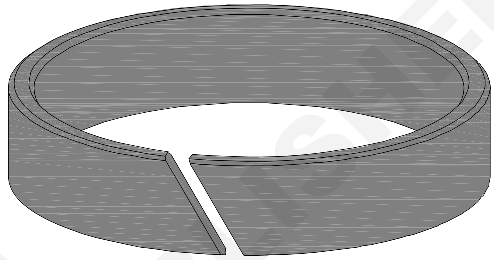
These seals are intended to maintain moving parts in the proper position throughout the process of relative motion. In addition to keeping the important components properly aligned, guide rings prevent any metal-on-metal abrasion that might occur during operation, preserving the life of your equipment.

These seals also add another level of protection against contaminants by keeping your more sensitive seals safe from added wear.

Materials Used in Seals

Hydraulic cylinder seals can be manufactured from a number of different materials. Each material has different properties that make them better suited to different

Fig 15



conditions, including high pressures and temperatures, as well as caustic chemicals. Here are the different materials you're likely to encounter:

Rubber

Rubber seals are used in situations that require a high degree of flexibility and compressibility. They possess good resistance to grease, mineral oils, and other hydraulic fluids.

PTFE

Polytetrafluoroethylene (PTFE) offers superior durability under extreme conditions, including temperature, pressure, and caustic chemicals. PTFE also has a very low coefficient of friction, which means that it requires less lubrication than other seals and can actually function quite well in dry operation.

Rigid Plastics

Encompassing a wide range of materials, plastic hydraulic cylinder seals offer moderate resistance to temperature and pressure, as well as chemical reactivity.

The durability of a plastic seal is largely dependent on the quality of the material itself, which can range from engineered plastics, which are superior to commodity plastic, to high-performance plastics. Because they have less flexibility than rubber or PTFE, these seals focus more on adding strength to your cylinder.

Thermoplastic Elastomers

Thermoplastic elastomers, or TPEs, combine the strength of plastic with the flexibility of rubber, which means that they stand up to high use while also providing superior elasticity. These hydraulic cylinder seals are highly resistant to abrasion and tearing and will maintain a constant pressure for longer than other materials can.

Cutting fluids

Objectives : At the end of this lesson you shall be able to
- **state what is coolant**
- **state the functions of cutting fluids & their advantages**
- **list the parts and functions of coolant system.**

Cutting fluids is also called as coolant and compounds are the substances used for efficient cutting while cutting operation takes place.

Functions

The functions of cutting fluids are:

- to cool the tool as well as the workpiece
- to reduce the friction between the chip and the tool face by lubricating
- to prevent the chip from getting welded to the tool cutting edge
- to flush away the chips
- to prevent corrosion of the work and the machine.

Advantages

As the cutting fluid cools the tool, the tool will retain its hardness for a longer period, so the tool life is more.

Because of the lubricating function, the friction is reduced and the heat generated is less. A higher cutting speed can be selected.

As the coolant avoids the welding action of the chip to the tool-cutting edge, the built up edge is not formed. The tool is kept sharp and a good surface finish is obtained.

As the chips are flushed away, the cutting zone will be neat.

The machine or job will not get rusted because the coolant prevents corrosion.

Coolant system

While machining, friction is generated, because of which large amount of heat is involved. In order to reduce the amount of heat, a coolant system is provided.

In metal cutting operation the coolant is being pumped by high pressure, with high volume directly to chip-tool interface, by a coolant system.

Typical coolant system is shown in Fig 1.

Parts of coolant system and its function

Coolant tank

Coolant tank is used to store and supply the coolant for the system and receive the return coolants.

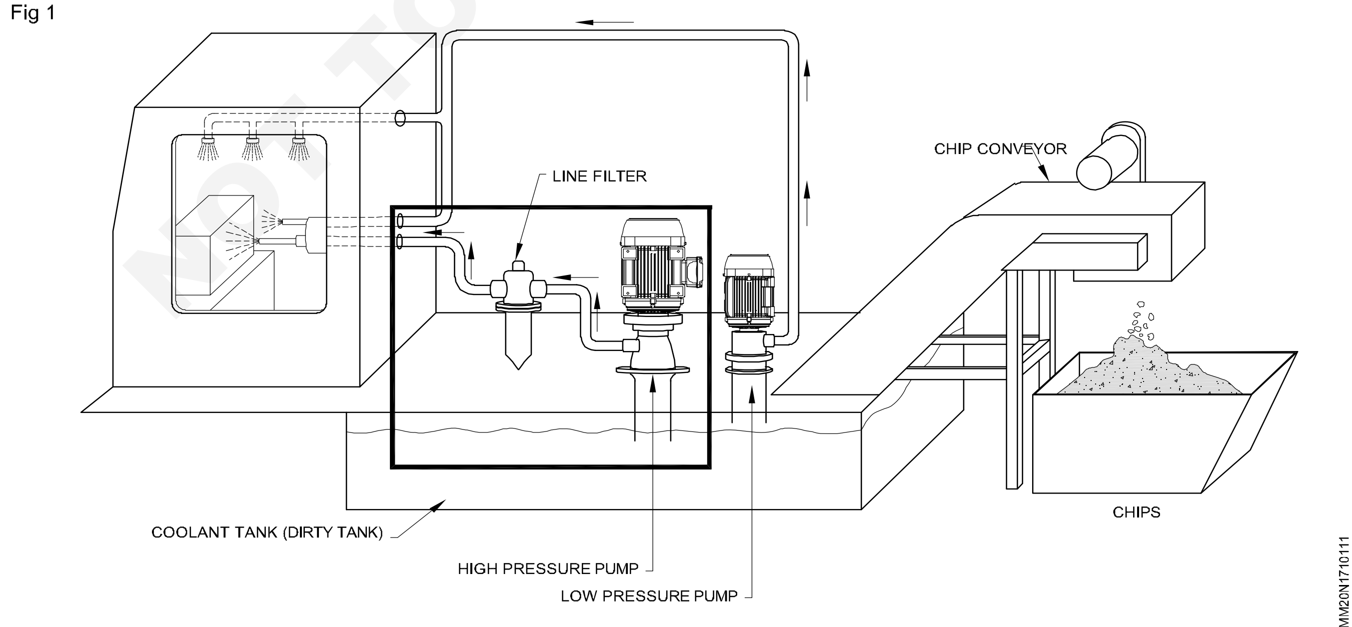
High pressure pump

It circulate the coolant from tank through the filter to the cutting tool and job.

Filter

The filter helps to maintain the coolant flow without any contamination, and send clean coolant to the cutting portion.

Fig 1



Types of coolants, its properties and uses

Objectives : At the end of this lesson you shall be able to
- **name the different types of cutting fluids**
- **distinguish the characteristics of each types of cutting fluid**
- **select a proper cutting fluid to suit various materials and machining operations.**

The different types of cutting fluids are:

Soluble mineral oils

Straight mineral oils

Straight fatty oils

Compounded or blended oils

Sulphurised oils.

Straight mineral oil

Straight mineral oils are the coolants which can be used undiluted. Use of straight mineral oil as a coolant has the following disadvantages.

It gives off a cloud of smoke.

It has little effect as a cutting fluid.

Hence straight mineral oils are poor coolants. But kerosene which is a straight mineral oil is widely used as a coolant for machining aluminium and its alloys.

Chemical solution (Synthetic oil)

These consist of carefully chosen chemicals in dilute solution with water. They possess a good flushing and a good cooling action, and are non-corrosive and non-clogging. Hence they are widely used for grinding and sawing. They do not cause infection and skin trouble. They are artificially coloured.

Compounded or blended oil

These oils are used in automatic lathes. These oils are much cheaper and have more fluidity than fatty oil.

Fatty oil

Lard oil and vegetable oil are fatty oils. They are used on heavy duty machines with less cutting speed. They are also used on bench-works for cutting threads by taps and dies

Soluble oil (Emulsified oil)

water is the cheapest coolant but it is not suitable because it causes rust to ferrous metals. An oil called soluble oil is added to water which gets a non-corrosive effect with water in the ratio of about 1: 20. It dissolves in water giving a white milky solution. Soluble oil is an oil blend mixed with an emulsifier.

Other ingredients are mixed with the oil to give better protection against corrosion, and help in the prevention of skin irritations.

Soluble oil is generally used as a cutting fluid for centre lathes, drilling, milling and sawing.

Soft soap and caustic soda serve as emulsifying agents.

Table 1 showing coolants for different metals is given below,

Table 1

Recommended cutting fluids for various metals and different operations

Material	Drilling	Reaming	Threading	Turning	Milling
Aluminium	Soluble oil Kerosene Kerosene and lard oil	Soluble oil Kerosene Mineral oil	Soluble oil Kerosene Lard oil	Soluble oil	Soluble oil Lard oil Mineral oil Dry
Brass	Dry Soluble oil Mineral oil	Dry Soluble oil	Soluble oil Lard oil	Soluble oil	Dry Soluble oil
Bronze	Dry Soluble oil Mineral oil Lard oil	Dry Soluble oil Mineral lard oil Lard oil	Soluble oil Lard oil	Soluble oil	Dry Soluble oil Mineral oil Lard oil
Cast iron	Dry Air jet Soluble oil	Dry Soluble oil Mineral lard oil	Dry Sulphurized oil Mineral lard oil	Dry Soluble oil	Dry Soluble oil
Copper	Dry Soluble oil Mineral lard oil Kerosense	Soluble oil Lard oil	Soluble oil Lard oil	Soluble oil	Dry Soluble oil
Steel alloys	Soluble oil Sulphurized oil Mineral lard oil	Soluble oil Sulphurized oil Mineral lard oil	Sulphurized oil Lard oil	Soluble oil	Soluble oil Mineral
General Purpose Steel	Soluble oil Sulphurized oil Lard oil Mineral lard oil	Soluble oil Sulphurized oil Lard oil	Sulphurized oil Lard oil	Soluble oil	Soluble oil Lard oil

Effect of cutting fluid in metal cutting

Objectives : At the end of this lesson you shall be able to
- **state the effects of cutting fluid in metal cutting**
- **list the different between coolants and lubricants.**

Effects of cutting fluids in metal cutting

Commonly, the use of cutting fluid can decrease cutting temperature, reduce the friction between tool and workpiece, extend tool life, and improve machining efficiency and surface Quality. These effects of cutting fluid were mainly obtained from its basic functions including cooling and cleaning This also suggests that the effect of cutting fluid on machined surface quality and performance will become an important research direction. There is a matching problem between the cutting fluids and the workpiece materials on effect of cutting fluids on machined surface should include physical and chemical mechanism of the cutting fluid action mechanism on fresh machined surface during machining process, action mechanism in the period of long-term service, stability of the composition and physical and chemical properties, and evaluation method of the effective use of cutting fluid

Difference Between Coolant and Lubricant (Table 1)

Coolant	Lubricant
The basic purpose of coolant is to remove the cutting heat generated from the cutting zone, and thus to keep the cutting zone temperature low	Lubricants can reduce the rate of heat generation, with no effect on the removal of previously generated heat.
It reduces the heat produced by Cutting tools and work	It reduces friction between moving parts
It Contains soluble oil with water	It does not contain any soluble oil or water.
It increases the life of the tool that's why it is also called the lifeblood for the cutting tool	It increases the life of moving parts of a machine so it is also called the lifeblood for the machine.
Its flash point is less than the lubricant	Its flash point is more than the coolant.
Oxidation occurred due to the presence of water	Oxidation does not occur in lubricant.
It removes chips during Cutting	It prevents the moving parts from any external materials.
It also helps in cutting	It serves as protective films.
Air, compressed air, water, soluble oil, etc. are used as a coolant that is found in gas and liquid state.	Oil, grease, graphite, etc. are used as lubricants, which are found in a liquid, solid and semi-solid state.

MMTM - Machine installation and maintenance

Installation of precision & heavy duty machines

Objectives : At the end of this lesson you shall be able to
- **define installation**
- **explain the method at employs in installation**
- **explain the erection of precision & heavy duty machines.**

Installation

Installation means is the stage at which machinery is unpacked reassembled, realigned connected to essential services and then tested exhaustively to ensure & works at peak operating efficiency when it finally goes into production

Purpose of foundation

Machinery foundation is a built up structure designed to support the machine and to take up the static and dynamic load of the machine, besides keeping the machine in alignment

The machine foundation must fulfil the following require ments

- It must support the machines at a given height and must be able to take up the static and dynamic loads.
- It should preserve the alignment of the machine.
- It should absorb the vibration of the moving parts.

The size of the foundation will be decided by:

- the type of the soil
- the weight of the machine
- the vibration when it is operating.

The accuracy shown in the chart will be re obtained only if the machine is correctly erected and leveled.

Foundation for precision and heavy duty machines.

Isolated foundation for active vibration damping for heavy forging machines like power presses for or hammers engine test rigs and passive vibration isolation of precision machines like machining centres, grinding, machines, measuring & testing equipments, laser cutters and micrometers.

Installation and errection methods

Positioning of machines

- Equipment may have the weight of a few tons. But to be loaded or unloaded, to be moved vertical horizontally to bring it at the site and to place it on foundation as well.
- Different types of lifting devices like pulley blocks, hoists, and overhead cranes may be used as per the availability and requirement.
- When the load is light, rope pulley blocks are widely used and chain pulley blocks may be useful, but for a very heavy load, electric cranes are generally employed.

However, the slinging should be done with much care to avoid any impact shock, to avoid formation of any scratches and breakages, etc.

Foundation,

- The shapes and sizes of the foundation differ according to the type and size of the machines
- They are also dependent on the property of the subsoil and the dynamic loads of the machine during operation.

If the weight of the installed machine is not too much of if the dynamic loads are insignificant the size of the foundation plates are also supported similarly, for different machines etc, At this time, a gap (minimum 50 to 70mm) depending on the type of the machine is maintained between the top of the foundation block and the bottom of the machine or base plate.

The foundation bolts are positioned before positioning the machine and the exact location of the machine is guided by the insertion of the projected foundation-bolt ends through the holes, provided at the machine footings or base plate

The bolt-ends should remain sufficiently projected to

accommodate the washers and nuts as well.

Leveling and alignment

The leveling is performed with leveling wedges, shoes etc, as stated before.

The horizontal and slight vertical movement of the heavy mass of machine is performed by pipes, rollers.

Straight edge, spirit level, dial indicator etc., are generally useful instruments to level the machine.

The leveling is to be checked in the both, longitudinal and transverse direction.

When leveling is completed, the foundation bolt cavity along with the bolt may be made concreted. Pouring of cement concrete is generally made through the gap provided at the top of the foundation.

Grouting

Grouting is a procedure of connecting the machine with the foundation by a concrete mixture of plastic consistency or cement mortar. It is extensively used in installing most of the machines.

Generally, quick setting cement is used to perform grouting The top of the foundation block is made roughened, made moistened with water and wooden partitions are placed all around the machine

The heights of such wooden boards are kept much higher than the gap between the top or the foundation and the bottom of the machine.

Quick setting cement is then poured within the boundary with care to eliminate any air gap within it

Once started, the pouring should be completed continuously and the machine must be felt undisturbed for a few days after grouting to provide it time to set

Fitting of other parts, accessories, piping etc..,

When the machine is erected, the other accessories may be joined accordingly

But, while laying out the foundation plan, the overall requirement should be kept in mind.

The auxiliary structures e g in case of a heavy duty diesel engine foundation, the structures for outer bearing pedestal, water pump blocks etc. should be planned at a time

This will minimize the problem of internal fittings

Final leveling and test runs

Accurate leveling can be carried out only when the grouting has set in after a few days

The machine is to be made cleaned and leveled then. Such leveling involves minor adjustments.

Whenever provided, the leveling screws and may be operated to achieve the final level. Everything should now be made ready to carry the test run. The style of testing will differ from machine to machine.

Different types of foundations

Objectives : At the end of this lesson you shall be able to
- **explain the types of structural foundation**
- **state location for foundation**
- **explain excavation for foundation**
- **explain the construction of the isolated foundation**
- **explain the reinforced foundation**
- **describe the positioning of wooden block.**

General Procedure of Machine Installation: Installation procedure of a machine involves a series of activities are follows

a Location and layout

- Once the location is finalized, the work of laying out the foundation plan is to be undertaken.
- Laying out means marking of the foundation plan. It may be done with the help of chalk on a concrete floor and by a string with a number of pegs.
- The general procedure is to indicate the outlines as per specification of the machine
- The axis lines are to be drawn both longitudinally and crosswise to locate the center of foundation.
- Excavation of soil may be started only when the layout is completed as per the requirement.

Excavation

The size of excavation is drawn with chalk if it is on concrete floor.

Excavating the hole should be done as neatly as possible but should the soil persist in falling into the hole it may be advisable to shore this up by the use of shuttering. The excavation should be made a few millimetres deeper than the required foundation depth. The bottom surface is well rammed prior to and after placing a layer of clean bottom in stones or broken bricks.

Types of Machine Foundation

Machine foundation design, which is also known as machinery foundation design is accomplished to protect the adjacent foundations of the structure from the vibration of the rotating or vibrating machine. There are four types of machine foundations generally used. Each of them is discussed briefly below.

1 Block Type
2 Box Type
3 Wall Type
4 Framed Type

Block Type (Fig 1)

Block type machine foundations consist of a pedestal resting on a footing. The foundation has a large mass and a small natural frequency

Box Type (Fig 2)

Box type machine foundation consists of a hollow concrete block. The mass of the foundation is less than the block type and the natural frequency is increased.

Fig 1

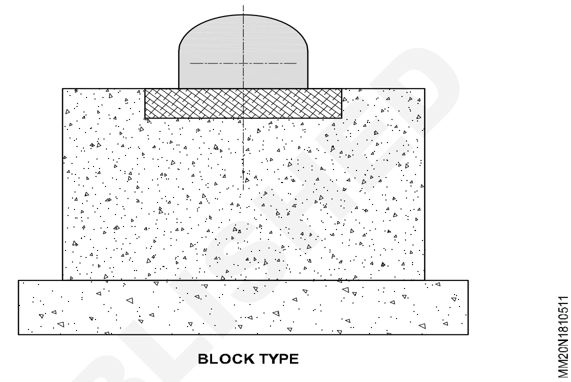
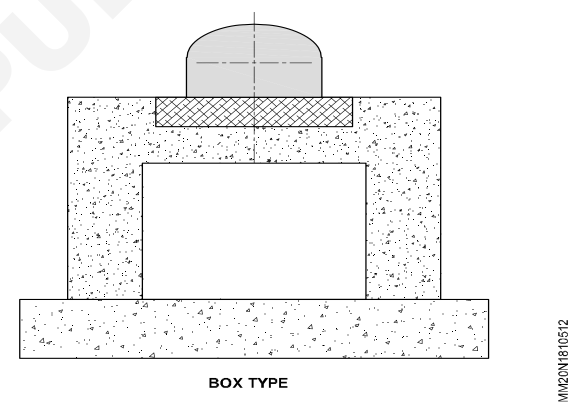


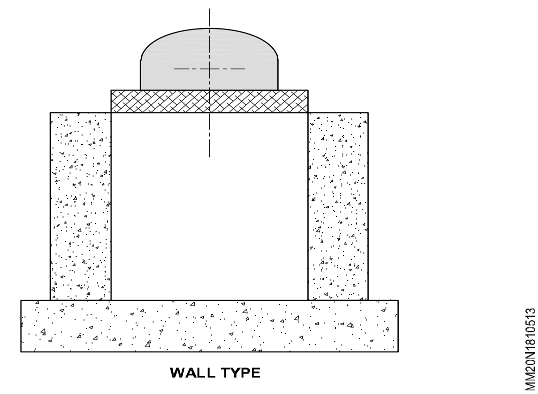
Fig 2



Wall Type (Fig 3)

It consists of a pair of walls having a top slab. The ma chine rests on the top slab it is economical for smaller projects Wall type machine foundation is made by homo- generous material in case of both horizontal and vertical member

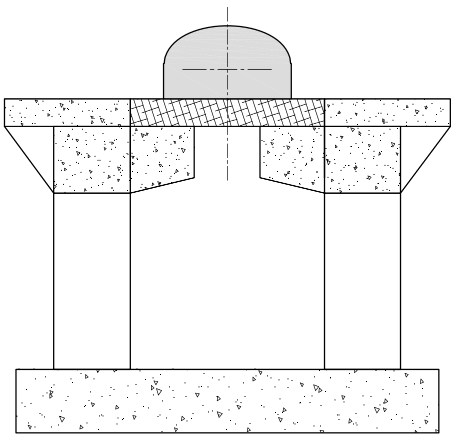
Fig 3



Frame type (Fig 4)

Frame type consists of vertical columns having a horizontal frame at their tops. The machine is supported on the frame it is economical for larger projects in frame type machine foundation, vertical and horizontal member is made by different materials

Fig 4



FRAMED TYPE

Reinforced foundations (Fig 5)

1 The reinforcement of the concrete block in no case lower than 25 kg/m3. For the machines demanding special design consideration of foundations like for the machine pumping explosive gases the lowest limit of reinforcement is 40 kg/m3.

2 The steel reinforcement around the pits and opening at minimum has to be 0.5-0.75% of cross-sectional area of the pits and openings

3 The reinforcement needs to run at all 3 directions. The minimum limit of reinforcement should have 12 mm bars at 200-250 mm spacing extending on both directions vertically and horizontally near all the faces of the foundation block. Remember the ends of each bars shall always be hooked.

4 In case the height of foundation block exceeds 1 meter, shrinkage reinforcement is required to be used at suitable spacing at all three directions.

5 Clear cover minimum ranges: 75 mm at bottom portion and 50 mm on sides and top portion of foundations

6 The characteristic strength of concrete need to be at minimum 15 N/mm2 i.e. M-15.

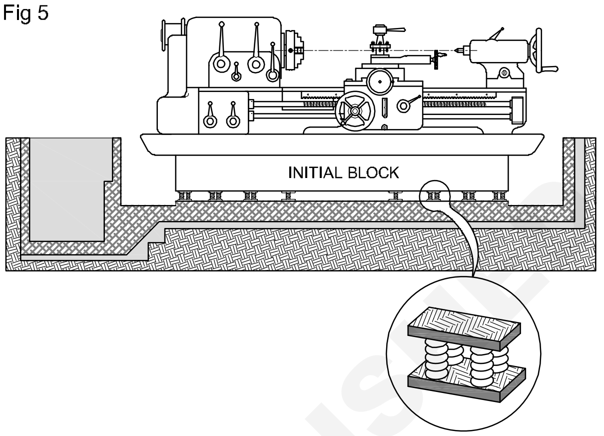
7 The castings of foundation block have to be performed preferably in a single and continuous operation. For very big/thick blocks (>5m) construction joint shall be used.

8 Procedure for construction of foundation starts with a decision on its depth. width, and marking layout for excavation and centerline of foundation. Foundation is the part of the structure below the plinth level in direct contact of soil and transmits the load of superstructure to the ground.

9 Generally, it is below the ground level. If some part of the foundation is above ground level, it is also covered with earth filling. This portion of the structure is not in contact with air, light, etc., or to say that it is the hidde part of the structure.

10 Footing is a structure constructed in brickwork, masonry, or concretes under the base of a wall or column for distributing the load over a large area.

Fig 5



REINFORCED FOUNDATION

Wooden block

The position of the foundation is first determined, marked off and wooden pegs are driven if it is in the soil. (Fig 6)

The size of excavation is drawn with chalk if it is on a concrete floor.

Excavating the hole should be done as neatly as possible but should the soil persist in falling into the hole it may be advisable to shore this up by the use of shuttering. The excavation should be made a few millimetres deeper than the required foundation depth. The bottom surface is well rammed prior to and after placing a layer of clean bottoming stones or broken bricks

Wooden template

A wooden template is formed as shown in Fig 7 to represent the base of the machine and to support bolts over the excavation as shown. The combined thickness of the template frame A and blocks B should equal the thickness of the foot of the machine as shown. These boxes are formed of light timber and are suitably nailed for easy removal later.

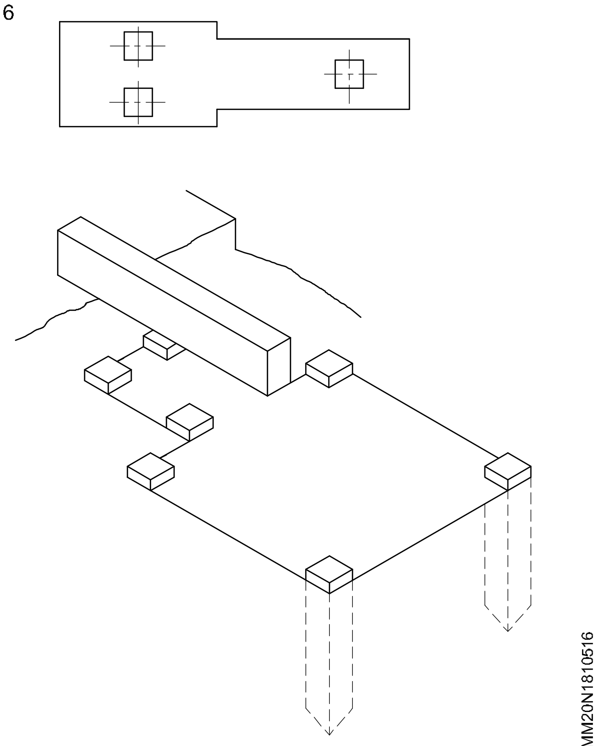
Wooden forms

Wooden forms for concrete foundations are made and placed over the excavation

Bracing the wooden form

After placing the wooden form in position in the excavation, it is firmly braced from the outside so as to withstand the pressure of the concrete and prevent any movement when the concrete is being poured

Fig 6



Concrete

Should be prepared from clean cement on a wooden surface. Proportions for the mixture vary. A good average mixture is 1:2:4. ie 1 part cement, 2 parts sand and 4 parts stone. This is mixed thrice when dry and thrice after wetting and is immediately placed on the excavated area after a good spraying with water on the excavated area.

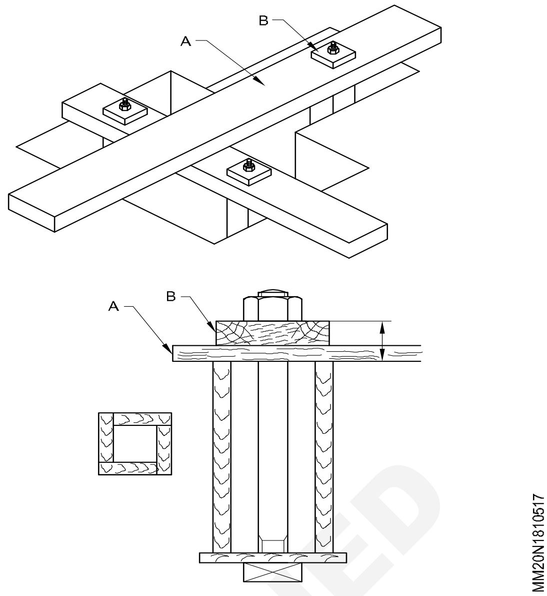
The foundation should be given a day atleast to set before the template is removed.

Isolated foundation (Fig 8)

Isolated foundation for active vibration damping for power presses, forging hammers, engine test rigs, and passive vibration isolation of machining centres. grinding machines, measuring & testing equipments, laser cutters and microscopes.

The Isolated foundation is required to reduce both active and passive vibrations. Vibration isolation mountings are required to reduce the transmission of vibration and shocks.

Fig 7

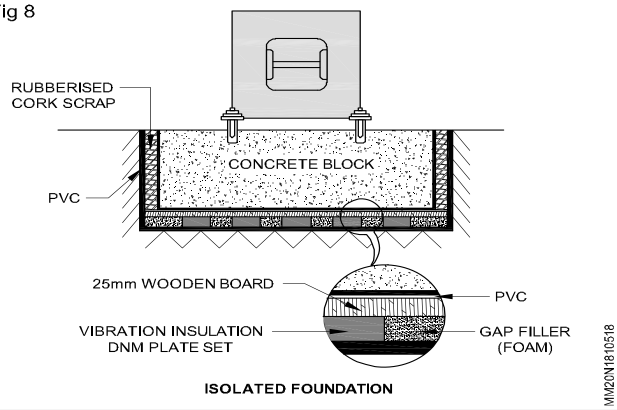


A foundation block or Vibration isolation mountings for high dynamic machines like power press, forging hammers, compressors, engine test rigs etc. is required in order to reduce the transmission of vibration and shock to nearby precision machines/building structures. To control the source of vibration disturbance through the use of resilient insulating materials is known as Active vibration isolation.

When it is not possible to prevent or sufficiently lower the transmission of shock and vibration from the source, a resiliently supported vibration insulating foundation block can be used for the passive vibration isolation of sensitive equipments like Machining Centres. Measuring and Testing Machines/ Equipments etc.

Isolated foundation lowers the centre of gravity of the machine foundation system and adds to the stability of the machine. Machine remains aligned during dynamic load changes and rapid movements within the machines.

Fig 8



Foundation bolts and types

Objectives : At the end of this lesson you shall be able to
- **state the purpose of foundation bolts**
- **state the different types of foundation bolts and their uses**
- **designate the foundation bolts as per BIS**
- **mention the purpose of grouting**
- **name the different types of grouting.**

Purpose of foundation bolts

For some machine tools, it is very essential to hold down the machines firmly on the foundation to prevent them from moving. For this purpose various types of foundation bolts or anchor bolts are used.

Types of foundation bolts

Foundation bolts are divided into two groups. They are:

- fixed type
- removable type.

Fixed type of bolts

Fig 1 shows the ordinary foundation bolt with mild steel plate. The rag bolt shown in Fig 2 is usually forged and filled up with lead or cement. A simple form, shown in Fig 3, is known as eye foundation bolt. A bent type of bolt is shown in Fig 4.

Fig 1

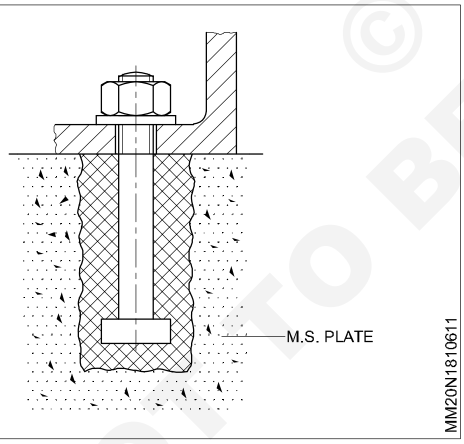


Fig 2

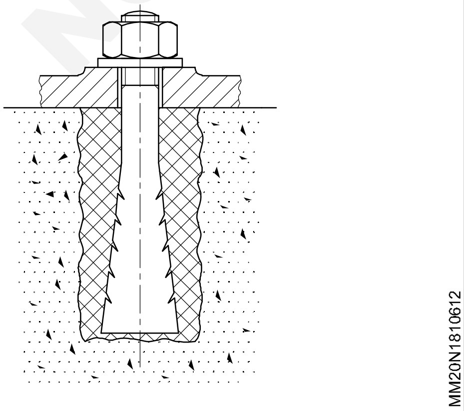


Fig 3

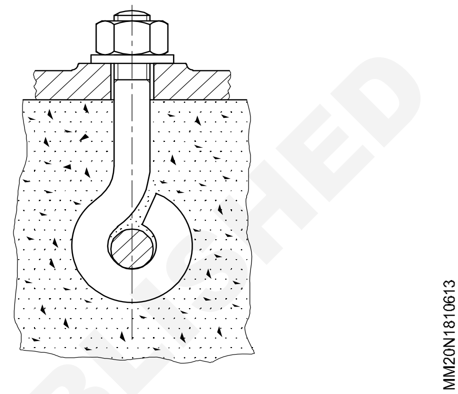


Fig 4

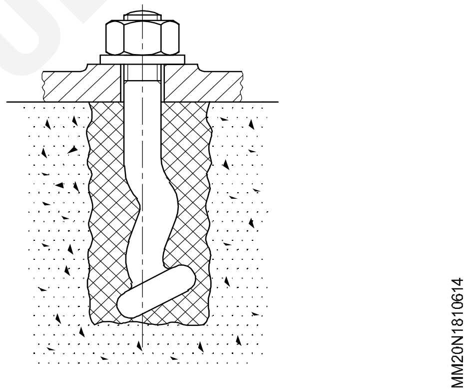
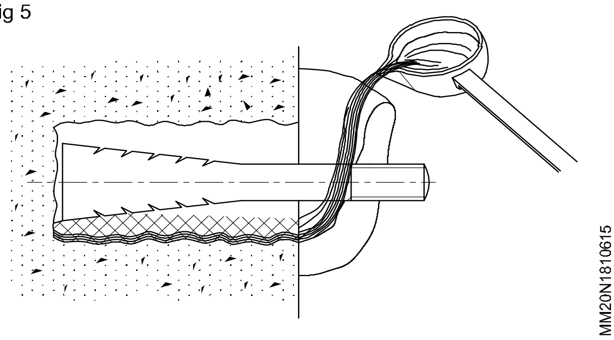


Fig 5 shows running up bolts in a horizontal position. A clay cap is formed around the bolt to support this and direct the lead into the hole. After running up, the lead should be caulked in position to consolidate this.

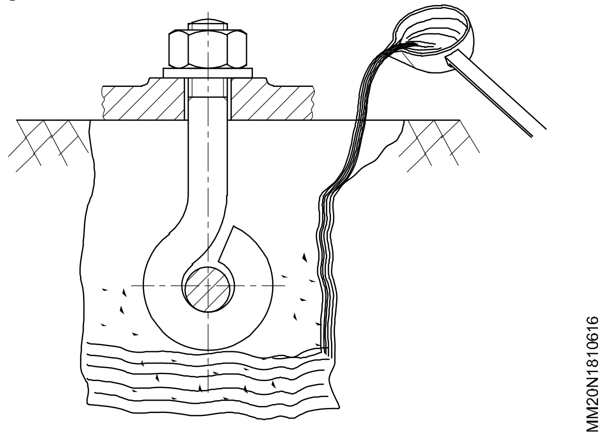
When running with lead, care should be taken to see that no water is collected in the hole; otherwise steam will be rapidly generated which will blow the lead out, which may cause serious burns.

Fig 5



As an alternative to lead, where quick setting is required, rock sulphur can be melted down in an old kettle or ladle and run into the bolt hole as quickly as possible. (Fig 6)

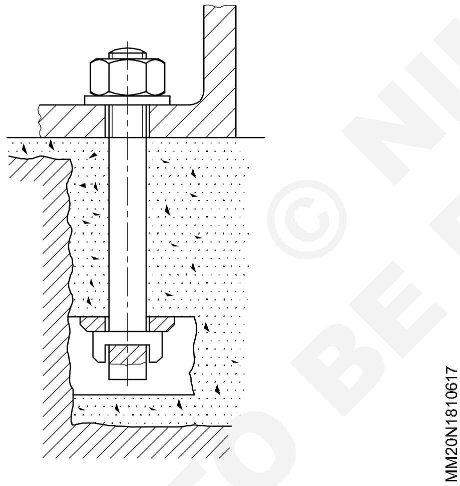
Fig 6



Removable type (Fig 7)

For large machines a long cotter bolt is commonly used. This bolt is provided with a square foundation plate and a removable cotter at the bottom. In forming the foundation, pockets are left in the sides of the bolt holes which are then capable of being replaced at any time, if necessary.

Fig 7



The rawl bolt (Fig 8)

In this type four clamps are flexibly mounted on the bolt which expand by wedge action when tightened up. The advantage is that they can be removed and used again, if necessary.

Expanding conical washer foundation bolt (Fig 9)

This consists of a bolt on which are threaded conical washers and ferrule. On drawing up the bolt, the washers are flattened which grip the inside of the hole by expansion.

Grouting

After levelling the machines in the aligned condition with the foundation bolts and wedges, there will be a gap left over between the bottom of the machine and the top of the floor or foundation block. This space is filled up with grouting materials such as cement concrete or sulphur or lead and the process is known as 'grouting'.

Fig 8

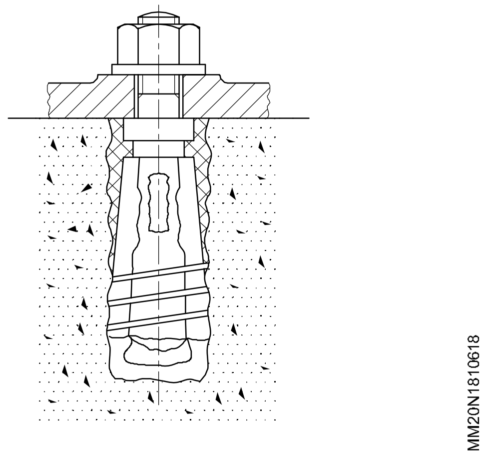
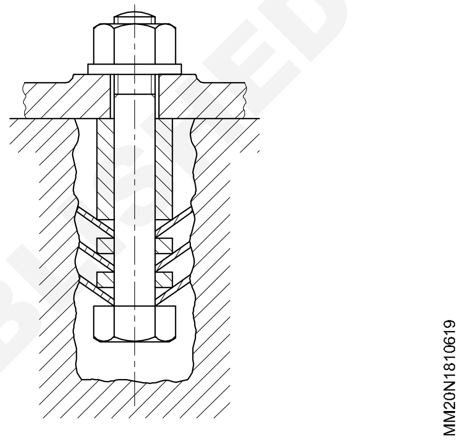


Fig 9



When 'mould' boxes are used and the anchor or foundation bolts are suspended in their respective pockets, the pockets are filled up with the grouting material.

Purpose

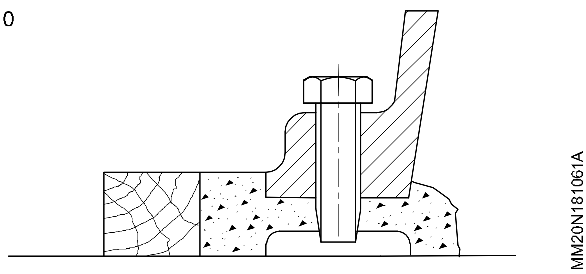
- To ensure that the machine rests firmly on the top of the foundation block or the floor.
- To prevent lateral shifting particularly for the machines like shaper, planer, surface grinder etc. which are having reciprocating motion.

Types of grouting

Cement concrete grout (Fig 10)

It is a most common grouting process wherein cement concrete mixture is used. This mixture can bear the compressive load of the machine. This is quite cheap and strong to withstand the displacement of the machine. This is not suitable for oil-soaked areas.

Fig 10



Errection tools

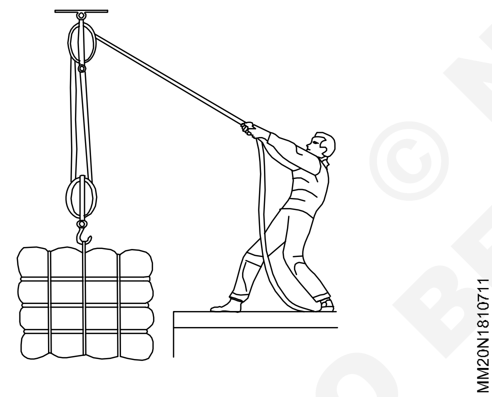
Objectives: At the end of this lesson you shall be able to
- **describe the pulley block**
- **name the different types of crowbar**
- **state the construction of sprit level**
- **state the construction plumb bob**
- **state the use it wooden block.**

Pulley block (Fig 1)

Pulley block is a system of two or more pulleys with a rope or cable threaded between them, usually used to lift heavy loads. The pulleys are assembled together to form blocks and then blocks are paired so that one is fixed and one moves with the load. The rope is threaded through the pulleys to provide mechanical advantage that amplifies the force applied to the rope.

A block is a set of pulleys or "Sheaves" mounted on a single frame. An assembly of blocks with a rope threaded through the pulleys is called tackle. A block and tackle system amplifies the tension force in the rope to lift heavy loads. They are common on boats and sailing ships, where tasks are often performed manually.

Fig 1



Crowbars give leverage, so that heavy loads can be lifted or moved. They are made in differnt lengths with hexagonal or octogonal steel bars. Short crowbars are easier to handle and the point will fit into a narrow gap, but requires more force. Long crowbars provide a greater leverage.

Types of crowbars (Fig 2)

There are two types of crowbars, single or double ended. A single ended crowbar is safer to use as the handle has a rounded end. The double ended crowbar normally has a curved end used for lifting, and a straight end used for pushing.

Levelling of the machine is a very important operation before proceeding to conduct geometrical tests. A precision spirit level is used to level the machine tools accurately.

Spirit level

It consists of a curved glass tube called 'VIAL' containing industrial alcohol 'spirit' and a bubble of 'AIR' trapped in the tube. The spirit and the bubble are both acted upon equally by the force of gravity. (Fig 3)

Fig 2

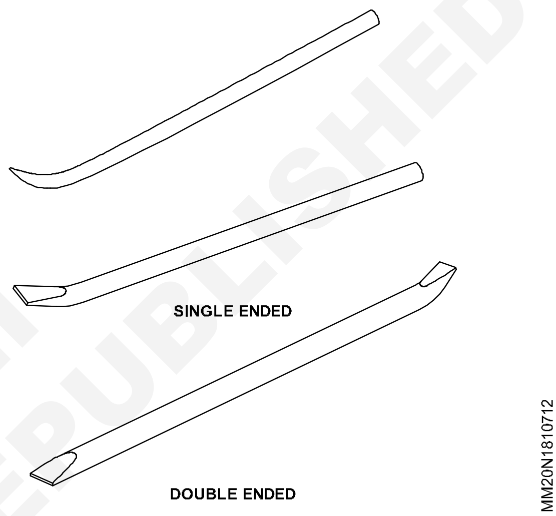
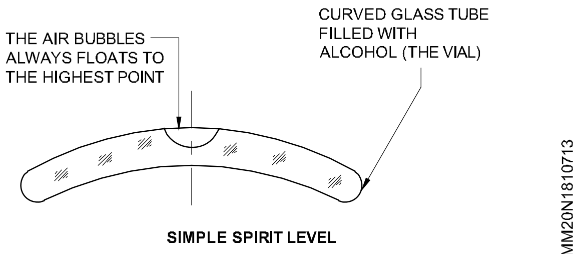


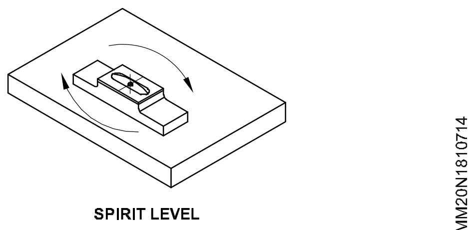
Fig 3



Since the spirit has a higher density, it is pulled down to the bottom of the tube and the bubble always floats to the top.

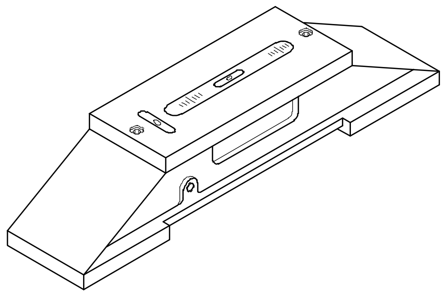
The vial is set in a cast iron base and adjusted such that the bubble rests at the centre of a scale (Fig 4) when the base is horizontal.

Fig 4



Precision spirit level (Fig 5)

Fig 5



Spirit levels used for high precision measurements should have a sensitivity of about 0.02 to 0.05 millimetre per 1000 millimetres for each division.

If the movement of the bubble by one division corresponding to a change in slope of 6 to 12 seconds

of a level of 0.04mm per 1000mm is chosen, then

1 division = 0.04 mm/1000 mm

3/4 division = 0.03 mm/1000 mm

1/2 division = 0.02 mm/1000 mm

1/4 division = 0.01 mm/1000 mm.

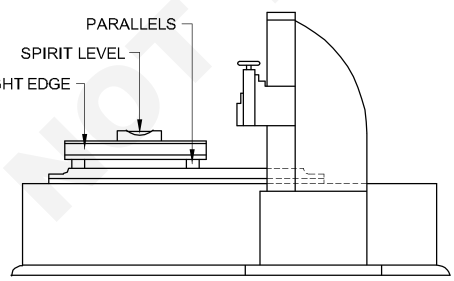
It is quite easy to estimate within a quarter of a division.

Hints on spirit level

Spirit levels which are too sensitive are difficult to bring to rest in a workshop in which machines are running. Levels with low sensitivity result in insufficient reading accuracy, as very small fractions of a division have to be estimated.

The bearing surfaces of spirit levels should be as long as possible. For testing medium size machines the level should not be less than 200mm long. It is often advisable to use a bridge piece (Fig 6) the feet of which are about 300 mm apart. The spirit level can then be placed on the scraped surface of the bridge. This method avoids errors which could be caused by irregular scraping of the surface to be measured.

Fig 6



TESTING INCLINATION OF BED WITH PARALLELES STRAIGHT EDGE AND SPIRIT-LEVEL BY BRIDGING

Causes for errors in spirit level reading

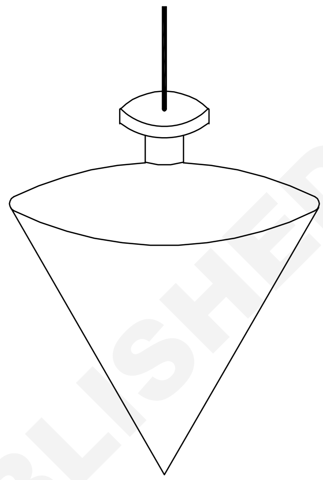
- Wrong position of the vial in the housing
- Faulty graduation
- The surface finish of the piece to be tested
- The influence of temperature
- Personal errors of the inspector

Reading spirit levels depends on:

- the quality and length of the bearing surface of the workpiece
- dimensional stability of the metal housing.

The plumb bob (Fig 7)

Fig 7



PLUMB BOB

The plumb bob employs the law of gravity to establish. A string, suspended with a weight at the bottom will be both vertical and perpendicular to any level plane through which it passes. In a sense, the plumb bob is the vertical of the line level.

The plumb consists of a specially designed weight and coarse string made of twisted cotton or nylon threads. At end of the string weight is affixed. Precisely machined and balanced bobs have point tips and can be made of brass, steel or other materials

How to use a plumb bob

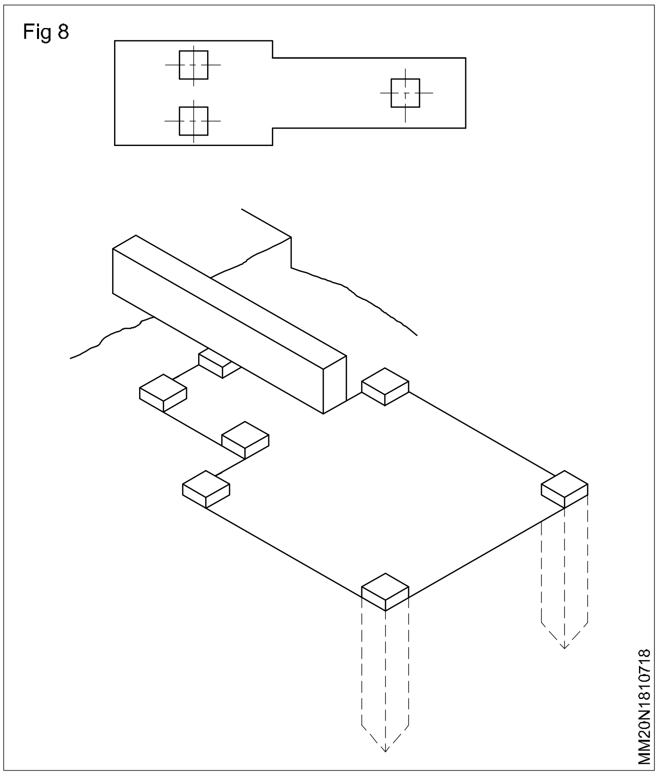
To use the plumb bob, the string is fixed at the point to be plumbed. The weight, or bob, is than allowed, to swing freely, when it stops, the point of the bob is precisely below the point at which the string is fixed above.

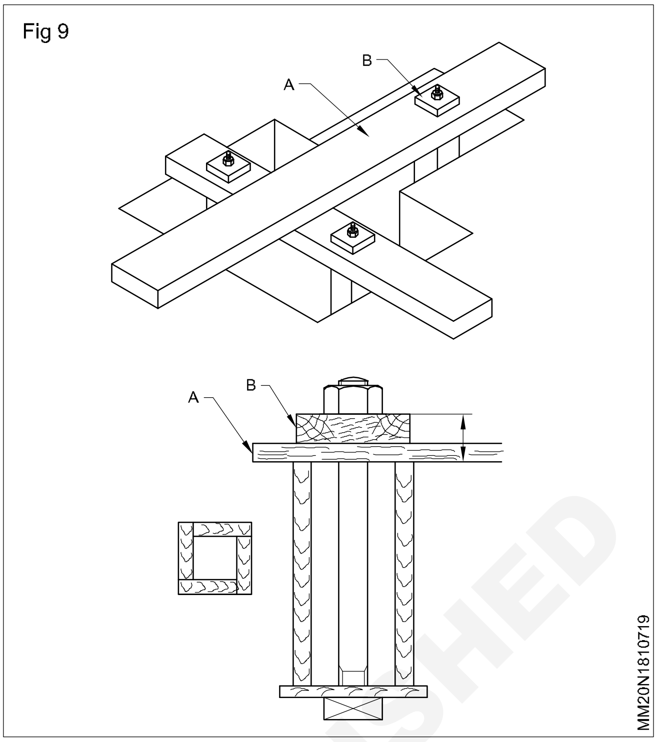
Wooden block

The position of the foundation is first determined, marked off and wooden pegs are driven if it is in the soil. (Fig 1)

The size of excavation is drawn with chalk if it is on a concrete floor.

Excavating the hole should be done as neatly as possible but should the soil persist in falling into the hole it may be advisable to shore this up by the use of shuttering. The excavation should be made a few millimetres deeper than the required foundation depth. The bottom surface is well rammed prior to and after placing a layer of clean bottoming stones or broken bricks.





Wooden template

A wooden template is formed as shown in Fig 2 to represent the base of the machine and to support bolts over the excavation as shown. The combined thickness of the template frame A and blocks B should equal the thickness of the foot of the machine as shown. These boxes are formed of light timber and are suitably nailed for easy removal later.

Wooden forms

Wooden forms for concrete foundations are made and placed over the excavation.

Bracing the wooden form

After placing the wooden form in position in the excavation, it is firmly braced from the outside so as to withstand the pressure of the concrete and prevent any movement when the concrete is being poured.

Concrete

Should be prepared from clean cement on a wooden surface. Proportions for the mixture vary. A good average mixture is 1:2:4. ie 1 part cement, 2 parts sand and 4 parts stone. This is mixed thrice when dry and thrice after wetting and is immediately placed on the excavated area after a good spraying with water on the excavated area.

The foundation should be given a day atleast to set before the template is removed.

Lifting appliances

Objectives: At the end of this lesson you shall be able to
- **state different type of lifting appliance**
- **state the common types of chain sling**
- **mention different types of fastening bolts,hooks, lifting clamps etc.**
- **illustrate various method of slinging practice**
- **define rigging and various rigs and fittings.**

Slinging is an important skill in lifting and shifting load in industrial practices.

Slings are made with fibre rope, (manila, sisal,nylon, terylene and polypropylene) chain, wire rope etc. Other appliances like hooks, eye bolts, shackles, lifting clamps etc are used to make or sling considering the type of the load.

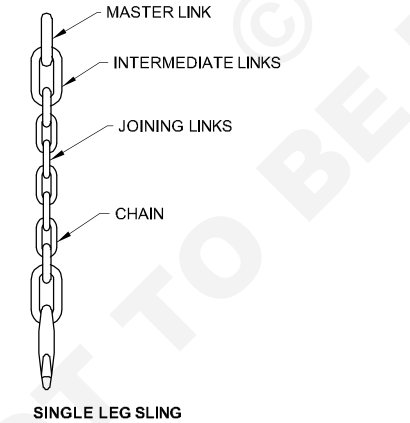
Chain sling

Chain links are fabricated by welding from carbon or alloyed steel. Links are formed to the shape and welded together to form a chain.

Chain slings are of different types, namely

- Single leg chain (Fig 1)

Fig 1



SINGLE LEG SLING

- Double leg chain (Fig 2)
- Four leg chain (Fig 3)
- Endless chain (Fig 4)

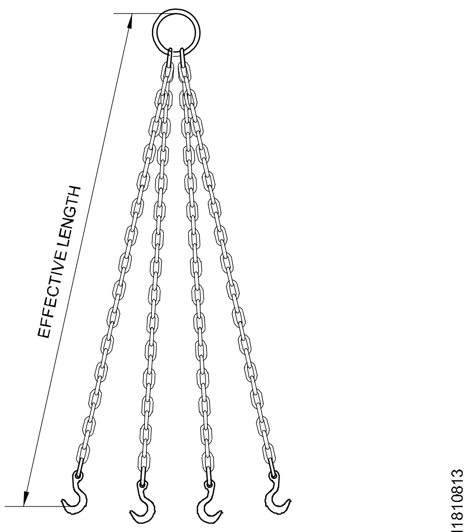
A chain will have the following components (Fig 1)

- Master link.
- Intermediate link.
- Joining link.
- Chain hook.

Fig 2

TWO-LEG CHAIN SLING, RING OR LINK AT ONE END, HOOKS AT OTHER ENDS

Fig 3



FOUR-LEG CHAIN SLING, RING OR LINK AT ONE END, HOOKS AT OTHER ENDS

Wire rope sling

Wire rope slings are made of steel wire rope to form eye thimble mechanically spliced which accommodates a master ring on one side and or plain eye look is known as single legged sling (Fig 5a). Similarly, two legged, three egged and four legged slings are shown in (Fig 5b,c and d) respectively.

Fig 4

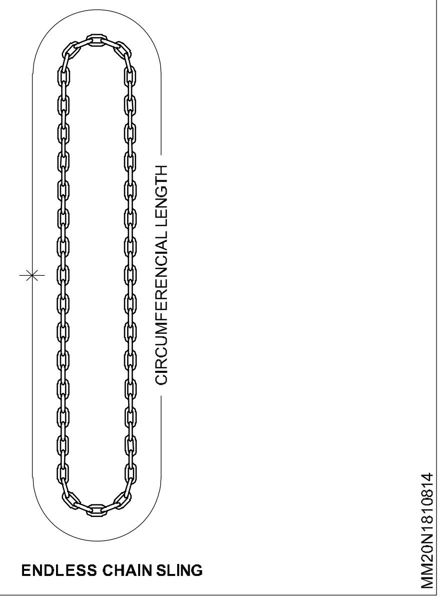
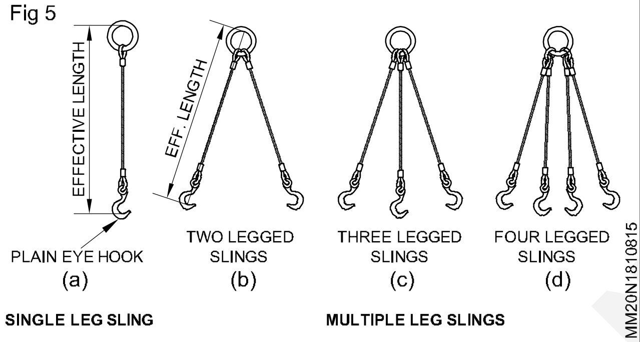
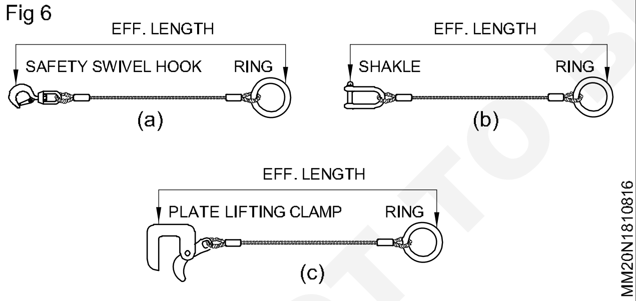


Fig 5



A few other slings like sling with safety swivel hook, Dee shackle and plate lifting clamp with effective length are shown in Fig (6a, b and c) respectively.

Fig 6



Some other types of single part rope slings include plain loop on both ends (Fig 7a), basket hitch (Fig 7b) and choker hitch (Fig 7c) are shown.

The following points are to be noticed and followed strictly.

- Fibre rope sling should be used only for lifting and shifting lighter loads.
- In case of sharp edges use soft pads (packer, wooden blocks) Fig.8 to protect the sling and the edges of the load as well.
- Check the condition of the sling and consider the load carrying capacity of the sling.

Fig 7

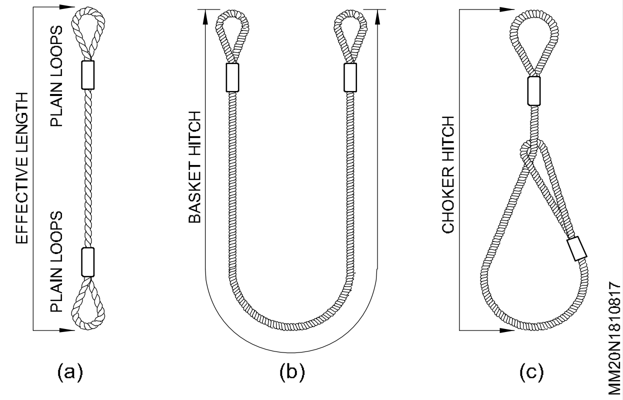
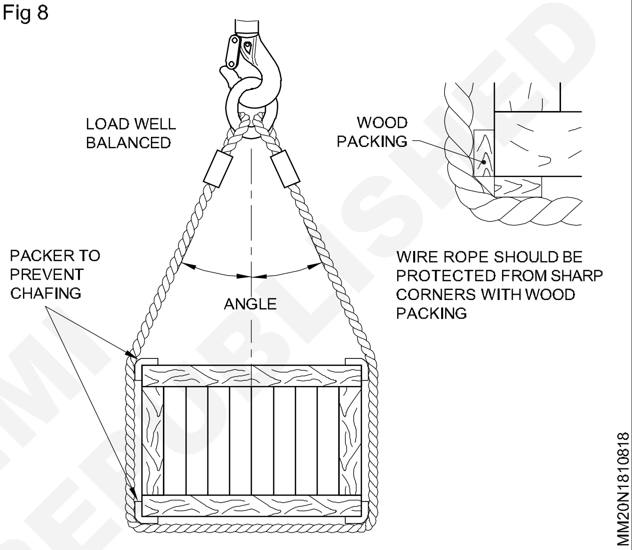
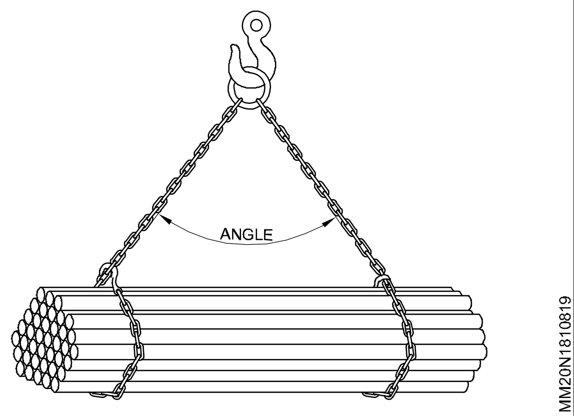


Fig 8



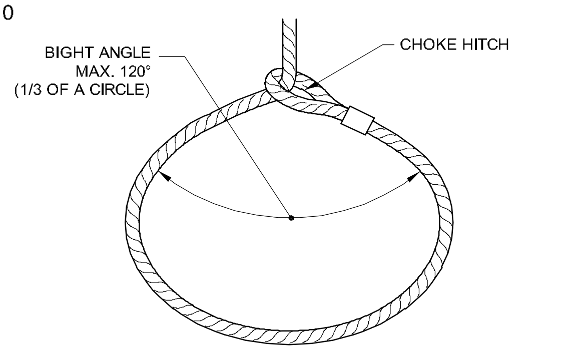
- Fibre rope get spoiled due to heat and in presence of toxic liquid and fumes. However, polypropylene ropes offer goods resistance to water chemicals and alkalis. They are stronger, reliable and durable comparing to other fibre ropes.
- Always prepare the sling to keep the load in well balanced condition.
- Prepare a sling for the load within permissible angle as in Fig.9 (30^0,90^0,120^0). Lesser the angle load carrying capacity of the slings is more. When the angle exceeds 120^0 ,the load carrying capacity of the sling is reduced to half.

Fig 9



- Ensure about the safe working load (SWL) of the chain and wire rope slings.
- Chains should not be twisted for slinging.
- Avoid formation of loop in wire rope slings which will lead to damage.
- Avoid riding on the load.
- Use guide rope for lengthy article being handled by a single crane.
- Avoid putting a sling round a radius of less than three times the rope diameter.
- Sling cylindrical object with wire rope wherein bight angle should not exceed 120^0. (Fig 10)

Fig 10

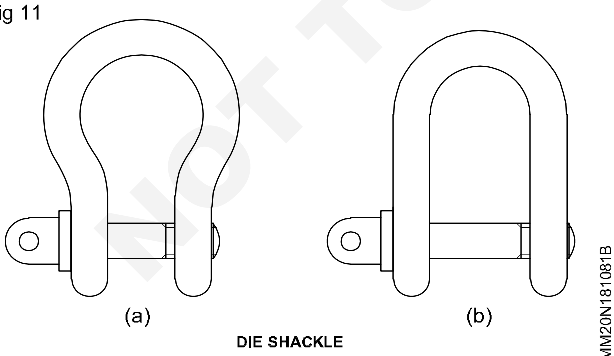


- Always keep yourself away from the suspended load.
- After completing of the work always return the hook fasten to the master ring.

Shackles

These are used for holding rings, eyes and hook which allow slings to adjust themselves easily to prevent bends, kinks etc in wire ropes. They are often used to join together the ends of slings. Bow shackle and Dee shackle are shown in (Fig 11a and b). Dynamo eye bolt (Fig 12a), Eye bolt with link (Fig 12b). These are used commonly to lift vertical load such as dynamo and other loads, provided with screwed holes to fit eye bolt.

Fig 11



Slinging hook

Hooks are used in chain and wire rope for anchoring load. A few common types are shown in (Fig 13a,b,c,d,e). These hooks are made of high Tensile steel and drop forged to the shape. Eye hook (Fig 13a) is commonly used for handling load by the crane. Bureau of indian Standard has recommend in eye hook with safety catch (Fig 13b) for general handling purposes. Swivel spring safety hook (Fig 13c) is capable of turning around and adjust itself to prevent twisting. Barrel hook (Fig 13d) is used for handling barrel. Chain clutch hook (Fig 13e) can be used for fastening to any portion of the chain after wrapping around the load. Cargo hook (Fig 14a) is used for handling general cargo in port. Ramshorm hook (Fig 14b) is used in heavy duty crane to fasten the sling from both sides of the hook. Joist or grider hook (Fig 14c) is used for handling joists or girders.

Fig 12

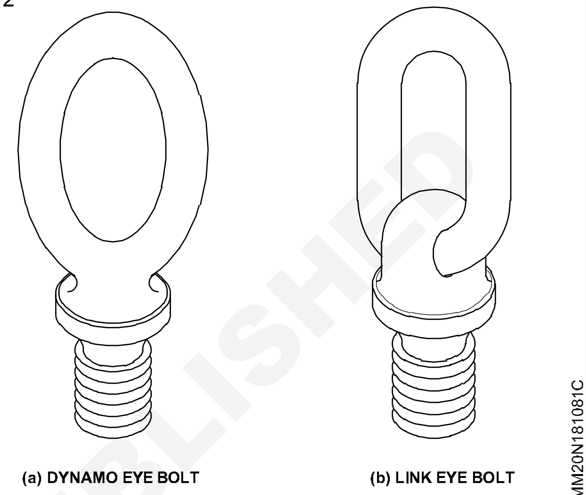


Fig 13

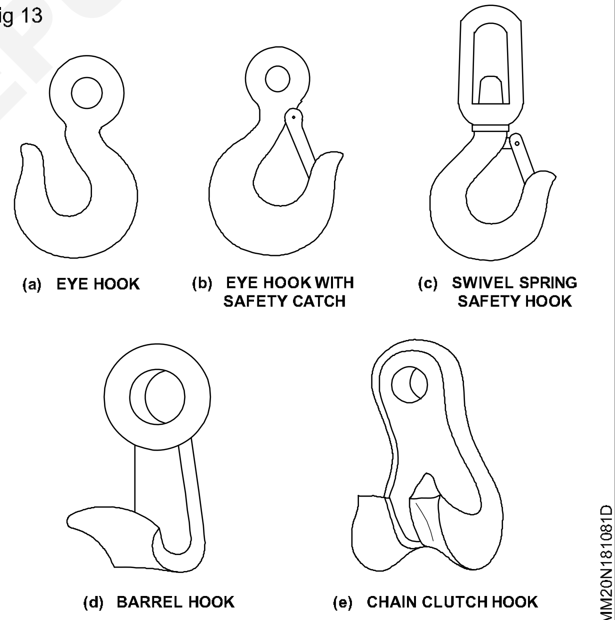
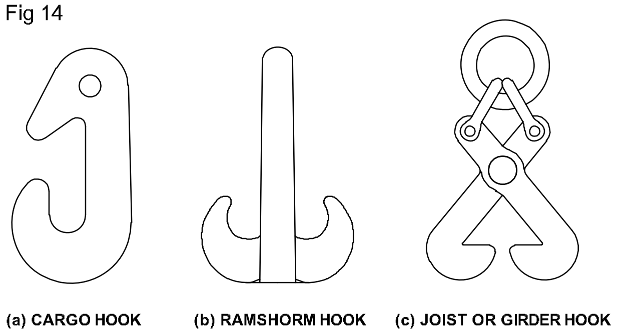


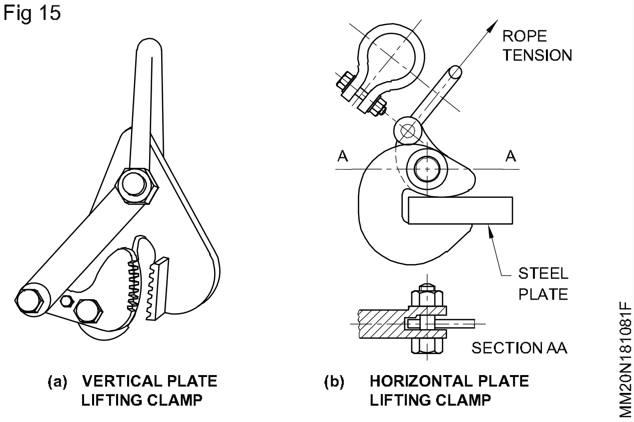
Fig 14



Lifting clamps

Lifting clamps are of various designs to suit the application. Vertical and horizontal plate lifting clamps as shown in (Fig 15a and b) respectively are used for lifting plates vertically and horizontally. As the tension is applied to the rope or chain, the jaws grip the plate tightly for effective lifting.

Fig 15



(a) VERTICAL PLATE LIFTING CLAMP (b) HORIZONTAL PLATE LIFTING CLAMP

Tensioning screws

These screws or bolts are used in a situation where adjustment in tension is essential.

Common types

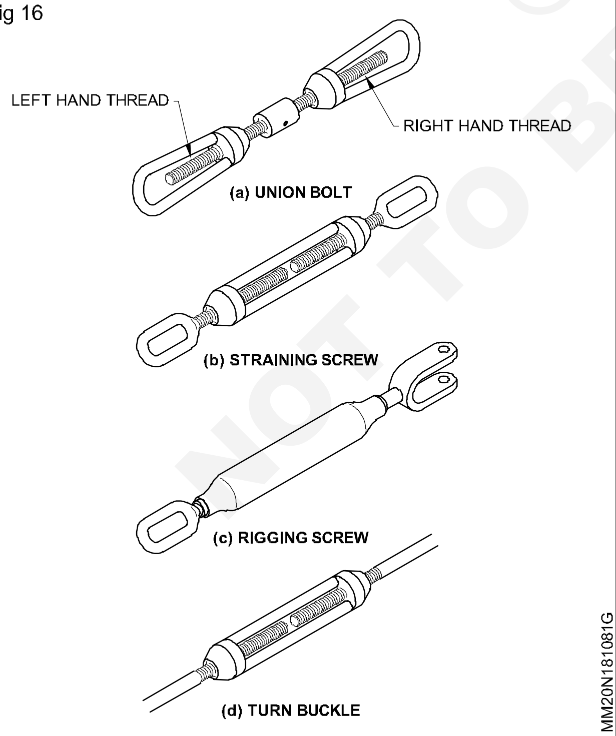
1 Union bolt (Fig 16a)

2 Straining screw (Fig 16b)

3 Rigging screw (Fig 16c)

4 Turn buckle (Fig 16d)

Fig 16



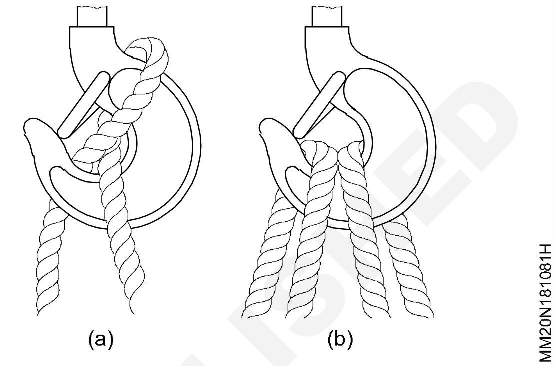
Union bolt is commonly on electrical post to keep it in erect condition. The centre part of the link is turned by tommy bar to keep the rope under tension.

Straining screw, rigging screw and turn buckle are also used in similar applications often in slinging ropes for adjusting the tension of the sling to keep the load in balanced condition.

Method of slinging

A few common methods of putting slings on the hooks have been shown in Figs 17a and 17b.

Fig 17



A cylindrical object slinging is shown by steel wire rope sling (basket hitch) Fig 18 which becomes automaticaly balanced when the slings are of equal size.

Fig 18

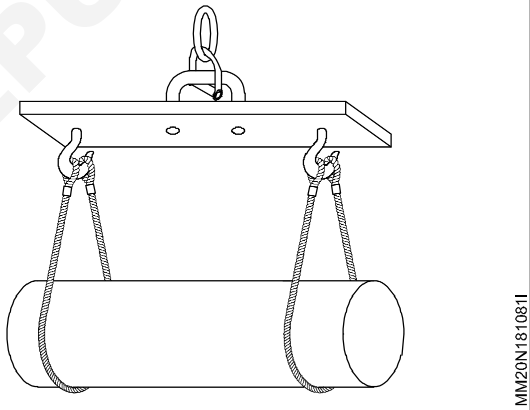
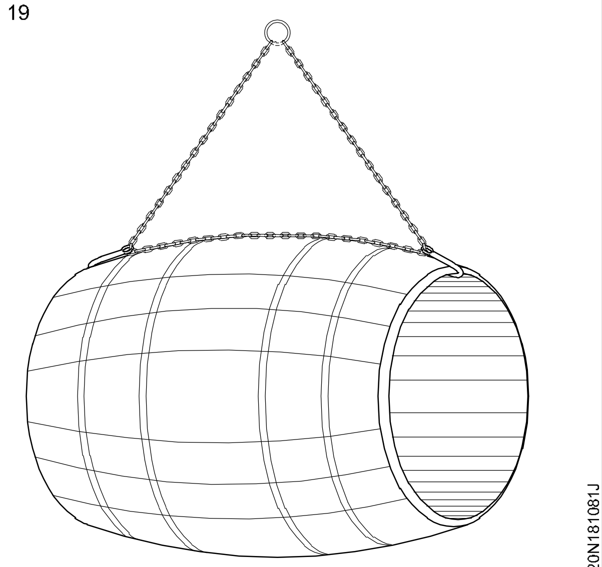


Fig 19 shows barrel slinging by chain using barrel hook. Fig 20 shows chain slinging with four legged chain sling using two endless chain wherein the object has the marking of slinging location.

Slinging methods

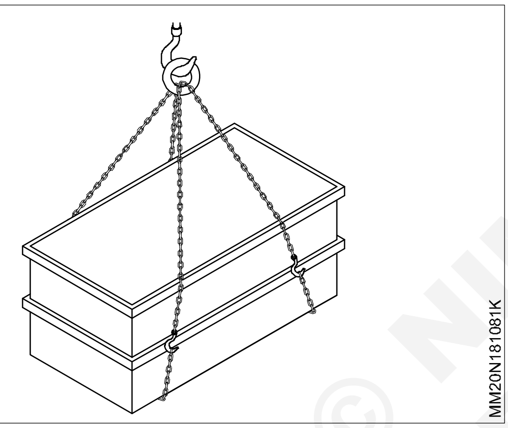
Wooden casing arrives at the purchaser's premises with sling marks as shown in Fig 21.The casing should be unpacked and suitable slings are made to shift to the place of installation.

Fig 19



BARREL OR CAN SLING

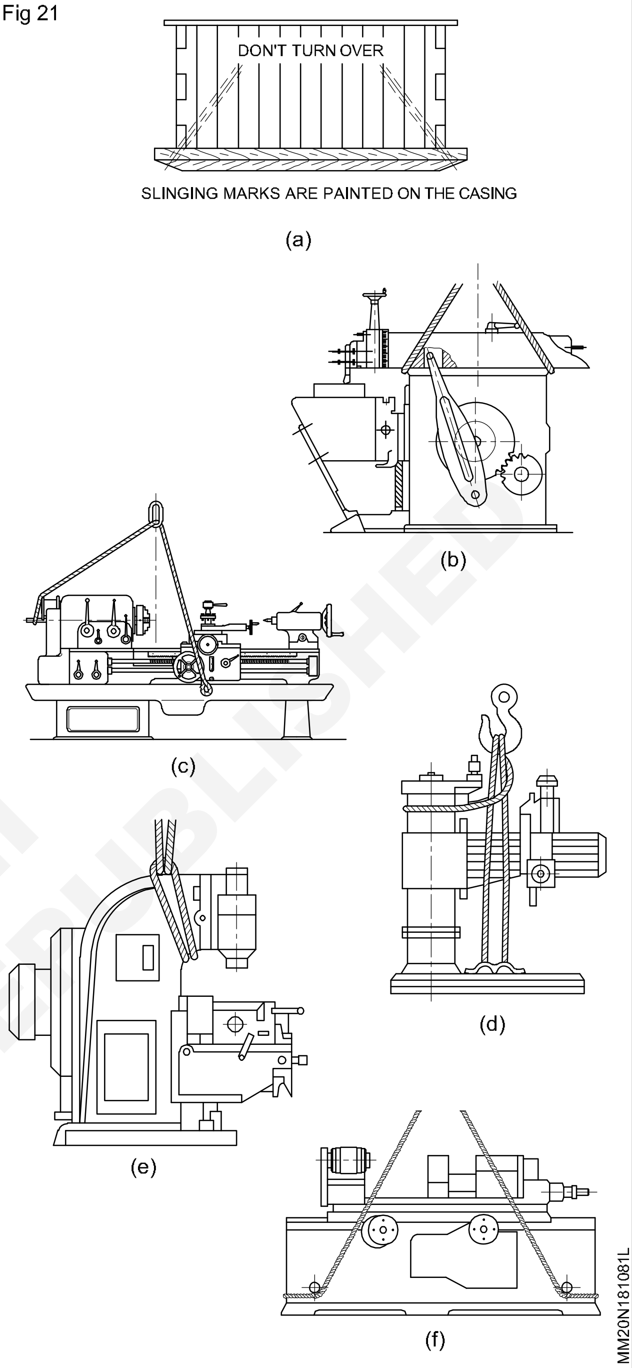
Fig 20



Such shifting is done commonly by fibre rope slings for lighter machines and comparatively heavier machines are shifted using suitable wire rope and chain slings. Suitable packings are to be used for protecting finished surfaces of the machineries.

A few method of slinging shaper, lathe, radial drilling machine, vertical milling and universal cylindrical grinder are shown in Fig 21 respectively.

Fig 21

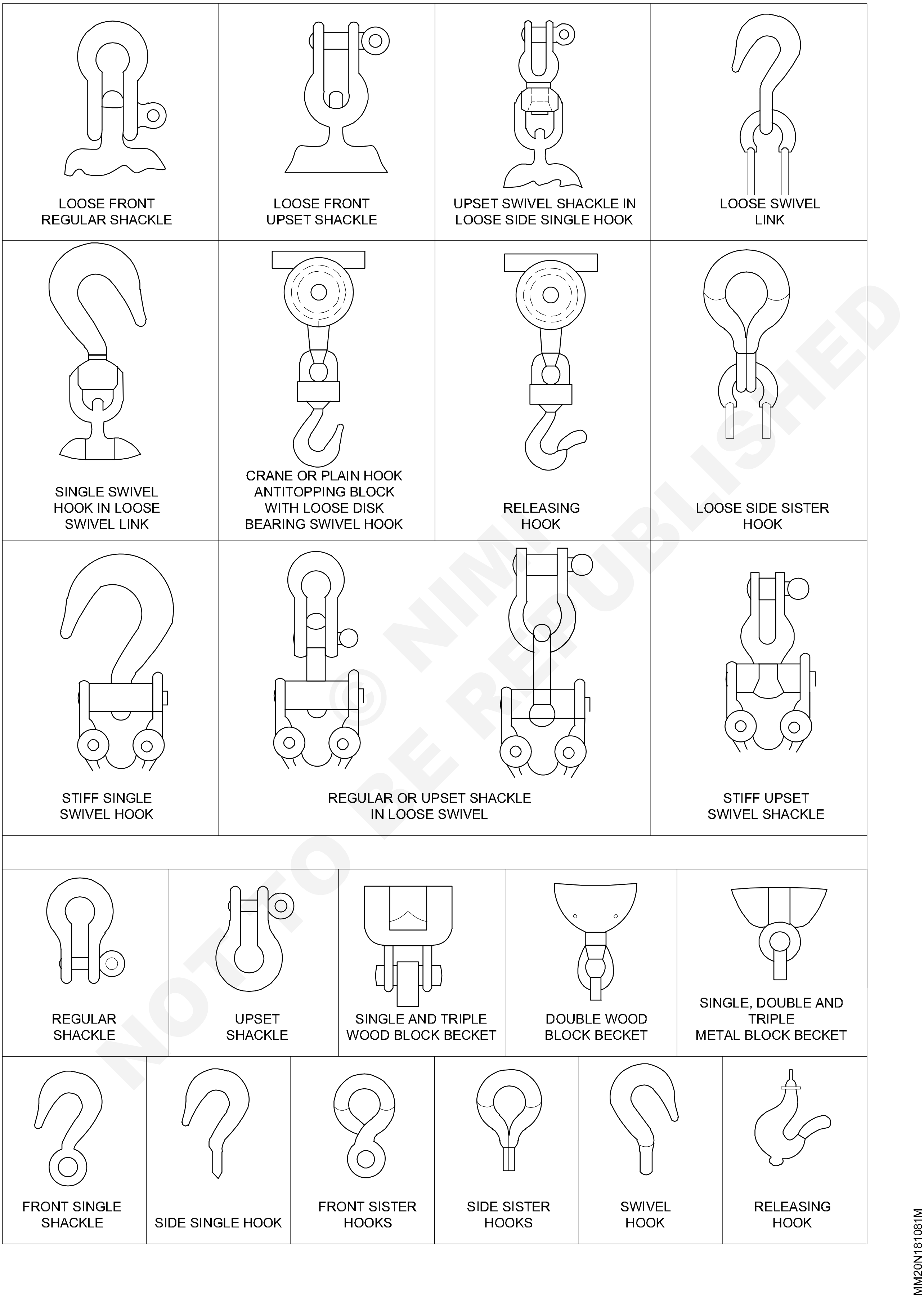


Rigging Theory

Rigging is the action of designing and installing the equipment, in the preparation to move objects. A team of riggers design and install the lifting or rolling equipment needed to raise, roll, slide or lift objects such as with a crane or block and tackle.

Rigging is the equipment such as wire rope. turnbuckles, clevis, jacks used with cranes and other lifting equipment (Fig 22) in material handling and structure relocation. Rigging systems commonly include shackles, master links and slings. Also, lifting bags in under water lifting.

Fig 22


LOOSE FRONT REGULAR SHACKLE
LOOSE FRONT UPSET SHACKLE
UPSET SWIVEL SHACKLE IN LOOSE SIDE SINGLE HOOK
LOOSE SWIVEL LINK
SINGLE SWIVEL HOOK IN LOOSE SWIVEL LINK
CRANE OR PLAIN HOOK ANTITOPPING BLOCK WITH LOOSE DISK BEARING SWIVEL HOOK
RELEASING HOOK
LOOSE SIDE SISTER HOOK
STIFF SINGLE SWIVEL HOOK
REGULAR OR UPSET SHACKLE IN LOOSE SWIVEL
STIFF UPSET SWIVEL SHACKLE
REGULAR SHACKLE
UPSET SHACKLE
SINGLE AND TRIPLE WOOD BLOCK BECKET
DOUBLE WOOD BLOCK BECKET
SINGLE, DOUBLE AND TRIPLE METAL BLOCK BECKET
FRONT SINGLE SHACKLE
SIDE SINGLE HOOK
FRONT SISTER HOOKS
SIDE SISTER HOOKS
SWIVEL HOOK
RELEASING HOOK
MM20N181081M

Fork lift and pallet truck

Objectives: At the end of this lesson you shall be able to
- **tell about fork lift (stacker)**
- **mention handling load by hand pallet truck**
- **state advantages of moving load by stracker and pallet truck.**

The fork lift is a small 4-wheel vehicle with diesel/petrol/ electrically powered engine. Heavy counter weight are fitted to the rear of the units. There are two lifting fork or arms in front of the machine which are adjustable to carry the load. They are available in various designs and capacities for shifting and stacking load in different positions.

Types

1) Diesel automotive fork lifter.
2) Battery powered fork lift stacker.
3) Hydraulic stacker.
4) Mechanical stacker.
5) Hand pallet truck.

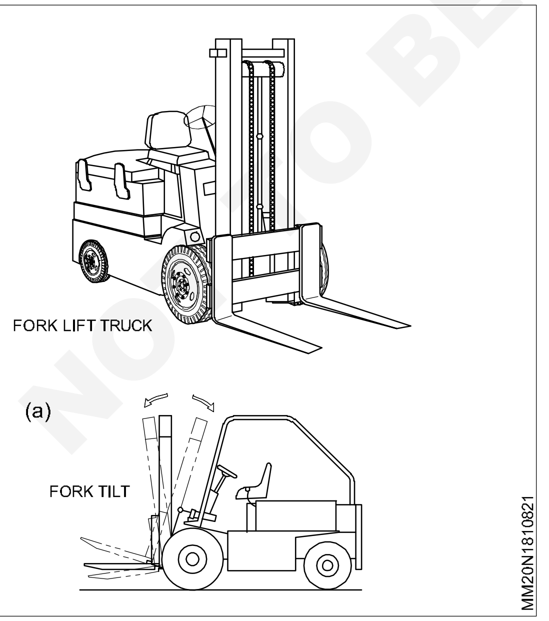
1 Diesel automotive fork lifter (Fig 1)

This diesel powered truck is driven by a driver to carry loads to considerable distances to and from the shop floor/yards to work place or for storage capacity 2 tonne to 10 tonne lift 2 meter height (common).

Fork unit can be hydraulically fitted, upto 15 degrees inward or outward and lifted to desired level. (Fig 1a)

This works very efficiently to move loads faster even on rough roads. Suitably used in harbour work,in industries, ware houses. transportation between lorry and railway terminals etc.

Fig 1



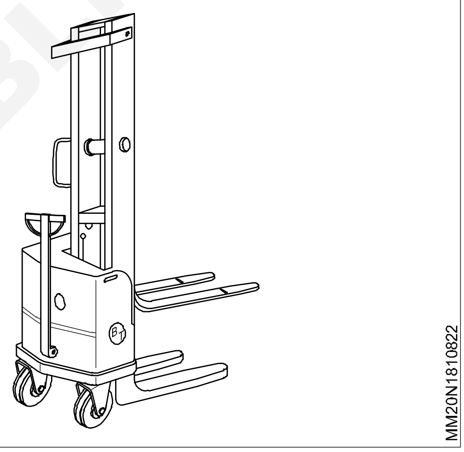
Maintenance

- Engine oil and hydraulic oils are to be changed periodically.
- Check for leakage in hydraulic cylinders.
- Cleaning and lubrication should be done to all motion parts including counter weight chain.

2 Battery powered fork lift stacker (Fig 2)

Powered fork lift stackers are compact in design and used to carry load mainly indoor within narrow space for shifting and stacking even to higher levels. The operator walks beside the truck to steer it. Lifting is done hydraulically.

Fig 2



They are commonly used in workshops, warehouse , rail containers, wagons etc. capacity 500 kg-2000 kg. Lift upto 5 meter commonly used.

Maintenance

- All motion parts are to be cleaned and lubricated periodically
- Hydraulic oil should be changed (Servo System 57/ 68 as recommended) once in two years.
- Oil seals are to be changed in case of leakage.
- Distilled water should be poured in the battery as and when the level goes down.
- Battery should be charged periodically.

3 Manually operated hydraulic stacker (Fig 3)

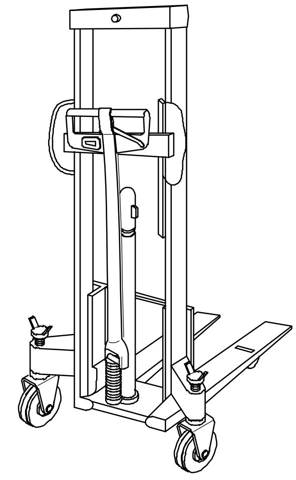
This type of stacker is used commonly as they are cheaper and can be easily handled manually for shifting and stacking load in a limited space.

Capacity- 500 Kg to 2000 Kg.

Lift upto 5 meter.

Beneficially used in light industries, ware house etc for loading, unloading and stacking.

Fig 3



MM20N1810823

Maintenance

- Clean and lubricate all motion parts.
- Change hydraulic oil once in two years (servosystem 57or 68 as recommended to be used)
- Replace oil seal for oil leakage.

Mechanical stacker (Fig 4)

This type of stacker is mechanically handled for moving, lifting and stacking load. These can be operated in a limited space so they are used in small scale industries.

Capacity 500 Kg.

Lift upto 2 meter.

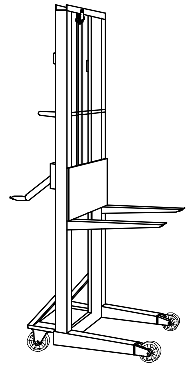
Maintenance

- Clean and lubricate all motion parts periodically.

Hand pallet truck (Fig 5)

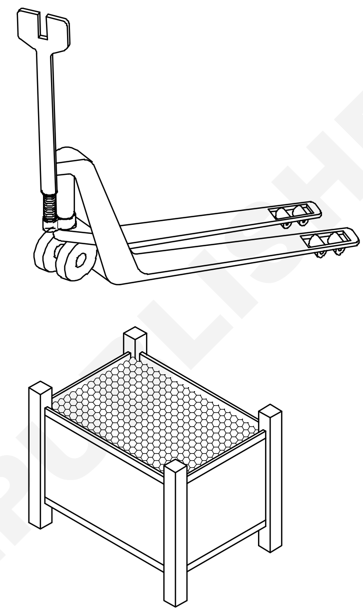
Pallet trucks are basically used for carrying pallet bins (Fig 5a) and other loads on floors, warehouses with high rate of turn over even bulky goods.

Fig 4



MM20N1810824

Fig 5



MM20N1810825

Capacity 500 kg to 2000 kg.

Maintenance

- Change hydraulic oil once in two years (servo system oil 57 or 68 as recommended). Topup oil periodically wherever required.
- Replace oil seals in case of oil leakage.
- Clean and lubricate other motion parts periodically.

Types of cranes

Objectives: At the end of this lesson you shall be able to
- **State basic function of crane**
- **mention the types of crane**
- **describe the application of various cranes**
- **state the highlights on troubleshooting**
- **narrate the safety on overhead crane repair.**

Basic function of crane

Crane is made up of sturdy structural member of steel, which are used in Industries, Port trust etc to shift the heavy materials from one place to another place for subsequent operation, assembly etc. The shape and its construction varies with application and types. There are many types of cranes are available.

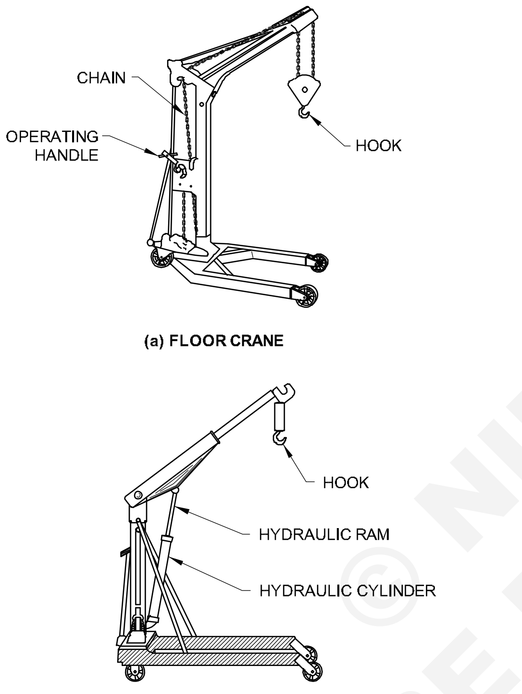
Types

- Floor cranes
- Jib cranes
- Derrick cranes
- Overhead cranes
- Gantry cranes
- Travelling cranes.

Floor cranes (Fig 1a & b)

Hand operated floor cranes are used for handling light loads (up to 2000 Kg.) on the shop floor.

Fig 1



(a) FLOOR CRANE

(b) HYDRAULIC OPERATED FLOOR CRANE

Hydraulic floor cranes are also used for lifting and shifting loads. The boom of the crane is moved up and down approximately 30^0 hydraulically. The boom can be extended to work for a longer reach. As the boom extends the loads carrying capacity decreases. Capacity ranges from 1000 Kg to 5000 Kg.

These floor cranes are mounted on wheels and can be moved from one place to another by pushing.

Fig 2 shows simple jib crane mounted on the strong base and supported by bearing plate at the top. The jib also called boom is supported by vertical mast with guy support at the front and stiff legs at the rear.

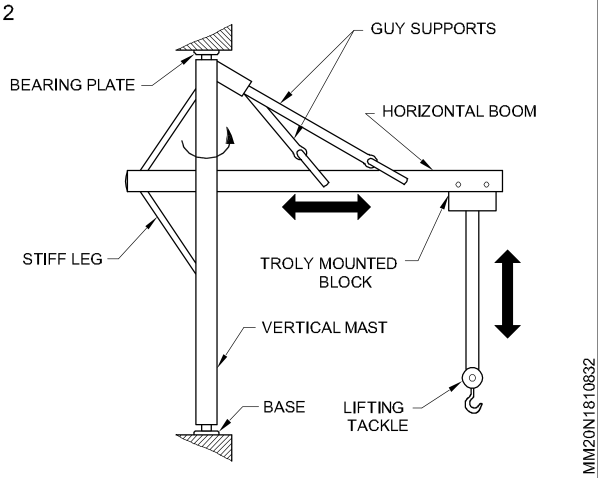
There are three possible movements of load ie.

a Raise or lower the load

b Horizontal movement of load between mast and end of boom

c 360^0 rotation of mast on its axis (slewing).

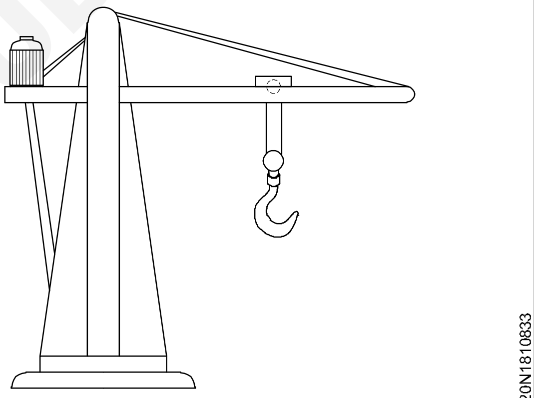
Fig 2



Pillar jib crane

Fig 3 show simple jib crane. The bottom is fastened to the mast about two-thirds of the way from the base. The rear end of the boom extends beyond the mast. Boom is supported by guys from the top of the mast to provide additional support. The lifting tackle on the boom hangs from a trolley-mounted block, which slides along the length of the boom to shift the load at any position. The load can be rotated within a radius from mast.

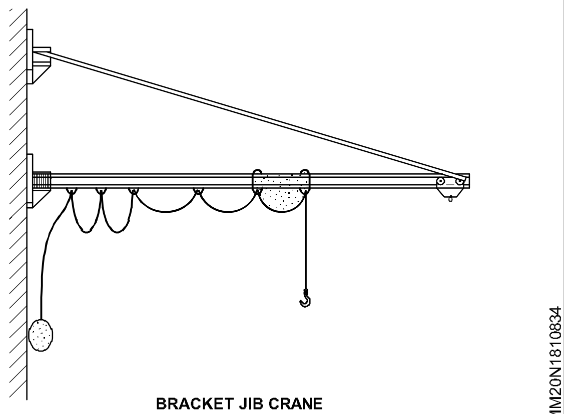
Fig 3



PILLAR JIB CRANE

Fig 4 shows the bracket jib crane used for light load.

Fig 4



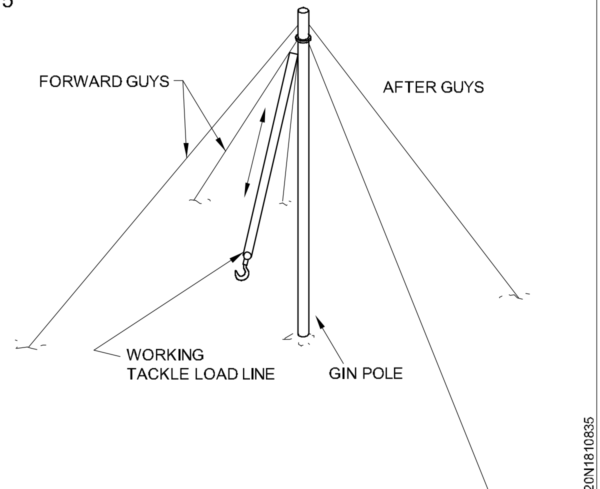
BRACKET JIB CRANE

Derricks cranes

Gin pole derrick crane (Fig 5)

Gin pole derrick one single pole units with one end firmly secured at the base to prevent movement. It is used as a temporary hoist to raise and lower a number of light loads. In setting up a gin pole, use atleast two after guys to provide support for the working end of the pole.

Fig 5

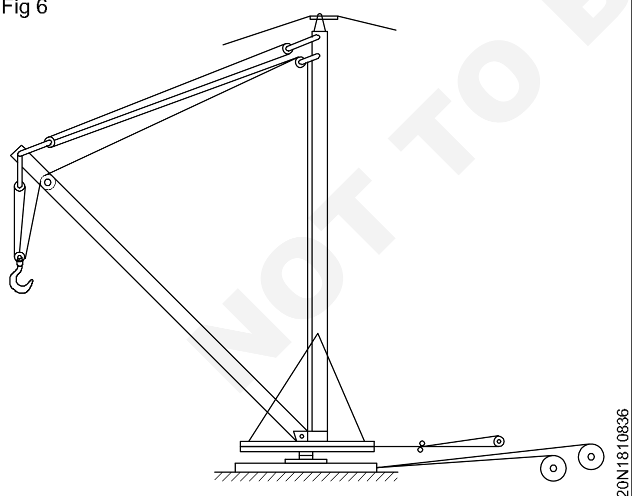


GIN POLE DERRICK

Guyed derrick crane (Fig 6)

The derricks are made of steel or wood. Derrick made of steel are mostly used. The derrick or boom is supported with mast. Mast and boom are either hand operated or power operated. The boom is rotate through bull gear, fastened at the bottom of the most. The mast is pivoted both at bottom as well as at top. The derricks is rotated by rope passing through sheaves at the top of the bottom. Derricks of power operated by pinion meshing with gear fastened to power drive also used.

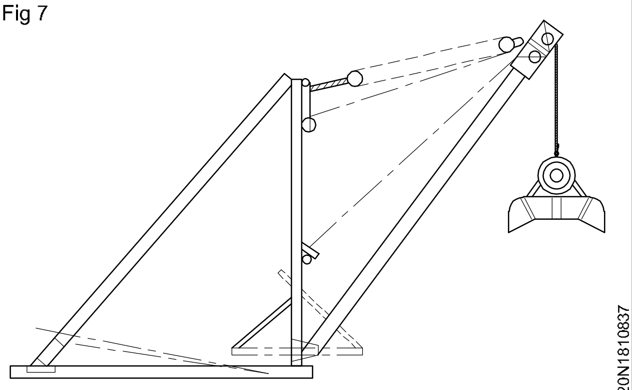
Fig 6



GUYED WOODEN DERRICK

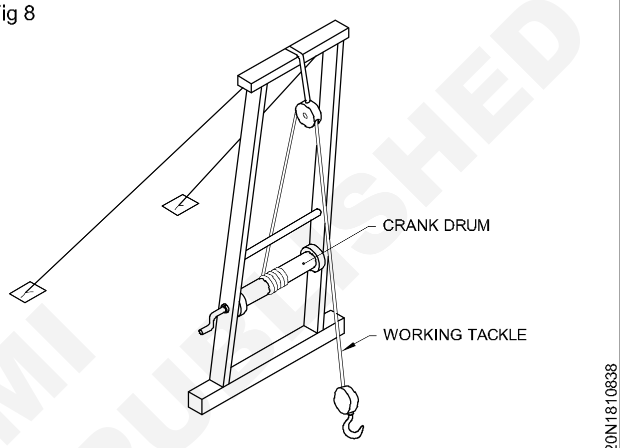
Fig 7 & 8 shows stiff leg derrick and breast derrick cranes used for matterial handling.

Fig 7



STIFF LEG DERRICK

Fig 8

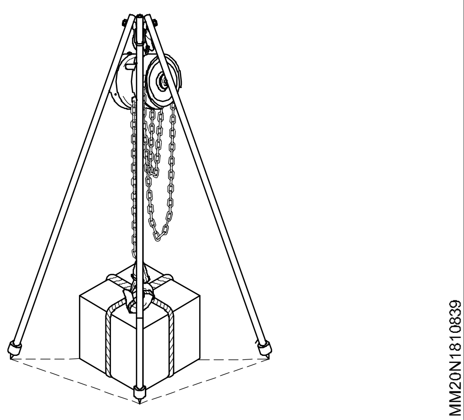


BREAST DERRICK

Tripod with chain pulley block

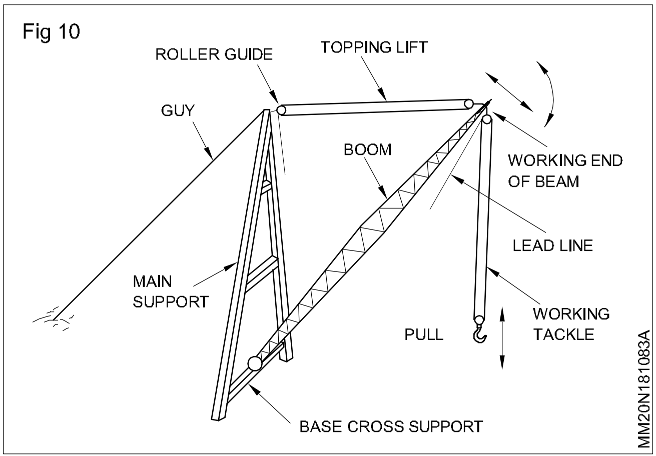
Each leg of the tripod is having a hole at its top end to fix up a stout bolt thorough 'u' shaped shackle. This bolt and shackle holds the tripod legs together at the top end and the chain pulley block can be hooked into the shackle. A nuts is screwed into the threaded end of the bolt which is riveted slightly to prevent unscrewing and coming out of nut. The bolt is kept a little loose adjust the position of three legs. (Fig 9)

Fig 9



Frame derrick crane

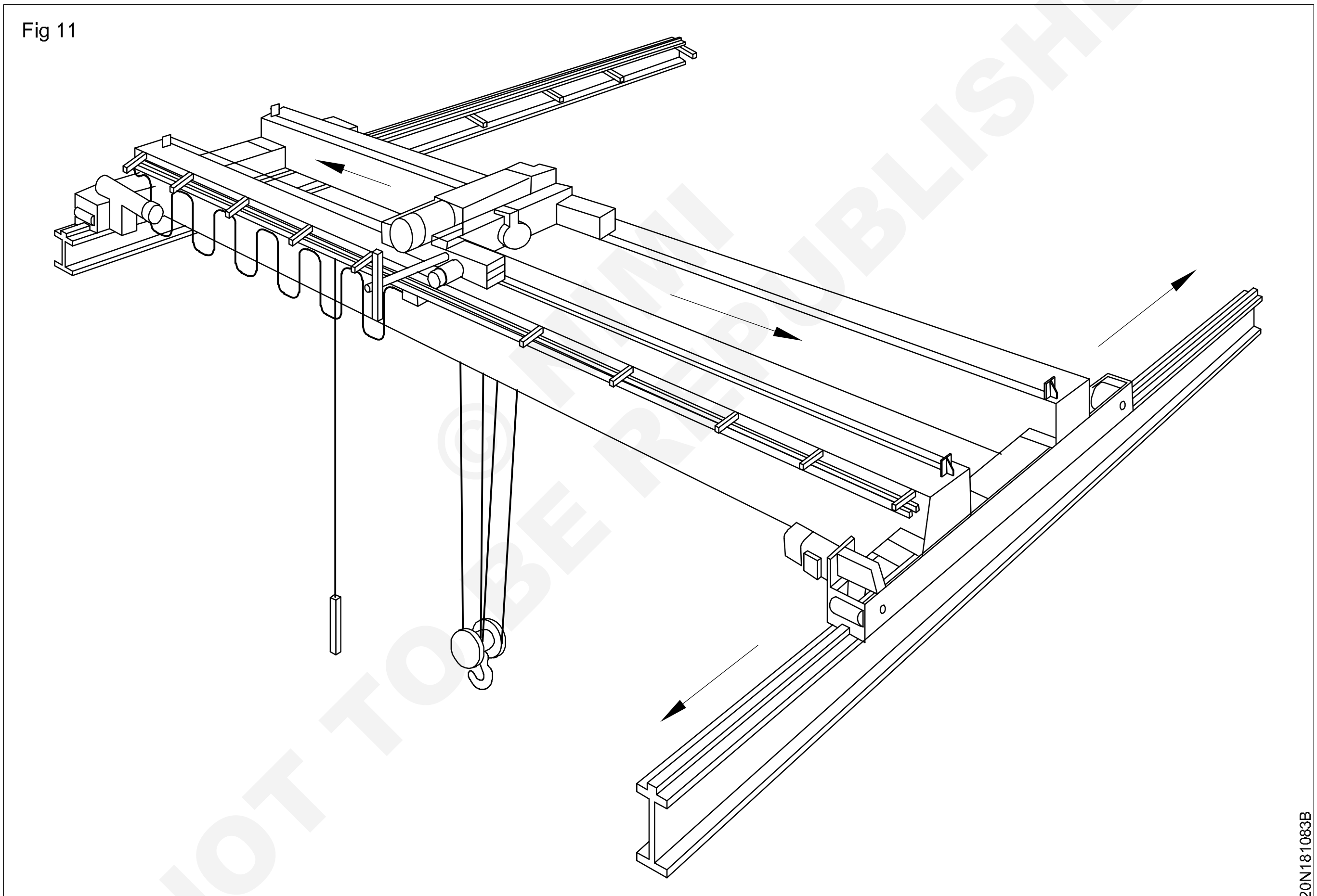
A 'frame derrick' gets its name from the shape of its main support. The main support, as shown in Fig 10 is triangular, with the base resting on the ground or floor.



For light load frames are made of wood and for heavy duty frames are made from steel. Frames are mounted in position that prevents the base from moving or shifting under load. To operate a framed derrick, the boom or moving section, connects to a cross support at the base of the frame up-right support. The working end of the boom carries the upper block for raising the load.

Overhead crane (Fig 11)

An overhead travelling crane consists of a bridge constructed from one or several girders supporting a travelling hoist. Electrically operated overhead crane is called in short EOT crane. They are used in workshop engine rooms and in open yards to move materials to a considerable distance in fabrication and assembly works. The capacity of the crane varies from 1 tonne (light duty) to 5 tonne (heavy duty) and above depends upon the application.



OVERHEAD CRANE

For assembling and dismantling of bulk component like diesel locomotive, carriege wagon etc. during periodical over hauling two cranes of equal capacity being used. Each crane is operated by individual certified operater. Both the operators should follow same signal at a time from the rigger. The operators sit in a cabin provided for them.

The crane normally having three individual drive are called.

- long travel
- cross travel
- hoisting

Each travel consists of individual motor drive coupled with reduction gear box. Heavy duty crane are provided with two hoisting one meant for higher load called main hoist and another one for light load called auxiliary hoist. The capacity of the crane is written on the structural member of the crane visibly is called safe working load (SWL).

While lifting the load by crane the load do not exceed safe working load of a crane at any circumtances.

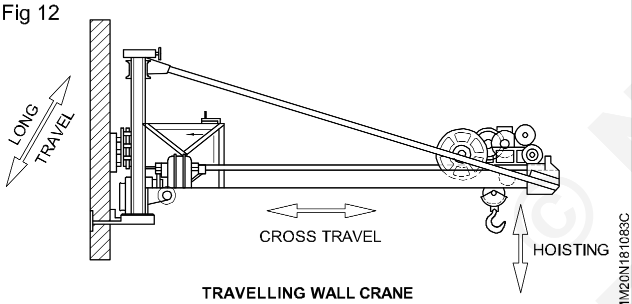
They are standard signals that every crane operator should follow while handling the load to control the crane.

While lifting load by using chain having more than one legs, ensure all the legs should have equal length.

While lifting load the structural member of the crane subjected to deflection from its position. The permissible deflection is 1mm for each 900 mm span measured at midpoint of the span by keeping the load at the centre. A crane having 9 meters span i.e. distance between two rails of long travel, the permissible deflection is 10mm.

Travelling wall crane also used in assembly shop. The long travel wheels runs on rails mounted on wheels. Fig 12 shows travelling wall crane.

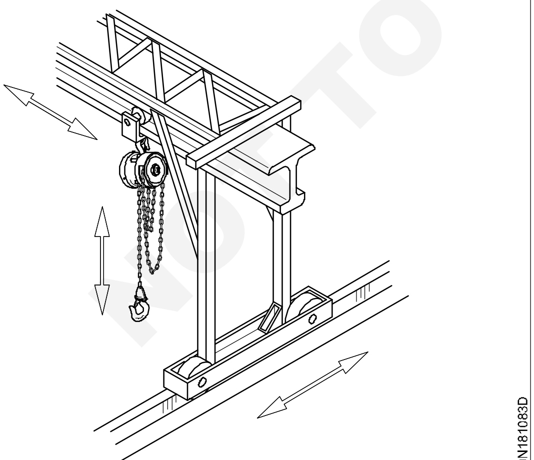
Fig 12



TRAVELLING WALL CRANE

Gantry crane (Fig 13)

Fig 13



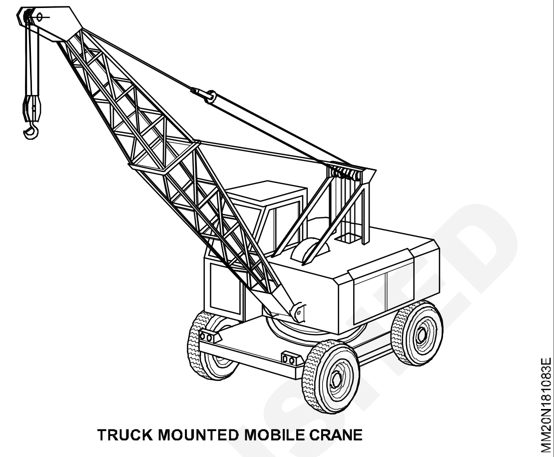
GANTRY CRANE

Most gantry cranes are much larger than over head travelling cranes. It is used outside of the buildings. Gantry cranes also move on tracks, but their tracks are on the ground rather than suspended overhead. Trolleys are mounted on two upright structures separated by the connecting bridge.

Trolley wheels support the gantry. The gantry's load movement capabilities are the same as those of the travelling crane.

Trucks mounted mobile crane (Fig 14)

Fig 14



TRUCK MOUNTED MOBILE CRANE

There are locomotive cranes, truck-mounted cranes which are also used for lifting and moving the loads.

These crane can be used in remote places.

Problem - "The crane is not working when switched on".

When attending any repair on the overhead crane wear helmet and safety belt. The safety belt to be tied with structural member while attending repair to avoid accident by slipping.

Precautions in the removal and replacement of heavy parts

People who install or dismantle machinery and equipment could:

- Work in isolation
- Work on machinery and equipment at heights, or over machinery and equipment to connect services, such as electricity, air or water
- Work in low light, or with bright directional light
- access machinery and equipment from the top, sides or underneath
- Work with or near craness, forklifts or rigging to lift machinery and equipment
- work in confined spaces
- use power tools, welders, extension leads, which present electrical hazards if damaged or wet.

People operating machinery and equipment could:

- be required to place their hands close to the mechanism of the machinery and equipment that does the work, and may be injured if caught or trapped by moving parts

- be exposed to constant harmful noise, radiated, energy or fumes being emitted form the machinery and equipment being operated, or are close to
- inadvertently bump or knock poorly placed control levers or buttons
- be required to make adjustments to the mechanism of machinery and equipment while the machine is in motion
- be required to clear away scrap
- make minor adjusments, or reach into the moving mechanism of the machinery and equipment being operated.

People providing maintenance or repair services could:

- work alone
- work on machinery and equipment at height, or over machinery and equipment to connect services, such as electricity, air or water
- access machinery and equipment from the rear or sides
- be required to enter confined spaces of larger machinery and equipment
- be trapped by the mechanism of the machinery and equipment through poor isolation of energy sources or stored energy, such as spring-loaded or counter-balance mechanisms, compressed air or fluids, or parts held in position by hydraulics or pneumatic (air) rams
- Move heavy parts when changing the set up of machinery and equipment, or repairing failed parts, such as electric motors or gear box assemblies
- disable or remove normal safety systems to access the mechanisms of machinery and equipment.

People providing cleaning services could:

- work alone
- access machinery and equipment from the rear or sides, or in unexpected ways
- climb on machinery and equipment
- enter confined spaces, or larger machinery and equipment
- become trapped by the mechanism of the machinery and equipment through poor isolation of energy sources or stored energy, such as spring - loaded or counter - balance mechanisms, compressed air or fluids, or parts held in position by hydraulics or pneumatic (air) rams
- care to be taken while work with chemicals
- Do not operate electrical equipment in wet areas.

Total productive maintenance

Objectives: At the end of this lesson you shall be able to
- **explain the concept of TPM**
- **explain the autonomous maintenance**
- **describe the function of routine maintenance**
- **explain the maintenance schedule.**

Total Productive Maintenance(TPM) concepts

TPM aims to maximize overall equipment effectiveness. Establishes a complete system of productive maintenance for the machines/equipments entire lifespan is implemented by various departments. [Engineering, Operations, Maintenance, Quality and Administration]

TPM can be considered as the medical science of machines.

TPM involves every single employee, from top management to all the operators on the shop floor. TPM raises and implements productive maintenance based on autonomous small group activities.

TPM is a maintenance program which involves a newly defined concept for maintaining plants and equipments.

The goal of TPM is to an extent increase production while, at the same time, increasing employee morale and job satisfaction.

TPM brings maintenance into focus as a necessary and vitally important part of the business. It is no longer regarded as a non-profit activity.

Downtime for maintenance is scheduled as a part of the manufacturing day. In some cases as an integral part of the production process.

The goal of TPM is to stop the emergency and unscheduled maintenance.

Form different teams to reduce defects and self maintenance.

Advantages of TPM

- Avoids wastage in quickly changing economic environment.
- Produces goods without reducing product quality.
- Reduces maintenance cost.
- Produces a low batch quantity at the earliest possible time.
- Ensures the non defective goods to the customers.
- Reduce customers complaints.
- Reduce accidents.
- Follow pollution control measures.
- Favorable change in the attitude of the operator.

Overall equipment effectiveness (OEE)

Overall equipment effectiveness (OEE) is a concept utilized in a lean manufacturing implementation. OEE is described as one such performance measurement tool that measures different types of production loses and indicate areas of process development. The OEE concept normally measures the effectiveness of a machine center or process line, but can be utilized in non-manufacturing operation also.

The high level formula for the lean manufacturing OEE is

OEE = Availability x Productivity x Quality

Availability

The availability is part of the above equation measures the percentage of time the machine/equipment of operation was running compared to the available time. For example if the machine was available to run 20 hours but was only run for 15, then the availability is 75 percent 15/20. The five hours when the machine didn't run would be set up time, breakdown or other downtime. The 4 hours the company did not plan to run the machine is rarely used in the calculation.

Performance

The performance part of the equation measures the running speed of the operation compared to its maximum capability often called the rated speed. For example, if a machine produced 80 pieces per hour while running, but the capability of the machine is 100, then the performance is 80% (80/100). The concept can be used multiple ways depending on the capability number. For example, the machine might be capable of producing 100 pieces per hour with the perfect part, but only 85 on that particular order. When the capability of 100 is used for the calculation, the result is more a measure of facility OEE.

Quality

The third portion of the equation measures the number of good parts produced compared to the total number of parts made. For example if 100 parts are made and 95 of them are good, the quality is 95% (95/100).

Combining the above example into the OEE equation the OEE is

OEE = 75% x 80% x 95% = 57%

Autonomous Maintenance

Autonomous Maintenance put simply is the restoration and prevention of accelerated deterioration and has a major positive effect on OEE. It is a step by step improvement process, rather than production teams taking on maintenance tasks, as shown in Table 1.

- Understanding the equipment functions and safety risks.

The seven steps of Autonomous Maintenance

Table 1

1	Initial cleaning (Initial inspection & registration)	- Detect problem of the lives and restore the original state. - Start managing the line autonomously (5s, Minor stops, quality) autonomously - Create & perform temporary “cleaning/ lubrication produces”
2	Source of contamination & Hard-to-reach areas	Solve “sources of contamination” and hard to reach clear (Cleaning, Inspection lubrication)
3	Standard of cleaning & lubrication	Develop tentative standards for cleaning lubrication and inspection.
4	General Inspection	Provide training on their equipments, products and materials, inspection skills and other Am skills.
5	Autonomous Inspection	Develop a routine maintenance standard by operations.
6	Standadize autonomous maintenance operation	Standadize routine operation related to work place management such as quality inspection of products, life cycle of jigs, tools, set up operation and safety
7	Autonomous management	Autonomous team working.

Routine maintenance

- In order to get trouble free service from productive equipment.
- Following activities is necessary to carry out.
  - i Lubrication
  - ii Periodic inspection
  - iii Adjustments of various parts
  - iv Cleaning

All the above maintenance operations are carried out while the machine is running or during pre-planned shutdowns.

This type of maintenance may prevent breakdown of equipment.

Routine maintenance should not interfere with production schedules.

Planned preventive maintenance (PPM), more commonly referred to as simply planned maintenance (PM) or scheduled maintenance, is any variety of scheduled maintenance to an object or item of equipment. Specifically, planned maintenance is a scheduled service visit carried out by a competent and suitable agent, to ensure that an item of equipment is operating correctly and to therefore avoid any unscheduled breakdown and downtime.

Along with condition based maintenance planned maintenance comprises preventive maintenance, in which the maintenance event is preplanned, and all future maintenance is preprogrammed. Planned maintenance is created for every item separately according to manufacturers recommendation or legislation. Plans can be date-based, based on equipment running hours, or on the distance travelled by the vehicle. A good example of planned maintenance program is car maintenance, where time and distance determine fluid change requirements. A good example of condition based maintenance is the oil pressure warning light that provides notification that you should stop the vehicle because engine lubrication has stopped and failure will occur.

Planned maintenance has some advantages over condition-based maintenance (CBM), such as:

- Easier planning of maintenance and ordering spares.
- Costs are distributed more evenly.
- No initial costs for instruments used for supervision of equipment.

Disadvantages are:

- Less reliable than equipment with fault reporting associated with CBM.
- More expensive due to more frequent parts change.
- Requires training investment and on going labour costs.

Parts that have scheduled maintenance at fixed intervals, usually due to wear out or a fixed shelf life, are sometimes known as time-change interval or TCI items.

Maintenance schedule

Any kind of action or activity there should be some procedure and sequence likewise maintenance also has some normal procedure to execute the maintenance activity without any confusion. If maintenance is not followed any procedure there will be time loss and the machine and equipment could not be ready in time. The procedure guides the maintenance people how to start, execute, where to inspect and how to complete the maintenance in time. The maintenance is carried out with the following procedure.

- Initial cleanup
- Identification of fault
- Dismantling
- Inspection
- Identification of cause for defect
- Inspection and replacement/ Repair of spares
- Reassembling
- Trial run
- Inspection with standards
- Maintaining records

Initial cleanup

Main machine, connected accessories, lubrication system, panels and adjacent parts are to be cleaned first.

Identification of fault

The fault of the machine is to be identified by visual inspection and getting information from the complaint and justified the same.

Dismantling

The fault area is dismantled with the referring to the manual and all the spares are kept separate in a tray and preserved safely.

Inspection

All the dismantled parts such as gear, bearing, shaft, key, etc. are cleaned and inspected for any damages. Any damages/breakage is recorded in the maintenance checklist.

Identification of cause for defect

The defect in spare parts thoroughly examined and analysed the causes for damage and the same has to be rectified.

Inspection and replacement/ repair of spares

The damaged or broken spares are procured from stores/ repaired and the same is inspected to the standards.

Reassembling

The next course of action is assembling the parts in reverse manner of dismantling order.

Trial run

After completion of assembling the machine is to run first manually and all the lubrication, electrical connection to be given. Finally the machine should run on is trial run for some time and observed for any unusual sound from the machine.

Inspection with standards

The machine is finally checked/inspected for geometry accuracy safety hazards etc., according to the manufacturer standard any other recommended standard as required by the nature of maintenance work carried.

Maintaining records

All the activities related to fault attended, spares changed, etc. to be recorded in the inspection report/maintenance record, machine history cards suitably for future reference.

Retrieval data from machine manuals:

Information Retrieval (IR) in computing and information science is the process of information system resources that are relevant to an information need from a collection of those resources. Automated Information retrieval systems are used to reduce what has been called information overload.

“Classification tasks that are well suited to machine learning” in many cases, tasks that until recently had to be accomplished manually install. Learning algorithms use examples, attributes and values, which information retrieval systems can supply in abundance.

Common instruments for geometrical test

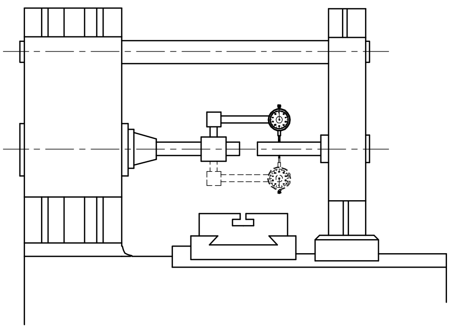
Objectives : At the end of this lesson you shall be able to
- **state the purpose of test mandrels**
- **name the different types of test mandrels**
- **state the applications of straight edge and block spirit level and master square.**

Test mandrels

Test mandrels are widely used as inspection tools during the manufacture and acceptance tests of new machine tools, and the repair of old ones. The quality as far as straightness and roundness are concerned is of paramount importance for accurate results.

The application of a test mandrel in measuring the swing over of a horizontal boring machine is shown in Fig 1.

Fig 1



Types

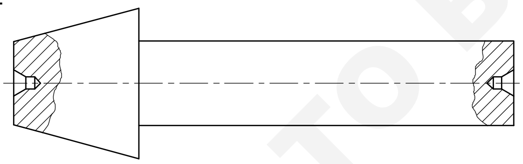
There are two types of test mandrels.

Solid mandrels

Solid mandrels are available in different lengths.

The diameter must be such that the sag is kept within the permissible limits. (Fig 2)

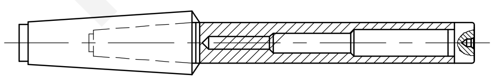
Fig 2



Hollow mandrel (Fig 3)

A hollow mandrel is made in order to reduce the weight of the mandrel. This avoids sag of the mandrel during inspection.

Fig 3



This mandrel also must be sized in between centre.

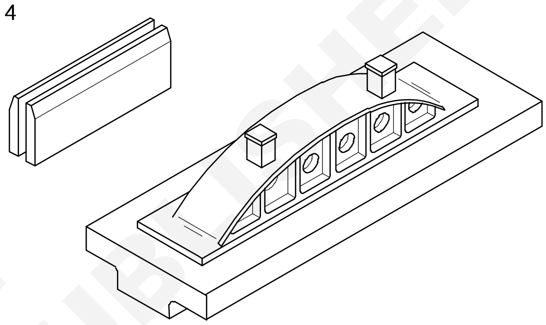
Size of mandrel

The measuring length of the cylindrical part of the mandrels depends on their purpose. The distance between the marks at the two ends of the cylindrical part represents the measuring length of the mandrel. It may be 75,150,200 300 or 500 mm. The diameter must be such that the sag is kept within permissible limits. In order to reduce the weight of the mandrel, it may be made hollow.

Straight edge

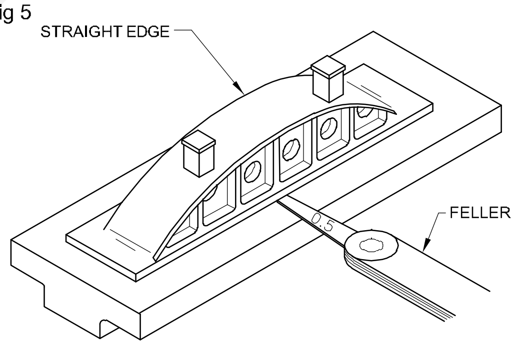
Straight edges are made for testing straightness. They are made of steel or cast iron and may be of 2 metres or 3 metres length. These should be heavy, well-ribbed and free of internal stresses. Their bearing surfaces should be as wide as possible. (Fig 4)

Fig 4



The application of a straight edge in testing the flatness of a surface is shown in Fig 5.

Fig 5



USE OF STRAIGHT EDGE -FELLER GAUGE

Block spirit level

A block spirit level is made of box sections with the faces accurately square or parallel. There are generally made of stress-free cast iron or steel and are used for checking the horizontal and vertical levels of a machine. (Fig 6)

The application of a block spirit level in testing a drilling machine is shown in Fig 7.

Fig 6

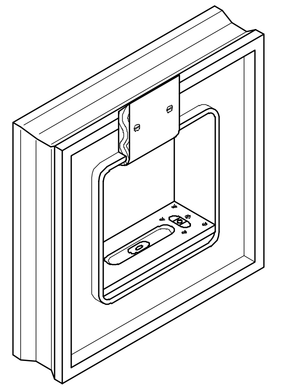
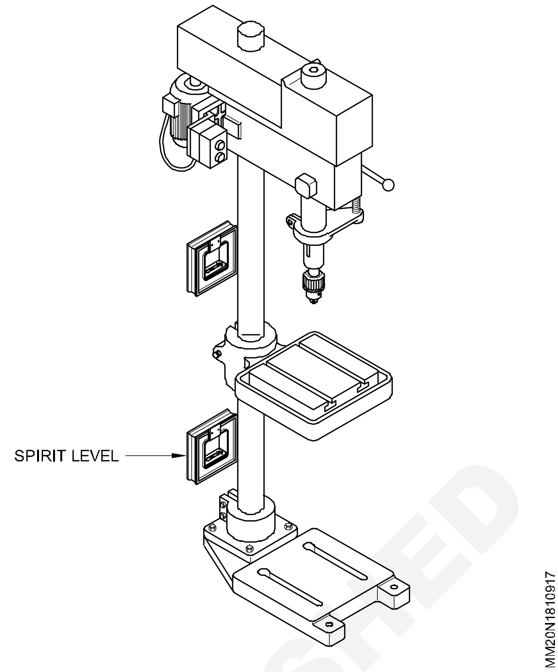


Fig 7



Preventive maintenance

Objectives: At the end of this lesson you shall be able to
- **state the need for preventive maintenance**
- **describe the functions of the P M department**
- **state the advantages of P M**
- **state the advantages of maintenance records and periodic inspection of machines.**

Need for Preventive maintenance

The machine tools are of high precision, and are sensitive and expensive.

They must be handled and maintained carefully in order to give good and long service.

The basic function of the maintenance department is the upkeep of the machines and equipment in good operating condition.

Earlier the maintenance of the equipment used to receive attention only when the equipment suffered some set-back or breakdown as a result of some minor/major fault. Such breakdowns not only brought a serious production hold-up but also used to upset the production flow of the industry where the other equipment also had to stand idle. This resulted in a more cautious approach to the maintenance of the equipment and this brought up the more scientific way of tackling the maintenance problem, through preventive maintenance. (P M)

Preventive maintenance

Preventive maintenance consists of a few engineering activities which help to maintain the machine tools in good working order.

The basic activities of preventive maintenance are the:

- Periodic inspection of machines and equipment to uncover conditions leading to production breakdowns or harmful depreciation
- Upkeep of machines and equipment to avoid such conditions or to adjust, repair or replace them while they are still in the initial stages.

Advantages of preventive maintenance system

- Less down time in production.
- Improves quantity and quality of product.
- Standby equipment is not needed which saves capital investment.
- Lower unit cost of manufacture.
- Reduces major and repetitive repairs of machines.
- P.M. helps in prolonging the life of the machines and reduction in un-expected breakdowns.

Functions of preventive maintenance department

- Periodic inspection of machines and equipment as per the ‘Check- lists’. (Annexure I)
- Lubrication of machines and equipment as per the manufacturer’s instruction manuals.
- Servicing and overhauling of machine and equipment as per the P M schedule.
- Keeping basic records of each machine and equipment. (Annexure II)
- Analysis of inspection reports and systematic review of reports of machines and equipment.

Periodic inspection of machines and equipment as per the check-list (Annexure 1)

The check-list items for the inspector about all the points to be checked on individual machines. While preparing the check-list of the machine, make sure that no machine part or item that is omitted needs attention. The inspection of machine tools like lathe and drilling machine includes the following.

- Driving system and feeding system
- Lubricating and coolant system
- Slides and wedges and gibs
- Belts, bearings, clutch, brake and operating controls
- Guideways, lead screws and their mating parts

After inspection of each machine, the inspector has to make out the list of parts which need repairs or spares for replacement.

Inspection

Inspection is necessary for any machine/equipment where remarkable risk to health and safety may arise from wrong installation, re-installation or any other circumstances. The purpose of inspection is to find whether machine can be operated, adjusted and maintained safely. The need for inspection and inspection intervals to be determined through risk assessment.

The summary of inspection should be recorded and same should be kept atleast until the next inspection of that machine. Machine/equipment that required inspection should not be used unless the machine has been inspected.

If the machine/equipment obtained from any other source (eg. hired). One should be ensure that physical evidence of last inspection is accompanied with the machine, such as inspection report, some form of tagging, labelling system or colour coding.

Function of Inspection in maintenance

1 Periodic inspection of machines and equipments as per checklist (Annexure 1)

2 Keeping basic records of each machine & equipments.

3 Preparation of list which need for repairs (or) spare for replacements.

4 Analysis of inspection report and systematic review of reports of machines/equipments.

5 Assigning of frequency of inspection.

The following Annexure 1 and 2 are the formats used in maintenance inspection.

Frequency of inspection

The frequency of inspection depends on the age, kind of machine and its operating conditions. Frequent inspection of machines and equipment may be expensive and frequency with long intervals may result in more breakdowns. A good balance is needed to bring optimum savings.

Lubrication of machines and equipment

The length of time a machine will retain its accuracy and give satisfactory service depends on the lubrication and care it receives. It is essential that lubrication of machines should be carried out systematically at regular intervals as recommended in the service manual supplied by the machine manufacturer.

Annexure I

Preventive Maintenance Programme

Name of the Machine : Location of the machine :

Machine Number : **CHECK-LIST FOR MACHINE INSPECTION**

Model No. & Make :

Inspect the following items and tick in the appropriate column and list the remedial measures for the defective items.

Items to be checked	Good working/satisfactory	Defective	Remedial measures
Level of the machine			
Belt and its tension			
Bearing sound			
Driving clutch and brake			
Exposed gears			
Working in all the speeds			
Working in all feeds			
Lubrication system			
Coolant system			
Carriage & its travel			
Cross-slide & its movement			
Compound slide & its travel			
Tailstock's parallel movement			
Electrical controls			
Safety guards			

Inspected by

Signature

Name :

Date : Signature of in-charge

Lubrication survey

Objectives: At the end of this lesson you shall be able to
- **state the benefit of lubrication survey**
- **prepare the cost estimation.**

How does a Lubrication survey work?

Lubrication survey of all equipment that requires lubrication.

- By points of lubrication
- Recommended products
- Application methods
- Drain or lube intervals
- Special remarks

The material is compiled and a report is returned with the recommended lubricants for all of your equipment included.

What are the benefits of a Lubrication survey?

- A key part of a good preventive maintenance program.
- Product consolidation
  - Reduces inventory requirements
  - Minimizes product misapplication
- Assists maintenance personnel in seeing that all lubrication points are lubricated as scheduled.
- Reduces downtime and repair parts. Minimizes time spent with OEM manuals researching proper lubricants.
- Easily updated by your LE Representative to keep the survey effective.
- Increases equipment life.

Increase your profitability

Preventing equipment downtime is directly reflected in increased productivity. A refocus from the repair maintenance philosophy to the preventive approach is needed.

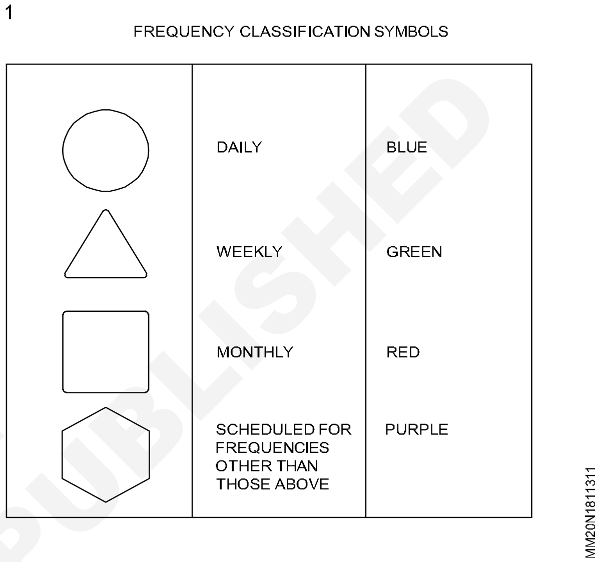
Hints for lubricating machines

- Identify the oiling and greasing points
- Select the right lubricants and lubricating devices
- Apply the lubricants

The manufacturer's manual contains all the necessary details for lubrication of parts in machine tools. Lubricants are to be applied daily, weekly, monthly or at regular intervals at different points or parts as stipulated in the manufacturer's manual.

These places are indicated in the maintenance manuals with symbols as shown in Fig 1.

Fig 1



The best guarantee for good maintenance is to follow the manufacturer's directives for the use of lubricants and greases. Refer to the Indian Oil Corporation chart for guidance.

The lubricant containers should be clearly labelled. The label must indicate the type of oil or grease and the code number and other details. Oil containers must be kept in the horizontal position while the grease container should be in the vertical position.

Cost Estimating Methods

Engineering Estimate with this technique, the system being costed is broken down into lower level components (such as parts or assembles), each of which is costed separately for direct labour, direct material and other costs. Engineering estimates for direct labour hours may be based on analyses of engineering drawings and contractor or industry wide standards. Engineering estimates for direct material may be based on discrete raw material and purchase part requirements. The remaining elements of cost (such as quality control of various overhead changes) may be factored from the direct labour and materials costs. The various discrete cost estimates are aggregated by simple algebraic equations (hence the common name 'bottoms-up estimate). The use of engineering estimates requires extensive knowledge of a system's (and its components) characteristics and lots of detailed data.

Simple estimation of material

Objectives: At the end of this lesson you shall be able to
- **state the purpose of estimation**
- **explain the details of formats for estimation sheet.**

Estimation is the method of calculating the various quantities and the expenditure to be incurred on a particular job or process.

In case the funds available are less than the estimated cost the work is done in part or by reducing it or specifications are altered,

The following essential details are required for preparing an estimate.

Drawings like plan, elevation and sections of important parts.

Detailed specifications about workmanship & properties of materials, etc.

Standard schedule of rates of the current year.

Estimating is the process of preparing an approximation of quantities which is a value used as input data and it is derived from the best information available.

An estimate that turns out to be incorrect will be an overestimate if the estimate exceeded the actual result, and an underestimate if the estimate fell short of the actual result.

A cost estimate contains approximate cost of a product process or operation. The cost estimate has a single total value and it is inclusive of identifiable component values, as shown in Table 1

Hand book and reference table: A hand book is a type of reference work, or other collection of instruction. That is intended to provide ready reference. The term originally applied to a small portable book containing information useful for its owner, but the oxford english dictionary defines as “any book.... giving information such as facts on a particular subject, guidance in some art or occupation, instruction for operating a machine etc. A handbook is sometimes referred to as a pocket reference.

Hand book may deal with any topic, and arc generally having compact information in a particular field (or) technique. They are designed to be easily consulted and provides quick answer in a certain area.

Example of engineering hand book include parry’s clerical engineers hand book, mark standard hand book for machine engineer and the CRC hand book of chemistry and physics.

Reference table: A reference table may mean a set of references that are author may have cited (or) gained inspiration from whilst writing an article, similar to a bibliography.

It can also mean an information table that is used as a quick and easy reference for things that are difficult to remember such as comparing imperial with metric measurements. This kind of data is known as reference data.

Causes for assembly failures and remedies

Objectives: At the end of this lesson you shall be able to
- **state the poor assembly**
- **list out poor service conditions**
- **state the cost of operation.**

Poor assembling

Error in assembly can result due to various reasons such as ambiguous, insufficient or inappropriate assembly procedure, misalignment, poor workmanship. Sometimes, failures are also caused by the inadvertent error performed by the workers during the assembly. For example, failure of nut and stud assembly (used for holding the car wheel) by fatigue can occur owing to lack of information regarding sequence of tightening the nuts and torque to be used for tightening purpose; under such conditions any sort of loosening of nut which is subjected to external load will lead to fatigue failure.

Poor service conditions

Failure of an engineering component can occur due to abnormal service condition experienced by them for which they are not designed. These abnormal service conditions may appear in the form of exposure of component to excessively high rate of loading, unfavorable oxidative, corrosive, erosive environment at high or low temperature conditions for which it has not been designed. The contribution of any abnormality in Service conditions on the failure can only be established after thorough investigation regarding compatibility of the design manufacturing (such as heat treatment) and material of the failed components with condition experienced by them during the service.

Weight of raw material

Calculate theoretically weight of material, calculate volume of material and multiply with density of material. It gives you exact weight of raw material required.

While calculating weight do not consider final dimension always consider plus size for machining and other operation.

Cost of operation

Decide each operation to be performed on flanges like Drilling, machining and boring. While selecting the process do take care of sequence of operation as it matters a lot on costing.

You need to allot time required for particular operation considering all factors of machine. On their basis of price of machine, depreciation and cost of electricity consumed you need to finalise cost of machine running per hour.

Now multiply time required for particular operation and machine running cost/hour

Tools Cost

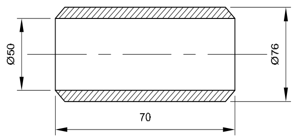
- **Cost of Labour:** For each piece calculate total working time consumed and calculate total cost need to pay to labour.
- **Accidental/Risk/Rejection cost:** As manufacturing of flange is a manual process, there may be chances of rejection of material, so this cost should be considered.

The simple method is add 1 piece's rate if manufacturing 100 qty in bulk

- Packaging and handling cost: Generally 2% of basic cost
- Profit: Approx. 5 to 15% to basic cost
- Admin and depreciation cost

Table 1

ESTIMATION SHEET

Part Name: Assembly: Assembly No.:	Part No.: 1 Material: Fe310.0 Stock size: ∅ 80 ISR-70L	Insert Part Drawing 

Operation No.	Operation description	Lathe	Estimated time	Rate / per hr.	Tools
01	Setting and aligning job on lathe	-	10 min	Rs.100.00	
02	Set speed and feed	-	2 min	-	
03	Align cutting tool in position	-	2 min	-	
04	Turn the job	-	50 min	-	
05	Chamfer 45º angle corner	-	8 min	-	vernier bevel protractor
06	Reverse the job on Lathe	-	10 min	-	
07	Turn the job	-	20 min	-	
08	Chamfer 45º on other side	-	20 min	-	
09	Centre drilling	-	10 min	-	
10	Mount drill chuck and drill using tail stock	Drilling	03 min	-	
11	Set drill rpm	Drilling	02 min	-	
12	Drill holes	Drilling	20 min	-	
13	Set the boring tool	Drilling	15 min	-	
14	Bore to the required diameter		08 min	-	
15	Check the bore dia		10 min	-	Inside micrometer or bore dial gauge
16	Deburr the job and clean the machine	-	10 min	-	
17	Total hours		200 min		
18	**Total estimation**			**Rs. 333.00**	

— — — — — —

Hazardous waste management & hierarchy

Objectives: At the end of this lesson you shall be able to
- **Explain waste management system**
- **State the hazardous waste management**

Waste Management System involves basically a two-tier approach worldwide involving prevention and control of environmental pollution. The preventive approach aims at minimizing waste generation at source of generation by all possible means with the help of:

a. Improvement in process technology & equipment which may completely eliminate waste streams;

b. Improvement in plant operations; and

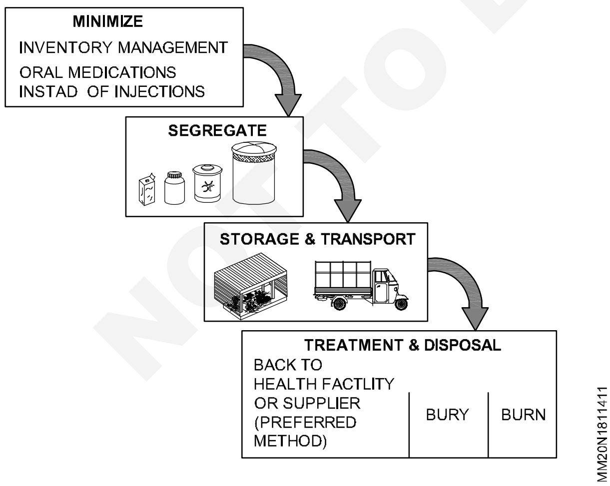
c. Promoting use of materials through recovery/recycle/ reuse of waste.

The hazardous waste management must also follow the same strategy. If not managed properly, it may have serious consequences, in view of its hazard potential.

The major obstacles in hazardous waste management, in our country, are more often institutional & behavioral rather than technical which are more related with the awareness and proper training. The hazardous wastes are seldom segregated from non-hazardous and/or recyclable wastes. Thus increasing the volume of hazardous waste which will increase the cost of treatment & disposal and depriving themselves of possible use of recoverable to minimize use of virgin raw materials.

Segregation is of utmost importance for Waste management in your company (Fig 1)

Fig 1



In the Hazardous Waste Management Hierarchy, waste minimization is at the top of the hierarchy and treatment & disposal of residual is at the bottom of the hierarchy.

The following steps may be taken by the generator of hazardous wastes for its handling in an effective manner:

Step 1: Systematically identify all hazardous & other wastes in your company as per the Schedules;

Step 2: Characterize and classify all Hws;

Step 3: Assign cost to all wastes in your company;

Step 4: Select and plan for waste management measures to:

- Segregate waste at source of generation;
- Have waste analyzed based on internal report;
- Arrange for safe on-site collection, labeling & storage of wastes according to their compatibility;
- Carry out preliminary/primary treatment on-site; and
- Arrange for off-site treatment and disposal.

The hazardous wastes can be possibly generated at every stage of handling chemicals and producing the goods. The possible sources of the hazardous waste generation in a company is summarized in the following diagram.

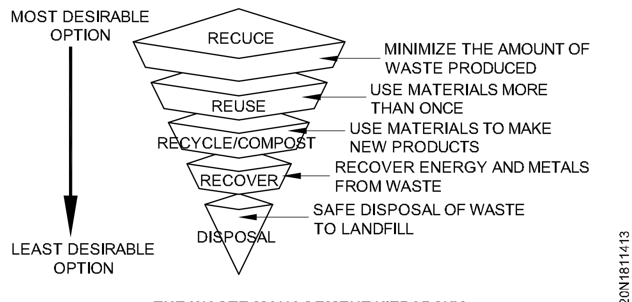
Fig - 2: Showing possible sources of Hazardous and other Wastes in a Facility

The waste hierarchy consists of four major stages:

- Reduce-reduce the quantity of waste produced;
- Reuse- reuse items wherever possible;
- Recycle-recycle old materials into new products; and
- Residual-dispose of residual waste to landfill.

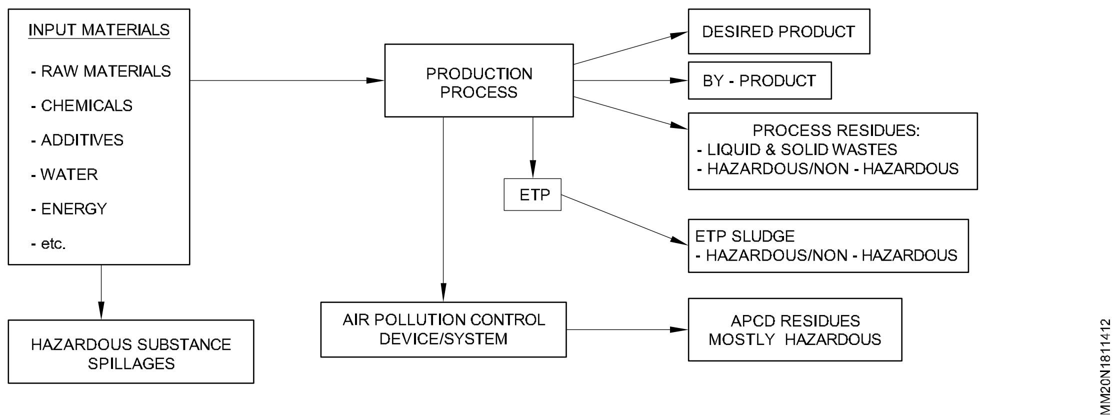
The principles of the waste hierarchy could be adopted as the basis for any waste management plan as per Fig 3.

Fig 3



THE WASTE MANAGEMENT HIERARCHY

Fig 2


INPUT MATERIALS
- RAW MATERIALS
- CHEMICALS
- ADDITIVES
- WATER
- ENERGY
- etc.
PRODUCTION PROCESS
DESIRED PRODUCT
BY - PRODUCT
PROCESS RESIDUES:
- LIQUID & SOLID WASTES
- HAZARDOUS/NON - HAZARDOUS
ETP
ETP SLUDGE
- HAZARDOUS/NON - HAZARDOUS
HAZARDOUS SUBSTANCE SPILLAGES
AIR POLLUTION CONTROL DEVICE/SYSTEM
APCD RESIDUES MOSTLY HAZARDOUS
MM20N1811412

Basic electrical current, voltage resistance

Objectives : At the end of this lesson you shall be to
- **simple electric circuit**
- **ohms laws and calculation**
- **principle of generators**
- **principle of motor**
- **faraday's Law**
- **fleming's rule.**

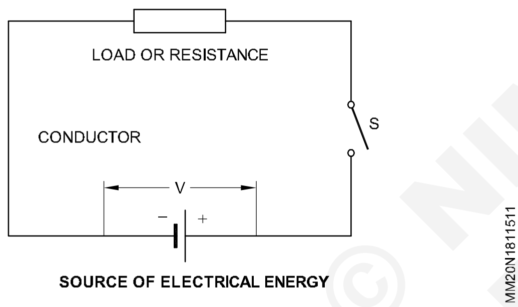
Introduction

A circuit should have a source of supply, load, insulated conductor to carry the current and a switch to control the circuit.

Simple electric circuit

A simple electric circuit (Fig 1) is the complete pathway of the current flow from the battery via the switch and the load, back to the battery.

Fig 1

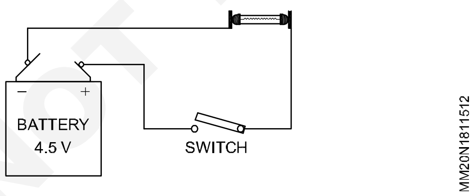


An electric circuit consists of

- voltage source
- connecting wires (conductors)
- load
- switch.

In Fig 2, which is the source of electrical energy and which is the load?

Fig 2



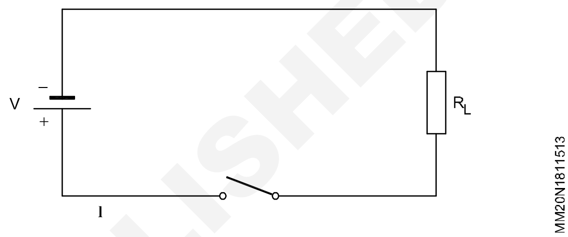
Open circuit

Two important extreme conditions can occur in a circuit: open circuit and short circuit.

In an open circuit, there is an infinitely high resistance in the circuit, provided most of the time by the open switch. Therefore, no current can flow.

For example, a battery is on an open circuit when it is not supplying current to the circuit, that is the switch is open, Fig 3. A wall socket, too, is an open circuit if no appliance is connected to it. Although there is no current flow, if there is no switch, there will be a voltage across the socket which will be live (a hazard).

Fig 3



In an open circuit what is the value of

(a) the circuit resistance and

(b) the current I.

Short circuit

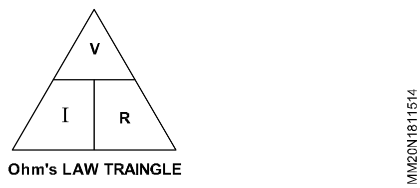
The other important extreme condition is the short circuit.

A short circuit will occur, for example, when the two terminals of a torch battery are joined. A short circuit may also occur if the insulation between the two cores of a cable is defective. The resulting small load resistance will cause large currents which can become a hazard. A fuse could then blow and automatically switch off the current.

Ohm's law (Fig 4)

Ohm's law states that in any electrical closed circuit, the current (I) is directly proportional to the voltage (V), and it is inversely proportional to the resistance 'R' at constant temperature.

Fig 4



(i.e.) I α V (When 'R' is kept constant)

I α R (When 'V' is kept constant)

I α V/R (Relation between I, V and R)

$$I = \alpha \frac{V}{R}$$

It means I = V/R

V = Voltage applied to the circuit in 'Volt'

I = Current flowing through the circuit in 'Amp'

R = Resistance of the circuit in Ohm (Ω)

The above relationship can be referred to in a triangle. In this triangle whatever the value you want to find out, place the thumb on it then the position of the other factors will give you the required value.

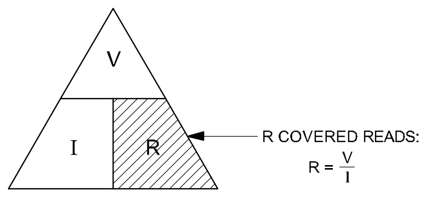
For example for finding 'V' close the value 'V' then readable values are IR, so V = IR.
Again for finding 'R', close the value R, then readable values are V/I so R = V/I, like that $I = \frac{V}{R}$

Written as a methodical expression, Ohm's Law is

$$\text{Resistance} = \frac{\text{Voltage (V)}}{\text{Cuttent (I)}} \text{(Refer Fig 5)}$$

(or) $R = \frac{V}{I}$

Fig 5

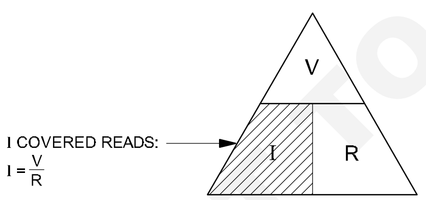


Of course, the above equation can be rearranged as :

$$\text{Current (I)} = \frac{\text{Voltage (V)}}{\text{Resistance (R)}}$$

or $I = \frac{V}{R}$ (Refer Fig 6)

Fig 6

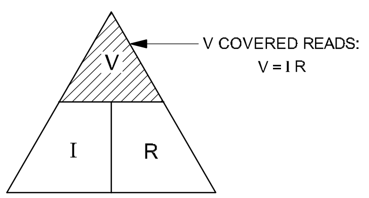


In the same way, 'V' can be found by covering 'V'

Voltage (V) = Current (I) x Resistance (R)

or V - IR (Refer Fig 7)

Fig 7

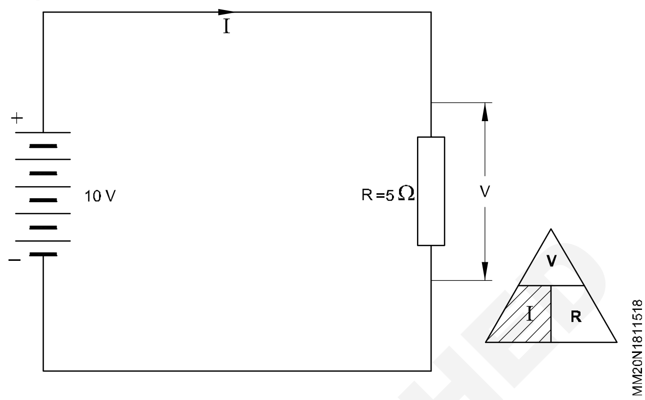


Application of Ohm's law in circuits

Example 1

Let us take a circuit shown in (Fig 8) having a source of 10V battery and a load of 5 Ohms resistance. Now we can find out the current through the conductor.

Fig 8



$I \alpha \frac{V}{R}$

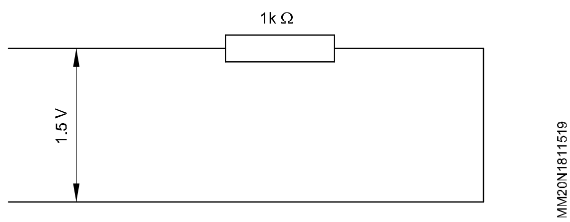
$I = \frac{V}{R}$

$I = \frac{10}{5} = 2 \text{ amp}$

Example 2

How much current (I) flows in the circuit shown in (Fig 9)

Fig 9



Given

Voltage (V) = 1.5 Volts
Resistance (R) = 1 k Ohm.
= 1000 Ohms

Find : Current (I)

Known

$I = \frac{V}{R}$

Solution :

$$I = \frac{1.5 \text{ V}}{1000 \text{ Ohms}} = 0.0015 \text{ amp}$$

Answer

The current in the circuit is 0.0015 A

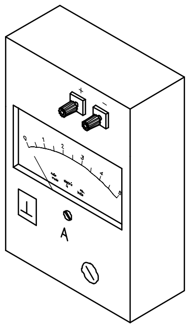
Ammeters

In order to measure current, measuring instruments called current meters or ammeters are used. (Fig 10)

An ammeter is used to measure current. For this the current must flow through the measuring instrument. Hence ammeter is connected in series with the load.

Electromotive force: It is now necessary to consider the reason for the motion of electrons in an electrical circuit.

Fig 10



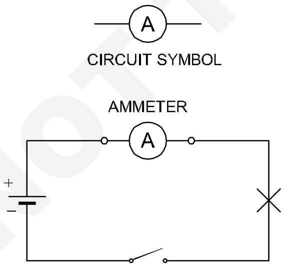
MM20N181151A

In order to move the free electrons in one direction and to produce a current, a source of electrical energy is required. The torch battery is a source of electrical energy.

Within the battery the negative terminal contains an excess of electrons whereas the positive terminal has a deficit of electrons. The torch battery is a source of electrical energy.

Within the battery the negative terminal contains an excess of electrons whereas the positive terminal has a deficit of electrons. The battery is said to have an electromotive force (emf) which is available to drive the free electrons in the closed path of the electrical circuit. The difference in the distribution of electrons between the two terminals of the battery produces this if now the unit of emf is the volt and, through common usage, it is now accepted that the emf of an electrical source may be refered to as its 'voltage'. (The terminals of the battery are indicated on the circuit symbol by two lines, the longer line for the positive and the shorter for the negative terminal).(Fig 11)

Fig 11



MM20N181151B

Potential difference: The voltage across the mains when the load is put on is known as potential difference and its unit is volt.

Electromagnetic induction

Faraday's Laws of Electromagnetic Induction are also applicable for conductors carrying alternating current.

What are Faraday's Laws of Electromagnetic Induction?

Faraday's First Law states that whenever the magnetic flux is linked with a circuit changes, an emf is always induced in it.

The Second Law states that the magnitude of the induced emf is equal to the rate of change of flux linkage.

Accordingly induced emf can be produced either by moving the conductor in a stationery magnetic field or by changing magnetic flux over a stationery conductor. When conductor moves and produces emf, the emf is called as dynamically induced emf Ex. generators.

When changing flux produces emf the emf is called as statically induced emf as explained below. Ex: Transformer.

Statically induced emf

When the induced emf is produced in a stationery conductor due to changing magnetic field, obeying Faraday's Laws of electro magnetism, the induced emf is called as statically induced emf.

There are two types of statically induced emf as stated below :

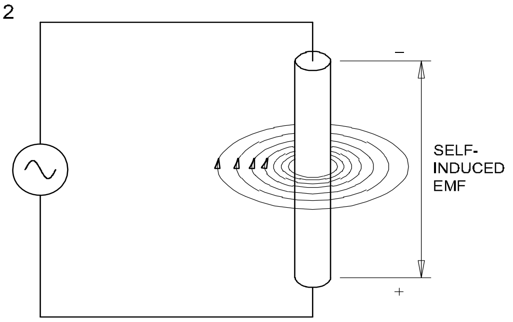
1 **Self induced emf** produced with in the same coil

2 **Mutually induced emf** produced in the neighboring coil.

Self-induction (Fig 12)

When an alternating current flows in a conductor and the current periodically changes the direction, the magnetic field it produces also reverses the direction. At any instant, the direction of the magnetic field is determined by the direction of the current flow.

Fig 12



MM20N181151C

With one complete cycle, the magnetic field around the conductor builds up and then collapses. It then builds up in the opposite direction, and collapses again. When the magnetic field begins building up from zero, the lines of force or flux lines expand from the centre of the conductor outward. As they expand outward, they can be thought of as cutting through the conductor.

According to Faraday's Laws, an emf is induced in the conductor. Similarly, when the magnetic field collapses, the flux lines cut through the conductor again, and an emf is induced once again. This is called self-inductance.

Working with solenoid

Objectives: At the end of this lesson you shall be able to
- **Explain the construction of a typical solenoid**
- **Explain the principle of working of a solenoid**
- **list a few uses of a solenoid**
- **list the points to be noted while making solenoids**
- **explain the use of solenoids in motor starter circuits.**

A solenoid is constructed by winding enameled copper wire on a hollow fiber or plastic former. The core, more commonly called a plunger is made of such a material that is easily magnetized but does not retain its magnetism when no longer flows through the coil.

A solenoid enables an electric current to control a mechanical part. The movable iron core or plunger can be used to operate, for example, water valves (to control water flow), a mechanical brake, a clutch and so on. Solenoids are generally made to operate on AC supply also. The AC operated solenoids are commonly used in door chimes.

Principle of operation

As already discussed, when current flows through a coil, the coil becomes a magnet. The coil concentrates the magnetic field inside the coil, and acts like a bar magnet. it will have north and south poles similar to a bar magnet. If a core of soft iron is placed along the axis of the coil, it will be attracted by the coil The core will be drawn into the centre of the coil The movement of the magnetic field associated with current flowing in the bimetal will cause a sideways pull to be applied to the bimetal elemet, attracting the bimetal towards the ferrous the core will stop when the forces at each end of the coil are balanced. This balance occurs when the core has centered itself in the coil where magnetic fields are strongest.

Points to be noted while making solenoids

1 Use a thin wire gauge to accommodate more number of turns for a given length of the former. This increases the magneto motive force (mmf) for lesser value of current.

2 Ensure that the hollow portion of the solenoids is friction free to avoid unwanted waste of energy while pulling the plunger.

3 Choose a core material having high permeability and very low relativity. This reduces the reluctance of the magnetic circuit and improves the pulling power of the solenoid and frequency of operation.

4 Choose the dimensions of the core such that it is not abnormally heavy and large. A heavy core reduces the net pulling power of the solenoid.

5 Ensure a firm fixing of the solenoid coil to same base to get maximum benefit of the core movement.

Application of solenoid in motor starters

A typical application of solenoid connected to an automobile starter is given below:

The starting system is used to start the engine in all four wheel vehicle.

When the starter switch (A) is pressed or turned, battery (B) gets connected to solenoid (C) and current flows through the solenoid. The solenoid plunger (D) is attracted and the plunger shorts the terminals (E) connecting the battery to the starting motor (F). Now the starter motor shafts rotates.

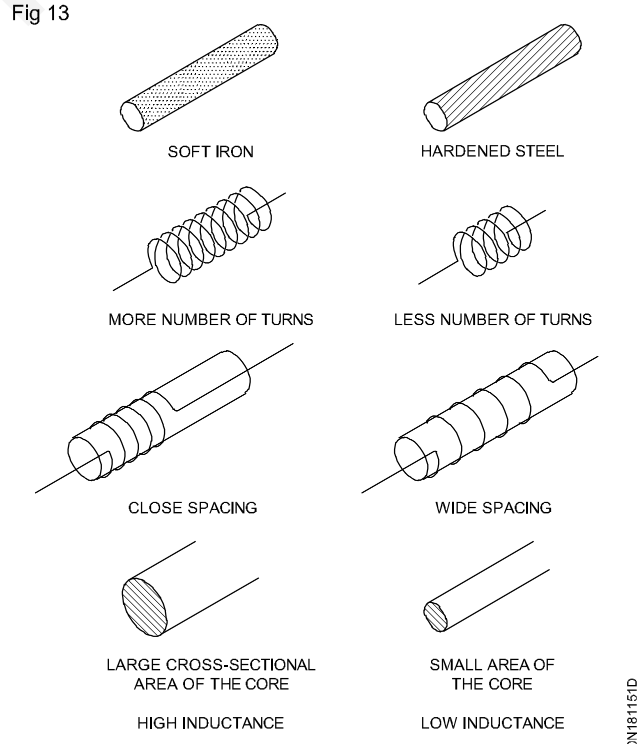
The shaft of the starter motor coupled to the engine flywheel turns on the engine by rotating the engine flywheel till the engine start working. Once the engine starts working, switch (A) is released. The current through the solenoid is cut-off and the plunger (D) is released and the terminals (E) become open, switching off the starting motor.

Inductance (L) is the electrical property of an electrical circuit or device to oppose any change in the magnitude of current flow in a circuit.

Devices which are used to provide inductance in a circuit are called inductors. Inductors are also known as chokes, coils and reactors. Inductors are usually coils of wire.

Factors determining inductance (Fig 13)

Fig 13



FACTORS DETERMINING INDUCTANCE

The inductance of an inductor is primarily determined by four factors.

- Type of core permeability of the core m_r
- Number of turns of wire in the coil 'N'
- Spacing between turns of wire (Spacing factor)
- Cross-sectional area (diameter of the coil core) 'a' or 'd'.

The amount of inductance in a coil of wire is affected by the physical make up of the coil.

Core

If soft iron is used as a core material instead of hardened steel, the coil will have more inductance.

If all the factors are equal, an iron core inductor has more inductance than an air core inductor. This is because iron has a higher permeability, that is, it is able to carry more flux. With this higher permeability there is more flux change, and thus more counter induced emf (cemf), for a given change in current.

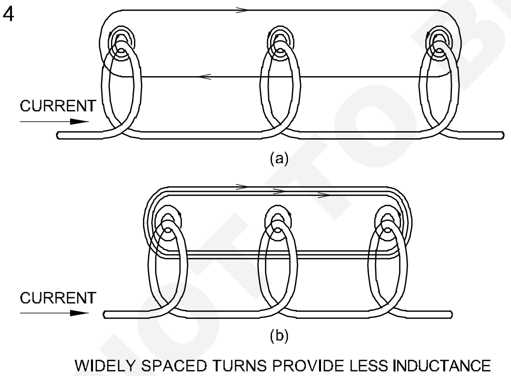
Number of turns

Adding more turns to an inductor increases its inductance because each turn adds more magnetic field strength to the inductor. Increasing the magnetic field strength results in more flux to cut the conductors (turns) of the inductor.

Spacing between turns of wire (Fig 14)

When the distance between the turns of wire in a coil is increased, the inductance of the coil decreases. illustrates why this is so. With widely spaced turns many of the flux lines from adjacent turns does not link together. Those lines that do not link together produce no voltage in other turns. As the turns come closer together only a fewer lines of flux fail to link up.

Fig 14



WIDELY SPACED TURNS PROVIDE LESS INDUCTANCE THAN CLOSELY SPACED TURNS

EFFECT OF TURN SPACING

Cross sectional area

For a given material having same number of turns, the inductance will be high with large cross-sectional area and will be low for smaller cross-sectional area.

Symbol and unit of Self-inductance

The property of a coil or conductor to self-induce an emf, when the current though it is changing, is called the coil's (conductor's) self-inductance of simply inductance. The letter symbol for inductance is L; its basic unit is Henry, H.

Henry

A conductor or coil has an inductance of one Henry if a current that changes at the rate of one ampere per second produces a induced voltage (cemf) of 1 volt.

The inductance or straight conductors is usually is very less and for our proposes can be considered zero. The inductance of coiled conductors will be high, and it plays an important role in the analysis of AC circuits.

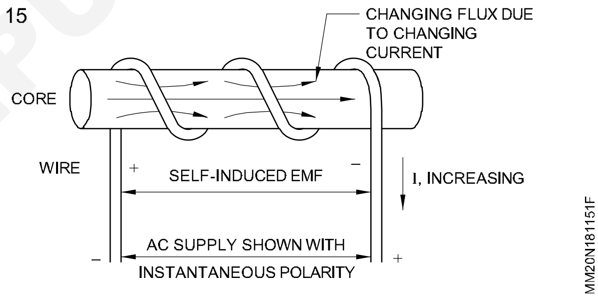
What will be the direction of the induced emf? (Leng's Law) (Fig 15)

The direction of the self-induced emf is explained by Lenz's Law.

A change in current produces an emf whose direction is such that it opposes the change in current. In other words, when a current is decreasing, the induced emf is in the same direction as the current and tries to oppose the current from decreasing. And when a current is increasing, the polarity of the induced emf is opposite to the direction of the current and tries to prevent the current from increasing.

The magnitude of self-induced emf depends on the rate at which the magnetic field changes. However magnetic field is proportional to current.

Fig 15



Generator

An electrical generator is a machine which converts mechanical energy into electrical energy.

Principle of the Generator

To facilitate this energy conversion, the generator works on the principle of Faraday's Laws of Electromagnetic Induction.

Faraday's Laws of Electromagnetic Induction

There are two laws

The first law states

- whenever the flux linking to a conductor or circuit changes, an emf will be induced.

The second law states

- the magnitude of such induced emf(e) depends upon the rate of change of the flux linkage.

$$e \propto \frac{\text{Change of flux}}{\text{Time taken for change}}$$

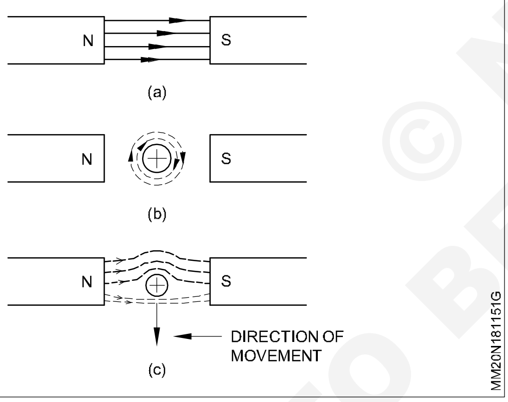
Introduction

A DC motor is a machine which converts DC electrical energy into mechanical energy. It is similar to a DC generator in construction. Therefore, a DC machine can be used as a generator or as a motor. Even today, because of the excellent torque, speed and load characteristics of DC motors, 90% of the motors used in precision machines, wire drawing industry and traction are of this type. The DC motor needs frequent care and maintenance by qualified electricians. Hence more job opportunities exist in this area for an electrician.

Principles of a DC motor

It works on the principle that whenever a current-carrying conductor is kept in a uniform magnetic field, a force will be set up on the conductor so as to move it at right angles to the magnetic field. It can be explained as follows. (Fig 16a) shows the uniform magnetic field produced by a magnet, whereas the magnetic field produced around the current-carrying conductor. Combining the effects of (Fig 16b) and the resultant field produced by the flux of the magnet and the flux of the current-carrying conductor. Due to the interactions of these two fields, the flux above the conductor will be increased and the flux below the conductor is decreased (Fig 16 c). The increased flux above the conductor takes a curved path thus producing a force on the conductor to move it downwards.

Fig 16



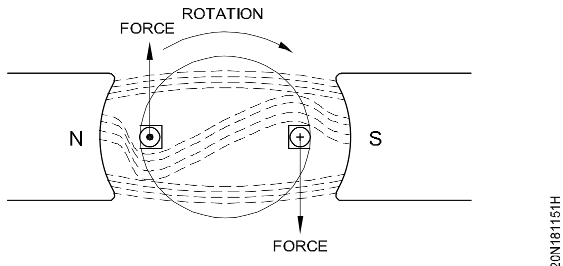
If the conductor is replaced by a loop of wire the resultant field makes one side of the conductor move upwards and the other side move downwards. It forms a twisting torque over the conductors, and they tend to rotate, if they are free to rotate. But in a practical motor, there are a number of such conductors/coils. When its armature and field are supplied with current, the armature experiences a force tending to rotate in an anticlockwise direction as shown in (Fig 17).

The direction of rotation or movement can be determined by Fleming's left hand rule. Accordingly, the direction of rotation of the armature could be changed either by changing the direction of armature current or the polarity of the field.

Fleming's Left Hand Rule

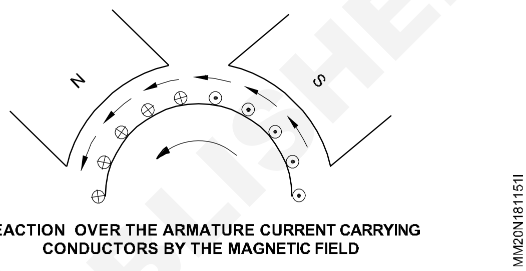
The direction of force produced on a current-carrying conductor placed in a magnetic field can be determined by this rule. Hold the thumb, forefinger and middle finger of the left hand mutually at right angles to each other, such that the forefinger is in the direction of flux, and the middle finger is in the direction of current flow in the conductor; then the thumb indicates the direction of motion of the conductor. For example, a loop of coil carrying current, when placed under north and south poles as shown in (Fig 18) rotates.

Fig 17



REACTION OVER A CURRENT CARRYING LOOP BY THE MAGNETIC FIELD

Fig 18



REACTION OVER THE ARMATURE CURRENT CARRYING CONDUCTORS BY THE MAGNETIC FIELD

Transformer

When a fluctuating electric current flows through a wire, it generates a magnetic field (invisible) or magnetic flux" all around it.The strength of the magnetism is directly related to the size of the electric current. When a magnetic field fluctuates around a piece of wire it generates an electric current in the wire.

So if we put a second coil of wire next to the first one, and create an electric current in the second wire. The current in the first coil is usually called the primary current and the current in the second wire is the secondary current and electric current through empty space from one coil of wire to another, this is called electromagnetic induction because the current in the first coil causes (induces) a current in the second coil we can make electrical energy passes more efficiently from one coil to the other key wrapping them around a soft iron bar (called core).

To make a coil of wire, simply curl the wire around into coils or turns".

Types

- Step down transformers
- Step up transformers

Step down Transformer

When the first coil have more turn than that of the second coil the secondary voltage will be smaller than the primary voltage than the transformer is called a step - down transformer (Fig 19)

Fig 19

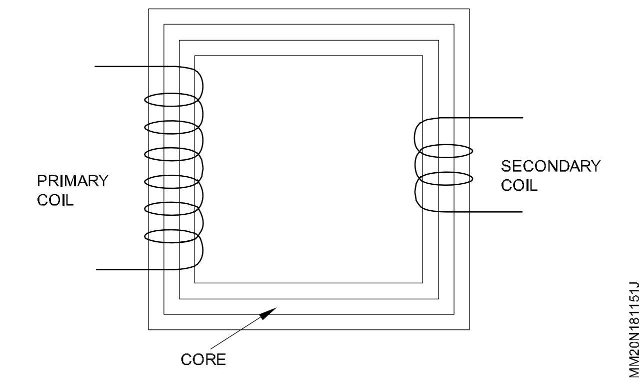
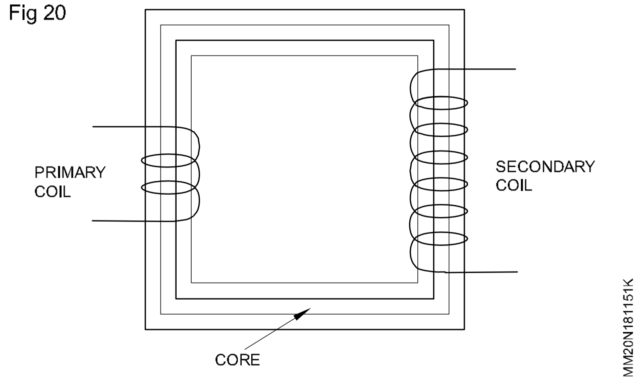


Fig 20



Step up transformer

When the first coil have less turns than that of the second coil, the secondary voltage will higher than the primary voltage then the transformer is called a step up transformer.(Fig 20).

Safety precautions to be observed while working on 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.

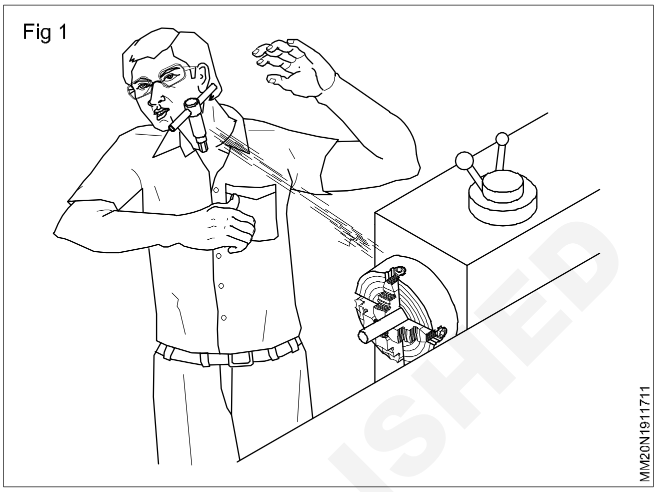
It is dangerous to leave the chuck key in the chuck. Remove it immediately after use. (Fig 1)

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 is.

Fig 1



After work

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

Oil the bed ways and lubricating points.

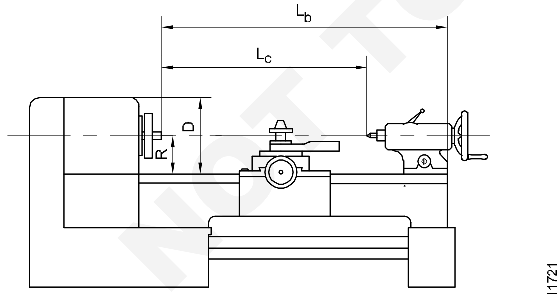
Clean the surroundings of the lathe, wipe the dirt and coolant and remove the swarf.

Specification of a centre lathe

Objective: At the end of this lesson you shall be able to
- **specify a centre lathe.**

Specification of a lathe (Fig 1)

Fig 1



R-RADIUS OF WORK (CENTRE HEIGHT OF LATHE) D-DIAMETER OF WORK (SWING) L_C-LENGTH BETWEEN CENTRES L_b-LENGTH OF THE BED

A lathe is to be specified by the following.

The maximum diameter of a work that can be held.

The swing over bed. This is the perpendicular distance from the lathe axis to the top of the bed.

The length of the bed. The length of the bed-ways.

The maximum length of work that can be turned between centres.

The range of threads that can be cut. The capacity of the lathe. The swing over carriage.

The value of each division on the graduated collars of the cross-slide and compound slide.

Range of spindle speeds.

Range of feeds.

Size of the spindle bore.

Type of spindle nose.

The specifications help in communication between the seller and the buyer of the lathe.

It helps the operator of the lathe to decide whether the work in hand can be accommodated for performing the operations.

Constructional features of lathe

Objectives: At the end of this lesson you shall be able to
- **name the main parts of a lathe**
- **state the constructional features of lathe**
- **explain the principle of a lathe.**

Centre lathe is a machine which is used 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 turning is carried out is known as a lathe.

Lathe is a machine tool which holds the job in between the centre and rotates the job on its own axis. Due to this quality of holding the job from the centre and rotating the job, it is called centre lathe. Work can be held on a chuck and face plate. Chuck and face plate are mounted on the front of spindle. Cutting tool is fed against work after holding it in the tool post firmly. The work rotates on it own axis and tool is moved parallel to work. When tool moves parallel to axis it produces cylindrical surface and when it rotates at some angle, it produces taper surface.

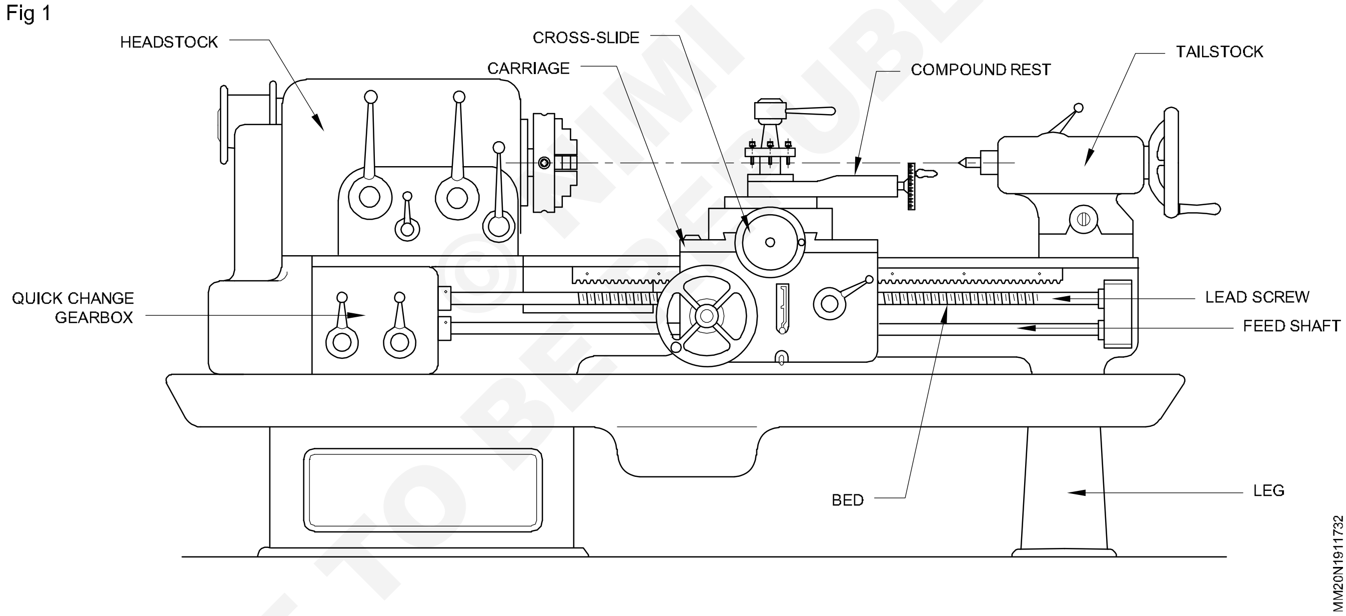
Constructional features of a lathe

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.

The following are the main parts of a lathe. (Fig 1)

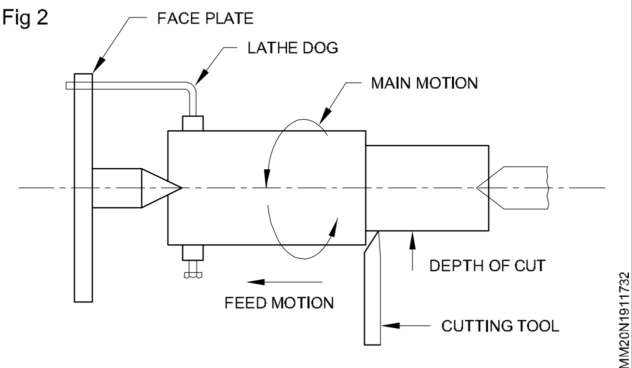
Fig 1



- Headstock
- Tailstock
- Carriage
- Cross-slide
- Compound slide
- Bed
- Quick change gearbox
- Legs
- Feed shaft
- Lead screw

Working principle of Lathe (Fig 2)

Fig 2



Lathe main parts

Objectives: At the end of this lesson you shall be able to
- **name the parts**
- **state the functions of the parts**

Lathe bed

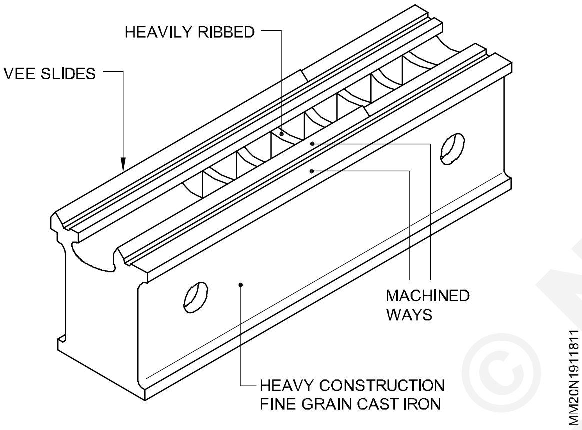
Functions of a lathe bed

The functions of a lathe bed are:

- To locate the fixed units in accurate relationship to each other.
- To provide slide-ways upon which the operating units can be moved.

Constructional features of a lathe bed (Fig 1)

Fig 1



The lathe bed generally consists of a single casting. In larger machines, the bed may be in two or more sections accurately assembled together. Web bracings are employed to increase the rigidity. For absorbing shock and vibration, the beds are made heavy.

A combined swarf and coolant tray is provided on lathes. This may be an integral part with the lathe bed.

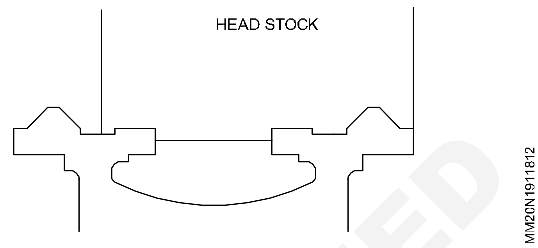
The bed is generally made by cast iron or welded sheet metal legs of box section. This provides the necessary working height for the lathe. Very often the electrical switch gear unit and the coolant pump assembly are housed in the box section of the legs at the headstock end.

Bed-ways (Fig 2)

The bed-ways or slide ways assist in accurate location and sliding of the accessories/parts mounted on this.

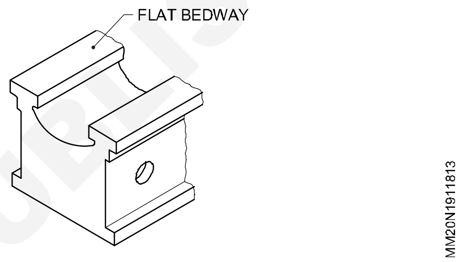
The bed-ways are of three types.

Fig 2



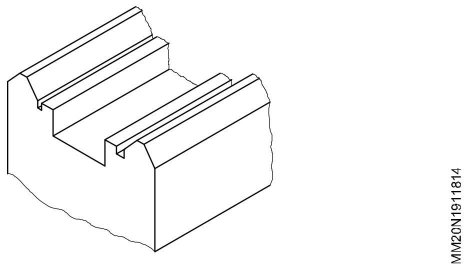
Flat bed-way (Fig 3)

Fig 3



'V' bed way (Fig 4)

Fig 4



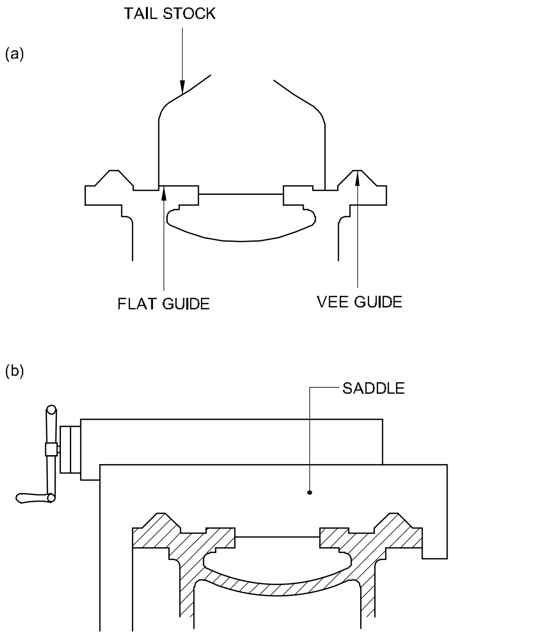
Combination bed way (Figs 5a & 5b)

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 the work.

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

The bed-ways are highly 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.

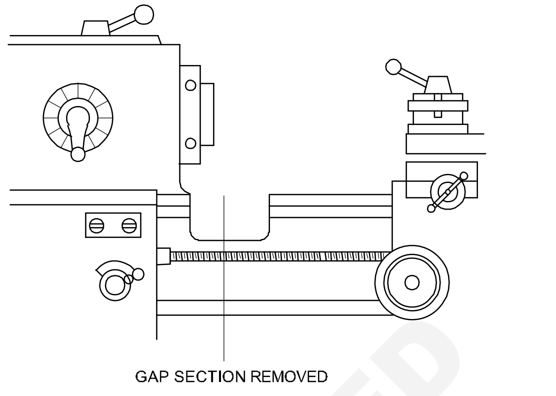
Fig 5



The beds are mostly made up of closely ground, grey cast iron.

Gap bed way (Fig 6)

Fig 6

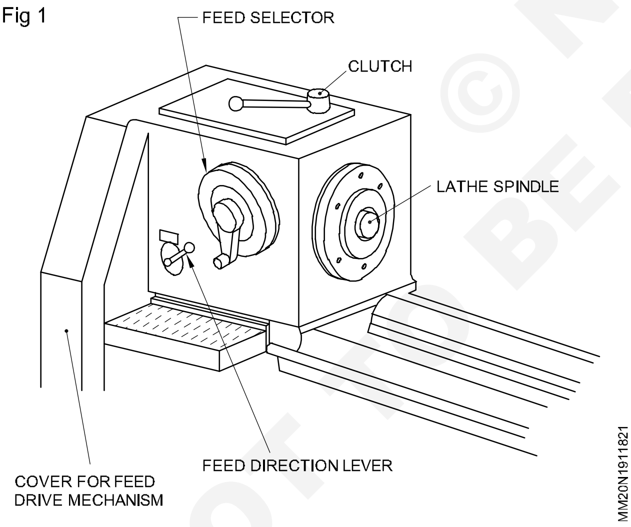


Headstock

Objectives: At the end of this lesson you shall be able to
- **state the function of the headstock**
- **differentiate between cone pulley headstock and all geared headstock.**

Functions (Fig 1)

Fig 1



To provide a means to assemble the work-holding devices. Transmit the drive from the main motor to the work.

To accommodate shafts, gears and levers for a wide range of varying work speeds.

To ensure arrangement for lubricating the gears, shafts and bearings.

Types of headstocks

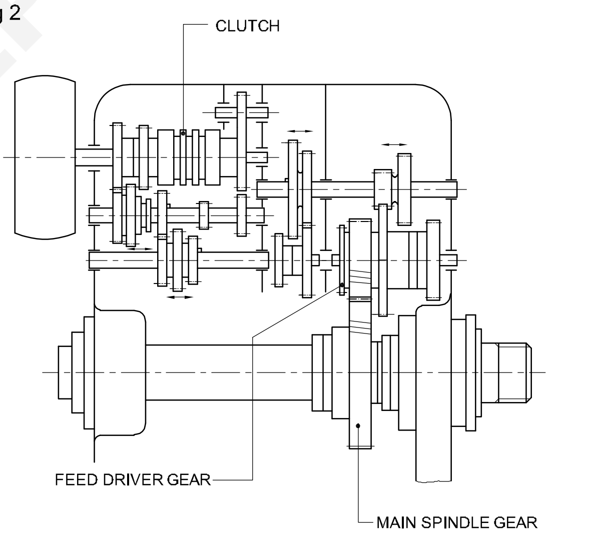
The following are the two types of headstocks.

1 All geared headstock.

2 Cone pulley headstock.

All geared headstock (Fig 2)

Fig 2



It is a box section casting having a removable top cover. It has internal webs for stiffening, and to take shaft bearings. It has an input shaft which is connected by means of 'V' belts to the main motor, and it runs at a constant speed. It is equipped with clutches and a brake.

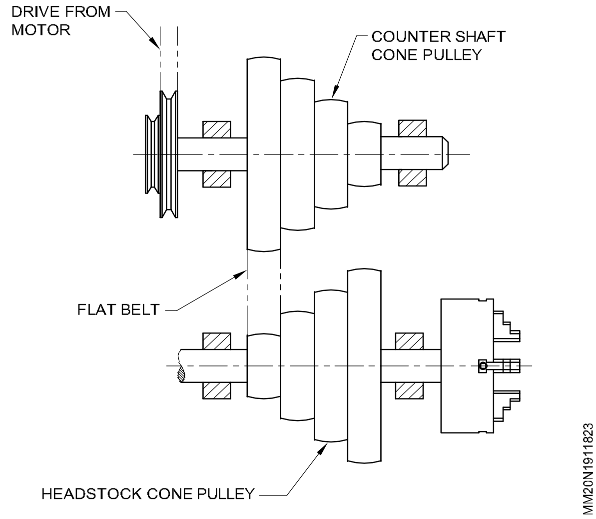
There may be two or more intermediate shafts on which sliding gears are mounted. The main spindle is the last driven shaft in the headstock assembly. The nose of the spindle is outside the headstock casting, and is designed to accommodate the work-holding devices.

The levers operating the forks for the sliding gears are situated outside in front of the headstock casting.

In the all-geared headstock, lubricating oil is filled for splash lubrication of the internal gears. A sight glass with an oil level mark is provided to see the oil level.

Cone pulley headstock (Fig 3)

Fig 3



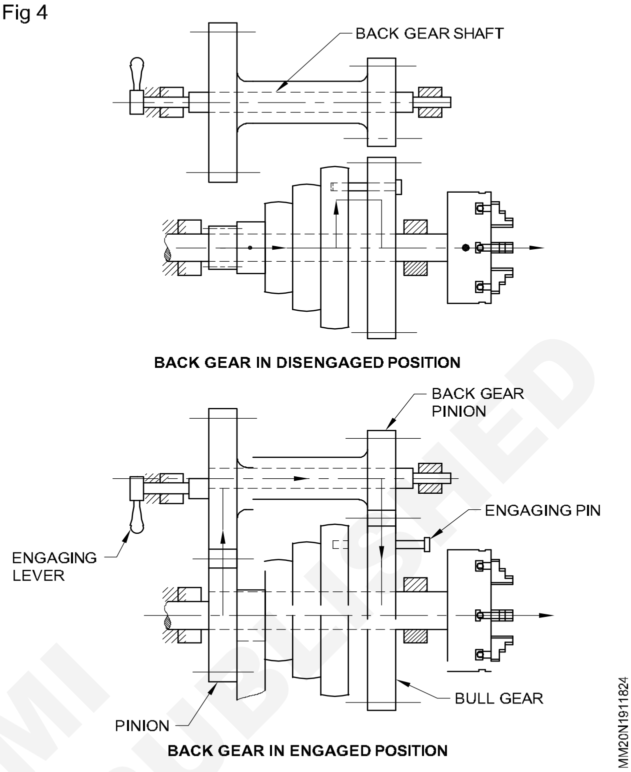
It has a stepped cone pulley mounted on the main spindle, and it is free to revolve. It is connected by means of a flat belt to a similar cone pulley, with steps arranged in the reverse order. This cone pulley gets the drive from the main motor.

The spindle is mounted on the bearing on the headstock casting and has a gear wheel called 'bull gear' keyed to it. A pinion is coupled to the cone pulley.

The back gear unit has a shaft which carries a gear and a pinion. The number of teeth of the gear and pinion on the back gear shaft corresponds to the number of teeth on the bull gear and pinion on the cone pulley. The axis of the back gear shaft is parallel to the axis of the main spindle. The back gear is engaged or disengaged with the cone pulley system by means of a lever. The back gear unit is engaged for reducing the spindle speeds. (Fig 4)

A three-stepped cone pulley headstock provides 3 direct ranges of speeds through a belt connection. With the back gear in engagement, 3 further ranges of reduced speeds can be obtained.

Fig 4



Advantages

- Can take up heavy load.
- Less noise during working.
- Easy to maintain.

Disadvantages

The number of spindle speeds is limited to the number of steps in the cone pulley.

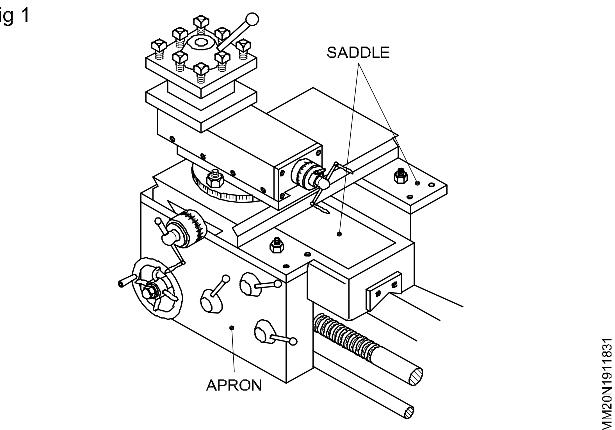
It takes time to change the spindle speeds.

Carriage

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

Carriage is the feature of a lathe that provides the method of holding and moving the cutting tool. (Fig 1) It can be locked at any desired position on the lathe bed. It consists of two major parts namely, apron and saddle.

Fig 1

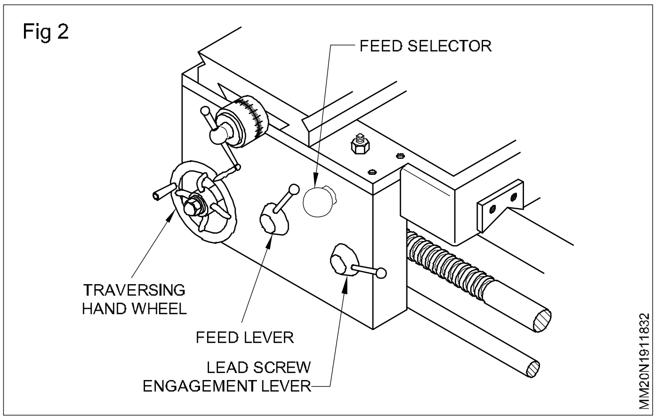


Apron (Fig 2)

The apron is bolted to the front of the saddle. It contains mechanism for moving and controlling the carriage. The main parts of an apron are :

- Traversing hand wheel
- Feed lever
- Feed selector
- Lead screw engagement lever.

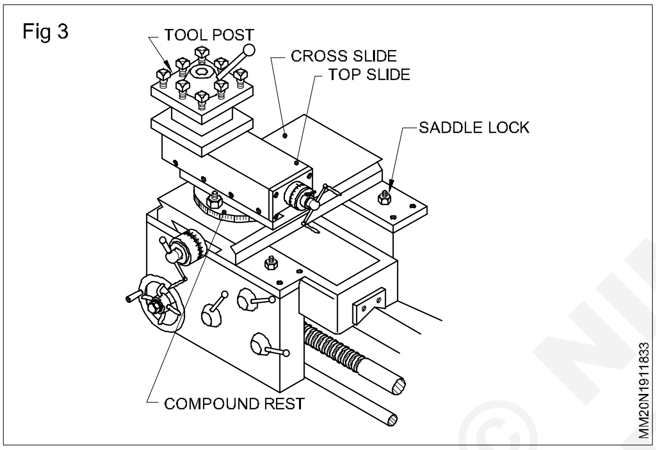
Fig 2



Saddle (Fig 3)

It is a 'H' shaped casting having 'V' guide grooves at the bottom face, corresponding to the lathe bed-ways for mounting on the lathe bed and for sliding.

Fig 3



Parts of a saddle

Cross-slide

The cross-slide is mounted on the top of the saddle, and it provides cross movement for the tool. This is fitted at right angles to the bed and is moved by means of a screwed spindle, fitted with a handle. A graduated collar, mounted on the screw rod along with the hand wheel, helps to set the fine movements of the cross- slide.

Compound rest

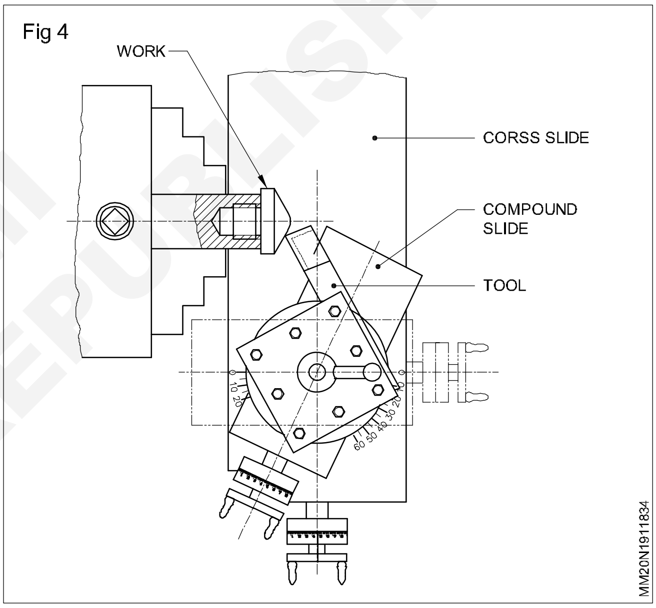
The compound rest is fitted on the top and to the front of the cross-slide. The compound rest can be swiveled horizontally through 360°.

Top slide

The top slide is fitted on the top of the compound rest. It supports the tool post which holds the cutting tool. The top slide provides a limited horizontal movement for the cutting tool.

By swiveled the compound rest, the top slide can be set at an angle to the cross-slide (Fig 4). Usually the compound rest is set in such a way that the top slide is at right angles to the cross-slide.

Fig 4



Tailstock

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

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 headstock.

The body and base are made out of cast iron. The parts of a tailstock are: (Fig 1)

a Base

b Body

c Spindle (barrel)

d Spindle locking lever

e Operating screw rod

f Operating nut

g Tailstock hand wheel

h Key

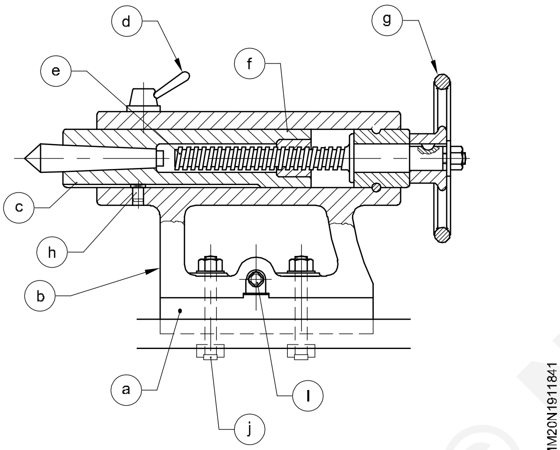
i Set screw/set over screw

j Clamping bolt

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.

Fig 1



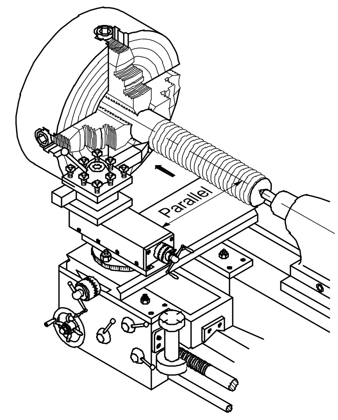
Purpose of the tailstock

To accommodate the dead center to support lengthy work to carry out lathe operations. (Fig 2)

To hold cutting tools like drills, reamers, drill chucks provided with taper shank. (Fig 3)

To turn external taper by offsetting the body of the tailstock with respect to the base. (Fig 4)

Fig 2



LONG WORKPIECE HELD BETWEEN CENTRES

Fig 3

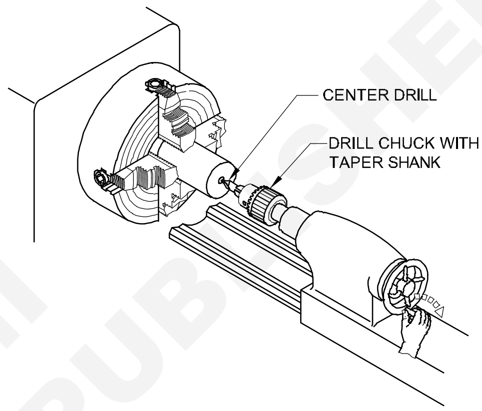
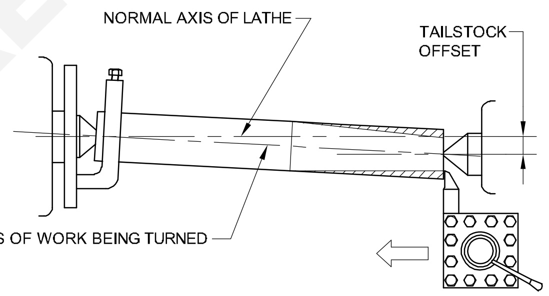


Fig 4

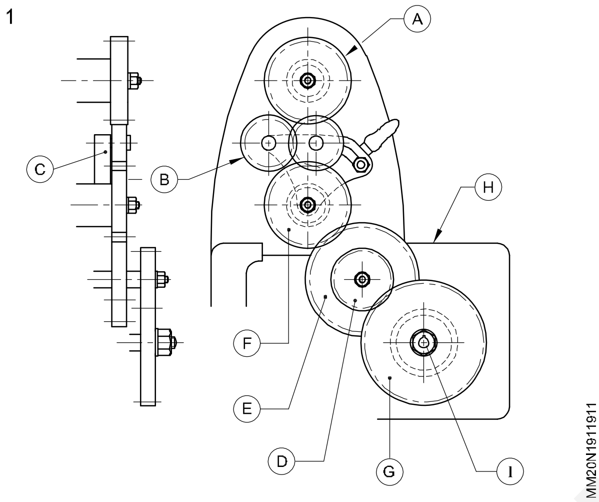


Feed & thread cutting mechanism

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

Feed mechanism (Fig 1)

Fig 1



The feed mechanism of a lathe enables automatic feeding for the tool longitudinally and transversely as needed. By automatic feeding the finish on the work will be better, the feeding of the tool will be at a uniform continuous rate and it takes less time to finish the operation while manual labour is avoided.

The feed mechanism comprises the following.

- Spindle gear (A)
- Tumbler gear unit (B)
- Fixed stud gear (C)
- Change gear unit (DEFG)
- Quick change gear box (H)
- Feed shaft / Lead screw (I)
- Apron mechanism (Fig 5)

The proportionate tool movement for each revolution of work is achieved through all the above units of the feed mechanism.

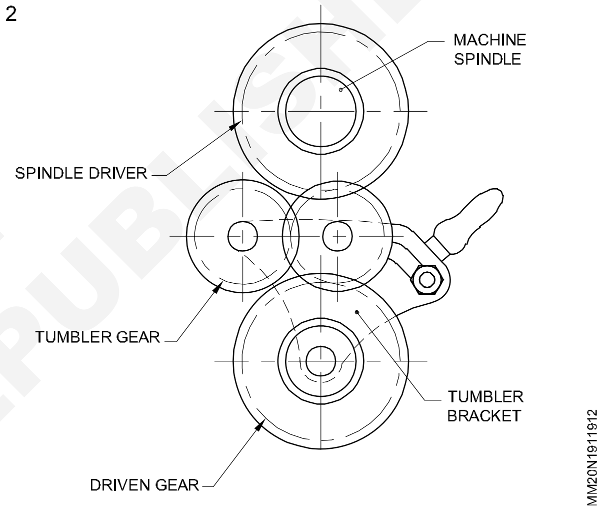
Spindle gear

The spindle gear is fitted to the main spindle, and it is outside the headstock casting. It revolves along with the main spindle.

Tumbler gear unit

The tumbler gear unit set of three gears, having the same number of teeth and it connects the spindle gear to the fixed gear. It is also called the reversing gear unit as it is used to change the direction of feed of the tool for the same direction of rotation of the spindle. It can be engaged and disengaged with the fixed stud 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 gear box. 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)

Quick change gear box

The quick change gear box is provided with levers outside the box casting, and by shifting the levers, different gears are brought in mesh so that different feed rates can be given to the tool. A chart listing the different feed rates for the different positions of the levers is fixed to the casting, and by referring to the table, the levers may be engaged in position for the required feed rate. (Fig 4)

Fig 3

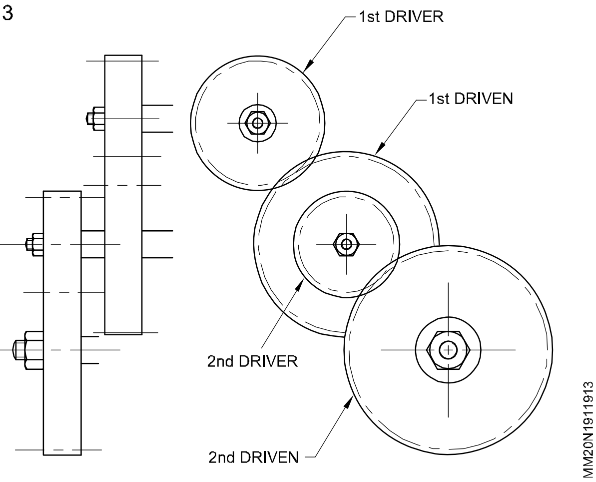
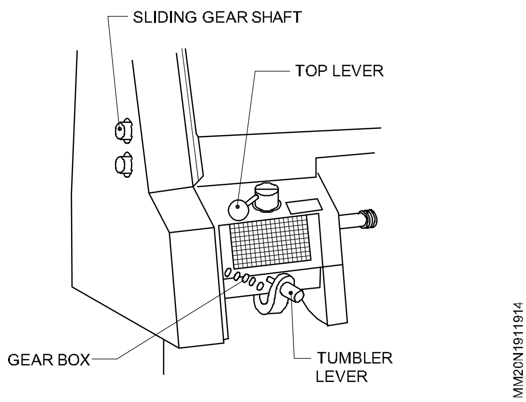


Fig 4



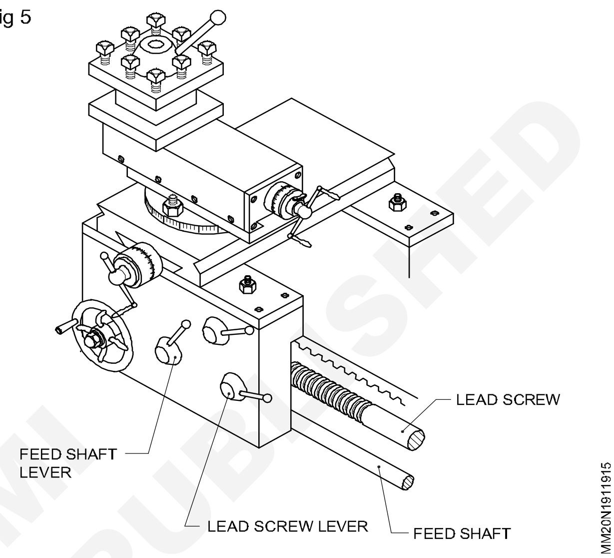
The feed shaft

The feed shaft gets its drive from the quick change gear box, 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 the arrangement for transmitting the drive from the feed shaft to the saddle for longitudinal movement of the tool or to the cross-slide for the transverse movement of the tool. (Fig 5)

Fig 5



Thread cutting with simple and compound gear trains

Objective: At the end of this lesson you shall be able to
- **thread cutting with simple and compound gear trains.**

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 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.

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 2) shows the arrangement of a compound gear train.

Fig 1

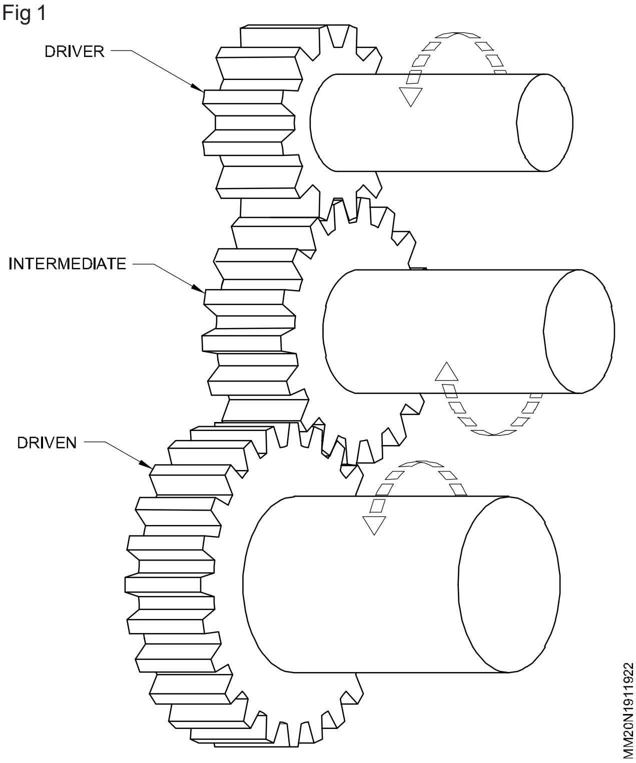
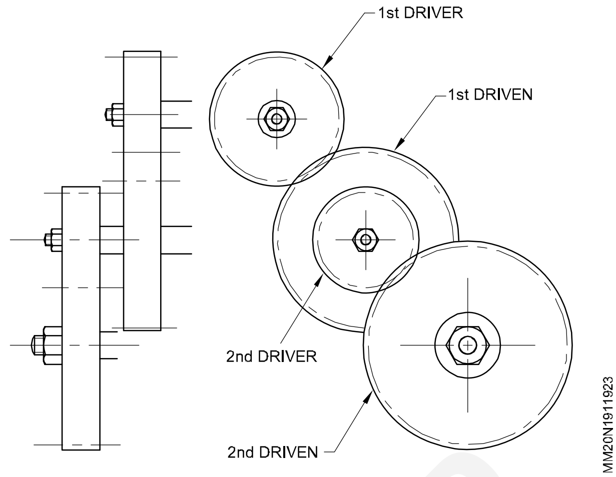

DRIVER
INTERMEDIATE
DRIVEN
MM20N1911922

Fig 2


1st DRIVER
1st DRIVEN
2nd DRIVER
2nd DRIVEN
MM20N1911923

Holding the job between centre and work with catch plate and dog

Objectives: At the end of this lesson you shall be able to
- **preparing work for turning between centre**
- **to set the catch plate**
- **working with catch plate and dog**

Turning work in-between centres avoids the need for truing the work. The work turned will be parallel through-out. But it requires great skill to perform operations especially like knurling, thread cutting, undercutting. It is limited to external operations only. The work needs the following preparations to be carried out before the actual operations are to be performed.

Face both sides of the work, and maintain the total length accurately within limits.

Choose the correct size and type of centre drill and do centre drilling at both ends.

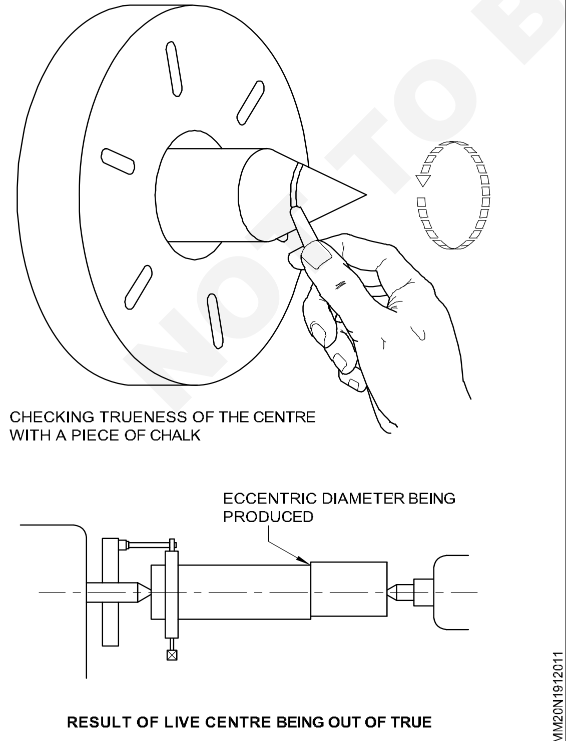
Diamantle the chuck from the spindle nose and assemble the driving plate or catch plate.

Assemble the spindle sleeve to the spindle nose and fix live centre to the sleeve.

Ensure that the spindle sleeve and live centre are free from damages, burrs and are thoroughly cleaned before assembly.

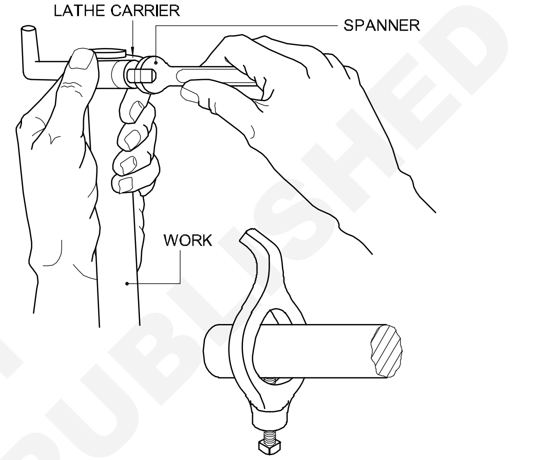
Check for the true running of the live centre. (Fig 1)

Fig 1



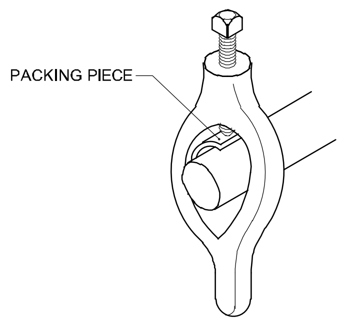
Select a suitable lathe carrier according to the diameter of the work and fasten it on one end of the work with the bent tail pointing outwards. (Fig 2)

Fig 2



Work that has a finished surface should be protected by inserting a small sheet of copper or brass between the end of the screw in the carrier and the work. (Fig 3)

Fig 3



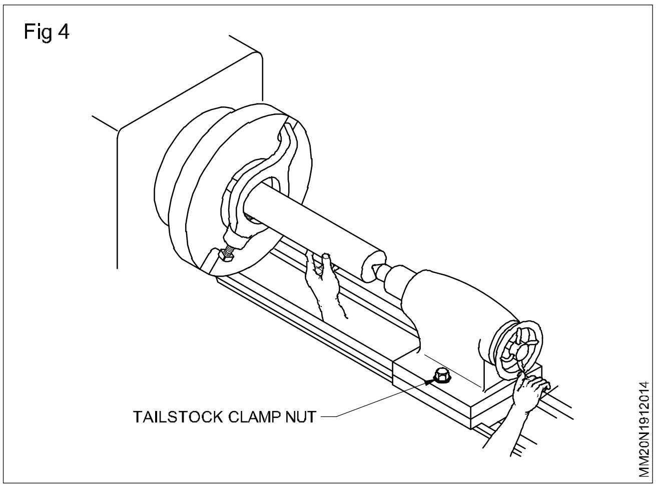
Apply a suitable lubricant (soft grease) to the centre hole of the workpiece to be engaged by the tailstock dead centre.

Move the tailstock to a position on the bed to suit the length of the workpiece. The tailstock spindle should extend approximately 60 to 100 mm beyond the tailstock.

Ensure there is sufficient space for the saddle to operate before clamping the tailstock to the bed.

Clamp the tailstock in position by tightening the tailstock clamp nut. (Fig 4)

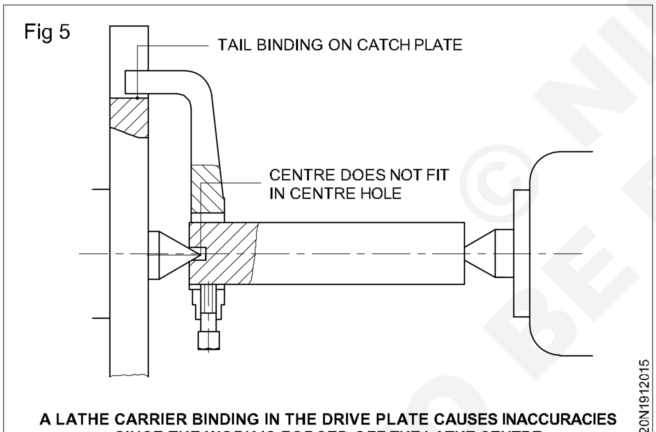
Fig 4



Engage the work-centre hole with the point of live centre and with the tail of the lathe carrier in the slot in the catch plate. Hold the work in this position with hand.

Ensure that the tail of the lathe carrier does not rest on the bottom of the slot in the driving plate. This will not permit the centre entering the centre hole of the work for proper seating. (Fig 5)

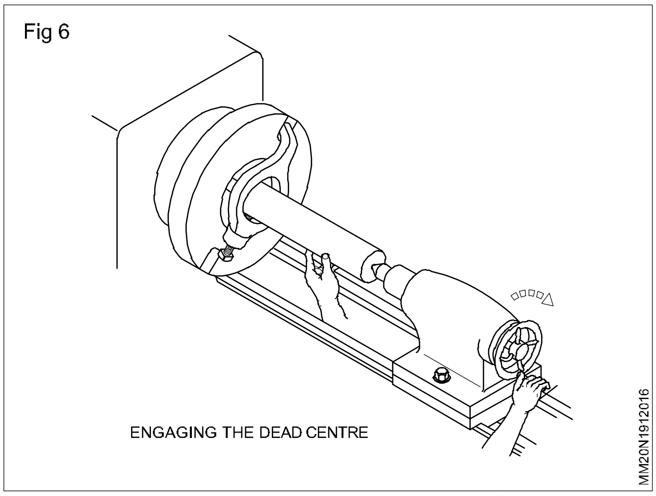
Fig 5



A LATHE CARRIER BINDING IN THE DRIVE PLATE CAUSES INACCURACIES SINCE THE WORK IS FORCED OFF THE LATHE CENTRE

Advance the tailstock spindle by the hand wheel rotation until the point of dead centre enters the centre hole of the work with proper seating eliminating all endwise movement. (Fig 6)

Fig 6



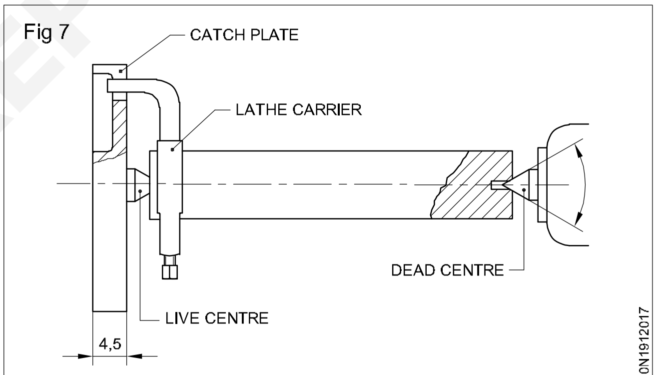
Move the tail of the carrier back and forth. At the same time adjust the hand wheel until only a slight resistance is felt.

Tighten the tailstock spindle clamp at this position and check that the resistance does not change. Set the machine for about 250 r.p.m. and allow the work to run for a few seconds.

Check once again for the resistance and adjust the tailstock spindle, if needed.

Work is now ready for operations. (Fig 7)

Fig 7



WORK HELD BETWEEN CENTRES

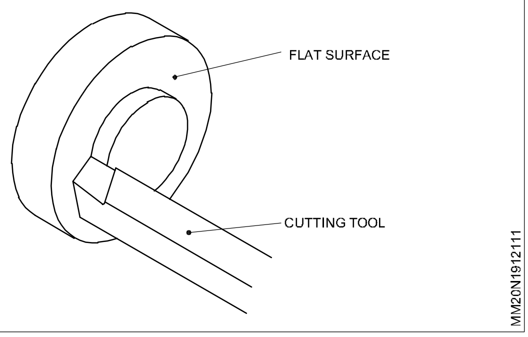
Before holding the work in between centres ensure that the centres are aligned.

Simple description of facing and roughing tool

Objectives: At the end of this lesson you shall be able to
- **state the purpose of facing**
- **setting the facing tool**
- **state the reasons for the defects**
- **state the remedies to overcome the defects in facing**

Facing: This is an operation of removing metal from the work-face by feeding the tool at right angles to the axis of the work. (Fig 1)

Fig 1



Purpose of facing

- To have a reference plane to mark and measure the step lengths of the work.
- To have a face at right angle to the axis of the work.
- To remove the rough surface on the faces of the work and have finished faces instead.
- To maintain the total length of the work.

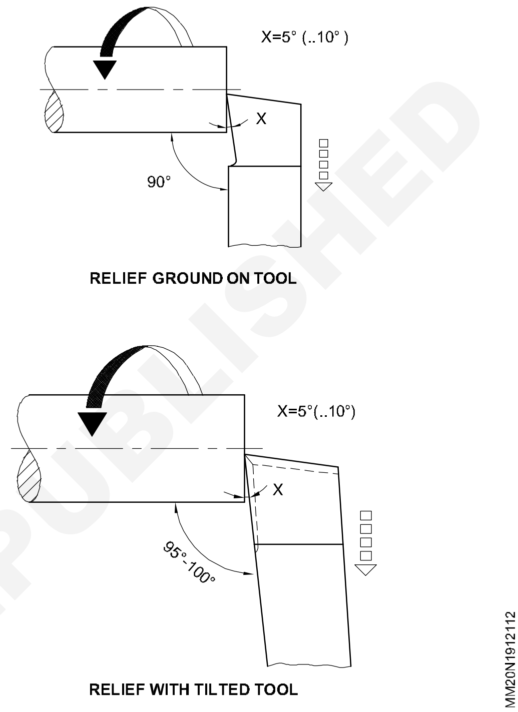
Facing may be rough or finish facing. Rough facing is done to remove the excess metal on the face of the work by coarse feeding with more depth of cut, leaving sufficient metal for finishing. Rough facing is done by feeding the tool from the periphery of work towards the centre of the work. Finish facing 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. (Fig 2)

Rough facing is done by choosing a spindle RPM according to the average diameter of the work, the recommended cutting speed, with a 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



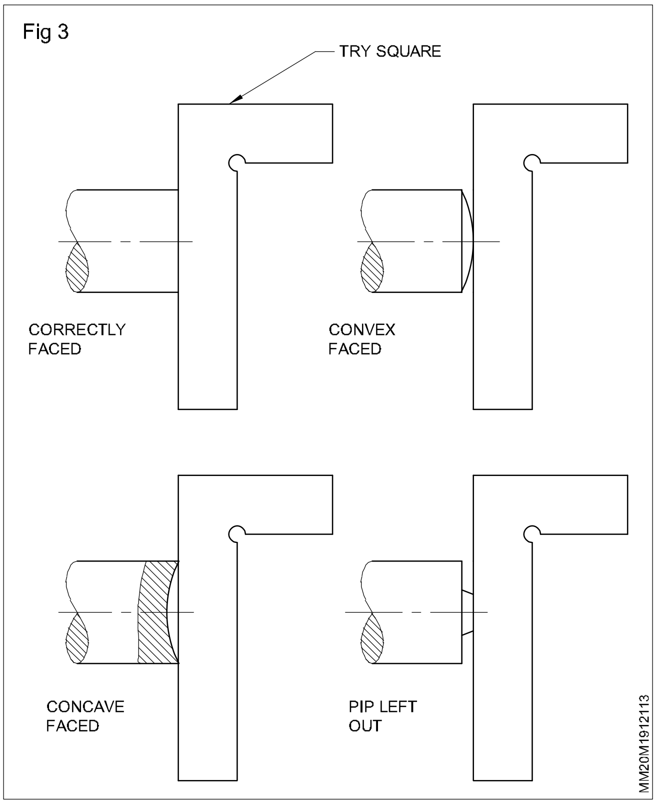
The following are the defects found in facing work (Fig 3)

A concave face: This is caused by the tool digging into the work during the feeding as the tool is not clamped rigidly. By clamping the tool rigidly with minimum overhang, this defect can be avoided.

A convex face: This is caused by the blunt cutting edge of the tool and the carriage not being locked. To avoid this defect, re-sharpen the tool and use it; Also lock the carriage to the bed of the lathe.

A pip left in the centre : This is due to the tool not being set to the correct centre height. By placing the tool to the centre height, this defect can be avoided.

Clamp the tailstock in position by tightening the tailstock clamp nut.



Rough turning tools: Rough turning tools are tools for removing large amounts of material from a workpiece in one go. That's why they are often to create neat shapes or to prepare surface for later finishing operations. (Fig 4)