MACHINIST GRINDER

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 : **Machinist Grinder - 1st Year - Trade Theory - NSQF Level - 4 (Revised 2022)**

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FOREWORD

The Government of India has set an ambitious target of imparting skills to 30 crores people, one out of every four Indians, by 2020 to help them secure jobs as part of the National Skills Development Policy. Industrial Training Institutes (ITIs) play a vital role in this process especially in terms of providing skilled manpower. Keeping this in mind, and for providing the current industry relevant skill training to Trainees, ITI syllabus has been recently updated with the help of Media Development Committee members of various stakeholders viz. Industries, Entrepreneurs, Academicians and representatives from ITIs.

The National Instructional Media Institute (NIMI), Chennai, has now come up with instructional material to suit the revised curriculum for **Machinist Grinder - Trade Theory 1st Year NSQF Level - 4 (Revised 2022)** in **Capital Goods & Manufacturing Sector** under **Yearly 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 trainees will also get the opportunities to promote life long learning and skill development. I have no doubt that with NSQF Level - 4 (Revised 2022) the trainers and trainees of ITIs, and all stakeholders will derive maximum benefits from these Instructional Media Packages IMPs and that NIMI's effort will go a long way in improving the quality of Vocational training in the country.

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

Jai Hind

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

New Delhi - 110 001

PREFACE

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

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

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

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 **Machinist Grinder - 1st year - NSQF Level - 4 (Revised 2022)** under the **Capital Goods & Manufacturing** Sector for ITIs.

MEDIA DEVELOPMENT COMMITTEE MEMBERS

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Shri.M. Sampath	-	Training officer (Retd) CTI, Chennai - 32.
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NIMI - CO-ORDINATORS

Shri. Nirmalya Nath	-	Deputy Director NIMI - Chennai - 32
Shri. V. Gopalakrishnan	-	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 **Machinist Grinder** 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**
Module 2	-	**Turning**
Module 3	-	**Basic Grinding**
Module 4	-	**Surface Grinding**
Module 5	-	**Grinding Operation**
Module 6	-	**Dry & Wet Grinding**
Module 7	-	**Bore Grinding**
Module 8	-	**Gauges**
Module 9	-	**Preventive Maintenance**

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

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

TRADE THEORY

The manual of trade theory consists of theoretical information for the Course of the **Machinist Grinder** Trade Theory NSQF Level - 4 (Revised 2022) in Plumbing. The contents are sequenced according to the practical exercise contained in NSQF Level - 4 (Revised 2022) syllabus on Trade Theory 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

S.No.	Learning Outcome	Ref.Ex.No
1	Plan and organize the work to make job as per specification applying different types of basic fitting operation and check for dimensional accuracy by using steel rule, caliper etc. [Basic Fitting operation- marking, hack sawing, chiseling, filing, drilling, reaming, taping, off-hand grinding etc. accuracy±0.25mm] following safety precautions. **(Mapped NOS: CSC/N0304)**	**1.1.01 to 1.1.29**
2	Produce simple components by setting different machine parameters and performing different lathe operation [Different machine parameters: - Cutting, speed, feed, depth of cut; Different lathe operation – Facing, plain turning, taper turning, boring and simple thread cutting.] **(Mapped NOS: CSC/N0110)**	**1.2.30 to 1.2.38**
3	Perform grinding wheel mounting, balancing, dressing, truing and set surface grinder to make job by rough & finish grinding and check accuracy with precision measuring instrument [Accuracy limit:- ±0.25mm.] **(Mapped NOS: CSC/N0109)**	**1.3.39 to 1.3.46**
4	Set cylindrical grinder to produce job/ components by performing external and internal cylindrical operation and check accuracy [Accuracy limit: - ±0.25mm.] **(Mapped NOS: CSC/N0109)**	**1.4.47 to 1.4.62**
5	Set up cylindrical grinder for automatic movement to perform different cylindrical grinding operation using different machine accessories and check accuracy [Different cylindrical grinding:- straight parallel, taper, bush eccentric; Different machine accessories: - steady rest, chuck face plate, angle plate and check accuracy limit ±0.02 mm] **(Mapped NOS: CSC/N0109)**	**1.5.63 to 1.5.76**
6	Perform dry & wet grinding to make different shaped job of various metals and check accuracy. [Different shaped job: - square block angle plate, angular block; various metal: - cast iron, steel & accuracy limit ±0.02 mm.] **(Mapped NOS: CSC/N0109)**	**1.6.77 to 1.6.80**
7	Make a component by performing bore grinding and check accuracy by telescopic gauge. [Accuracy limit ±0.02 mm.] **(Mapped NOS: CSC/N0109)**	**1.7.81 to 1.7.82**
8	Perform operations on tools & cutter grinder and resharpening different tools on pedestal grinder. [Different tools: - lathe tools, drill, tool bit] **(Mapped NOS: CSC/N0109)**	**1.7.83 to 1.7.88**
9	Make components having angular and straight surface and check accuracy with different gauges and instruments. Different gauges: - sine bar, slip gauge & DTI (dial test indicator) and accuracy limit ±0.02mm.] **(Mapped NOS: CSC/N0109)**	**1.8.89 to 1.8.93**
10	Perform preventive maintenance of grinding machines. [Grinding machines: - surface and cylindrical] **(Mapped NOS: CSC/N0109)**	**1.9.94 to 1.9.95**
11	Make job of different material by cylindrical parallel grinding with appropriate accuracy. [Different material: - soft & hard metals; Accuracy limit±0.01mm] **(Mapped NOS: CSC/N0109)**	**1.9.96**

SYLLABUS

Duration	Reference Learning Outcome	Professional Skills (Trade Practical) with Indicative hours	Professional Knowledge (Trade Theory)
Professional Skill 100 Hrs; Professional Knowledge 20 Hrs	Plan and organize the work to make job as per specification applying different types of basic fitting operation and check for dimensional accuracy by using steel rule, caliper etc. [Basic Fitting operation-marking, hack sawing, chiseling, filing, drilling, reaming, taping, off-hand grinding etc. accuracy±0.25mm] following safety precautions. **(Mapped NOS: CSC/N0304)**	1. Importance of trade training. (02 hrs) 2. List of tools & Machinery used in the trade. (02 hrs) 3. Health & Safety: Introduction to safety equipments and their uses. (02 hrs) 4. Introduction of First-aid. (01 hr) 5. Operation of Electrical mains (02 hrs) 6. Occupational Safety. (02 hrs) 7. Health Importance of housekeeping & good shop floor practices. (02 hrs) 8. Safety and Environment guidelines. Legislations & regulations as applicable. (02 hrs) 9. Disposal procedure of waste materials like cotton waste, metal chips/burrs etc. (03 hrs) 10. Personal protective Equipment's (PPE):- Basic injury prevention. (03 hrs) 11. Hazard identification and avoidance. (03 hrs) 12. Safety signs for Danger, Warning, caution & personal safety message. (02 hrs) 13. Preventive measures for electrical accidents & steps to be taken in such accidents. Use of Fire extinguishers. (02hrs)	Importance of safety and general precautions observed in the in the industry/shop floor. 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. Introduction of First aid. Operation of electrical mains. Introduction of PPEs. Introduction to 5S concept & its application. Response to emergencies e.g.; power failure, fire, and system failure. Introduction to Grinding trade and machine safety precautions according to IS: 1991-1962.(06 hrs.)
		14. Identify of tools & equipment's as per desired specifications for marking & sawing (Hand tools, Fitting tools & Measuring tools) (05 hrs) 15. Select material as per application, Inspect visually of raw material for rusting, scaling, corrosion etc. (05 hrs) 16. Mark out lines on job, (04 hrs) 17. Grip suitably in vice, cut different types of metals of different sections to given dimensions by a Hacksaw. (6 hrs) 18. Mark, punch and grind on pedestal grinder. (03 hrs)	Description of hand tools, Safety precautions, care and maintenance and material from which they are made. Ferrous and nonferrous metal and their identification by different methods. Heat treatment of metals, its importance, various methods of heat treatment such as hardening, tempering, normalizing, annealing etc. (05 hrs.)
		19. Measure different types of jobs by steel rule, caliper etc. and put dimension on freehand drawing (05 hrs)	Theory of Semi precision measuring instruments. General measuring tools

		20. Taper by angular protractor. (03 hrs)	(used in grinding shop) their description, use care and maintenance. (02 hrs.)
		21 Drill different sizes of holes by hand, Ream the holes, (05 hrs) 22. Make thread in drilled holes by tap. (02 hrs) 23. Prepare thread on a round bar (02 hrs) 24. Match an internal and external thread cutting with taps and dies using coolants. (03 hrs)	Relation between drill & tap sizes, care of taps and dies and their correct use. Types, properties and selection of coolants and lubricants. (03 hrs)
		25. Drill different sizes of holes by machine. (04 hrs) 26. Use of screw drivers, spanners, pliers etc. (03 hrs) 27. Make simple fitting job within accuracy ±0.4. (5 Hrs)	Brief description of drilling machine use and care Knowledge of tool fixing and job holding device on drilling machine. (02 hrs.).
		28. File a MS flat as given dimension. (12 hrs) 29. Make simple fitting job within accuracy ±0.2. (5 Hrs)	Knowledge of different types of files according to cut and shape. Methods of filing operation. Knowledge of surface finish accuracy by filing. (02 hrs.)
Professional Skill 80 Hrs; Professional Knowledge 22 Hrs	Produce simple components by setting different machine parameters and performing different lathe operation [Different machine parameters: - Cutting, speed, feed, depth of cut; Different lathe operation – Facing, plain turning, taper turning, boring and simple thread cutting.] **(Mapped NOS: CSC/ N0110)**	30. Identify Centre lathe and its parts, (04 hrs) 31. Set lathe machine and perform on lathe operation with idle or dry run. (10 hrs) 32. Grind Lathe Tools on Pedestal Grinder. (10 hrs)	Brief description of a Centre lathe, its use. Knowledge of transmission of speed from motor to spindle of a lathe. Knowledge of aligning a job on lathe. Lathe tools nomenclature. (07 hrs.)
		33. Perform facing and turning on lathe. (05 hrs) 34. Perform drilling operation on lathe. (05 hrs) 35. Perform taper turning using compound rest and taper turning attachment. (05 hrs) 36. Perform boring operation on lathe. (11 hrs)	Knowledge of controlling cutting speed, feed and depth of cut. Lathe tools and their uses. Selection of tools for different operation in lathe. Taper and its types and problems. Taper turning methods and calculations. i.e. Form tool, TT attachment, Compound rest etc. (08 hrs.)
		37. Perform simple external screw cutting. (15 hrs) 38. Perform simple internal screw cutting. (15 hrs)	Method of screw cutting and simple calculation. Knowledge of spindle speed mechanism related to lead screw of lathe. (07 hrs.)
Professional Skill 100 Hrs; Professional Knowledge 20 Hrs	Perform grinding wheel mounting, balancing, dressing, truing and set surface	39. Set grinding wheel on wheel flange, truing and balancing of wheels. (20 hrs) 40. Dress grinding wheel. (05 hrs)	Application and use of pedestal grinder. General dressing tools used in grinding section such as wheel, diamond dresser, steel type dresser, abrasive dresser and nonferrous dresser. (05 hrs.)

	grinder to make job by rough & finish grinding and check accuracy with precision measuring instrument [Accuracy limit:- ±0.25mm.] **(Mapped NOS: CSC/N0109)**	41.Check and measure various types of jobs using micrometers, Vernier caliper, Height gauge etc. (10 hrs) 42. Identify different parts of surface grinding machine. (10 hrs) 43. Set surface grinding machine and perform operating with dry / idle run. (12 hrs)	Precision measuring instruments English and metric micrometer, vernier caliper, dial test indicator etc. their description and uses. Knowledge of digital measuring instruments and its uses. Pneumatic gauges – its accessories and control device and use for checking dimensions. (06 hrs.)
		44.Perform rough and finish grinding on surface work. (15 hrs) 45.Perform rough and finish grinding on cylindrical job. (20 hrs) 46.Include diamond and CBN grinding wheel. (08 hrs)	Different types of abrasive, manufacture of grinding wheels, their grades. (09 hrs.)
Professional Skill 90 Hrs; Professional Knowledge 20 Hrs	Set cylindrical grinder to produce job/ components by performing external and internal cylindrical operation and check accuracy [Accuracy limit: - ±0.25mm.] **(Mapped NOS: CSC/N0109)**	47. Perform grinding on surface grinding machine. (07 hrs) 48.Identify different parts of cylindrical grinding machine. (02 hrs) 49.Set cylindrical grinding machine and perform operation with dry / idle run. (07 hrs) 50. Perform grinding on Cylindrical grinding machine (Grinding should be performed both on soft and hardened materials). (07 hrs)	Principle and value of grinding in finishing process, various types of grinding wheels their construction and characteristic glazed and loaded wheels. (03 hrs.)
		51. Grind parallel block within accuracy ±0.2mm. (06 hrs) 52. Perform Plain-mandrel grinding to size within accuracy ± 0.2. (06 hrs)	Knowledge how to square up a workpiece using an angle plate. Checking of squareness. Multiple clamping of parts to achieve concentricity & uniformity in size. (04 hrs.)
		53. Demonstrate selection of grinding wheels for grinding different metals. (03 hrs) 54. Select of suitable wheel to obtain rough and IS: 1249-1958. (03 hrs)	Factors effecting selection of wheels, identification of wheel, marking system of grinding wheels IS: 551- 1966. (03 hrs.)
		55. Grind different metals with suitable grinding wheels. (24 hrs)	Grit and different types of bonds, such as vitrified, resinoid, rubber etc. Different types of metals and electroplated bond. (05 hrs.)
		56. Perform externals cylindrical grinding operation within accuracy ± 0.1mm. (03 hrs) 57. Perform internal cylindrical grinding operation within accuracy ± 0.1mm. (03 hrs) 58. Change the recommended wheel speed and control depth of cut. (02 hrs)	Grinding wheel speed, surface speed per minute conversion of peripheral speed to r.p.m. Depth of cut and range at usefulness. Depth micrometer and vernier caliper. Common types of surface grinding machine, plain surface, rotary surface, horizontal and vertical surface grinder etc. Method of grinding tapers. (05 hrs.)

		59. Perform grinding of sockets both internal and external and check. (05 hrs) 60. Perform Morse taper grinding both internal and external and check. (05 hrs) 61. Perform grinding External sleeve and check. (05 hrs) 62. Perform depth checking by depth gaugemicrometer. (02 hrs)	
Professional Skill 200 Hrs; Professional Knowledge 30 Hrs	Set up cylindrical grinder for automatic movement to perform different cylindrical grinding operation using different machine accessories and check accuracy [Different cylindrical grinding:- straight parallel, taper, bush eccentric; Different machine accessories: - steady rest, chuck face plate,angle plate and check accuracy limit ±0.02 mm] **(Mapped NOS: CSC/N0109)**	63. Revise previous works. (05 hrs) 64. Perform machine setting for automatic movements. (10 hrs) 65. Perform parallel grinding on cylindrical grinder. (15 hrs)	Introduction TrainingRevision of previous works. Common types of grinding machines. Plain cylindrical external and internal cylindrical grinder and universal grinder. (04 hrs.)
		66. Test and mount wheels, sleeves, check truing and rebalancing. (15 hrs) 67. Perform grinding parallel mandrel within ± 0.03mm. (10 hrs)	Test for alignment and checking, balancing at wheel, dressing different types of wheel, dressers, their description and uses. (04 hrs.)
		68.Perform wheel balance and dressing grinding long bar using steady rest. (25 hrs)	Test for alignment and checking, balancing of wheel, dressing different types of wheel, dressers their description and uses. (03 hrs.)
		69. Perform grinding different types of jobs using machine chuck, face angle plate collets. (25 hrs)	Holding devices such as Magnetic chuck, chucks and face plates collets their description and uses. Method of holding jobs on magnetic chuck, face plate and chucks. (03 hrs.)
		70. Align table with the help of test bar and dial test indicator. (05 hrs) 71. Perform parallel grinding within accuracy ±0.02mm. (05 hrs) 72. Perform cylindrical Taper grinding (by swiveling machine table) (10 hrs) 73.Grind an eccentric job. (10 hrs) 74. Finish different types of jobs using jigs and fixtures, angle plates by grinding. (15 hrs)	External grinding operational steps in external grinding of a job and precautions to be taken. (04 hrs.) Holding devices such as jig and fixture angle plates 'V' blocks etc. their description and uses. (04 hrs.)
		75. Perform grinding of job by using face plate angle plate etc. (25 hrs,)	Internal grinding operational steps in internal grinding of a job precautions to be taken. (03 hrs.)
		76. Finish surfaces of bushes on mandrel within ±0.02 mm by grinding. (25 hrs)	Rough and finish grinding limit fit and tolerances as per ISI: 919-1963. Basic size and its deviation, position of tolerances as per ISI: 919-1963. Basic size and its deviation, position

			of tolerance zones with respect of zero line. Fits different types clearance, interference and transition. Interchangeable system. Letter symbols for holes and shaft and fundamental deviation hole basis and shaft basis system. (05 hrs.)
Professional Skill 40 Hrs; Professional Knowledge 10 Hrs	Perform dry & wet grinding to make different shaped job of various metals and check accuracy. [Different shaped job: - square block angle plate, angular block; various metal: - cast iron, steel & accuracy limit ±0.02 mm.] **(Mapped NOS: CSC/N0109)**	77.Perform dry and wet grinding of different classes of metals such as cast iron, brazed carbide tip and different classes of steel. (22 hrs)	Heat generated in grinding dry and wet grinding use of coolant, their composition and selection. Characteristic of coolant. (05 hrs.)
		78. Grind square block within accuracy ±0.02mm. (06 hrs) 79. Grind angle plate within accuracy ±0.02mm (06 hrs) 80.Grind angular block within accuracy ±0.02mm. (06 hrs)	Grinding a square job grinding angular surface taker grinding by stane land taper and angle protractor. (05hrs.)
Professional Skill 25 Hrs; Professional Knowledge 05 Hrs	Make a component by performing bore grinding and check accuracy by telescopic gauge. [Accuracy limit ±0.02 mm.] **Mapped NOS: CSC/N0109)**	81.Perform bore grinding withinaccuracy ±0.02mm. (13 hrs) 82.Use of Telescopic gauge for checking of bore. (12 hrs)	Grinding defects vibration, chattering, glazing and loading their causes and remedies. (05 hrs.)
Professional Skill 25 Hrs; Professional Knowledge 05 Hrs	Perform operations on tools & cutter grinder and resharpening different tools on pedestal grinder. [Different tools: - lathe tools, drill, tool bit] (Mapped NOS: CSC/N0109)	83.Perform operation on tools and cutter grinding machine. (09 hrs) 84.Manipulate and control tools and cutter grinding machine (05 hrs) 85.Mount jobs on mandrel in tools and cutter grinding machine. (02 hrs) 86. Mount wheel and guards on pedestal grinder. (02 hrs) 87.Sharpen lathe tools on pedestal grinder. (02 hrs) 88.Sharpen drill, tool-bit on pedestal grinder. (05 hrs)	Tool and cutter grinding machine-parts and accessories, description use, care and maintenance, pedestal grinder and bench grinder-their description and uses. (05 hrs.)
Professional Skill 100 Hrs; Professional Knowledge 16 Hrs	Make components having angular and straight surface and check accuracy with different gauges and instruments. [Different components: - V' block, parallel bar, drill point angle; Different gauges: - sine bar, slip gauge & DTI (dial test indicator) and accuracy limit ±0.02 mm.]	89. Check tapered or angular jobs with help of sine bar, slip gauges and dial gauge. (23 hrs)	Use of snap gauges, sine bar and slip gauges their description and uses. Polishing, lapping powder and emery clothes lapping flat surface. (04 hrs.)
		90. Perform cylindrical and surfaces grinding operation (25 hrs)	Tools and cutter grinder their description, workin principles, operations care and maintenance. (04 hrs.)
		91. Perform step grinding on cylindrical grinding machine. (25 hrs)	Special types of grinding machines and centreless grinders. Their description, working principles, operations, care and maintenance. (04 hrs.)

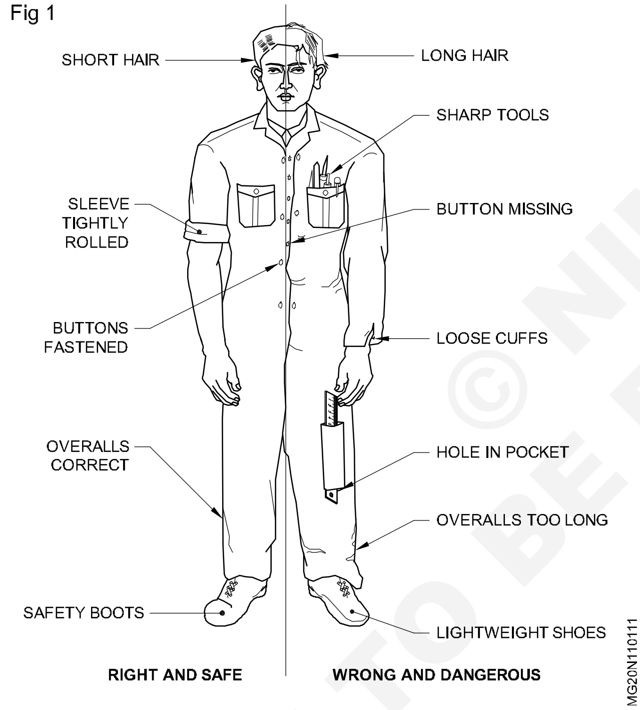
	(Mapped NOS: CSC/N0109)	92. Grind Parallel block on surface grinding machine (12 hrs) 93. Grind gauges within finish accuracy ±0.02mm. (Rough and finish grinding using disc and diamond wheels). (15 hrs)	Diamond Wheel and Applications of diamond wheel in grinding. (04hrs.)
Professional Skill 30 Hrs; Professional Knowledge 06 Hrs	Perform preventive maintenance of grinding machines. [Grinding machines: - surface and cylindrical] (Mapped NOS: CSC/N0109)	94. Make simple utility jobs suchas V' block, Parallel bar, Drill point angle checking gauge with surface and cylindrical grinders. (12 hrs) 95.Perform preventive maintenance of grinding machines. (18 hrs)	Preventive maintenance and its necessity. Mode of frequency of lubrication. Preparation of Maintenance schedule, simple estimation, use of hand book and reference table. Total preventive Maintenance. (06hrs.)
Professional Skill 50 Hrs; Professional Knowledge 12 Hrs	Make job of different material by cylindrical parallel grinding with appropriate accuracy. [Different material: - soft & hard metals; Accuracy limit±0.01mm] (Mapped NOS: CSC/N0109)	96. Finish cylindrical surfaces by grinding within accuracy ±0.01mm (Maintaining parallelism) on both soft and hard metals. (50 hrs)	Cylindrical grinding machine, its parts, use care and maintenance surface grinding machine-its parts use care and maintenance Universal cylindrical grinding machines parts description use, care and maintenance. Internal grinding machine and its parts their description, use care and maintenance. (12 hrs.)

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

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

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

Fig 1



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

- General safety
- Personal safety
- Machine safety

General safety

Keep the floor and gangways clean and clear.

Move with care in the workshop, do not run.

Don't leave the machine which is in motion.

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

Don't walk under suspended loads.

Don't cut practical jokes while on work.

Use the correct tools for the job.

Keep the tools at their proper place.

Wipe out split oil immediately.

Replace worn out or damaged tools immediately.

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

Ensure adequate light in the workshop.

Clean the machine only when it is not in motion.

Sweep away the metal cuttings.

Know everything about the machine before you start it.

Personal safety

Wear a one piece overall or boiler suit.

Keep the overall buttons fastened.

Don't use ties and scarves.

Roll up the sleeves tightly above the elbow.

Wear safety shoes or boots

Cut the hair short.

Don't wear a ring, watch or chain.

Never lean on the machine.

Don't clean hands in the coolant fluid.

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

Don't use cracked or chipped tools.

Don't start the machine until

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

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

Never touch the electrical equipment with wet hands.

Don't use any faulty electrical equipment.

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

Concentrate on your work. Have a calm attitude.

Do things in a methodical way.

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

Don't distract the attention of others.

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

Machine safety

Switch off the machine immediately if something goes wrong.

Keep the machine clean.

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

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

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

Stop the machine before changing the speed.

Disengage the automatic feeds before switching off.

Check the oil level before starting the machine.

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

Take measurements only after stopping the machine.

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

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

Familiarisation industrial training institute in India

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

Introduction to ITI

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

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

The objectives of an ITI

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

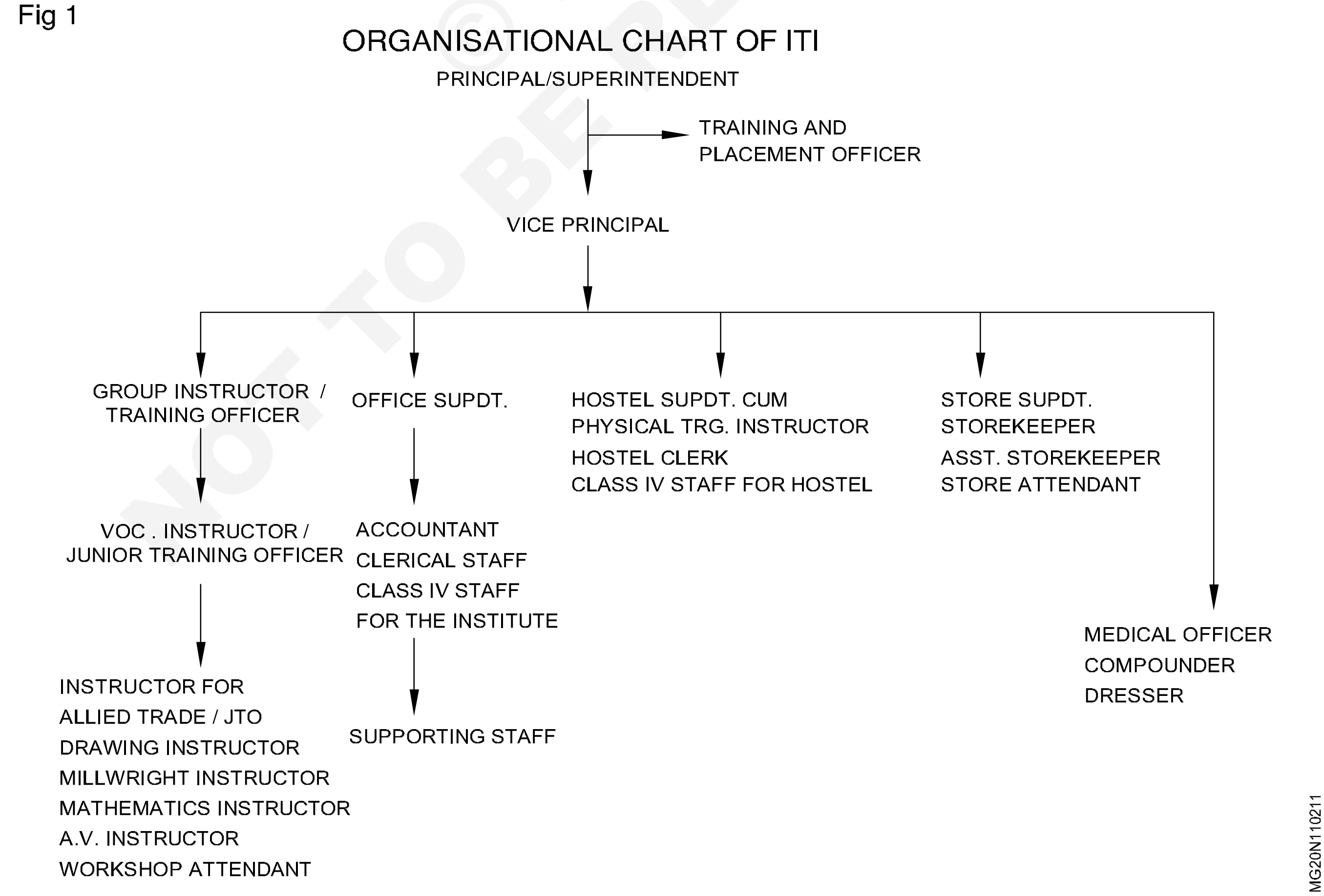
The institute imparts training in engineering and non-engineering two years/ one-year trade courses approved by the Government of India in consultation with the National Council for Vocational Training, New Delhi.

Structure of ITI

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

In every ITI there is a store and the in-charge 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.

Fig 1



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.

Various job available in different industries in India and abroad

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

Opportunity of job after training

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

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

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

Approach on soft skills

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

Concept

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

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

Common soft skills

Strong work ethic

Positive attitude

Good communication skills

Interpersonal skills

Time management abilities

Problem-solving Skills

Team work

Initiative, Motivation

Self-confidence

Loyalty

Ability to accept and learn from criticism

Flexibility adaptability

Working well under pressure

First-aid

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

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

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

Important guideline for first aiders

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

Remember A-B-Cs

The ABCs of first aid refer to the three critical things the first aiders need to look for.

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

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

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

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

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

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

Fig 1

Look, listen and feel for signs of breathing

Look for the victim's chest to raise and fall, listen for sounds of breathing.

If the victim is not breathing, see the section below

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

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

Treat bleeding, shock and other problems as needed

After establishing that the victim is breathing and has a pulse, next priority should be to control any bleeding. Particularly in the case of trauma, preventing shock is the priority.

- **Stop bleeding:** Control of bleeding is one of the most important things to save a trauma victim. Use direct pressure on a wound before trying any other method of managing bleeding.
- **Treat shock:** Shock, a loss of blood flow from the body, frequently follows physical and occasionally psychological trauma. A person in shock will frequently have ice cold skin, be agitated or have an altered mental

status, and have pale colour to the skin around the face and lips. Untreated, shock can be fatal. Anyone who has suffered a severe injury or life-threatening situation is at risk for shock.

- **Choking victim:** Choking can cause death or permanent brain damage within minutes.
- **Treat a burn:** Treat first and second degree burns by immersing or flushing with cool water. Don't use creams, butter or other ointments, and do not pop blisters. Third degree burns should be covered with a damp cloth. Remove clothing and jewellery from the burn, but do not try to remove charred clothing that is stuck to burns.
- **Treat a concussion:** If the victim has suffered a blow to the head, look for signs of concussion. Common symptoms are: loss of consciousness following the injury, disorientation or memory impairment, vertigo, nausea, and lethargy.
- **Treat a spinal injury victim:** If a spinal injury is suspected, it is especially critical, not move the victim's head, neck or back unless they are in immediate danger.

Stay with the victim until help arrives: Try to be a calming presence for the victim until assistance can arrive.

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

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

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

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

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

First aid

- Call EMERGENCY number.
- Check the person's airway, breathing, and pulse frequently. If necessary, begin rescue breathing and CPR.
- If the person is breathing and lying on the back and after ruling out spinal injury, carefully roll the person onto the side, preferably left side. Bend the top leg so both hip and knee are at right angles. Gently tilt the head back to keep the airway open. If breathing or pulse stops at any time, roll the person on to his back and begin CPR.
- If there is a spinal injury, the victims position may have to be carefully assessed. If the person vomits, roll the entire body at one time to the side. Support the neck and back to keep the head and body in the same position while you roll.
- Keep the person warm until medical help arrives.
- If you see a person fainting, try to prevent a fall. Lay the person flat on the floor and raise the level of feet above and support.
- If fainting is likely due to low blood sugar, give the person something sweet to eat or drink when they become conscious.

DO NOT

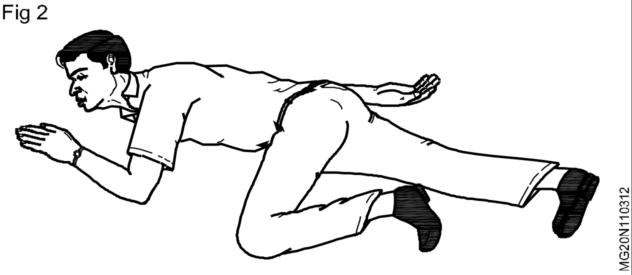
- Do not give an unconscious person any food or drink.
- Do not leave the person alone.
- Do not place a pillow under the head of an unconscious person.
- Do not slap an unconscious person's face or splash water on the face to try to revive him.

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

How to diagnose an unconscious injured person

- **Consider alcohol:** look for signs of drinking, like empty bottles or the smell of alcohol.
- **Consider epilepsy:** are there signs of a violent seizure, such as saliva around the mouth or a generally disheveled scene?
- **Think insulin:** might the person be suffering from insulin shock (see 'How to diagnose and treat insulin shock")?

Fig 2



- **Think about drugs:** was there an overdose? Or might the person have under dosed - that is not taken enough of a prescribed medication?
- **Consider trauma:** is the person physically injured?
- **Look for signs of infection:** redness and/ or red streaks around a wound.
- **Look around for signs of Poison:** an empty bottle of pills or a snakebite wound.
- **Consider the possibility of psychological trauma:** might the person have a psychological disorder of some sort?
- Consider stroke, particularly for elderly people.
- Treat according to what you diagnose.

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

Operation of electrical mains

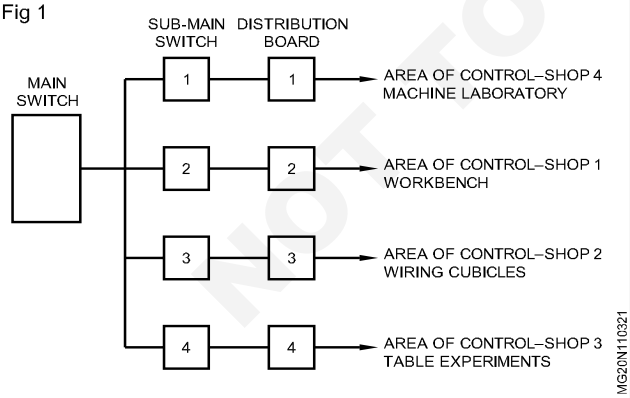
Objectives: At the end of this lesson you shall be able to
- **explain the term 'emergency'**
- **explain the need to switch off the circuit during emergency**
- **explain the method of locating the area sub-main and switches in the shop floor**
- **explain the position of handle with respect to ON &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

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

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

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

Fig 1



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

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

Fig 2

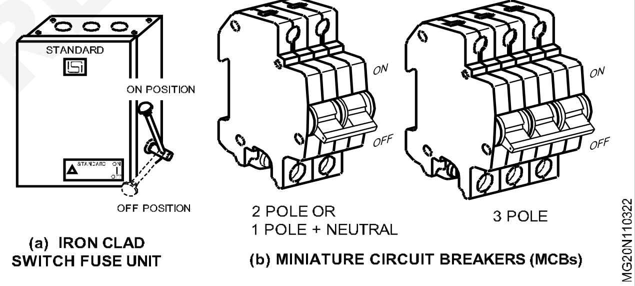
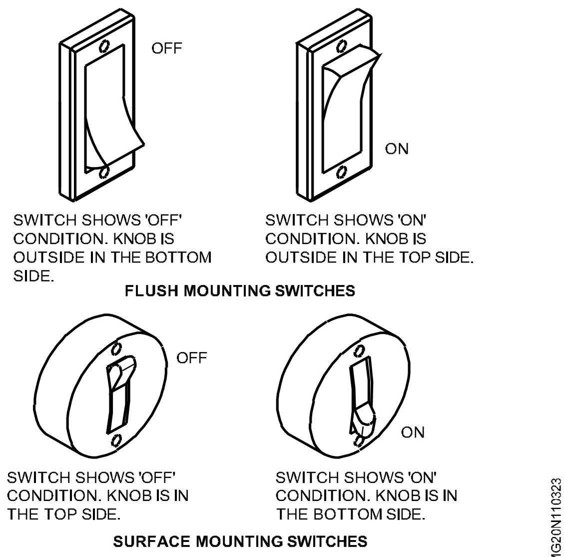


Fig 3



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

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

Electrical safety

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

Safety rules

Necessity of safety rules: Safety consciousness is one of the essential attitudes required for any job. A skilled electrician always should strive to form safe working habits. Safe working habits always save men, money and material. 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 film ground.
- While using a ladder, ask the helper to hold the ladder against any possible slipping.
- Always use safety belts while working on poles or high rise points.
- Never place your hands on any moving part of rotating machine and never work around moving shafts or pulleys of motor or generator with loose shirt sleeves or dangling neck ties.
- Only after identifying the procedure of operation, operate any machine or apparatus.
- Run cables or cords through wooden partitions or floor after inserting insulating porcelain tubes.
- Connections in the electrical apparatus should be tight. Loosely connected cables will heat up and end in fire hazards.
- Use always earth connection for all electrical appliances along with 3-pin sockets and plugs.
- While working on dead circuits remove the fuse grips; keep them under safe custody and also display 'Men on line' board on the switchboard.
- Do not meddle with inter locks of machines/switch gears
- Do not connect earthling to the water pipe lines.
- Do not use water on electrical equipment.
- Discharge static voltage in HV lines/equipment and capacitors before working on them.

Personal Protective Equipment (PPE)

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

Personal protective equipment

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

Categories of PPE-Small's'

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

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

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

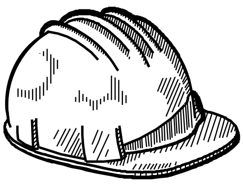
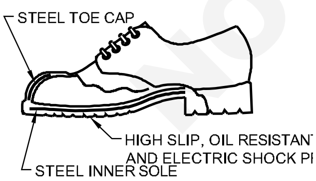
They are to meet the applicable BIS (Bureau of Indian Standards) standards for different types of PPE.

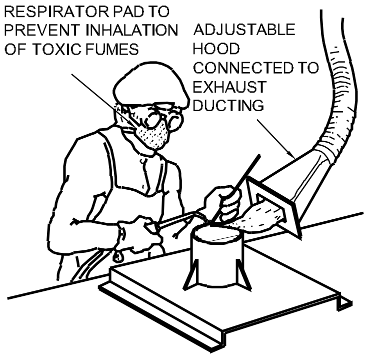
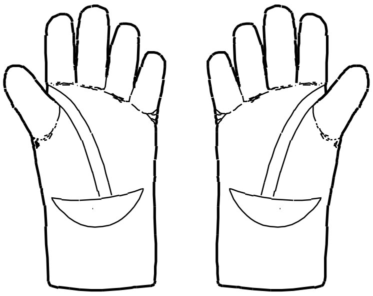
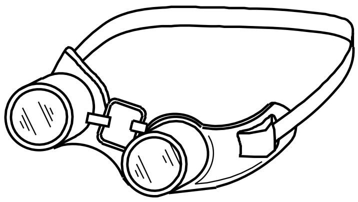
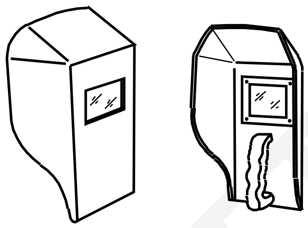
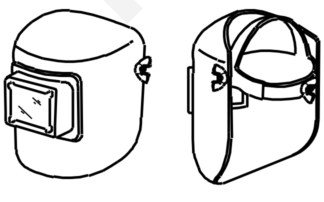
The guidelines on 'Personal Protective Equipment' is issued to facilitate the plant management in maintaining an effective programmer with respect to protection of persons against hazards, which cannot be eliminated or controlled by engineering methods listed in table 1.

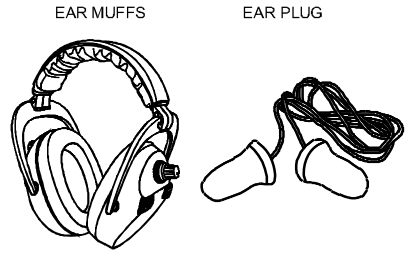
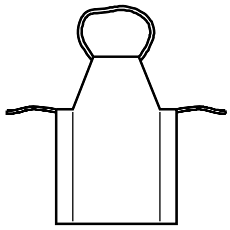
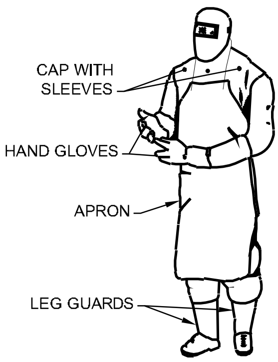
Table 1

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

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

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

Types of protection	Hazards	PPE to be used
Nose (Fig 3)  	1. Dust particles 2. Fumes/gases/ vapors	Nose mask
Hand Protection (Fig 4)  GLOVES	1. Heat burn due to direct contact 2. Blows spark moderate heat 3. Electric shock	Hand gloves
Eye protection (Fig 5 & Fig6)   HAND SCREEN	1. Flying dust particles 2. UV rays, IR rays heat and High amount of visible	Goggles Face shield radiation Hand shield Head shield
Face protection (Fig 7)  WELDING HELMET	1 Spark generated during Welding, grinding 2 Welding spatter striking 3 Face protection from UV rays	Face shield Head shield with or without ear muff Helmets with welders Screen for welders

Types of protection	Hazards	PPE to be used
Ear protection (Fig 8) 	1. High noise level	Ear plug Ear muff
Body protection (Fig 9, & Fig 10)  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
- Ease of maintenance and cleaning
- Conformity to Indian / International standards and availability of test certificate.

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

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

Introduction to 5S concept & its application

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

Benefits of a shop floor maintenance

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

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

5S Concept

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

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

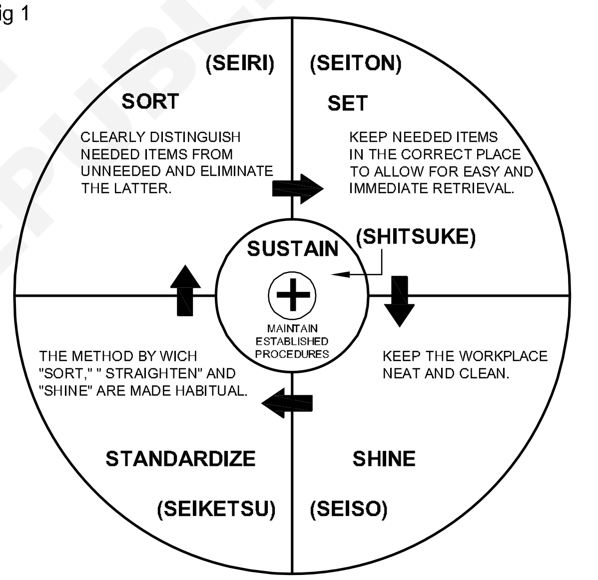
The list describes how to organize a work space for efficiency and effectiveness by identifying and stroing the items used, maintaining the area and items, and sustaining the new order.

5S Wheel

The Benefits of the 5s system

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

Fig 1



5S WHEEL

Importance of housekeeping

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

House keeping

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

- **Cleaning of shop floor:** Keep clean and free from accumulation of dirt and scrap daily
- **Cleaning of machines:** Reduce accidents by keeping machines cleaned well
- **Prevention of leakage and spillage:** Use splash guide in machine and collecting tray
- **Disposal of scrap:** Empty scrap, wastage, swarf from respective containers regularly
- **Tools storage -** Use special racks, holders for respective tools

- **Storage spaces:** Identify storage areas for respective same do not leave any material in gangway
- **Filling methods-** Do not overload platform, floor and keep material at safe height.
- **Material handling:** Use forklifts, conveyors and hoist according to the volume and weight of the package.

Good shop floor practices followed in industry

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

Response to emergencies - Power failure, fire and System failure

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

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

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

2 System failure

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

1. Assassin bug
2. Lightening bug
3. Brain bug

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

3 Fire failure

When fire alarm sounds in your buildings

1. Evacuate to outside immediately.
2. Never go back
3. Make way for fire fighters and their trucks to come
4. Never use an elevator
5. Do not panic

Reporting emergency

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

Report an emergency

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

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

- A fire - If you're reporting a fire, describe how the fire started and where exactly it is located. If someone has already been injured, missing, report that as well.
- A life - threatening medical emergency, explain how the incident 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 that the emergency services can get there as quickly as possible. Give the exact street address, if you're not sure of the exact address, give approximate information like landmarked etc.

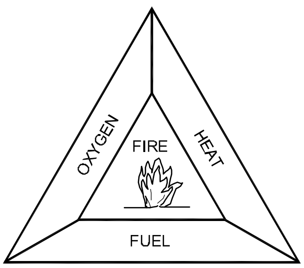
Fire extinguishers

Objectives: At the end of this lesson you shall be able to
- **state the effects of a fire breakout**
- **state the causes for fire in the workshop**
- **state the conditions required for combustion relevant to fire prevention**
- **state the general precautionary measures to be taken for fire prevention.**

Fire is the burning of combustible material. A fire in an unwanted place and on an unwanted occasion and in uncontrollable quantity can cause damage or destroy property and materials. Fires injure people, and sometimes, cause loss of life. Hence, every effort must be made to prevent fire. When a fire outbreak is discovered, it must be controlled and extinguished by immediate correct action.

Is it possible to prevent fire? Yes, by eliminating anyone of the three factors that cause fire. (Fig 1)

Fig 1



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The factors that must be present in combination for a fire to continue to burn are as follows.

Fuel Any substance, liquid, solid, or gas will burn if given oxygen and high enough temperature.

Heat Every fuel will begin to burn at a certain temperature. Solids and liquids give off vapour when heated and it is this vapour which ignites. Some liquids give off vapour even at normal room temperature say 15°C,eg. petrol.

Oxygen Usually it exists in sufficient quantity in air to keep a fire burning.

Extinguishing of fires

Isolating or removing any of these factors from the combination will extinguish the fire. There are three basic ways of achieving this.

- Starving the fire of fuel by removing the fuel in the vicinity of fire.
- Smothering - i.e by isolating the fire from the supply of oxygen by blanketing it with foam, sand etc.
- Cooling - i.e. by using water to lower the temperature.

Preventing fires

The majority of fires begin with small outbreaks which burn unnoticed until they become big fires of uncontrollable magnitude. Most of the fires could be prevented with more care and by following some rules of simple commonsense.

Accumulation of combustible refuse (cotton waste soaked with oil, scrap wood, paper, etc.) in odd corners are of fire risk. Refuse should be removed to collection points.

The cause of fire in electrical equipment is misuse or neglect. Loose connections, wrongly rated fuses or cables, overloaded circuits cause over heating which may in turn lead to fire. Damage to insulation between conductors in cables also causes fire.

Clothing and anything else which might catch fire should be kept well away from heaters. Make sure the heater is shut off at the end of a working day.

Highly flammable liquids and petroleum mixtures (Tinner, Adhesive solutions, Solvents, Kerosene, Spirit, LPG Gas etc.) should be stored in a separated place called the flammable material storage area.

Blowlamps and torches must not be left burning when they are not in use.

Classification of fires and recommended extinguishing agents.

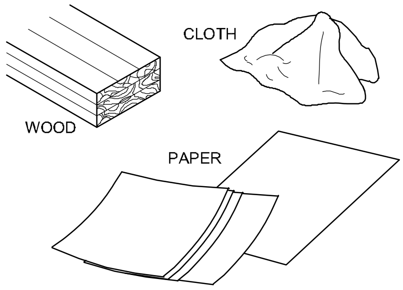
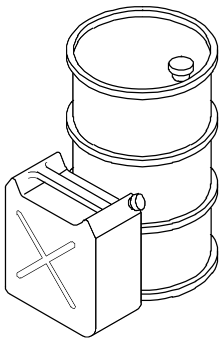
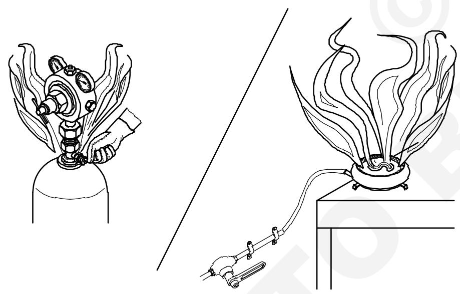
Fire are classified into four types in terms of the nature of fuel.

Different types of fire have to be dealt with different ways and with different extinguishing agents.

An agent is the material or substance used to put out the fire, and is usually (but not always) contained in a fire extinguisher with a mechanism for spraying into the fire.

It is important to know the right type of agent for a particular type of fire. Using the worng one can make things worse.

There is no classification for 'electrical fires' as such since these are only fires in materials where electricity is present.

Fuel	Extinguishing
CLASS 'A' Fire Wood, paper, cloth etc Solid materials  	Most effective i.e. cooling with water. Jets of water should be sprayed on the base of the fire and then gradually upwards.
CLASS 'B' Fire Flammable liquid. liquefiable solids 	Should be smothered. The aim is to cover the entire surface of the burning liquid. This has the effect of cutting off the supply of oxygen to the fire. Water should never be used on burning liquids. Foam, dry powder or CO_2 may be used on this type of fire.
CLASS 'C' Fire Gas and liquefied gas 	Extreme caution is necessary in dealing with liquified gases. There is a risk of explosion and sudden spreading of fire in the entire vicinity. If an appliance fed from a cylinder catches fire - shut off the supply of gas. The safest course is to raise an alarm and leave the fire to be dealt with by trained personnel. Dry powder extinguishers are used on this type of fire. Special powders have now been developed which are capable of controlling and/or extinguishing this type of fire
CLASS 'D' Fire Involving metals  	The standard range of fire extinguishing agents is inadequate or dangerous when dealing with metal fires. Fire on electrical equipment. Carbon dioxide, dry powder and vapourising liquid (CTC) extinguishers can be used to deal with fires in electrical equipment. Foam or liquid (e.g Water) extinguisher must not be used on electrical equipment under any circumstances.

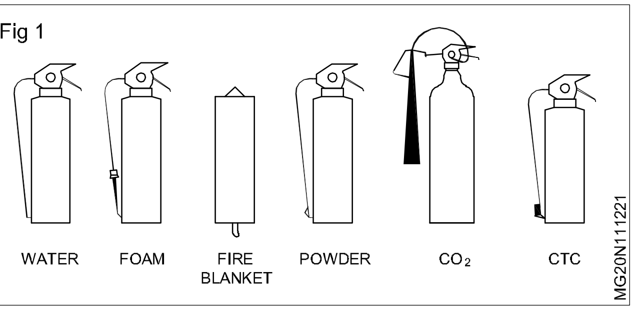
Types of fire extinguishers

Objectives : At the end of this lesson you shall be able to
- **described different types of fire extinguishers**
- **explain about correct type of fire extinguisher to be used based on the class of fire**
- **describe the general procedure to be adopted in the event of a fire.**

A fire extinguisher, flame extinguisher or simply extinguisher is an active fire protection device used to extinguish or control small fires, often in emergency situation. It is not intended for use on and out off control fire.

Many types of fire extinguishers are available with different extinguishing 'agents' to deal with different classes of fires. (Fig 1)

Fig 1



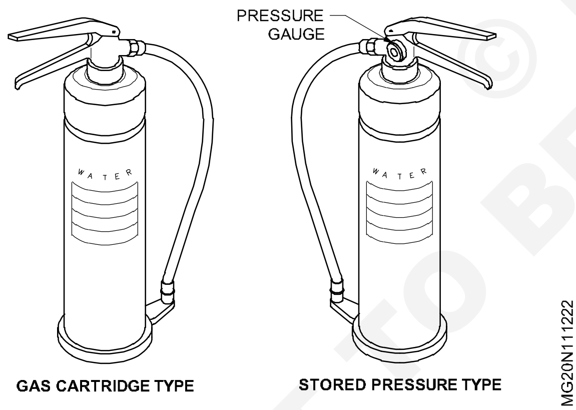
Water-filled extinguishers

There are two methods of operation. (Fig 2)

- Gas cartridge type

- Stored pressure type

Fig 2



With both methods of operation the discharge can be interrupted as required, conserving the contact and preventing unnecessary water damage.

Foam extinguishers (Fig 3)

These may be of stored pressure or gas cartridge types.

Always check the operating instructions on the extinguisher before use.

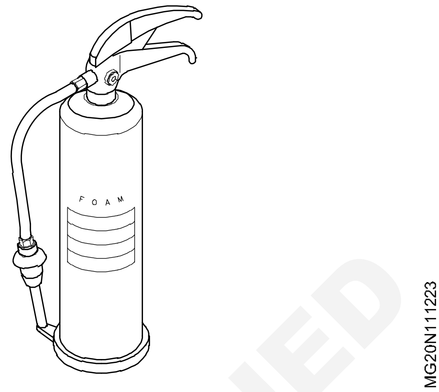
Foam extinguishers are most suitable for:

- flammable liquid fires

- running liquid fires

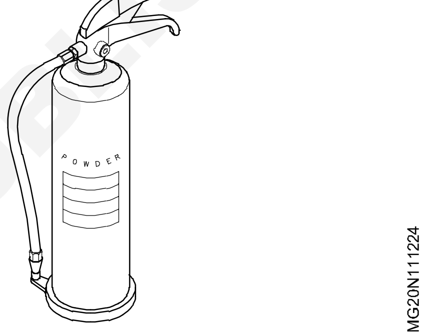
Must not be used where electrical equipment is involved.

Fig 3



Dry powder extinguishers (Fig 4)

Fig 4

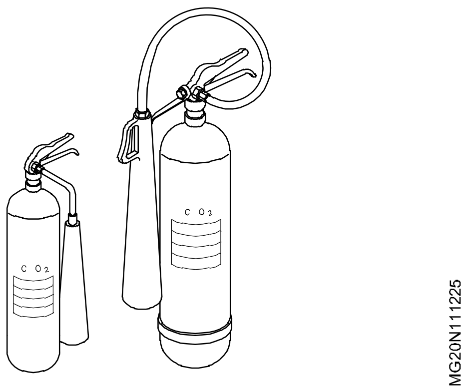


Extinguishers fitted with dry powder may be of the gas cartridge or stored pressure type. Appearance and method of operation is the same as that of the water-filled one. The main distinguishing feature is the fork- shaped nozzle. Powders have been developed to deal with class D fires.

Carbon dioxide (Co_2)

This type is easily distinguished by the distinctively shaped discharge horn. (Fig 5)

Fig 5

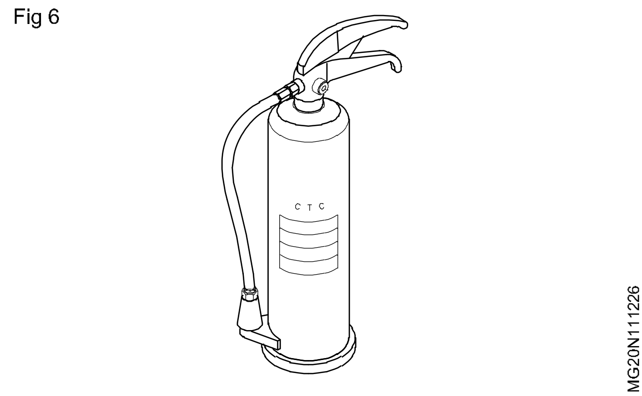


Suitable for class B fires. Best suited where contamination by deposits must be avoided. Not generally effective in open air.

Always check the operating instructions on the container before use, available with different gadgets of operation such as -plunger, lever trigger etc.

Halon extinguishers (Fig 6)

Fig 6



Theses extinguishers may be filled with carbon tetrachloride and bromochlorodifluoro methane (BCF).

They may be of either gas cartridge or stored pressure type.

They are more effective in extinguishing small fires involving pouring liquids. These extinguishers are particularly suitable and safe to use on electrical equipment as the chemicals are electrically non-conductive.

The fumes given off by these extinguishers are dangerous, especially in confined space.

General procedure to be adopted in the event of a fire to be adopted.

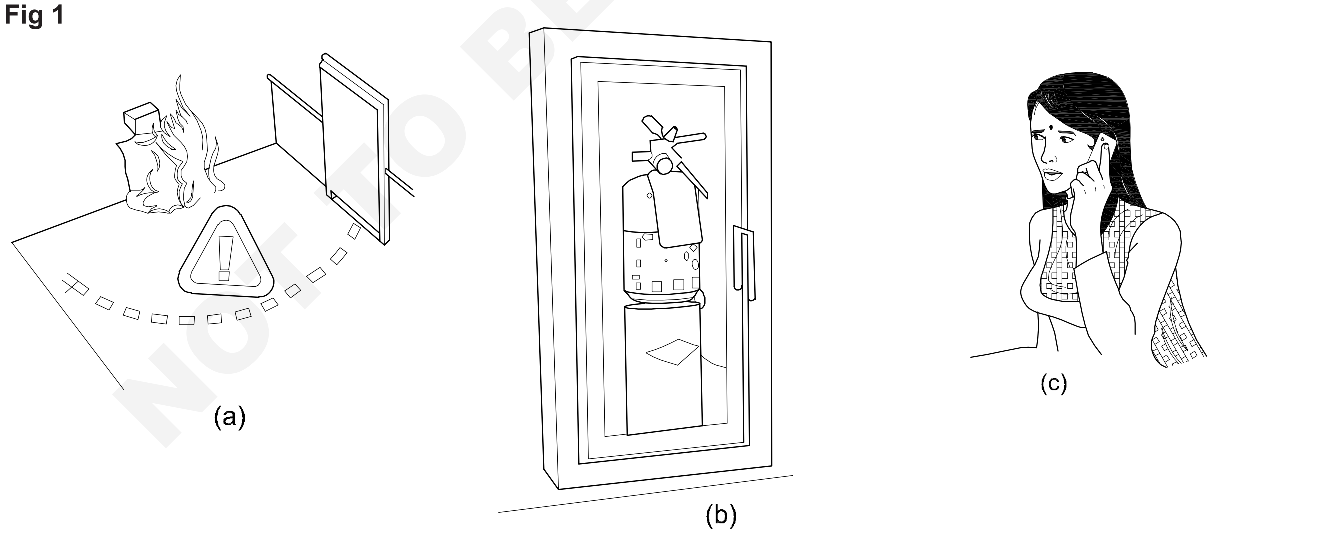
- Raise an alarm.
- Turn off all machinery and power (gas and electricity).
- Close the doors and windows, but do not lock or bolt them. This will limit the oxygen fed to the fire and prevent its spreading.
- Try to deal with the fire if you can do so safely. Do not take risk, getting in trapped.
- Anybody not involved in fighting the fire should leave calmly using the emergency exits and go to the designated assembly point. Failure to do this may mean that some person is unaccounted for and others may have to put themselves to the trouble of searching for him or her at risk to themselves.

Working on fire extinguishers

Objectives: At the end of this lesson you shall be able to
- **state about the selection of the fire extinguishers according to the type of fire**
- **state the method of operation of the fire extinguishers**
- **explain how to extinguish the fire.**

- Alert people surrounding by shouting fire, fire, fire when observe the fire (Fig 1a& b)

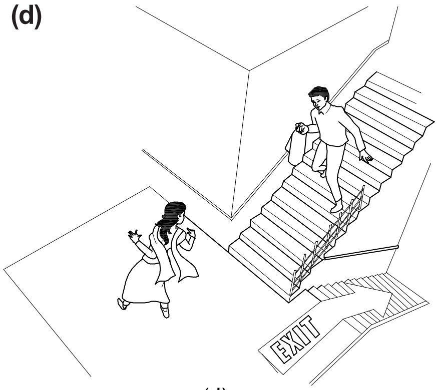
Fig 1



- Inform fire service or arrange to inform immediately. (Fig 1c)
- Open emergency exit and ask them to go away. (Fig 1d)
- Put "off" electrical power supply.

Don't allow people to go nearer to the fire.

(d)



(d)

- Analyze and identify the type of fire. Refer Table 1.

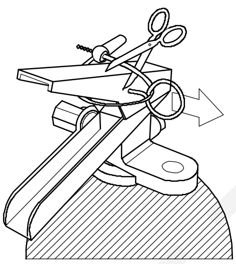
Table 1

Class 'A'	Wood, paper, cloth, soild material
Class 'B"	Oill based fire (grease gasoline, oil) liquefiable gases
Class 'C'	Gas and liquefiable gases
Class 'D'	Metals and electrical equipment

Assume the fire is 'B' Type (flammable liquefiable solids)

- Select CO_2 (Carbon di oxide) fire extinguisher.
- Locate and pick up co_2 fire extinguisher. Click for its expiry date.
- Break the seal (Fig 2)

Fig 2



BREAK THE SEAL

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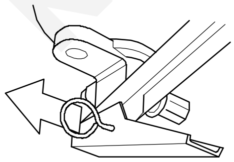
- Pull the safety pin from the handle (Pin located at the top of the fire extinguisher) (Fig 3)

Fig 3



PULL THE SAFTY PIN

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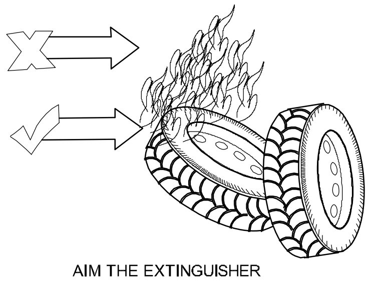
- Aim the extinguisher nozzle or hose at the base of the fire (this will remove the source of fuel fire) (Fig 4)

Keep yourself low

Fig 4



AIM THE EXTINGUISHER

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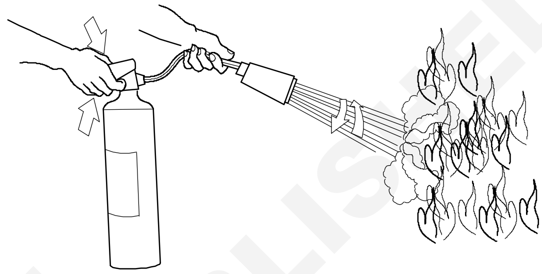
- Squeeze the handle lever slowly to discharge the agent (Fig 5)
- Sweep side to side approximately 15 cm over the fuel fire until the fire is put off (Fig 5)

Fig 5



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Fire extinguishers are manufactured for use from the distance.

Caution

While putting off fire, the fire may flare up

Do not be panicked before it is put off promptly.

If the fire doesn't respond well after you have used up the fire extinguisher move away yourself away from the fire point.

Do not attempt to put out a fire where it is emitting toxic smoke leave it for the professionals.

Remember that your life is more important than property. So don't place yourself or others at risk.

In order to remember the simple operation of the extinguisher, remember P.A.S.S. This will help you to use the fire extinguisher.

P for Pull

A for Aim

S for Squeeze

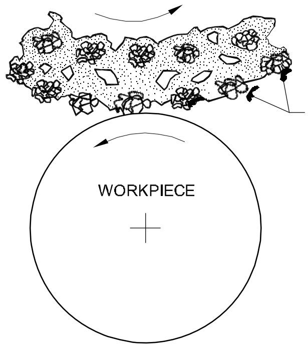
S for Sweep

Introduction to grinding trade and machine safety

Objectives: At the end of this lesson you shall be able to
- **state the importance of the grinding operation**
- **state the three basic kinds of precision grinding and their working principles**
- **state the purpose of a grinding machine**
- **name the common types of precision grinders**
- **state the safety precautions.**

Grinding is a metal cutting operation performed by means of a rotating abrasive wheel that act as a cutting (multipoint) tool (Fig 1). Mostly grinding is a finishing operation with high degree of surface quality accuracy of shape and dimension. It removes comparatively less metal (0.25 to 0.50mm) in most operations.

Fig 1



Grinding has three advantages over other metal cutting methods.

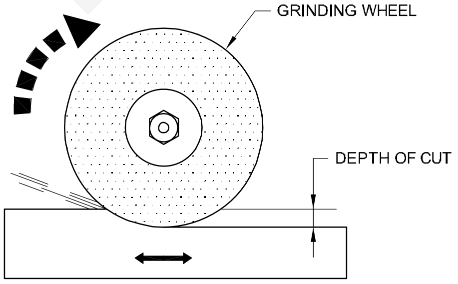
- It is the only economical method of cutting hard materials like hardened steel.
- It produces very smooth surfaces up to N4, suitable for bearing surface.
- Surface pressure is minimum in grinding. It is suitable for light work, which will spring away from the cutting tool in the other machining processes.

Types of grinding operations

There are four main grinding operations.

Surface grinding (Fig 2)

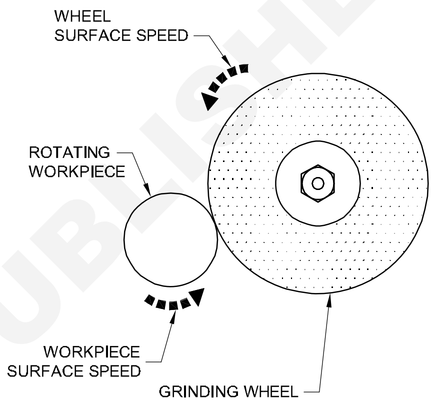
Fig 2



It is the operation of using precision grinding machines to produce flat or plain surfaces on workpieces. The workpiece is at a constant speed below the grinding wheel.

External cylindrical grinding (Fig 3)

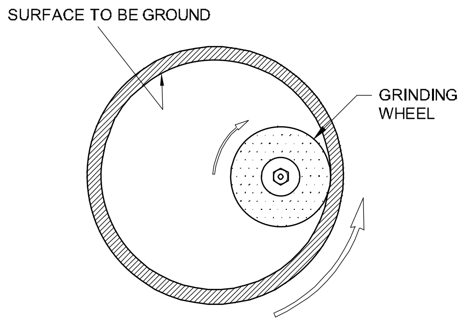
Fig 3



It produces a straight or tapered cylindrical surface. The workpiece is rotated about its own axis between centres as it passes lengthwise across the face of a revolving grinding wheel.

Internal cylindrical grinding (Fig 4)

Fig 4

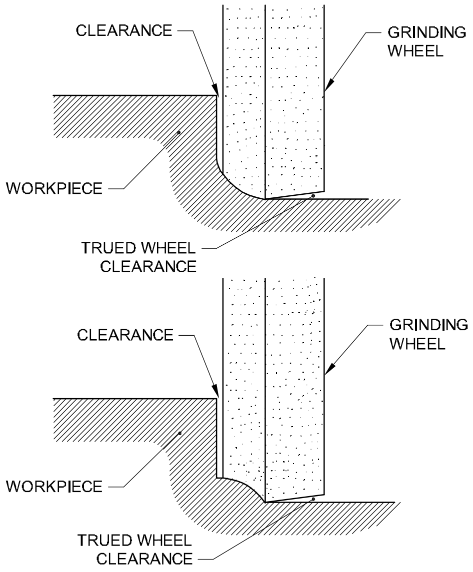


The workpieces are held in the chuck and rotated precisely about their axis. A revolving grinding wheel, smaller than the dia. of the hole to be ground, is set against the rotation of the workpiece and traverses along the surface of the hole.

Form grinding (Fig 5)

It produces formed surfaces. Specially shaped grinding wheels grind the formed surfaces as is the case in grinding gear teeth, threads, splined shafts etc.

Fig 5



RADIUS WITH INCLUDED FACES

Grinding Machines

Grinding machines are precision machine tools, designed to remove metal from a workpiece to close tolerances (up to 0.0025 mm) and to produce high quality surface finish (up to N4).

There are two major groups of grinding machines.

- Off hand or rough grinders
- Precision grinders

The common types of precision grinders are:

- Surface grinders
- Cylindrical grinders
- Tool and cutter grinders.

Surface grinders

Surface grinders are used to grind flat, parallel surfaces or stepped surfaces. The surface produced by a surface grinder is more economical and more accurate than the surface obtained by filling or scraping.

Cylindrical grinder

Cylindrical grinders are used to grind external and internal cylindrical surfaces. The cylindrical surfaces produced may be plain, tapered or stepped.

Tool and cutter grinder

A tool and cutter grinder is mainly used to sharpen single point cutting tools, milling cutters etc. It also can be used as a surface and cylindrical grinder along with some attachments.

Safety precautions

All grinding machines have parts that move at high speed.

The machines are fitted with guards to protect the operator from injury and to make operation of the machine as safe as possible.

Despite this, accidents still happen.

These accidents are usually caused by

- Ignorance
- Thoughtlessness
- Carelessness
- Lack of consideration for the safety of others.

These accidents can be prevented by thinking before doing.

Various unsafe conditions and procedures are mentioned throughout this manual. Learn to recognize them and gain a clear understanding of what should be done in each case.

The safety precautions to be taken when using grinding machines may be divided into four areas

- General
- Machine
- Personal

General safety precautions

- Keep the work area around machines free of obstacles and waste a material.
- Immediately clean up any oil, grease or coolant spilled on the floor.
- Place cleaning cloths and waste materials in the proper containers after use.
- Store hand tools and accessories away from machines after use.
- Do not handle workpieces which may be hot as a result of grinding operations.
- Use the correct hand tool for the job in hand.
- Seek assistance when handling heavy machine accessories, grinding wheels or workpieces.
- Learn the location of the nearest fire alarm.
- Learn where fire extinguishers are located and how to use them.
- Stop, look and think before starting any new operation.
- Ensure lighting is adequate.
- Always be courteous, considerate an obliging to others.

Machine safety precautions

- Operate machines only when you are authorised by your instructor to do so.
- Follow your instructor's directions carefully.
- Keep your fingers away from the moving parts of the machine.
- Do not start a machine unless all machine guards are correctly fitted.

- Make sure the workpiece is securely fitted to the worktable before starting a grinding operation.
- Do not handle the surface of the workpiece while the machine is operating.
- Do not use your hand to stop movement of any part of the machine.
- Use a brush, not your hand, to clean ground material from the workpiece and machine.
- Keep the machine free of tools, accessories and parts not being used at the time.
- When setting the worktable for automatic traverse, allow the wheel to over travel the workpiece in each direction.
- Do not clamp hardened workpiece too tightly in the jaws of a vice.
- Whenever possible, use a coolant during a grinding operation.
- If a grit exhaust system is fitted to the machine, use it all times during grinding.
- Stop the machine before cleaning or oiling it, or before making any adjustments to the accessories or to the workpiece.
- Do not leave a machine while it is still running.
- Do not touch or learn on a machine someone else is using.
- Do not divert an attention of the operator.

Personal safety precautions

- Wear goggles at all times when using a grinding machine.
- Report any injuries, however slight, to your instructor or supervisor.
- Wear close-fitting clothes.
- Avoid wearing a tie and long sleeves.
- If your hair is long, wear a protective head covering and make sure your hair is completely enclosed inside it.
- Do not wear a watch, rings or other loose ornaments.
- Do not wear gloves.
- Wipe your hands clean before operating a machine, adjusting accessories or handling a workpiece.

Description of hand tools

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

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

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

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

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

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

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

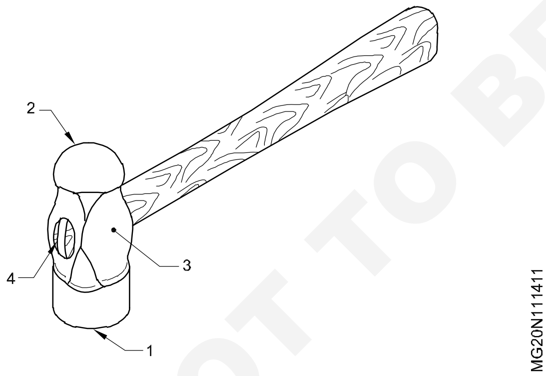
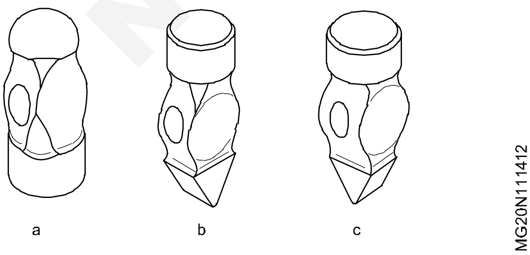


Fig 2



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

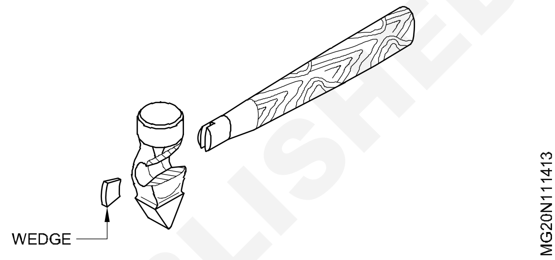
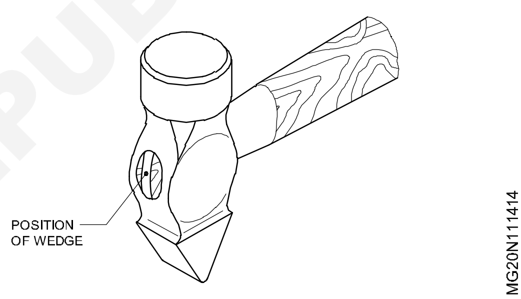
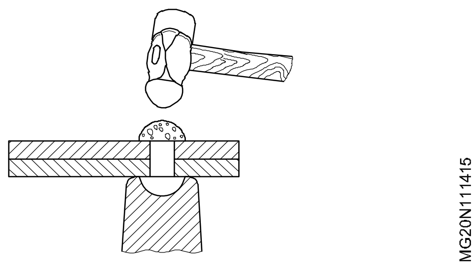


Fig 4



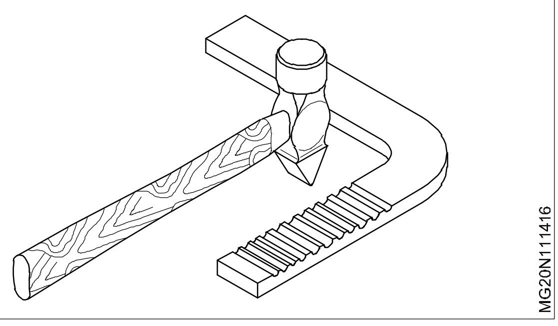
Application of hammer pein: The ball pein is used for riveting. (Fig 5)

Fig 5



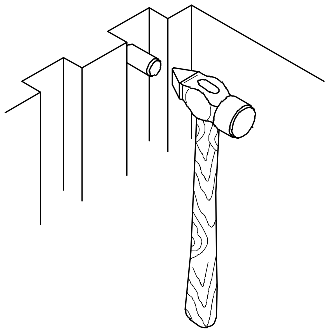
The cross- pein is used for spreading the metal in one direction. (Fig 6)

Fig 6



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

Fig 7



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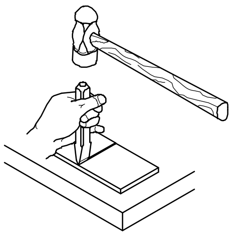
The ball pein hammer is used for driving a chisel in parting metal. (Fig 8)

Fig 8



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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, general work in a machine/ fitting shop.

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

Before using a hammer

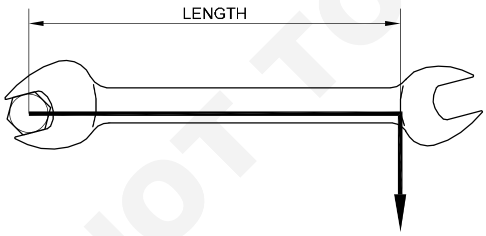
- make sure the handle is properly fitted
- select a hammer with the correct weight suitable for the job
- check the hammer head and handle whether any crack is there
- ensure that the face of the hammer is free from oil or grease.

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.**

Spanners are used for operating threaded fasteners, bolts and nuts. In doing so a turning moments or torque is exerted. This torque is applied to the bolt heads or nut is equal to the applied force multiplied by the length of the spanner. (Fig 1)

Fig 1



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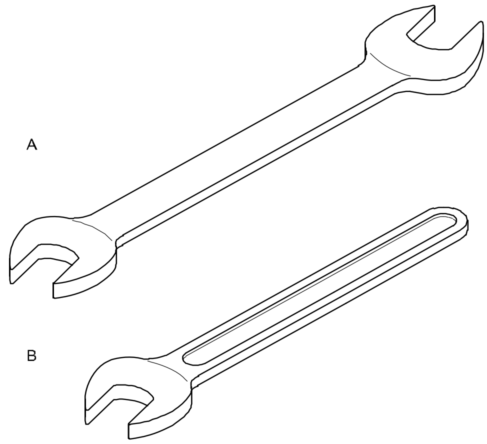
Types of spanners: Spanners vary considerably in shape to provide ease of operation under different conditions.

– Open ended spanners
– Ring spanners
– Combination spanners
– Socket wrench
– Adjustable spanners
– Torque wrench

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.

Open Ended Spanners: These spanners have successive jaw size. (Fig 2 & 3)

Fig 2



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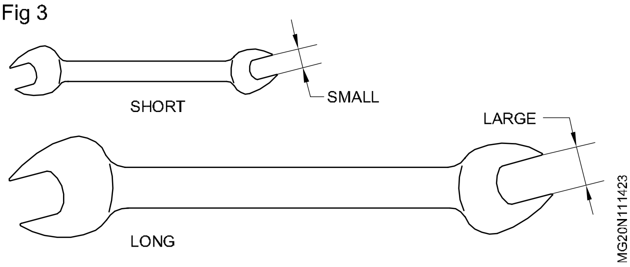
Example

If one end of the spanner is of No.7 size, then the other end will be of No.8 and the next size spanner will have 9 and 10 size and so on.

Fig 3



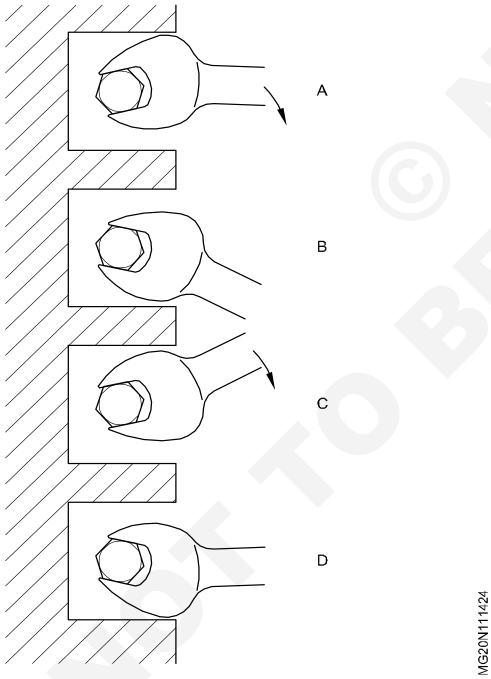
The jaws of open ended spanners are positioned at an angle to the centre line of the handle. This has been to permit tightening of nuts even when the space available allows only for a short swing. An open ended spanner can be placed on the bolt head from the side as well as from above. (Fig 4A to D)

It can be used with one hand. 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.

Single Ended Spanner (Fig 2B)**:** These are general purpose spanner. Single ended spanners are mostly supplied with machine tool for a specific purpose.

Ring spanners and combination spanners: Both heads of the ring spanners in fig 5 have an internal dodecagon (12 points) or Hexagon and as with the open ended spanners.

Fig 4



The sizes at each end are successive. Both heads are off set relative to the handle.

A ring spanner can be placed only from above the nut or bolt heads and can be used in one hand (Fig 5).

Combination spanners are shown in (Fig 6) having one side open end and the other side ring but both side having same sizes.

Fig 5

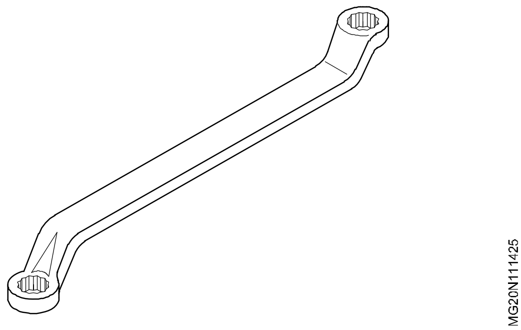
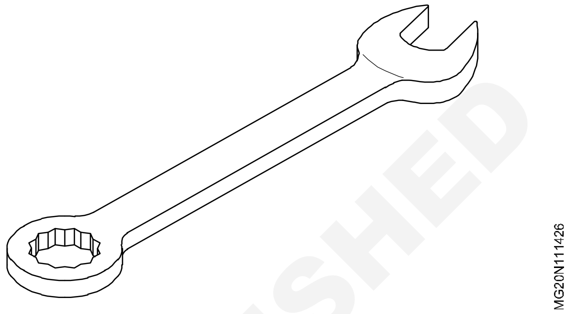


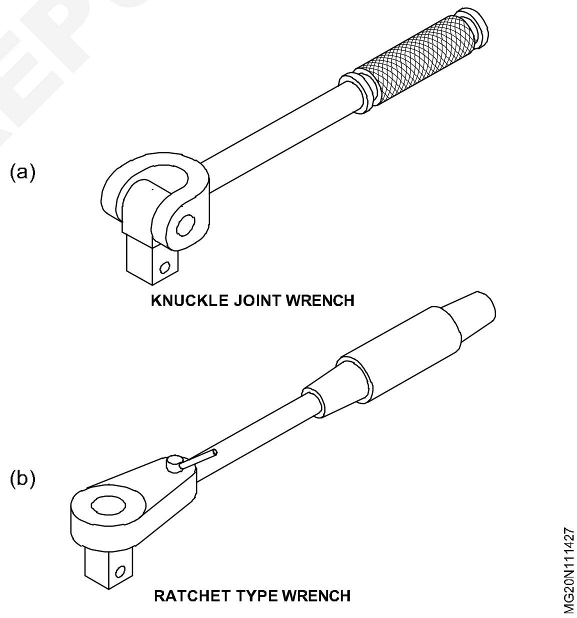
Fig 6



Socket wrenches and torque wrenches: The basic socket wrenches consists of (Ratchet or without Ratchet)

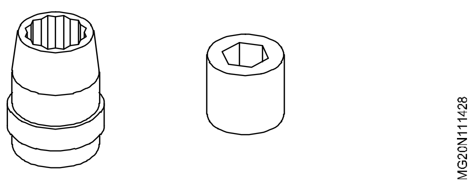
– A lever with square Tenon (6,10,12,16 mm SQ) according to the size of socket. (Fig 7a & b).

Fig 7



– A number of sockets of different sizes. (Fig 8)

Fig 8



Each socket having an internal dodecagon or Hexagon on one end an internal square on the other end.

The universal joint and extension piece make it possible to tighten nuts which are inaccessible for ring spanners and open ended spanners (Fig 9,10 & 11). In some cases socket wrenches require two handed application may be necessary. (Fig 12)

Fig 9

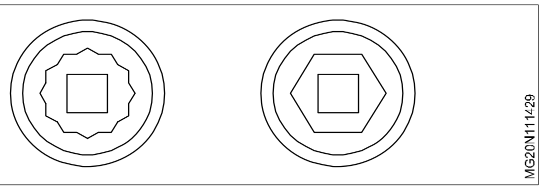
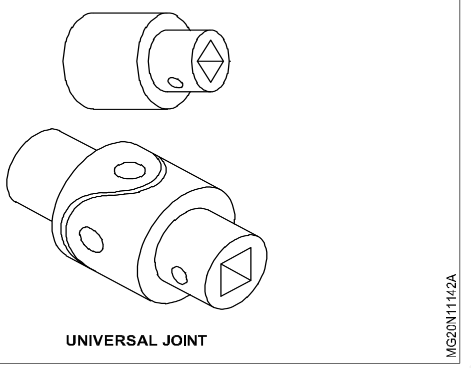
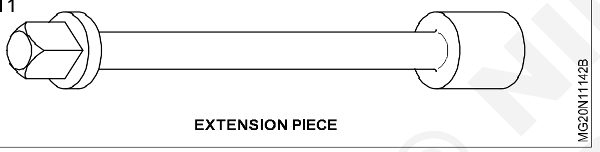


Fig 10



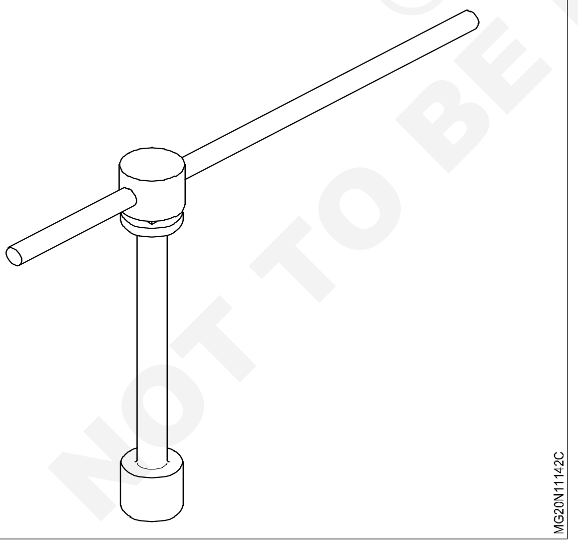
UNIVERSAL JOINT

Fig 11



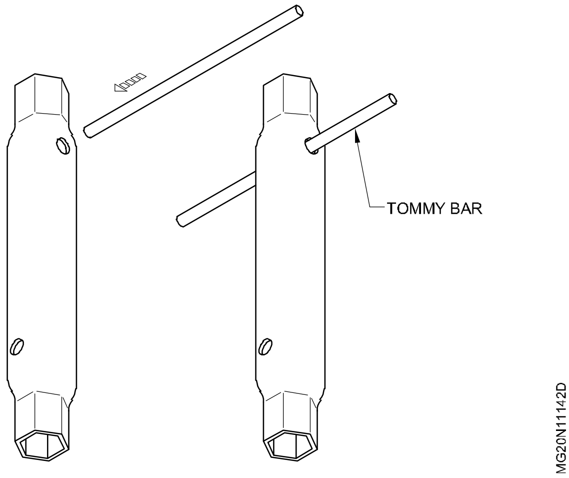
EXTENSION PIECE

Fig 12



Tube or Tubular box spanner (Fig 13)**:** Nuts in inaccessible position may be reached with Tubular Box spanner. This is made of steel tube. It is available with Tommy Bar.

Fig 13



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 yourself, if the spanner slips suddenly. Hold on to some support, if there is any chance of falling.

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.

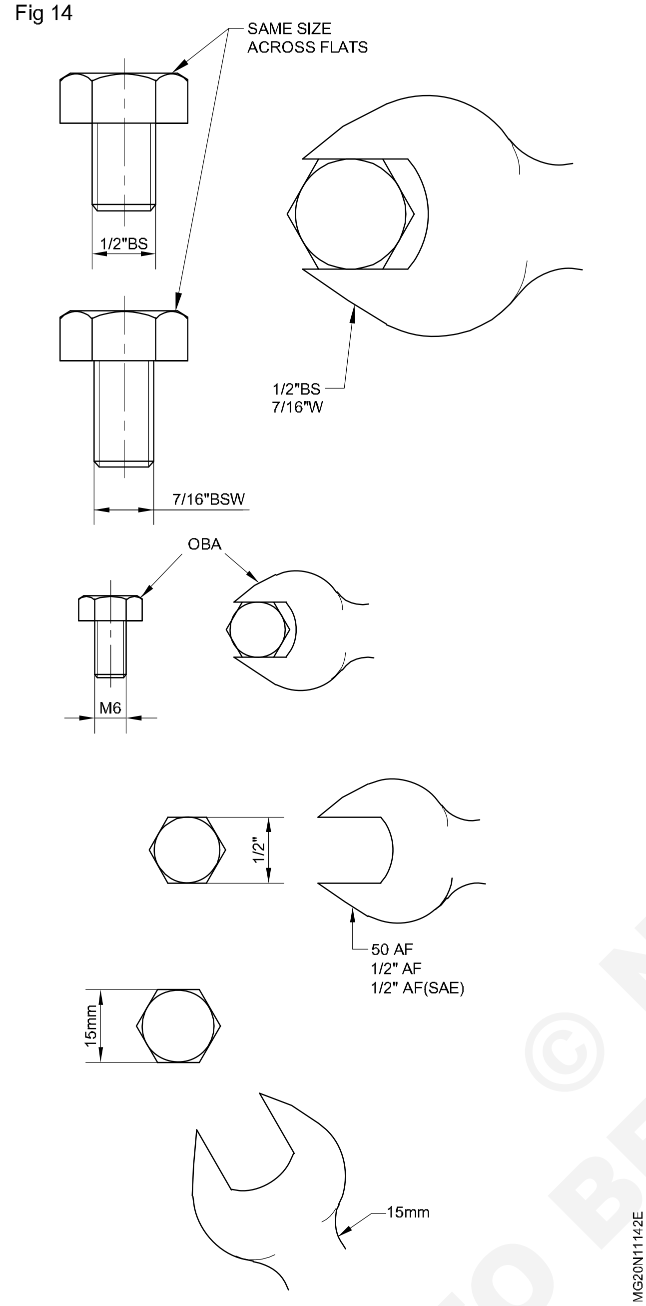
In the unified standard system, the spanners are marked with a number based on the decimal equivalent of the nominal fractional size across the flats of the hexagon, following the sign A/F or with the fractional size across the flats following the sign A/F. In the metric system, spanners are marked with the size across the jaw opening followed by the abbreviation 'mm'. (Fig 14)

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.

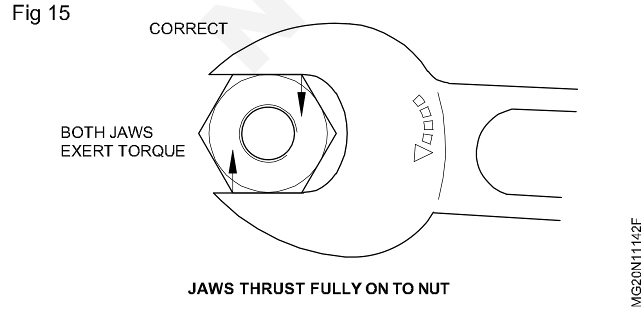
Fig 14



Place the spanner so that its jaws bear fully on the flats of the nut. (Fig 15)

Incorrect use damages the spanners.

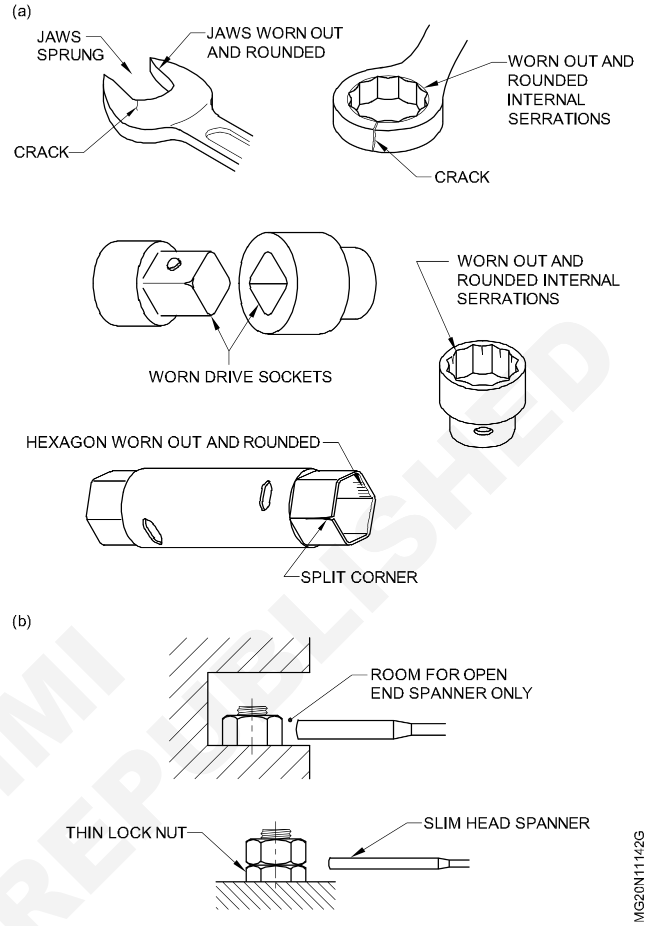
Fig 15



Discard any defective spanners. The spanners illustrated here are dangerous for use. (Fig 16a)

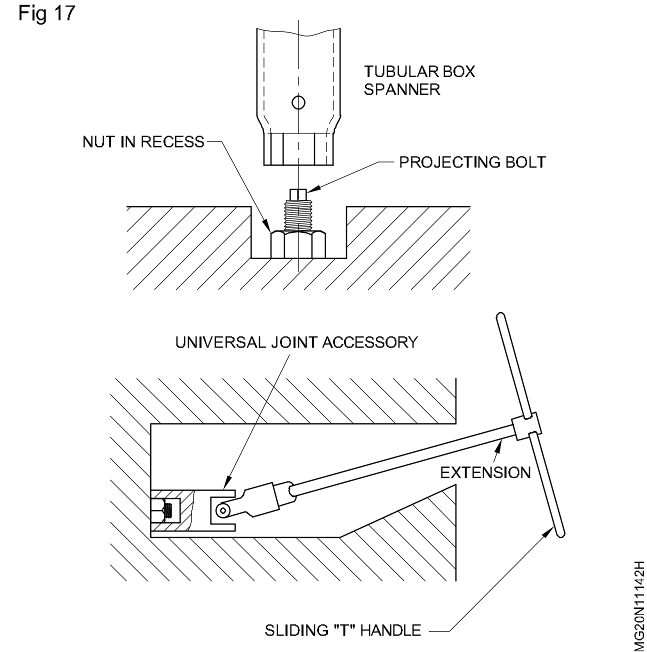
Choose spanners that allow room for use. (Fig 16b)

Fig 16



Nuts in inaccessible positions may be reached with socket spanners, with special drawing accessories. (Fig 17)

Fig 17



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

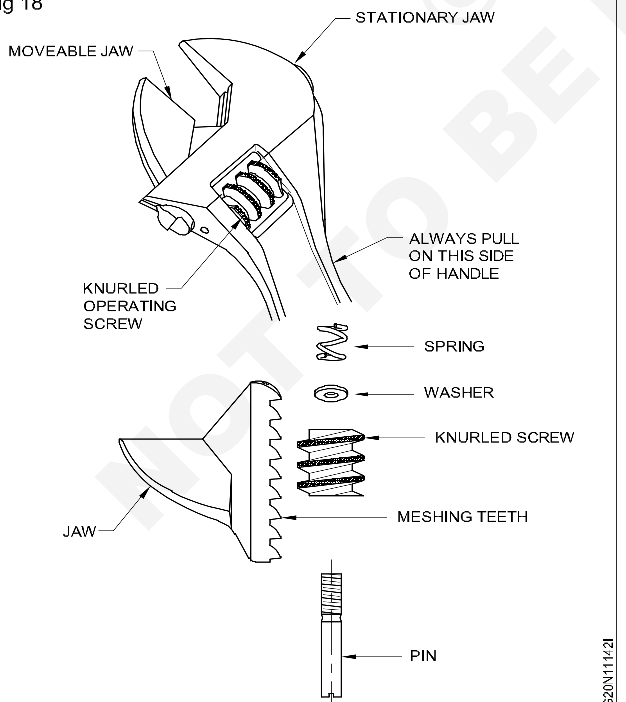
– making the spanner slip and cause an accident.

Adjustable spanners (Fig 18)**:** 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 25 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.

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.

Fig 18

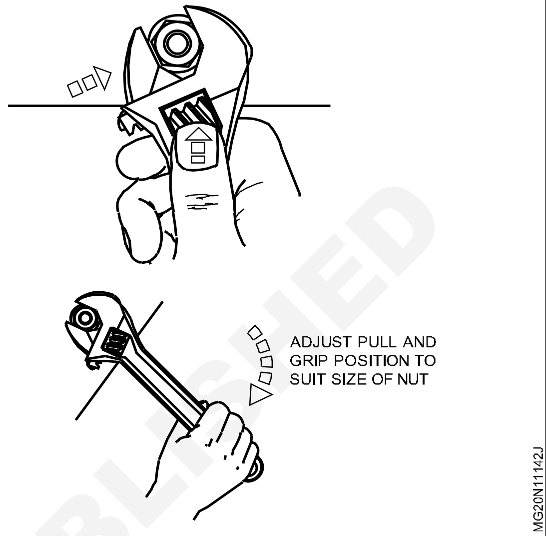


Push the jaws into full contact with the nut. (Fig 19)

Use the thumb to tighten the adjusting knurl so that the jaws fit the nut snugly.

Pull continuously. The length of the handle is designed to suit the maximum opening of the jaws. With small nuts, a very small pull on the handle will produce the required torque. (Fig 19)

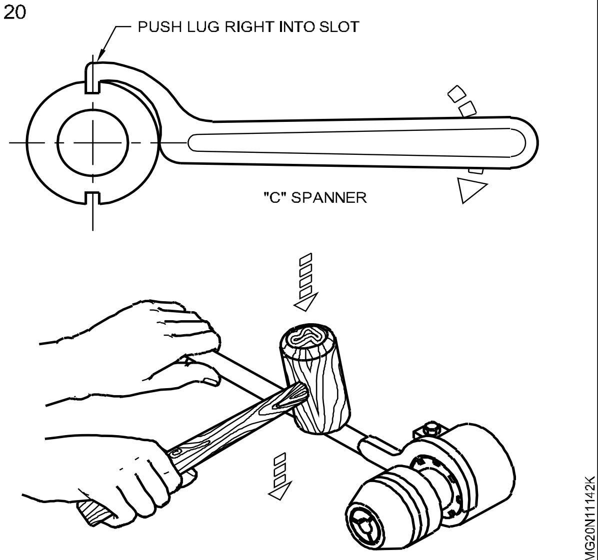
Fig 19



`C' spanners (Hook spanners)**:** 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 120mm.

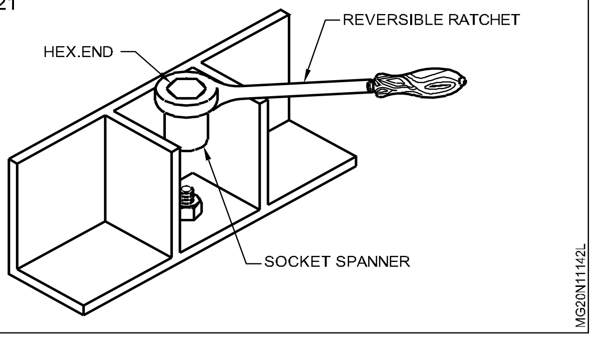
The applications of 'C' spanners are shown in Fig 20.

Fig 20



With socket spanners, use the reversible ratchet handle for doing fast work, where turning space is restricted. (Fig 21)

Fig 21



Torque wrench (Fig 22)**:** A tension wrench acts as a torque limiting device for turning (rotating) nuts to a predetermined degree of tightness. This avoids breaking the fasteners. It is also essential to avoid warping or springing components held by multiple fasteners that could be unevenly or excessively tightened. Cylinder heads of engines is an example.

Fig 22

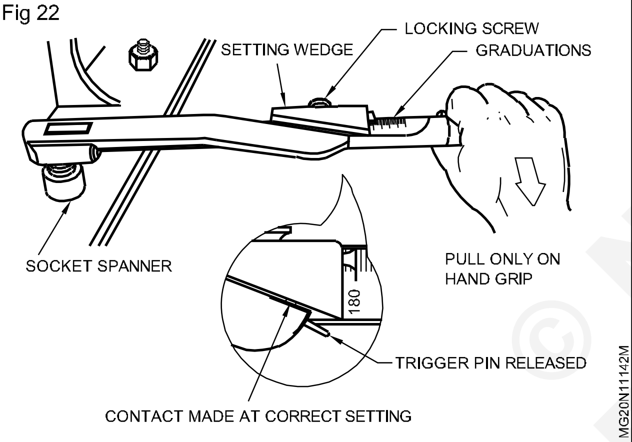
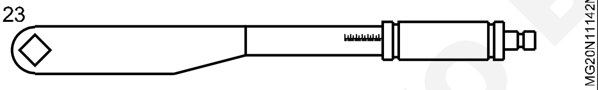


Fig 23



Some tension wrenches have direct reading indicators that you must watch as you pull the handle to the desired extent. With others, you present to the desired graduation and pull until you detect a signal which may be an audible click, the release of a trigger pin or an automatic release within the wrench mechanism.

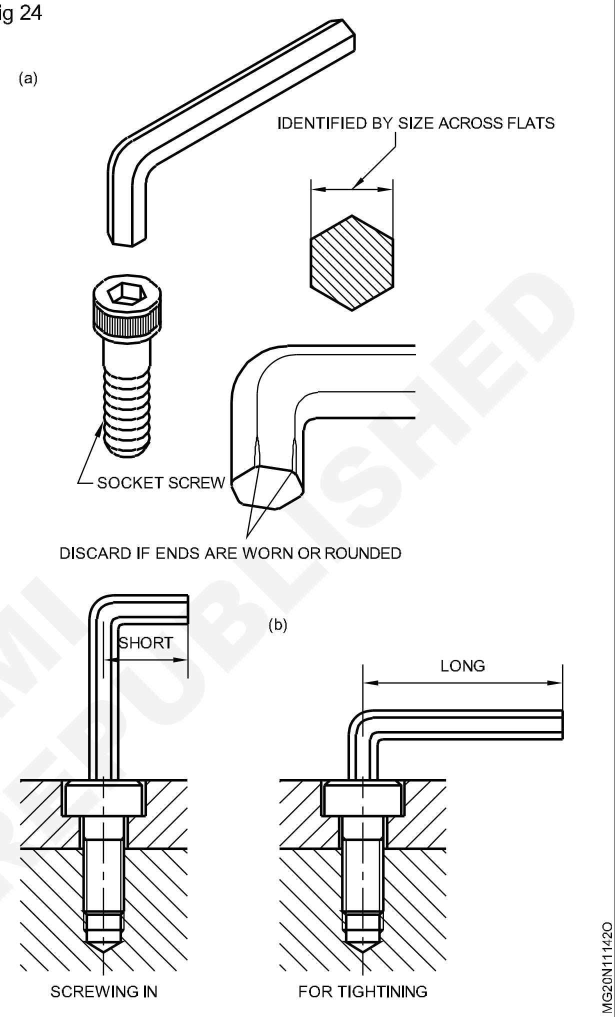
To apply the correct torque with a tension wrench

Check that the threads of the nut and the bolt are clean and well formed.

Pull slowly with evenly increasing effort on the hand grip of the handle.

This type torque wrench has a square tenon which fits into the square of the socket. The torque can be set at a prescribed amount by screwing in the end of the wrench handle. (Fig 23) A mechanism within the head of the spanner allows the handle to turn without applying more than the prescribed torque to the nut.

Fig 24



Hexagonal socket wrench: These are hexagonal section bars of tool steel bent to the shape. They are sometimes called Allen keys. (Fig 24a)

These are used to rotate set screws having internal hexagon sockets. They are available in sets ranging in size from 1.5 mm to 20 mm across the flats.

Make sure that the socket and wrench are clean before use. Use the correct size. Insert to the full depth. Discard if the ends become worn out or rounded as they are to slip under load.

The short leg of the Allen key is inserted into the socket of the bolt for final tightening (Fig 24b) Since the greater torque can be applied using long leg as a lever although it may be more convenient to use the longer end into the bolt socket for assembly purposes.

Pliers

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

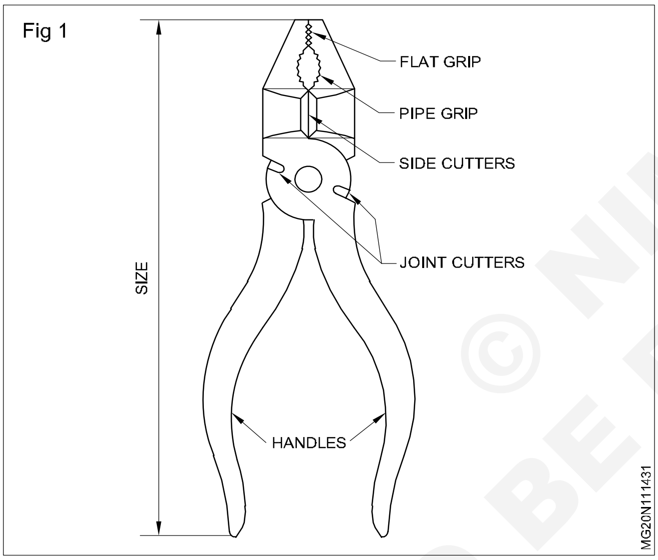
Features: Pliers have a pair of legs joined by a pivot, hinge or fulcrum pin. Each leg consists of a long handle and a short jaw.

Elements of pliers with two joint cutters (Fig 1) (Combination pliers)

- Flat grip
- Pipe grip
- Side cutters
- Joint cutters
- Handles

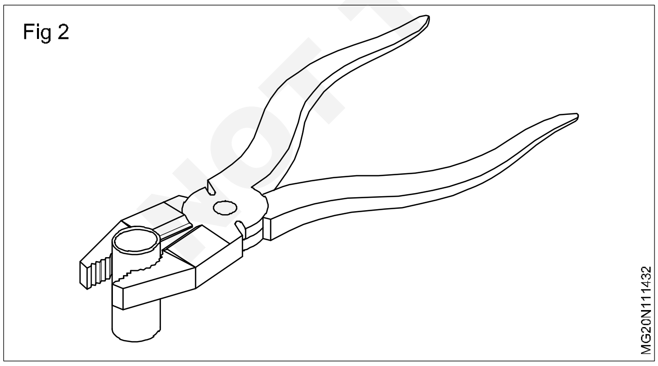
Features (Fig 1)**:** Flat grip jaw tips are serrated for general gripping.

Fig 1



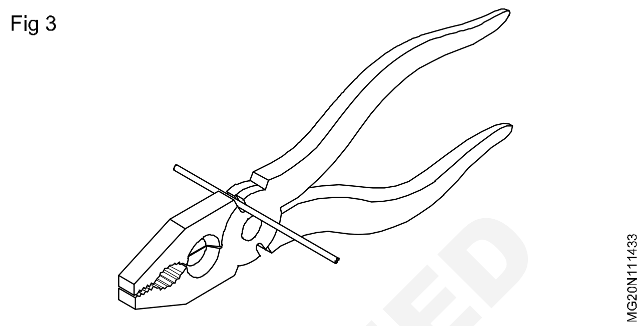
Pipe grip is serrated for gripping cylindrical objects. (Fig 2)

Fig 2



Two joint cutters are provided for cutting or shearing off steel wires. (Fig 3)

Fig 3

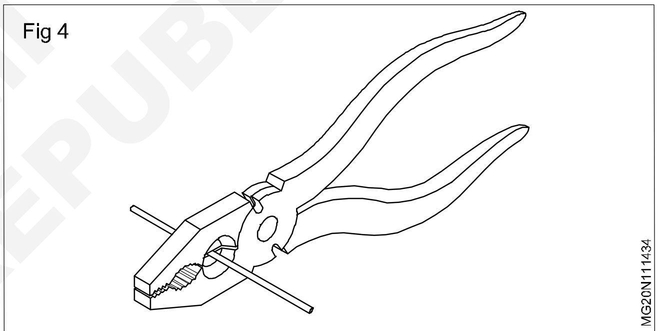


Side cutters are provided for cutting off soft wires. (Fig 4)

Handles are used for applying pressure by hand.

Pliers are available in sizes from 150 mm to 230 mm. (Size = Overall length)

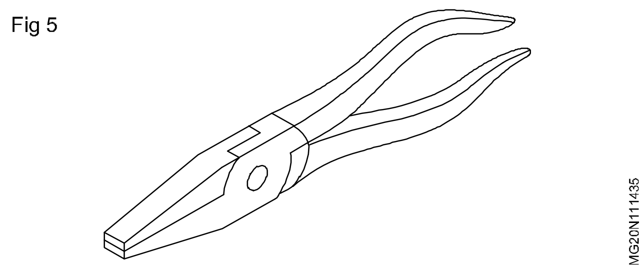
Fig 4



Other types of pliers

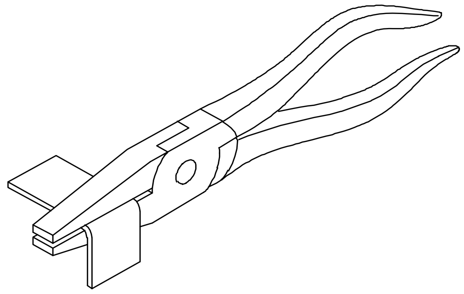
Flat nose pliers: It has tapered wedge jaws with flat gripping surfaces which may be either smooth or serrated. (Fig 5)

Fig 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

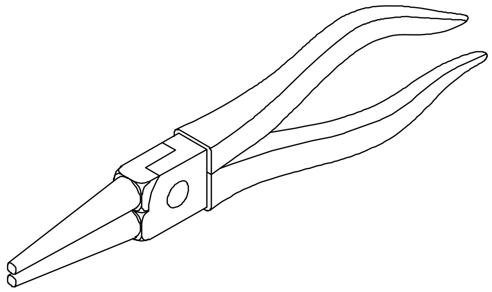
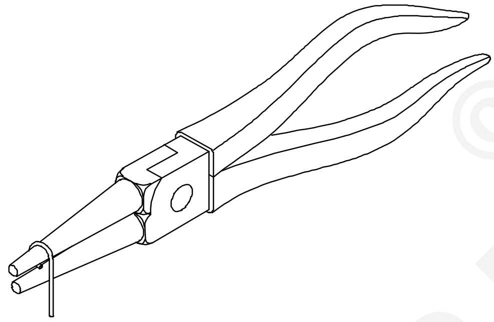


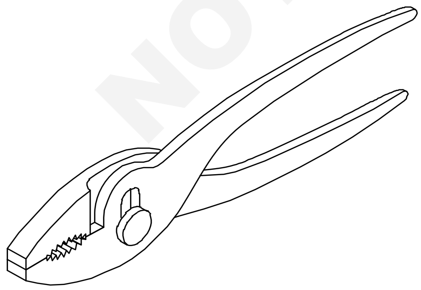
Fig 8



Slip-joint pliers: These pliers are available in various ranges of positions with different shapes of pivot pins so that they have various ranges of jaw openings.

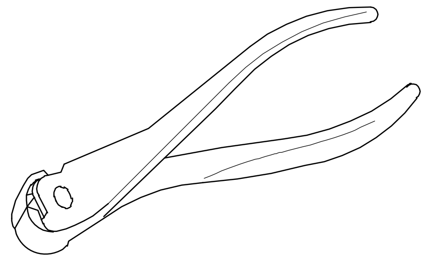
Mainly used for gripping. (Fig 9)

Fig 9



End cutting pliers: These pliers have the same uses as the side cutting pliers. (Fig 10)

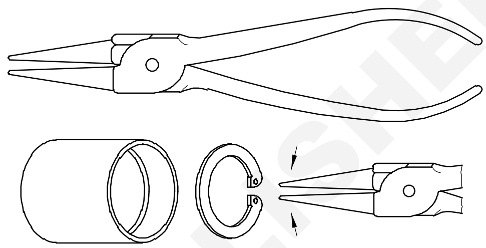
Fig 10



Circlip pliers: Circlip pliers are used for fitting and removing circlips in assembly works. (Fig 11 & 17)

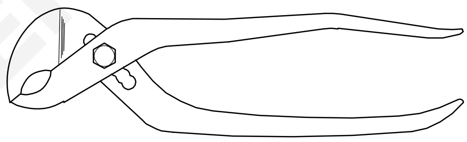
Internal circlip plier: It is used to fit and remove the internal circlip in the groove of the bore. (Fig 11)

Fig 11



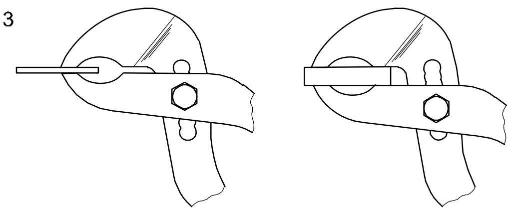
Slip-joint, multi-grip pliers: It is similar to the grip pliers but has more openings in the legs. It gives a range of jaw openings. It allows parallel gripping by the jaws in a number of positions. (Fig 12)

Fig 12



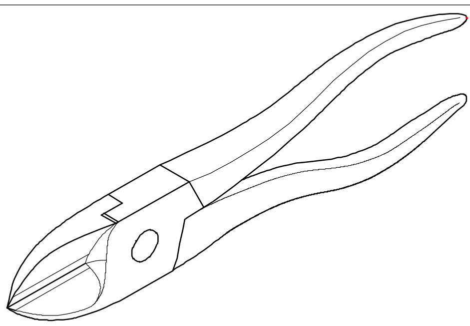
The shape and length of the leg are different from those the slip-joint pliers. (Fig 13)

Fig 13



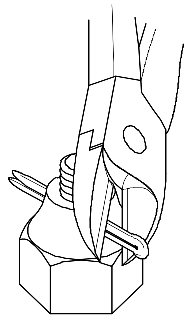
Side cutting pliers: It is made with jaws set at an angle. (Fig 14)

Fig 14



They are used for shearing off wires in confined spaces and cutting off wires close to the surface level. (Fig 15)

Fig 15



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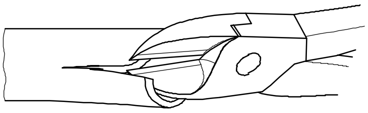
They are also used for spreading the cotter pin. (Fig 16)

Fig 16



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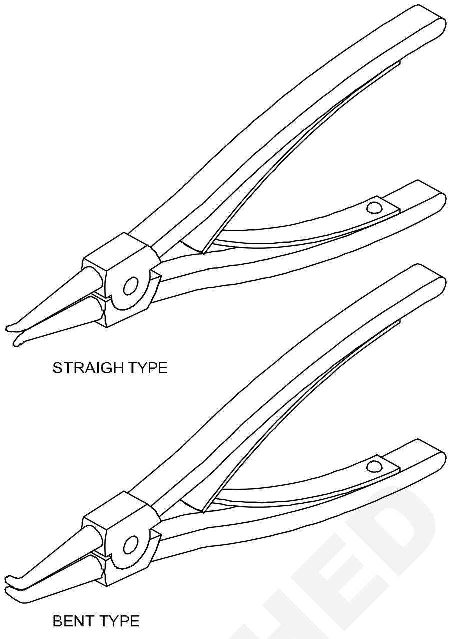
External circlip pliers: External circlip pliers are used to fit and remove the external circlip in the grooves of the shafts. (Fig 17)

Fig 17



CIRCLIP PLIERS

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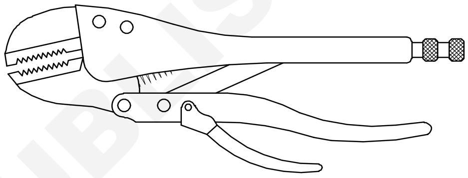
Grip pliers: The locking lever of the locking pliers is attached with a movable handle which clamps the jaws on to an object of any shape. (Fig 18)

Fig 18



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It has high gripping power.

The screw in the handle enables adjustment of the lever action to the work size.

Standard and special screw drivers and their uses

Objectives: At the end of this lesson you shall be able to
- **classify the hand-held screwdrivers**
- **state the features of standard screwdrivers**
- **identify the different types of standard screwdrivers and their specific uses**
- **identify the different types of special screw drivers and their specific uses**
- **specify standard screwdrivers.**

Screwdrivers are used to tighten or loosen screws which are fixed in the machine element.

Classification

– Standard type with tips to suit recessed head screw slots.

– Special type with tips to suit recessed head screws.

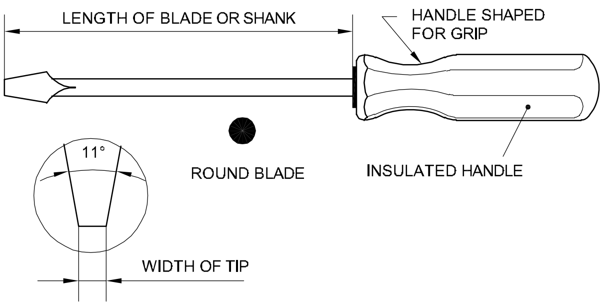
Features of the standard screw drivers (Fig 1)**:** Screw drivers must have:

– tips to turn screws with slotted heads

– handles of metals, wood or moulded insulating material, shaped to give a good grip for turning

– blades of hardened and tempered carbon steel or alloy steel

Fig 1



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– round or square blade with length ranging from 40 mm to more than 350 mm

– flared tips which vary in length and thickness with the length of the blade.

Standard screw drivers

Standard screw drivers are classified as:

– heavy duty screw drivers

– light duty screw drivers

– stumpy screw drivers

Heavy duty screw drivers (Fig 2)**:** This screw driver has a square blade for applying extra twisting force with the end of the spanner. Heavy duty screw drivers of London pattern (Fig 3) have a flat blade and are mostly used by carpenters.

Fig 2

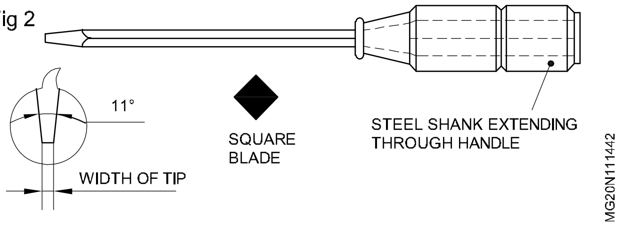
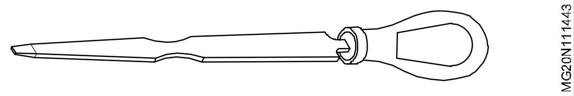
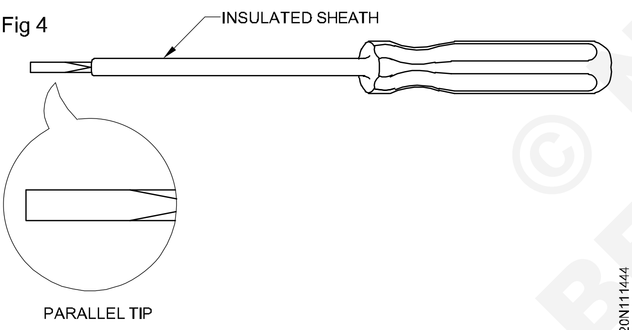


Fig 3



Light duty screw drivers (Fig 4)**:** This screw driver has a round blade with parallel tips. This screw driver is used by electricians. The blades are sheathed in insulation to avoid short-circuiting live parts.

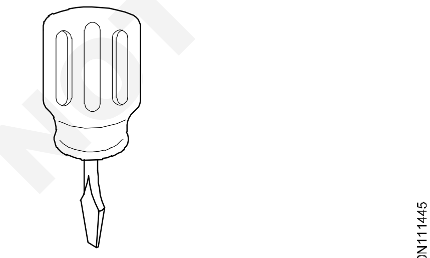
Fig 4



LIGHT DUTY SCREW DRIVER

Stumpy screw drivers (Fig 5)**:** These are small sturdy screw drivers. They are used when other types of screw drivers cannot be used due to the space limitations.

Fig 5

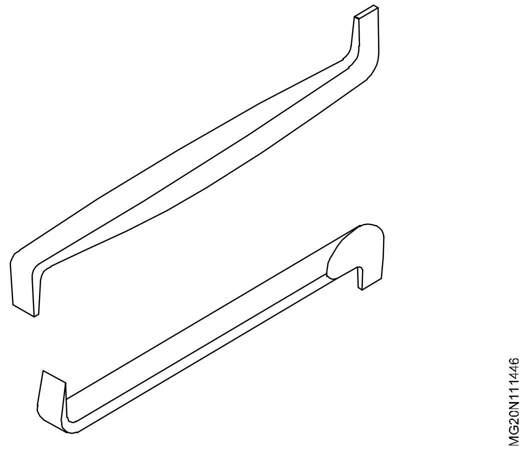


STUMPY SCREW DRIVER

Special screw drivers and their uses

Offset screw driver (Fig 6)**:** Offset screw drivers are used on screws which cannot be reached from above.

Fig 6

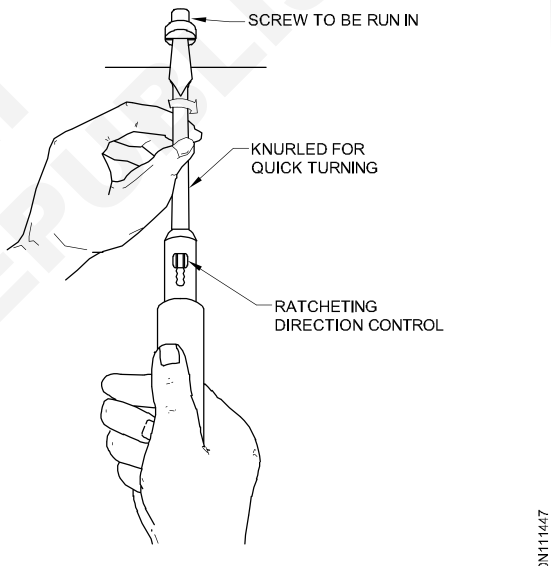


They are made with short blades and with the tips at right angle.

Greater turning force can be applied on screws by these screw drivers because of their leverage.

Ratchet screw driver (Fig 7)**:** The following are the features of ratchet screw drivers.

Fig 7



RATCHET SCREWDRIVER

These screw drivers are made with a three-position ratchet control for screwing, unscrewing of a screw and also providing a neutral position.

Are used for turning screws in confined spaces.

Can be operated without changing the hand grip.

Are used for slackening or tightening with a medium force.

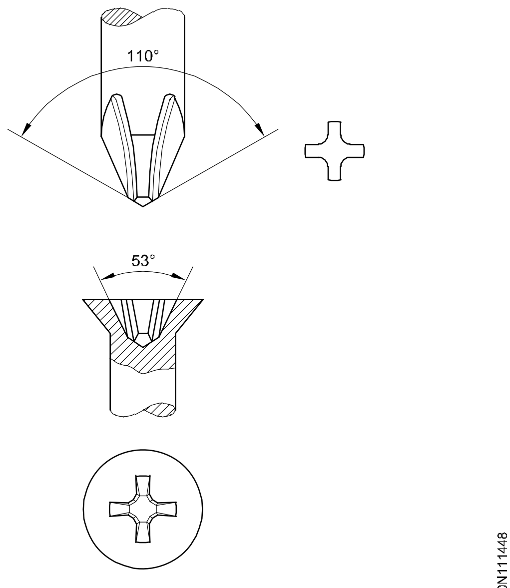
They are used in mass production.

Phillips (cross-recess) **screw drivers** (Fig 8)**:** Phillips screw drivers have cruciform or cross-shaped tips that are unlikely to slip from the cruciform slots in Phillips recessed head screws.

The end of the four flats is tapered to an angle of 53°.

The extreme end is ground to 110°.

Fig 8

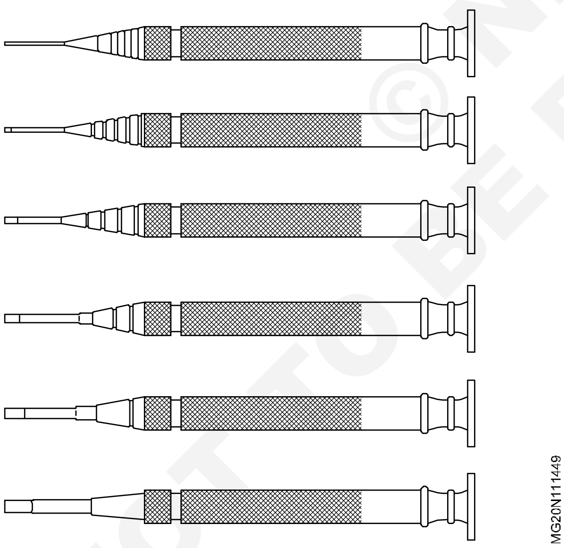


PHILLIPS SCREWDRIVER

Four different sizes to cover the full range of screws are available. These are specified by point sizes 1,2,3 & 4 which correspond to the size of the Phillips screw heads.

Watchmaker's screw driver (Fig 9)**:** These are small, fully metallic screwdrivers coming in sets of 4 or 6. They are mainly used by watchmakers for tightening or slackening very small screws which require slight force only. They are also called jewelers screwdrivers.

Fig 9



Specification of a screwdriver: Screwdrivers are specified according to the

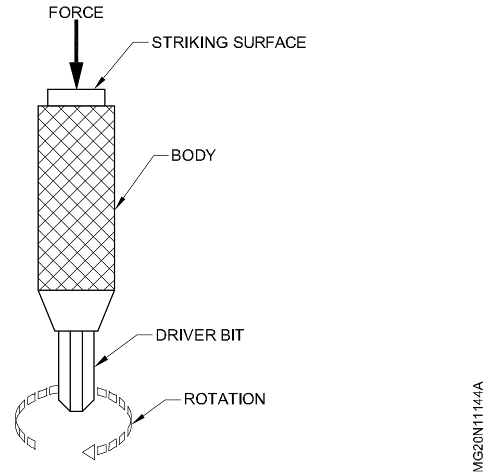
– length of the blade

– width of the tip

The normal blade length varies from 45 mm to 300 mm and the width of the blade varies from 3 mm to 10 mm.

Impact Screw driver: Impact screw driver contain heavy springs which holds the screw driver bit extended. A blow with a hammer on the striking surfaces the spring to compress and impart Rotary motion to the blade. (Fig 10)

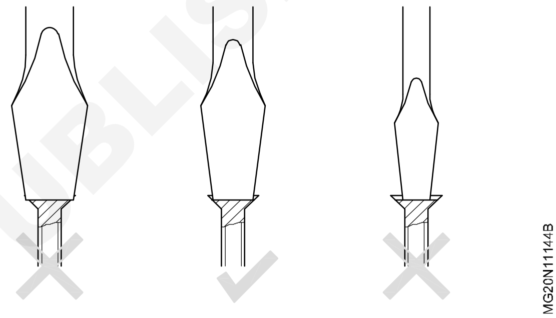
Fig 10



Selection of flat blade screw driver: The following points should be taken into account when using flat blade screw driver.

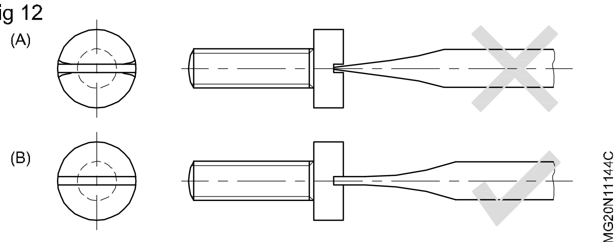
– The width of the blade should be correct as shown in Fig 11.

Fig 11



– The thickness of the blade should be correct as shown in figs. 12A,B.

Fig 12



Important points while using screw driver

– Hold the screw driver axis in line with axis of screw.

– While using philips screw driver apply more downward pressure.

– Keep your hand away to avoid injury due to slipping of screw driver.

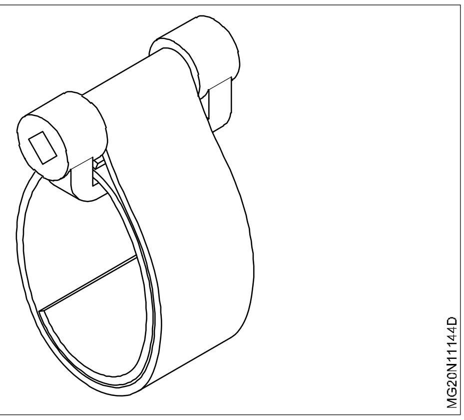
– Do not use screw drivers with split or defective handles.

– While using screw drivers on small jobs place the job on workbench or hold them in vice.

– Do not use the screw driver as a leverage or a chisel.

Strap wrench (Fig 13)**:** 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 13



Footprint wrench (Fig 14)**:** These are used for gripping and turning pipes and round stocks in confined places.

The required size is adjusted by placing the pivot pin in the different holes of the solid handle.

The grip is obtained by squeezing both the solid handles together. (Fig 15)

The selection of holes should be such that the handles are not too far as this may result in uncomfortable holding of the handles.

Fig 14

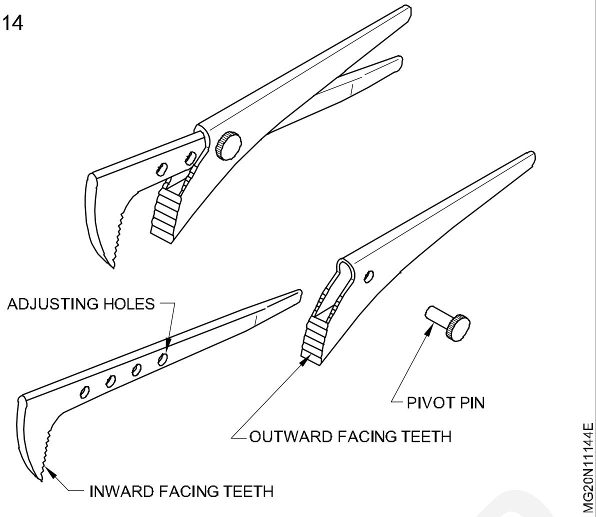
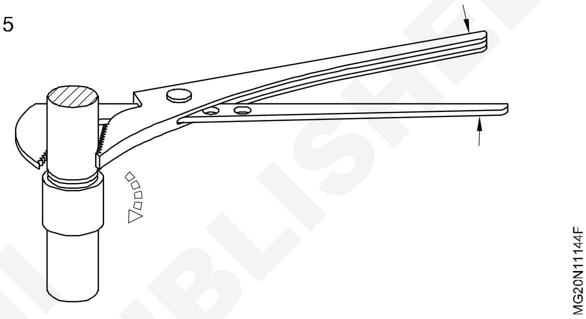


Fig 15



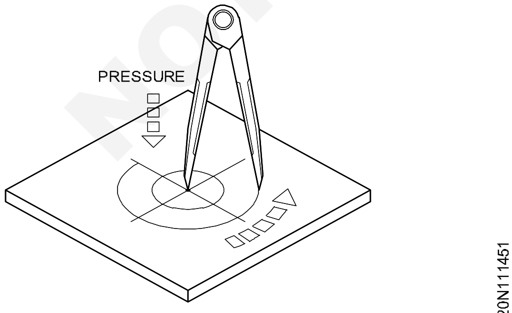
Dividers

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

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

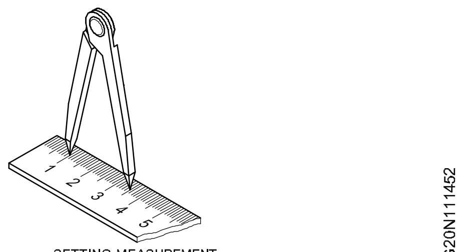
Dividers are available with firm joints and spring joints. (Figs 1 & 4). The measurements are set on the dividers with a steel rule. (Fig 2)

Fig 1



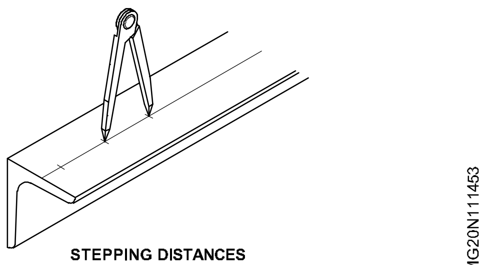
SCRIBING CIRCLES

Fig 2



SETTING MEASUREMENT

Fig 3

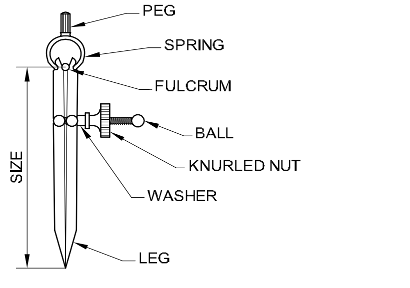


STEPPING DISTANCES

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

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

Fig 4

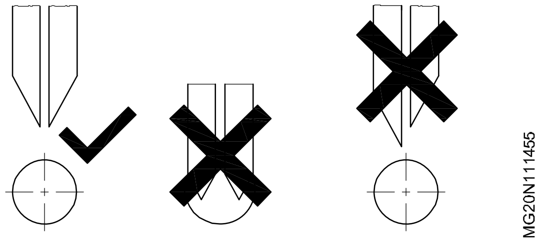


SPRING JOINT DIVIDER

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

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

Fig 5



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

Calipers

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

- **state the commonly used calipers**
- **state the advantages of spring joint calipers.**

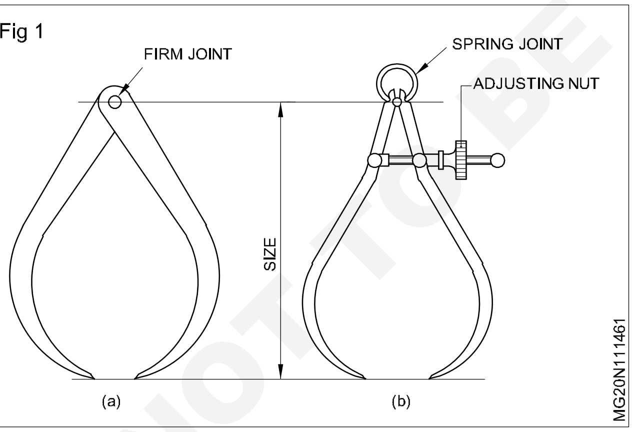
Calipers are indirect measuring instruments used for transferring measurements from a steel rule to a job, and vice versa.

Calipers are classified according to their joints and their legs.

Joint

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

Fig 1



Legs

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

Fig 2

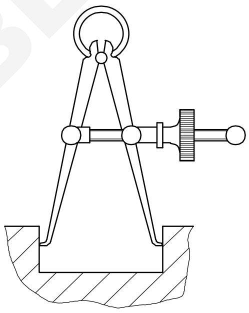
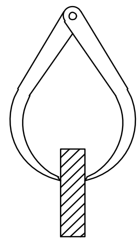


Fig 3



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.

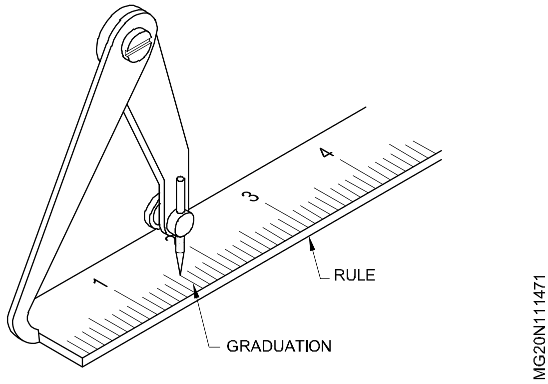
Jenny calipers

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

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

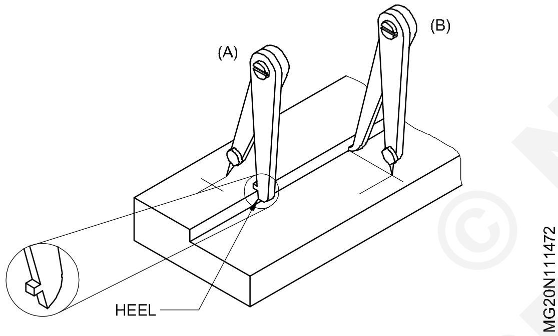
Jenny calipers are used

Fig 1



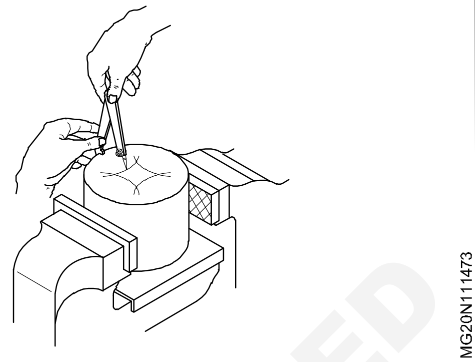
- for marking lines parallel to the inside and outside edges (Fig 2)

Fig 2



- for finding the centre of round bars (Fig 3)

Fig 3



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

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

The other names for this caliper are:

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

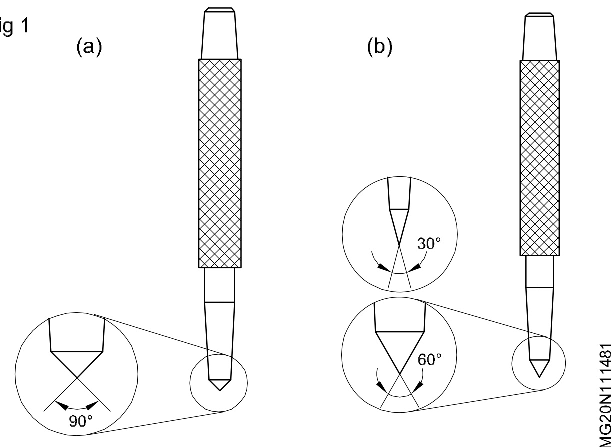
Types of marking punches

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

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

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

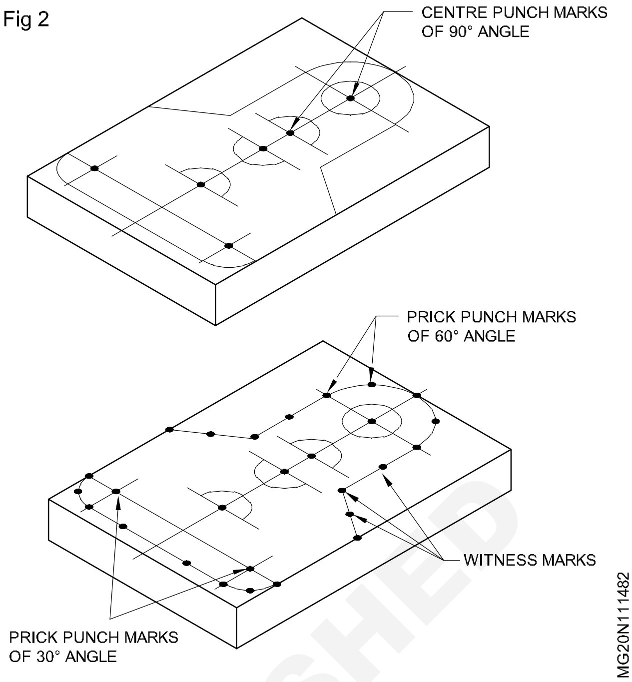
Fig 1



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

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

Fig 2



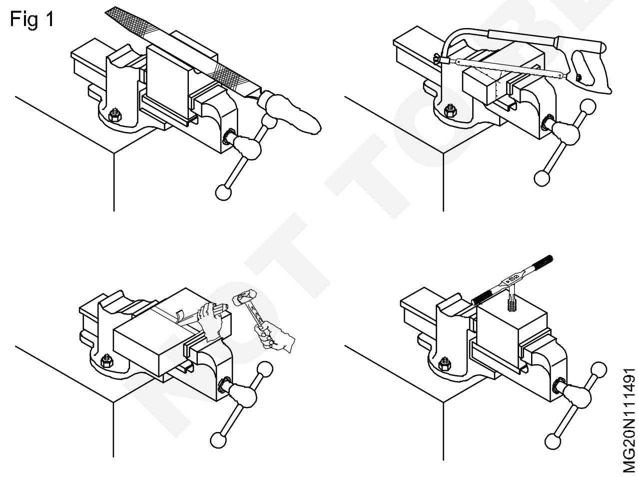
Bench vice

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

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

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

Fig 1



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

Positioning of bench vice

Vices are mounted rigidly on a work bench with the fixed jaw in line with the bench edge to permit a long work to be clamped in a vertical position.

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

The correct height of a bench vice

Fig 2

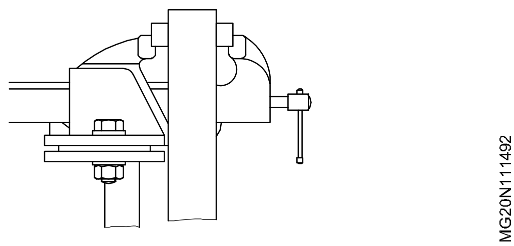
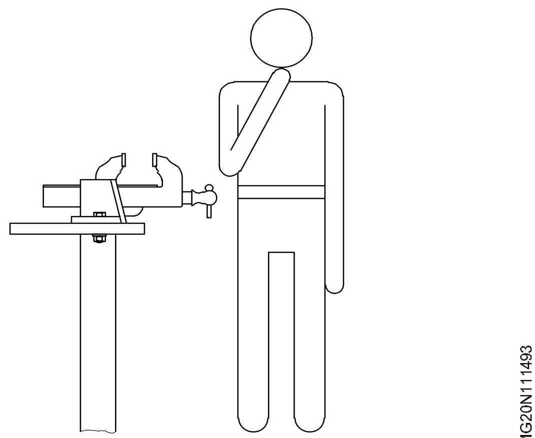


Fig 3



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

> **Lubricate the spindle and the box-nut periodically. Do not tighten the jaws of he vices without any work in between**
>
> **Do not hammer on the vices for levelling metal**

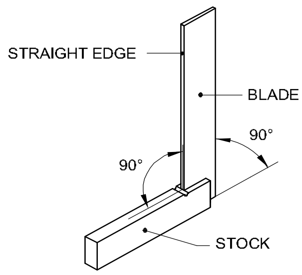
Try-Square

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

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

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°.

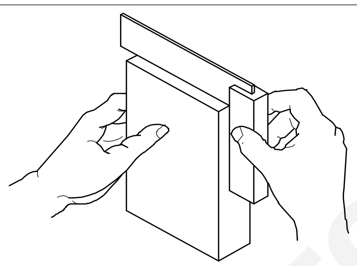
Fig 1



Uses

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

Fig 2



Check the flatness of surfaces (Fig 3)

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

Fig 3

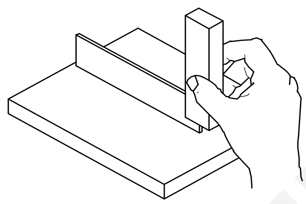
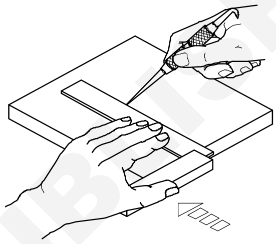


Fig 4

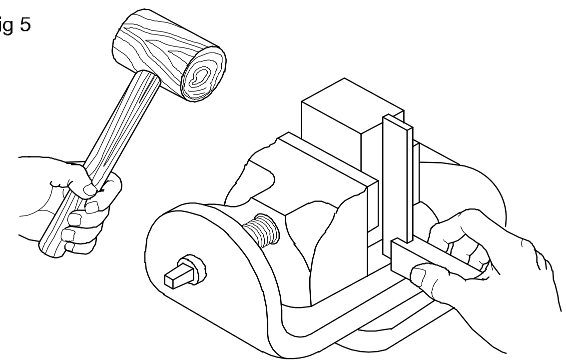


Set workpieces at right angles on work-holding devices. (Fig 5)

Try-squares are made of hardened steel.

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

Fig 5



Parts of a bench vice

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

Parts of a bench vice (Fig 1)

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.

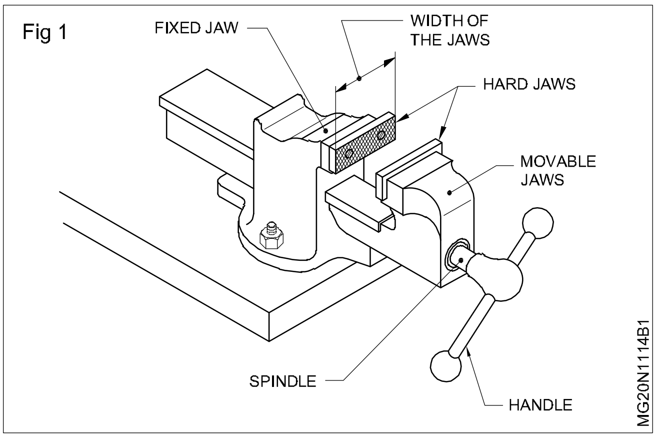


Fig 1

Vice clamps or soft jaws (Fig 2)

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

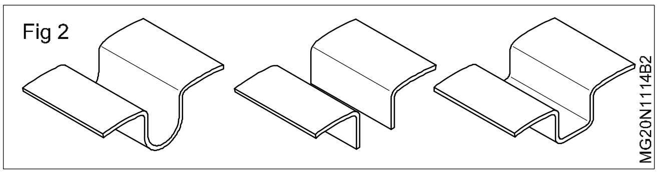


Fig 2

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

Care and maintenance of vices

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

Types of vices

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

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

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

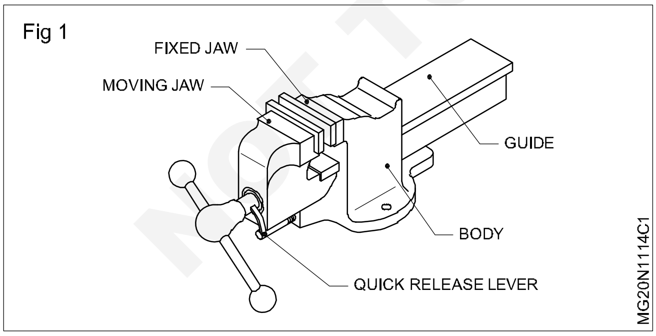


Fig 1

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

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

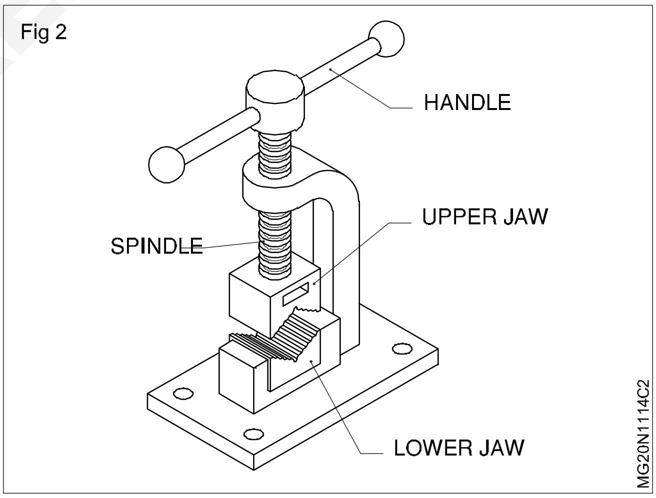
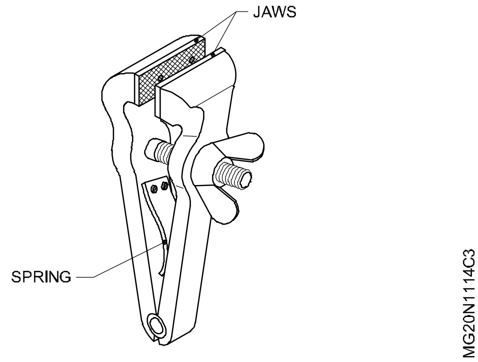


Fig 2

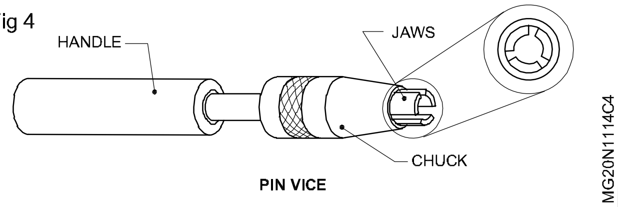
Hand vice (Fig 3)**:** Hand vices are used for gripping screws, rivets, keys, small drills and other similar objects which are too small to be conveniently held in the bench vice. A hand vice is made in various shapes and sizes. The length varies from 125 to 150 mm and the jaw width from 40 to 44 mm.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

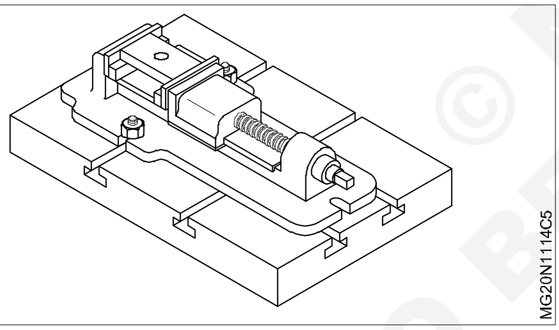
Fig 4



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.

Toolmaker's vice is accurately machined.

Fig 5

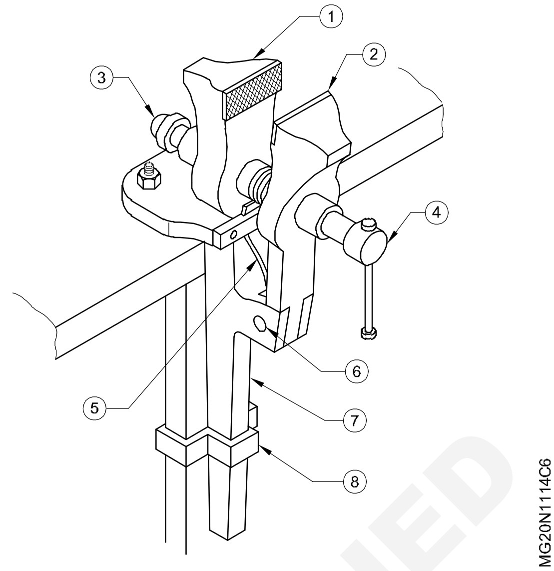


Leg vice

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

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

Fig 6

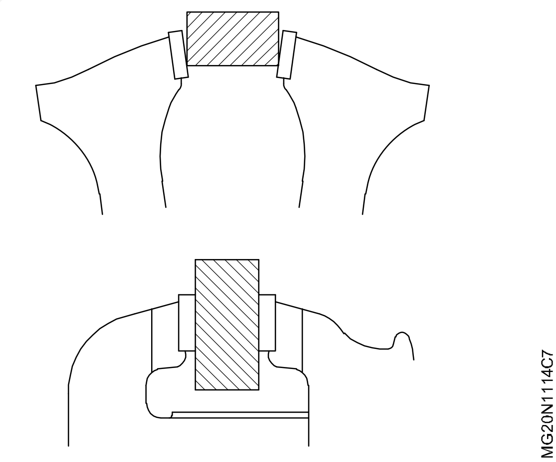


The following are the main parts of a leg vice.

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

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

Fig 7



Hacksaw frames and blades

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

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

Example

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

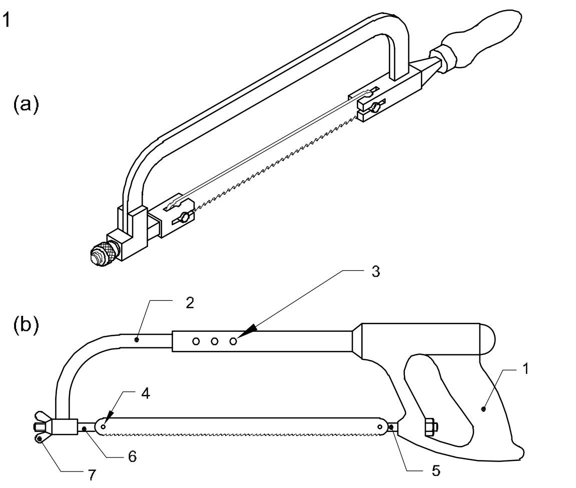
Types of hacksaw frames

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

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

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

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)

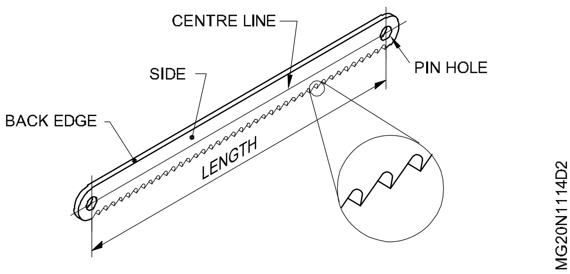
1 Back edge

2 Side

3 Centre line

4 Pin holes

Fig 2



Type of hacksaw blades

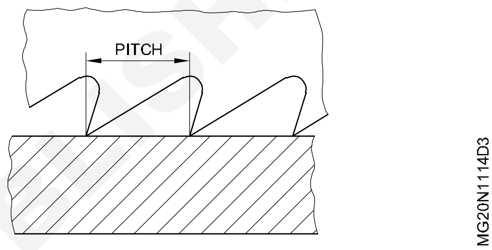
All-hard blade: The full length of the blade between the pins is hardened and it is used for harder metals such as tool steel, die steel and HCS.

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)

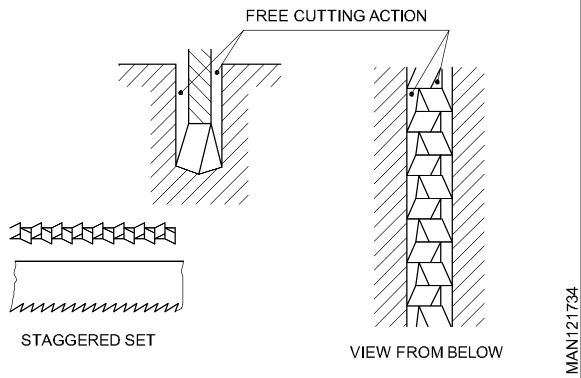
Example

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



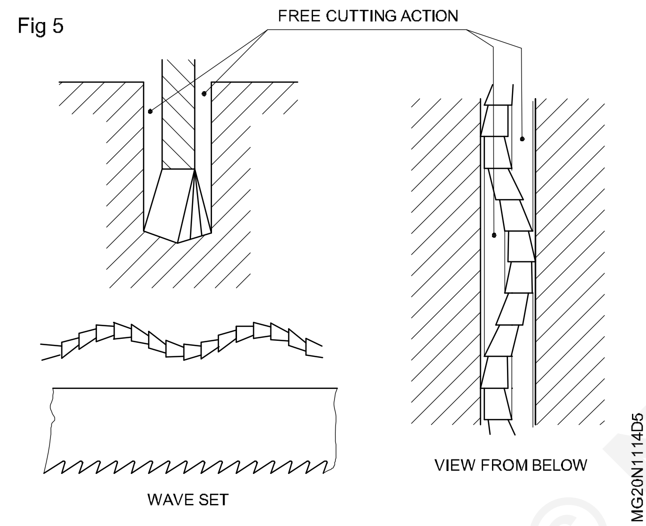
Wave set (Fig 5)**:** In this, the teeth of the blade are arranged in a wave-form. The types of sets for different pictures are as follows:

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

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

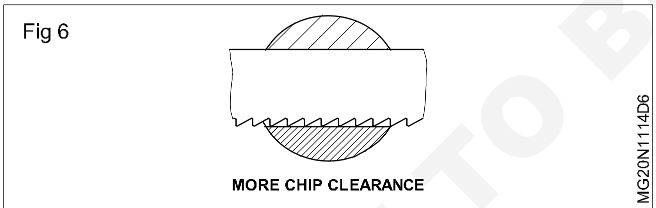
Selection of blade: The selection of the blade depends on the shape and hardness of the material to be cut.

Fig 5



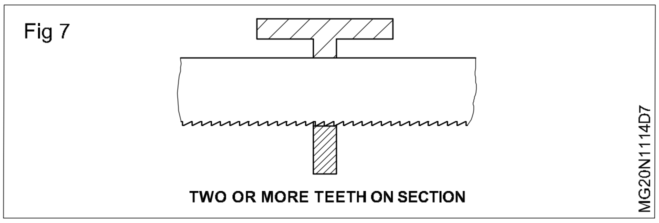
Pitch selection (Fig 6)**:** For soft materials such as bronze, brass, soft steel, cast iron, heavy angles etc. use a 1.8 mm pitch blade.

Fig 6



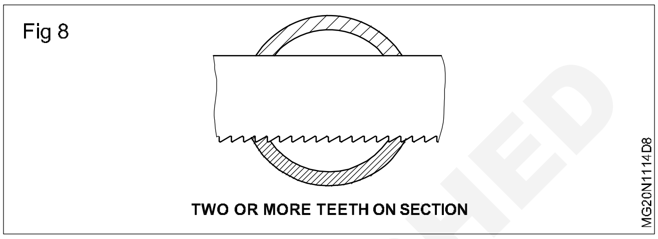
For tool steel, high carbon, high speed steel etc. use a 1.4 mm pitch. For angle iron, brass tubing, copper, iron pipe etc. use a 1 mm pitch blade. (Fig 7)

Fig 7



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

Fig 8



Method of sawing

Select the correct blade for the material to be cut.

HSS - Blades are used for tough resistant materials

High Carbon Steel - General cutting

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

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

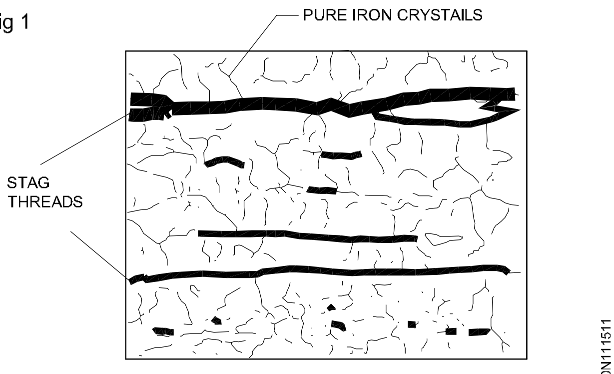
The other hand holds the frame, near the wing nut. Cutting/ sewing should be carried out close to the jaws of the vice. This ensures that the metal does not flex or bend under the force of the hacksaw and the sawing motion.

Wrought iron and plain carbon steels

Objectives: At the end of this lesson you shall be able to
- **state the manufacturing process of wrought iron**
- **state the properties and uses of wrought iron.**

Wrought iron is the purest form of iron. The analysis of wrought iron shows as much as 99.9% of iron. (Fig 1)

Fig 1



MICROSTRUCTURE OF WROUGHT IRON

When heated, wrought iron does not melt, but only becomes pasty and in this form it can be forged to any shape.

Modern methods used to produce wrought iron in large quantities are the:

- Puddling process
- Aston or Byers process.

Puddling process

Wrought iron is manufactured by refining pig-iron.

By refining pig-iron silicon is removed completely, a greater amount of phosphorus is removed, and graphite is converted to combined carbon.

The above process is carried out in a puddling furnace.

Puddling furnace

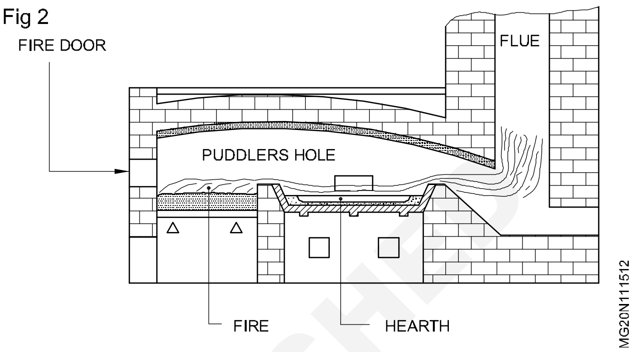
This furnace is a coal-fired reverberator furnace. (Fig 2)

The term reverberator is applied because the charge is not in actual contact with the fire, but receives its heat by reflection from the dome shaped furnace roof.

The product obtained is taken out from the furnace in the form of balls (or blooms) having a mass of about 50 kgs.

The hot metal is then passed through grooved rollers which convert blooms into bars called Muck bars or Puddle bars.

Fig 2



These bars are cut into short lengths, fastened together in piles, reheated to welding temperatures and again rolled into bars.

Aston process

In this process molten pig-iron and steel scrap are refined in a Bessemer converter.

The refined molten metal is poured into an open hearth furnace in the iron silicate stage. This removes most of the carbon.

The slag cools the molten metal to a pasty mass which is later squeezed in a hydraulic press to remove most of the slag. Rectangular blocks known as blooms are formed from this mass.

The hot bloom is immediately passed through rolling mills to produce products of wrought iron of different shapes and sizes.

Composition of Wrought Iron

Carbon	-	0.02 to 0.03%
Silicon	-	0.1 to 0.2%
Manganese	-	0.02 to 0.1%
Sulphur	-	0.02 to 0.04%
Phosphorous	-	0.05 to 0.2%
Iron forms of the rest of the content.		

Properties and uses of Wrought Iron

Properties	Uses
Malleable and ductile. It can neither be hardened nor tempered.	Architectural works.
Tough, shock-resistant fibrous structure; easy for forge welding. Ultimate tensile strength of about 350 newton's per sq. mm.	Crane hooks, chain links, bolts and nuts & railway couplings.
No effect in salt water.	Marine works.
Will not retain the magnetism.	Temporary magnets. Core of dynamos.
Corrosion resistant.	Agricultural equipment.
Easy to forge - wide temperature range 850°C to 1350°C.	Pipes, flanges etc.

Steel (plain carbon steel)

Objective: At the end of this lesson you shall be able to
- **state the composition and properties of plain carbon steel.**

Steel is fundamentally an alloy of iron and carbon, with the carbon content varying up to 1.5%. The carbon present is in a combined state.

Plain carbon steels are classified according to their carbon content.

Classification and content of Plain Carbon Steel is given in Table 1.

Table 1

Classification and content of Plain Carbon Steel

Name of the plain carbon steel	Percentage of Carbon	Properties and uses
Dead mild steel	0.1 to 0.125 %	Highly ductile. Used for making wire rods, thin sheets & solid drawn tubes.
Mild steel	0.15 to 0.3%	Relatively soft and ductile. Used for general workshop purposes, boiler plates, bridge work, structural sections and drop forgings.
Medium carbon	0.3 to 0.5%	Used for making axles,drop forgings,high tensile tubes, wires and agricultural tools.
- do -	0.5 to 0.7%	Harder, tougher and less ductile. Used for making springs, locomotive tyros, large forging dies, wire ropes, hammers and snaps for riveters.
High carbon steel	0.7 to 0.9%	Harder, less ductile and slightly less tough Used for making springs, small forging dies, shear blades and wood chisels.
- do -	0.9 to 1.1%	Used for making cold chisels, press dies, punches, wood-working tools, axes, etc.
- do -	1.1% to 1.4%	Used for making hand files, drills, gauges, metal-cutting tools & razors.

Non-ferrous metals - copper

Objectives: At the end of this lesson you shall be able to
- **name the commonly used copper alloys**
- **state the properties and uses of copper**
- **state the composition and uses of different types of brasses**
- **state the composition and uses of different types of bronze.**

Metals without iron are called non-ferrous metals. Eg. Copper, Aluminium, Zinc, Lead and Tin.

Copper

This is extracted from its ores 'MALACHITE' which contains about 55% copper and 'PYRITES' which contains about 32% copper.

Properties

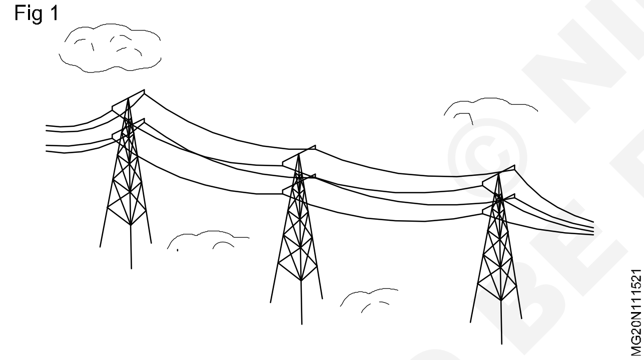
Reddish in colour. Copper is easily distinguishable because of its colour.

The structure when fractured is granular, but when forged or rolled it is fibrous.

It is very malleable and ductile and can be made into sheets or wires.

It is a conductor of electricity. Copper is extensively used as electrical cables and parts of electrical apparatus which conduct electric current. (Fig 1)

Fig 1

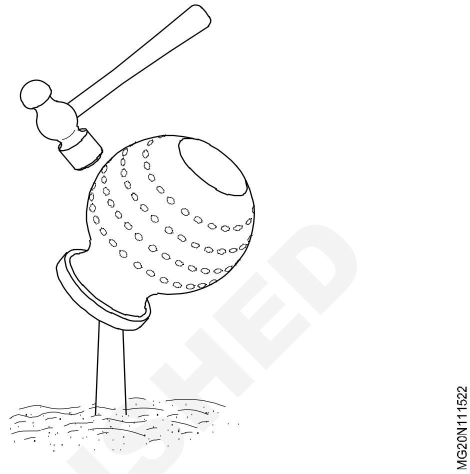


Copper is a good conductor of heat and also highly resistant to corrosion for this reason it is used for boiler fire boxes, water heating apparatus, water pipes and vessels in brewery and chemical plants. Also used for making soldering iron.

The melting temperature of copper is 1083^{o} C.

The tensile strength of copper can be increased by hammering or rolling. (Fig 2)

Fig 2



Copper alloys

Brass

It is an alloy of copper and zinc. For certain types of brass small quantities of tin or lead are added. The colour of brass depends on the percentage of the alloying elements. The colour is yellow or light yellow, or nearly white. It can be easily machined. Brass is also corrosion-resistant.

Brass is widely used for making motor car radiator core and water taps etc. It is also used in gas welding for hard soldering/brazing. The melting point of brass ranges from 880 to 930^{o}C.

Brasses of different composition are made for various applications. The following Table-1 gives the commonly used brass alloy compositions and their application.

Bronze

Bronze is basically an alloy of copper and tin. Sometimes zinc is also added for achieving certain special properties. Its colour ranges from red to yellow. The melting point of bronze is about 1005^{o}C. It is harder than brass. It can be easily machined with sharp tools. The chip produced is granular. Special bronze alloys are used as brazing rods. Bronze of different compositions are available for various applications. Table-2 gives the type compositions and applications of different bronzes.

Table 1 - Composition of different types of Brass

Name	Composition (%)			Applications
	Copper	Zinc	Other elements	
Cartridge brass	70	30	-	Most ductile of the copper/zinc alloys. Widely used in sheet metal pressing for severe deep drawing operations. Originally developed for making cartridge cases, hence its name.
Standard brass	65	35	-	Cheaper than cartridge brass and less ductile. Suitable for most engineering processes.
Basic brass	63	37	-	The cheapest of the cold working brasses. It lacks ductility and is only capable of withstanding simple forming operations.
Muntz metal	60	40	-	Not suitable for cold working, but suitable for hot-working. Relatively cheap due to its high zinc content. It is widely used for extrusion and hot-stamping processes.
Free-cutting brass	58	39	3% lead	Not suitable for cold working but excellent for hot working and high speed machining of low strength components.
Admiralty brass	70	29	1% tin	This is virtually cartridge brass plus a little tin to prevent corrosion in the presence of salt water.
Naval brass	62	37	1% tin	This is virtually Muntz metal plus a little tin to prevent corrosion in the presence of salt water.
Gilding metal	95	5	-	Used for jewellery.

Table 2 - Composition of different types of bronze

Name	Composition (%)				Applications
	Copper	Zinc	Phosphorus	Tin	
Low tin bronze	96	-	0.1 to 0.25	3.9 to 3.75	This alloy can be severely cold-worked to harden it so that it can be used for springs where good elastic properties must be combined with corrosion resistance,fatigue-resistance and electrical conductivity. Eg.Contact blades
Drawn phosphor/ bronze	94	-	0.1 to 0.5	5.9 to 5.5	This alloy is used for turned components requiring strength and corrosion resistance, such as valve spindles.
Cast phosphor/ bronze	89.75 to 89.97		0.03 to 0.25	10	Usually cast into rods and tubes for making bearing bushes and worm wheels. It has excellent anti-friction properties.
Admirality gun-metal	88	2	-	10	This alloy is suitable for sand casting where fine-grained, pressure-tight components such as pump and valve bodies are required.
Leaded gun-metal (free cutting)	85	5 (5%lead)	-	5	Also known as 'red brass' this alloy is used for the same purposes as standard, admirality gun-metal. It is rather less strong but has improved toughness and machining properties.
Leaded (plastic) bronze	74	(24%lead)	-	2	This alloy is used for lightly loaded bearings where alignment is difficult. Due to its softness, bearings made from this alloy "bed in" easily.

Lead

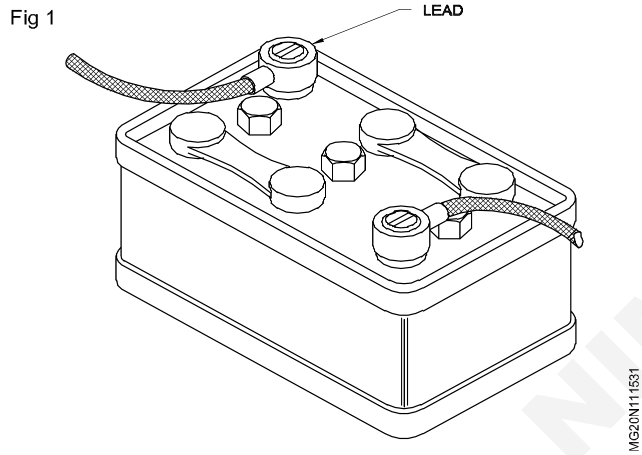
Objectives: At the end of this lesson you shall be able to
- **state the properties of lead**
- **state the various uses of lead**
- **state the uses of babbitt metal.**

Lead is a very commonly used non-ferrous metal and has a variety of industrial applications.

Lead is produced from its ore 'GALENA'. Lead is a heavy metal that is silvery in colour when molten. It is soft and malleable and has good resistance to corrosion. It is a good insulator against nuclear radiation. Lead is resistant to many acids like sulphuric acid and hydrochloric acid.

It is used in car batteries, in the preparation of solders etc.It is also used in the preparation of paints. (Fig 1)

Fig 1



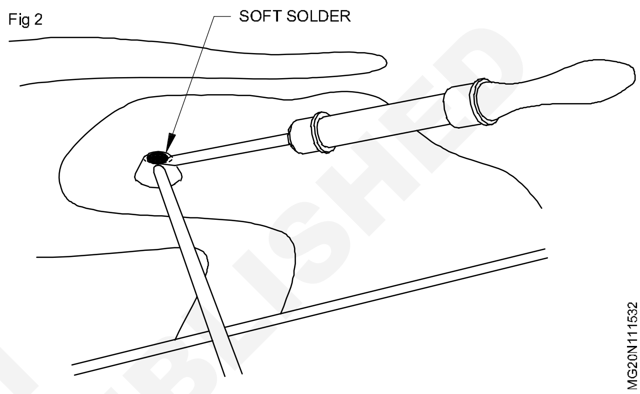
Lead Alloys

Babbitt metal

Babbitt metal is an alloy of lead, tin, copper and antimony. It is a soft, anti-friction alloy, often used as bearings.

An alloy of lead and tin is used as 'soft solder. (Fig 2)

Fig 2



Zinc

Objectives: At the end of this lesson you shall be able to
- **state the properties and uses of zinc**
- **state the uses of zinc alloys.**

Zinc is a commonly used metal for coating on steel to prevent corrosion. Examples are steel buckets, galvanized roofing sheets, etc.

Zinc is obtained from the ore-calamine or blende.

Its melting point is 420° C.

It is brittle and softens on heating; it is also corrosion-resistant. Due to this reason it is used for battery containers and is coated on roofing sheets etc.

Galvanized iron sheets are coated with zinc.

Tin

Objectives: At the end of this lesson you shall be able to
- **state the properties and uses of tin**
- **name the common tin alloys and state their uses.**

Tin

Tin is produced from cassiterite or tinstone. It is silvery white in appearance, and the melting point is 231° C. It is soft and highly corrosion-resistant.

It is mainly used as a coating on steel sheets for the production of food containers. It is also used with other metals, to form alloys.

Example: Tin with copper to form bronze. Tin with lead to form solder. Tin with copper, lead and antimony to form Babbitt metal.

Aluminium

Objectives: At the end of this lesson you shall be able to
- **state the properties and uses of aluminium**
- **name the commonly used aluminium alloys and their uses**
- **name the ores from which aluminium is produced.**

Aluminium

Aluminium is a non-ferrous metal which is extracted from 'BAUXITE'. Aluminium is white or whitish grey in colour. It has a melting point of 660° C. Aluminium has high electrical and thermal conductivity. It is soft and ductile, and has low tensile strength. Aluminium is very widely used in aircraft industry and fabrication work because of its lightness. Its application in the electrical industry is also on the increase. It is also very much in use in household heating appliances. Some typical aluminium alloys, their composition and applications are given in the table that follows.

ALUMINIUM ALLOYS - COMPOSITION - USES

Composition(%) (Only the percentage of alloying elements is shown. The remaining is aluminium.)						**Category**	**Applications**
Copper	Silicon	Iron	Manganese	Magnesium	Other elements		
0.1 max.	0.5 max.	0.7 max.	0.1 max.	-	-	Wrought. Not heat treatable.	Fabricated assemblies, Electrical conductors. Food and brewing, processing plants. Architectural decorations.
0.15 max.	0.6 max.	0.75 max.	1.0 max.	4.5 to 5.5	0.5 Chromium	Wrought. Not heat treatable.	High strength ship building and engineering products. Good corrosion resistance.
1.6	10.0	-	-	-	-	Cast, not heat treatable.	General purpose alloy for moderately stressed pressure die-castings.
-	10.0 to 13.0	-	-	-	-	Cast, not heat treatable	One of the most widely used alloys. Suitable for sand,gravity and pressure die castings. Excellent foundry characteristics Used for large marine, automotive and general engineering castings.
4.2	0.7	0.7	0.7	0.7	0.3 Titanium (option)	Wrought. Heat treatable.	Traditional'Duralumin'. General machining alloy. Widely used for stressed components in aircraft.
-	0.5	-	-	0.6	-	Wrought. Heat treatable.	Corrosion-resistant alloy for lightly stressed components such as glazing bars, window sections and automotive body components.
1.8	2.5	1.0	-	0.2	0.15 Titanium 1.2 Nickel	Cast. Heat treatable.	Suitable for sand and gravity die casting. High rigidity with moderate strength and shock resistance. A general purpose alloy
-	-	-	-	10.5	0.2 Titanium	Cast. Heat treatable.	A strong, ductile and highly corrosion-resistant alloy used for air craft and marine castings, both large and small.

Identification of metals

Objectives : At the end of this lesson you shall be able to
- **state the different methods of identifying ferrous metals and alloys**
- **state how non-ferrous metals and alloys are identified.**

A fitter has to handle different types of metals in his work. A knowledge about how to recognise and differentiate the commonly used metals will help him in many ways.

Ferrous metals and alloys can be identified by

their appearance (colour, texture etc)

their weight (light or heavy)

the sound

cold hammering

the spark test (grinding).

NOTE

The above characteristics of different ferrous metals and alloys are given in Table 1. Apart from the above tests, steel bars are also identified by the code colours painted on them.

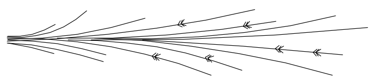
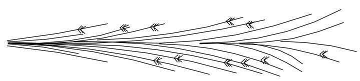
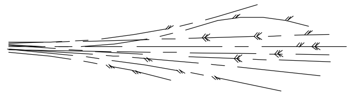
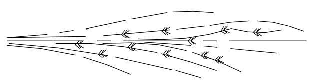
Different colours are marked, based on the different composition of materials and grade. Colour charts are available to determine the different metals.

Most non-ferrous metals and alloys can be identified by their colour. (Table 2)

TABLE 2

Metal/Alloy	Colour
Copper	Distinctive red colour
Aluminium	Dull white
Lead	Bluish-grey colour
Tin	Silvery white, with a slightly yellowish tinge
Brass (Alloy) (free cutting)	Distinctive yellow colour
Bronze (alloy)	Colour between copper and brass

TABLE 1

Ferrous Metals & alloys	Appearance	Density/ weight	Sound (Drop a ø 15 bar 25 cm long, on to the ground)	Cold hammer ing	Spark test	
Low carbon steel	Smooth scale with blue/ black sheen/ silver grey	7.85 medium weight	Medium metallic sound	Flattens easily	Stream of yellow white sparks varying in length slightly `fiery`.	
Medium carbon steel	Smooth scale black sheen	7.85 medium weight	Higher note than than of low carbon steel	Fairly difficult to flatten	Yellow sparks shorter than those of low carbon steel, finer and more feathery.	
High carbon steel	Rougher scale black	7.85 medium weight	Good ringing sound	Difficult to flatten	Sparkless bright, starting near grinding wheel and more feathery with secondary branching.	
High speed steel	Roughness scale black with reddish tint	9 compara tively heavy	Lower ringing more like low carbon steel	Very diffi- cult to flatten Tends to crack easily.	Faint red streak ending in fork.	

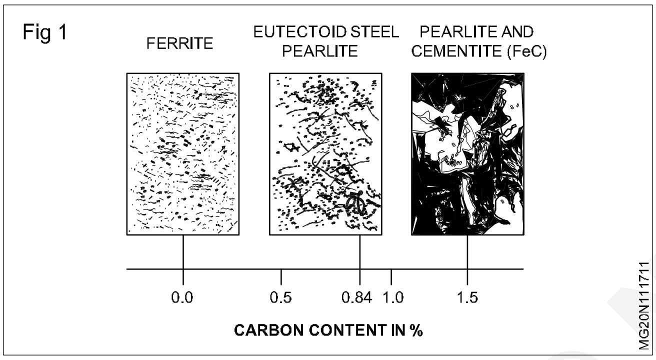
Heat treatment of plain carbon steels

Objectives: At the end of this lesson you shall be able to
- **state the purpose of heat treatment of steel**
- **state the types of structure, constituents and properties of plain carbon steels.**

Heat treatment and its purpose

The properties of steel depend upon its composition and its structure. These properties can be changed to a considerable extent, by changing either its composition or its structure. The structure of steel can be changed by heating it to a particular temperature, and then, allowing it to cool at a definite rate. The process of changing the structure and thus changing the properties of steel, by heating and cooling, is called 'heat treatment of steel'.

Types of structure of steel (Fig 1)



The structure of steel becomes visible when a piece of the metal is broken. The exact grain size and structure can be seen through a microscope. Steel is classified according to its structure.

Steel is an alloy of iron and carbon. But the carbon content in steel does not exceed 1.7%.

Ferrite

Pig iron or steel with 0% carbon is FERRITE which is relatively soft and ductile but comparatively weak.

Cementite

When carbon exists in steel as a chemical compound of iron and carbon it is called 'iron carbide' or CEMENTITE. This alloy is very hard and brittle but it is not strong.

Eutectoid/Pearlite steel

A 0.84% carbon steel or eutectoid steel is known as PEARLITE steel. This is much stronger than ferrite or cementite.

Hypereutectoid steel

More than 0.84% carbon steel or Hypereutectoid steel is pearlite and cementite.

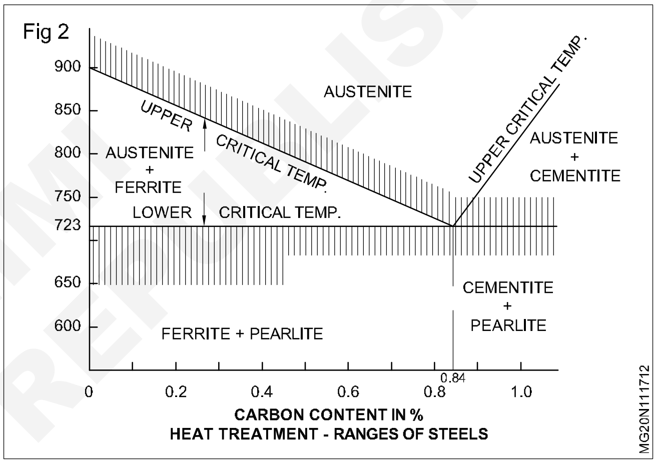
Hypereutectoid steel

Less than 0.84% carbon steel or Hyper eutectoid steel is pearlite and ferrite.

Structure of steel when heated (Fig 2)

If steel is heated, a change in its structure commences from 723°C. The new structure formed is called 'AUSTENITE'. Austenite is non-magnetic. If the hot steel is cooled slowly, the old structure is retained and it will have fine grains which makes it easily machin able.

If the hot steel is cooled rapidly the austenite changes into a new structure called 'MARTENSITE'. This structure is very fine grained, very hard and magnetic. It is extremely wear-resistant and can cut other metals. .



Heat treatment processes and purpose

Because steel undergoes changes in structure on heating and cooling, its properties may be greatly altered by suitable heat treatment.

The following are the various heat treatments and their purposes.

Hardening:	To add cutting ability.
	To increase wear resistance.
Tempering:	To remove extreme brittleness caused by hardening to an extent.
	To induce toughness and shock resistance.
Annealing:	To relieve strain and stress.
	To eliminate strain/hardness.
	To improve machinability.
	To soften the steel.
Normalising:	To refine the grain structure of the steel.

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

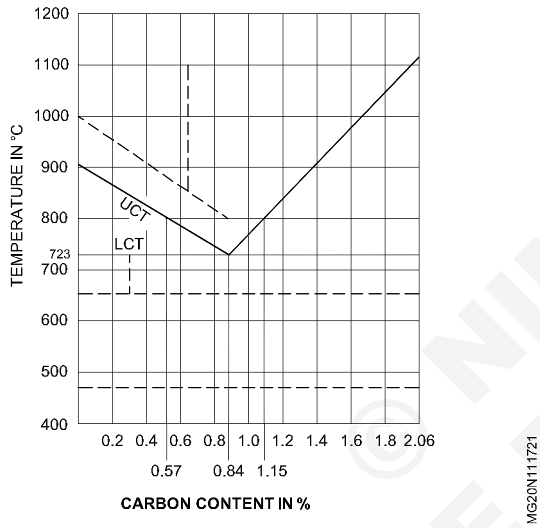
Lower Critical Temperature (LCT)

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 (UCT)

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

This 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 temperatures 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 than 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-treated.

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 fuming 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.

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 steel**
- **state the process of hardening.**

What Is hardening?

Hardening is a heat-treatment process in which steel is fitted to 30 - 50°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

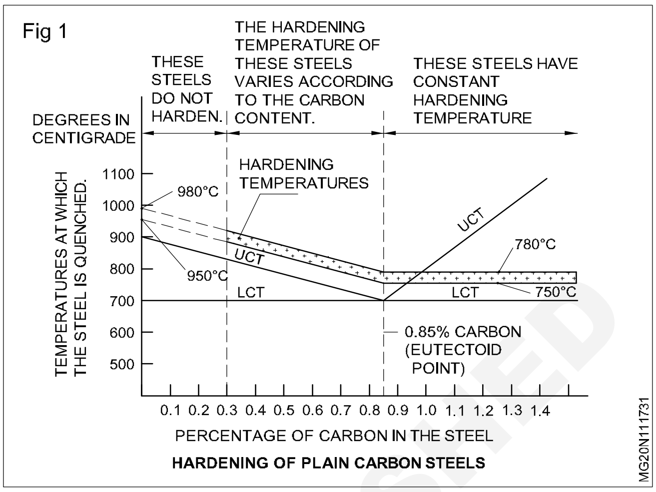
To develop high hardness and wear-resistance properties.

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 30-60°C above the upper critical temperature. (Fig 1) A soaking time of 5mts. / 10 mm thickness of steel is allowed. (Fig 1)



Then the steel is cooled rapidly in a suitable medium. Water, oil, brine or air is used as a cooling medium, depending upon the composition of the steel and the hardness required.

Tempering the hardened steel

Objectives: At the end of this lesson you shall be able to
- **state what is tempering**
- **state the purpose of tempering**
- **relate the tempering colours and temperatures with the tools to be tempered**
- **state the purpose of tempering of steels.**

What is tempering?

Tempering is a heat-treatment process consisting of reheating the hardened steel to a temperature below 400°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 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 shows the tempering temperature and the colour for different tools.

TABLE 1

Tools or articles	**Temp in deg. (^{0}C)**	**Colour**
Turning tools.	230	Pale straw.
Drills and milling cutters.	240	Dark straw.
Taps and shear blades.	250	Brown.
Punches, reamers, twist drills.	260	Reddish brown
Rivets, snaps.	270	Brown purple.
Press tools, cold chisels	280	Dark purple.
Cold set for cutting steels.	290	Light blue.
Springs	300	Dark blue.
Wrenches, screwdrivers	320	Very dark blue.
Wood cutting saw	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 process of annealing.**

The annealing process is carried out by heating the steel above the critical range, soaking it for sufficient time to allow the necessary changes to occur, and cooling at a predetermined rate, usually very slowly, within the furnace.

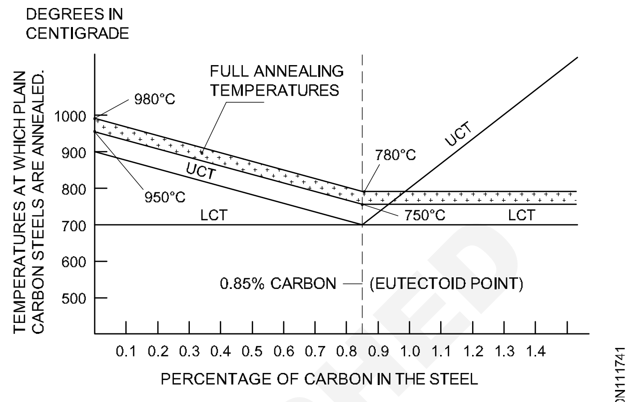
Purpose

- To soften the steel.
- To improve the machinability.
- To increase the ductility.
- To relieve the internal stresses.
- To refine the grain size and to prepare the steel for subsequent heat treatment process.

Annealing process

Annealing consists of heating of hypo eutectoid steels to 30 to 50°C above the upper critical temperature and 50°C above the lower critical temperature for hypereutectoid steels. (Fig 1)

Fig 1



ANNEALING TEMPERATURES FOR PLAIN CARBON STEELS

Soaking is holding at the heating temperature for 5mts./ 10 mm of thickness for carbon steels.

The cooling rate for carbon steel is 100 to 150°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.

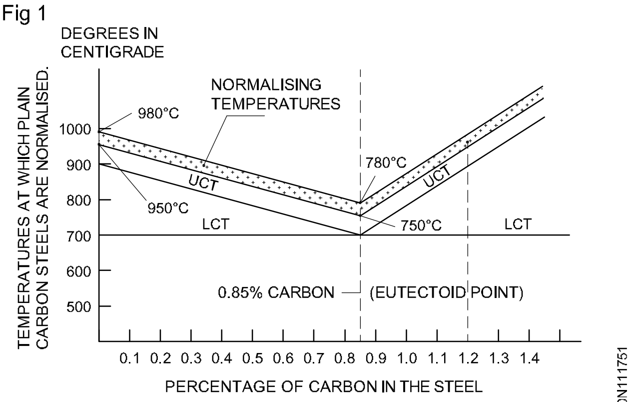
Purpose

- 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
- hammering.
- To reduce ductility.
- To prevent warping.

Process (Fig 1 & Fig 2)

To get the best results from normalising, the parts should be heated uniformly to a temperature of 30 to 40°C 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.

Fig 1



NORMALISING TEMPERATURES FOR PLAIN CARBON STEELS

Precautions

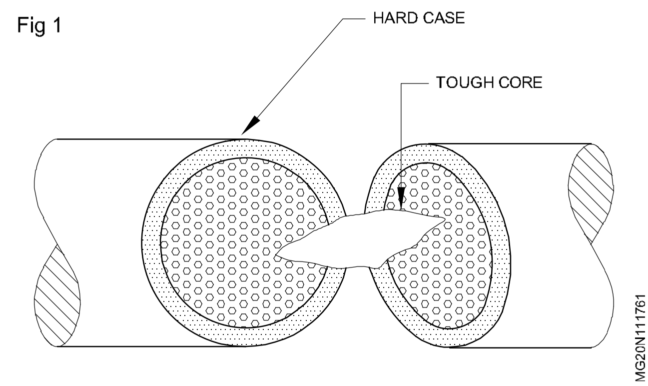
Avoid placing the component in a wet place or wet air, thereby restricting the natural circulation of air around the component. Avoid placing the component on a surface that will chill it.

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

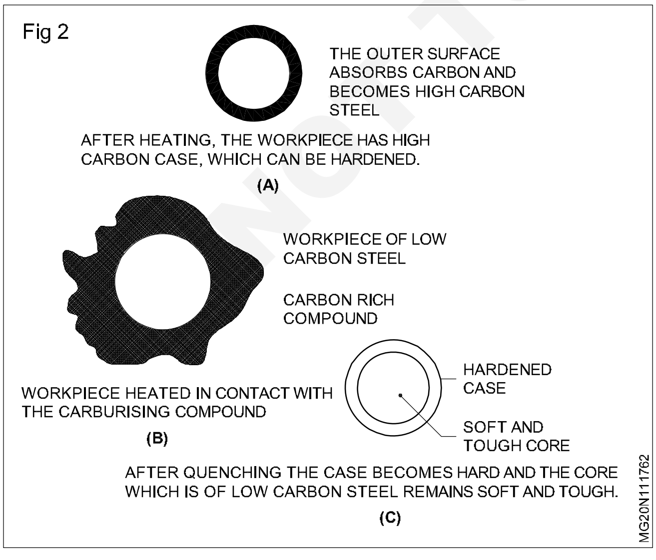
- Case hardening
- Nitriding
- Flame hardening
- Induction hardening

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%.

Fig 2



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)

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.

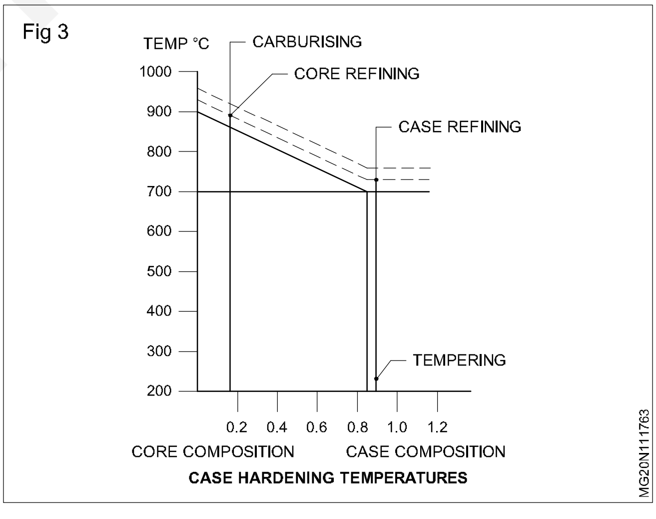
Carburising

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



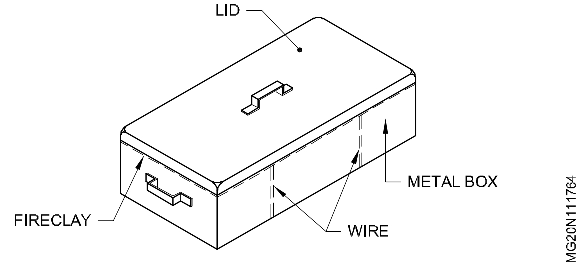
CASE HARDENING TEMPERATURES

Pack carburising (Fig 4)

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.

Fig 4



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.

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.

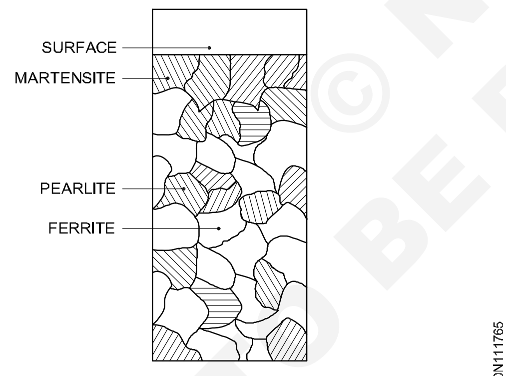
Gas carburising

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

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 thecarbon content between the case and the core.

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°G 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 and therefore, an extremely brittle marten site will be produced.

The case and the outer layers of the core must now be refined.

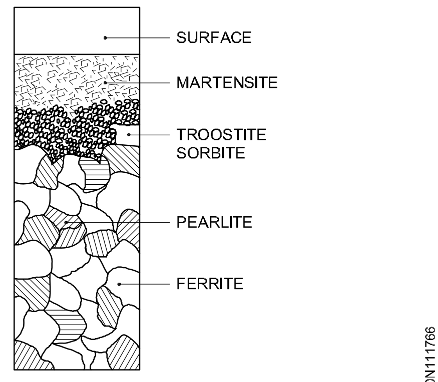
The refining is done by reheating the steel to about 760°G, to suit the case, and quenching it.

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°G 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 (about400°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 be- cause 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-resistanceare 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

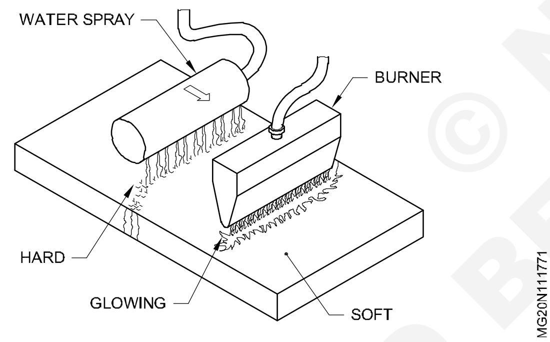
Flame hardening

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 work piece by specially constructed burners. The heat is applied to the surface very rapidly and the work is quenched immediately by spraying it with water. (Fig 1 & 2) The hardening temperature is generally about 50°C higher than that for full hardening.

Fig 1



Gas nitriding

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%.

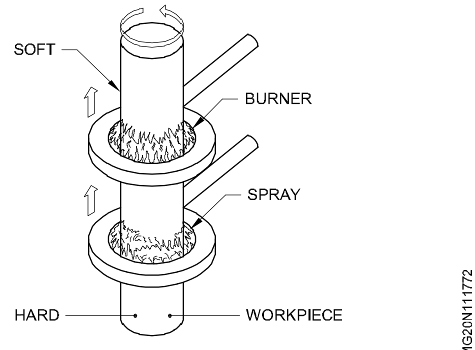
The following are the advantages of this type of hardening.

- 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 hard ening.

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.**

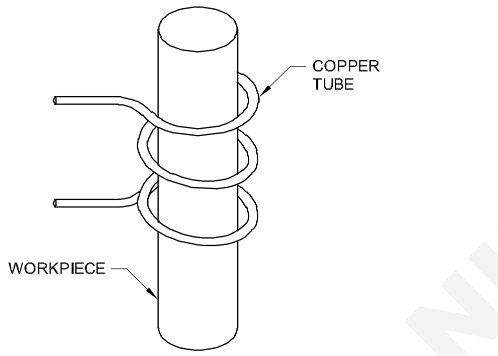
Induction hardening

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.

After induction-hardening of the workpieces, stress relieving is necessary.

Fig 1



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.

Semi precision measuring instruments

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

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

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

Length - SI UNITS and MULTIPLES

Base unit

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

METRE(m) = 1000 mm

CENTIMETRE (µm) = 10 mm

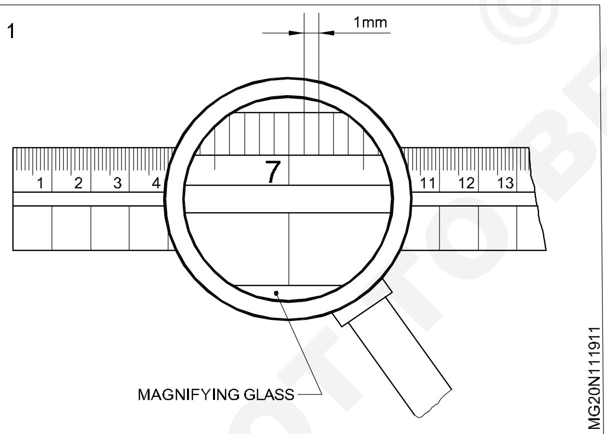
MILLIMETRE (mm) = 1000 µm

MICROMETRE (µm) = 0.001 mm

Measurement in engineering practice

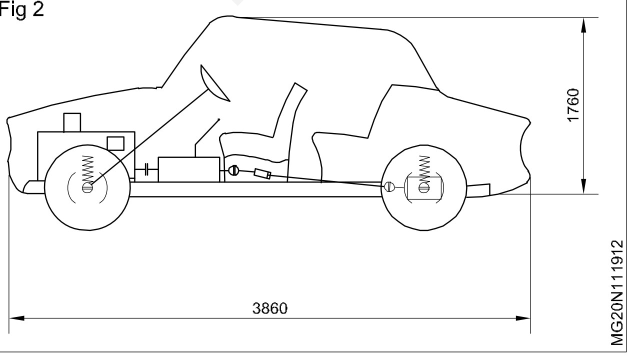
Usually, in engineering practice, the preferred unit of length measurement is millimetre. (Fig 1)

Fig 1



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

Fig 2

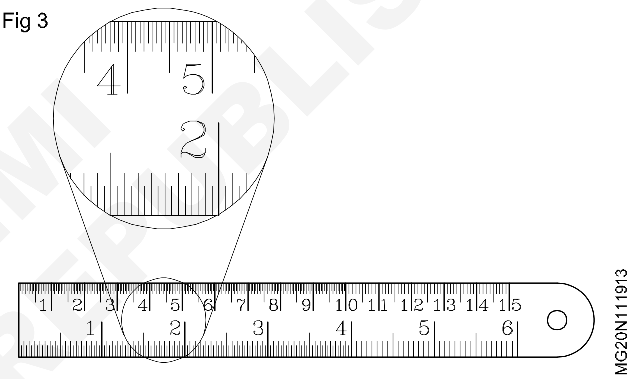


The British system of length measurement

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

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

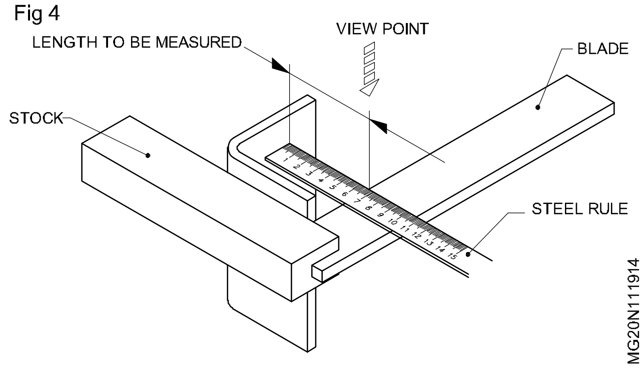
Fig 3



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

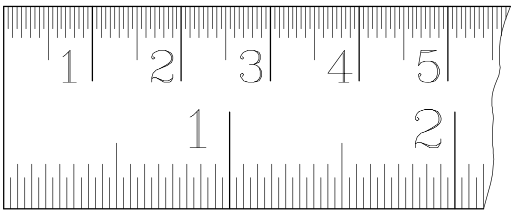
For accurate reading it is necessary to read vertically to avoid errors arising out of parallax. (Fig 4)

Fig 4



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

Fig 5



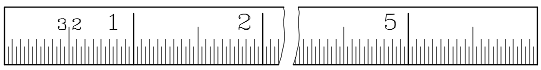
Other types of rule

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

Narrow steel rule

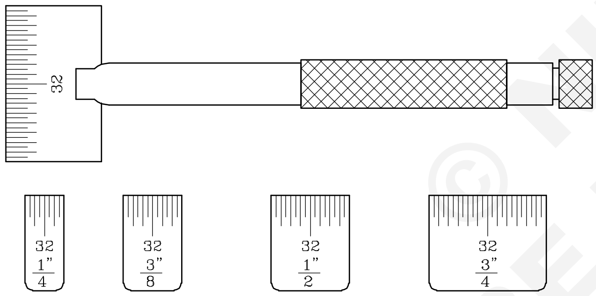
Narrow steel rule is used to measure the depth of keyways and depth of smaller dia, blind holes of jobs, where the ordinary steel rule cannot reach. Its width is approximately 5 mm and thickness 2 mm. (Fig 6)

Fig 6



Short steel rule (Fig 7)

Fig 7



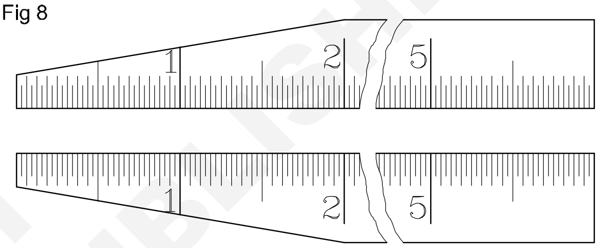
This set of five small rules together with a holder is extremely useful for measurements in confined or hard to reach locations which prevent the use of ordinary steel rules. It is used suitably for measuring grooves, short shoulder, recesses, key ways etc. In machining operation on shapers, millers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

The rules are easily inserted in the slotted end of the holder and are rigidly clamped in place by a slight turn of the knurled nut at the end of the handle. Five rule lengths are provided 1/4", 3/8" and 1" and each rule is graduated in 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 end permits measuring of inside size of small holes, narrow slots, grooves, recesses etc. This rule has a taper from 1/2 inch width at the 2 inch graduation to 1/8 inch width at the end. (Fig 8)

Fig 8



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

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

Angular measurement

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

Measurements of fundamental, derived units

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

Calipers

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

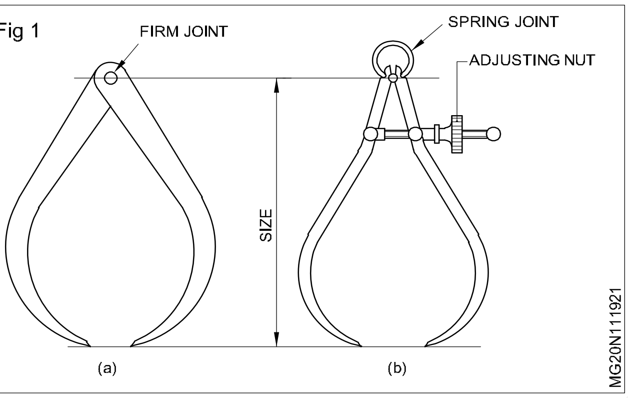
Calipers are indirect measuring instruments used for transferring measurements from a steel rule to a job, and vice versa.

Calipers are classified according to their joints and their legs.

Joint

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

Fig 1



Legs

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

Fig 2

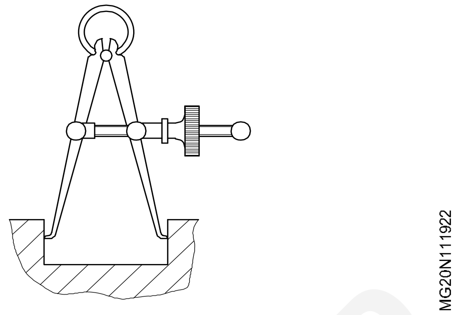
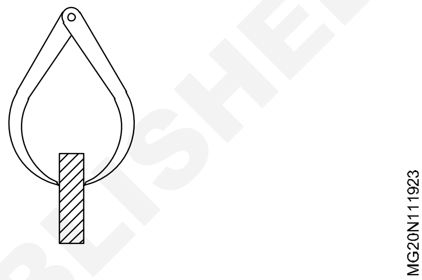


Fig 3



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.

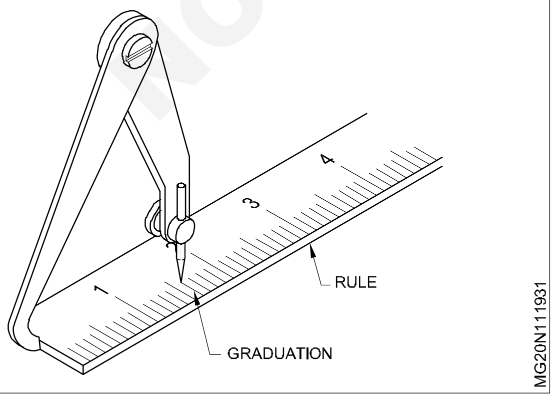
Jenny calipers

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

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

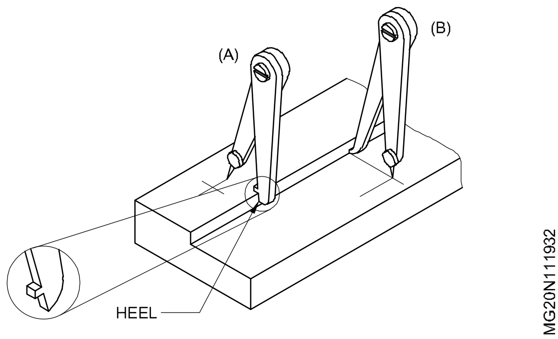
Jenny calipers are used

Fig 1



- for marking lines parallel to the inside and outside edges (Fig 2)

Fig 2



- for finding the centre of round bars (Fig 3)

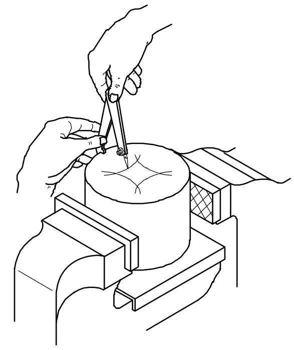
These calipers are available with the usual bent leg or with heel.

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

The other names for this caliper are:

- hermaphrodite calipers
- leg and point calipers
- odd leg caliper
- ensure that the face of the hammer is free from oil or grease.

Fig 3



Ordinary depth gauge

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

Ordinary depth gauge

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

Parts of ordinary depth gauge

1 Graduated beam

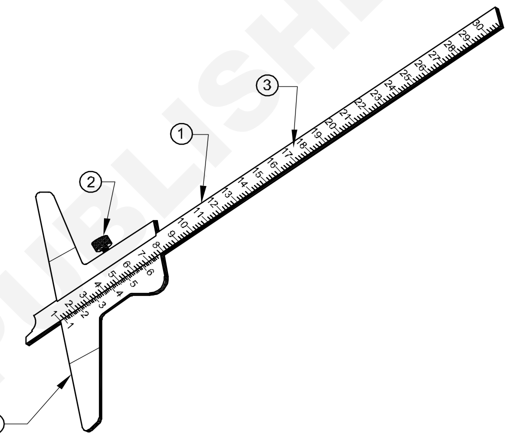
2 Clamping screw

3 Scale

4 Base

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

Fig 1



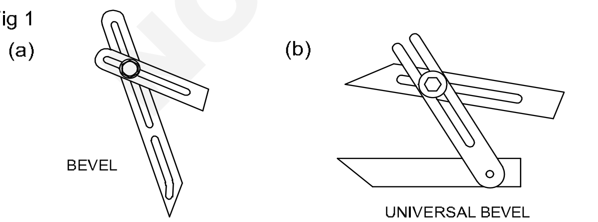
Angular measuring instruments (semi-precision)

Objectives: At the end of this lesson you shall be able to
- **state the names of semi-precision angular measuring instruments**
- **differentiate between bevel and universal bevel gauges**
- **state the features of bevel protractors.**

The most common instruments to check angles are the

- Bevel or bevel gauge (Fig 1a)
- Universal bevel gauge (Fig 1b)

Fig 1

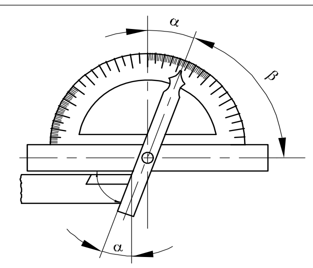


- Bevel protractor (Fig 2)

Bevel gauges

The bevel gauges connote measure angles directly. They are therefore, angular measuring instruments. The angles can be set and measured with bevel protractors.

Fig 2



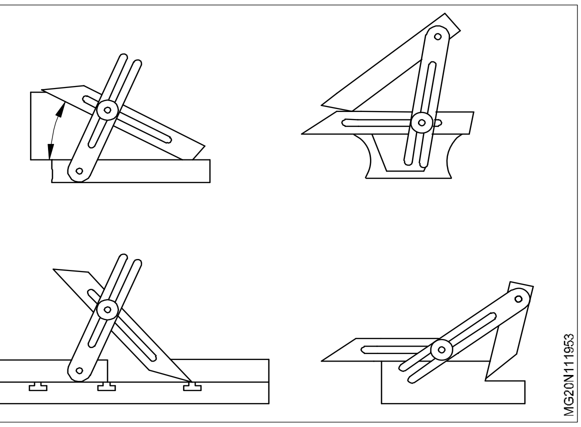
Universal bevel gauges

The universal bevel gauge has an additional blade. This helps in measuring angles which cannot be checked with an ordinary bevel gauge. (Fig 3)

Bevel protractor

The bevel protractor is a direct angular measuring instrument and has graduations marked from 0° to 180° angles can be measured within an accuracy of 1° using this instrument (Fig 3)

Fig 3



Combination set

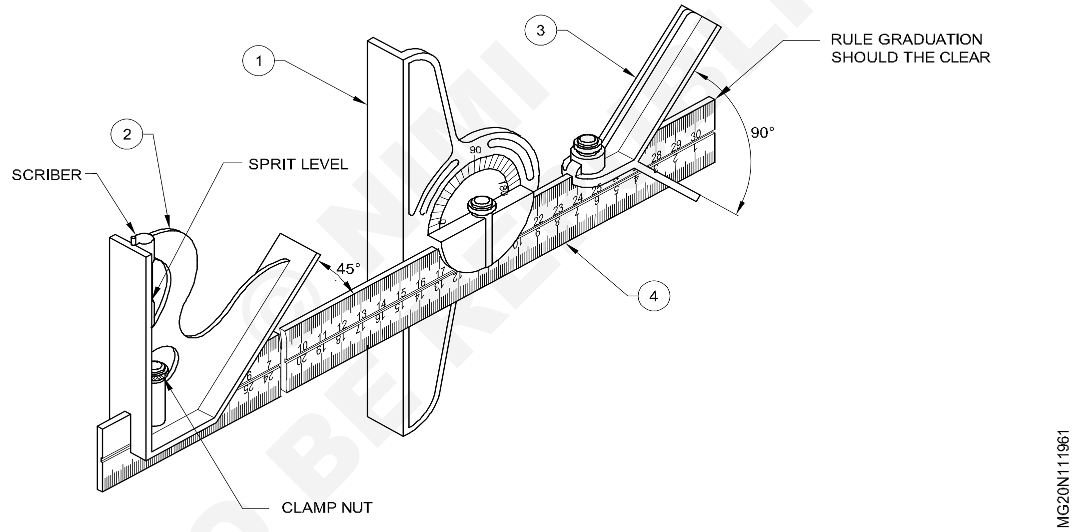
Objectives: At the end of this lesson you shall be able to
- **explain the parts of a combination set**
- **state the uses of each attachment in a combination set.**

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

The combination set has a following part (Fig 1)

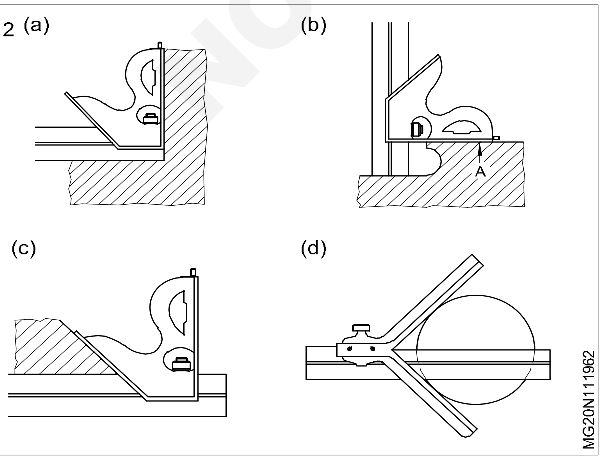
- protractor head
- square head
- centre head
- rule.

Fig 1



Square head: The square head has one measuring face at 90° and another at 45° to the rule. It is used to mark and check 90° and 45° angles. It can also be used to set workpieces on the machines and measure the depth of slots. (Figs 2 and 3)

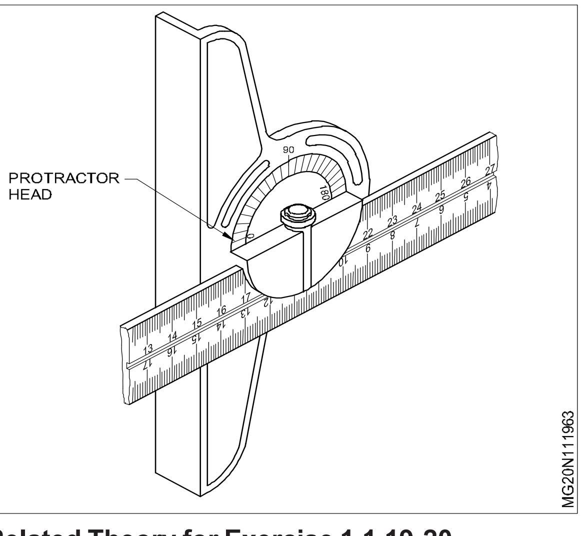
Fig 2



Centre head

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

Fig 3



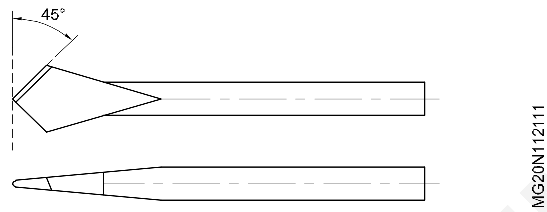
Drill & Tap

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

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

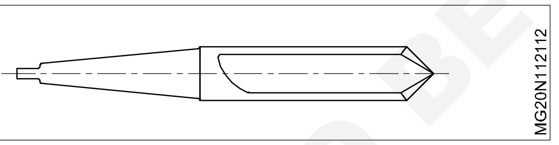
Flat or spade drill (Fig 1) : This type of drill is used where the required size of twist drill is not available. It is made from a round tool steel piece which is forged to shape and ground to size, and then hardend and tempered. This type of drill is used for hand drilling (without power) or with a ratchet brace.

Fig 1



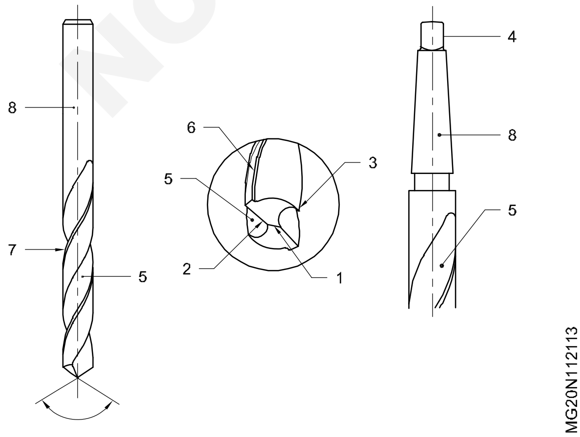
Straight fluted drill (Fig 2): It has grooves or flutes running parallel to the drill axis. It is mainly used in drilling brass, copper or soft materials. This type of drill is inconvenient in standard practice as the chips do not come out from the hole automatically. It is used to drill sheet metals and cores in the castings.

Fig 2



Twist drills (Fig 3) : In this type, two spiral flutes or grooves run lengthwise around the body of the drill. It is the most common type of drill used for all purposes, and especially for faster drilling of accurate holes and for harder materials - in comparison with the other drills.

Fig 3



PARTS OF A TWIST DRILL (Fig 3)

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

Tang (4): This is provided only on taper shank drills, for driving (giving torque to) the drill, which when overloaded, becomes twisted or gets sheared off.

Flutes (5): Flutes are the spiral grooves which run to the length of the drill. The flutes help.

to form the cutting edge

to curl the chips and allow these to come out

the coolant to flow to the cutting edge.

Shank (8): This is the driving end of the drill which is fitted on to the machine. Shanks are of two types.

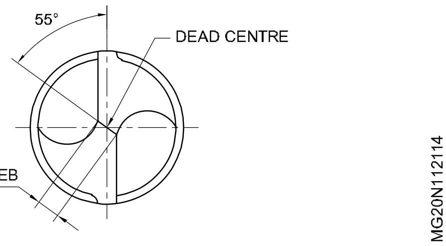
Taper shank, with Morse taper provided, is used for larger diameter drills, and the straight shank is used for smaller diameter drills.

Land/margin (6): The land/margin is the narrow strip which extends to the entire length of the flutes. The diameter of the drill is measured across the land/margin.

Body clearance (7): Body clearance is that part of the body which is reduced in diameter to cut down the friction between the drill and the hole being drilled.

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

Fig 4



Material for twist drills

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

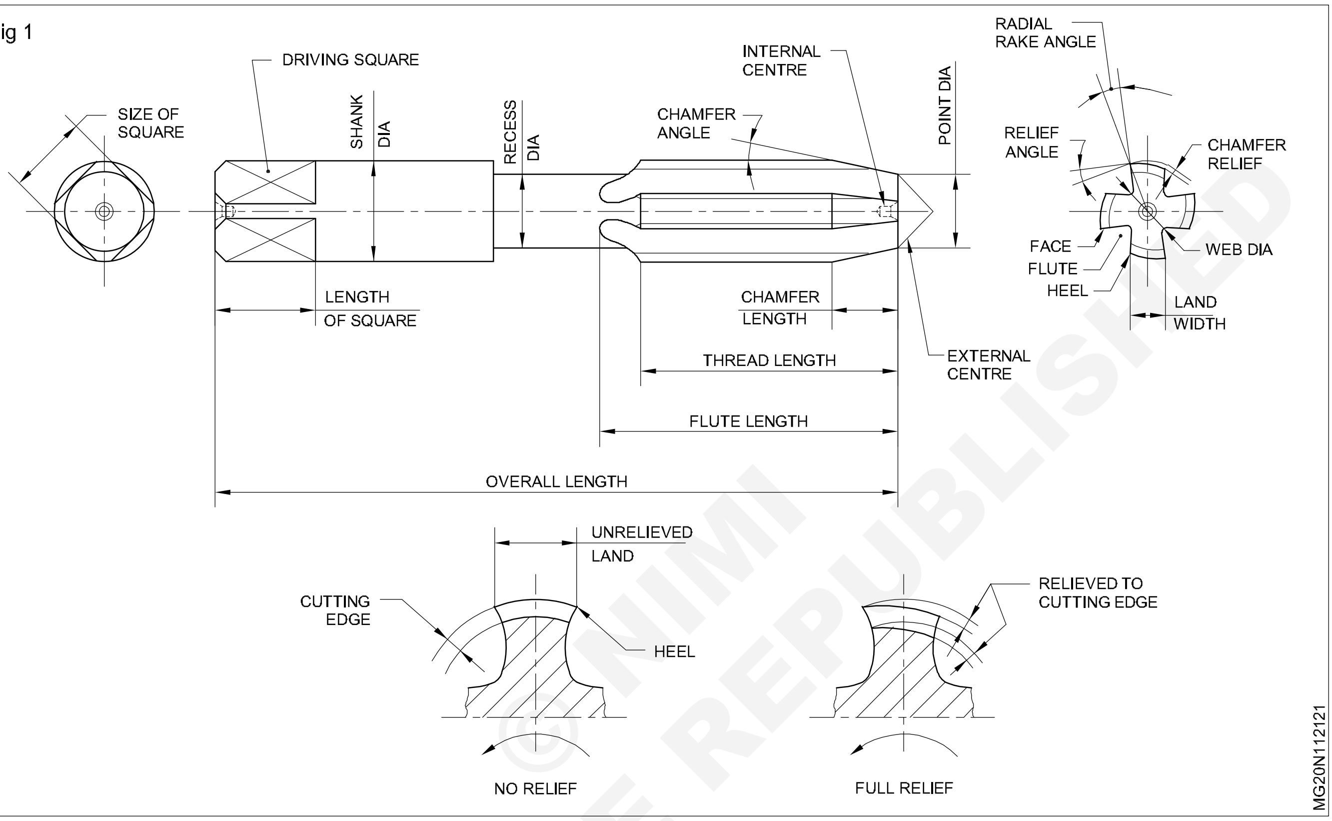
Hand taps and wrenches

Objectives: At the end of this lesson you shall be able to
- **state the uses of hand taps**
- **state the features of hand taps**
- **explain the different types of tap wrenches**
- **state the uses of the different types of wrenches.**

Use of hand taps: Hand taps are used for internal threading of components.

Features (Fig 1): They are made from high carbon steel or high speed steel, hardened, tempered and ground.

Fig 1



The threads are cut on the periphery and are accurately finished.

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

The end of the shank of the tap is made of square shape for the purpose of holding and turning the taps.

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

The size of the taps, the thread standard, the pitch of the thread, the diameter of the tapping hole are usually marked on the shank.

Marking on the shank are also made to indicate the type of tap i.e. first, second and plug.

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

These are:

- first tap or taper tap
- second tap or intermediate tap
- plug or bottoming tap

These taps are identical in all features except in the taper lead.

The taper tap is to start the thread. It is possible to form full threads by the taper tap in through holes which are not deep.

The bottoming tap (plug) is used to finish the threads of a blind hole to the correct depth.

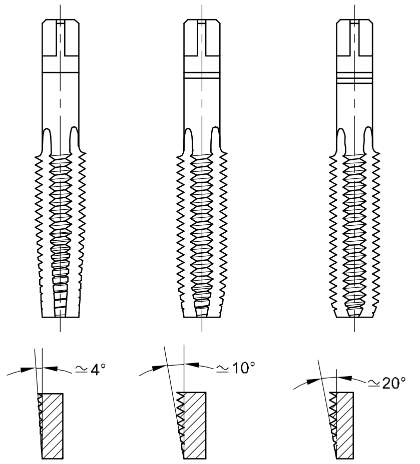
For identifying the type of taps quickly - the taps are either numbered 1,2 and 3 or rings are marked on the shank.

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

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

Tap wrenches are of different types, such as double-ended adjustable wrench, T-handle tap wrench, solid type tap wrench etc.

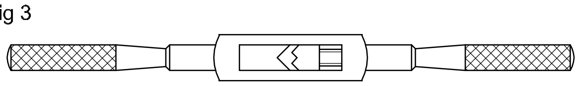
Fig 2



Double-ended adjustable tap wrench or bar type tap wrench (Fig 3)**:** This is the most commonly used type of tap wrench. It is available in various sizes - 175, 250, 350 mm long. These tap wrenches are more suitable for large diameter taps, and can be used in open places where there is no obstruction to turn the tap.

It is important to select the correct size of wrench.

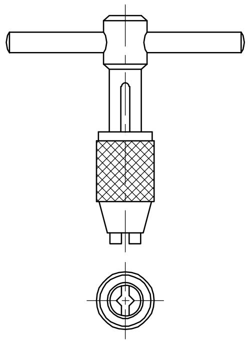
Fig 3



T-handle tap wrench (Fig 4)**:** These are small, adjustable chucks with two jaws and a handle to turn the wrench.

This tap wrench is useful to work in restricted places, and is turned with one hand only. Most suitable for smaller sizes of taps.

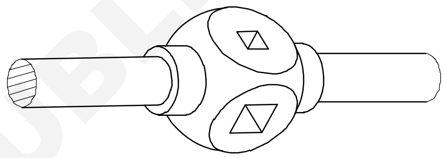
Fig 4



Solid type tap wrench (Fig 5)**:** These wrenches are not adjustable.

They can take only certain sizes of taps. This eliminates the use of wrong length of the tap wrenches, and thus prevents damage to the taps.

Fig 5



Tap drill size

Objectives: At the end of this lesson you shall be able to
- **state tap drill size**
- **state the tap drill sizes for metric and BSW thread tables**
- **state the tap drill sizes for ISO metric ISO inch.**

What is tap drill size?

Before a tap is used for cutting internal threads, a hole is to be drilled. The diameter of the hole should be such that it should have sufficient material in the hole for the tap to cut the thread.

Tap drill sizes for different threads

ISO metric thread

Tap drill size for M 10 x 1,5 thread

Minor diameter = Major diameter - (2 x depth)

Depth of thread = 0.6134 x pitch of a screw

2 depth of thread = 0.6134 x 2 x pitch

= 1.226 x 1.5 mm

= 1.839 mm

Minor dia. = 10 mm - 1.839 mm

= 8. 161 mm or 8.2 mm.

This tap drill will produce 100% thread because this is equal to the minor diameter of the tap. For most fastening purposes a 100% formed thread is not required.

A standard nut with 60% thread is strong enough to be tightened until the bolt breaks without stripping the thread. Further it also requires a greater force for turning the tap if a higher percentage formation of thread is required.

Considering this aspect, a more practical approach for determining the tap drill sizes is

Tap drill size = major diameter minus pitch

= 10mm - 1.5 mm

= 8.5 mm.

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

BSW inch (unified) threads formula

Tap drill size =

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

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

Tap drill size = 5/8" - 1/11"

= 0.625" - 0.091"

= 0.534"

The next drill size is 17/32" (0.531 inches).

Compare this with the table of drill sizes for unified inch threads.

What will be the size for the following threads?

a) M20

b) BSW 3/8

Refer to the chart for determining the pitches of the thread.

Table for tap drill size

Nominal diameter M.M	ISO Metric (60°)		B.S.W. (55°)		Tap drill sizes
	Pitch	Tap drill sizes	Nominal diameter (inch)	Threads per inch (mm)	
3	0.5	2.05	1/8	40	2.5
4	0.7	3.30	5/32	32	3.2
5	0.8	4.20	3/16	24	4.0
6	1.0	5.00	1/4	20	5.0
8	1.25	6.80	5/16	18	6.0
10	1.50	8.0	3/8	16	8.0
12	1.75	10.20	1/2	12	10
14	2.00	12.00	9/16	12	12.5
16	2.00	14.00	5/8	11	14.00
18	2.50	15.50	3/4	10	16.00
20	2.50	17.50	13/16	10	18.00
22	2.50	19.50	7/8	9	19.5
24	3.00	21.00	1	8	22.2

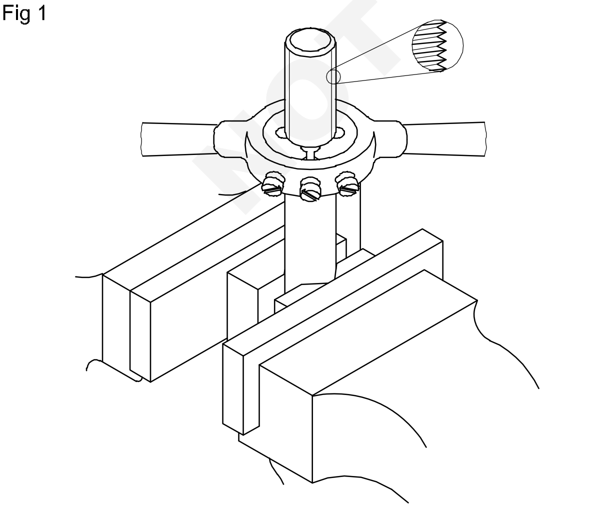
Die and die stock

Objectives: At the end of this lesson you shall be able to
- **explain the different types of dies**
- **state the features of each type of die**
- **state the use of each type of die**
- **name the type of die stock for each type of die.**

Uses of dies

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

Fig 1



Types of Dies

The following are the different types of dies.

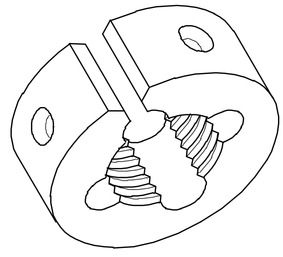
– Circular split die (Button die)

– Half die

– Adjustable screw plate die

Circular split die/button die (Fig 2)

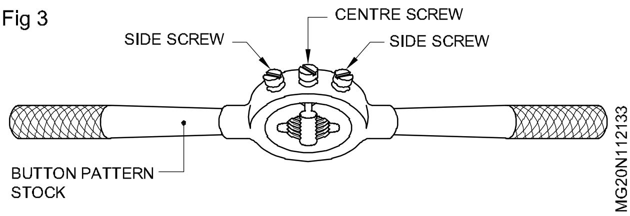
Fig 2



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

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

Fig 3



Half die (Fig 4)

Half dies are stronger in construction.

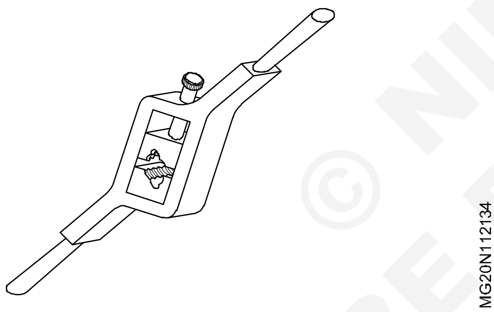
Adjustments can be made easily to increase or decrease the depth of cut.

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

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

They need a special die holder.

Fig 4



Adjustable screw plate die (Fig 5)

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

This provides greater adjustment than the split die.

The two die halves are held securely in a collar by means of a threaded plate (guide plate) which also acts as a guide while threading.

When the guide plate is tightened after placing the die pieces in the collar, the die pieces are correctly located and rigidly held.

The die pieces can be adjusted, using the adjusting screws on the collar.

This type of die stock is called quick cut die stock. (Fig 6)

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

Both pieces should have the same serial numbers.

Fig 5

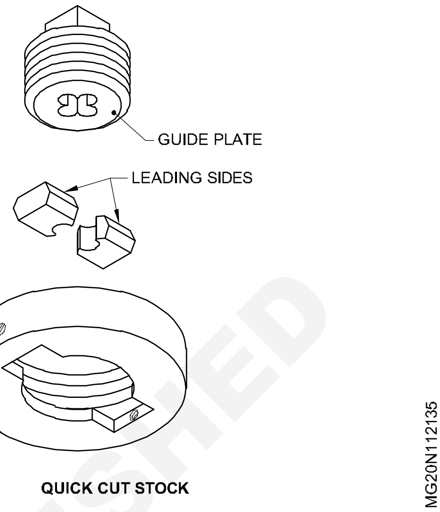
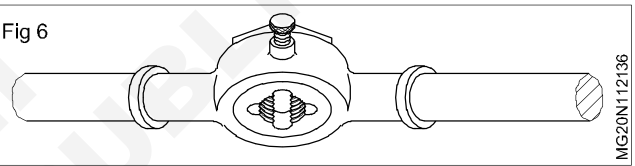


Fig 6



Die nut (Solid die) (Fig 7)

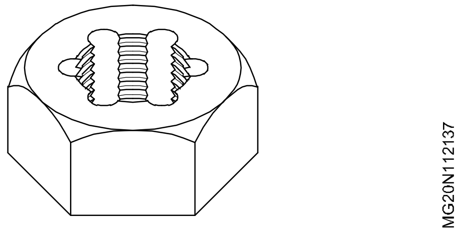
The die nut is used for chasing or reconditioning the damaged threads.

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

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

The die nut is turned with a spanner.

Fig 7



Blank size for external threading

Objective: At the end of this lesson you shall be able to
- **state the diameter of blank size for external thread cutting.**

Why should the blank size be less?

It has been observed from practice that the threaded diameters of steel blanks show a slight increase in diameter. Such increase in the diameter will make the assembly of external and internal threaded components very difficult. To overcome this, the diameter of the blank is slightly reduced before commencing the threading.

What should be the blank size?

The diameter of the blank should be less by 1/10th of the pitch of the thread.

Example

For cutting the thread of M12 with 1.75 mm pitch the diameter of the blank is 11.80.

Formula, D = d – p/10

= 12 mm – 0.175 mm

= 11.825 or 11.8 mm.

d = diameter of bolt

D = the blank diameter

p = pitch of thread

Calculate the blank size for preparing a bolt of M16 x 1.5.

Answer

____

____

____

Coolants

Objectives: At the end of this lesson you shall be able to
- **state the purpose of using coolant**
- **state the properties of coolant**
- **list the type of coolant.**

Coolant

It is matter/substance used to reduce the heat produced by tool and work. The heat affects the life and accuracy of machine, tool and job becomes hardened.

Purpose of coolant

To cool the job to avoid expansion by heat

To cool the cutting points of the tool and save temper and cutting efficiency.

To wash away the chip

To obtain a smooth finishing

To reduce friction between the tool and work

To prevent the machine from corrosion

Properties of coolant

Higher the viscosity

Good oiliness

Should have high fire point

Should be chemically stable

Low Sulphur content (less than 3%)

Should be harmless to skin of operator

Odorless - Should not have bad smell.

Types of coolant

The most common machine coolants used today belong to one of two categories based on their oil content.

Oil based machine coolants - Including straight oils and soluble oils

Chemical machine coolants - Including synthetics and semi synthetics

Fluids vary in suitability for metal working operations due to their excellent lubricity while water miscible fluids provide the cooling properties required for most turning and grinding operations.

Oil based machine coolants

Straight oils - 100% petroleum oil

Soluble oils - 60% to 90% petroleum oil

Chemical machine coolants

Synthetics - No petroleum oils

Semi synthetics - 2% to 30% petroleum oil

Lubricants

Objectives: At the end of this lesson you shall be able to
- **state the purpose of using lubricants**
- **state the properties of lubricants**
- **state the qualities of a good lubricant.**

With the movement of two mating parts of the machine, heat is generated. If it is controlled the temperature may rise resulting in total damage of the mating parts. There fore a film of cooling medium with high viscosity is applied between the mating parts which is known as a 'lubricant'.

A 'lubricant' is a substance having an oily property available in the form of fluid, semi-fluid, or solid state. It is the lifeblood of the machine, keeping the vital parts in perfect condition and prolonging the life of the machine. It saves the machine and its parts from corrosion, wear and tear, and it minimise friction.

Purposes of using lubricants

- Reduces friction.
- Prevents wear.
- Prevents adhesion.
- Aids in distributing the load.
- Cools the moving elements.
- Prevents corrosion.
- Improves machine efficiency.

Properties of lubricants

Viscosity

It is the fluidity of an oil by which it can withstand high pressure or load without squeezing out from the bearing surface.

Oiliness: Oiliness refers to a combination of wettability, surface tension and slipperiness. (The capacity of the oil to leave an oily skin on the metal.)

Flash point

It is the temperature at which the vapour is given off from the oil (it decomposes under pressure soon).

Fire point

It is the temperature at which the oil catches fire and continues to be in flame.

Pour point

The temperature at which the lubricant is able to flow when poured.

Emulsification and de-emulsibility

Emulsification indicates the tendency of an oil to mix intimately with water to form a more or less stable emulsion. De-emulsibility indicates the readiness with which subsequent separation will occur.

Methods of applying lubricant

Objectives: At the end of this lesson you shall be able to
- **state the different methods of lubrication**
- **state the gravity feed methods of applying lubrication**
- **state the splash methods of applying lubrication**
- **state the different types of lubricators**
- **explain the different methods of lubrication.**

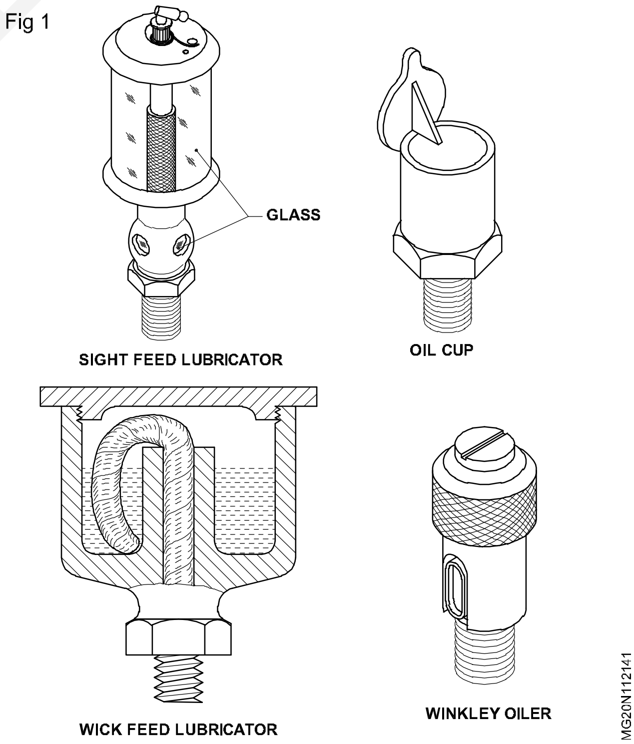
The following methods are used for efficient lubrication.

- Gravity feed method
- Force feed method
- Splash method

Gravity feed method

There are numerous ways of employing this principle, varying from the simple oil hole to the more elaborate wick and glass-sided drip feed lubricators in which the flow of the oil may be controlled and observed through the glass. A selection of these lubricators is shown in Fig 1.

Fig 1

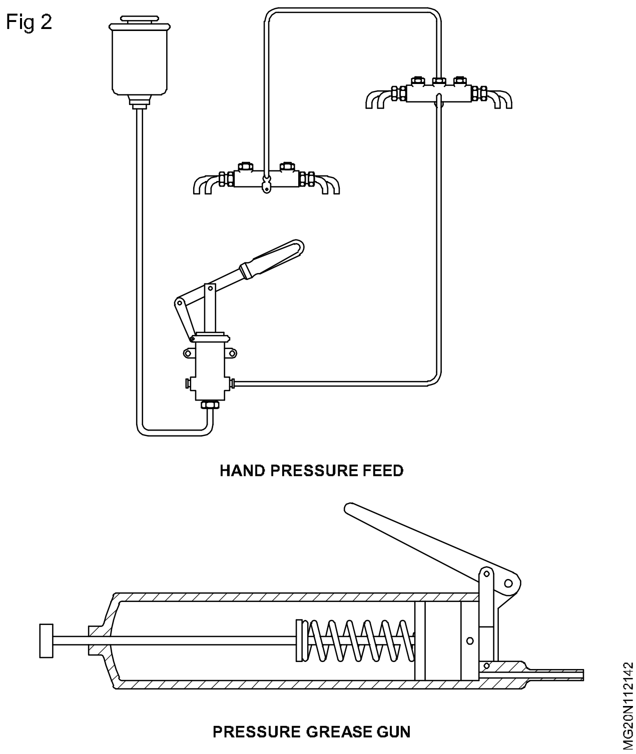


Force (Pressure) feed method

There are various systems of lubrication employing a pressure feed to the lubricant, and the most important of such systems may be classified roughly into the following.

- Continuous feed of oil under pressure to each bearing concerned. In this method an oil pump driven by the machine delivers oil to the bearings and back to a sump from which it is drawn by the pump.
- Pressure feed by hand pump in which change of oil is delivered to each bearing at intervals (once or twice a day) by the machine operator. (Fig 2)
- Oil or grease gun method. The oil hole leading to each bearing is fitted with a nipple and by pressing the nose of the gun against this and the lubricant is forced into the bearing. (Figs 3 a, b, c & d)

Fig 2



Splash method

In this method the shaft, or something attached to it, actually dips into the oil and a stream of lubricant is continually splashed round the parts requiring lubrication. This method is employed for the gears and bearings inside all gear drives, the lower parts of the gears actually dipping in the oil. (Figs 4a, b and c)

A common method of employing splash lubrication is known as 'ring oiling.'

Fig 3

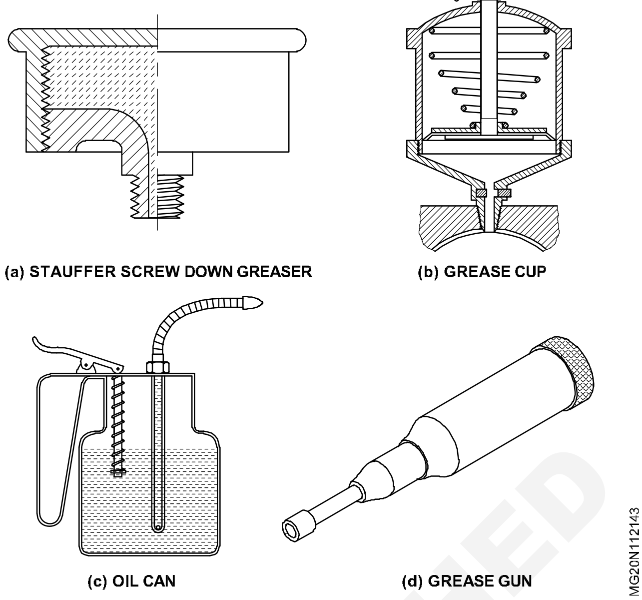
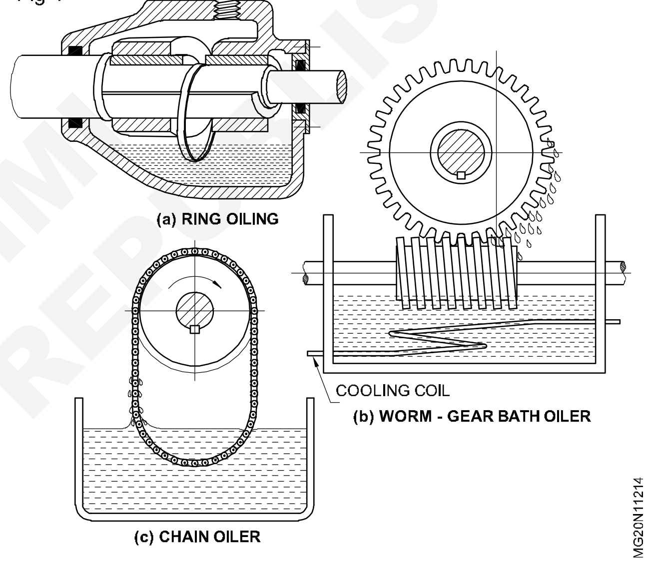


Fig 4



Classification of lubricants

Objectives: At the end of this lesson you shall be able to
- **state solid lubricants and their application**
- **state liquid and semi-liquid lubricants and their application**
- **state the classification of lubricants as per Indian Oil Corporation.**

Lubricants are classified in many ways. According to their state, lubricants are classified as:

- solid lubricants
- semi-solid or semi-liquid lubricants
- liquid lubricants.

Solid lubricants

These are useful in reducing friction where an oil film cannot be maintained because of pressure and temperature. Graphite, molybdenum disulphide, talc, wax, soap stone, mica and French chalk are solid lubricants.

Semi-liquid or semi-solid lubricants

Greases are semi-liquid lubricants of higher viscosity than oil. Greases are employed where slow speed of heavy pressure exists. Another type of application is for high temperature components, which would not retain liquid lubricants.

Liquid lubricants

According to the nature of their origin, liquid lubricants are classified into:

- mineral oil
- animal oil
- synthetic oil.

According to the product line of Indian Oil Corporation the lubricants are classified as:

- automotive lubricating oils
- automotive special oils
- rail-road oils
- industrial lubricating oils
- metal working oils
- industrial special oils
- industrial greases
- mineral oils.

For industrial purposes the commonly used lubricants for machine tools are:

- turbine oils
- circulating and hydraulic oils (R & O Type)
- circulating and hydraulic oils (anti-wear type)
- circulating oil (anti-wear type)
- special purpose hydraulic oil (anti-wear type)
- fire-resistant hydraulic fluid
- spindle oil
- machinery oils
- textile oils
- gear oils
- straight mineral oils
- morgen bearing oils
- compressor oils.

In each type, there are different grades of viscosity and flash point. According to the suitability, lubricants are selected using the catalogue.

Example 1

Spindle oils are graded according to their viscosity and flash point.

Servospin - 2

Servospin - 5

Servospin - 12

Servospin - 22

Servospin oils are low viscosity lubricants containing anti-wear, anti-oxidant, anti-rust and anti-foam additives. These oils are recommended for lubrication of textile and machine tool spindle bearings, timing gears, positive displacement blowers, and for tracer mechanism and hydraulic systems of certain high precision machine tools.

Example 2

Gear oils are graded according to their viscosity and flash point.

Servomesh - 68

Servomesh - 150

Servomesh - 257

Servomesh - 320

Servomesh - 460

Servomesh - 680

Servo mesh oils are industrial gear oils blended with lead and sulphur compounds. These oils provide resistance to deposit formation, protect metal components against rust and corrosion, separate easily from water and are non-corrosive to ferrous and non-ferrous metals.

These oils are used for plain and anti-friction bearings subjected to shock and heavy loads, and should be used in systems where the operating temperature does not exceed 90^{o} C. These oils are not recommended for use in food processing units.

Servomesh A-90 is a litumenous product which contains sulphur-lead type and anti-wear additive. It is specially suitable for lubrication of heavily loaded low-speed open gears.

Servomesh SP 68

Servomesh SP 150

Servomesh SP 220

Servomesh SP 257

Servomesh SP 320

Servomesh SP 460

Servomesh SP 680

Servomesh SP oils are extreme pressure type industrial gear oils, which contain sulphur-phosphorous compounds and have better thermal stability and higher oxidation resistance compared to conventional lead nap the nate gear oils.

These oils have good de-emulsibility, low foaming tendency and provide rust and corrosion protection to metal surfaces. These oils are recommended for all heavy duty enclosed gear drives with circulation or splash lubrication system operating under heavy or shock load conditions up to a temperature of 110^{o} C.

Drilling machines - Types & Application

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

The drilling machine is one of the most important machine tools in a workshop and second to lathe. It was primarily designed to originate a hole.

Types of drilling machine

Drilling machines are made in many different types and sizes, each designed to handle a class of work or specific job to the best advantage.

The different types of drilling machines are

1) Portable drilling machine
2) Sensitive drilling machine
   a) Bench mounting
   b) Floor mounting
3) Upright drilling machine
4) Radial drilling machine
5) Gang drilling machine
6) Multiple spindle drilling machine
7) Automatic drilling machine
8) Deep hole drilling machine

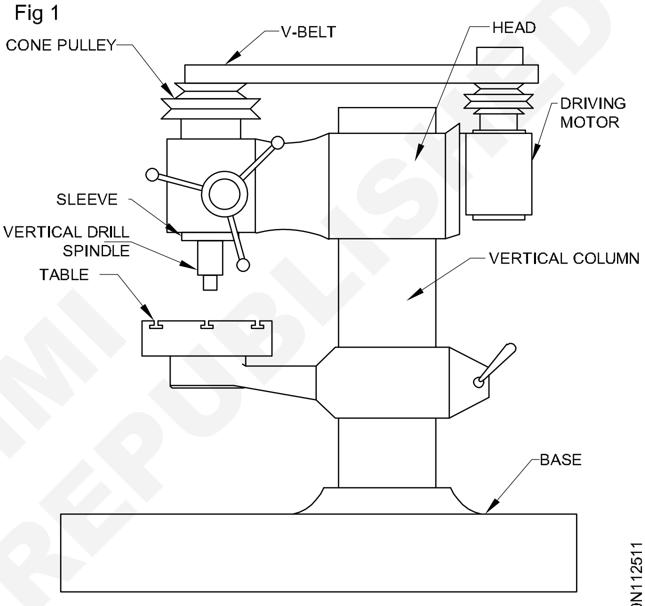
Portable Drilling machine

As the name implies this type of drilling machine can be operated with ease anywhere in the workshop and is used for drilling holes in work pieces in any position which cannot be drilled in a standard in a standard drilling machine. Some of the portable machines are operated by hand power, but most of the machines are driven by individual motor. The entire drilling mechanism including the motor is compact and small in size. The motor is usually of universal type which may be driven by both A.C. and D.C. The maximum size of the drill that it can be accommodated is not more than 12 to 18mm. the machine is operated at high speed as smaller size drills are only used. Some of the portable machines are driven by pneumatic power.

Sensitive Drilling Machine

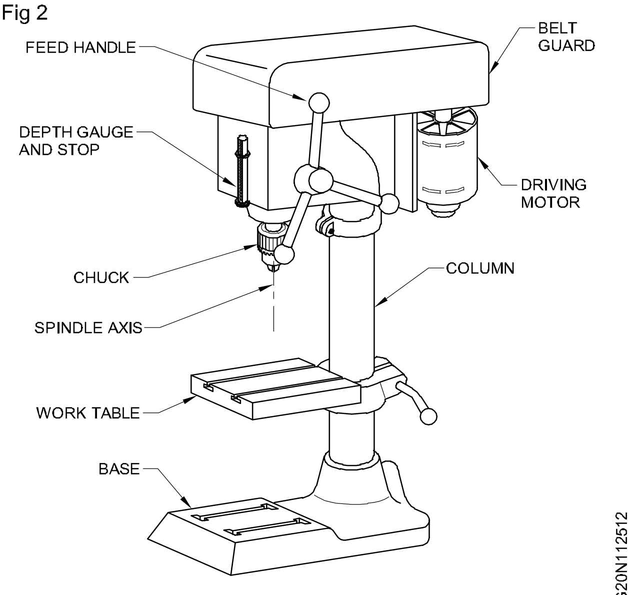
The sensitive drilling machine is a small machine designed for drilling a small hole at high speed in light jobs, the base of the machine may be mounted on a bench or on the floor. It consists of a vertical column, a horizontal table, a head supporting the motor and driving mechanism, and a vertical spindle for driving and rotating the drill. There is no arrangement for any automatic feed of the drill spindle. The drill is fed into the work by purely hand control. High speed and hand feed are necessary for drilling small holes. High speeds are necessary to attain required cutting speed by small diameter drill. Hand feed permits the operator to feel or sense the progress of the drill into the work, so that the drill becomes worn out or jams on any account, the pressure on the drill may be released immediately to prevent it from breaking.

Fig 1



SENSITIVE DRILLING MACHINE

Fig 2

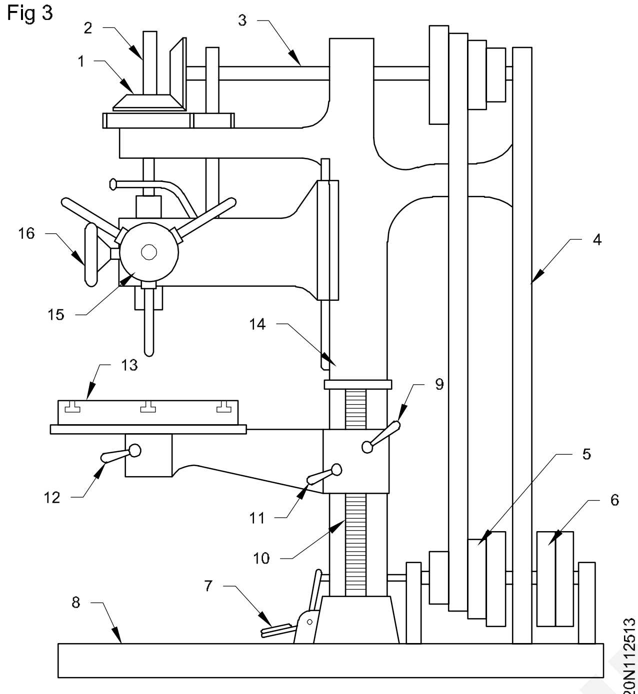


BENCH DRILLING MACHINE

Box column section upright drilling machine

The upright drilling machine with box column section has square table fitted on the slides at the front face of the machine column. Heavy box column gives the machine strength and rigidity. The table is raised or lowered by an elevating screw that gives additional support to the table. These special features permit the machine to work with heavier workpieces, and holes more than 50mm in diameter can be drilled by it.

Fig 3



UPRIGHT PILLAR DRILLING MACHINE

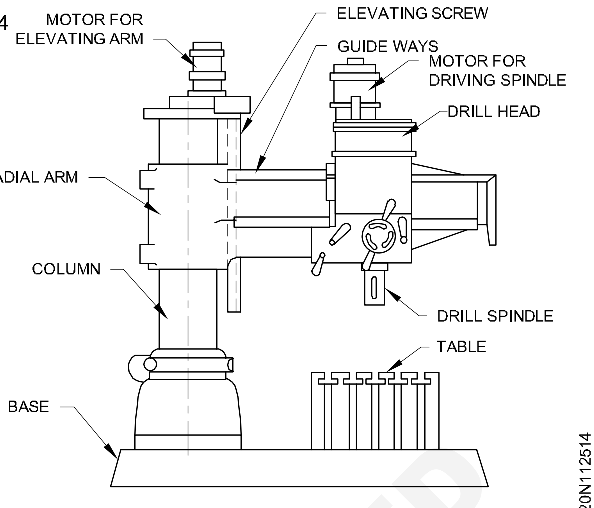
1. Bevel gear drive to spindle, 2 Spindle, 3 Overhead shaft, 4 Back stay, 5 Counter shaft cone pulley, 6. Fast and loose pulley, 7. Table elevating handle, 8. Foot pedal, 9.Base, 10. Rack 11. Table elevating clamp handle, 12. Table clamp, 13. Table, 14. Column, 15. Hand wheel for quick hand feed, 16.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

Radial Drilling machine

The radial drilling machine is intended for drilling medium to large and heavy workpieces. The machine consists of a heavy, round, vertical column mounted a radial arm which can be raised and lowered to accommodate work pieces of different heights. The arm may be swung around to any position over the work bed. The drill head containing mechanism for rotating and feeding the drill is mounted on a radial arm and can be moved horizontally on the guide - ways and clamped at any desired position. These three movements in a radial drilling machine when combined when combined together permit the drill to be located at any desired point on a large work piece, the position of the arm and the drill head is altered so that the drill spindle may be moved from one position to the other after drilling the hole without altering the setting of the work. This veracity of the machine allows it to work on large work pieces. The work may be mounted on the table or when the work is very large it may be placed on the floor or in a pit. Fig.5.3 illustrates a radial drilling machine.

1. Base, 2. column, 3. Radial arm, 4. Motor for elevating the arm, 5. Elevating screw, 6. Guide ways, 7. Motor for driving the drill spindle, 8. Drill head, 9. Drill spindle, 10. Table

Fig 4

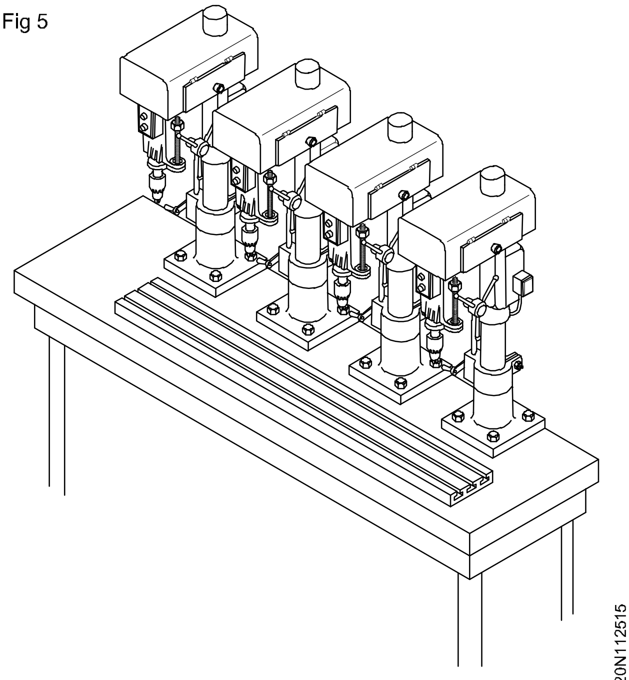


RADIAL DRILLING MACHINE

Gang Drilling Machine

When a number of single spindle drilling machine columns are placed side by side on a common base and have a common work table, the machine is known as the gang drilling machine. In a gang drilling machine four to six spindles may be mounted side by side. In some machines the drill spindles are permanently spaced on the work table, and in others the position of the columns may be adjusted so that the space between the spindles may be varied. The speed and feed of the spindles are controlled independently. This type of machine is specially adapted for production work. A series of operations may be performed on the work by simply shifting the work from one position to the other on the work table. Each spindle may be set up properly with different tools for different operations.

Fig 5

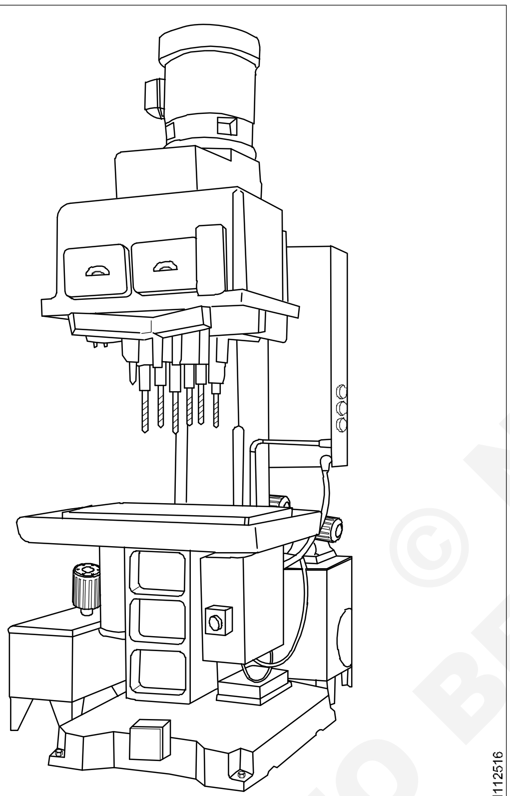


GANG OF FOUR DRILLING MACHINES

Multiple Spindle Machine

The function of a multiple spindle drilling machine is to drill a number of holes in a piece of work simultaneously and to reproduce the same pattern of holes in a number of identical pieces in a mass production work. Such machine shave several spindles driven by a single motor and all the spindles holding drills are fed into the work simultaneously. Feeding motion is usually obtained by raising the work table. But the feeding motion may also be secured by lowering the drill heads. The spindles are so constructed that their centre distance may be adjusted in any position as required by various jobs within the capacity of the drill head. For this purpose, the drill spindles are connected to the main drive by universal joints. Drill jigs may be used for guiding the drills in mass production work.

Fig 6



MULTI SPINDLE DRILLING MACHINE

Automatic Drilling machine

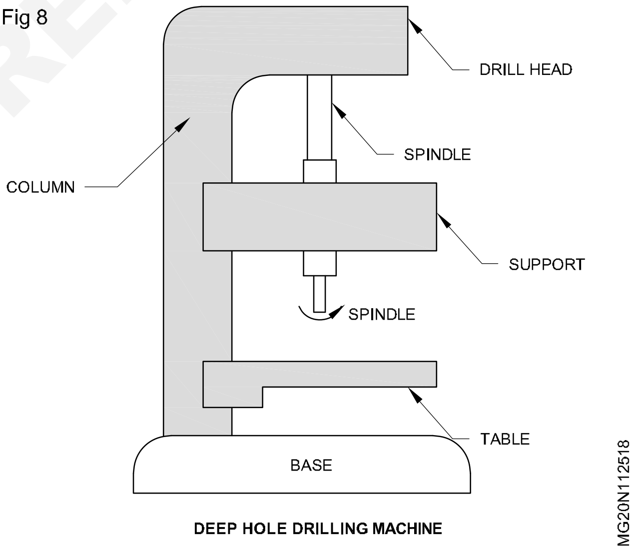
Automatic drilling machine can perform a series of machining operations at successive units and transfer the work from one unit to the other automatically. Once the work is loaded at the first machine, the work will move from one machine to the other where different operations can be performed and the finished work comes out from the last unit without any manual handling. This type of machine is intended purely for production purposes and may be used for milling, honing and similar operations in addition to drilling and tapping.

Fig 7

Deep Hole Drilling Machine

Special machines and drills are required for drilling deep holes in rifle barrels, crank shafts, etc. The machine is operated at high speed and low feed. Sufficient quantity of lubricant is pumped to the cutting points for removal of chips and cooling the cutting edges of the drill. A long job is usually supported at several points to prevent any deflection. The work is usually while the drill is fed into the work. This helps in feeding the drill in a straight path. The machine may be horizontal or vertical type In some machines step feed is applied. The drill is withdrawn automatically each time when it penetrates into the work on a depth equal to its diameter. This process permits the chip to clear out from the work.

Fig 8



DEEP HOLE DRILLING MACHINE

Construction of Pillar type drilling machine

Objectives: At the end of this lesson you shall be able to
- **state the features of a pillar drilling machine**
- **state the parts and uses of pillar drilling machine**
- **explain the features and function of a pillar drilling machine.**

Upright Drilling Machine

The upright drilling machine is designed for handling medium sized workpieces. In Construction the machine is very similar to a sensitive drilling machine for having a vertical column mounted upon the base. But this is larger and heavier than a sensitive drilling machine and is supplied with power feed arrangement. In an upright drilling machine a large number of spindle speeds and feeds may be available for drilling different types of work. The table of the machine also have different types of adjustments. There are two general classes of upright drilling machine.

- Round column section or pillar drilling machine.
- Box column section

Construction of Pillar drilling machine: The round column section upright drilling machine or pillar drilling machine consists of a round column that rises from the base which rests on the floor, an arm and a round table assembly, and a drill head assembly.

The arm and the table have three adjustments for locating workpieces under the spindle. The arm and the table may be moved up and down on the column for accommodating workpieces of different heights. The table and the arm may be moved in an arc upto 180º around the column and may be clamped at any position. This permits setting of the work below the spindle. Moreover, heavy and odd-size work may be supported directly on the base of the machine and drilled after the arm is swung out the way. The table may be rotated 360º about its own centre independent of the position of the arm for locating workpieces under the spindle.

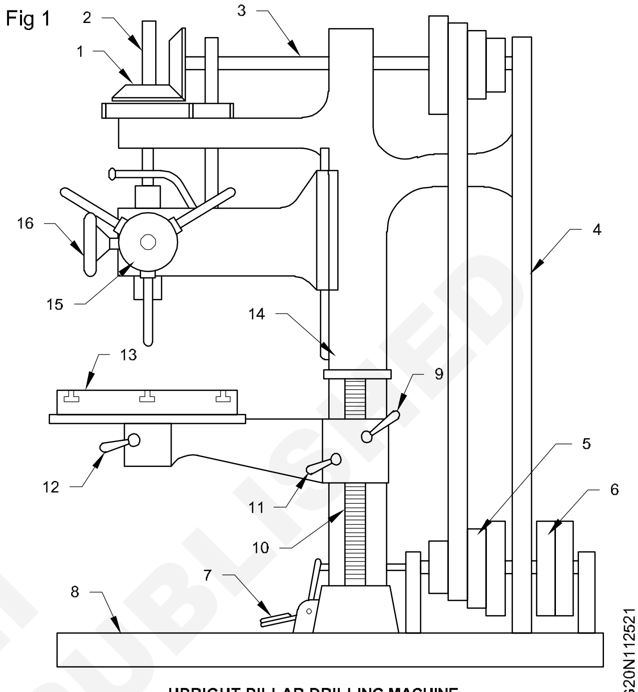
The construction of the machine being not very rigid and the table being supported on a horizontal arm, this is particularly intended for lighter work. The maximum size of holes that the machine can drill is not more than 50mm

1 Bevel gear drive to spindle, 2. Spindle. 3. Overhead shaft, 4. Nack stay counter shaft cone pulley, 6. Fast and loose pulley, 7. Table elevating handle foot pedal, 9. Base, 10. Rack on column, 11. Table elevating clamp handle Table clamp, 13. Table, 14. Column, 15. Handwheel for quick hand feed and Handwheel for sensitive hand feed.

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

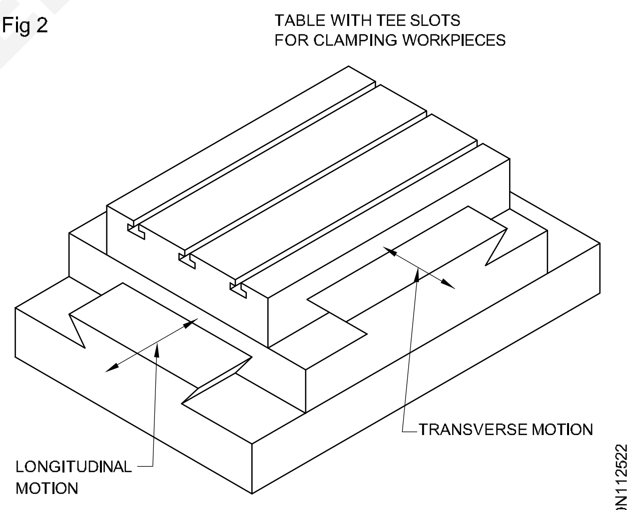
This is a development of the box-column type pillar drilling machine with a table mounted on the two sideways to give horizontal motions at 90° to each other, and controlled by the operating screws.

Fig 1



UPRIGHT PILLAR DRILLING MACHINE

Fig 2

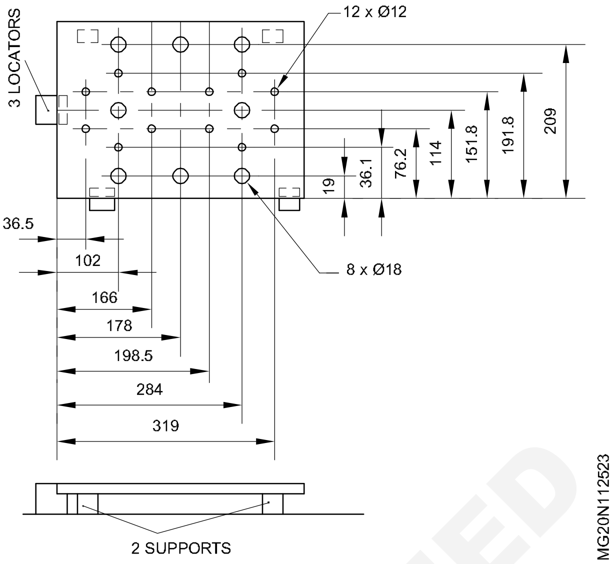


BASE REPLACES NORMAL MACHINE TABLE

A typical component for drilling on a compound table machine is shown in Fig 3.

The work is clamped to the compound table which can then be accurately adjusted to bring each hole under the spindle axis, in turn for drilling. If the work is located accurately on the table by locators in the 'T' slots, once the position to the first hole is fixed the remaining holes can be positioned by means of table movements without recourse to marking out.

Fig 3



Radial drilling machines

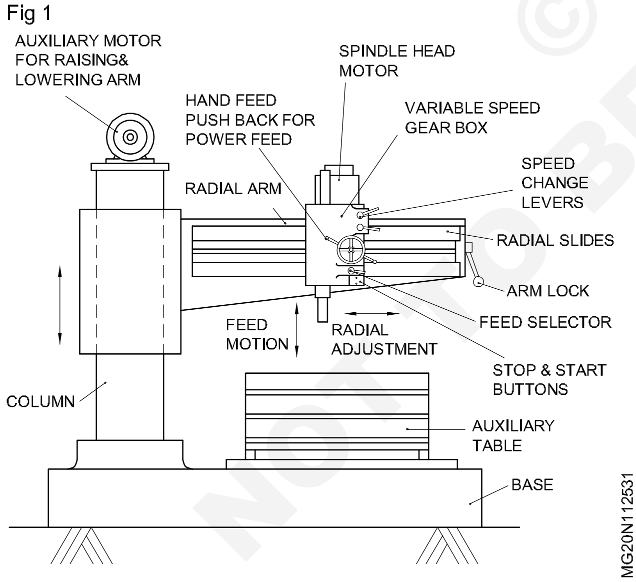
Objectives: At the end of this lesson you shall be able to
- **state the features of a radial drilling machine**
- **state the uses of a radial drilling machine.**

Features (Fig 1)

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

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

Fig 1

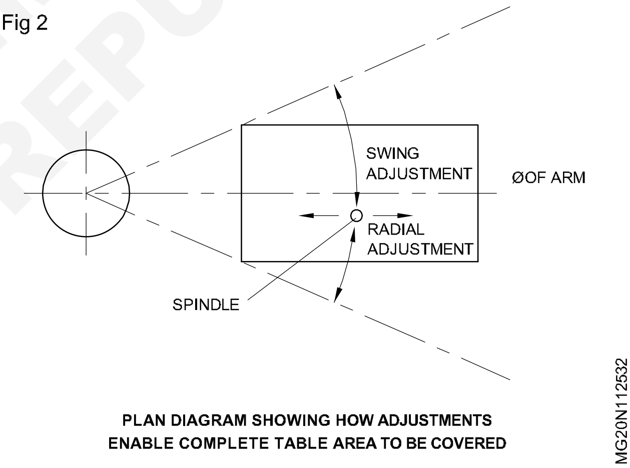


The arm is supported by a pillar (column). It can be rotated about with the pillar as centre. Therefore, the drill spindle can cover the entire working surface of the table. The arm can be lifted or lowered. (Fig 2)

The motor mounted on the spindle head rotates the spindle. The variable speed gearbox provides a large range of r.p.m.

The spindle can be rotated in both clockwise and anti-clockwise directions.

Fig 2



The base of the machine itself is the work table and is provided with 'T' slots for clamping large workpieces. An auxiliary table is usually provided to which smaller workpieces can be clamped, and in some cases, two such tables are used. One is placed on the machine while drilling is in progress and the other is on one side, with the previously finished work removed and new work positioned. When the work is completed the tables are interchanged by a hoist, the radial arm being swung clear for the purpose.

Radial drilling machines are used to drill

– large diameter holes
– multiple holes in one setting of the work
– heavy and large workpieces.
– angular holes on machines having tilting tables.

Drill-holding devices

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

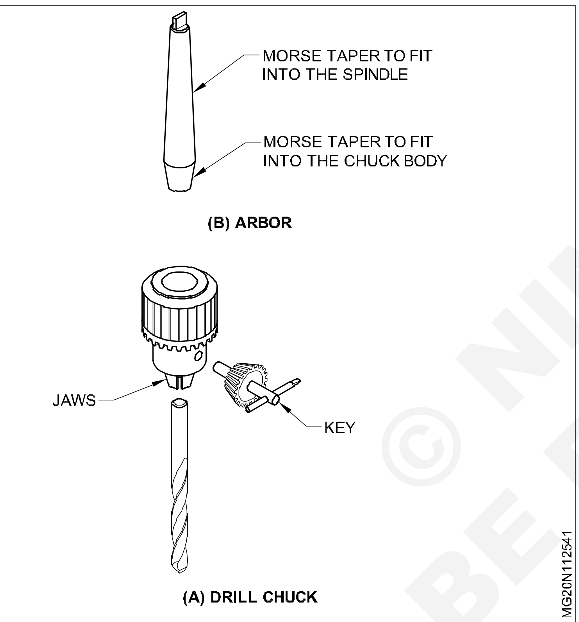
For drilling holes on materials, the drills are to be held accurately and rigidly on the machines.

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

Drill chucks: Straight shank drills are held in drill chucks. (Fig 1A) For fixing and removing drills, the chucks are provided either with a pinion and key or a knurled ring.

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

Fig 1



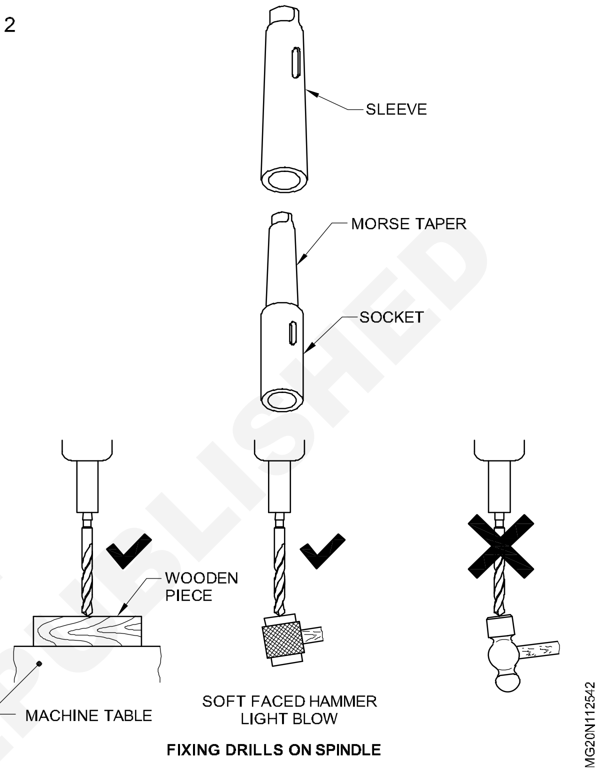
Taper sleeves and sockets (Fig 2): Taper shank drills have a Morse taper.

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

The drills are provided with five different sizes of Morse tapers, and are numbered from MT 1 to MT 5.

In order to make up the difference in sizes between the shanks of the drills and the bore of machine spindles, sleeves of different sizes are used. When the drill taper shank is bigger than the machine spindle, taper sockets are used. (Fig 2)

Fig 2

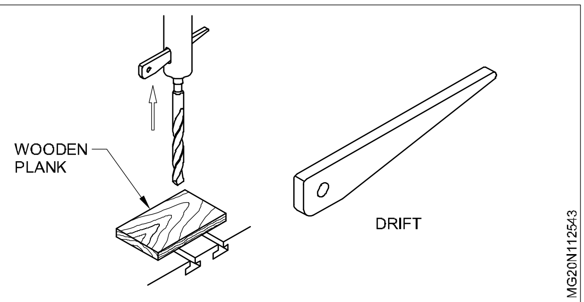


While fixing the drill in a socket or sleeve, the tang portion should align in the slot. This will facilitate the removal of the drill or sleeve from the machine spindle.

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

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

Fig 3



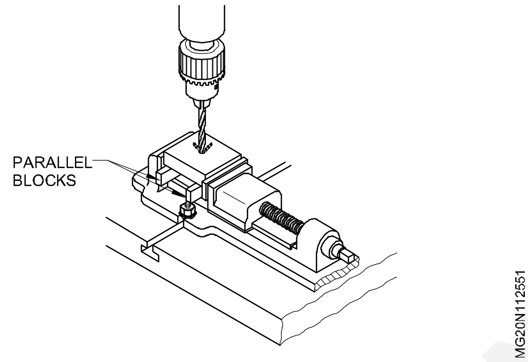
Work-holding devices

Objectives: At the end of this lesson you shall be able to
- **state the purpose of work-holding devices**
- **name the devices used for holding work**
- **state the precautions to be observed while using work-holding devices.**

Workpieces to be drilled should be properly held or clamped to prevent them from rotating along with the drill. Improperly secured work is not only a danger to the operator but can also cause inaccurate work, and breakage of the drill. Various devices are used to ensure proper holding.

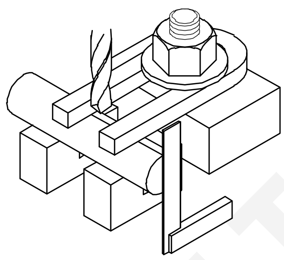
The machine vice: Most of the drilling work can be held in a machine vice. Ensure that the drill does not pass through the vice after it has passed through the work. For this purpose, the work can be lifted up and secured on parallel blocks providing a gap between the work and the bottom of the vice (Fig 1)

Fig 1



Clamps and bolts: Drilling machine tables are provided with T-slots for fitting bolt heads. Using clamps and bolts, the workpieces can be held very rigidly. (Fig 2)

Fig 2



While using this method, (Fig 2) the packing should be, as far as possible, of the same height as the work, and the bolt nearer to the work. (Fig 3)

Fig 3

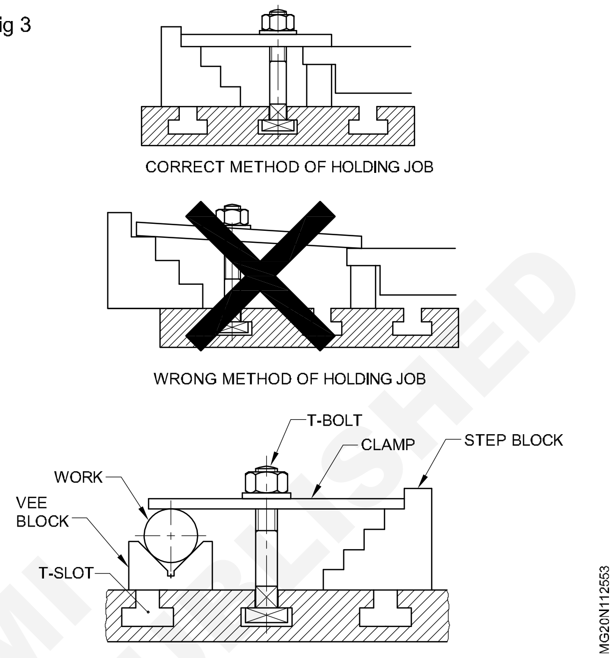


Fig 4

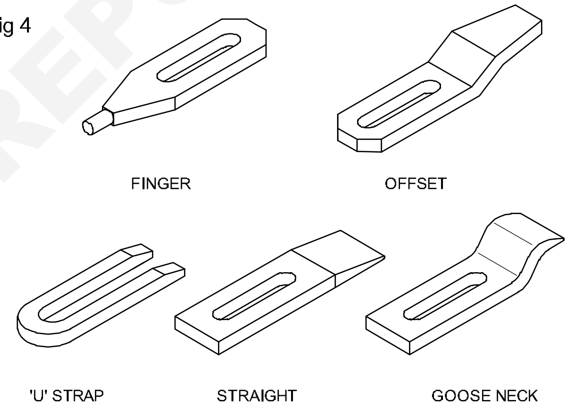
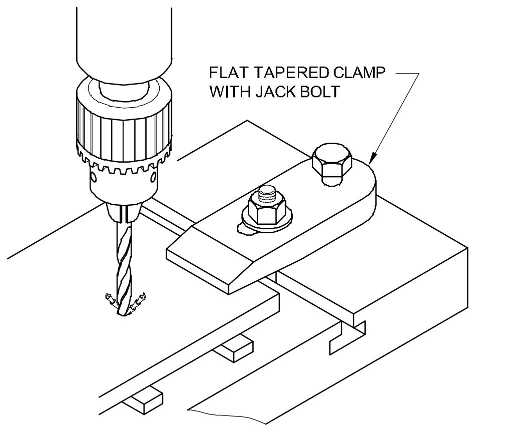


Fig 5



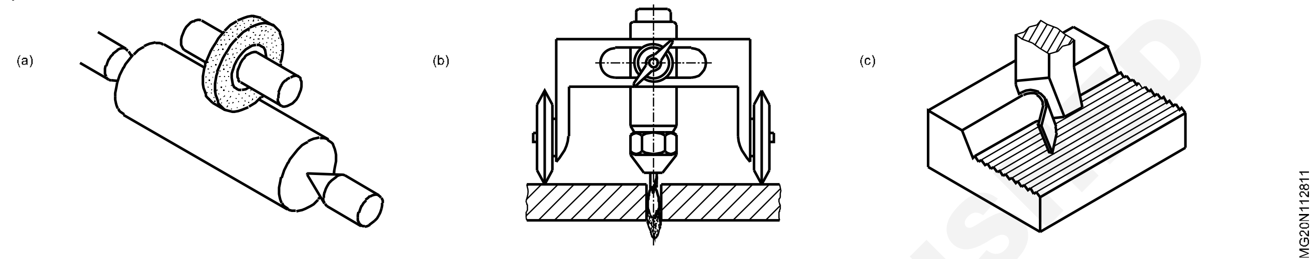
Elements of a file

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

Methods of material cutting

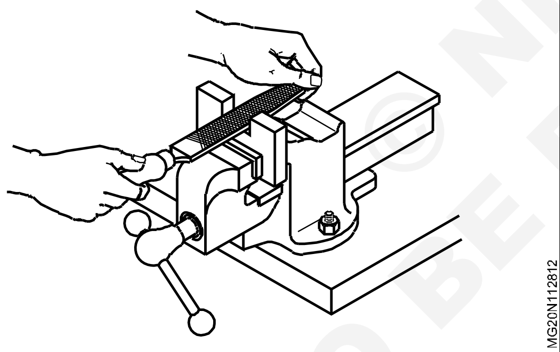
The three methods of mental cutting are abrasion (Fig 1a) fusion (Fig 2b) and incision (Fig 3c)

Fig 1



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

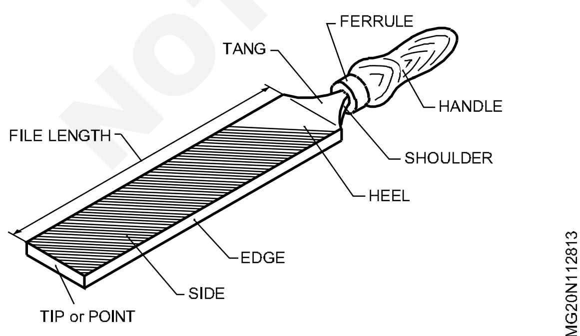
Fig 2



Parts of a file (Fig 5)

The parts of a file can be seen in Fig 5 are

Fig 3



Edge

The thin part of the file with a teeth cut on its surface

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 file 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

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

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

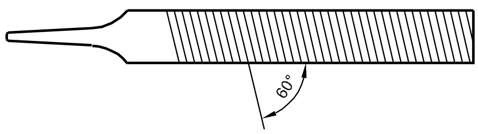
Types of cuts

Basically there are four types.
Single cut, Double cut, Rasp cut and Curved cut.

Single cut file (Fig 1)

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

Fig 1

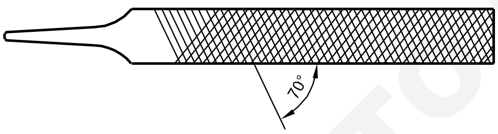


Single cut files do not remove stock as fast double cut files, but the surface finish obtained is much smoother.

Double cut file (Fig 2)

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

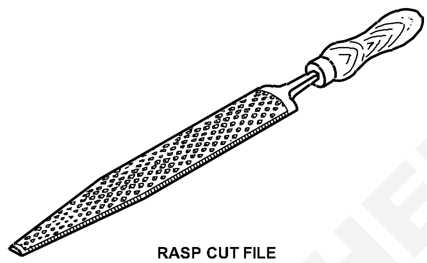
Fig 2



Rasp cut file (Fig 3)

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

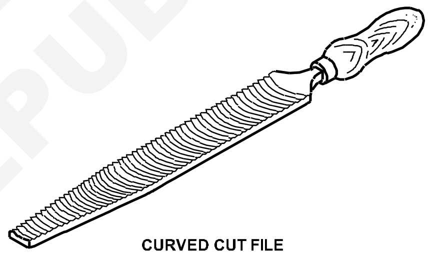
Fig 3



Curved cut file (Fig 4)

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

Fig 4



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

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

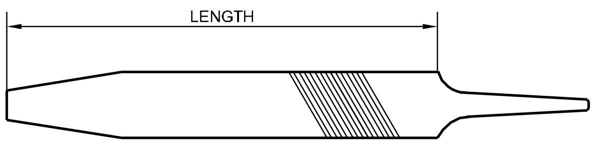
File specifications and grades

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

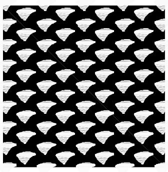
Files are manufactured in different types and grades to meet the various needs.

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

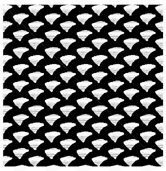
Length is the distance from the tip of a file to the heel.



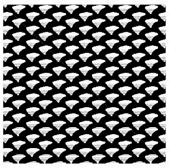
File grades are determined by the spacing of the teeth.



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.

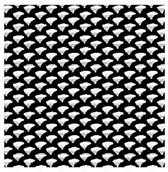


A **bastard file** is used in cases where there is a heavy reduction of material

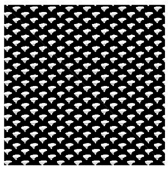


A **second cut file** is used to give a good finish on metals. It is excellent to file hard metals. It is useful for bringing the jobs close to the finishing size.

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

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

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

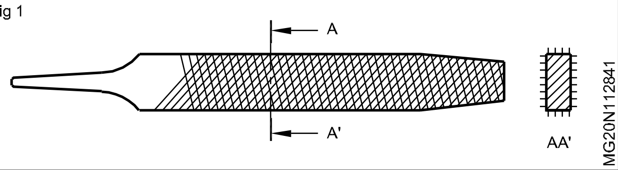
The shape of files is stated by its cross section.

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

Flat file (Fig 1)

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

Fig 1

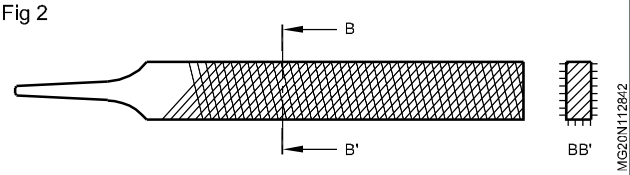


Hand file (Fig 2)

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

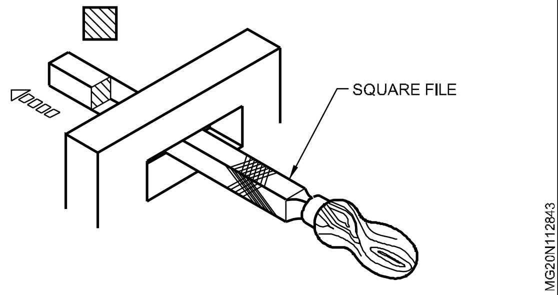
Flat files are general purpose files. They are available in all grades. Hand files are particularly useful for filling at right angles to a finished surface.

Fig 2



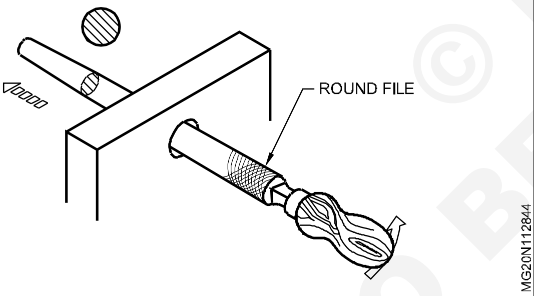
Square File: The square file is square in its cross section. It is used for filing square holes, internal square corners, rectangular openings, keyways and splines. (Fig 3)

Fig 3



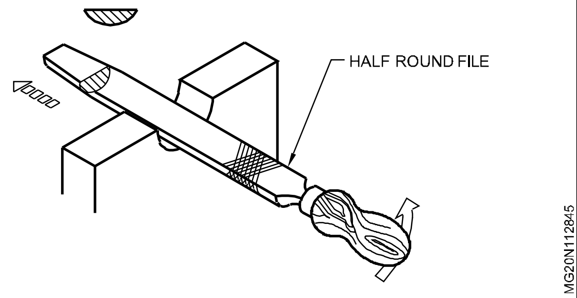
Round file: A round file is circular in its cross section. It is used for enlarging the circular holes and filing profiles with fillets. (Fig 4)

Fig 4



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

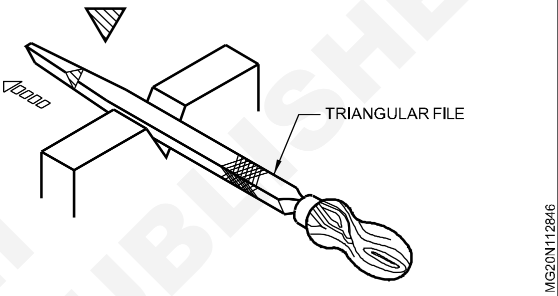
Fig 5



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.6)

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.

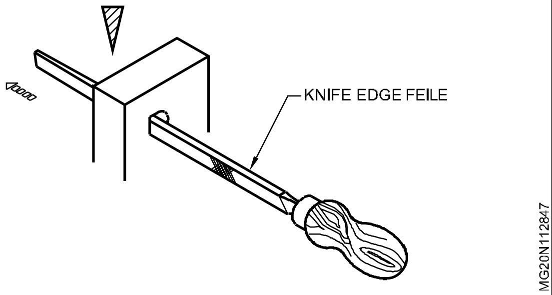
Fig 6



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.7)

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

Fig 7



Needle files

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

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

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

Nomenclature of needle files. (Fig.2)

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

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

- bastard - Cut 0.

- smooth - Cut 2.

Fig 1

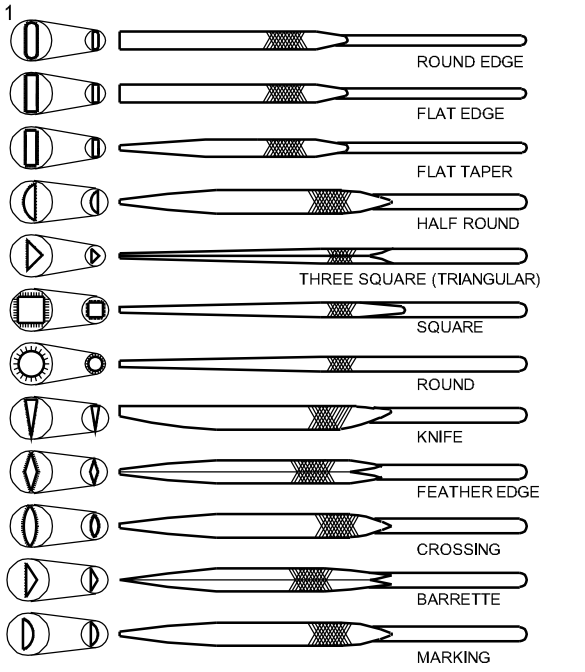
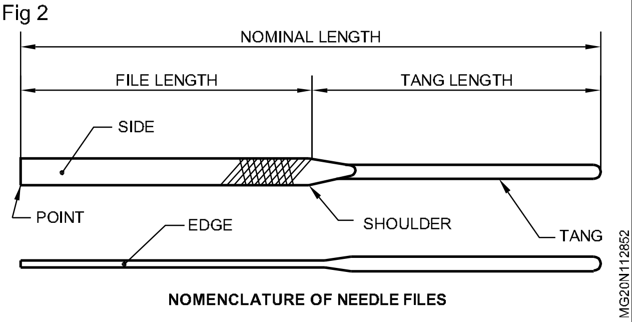


Fig 2



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

- grade of cut

- nominal length

- BIS number

Example

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

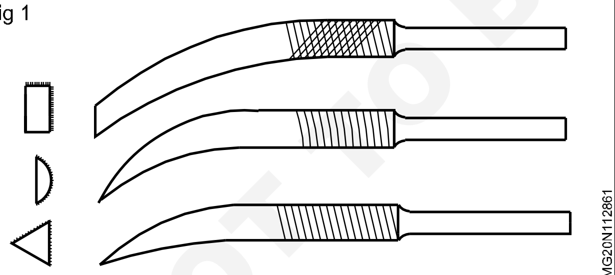
Special files

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

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

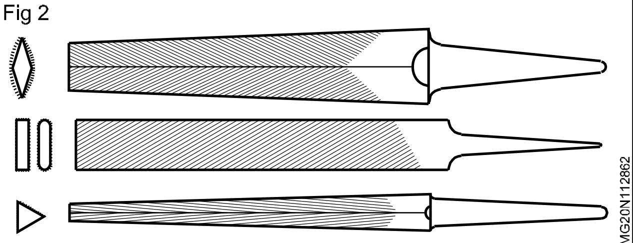
Riffle files (Fig 1)**:** These files are used for die-sinking, engraving and in silversmith's work. They are made in different shapes and sizes and are made with standard cuts of teeth.

Fig 1



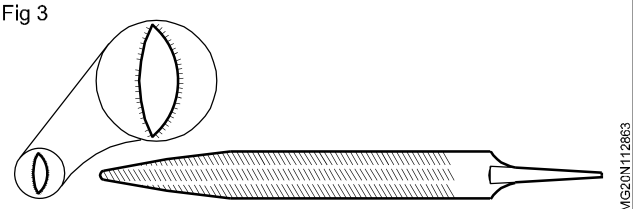
Mill saw files (Fig 2)**:** Mill saw files are usually flat and have square or rounded edges. These are used for sharpening teeth of wood-working saws, and are available in single cut.

Fig 2



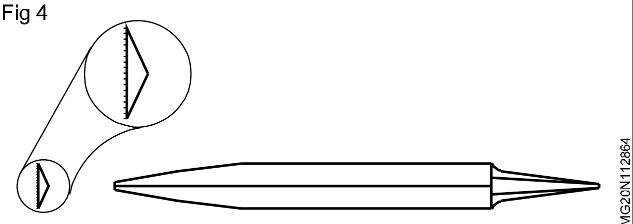
Crossing file (Fig 3)**:** This file is used in the place of a half round file. Each side of the file has different curves. It is also known as 'fish back' file.

Fig 3



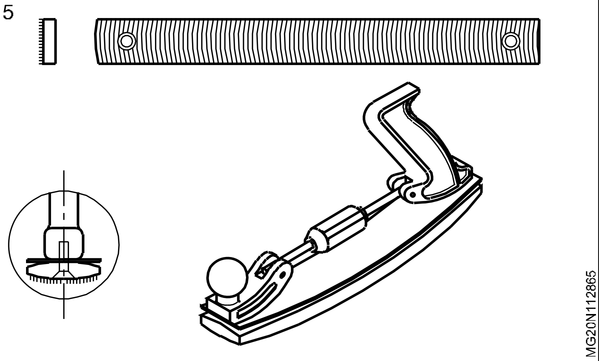
Barrette file (Fig 4)**:** This file has a flat, triangular face with teeth on the wide face only. It is used for finishing sharp corners.

Fig 4



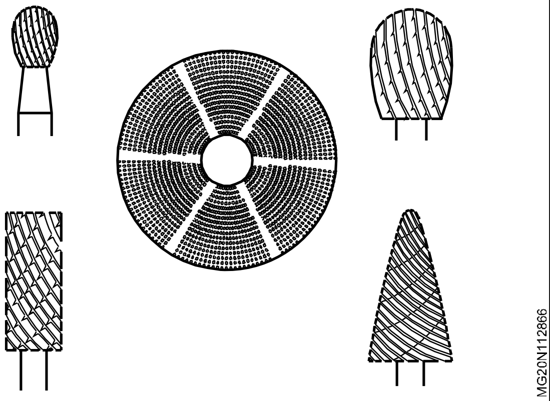
Tinker's file (Fig 5)**:** This file has a rectangular shape with teeth only at the bottom face. A handle is provided on the top. This file is used for finishing automobile bodies after tinkering.

Fig 5



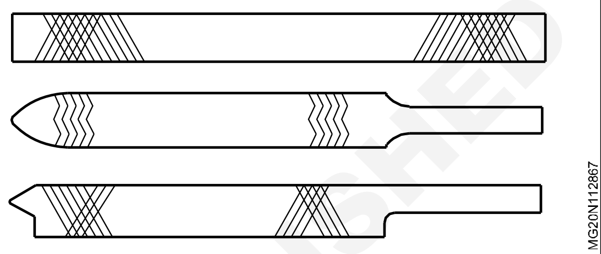
Rotary files (Fig 6)**:** These files are available with a round shank. They are driven by a special machine with a portable motor and flexible shaft. These are used in die sinking and mound-making work.

Fig 6



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

Fig 7



Pinning of files

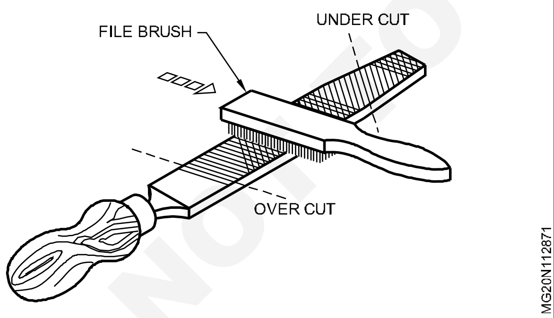
Objective: At the end of this lesson you shall be able to
- **clean the files.**

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 1) with either forward or backward stroke.

Fig 1



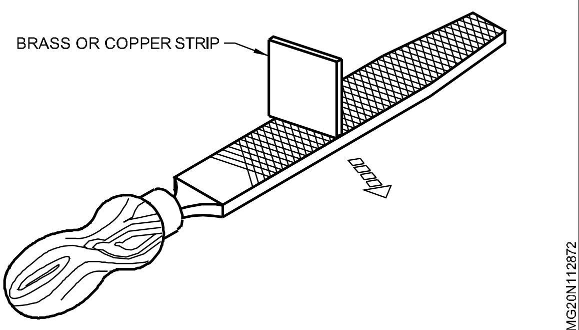
Filings which do not come out easily by the file card should be taken out with a brass or copper strip. (Fig 2)

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

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

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

Fig 2



Care and maintenance

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

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

Convexity of files

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

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

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

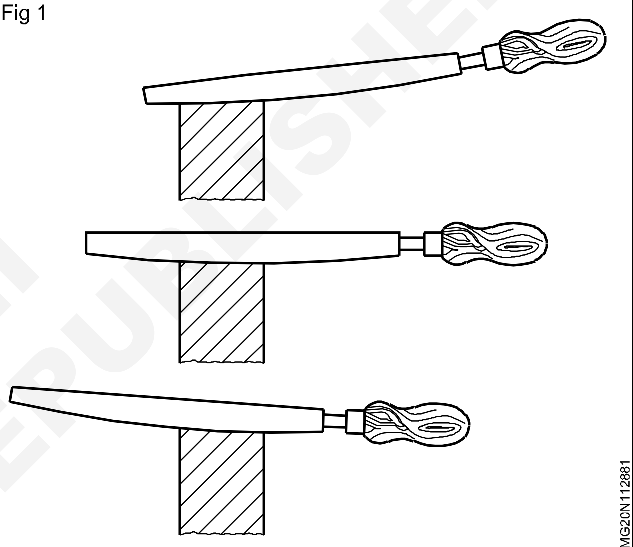
It is more difficult to control a file of uniform thickness.

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

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

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

Fig 1



Methods of filing

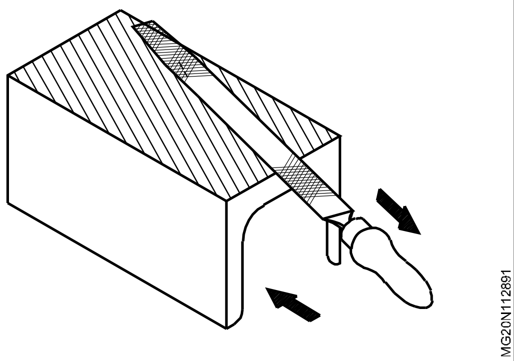
Objective: At the end of this lesson you shall be able to
- **File flat surface using different methods.**

Filing methods

The method of filing to be adopted defends on the types of surface texture require and the amount of material to be removed

Diagonal filing (Fig 1) or cross filing this type of filing is done when heavy reduction of materials is requiring. The strokes are at an angle of 45°because the stoke directions cross each other the surface tecuture formed can clearly indicate the high and low spots.

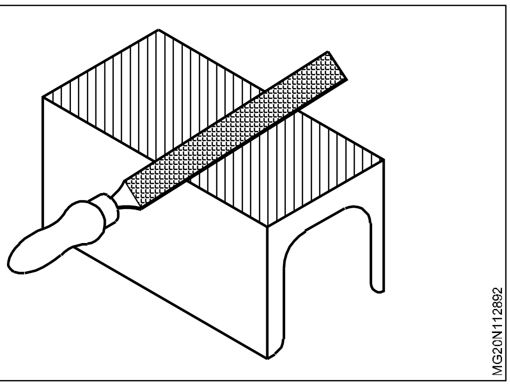
Fig 1



Straight filling Fig 2

In this method the file stokes are at right angles to the longer side of the work. When a short length of work piece is required to have a flat surface straight filing is used.

Fig 2

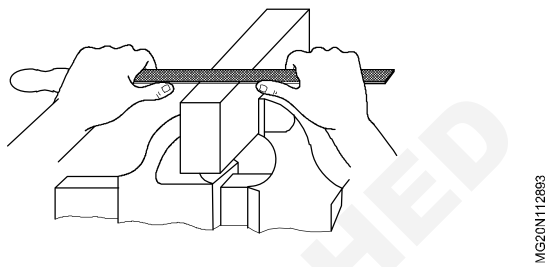


Draw filing **Fig 3**

Draw filling is a modified technique that should only be used with single and double cut file. In this technique, the file is turned size ways and is grasped on both ends. The file is then sawed back and forth to remove material generally the draw filling done on the edge of narrow space to remove high spots to get higher geometrical finish

Surface finish accuracy by filing is according to the grade of file and skill of operator 0.00025mm to 0.025mm (025 micron to 25 micron)

Fig 3



Description of centre lathe

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

Turning and centre lathe

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

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

Constructional features of a lathe

A lathe should have provision:

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

Various Lubrication Points

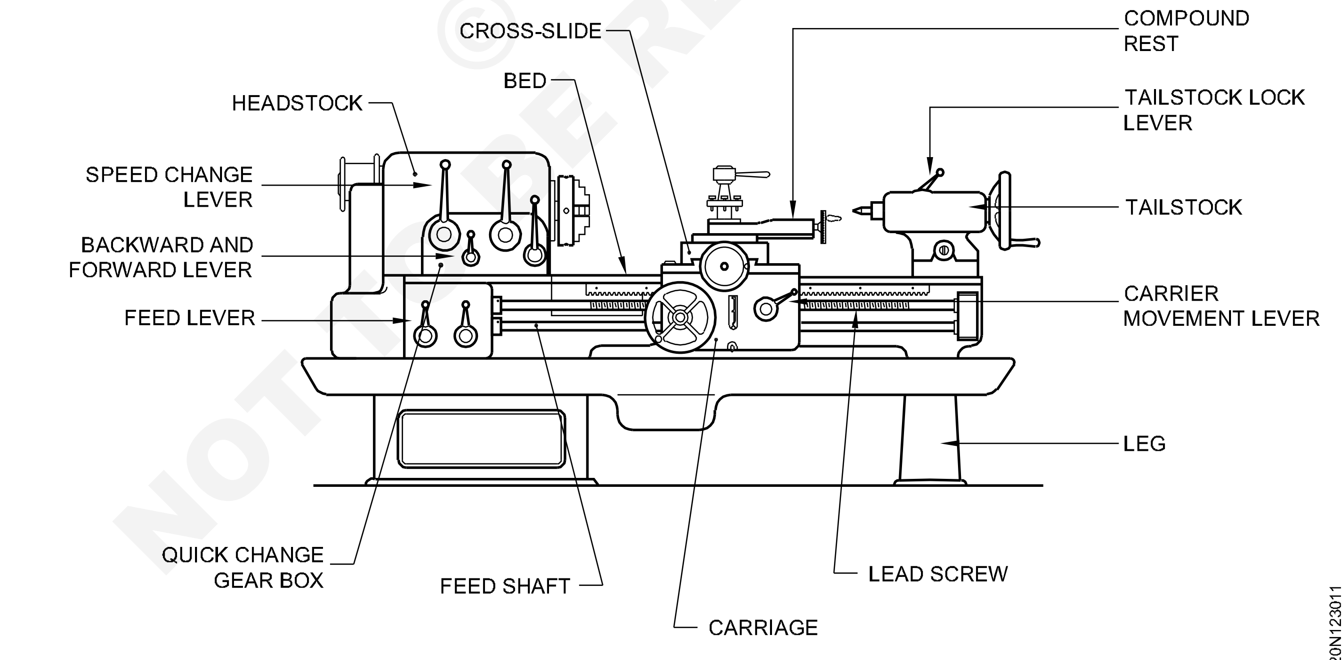
1 Place a few drops of oil on the rocker shaft bearing and cams every time the lathe is in use.

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

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

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

Fig 1



CENTRE LATHE - MAJOR PARTS & LEVER POSITIONS

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

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

7 Back gear spindle - every time the back gears are used, remove the small screw in the centre of the back gear spindle and oil freely with No 10 motor oil or equivalent. Replace screw.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Lathe bed

Objectives: At the end of this lesson you shall be able to
- **state the functions of a lathe bed**
- **explain the different types of bed-ways**
- **state the advantage of gap beds.**

Functions of a lathe bed

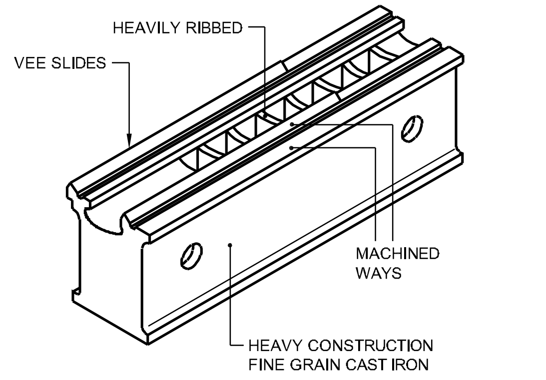
The functions of a lathe bed are:

- to locate the fixed units in accurate relationship to each other
- to provide sideways upon which the operating units can be moved.

Constructional features of a lathe bed (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.

Fig 1



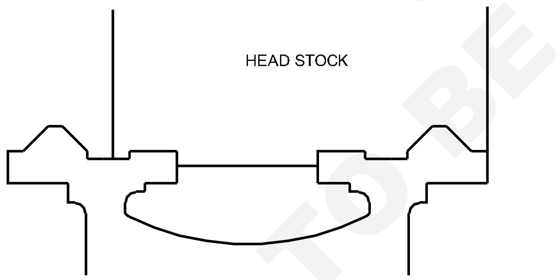
A combined scarf and coolant tray is provided on the lathes. This may be an integral part with the lathe bed.

The bed is generally carried by cast iron or welded sheet metal legs of box section. This provides the necessary working height for the lathe. Very often the electrical switchgear unit and the coolant pump assembly are housed in the box section of the legs at the headstock end.

Bed-ways (Fig 2)

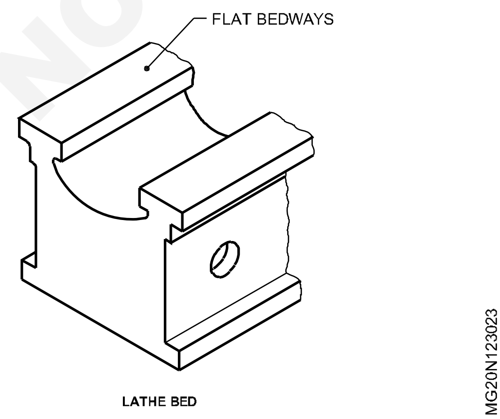
The bed-ways or sideways assist in accurate location and sliding of the accessories/parts mounted on this. The bed-ways are of three types.

Fig 2



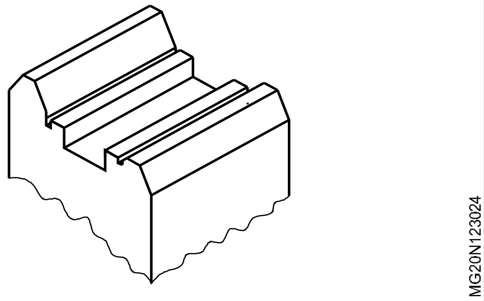
- Flat bed-ways (Fig 3)

Fig 3



- 'V' bed-ways (Fig 4)

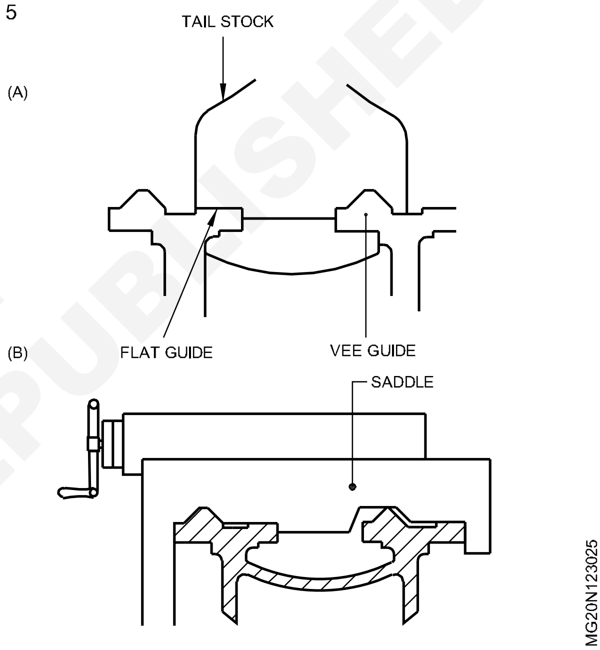
Fig 4



- Combination bed-ways (Fig 5 & 6)

Normally the bed-ways stop at a distance away from the headstock with a gap at this point. This enables to mount larger diameters of works.

Fig 5

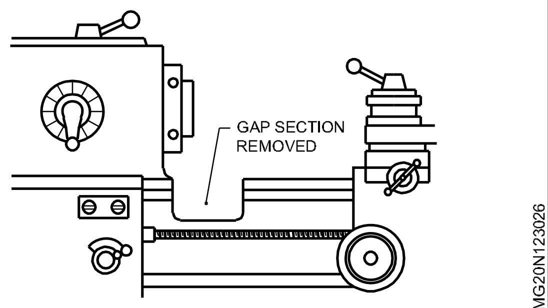


Some lathes have detachable section of the bed, which can be fitted when desired, to enable the saddle to operate close to the headstock. (Fig 6)

Some bed-ways are fine finished by grinding. Some lathes have their bed-ways hand-scraped. Some have their bed-ways hardened and ground. The wear-resisting qualities of bearing surfaces are improved by employing chilled iron castings.

The beds are mostly made up of close grained grey cast iron.

Fig 6



Lathe carriage

Objectives: At the end of this lesson you shall be able to
- **state the parts of a lathe carriage**
- **state the functions of the apron**
- **state the parts and functions of the saddle**
- **state the functions of the feed shaft, lead screw and feed lever.**

Carriage (Fig 1)

The carriage is the lathe feature that provides the method of holding and moving the cutting tool. It consists of two major parts.

- The apron
- The saddle

The apron (Fig 1)

The apron is bolted to the front end of the saddle. It contains the mechanism for moving and controlling the carriage.

The saddle (Fig 1)

The saddle is that part of the carriage that fits the bed slideways and moves along the bed between the head and the tailstock.

It is an assembly consisting of the following parts.

- Cross-slide
- Compound rest
- Top slide
- Tool post

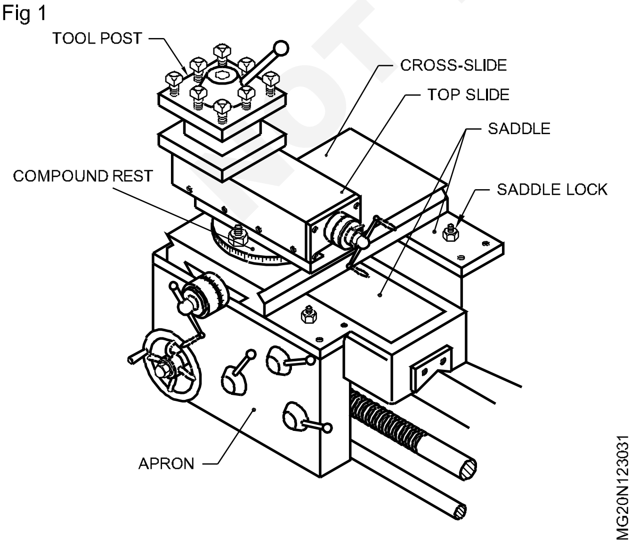
Cross-slide (Figs 1 & 2)

This part is mounted on the top of the saddle base and it moves along the saddle base in a direction perpendicular to the bed. This movement is accomplished by means of a screwed spindle and hand wheel.

Compound rest (Figs 1 & 2)

This is fitted on the top of the cross-slide and may be swiveled horizontally, clockwise or anticlockwise through 360°.

Fig 1



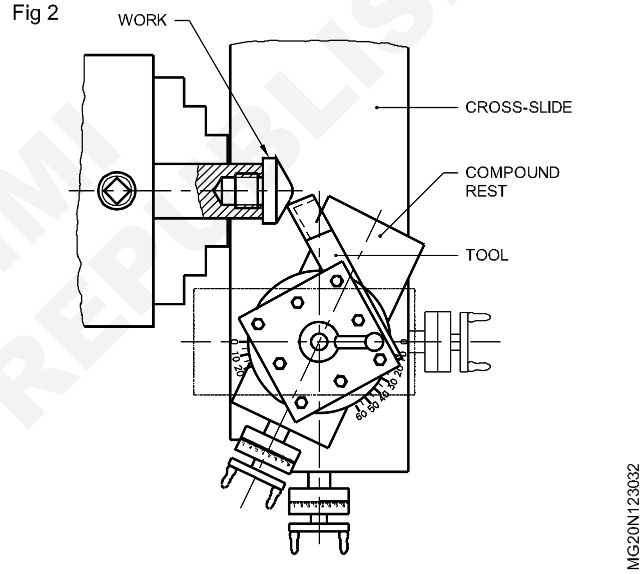
Top slide (Fig 1)

This part is connected to the compound rest by means of a screwed spindle and it has a short travel on the compound rest. It provides a means of supporting the tool post which holds the cutting tool.

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

In the normal case the compound rest is set so that the top slide is at right angles to the cross-slide and in this position the setting angle is 0°.

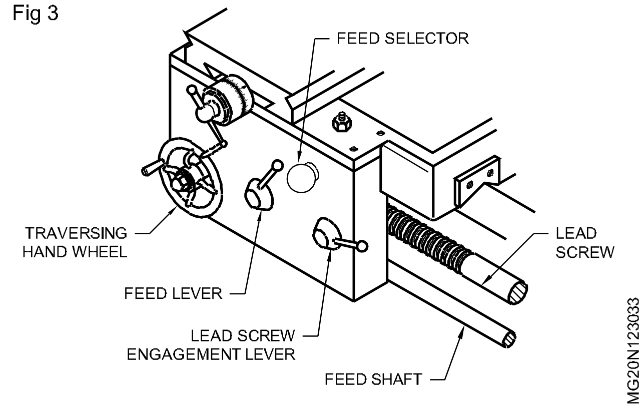
Fig 2



Feed shaft (Fig 3)

Usually the carriage is moved manually by means of a hand wheel. But the carriage can also be moved by power (automatic feed). The power for automatic feed comes from the headstock and is transmitted to the carriage through the feed shaft.

Fig 3



Lead screw (Fig 3)

Centre lathes, equipped with power feed, also have a provision for screw cutting. A special threaded spindle called lead screw, mounted on the front of the lathe bed and driven through the quick change gearbox, helps to cut screw threads.

In some small lathes the lead screw and feed shafts are combined.

Both the lead screw and the feed shaft pass through the apron of the carriage. Controls on the apron enable the feed shaft or the lead screw to be connected to the carriage at the operator's will.

Feed lever

This lever is used to engage and disengage the automatic feed mechanism which provides automatic feeding for both facing and turning operations.

Tool posts

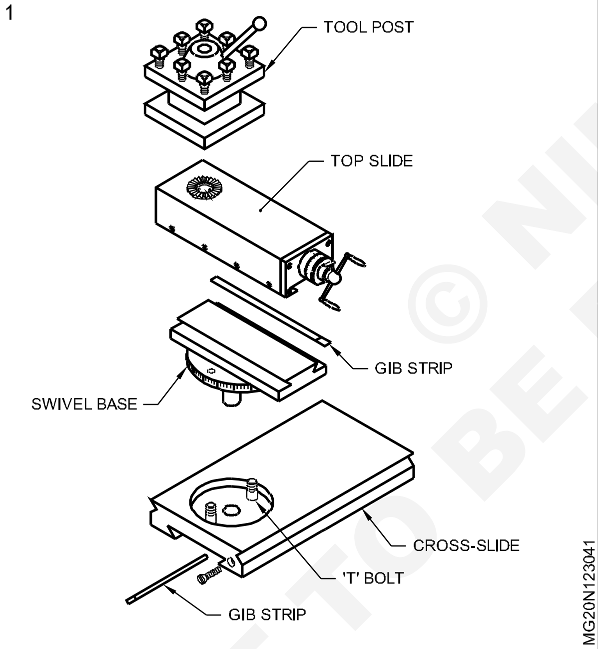
Objectives: At the end of this lesson you shall be able to
- **explain the commonly used types of tool posts**
- **state the features of the different types of tool posts.**

The tool post fitted on the top slide holds and supports the tool firmly. (Fig 1)

The commonly used types of tool posts are:

- American type tool post or single way tool post
- indexing type tool post or square tool post
- quick change tool post.

Fig 1

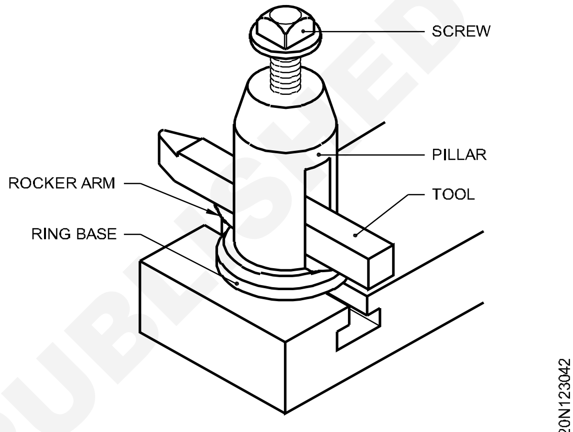


Single way tool post (Fig 2)

It consists of a circular tool post body and a pillar with a slot for accommodating the tool or tool-holder. A ring base, a rocker arm (boat piece) and a tool-clamping screw complete the assembly of this type of tool post.

The tool is positioned on the boat piece and is clamped by the screw. The centre height of the tool tip can be adjusted with the help of the rocker arm and the ring base. Only one tool can be fixed in this type of tool post. The rigidity of the tool is less as it is clamped with only one screw.

Fig 2



AMERICAN (PILLAR) TYPE TOOL POST

Indexing type tool post (Fig 3)

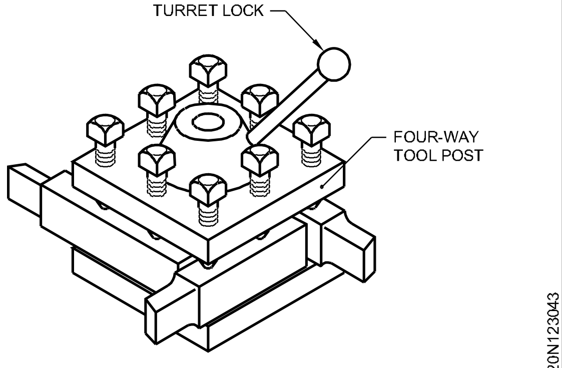
It is also called a square tool post or a four-way tool post. Four tools can be fixed in this type of tool post, and any one of them can be brought into the operating position. The indexing may be manual or automatic.

The advantages are as follows.

Each tool is secured in the tool post by more than one screw and, therefore, the rigidity is more.

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

Fig 3



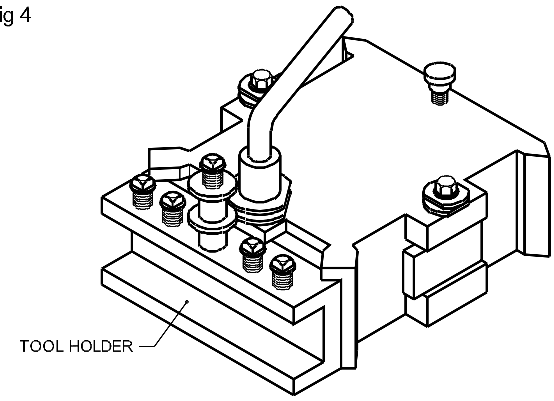
INDEXING TYPE TOOL POST

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

Quick change tool post (Fig 4)

Modern lathes are provided with this type of tool post. Instead of changing the tools, the tool-holder is changed in which the tool is fixed. This is expensive as a number of tool-holders may be needed to preset various tools. But it can be set to the centre height easily, and has the best rigidity for the tool.

Fig 4



QUICK CHANGE TOOL POST

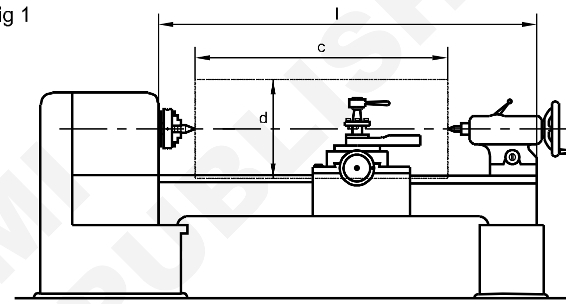
Centre lathe specification

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

The size of a lathe is specified by (Fig 1)

- the length of the bed (l)
- the maximum diameter (swing) of the work that can be turned (d)
- the length between centres (c) and
- the pitch of the lead screw.
- the maximum diameter of bar that passes through hole of the head stock spindle.
- number of spindle speeds and feeds available.
- power input.
- floor space required.

Fig 1



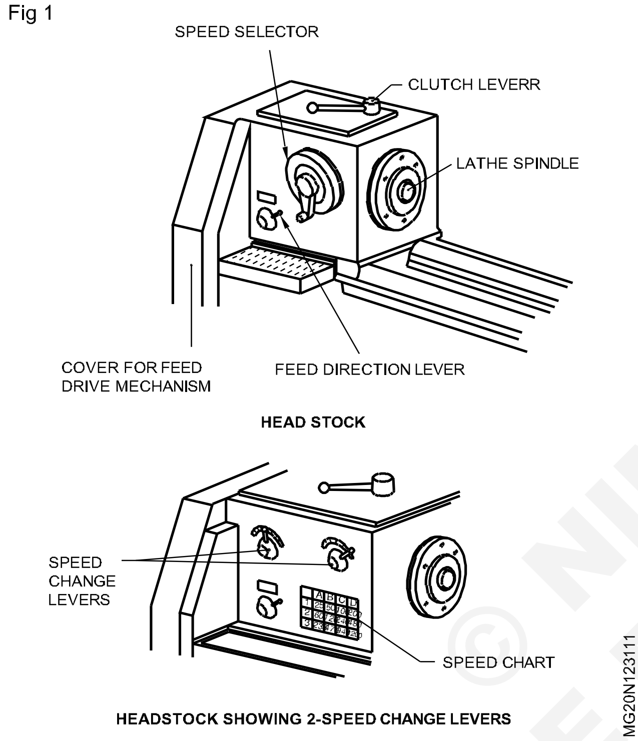
Transmission of speed from motor to spindle of a lathe

Objectives: At the end of this lesson you shall be able to
- **state the functions of headstock**
- **explain the difference between cone pulley headstock and all geared headstock**

Headstock

It is a fixed unit of lathe on the left hand side. (Fig 1)

Fig 1



Its main functions are to:

- provide a means to assemble work - holding devices

Transmit the drive from the main motor to work to make it revolve

Accommodate shafts with fixed and sliding gears for providing a wide range of work speeds

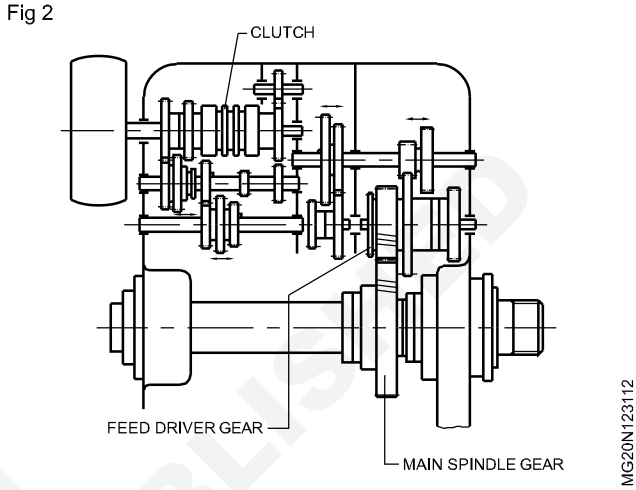
Have shift levers to slide gears to bring in mesh for different speeds

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

Constructional features of all-geared headstock (Fig 2): It is a box-section alloy iron casting having a top cover which can be removed, if needed, It has an input shaft which is connected by means of 'V' belts to the main motor, and runs at constant speed. It is equipped with clutches and a brake.

There may be two or more intermediate shafts on which sliding gears are mounted. The main spindle is the last driven shaft in the headstock assembly. The nose of the spindle is outside the headstock casting and is designed to accommodate the work-holding devices.

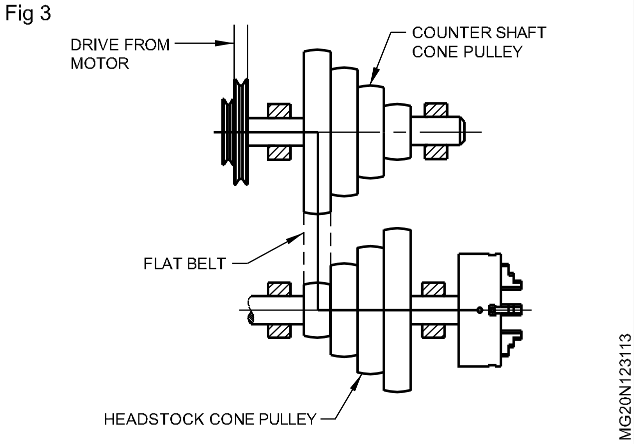
Fig 2



The levers operating the forks of the sliding gears are situated outside in the front of the headstock casting. A sight glass is provided on the top to indicate the functioning of the automatic lubricating system and side of sight glass is provided oil length of the machine.

Cone pulley headstock (Fig 3)

Fig 3

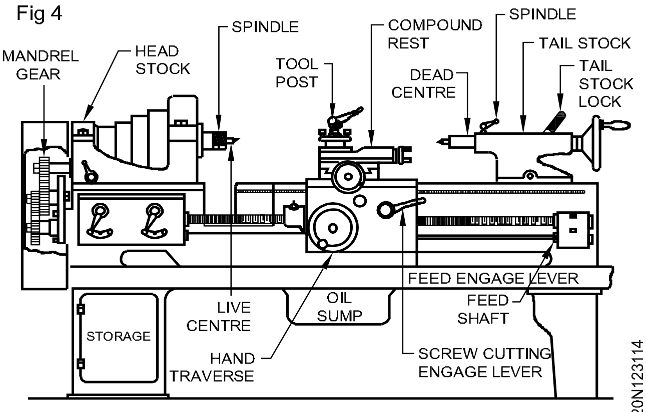


It has a stepped cone pulley mounted on the main spindle and is free to revolve. It is connected by means of a flat belt to a similar cone pulley, the steps arranged in a reversing order. This cone pulley gets the drive from the main motor.

The spindle is mounted on the bush bearings in the headstock casting and a gearwheel called 'bullgear' keyed to it. A pinion is coupled to the cone pulley. The back gear unit has a shaft which carries a gear and a pinion. The number of teeth of the gear and pinion on the back gear

Shaft corrresponds to the number of teeth on the bull gear and the pinion on the cone pulley. The axis of the back gear shaft is parallel to the axis of the main spindle, and the back gear is brought in engagement or disengagement with the cone pulley system by means of a lever. The back gear unit is engaged to have reduced spindle speeds. (Fig 4)

Fig 4



CORE PULLEY HEAD STOCK

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

Advantages

Easy for maintenance.

Can take up heavy load.

Less noise during functioning.

During overloads, the belt slips off, and hence, no major damage to the lathe is caused.

Positive drive when the back gear is in engagement.

Disadvantages

Number of spindle speeds limited to the number of steps in the cone pulley.

Takes time to change spindle speeds.

Needs adjustments of bush bearings.

Back gear

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

Back gear

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

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

Use of back gear

It enables to rotate the chuck at very slow speed

It provides increased turning power

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

It reduces the rpm but increases the torque

Even the largest face plate mounted job can be turned successfully

The spindle is mounted on the bush bearings in the headstock casting and a gear wheel called ‘bullgear’ keyed to it. A pinion is coupled to the cone pulley. The back gear unit has a shaft which carries a gear and a pinion. The number of teeth of the gear and pinion on the back gear shaft corresponds to the number of teeth on the bull gear and the pinion on the cone pulley. The axis of the back gear eccentric shaft is parallel to the axis of the main spindle, and the back gear is brought in engagement or disengagement with the cone pulley system by means of a lever. The back gear unit is engaged to have reduced spindle speeds. (Fig 1)

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

Fig 1

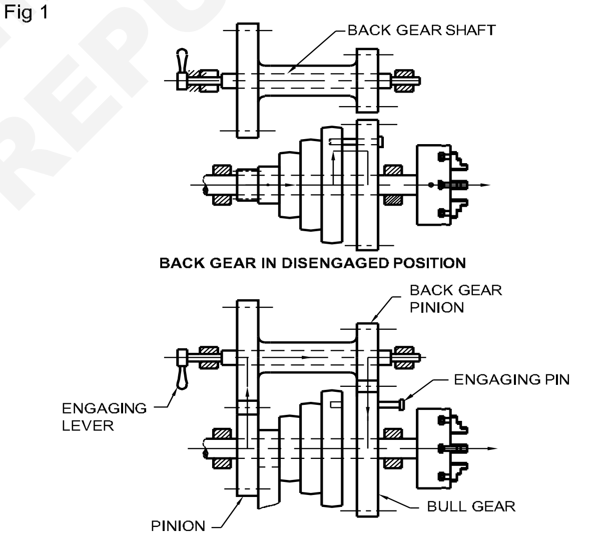
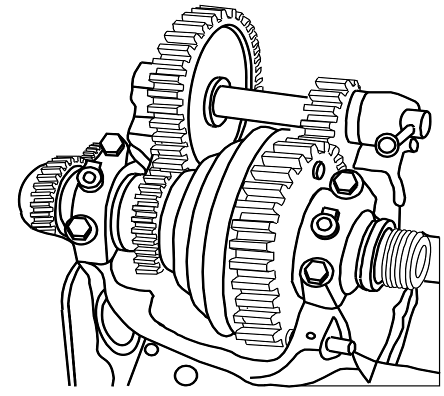


Fig 2



BACK GEAR

Tumbler gear set

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

Tumbler gear mechanism (Fig 1)

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

For forward rotation of the lead screw and feed shaft.

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

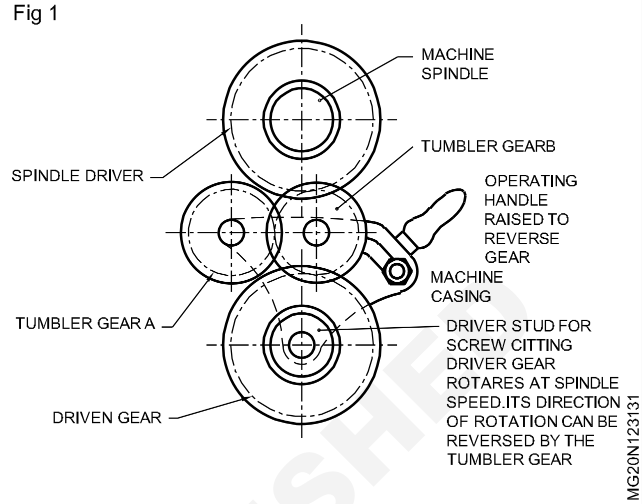
For the reverse rotation of the lead screw and feed shaft.

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

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

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

Fig 1



Forward: Driver —> A —> Driven

Reverse: Driver —> B —> A —> Driven.

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

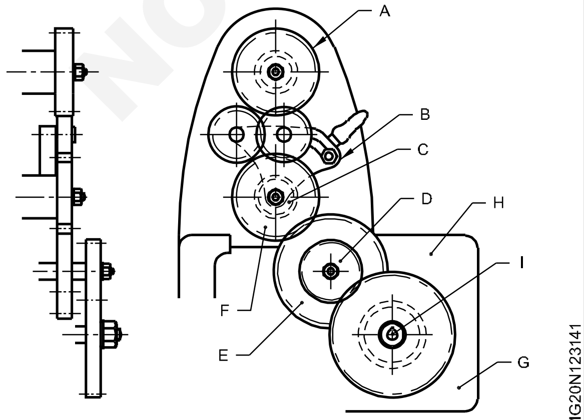
Feed mechanism of lathe & cutting speed

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

Feed mechanism (Fig 1)

The feed mechanism of a lathe enables automatic feeding longitudinally and transversely as needed. By automatic feeding the finish on the work will be better, the feeding of the tool will be uniform by a continuous rate and it takes less time to finish the operation while manual labour is avoided.

Fig 1



The feed mechanism comprises the following.

Spindle gear (A)

Tumbler gear unit (B)

Fixed stud gear (C)

Change gear unit (DEFG)

Quick change gearbox (H)

Feed shaft/ lead screw (I)

Apron mechainsm (not in figure)

The proportionate tool movement for each revolution of work is achieved through all the above units of the feed mechanism.

Aligning a job on lathe

Objective: At the end of this lesson you shall be able to
- **true round rods in a four jaw chuck using a surface gauge.**

Workpieces are to be set and trued before commencing the turning in lathe. If this not done the result will be:

an uneven load on the cutting tool

more metal will be removed from the out of centre portion

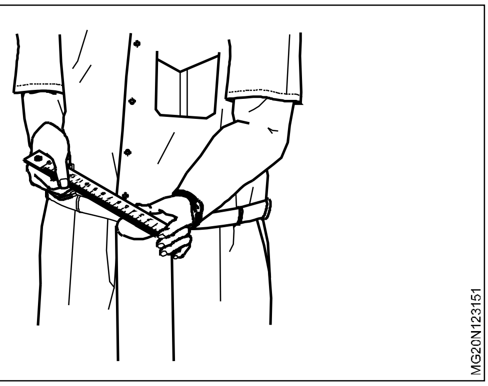
surface turned may not be cylindrical

Sequence for truing

disengage the gears to allow the spindle to rotate freely.

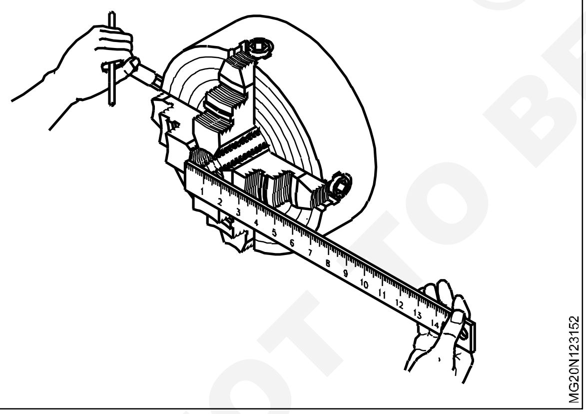
Measure the job diameter. Fig 1

Fig 1



Position the four jaws of the independent chuck at equal distance from the centre. The distance between the inner faces of the opposite jaws should be approximate to the diameter of the work. (Fig 2)

Fig 2



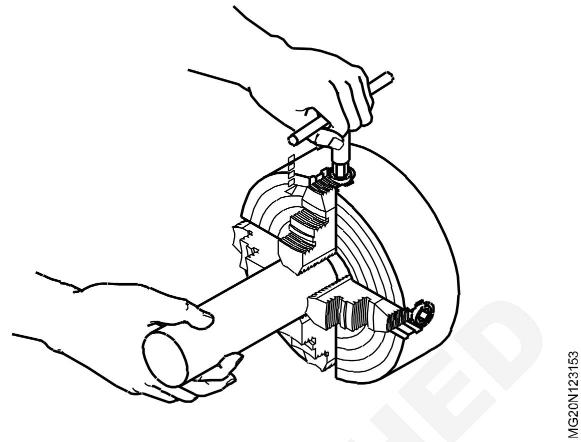
Use the concentric circles marked on the chuck as a guide to maintain equal distance between the jaws

open the adjacent jaws sufficiently to insert the work. (Fig 3)

Place the work inside the chuck, keeping a sufficient portion for turning and tighten the two adjacent jaws, enough to grip the work.

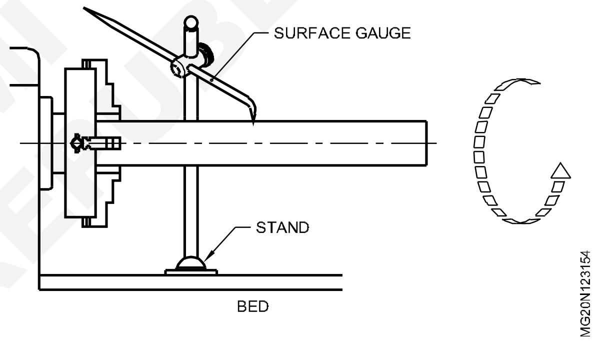
Place the surface gauge on the rear-ways of the bed close to the chuck.

Fig 3



Adjust the pointer to make its tip move close to the top or the side portion of the work with a minimum gap. (Fig 4)

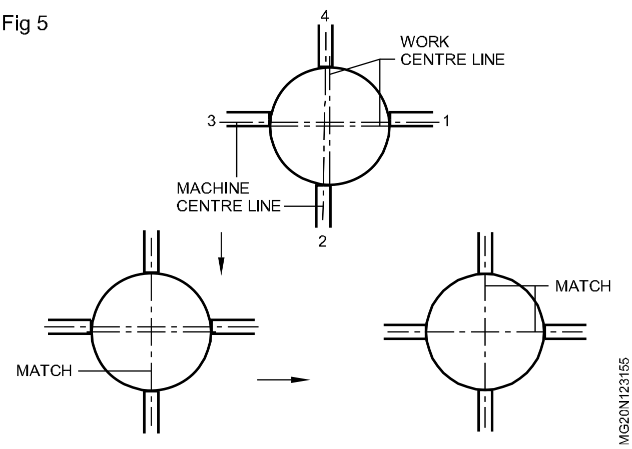
Fig 4



Rotate the chuck by hand and observe the gap between the pointer and the work surface for the position of the tow opposite jaws.

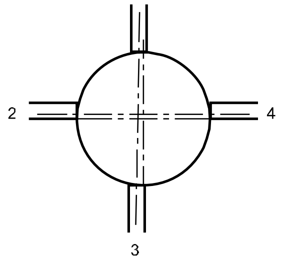
Open the jaw slightly on the side where more gap is observed and tighten the opposite jaw. (Fig 5)

Fig 5



Repeat until the gap is equal around the circumference. (Fig 6)

Fig 6



This indicates the work centre line is matching with the machine centre line set the gear levers for about 250 rpm and run the machine give slight pressure on the top of the pointer to make the tip to touch the work and feel.

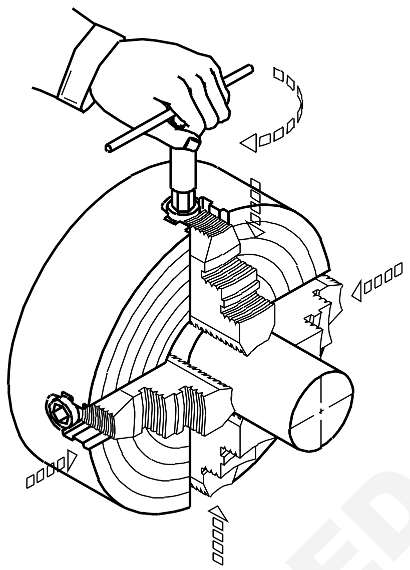
If the feel of contacting of the pointer tip is uniform, it indicates that the work is trued.

If the 'feel' is not uniform tighten the jaw on the side where the feel is high.

Repeat till a uniform touch is felt.

Finally, tighten the opposite jaws with the same amount of pressure (Fig 7)

Fig 7



Check once again for the true running of the work.

Ensure that the chuck key is removed before starting the lathe.

Lathe tools nomenclature

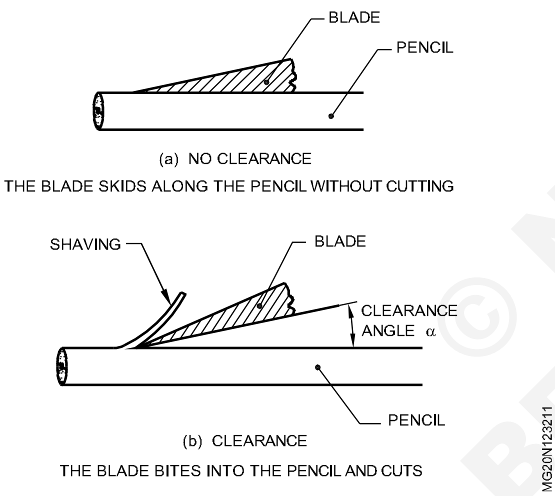
Objectives: At the end of this lesson you shall be able to
- **state the nomenclature of lathe tools**
- **name the angles of a lathe cutting tool**
- **state the characteristics of a rake angle**
- **state the characteristics of a clearance angle**
- **refer to a chart to determine the recommended rake and clearance angles for turning different metals.**

Need to provide angles and clearances

The cutting action of a lathe tool during turning is the wedging action. The wedge-shaped cutting edge has to penetrate into the work and remove the metal. This necessitates the grinding of the solid tool bit to have the wedge formation for the cutting edge.

When we sharpen a pencil with a pen knife by trial and error, we find that the knife must penetrate into the wood at a definite angle, if success is to be achieved. (Fig 1)

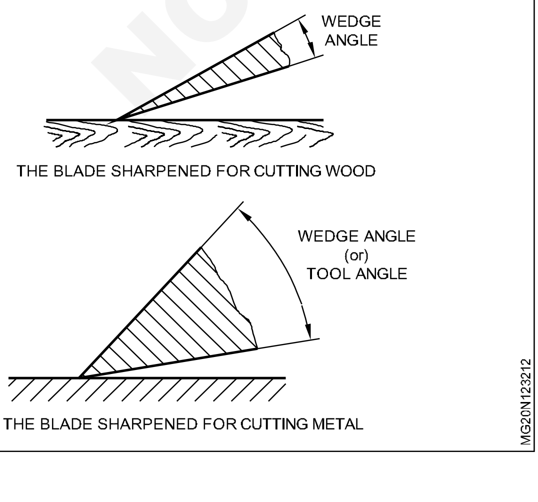
Fig 1



If, in the place of a wooden pencil, a piece of soft metal, such as brass is cut, it will be found that the cutting edge of the blade soon becomes blunt, and the cutting edge has crumbled. For the blade to cut brass successfully,

the cutting edge must be ground to a less acute angle to give greater strength as can be seen in Fig 2.

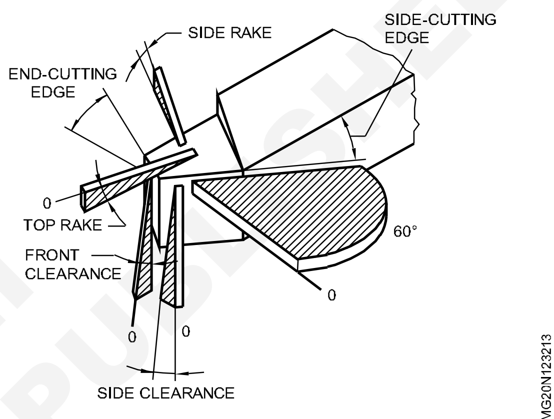
Fig 2



The angle shown in Fig 1 is known as a clearance angle and that shown in Fig 2 is a wedge angle.

Angles ground on a lathe cutting tool (Fig 3)

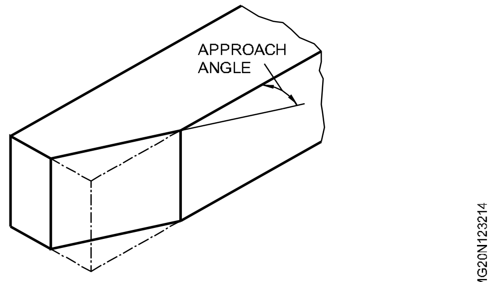
Fig 3



Side cutting edge angle

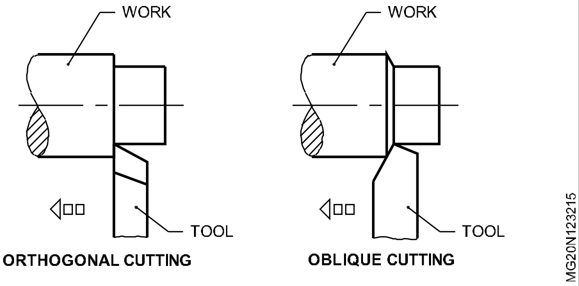
(Approach angle) (Fig 4)

Fig 4



This is ground on the side of the cutting tool. The cutting will be oblique. The angle ground may range from 25°to 40° but as a standard a 30° angle is normally provided. The oblique cutting has certain advantages over an orthogonal cutting, in which the cutting edge is straight. More depth of cut is given in the case of oblique cutting since when the tool is fed to the work, the contact surface of the tool gradually increases as the tool advances, whereas, in the case of orthogonal cutting, the length of the cutting edge for the given depth fully contacts the work from the beginning itself, which gives a sudden maximum load on the tool face. The area, over which heat is distributed, is more in oblique cutting. (Fig 5)

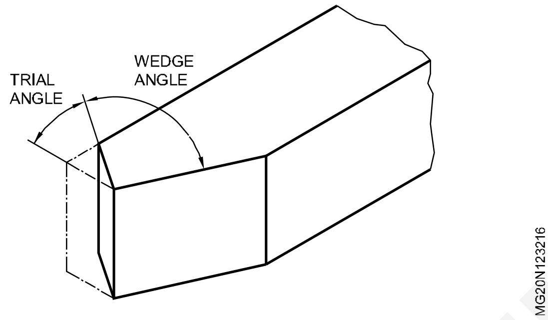
Fig 5



End-cutting edge angle (Trial angle) (Fig 6)

The end-cutting edge angle is ground at 30° to a line perpendicular to the axis of the tool, as illustrated in Fig 3. The side-cutting edge angle and the end-cutting edge angle, when ground, form a nose (wedge) angle of 90° for the tool.

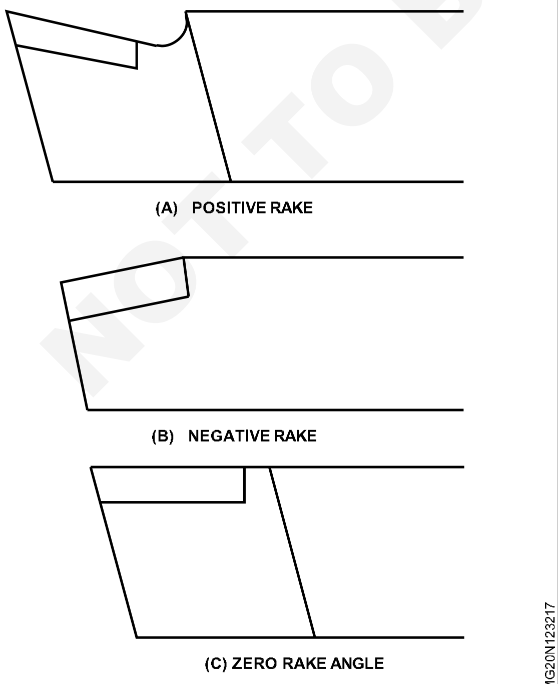
Fig 6



Top or back rake angle (Fig 7)

The rake angle ground on a tool controls the geometry of chip formation for any given material. It controls the mechanics of the cutting action of the tool. The top or back rake angle of the tool is ground on the top of the tool, and it is a slope formed between the front of the cutting edge and the top face.

Fig 7



Resistive top rake angle (Fig 7A)

If the slope is from the front towards the back of the tool, it is known as a positive top rake angle. When turning soft materials which form curly chucks and good surface finish. Cutting tool life is very short.

Negative top rake angle (Fig 7B)

If the slope is from the back of the tool towards the front of the cutting edge, it is known as the negative top rake angle. When turning the hard brittle metals with carbide tools it is usual practice to give a negative top rake.

Negative top rake tools have more strong than positive top rake angle tools. Tool life is too long. Chip should be broken and rough surface finish.

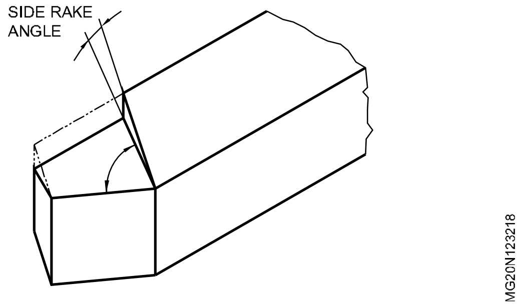
Zero top rake angle (Fig 7C)

If the cutting edge is straight line is called zero top rake angle when turning soft, ductile materials i.e. aluminium, brass, copper.

Side rake angle (Fig 8)

The side rake angle is the slope between the side of the cutting edge to the top face of the tool widthwise. The slope is from the cutting edge to the rear side of the tool. It varies from 0° to 20° according to the material to be machined. The top and side rakes, ground on a tool, control the chip flow and this results in a true rake angle which is the direction in which the chip that shears from the work passes.

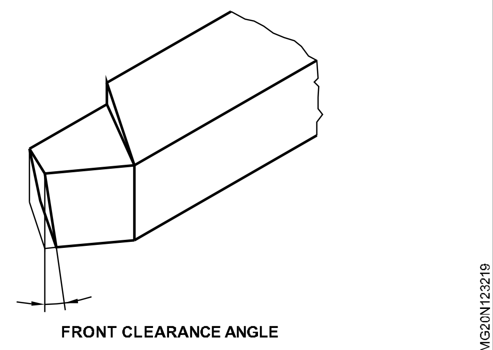
Fig 8



Front clearance angle (Fig 9)

This angle is the slope between the front of the cutting edge to a line perpendicular to the axis of the tool drawn downwards. The slope is from the top to the bottom of the tool, and permits only the cutting edge to contact the work, and avoids any rubbing action. If the clearance ground is more, it will weaken the cutting edge.

Fig 9

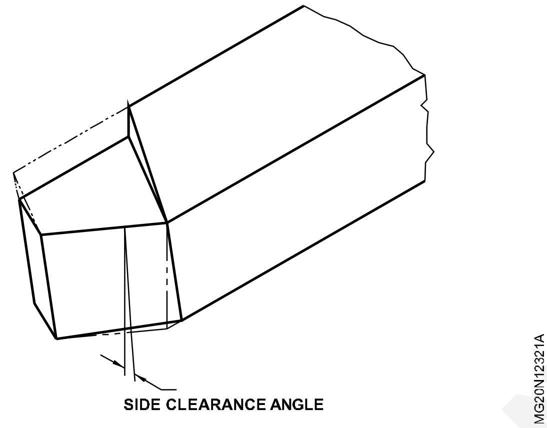


Side clearance angle (Fig 10)

The side clearance angle is the slope formed between the side cutting edge of the tool with a line perpendicular to the tool axis drawn downwards at the side cutting edge of the tool. The slope is from the top of the side cutting edge to the bottom face. This is also ground to prevent the tool from rubbing with the work, and allows only the cutting edge to contact the work during turning. The side clearance angle needs to be increased when the feed rate is increased.

When grinding the rake and clearance angles, it is better to refer to the standard chart provided with the recommended values, and then grind. However, actual operation will indicate the performance of the tool and if any modification is needed for the angles ground on the tool.

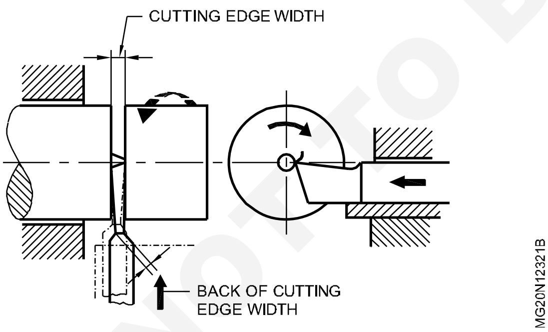
Fig 10



Side relief angle (Fig 11)

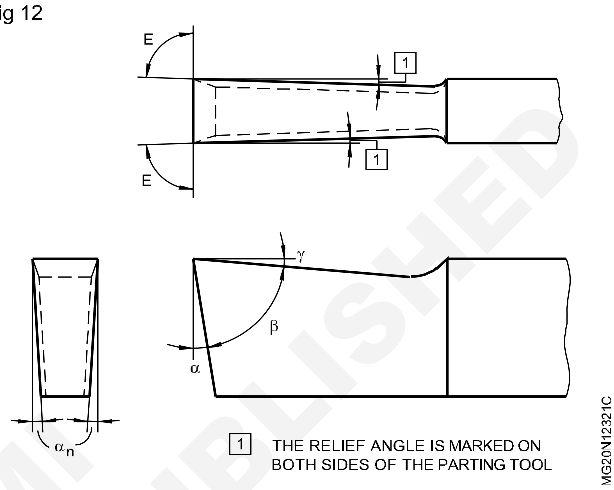
This angle is ground on the parting and the undercutting tools on both sides. This will provide the width of the cutting edge slightly broader than the back of the cutting edge.

Fig 11



This permits clearance between the sides of the tool and the groove walls formed by the plunging action of the tool, thereby, preventing the tool from getting jammed in the groove and causing breakage. The relief is kept as minimum as possible. Too much of relief will weaken the tool cutting edge, and also permit the chips to clog in the gap, causing the tool in both cases to break. Side relief is also provided sometimes to the main cutting edge of the facing tools, permitting only the cutting point performing the operation, when the tool axis is set perpendicular to the lathe axis. The side relief angle normally does not exceed 2°.

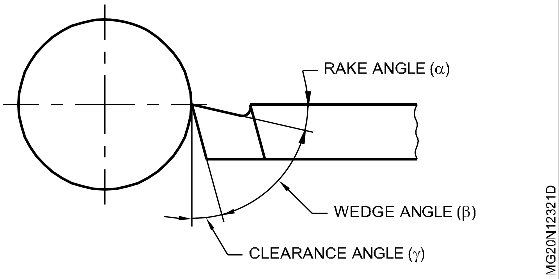
Fig 12



Relationship between rake, clearance and wedge angles (Fig 13)

The rake angle (∝), clearance angle (γ) and the wedge angle (β) have close relationship for efficiency in cutting. Excessive rake angle reduces the wedge angle, which helps in good penetration and it is particularly useful for cutting soft metals. A decreased wedge angle weakens the tool strength. Therefore, for cutting hard metals, the rake angle is zero or negative. The clearance angle is generally fixed depending on the geometry of the surface being cut.

Fig 13



Cutting speed, feed & depth of cut

Objectives : At the end of this lesson you shall be able to
- **distinguish between cutting speed and feed**
- **read and select the recommended cutting speed for different materials from the chart**
- **point out the factors governing the cutting speed**
- **state the factors governing feed.**

Cutting speed (Fig 1)

The speed at which the cutting edge passes over the material, which is expressed in metres per minute is called the cutting speed. When a work of a diameter 'D' is turned in one revolution the length of portion of the work in contact with the tool is π x D. When the work is making 'n' rev/min, the length of the work in contact with the tool is π x D x n. This is converted into metres and is expressed in a formula form as

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

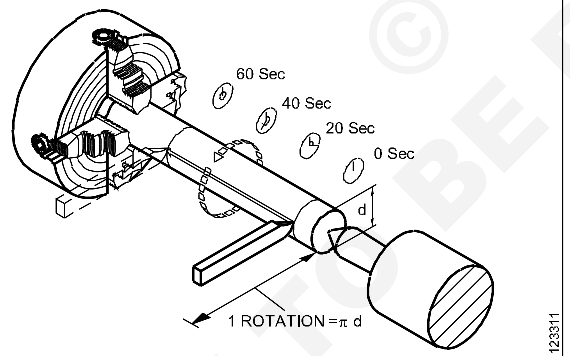
Where V = cutting speed in metre/min

π = 3.14

D = diameter of the work in mm.

N = r.p.m.

Fig 1



CUTTING SPEED FOR TURNING OPERATION

When more material is to be removed in lesser time, a higher cutting speed is needed. This makes the spindle to run faster but the life of the tool will be reduced due to more heat being developed. Recommended cutting speeds are given in a chart form which provides normal tool life under normal working conditions. As far as possible the recommended cutting speeds are to be chosen and the spindle speed calculated before performing the operation. (Fig 2)

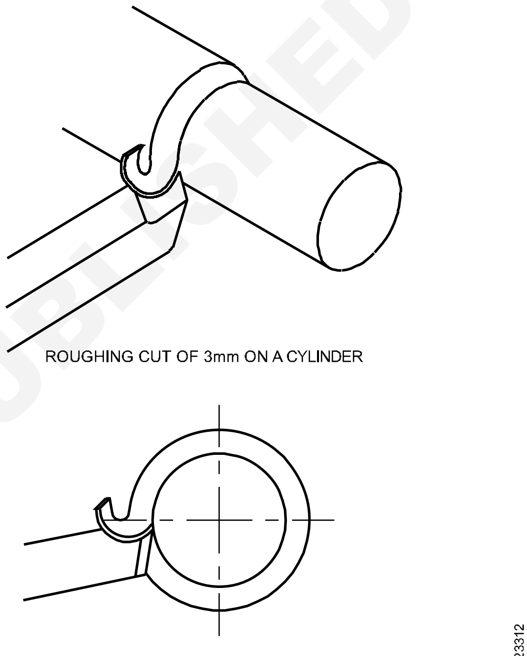
Example

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

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

$$\frac{1000 \times 25}{3.14 \times 50} = \frac{500}{3.14} = 159 \text{ r.p.m}$$

Fig 2



DEPTH OF CUT

Factors governing the cutting speed

Finish required

Depth of cut

Tool geometry

Properties and rigidity of the cutting tool and its mounting

Properties of the workpiece material

Rigidity of the workpiece

Type of cutting fluid used & Rigidity of machine tool

Feed (Fig 3)

The feed of the tool is the distance it moves along the work for each revolution of the work, and it is expressed in mm/rev.

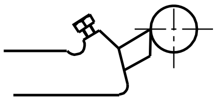
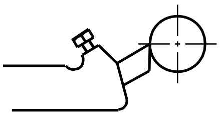
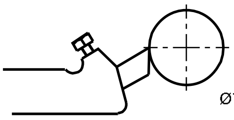
Factors governing feed

Tool geometry

Surface finish required on the work

Rigidity of the tool

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

Cutting speed 120m/min	Length of metal passing cutting tool in one revolution	Calculated r.p.m of spindle
 Ø25 mm	.... 78.5 mm	1528
 Ø50 mm	.... 157.0 mm	764
 Ø75 mm	.... 235.5 mm	509.5

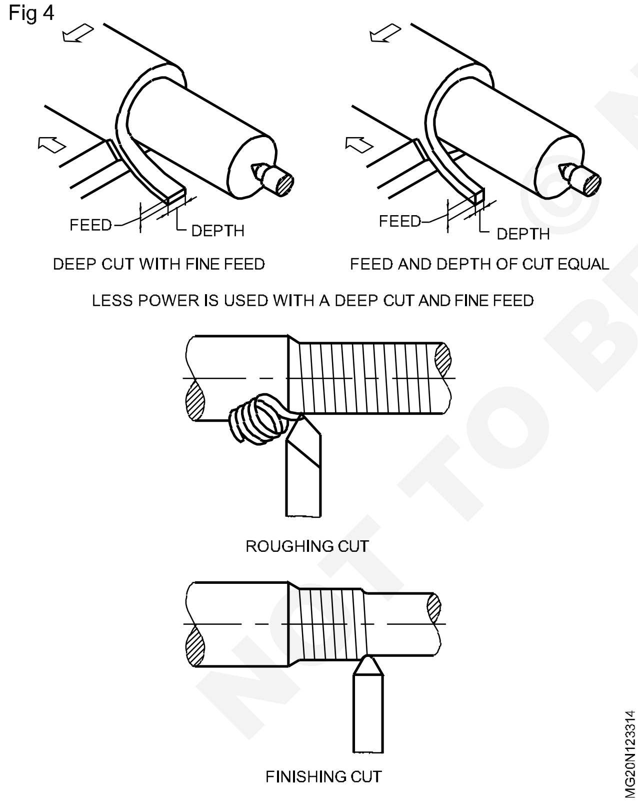
Coolant used.

Depth of cut (Fig 4)

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

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

Fig 4



Rate of metal removal

The volume of metal removal is the volume of chip that is removed from the work in one minute, and is found by multiplying the cutting speed, feed rate and the depth of cut.

Cutting speeds and feeds for H.S.S. tools are given in Table 1

Table 1

Material being turned	Feed	Cutting speed
Aluminium	0.2 - 1.00	70 - 100
Brass (alpha) - ductile	0.2 - 1.00	50 - 80
Brass (free cutting)	0.2 - 1.5	70 - 100
Bronze (phosphor)	0.2 - 1.00	35 - 70
Cast iron (grey)	0.15 - 0.7	25 - 40
Copper	0.2 - 1.00	35 - 70
Steel (mild)	0.2 - 1.00	35 - 50
Steel (medium-carbon)	0.15 - 0.7	30 - 35
Steel (alloy high tensile)	0.08 - 0.3	5 - 10
Thermosetting plastics	0.2 - 1.00	35 - 50

The recommended cutting speed and feed for different metals are given in the table. It can be observed that soft materials has a very high cutting speed and hard metal has a lesser cutting speed. The feed for hard material is generally very low compare to the feed given for soft materiral.

Note

For super HSS tools the feeds would remain the same, but cutting speeds could be increased by 15% to 20%

A lower speed range is suitable for heavy, rough cuts.

A higher speed range is suitable for light, finishing cuts.

The feed is selected to suit the finish required and the rate of metal removal.

When carbide tools are used, 3 to 4 times higher cutting speed than that of the H.S.S. tools may be chosen.

Calculation involving cutting speed, feeds

Objectives : At the end of this lesson you shall be able to
- **determine the spindle speed for turning jobs of different materials of different diameters with different tool materials**
- **determine the turning time with the given data.**

The selection of the spindle speed is one of the factors which decides the efficiency of cutting. It depends on the size of the job, material of the job and material of the cutting tool. The formula to determine cutting speed is.

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

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

To determine the spindle speed (N)

Example 1

Calculate the spindle speed to turn a MS rod of ø40 mm. Using HSS tool data in the above problem, since the material is mild steel and tool is HSS, the recommended cutting speed from the chart is 30m/min.

ø = 40 mm

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

$$= \frac{30 \times 1000}{\frac{22}{7} \times 40}$$

$$= \frac{30 \times 1000 \times 7}{22 \times 40}$$

$$= \frac{30 \times 25 \times 7}{22}$$

= 238.6 r.p.m.

The spindle speed should be set nearest to the calculated r.p.m., on the lower side.

Example 2

Determine the spindle speed to be set for a hard cast iron round rod of ø 40 mm using a HSS tool.

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

ø = 40 mm

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

$$= \frac{15 \times 1000}{\frac{22}{7} \times 40}$$

$$= \frac{15 \times 1000 \times 7}{22 \times 40}$$

$$= \frac{15 \times 25 \times 7}{22}$$

= 119.3 r.p.m.

The spindle speed should be set nearest to the calculated r.p.m., on the lower side.

Example 3

Calculate the spindle speed to turn a ø40 mm MS rod using a cemented carbide tool.

Data: The cutting speed recommended for-turning mild steel using a carbide tool is 92 mtr/minute.

ø of job = 40 mm

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

$$= \frac{92 \times 1000}{\frac{22}{7} \times 40}$$

$$= \frac{92 \times 1000 \times 7}{22 \times 40}$$

$$= \frac{92 \times 25 \times 7}{22}$$

= 731.8 r.p.m.

The spindle speed should be set to the nearest calculate r.p.m.

Turning time calculation

The time factor is very important to decide the manufacturing of the component as well as to fix the incentives to the operator. If the spindle speed, feed and length of the cut are known, the time can be determined for a given cut. If the feed is 'f' and length of cut is 'l', then the total number if revolutions the job has to make for a cut is l/f. If N is the rpm, the time required for a cut is found by

$$\text{Time to turn} = \frac{\text{Length of cut} \times \text{No.of cuts}}{\text{Feed} \times \text{r.p.m}}$$

$$T = \frac{l \times n}{f \times N}$$

where 'n' is the number of cuts and 'N' is the r.p.m.

Example 1

A mild steel of ø 40 mm and 100 mm length has to be turned to ø 30 mm in one cut for full length using a HSS tool with a feed rate of 0.2 mm/rev. Determine the turning time.

$$\text{Turning time} = \frac{l \times n}{f \times N}$$

The r.p.m. for the above is calculated Hand found out as 238.6 r.p.m.

l = 100mm

f = 0.2 mm

n = 1

N = 238.6 r.p.m.

$$\text{Time} = \frac{100 \times 1}{0.2 \times 238.6}$$

$$= \frac{100 \times 10}{2 \times 238.6}$$

$$= \frac{500}{238.6}$$

= 2.09 minutes

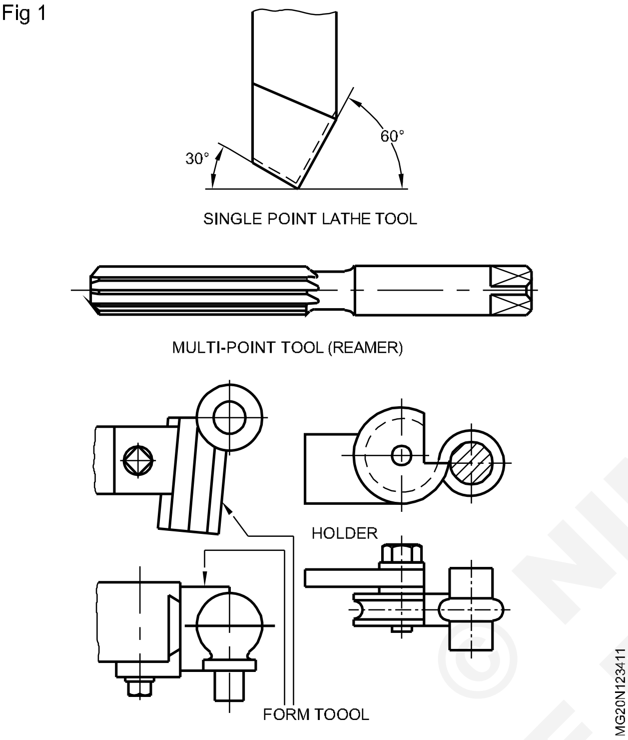
2 minute 5.4 seconds.

Lathe tools and their uses. Selection of tools for different operation on lathe

Objectives: At the end of this lesson you shall be able to
- **classify lathe cutting tools**
- **list the types of lathe cutting tools**
- **state the features of each type.**

Cutting tool classification (Fig 1)

Fig 1



Cutting tools are classified as:

- single point cutting tools
- multi-point cutting tools
- form tools.

Single point cutting tools

Single point cutting tools have one' cutting edge which performs the cutting action. Most of the lathe cutting tools are single point cutting tools.

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

- Side cutting tools
- End cutting tools. (Fig 2)

Side cutting tools

Side cutting edge tools have their cutting edges formed on the side of the cutting tool, and are used on lathes for most of the operations. They are again classified as right hand tools and left hand tools. (Fig 3) A right hand tool operates from the tailstock end towards headstock and a left hand tool operates from the headstock end towards the tailstock. The cutting edge is formed accordingly.

Fig 2

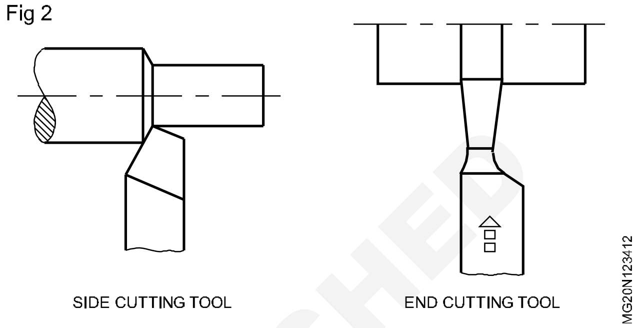
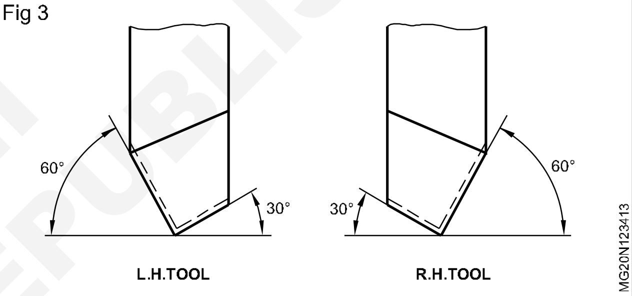


Fig 3



End cutting tools

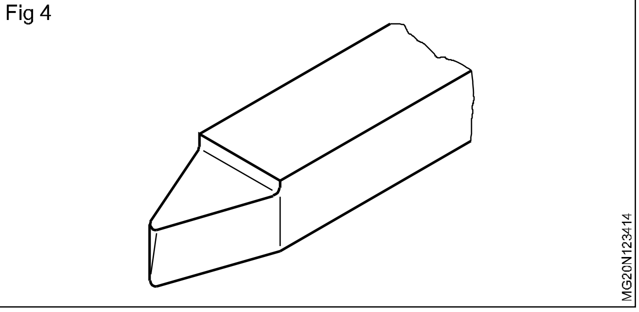
End cutting tools have their cutting edge at the front end of the tools and are used on lathes for plunge cut operations.

Multi-point cutting tools

These tools have more than one cutting edge, and they remove metal from the work simultaneously by the action of all the cutting edges. The application of the multi-point cutting tools on the lathe is mostly done by holding the tool in the tailstock and feeding it to the work.

Form tools (Fig 4)

Fig 4



These tools reproduce on the work the form and shape of the cutting edge to which they are ground. The form tools perform the operations on the work by a plunging action, and are fixed on the tool post square to the axis of the work and fed by a cross-slide. They may have their cutting edges formed on square or rectangular section tool blanks acting radially. The form tools may be circular form tools and tangential form tools. They may require special holders to which they can be fixed, and the holders are clamped on the tool posts for operation.

Lathe cutting tool types

The tools used on lathes are classified as:

- solid type tools
- brazed type tools
- inserted bits with holders
- throw-away type tools.

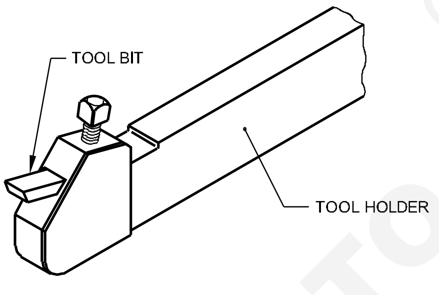
solid bits of square, rectangular and round cross sections. Most of the lathe cutting tools are of solid type, and high carbon steel and high speed steel tools are used. The length and cross-section of the tool depend upon the capacity of the machine, the type of tool post and the nature of the operation.

Inserted bits with holders (Fig 5)

Solid high speed steel tools are costly hence they are sometimes used as inserted bits. These bits are small in sizes and inserted in the holes shaped according to the cross-section of the bit to be inserted. These holders are held and clamped in the tool posts to carry out the operations.

The disadvantage in these types of tools is that the rigidity of the tool is poor in the slot.

Fig 5

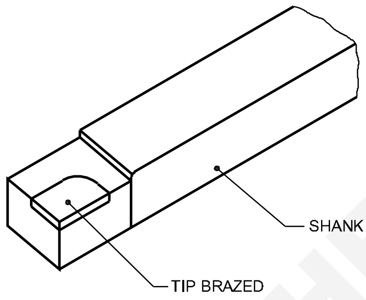


Brazed tools (Fig 6)

These tools are made of two different metals. The cutting portions of these tools are good cutting tool materials, and the body of the tools does not possess any cutting ability and is tough. Tungsten carbide tools are mostly of the brazed type. Tungsten carbide bits of square, rectangular and triangular shape with proportionately less thickness are brazed to the tips of the shank metal.

The tips of the shank metal pieces have machined top surface according to the shape of the bit to accommodate the carbide bits. These tools are economical and give better rigidity to the tools than the inserted bits clamped in the tool-holders. This is applicable to high speed steel brazed tools also.

Fig 6

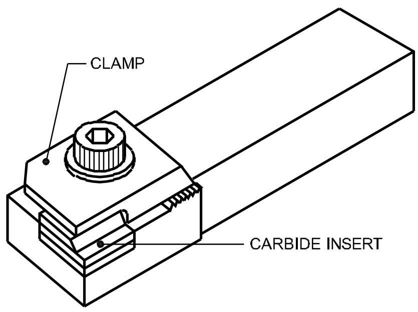


Throw-away type tools (Fig 7)

Carbide-brazed tools, when blunt or broken, need grinding which is time absorbing and expensive. Hence they are used as throw-away inserts in mass production. Special tool-holders are needed, and the carbide bits of rectangular, square or triangular shapes are clamped in the seating faces machined in these types of special holders.

The seating faces are machined such that the rake and clearances needed for the cutting bits are automatically achieved when the bits are clamped. As these tools are to be operated at very high cutting speeds, the capacity of the machine must also be high and the rigidity of the machine must be good as well.

Fig 7



HOLDER FOR THROW-AWAY CARBIDE INSERTS

Taper and its types and problems

Objectives : At the end of this lesson you shall be able to
- **state the uses of tapers**
- **identify the elements of a taper**
- **state the different standard tapers and their uses**

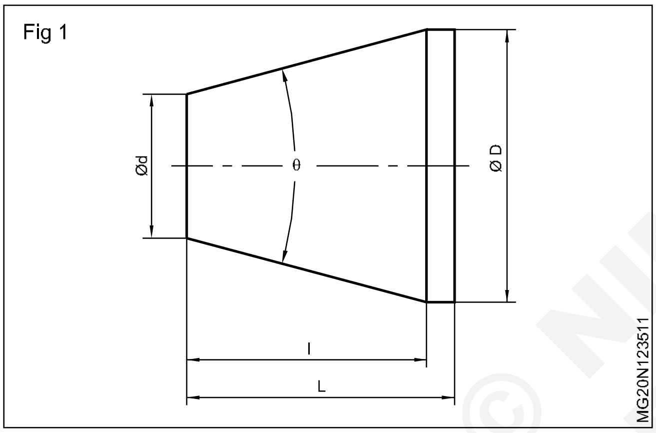
A taper is uniform increase or decrease in diameter along the length of a cylinder.

Uses of taper

Tapers are used for the following.

- Assist to transmit drive in the assembled parts.
- Used for easy assembly and disassembly of parts.
- Gives self-alignment in the assembled parts.

Fig 1



Elements of taper (Fig 1)

Big diameter in mm	D
Small diameter in mm	d
Length of the taper in mm	ℓ
Included taper angle in degrees	θ
Total length of job in mm	L

Expression of taper and its conversion

The methods by which tapers can be expressed are:

- giving the big dia. small dia. and the length of taper (Fig 2)
- giving the included angle of the taper in degrees. (Fig 3)
- giving Taper per foot (TPF)

Example

5/8" taper per foot means in a length of 12" taper (1 foot) the difference in diameter is 5/8" or mm per metre (Fig 4)

- giving taper in ratio - Ratio 1:20 means, for a taper length of 20 units the difference in diameter is 1 unit (Fig 5)

Fig 2

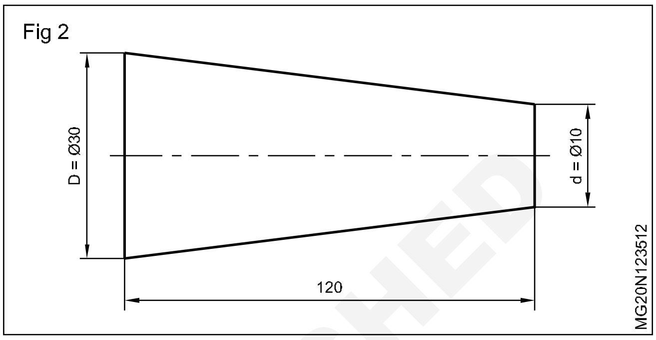


Fig 3

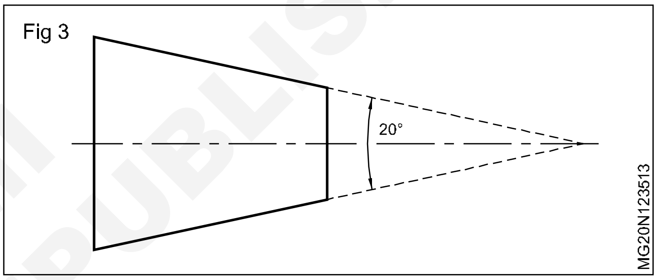


Fig 4

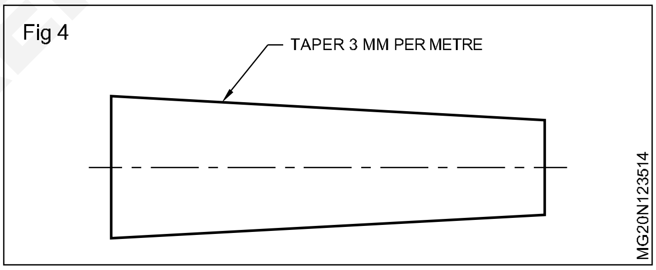
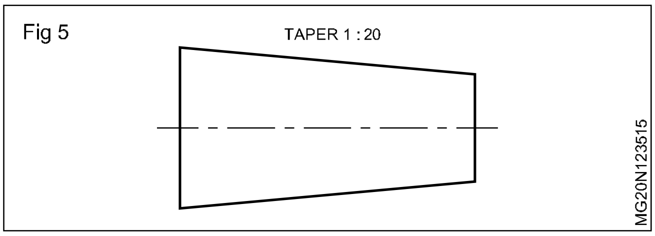


Fig 5



- mentioning by standard taper.

Example

MT3 (Morse taper number 3)

The relationship between the elements of a taper-

φ = included angle of a taper

α = Half included angle of a taper

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

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

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

Classification of tapers

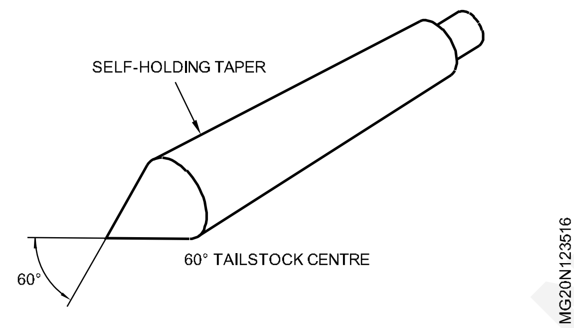
Tapers are classified as

- self-holding tapers
- quick releasing tapers.

Self-holding taper (Fig 6)

A self-holding taper has the property of holding the two parts together and be able to assemble together without any additional locking device such as keys. Just insert the internal taper into the external taper with a slight 'bang' and they get locked together. These tapers have a smaller taper angle that is limited to a maximum of 3°.

Fig 6



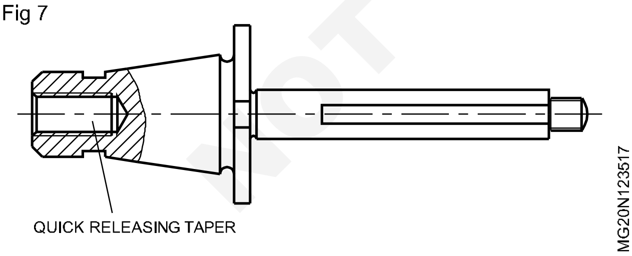
Example

Taper shank of drills, reamers and sleeves.

Quick releasing taper (Fig 7)

Quick releasing tapers in contrast to the self-holding tapers do not hold the parts together by themselves. They require additional locking devices for holding. (They have a larger included angle the value of which is not less than 18°. The purpose of quick releasing tapers is only to provide perfect alignment of the tool mating parts.)

Fig 7



Example

Arbor of milling machines.

Different standard tapers and their uses

The common standard tapers in use are:

- Morse taper (MT)
- Brown and Sharpe taper (BS)
- Jarno taper (JT)
- metric taper
- pin taper.

Morse taper

The Morse taper is the most commonly used standard taper in the industry. It is a self-holding taper. This taper is usually used in spindles of lathes and drilling machines, shanks of drills, reamers, centres, etc. The Morse taper is denoted by the letters MT. It is available from MT0 to MT7. The numbers MT0 to MT5 are commonly used on taper shanks of twists of drills, reamers and lathe centres. The included angle of the Morse taper is approximately 3° and the taper per foot is 5/8".

Brown and Sharpe taper

Both quick releasing and self-holding tapers are available in Brown and Sharpe tapers. The taper used in the arbors of a milling machine is a quick-releasing Brown and Sharpe taper, having a taper of 3 1/2" T.P.F.

Brown and Sharpe self-holding tapers are available from BSI to BS18. The taper per foot is 1/2" except BS10 which has a taper of 0.5161" taper per foot.

Jarno taper

Jarno tapers are self-holding and are used on external tapers of the lathe spindle nose where the chuck or face plate is mounted. It is available from Nos. 1 to 20. The amount of taper per foot is 0.6". The dimensions of this taper will be as follows.

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

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

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

Jarno taper is mostly used in die-making machines.

Metric taper

Metric taper is available as both self-holding and quick-releasing tapers. A self-holding metric taper has an included angle of 2° 51' 51".

Quick releasing metric tapers are used as the external tapers of lathe spindle noses. Metric tapers are expressed by numbers which represent the big diameter of the taper in millimetres.

Standard pin taper

Standard pin tapers are used in taper pins. It is a self-holding taper. It is available both in Metric and British systems. The amount of taper is 1:50 in the metric system and 1:48 (1/4" TPF) in the British system.

Taper turning methods and calculations

Objectives: At the end of this lesson you shall be able to
- **state the methods of turning tapers on lathes**
- **state how each method is performed**
- **state the advantages and disadvantages of each method.**

Methods of turning taper on a lathe

The different methods of taper turning on a lathe are:

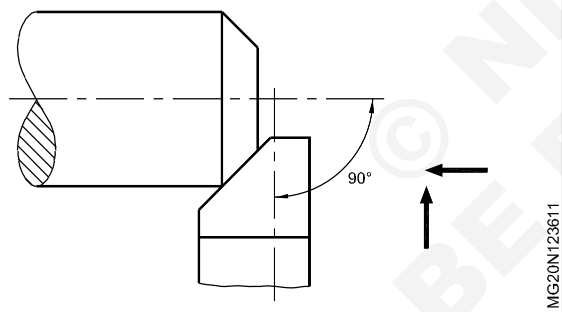
- form tool method
- compound rest method
- tailstock offset method
- taper turning attachment method
- taper turning by combining feeds.

Form tool method (Fig 1)

This method is used in mass production for producing small lengths of taper. The form tool should be set at right angles to the axis of the work and feed.

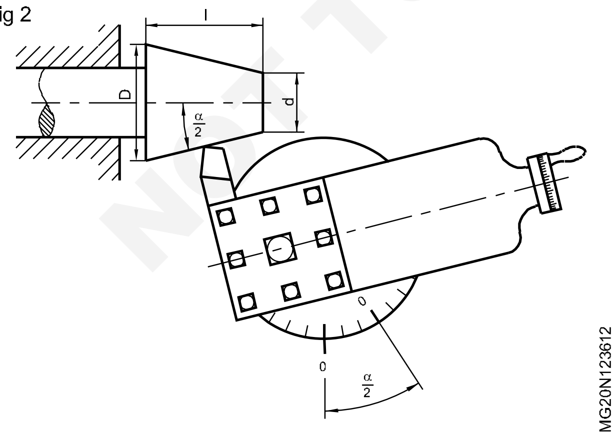
The carriage should be locked while turning taper by this method.

Fig 1



Compound rest method (Fig 2)

Fig 2



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

The angle '$\frac{\alpha}{2}$' to which the compound rest is set is found by the formula

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

where

D = big diameter of taper

d = small diameter of taper

ℓ = length of taper

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

Advantages

- Both internal and external tapers can be produced.
- Steep tapers can be produced.
- Easy setting of the compound rest.

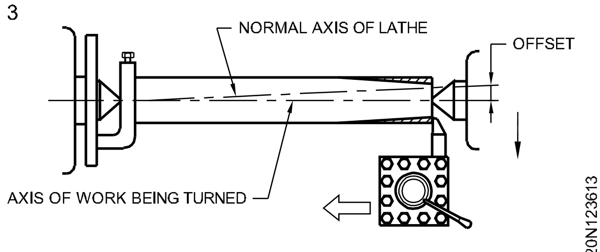
Disadvantages

- Only hand feed can be given.
- Threads on the taper portion cannot be produced.
- The taper length is limited to the movement of the top slide.

Tailstock offset method (Fig 3)

In this method the job is held at an angle, and the tool moves parallel to the lathe axis. The body of the tailstock is shifted on its base to an amount corresponding to the angle of the taper.

Fig 3



IF CENTRES ARE NOT IN LINE TAPERED WORK WILL RESULT.

These tapers can be turned between centres only, and this method is not suitable for producing steep tapers. The amount of offset is found by the formula

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

where

D = big diameter of taper

d = small diameter of taper

ℓ = taper length

L = total length of the job.

Advantages

- Power feed can be given.
- Good surface finish can be obtained.
- Maximum length of taper can be produced.
- External thread on taper portion can be produced.
- Duplicate tapers can be produced.

Disadvantages

- Only external taper can be turned.
- Accurate setting of the offset is difficult.
- Taper turning is possible when the work is held between centres only.
- Damages the centre drilled holes of the work.
- The alignment of the lathe centres will be disturbed.

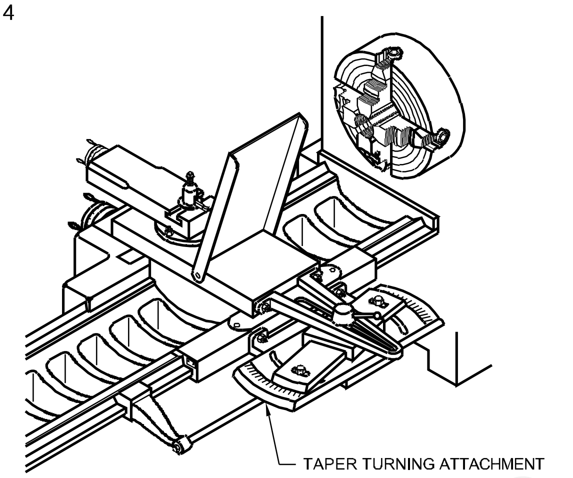
Taper turning attachment method (Fig 4)

A special attachment is provided on a few modern lathes. Here the job is held parallel to the axis and the tool moves at an angle. The movement of the tool is guided to the required angle by the attachment.

Advantages

- Both internal and external tapers can be produced.

Fig 4



- Threads on both internal and external taper portions can be cut.
- Power feed can be given.
- Lengthy taper can be produced.
- Good surface finish is obtained.
- The alignment of lathe centres is not disturbed.
- It is most suitable for producing duplicate tapers because the change in length of the job does not affect the taper.
- The job can be held either in chuck or in between centres.

Disadvantage

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

Calculation of the compound slide swivel angle

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

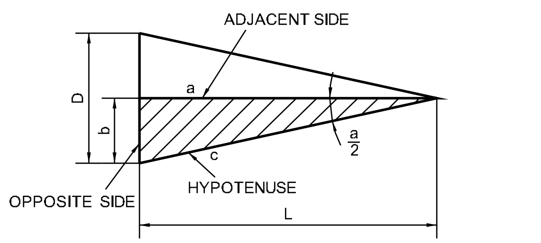
- **derive a formula to determine the swivel angle**
- **solve problems involving taper calculation**
- **refer to tables and determine the value of the angle for the arrived result**
- **determine the depth of cut to reduce the taper length**

Derivation of the formula

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

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

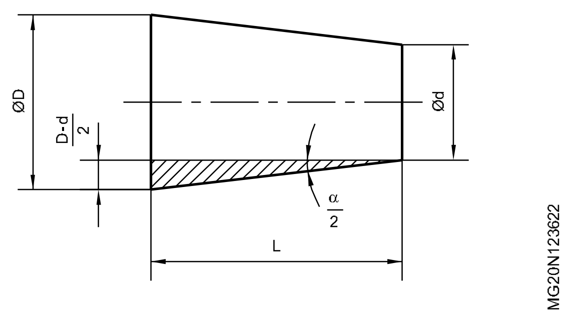
Fig 1



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

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

Fig 2



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

Now the formula becomes

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

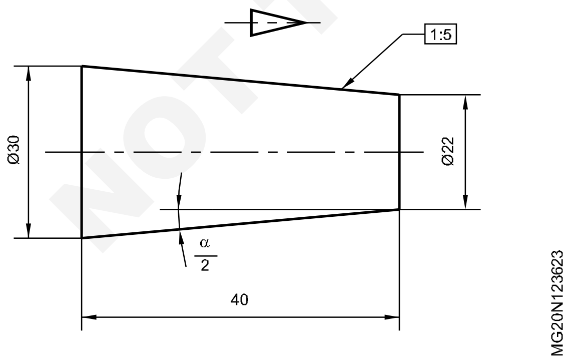
For example, referring to Fig 3 we have

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

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

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

Fig 3



TAPER EXPRESSED AS A RATIO TO DETERMINE THE SWIVEL ANGLE

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

This can be rewritten as

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

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

Hence the formula becomes

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

The taper ratio is given as 1:5

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

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

$$\frac{\alpha}{2} = 5° \, 45'.$$

The compound slide swivel angle is 5° 45'.

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

Example

(Given 5/8" TPF)

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

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

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

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

$$\alpha/2 = 1°26'$$

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

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

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

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

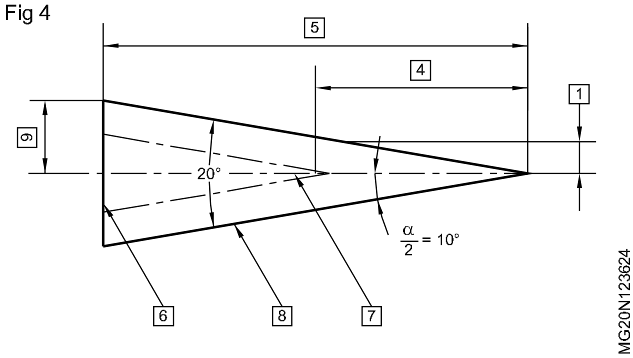
6 Opposite side to $\frac{\alpha}{2}$

7 Adjacent side

8 Hypotenuse

Then l = 4 x tan $\alpha/2$.

Fig 4



Example

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

$$l = 4 \text{ x } \tan \frac{\alpha}{2}$$

$$1 = 2 \text{ mm x } \frac{\tan 20°}{2}$$

=2 mm x tan 10°

=2 x 0.1763

= 0.3526 mm.

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

Taper turning by offsetting tailstock

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

Calculation of the amount of offset

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

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

Where L = total length of job

Example

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

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

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

Total length of job (L) = 200 mm

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

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

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

= 4 mm

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

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

where TPF is given in inches

L = total length of job

If taper is expressed as a ratio then the amount of offset

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

If taper is expressed by included angle i.e. 2

Offset = L x tan

where L = total length

= 1/2 included angle in degrees.

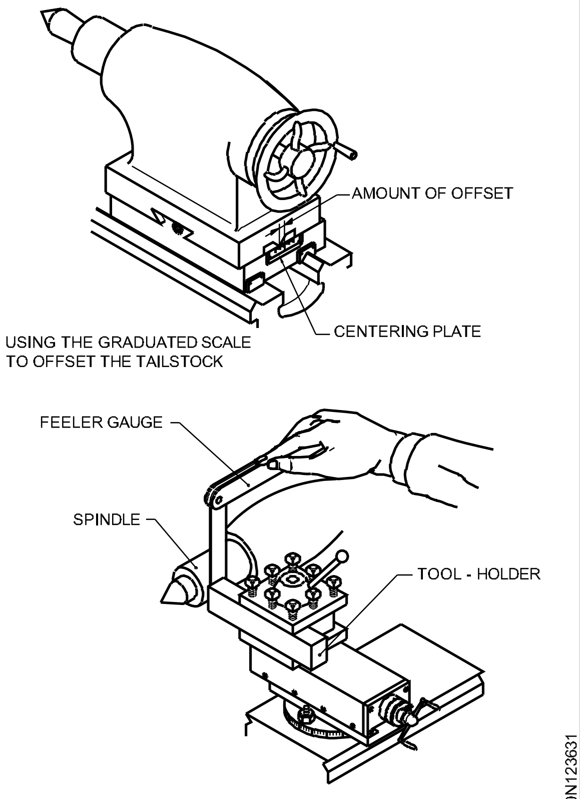
Different methods of offsetting the tailstock (Fig 1)

Setting offset with the help of the inside measuring jaws of a vernier caliper to the required mm, if direct graduation is not provided on the base of the tailstock.

Using a dial test indicator.

Using a cross-slide graduated collar and feeler gauge.

Fig 1



USING A FEELER GAUGE TO OFFSET THE TAILSTOCK

Method cutting screw thread and simple calculation

Objectives: At the end of this lesson you shall be able to
- **state the principle of thread cutting by a single point tool**
- **list the parts involved in the thread cutting mechanism and state their functions**
- **derive formula for change gear calculation.**

Principle of thread cutting

The principle of thread cutting involves producing a uniform helical groove on a cylindrical or conical surface by rotating the job at a constant speed, and moving the tool longitudinally at a rate equal to the pitch of the thread, per revolution of the job.

The cutting tool moves with the lathe carriage by the engagement of a half nut with the lead screw. The shape of the thread profile on the work is the same as that of the tool ground. The direction of rotation of the lead screw determines the hand of the thread being cut.

Parts involved in thread cutting

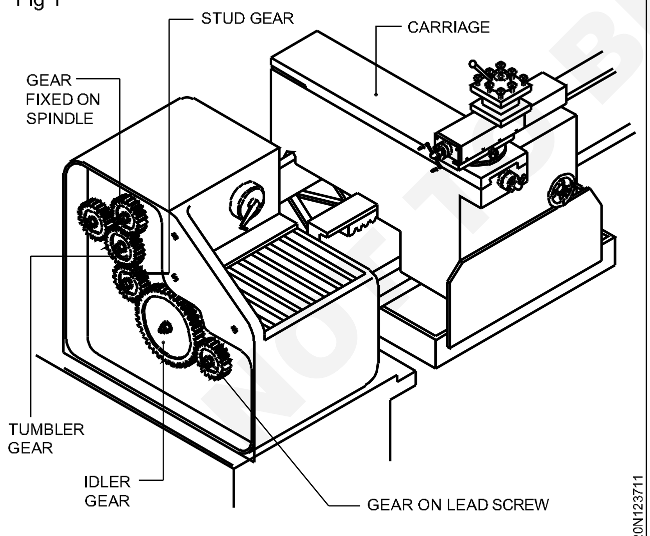
Figures 1 & 2 illustrate how the drive is transmitted from the spindle to the lead screw through a change gear arrangement. From the lead screw the motion is transmitted to the carriage by engaging the half nut with the lead screw.

Derivation of the formula for change gears

Example

CASE 1 : To cut 4 mm pitch (lead) thread on the job in a lathe having a lead screw of 4 mm pitch.

Fig 1



TRANSMITTING MOTION FROM SPINDLE TO CARRIAGE

When the job rotates once, the lead screw should make one revolution to move the tool by 4 mm. Hence, if the stud gear (Driver) has a 50 teeth wheel, the lead screw should be fixed with a gear of 50 teeth (Driven) to get the same number of revolutions as the spindle. (Fig 3)

Fig 2

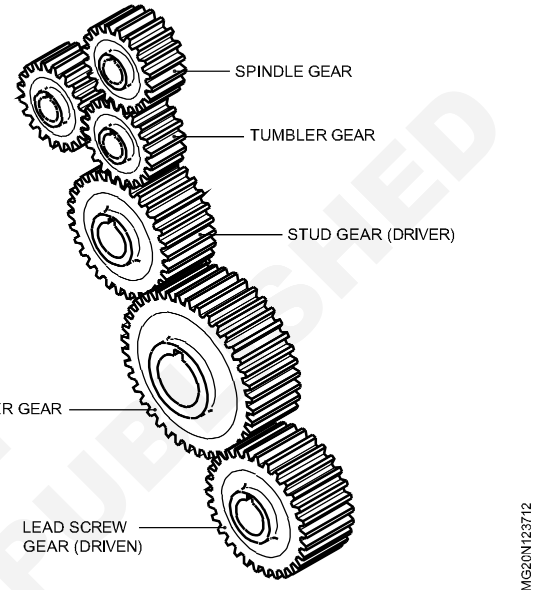
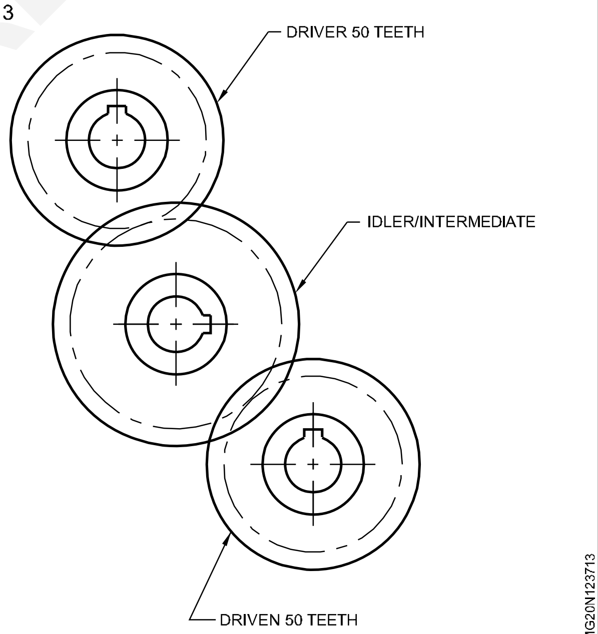


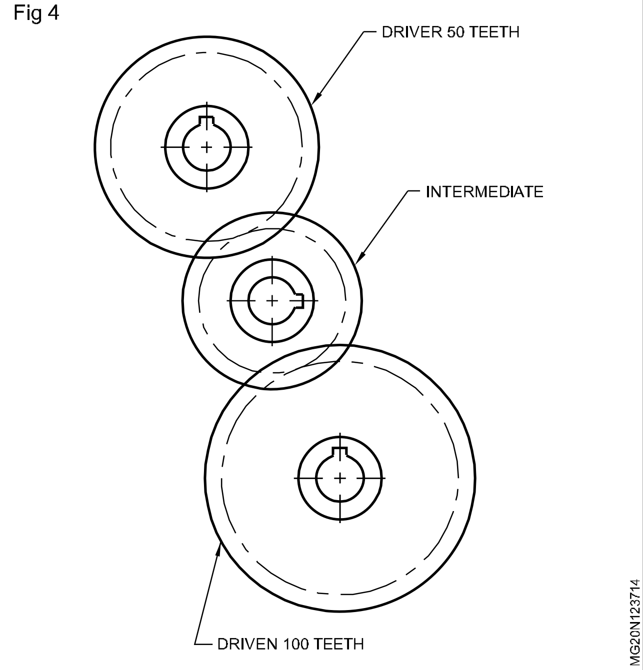
Fig 3



CASE 2 : To cut 2 mm pitch threads instead of 4 mm in the same lathe.

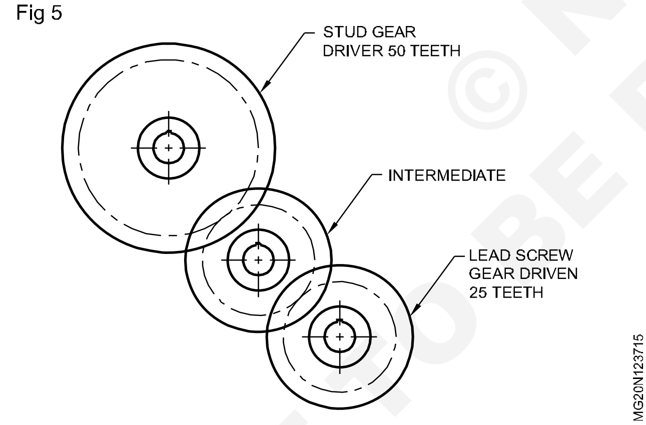
When the job makes one rotation, the lead screw should rotate 1/2 revolution so that the lead screw rotation is slower. Therefore, the driven wheel (lead screw gear) should be of 100 teeth if the driver (stud gear) is of 50 teeth. (Fig 4)

Fig 4



CASE 3 : If we have to cut a 8 mm pitch thread on a job, with a 4mm lead screw pitch, the tool should move 8 mm per revolution of the job. The lead screw should rotate 2 revolutions when the job makes one rotation, making the L S to run twice as fast as the spindle. So the driven wheel (lead screw gear) should be of 25 teeth if the driver wheel is of 50 teeth. (Fig 5)

Fig 5



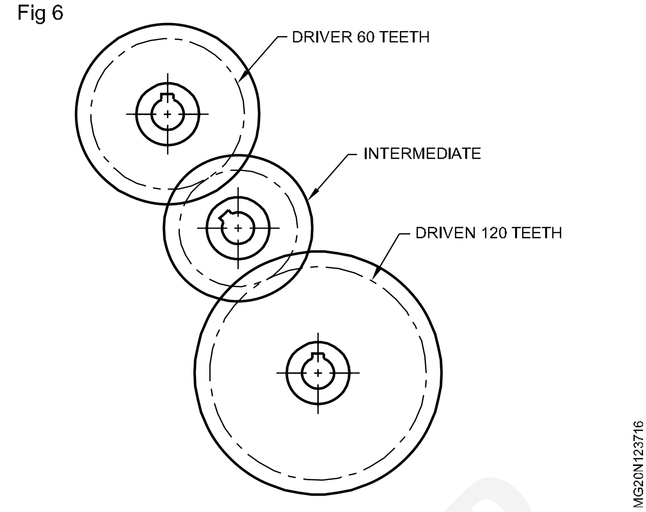
Let us compare the above three examples.

Examples :	Case 1	Case 2	Case 3
Pitch(Lead) of job	4	2	8
Pitch(Lead) of L.S	4	4	4
Driver	50	50	50
Driven	50	100	25

Stating the above in a formula,

$$\text{The gear ratio} = \frac{\text{Driver}}{\text{Driven}} = \frac{\text{Lead of work}}{\text{Lead of lead screw}}$$

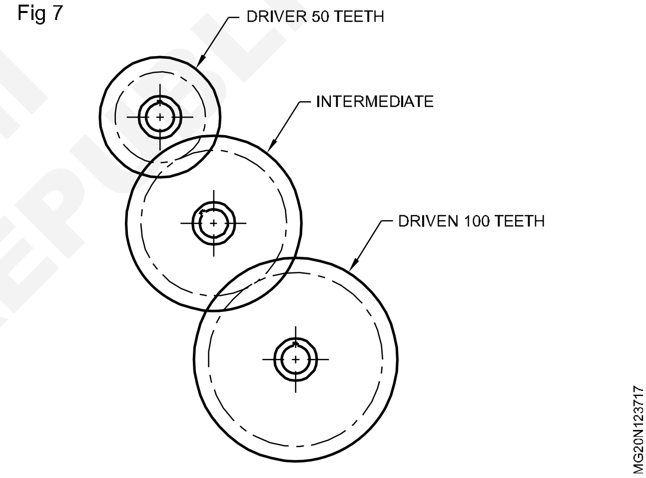
Fig 6



Solved examples

1 Find the change gears required to cut a 3 mm pitch on a job in a lathe, having a lead screw of 6 mm pitch. (Fig 6)

Fig 7



Ratio = Driver = Lead of work

$$\text{The gear ratio} = \frac{3}{6} = \frac{3 \times 20}{6 \times 20} = \frac{60}{120}$$

Driver = 60 teeth

Driven = 120 teeth

2 Find the change gears required to cut a 2.5 mm pitch in a lathe, having a lead screw of 5 mm pitch. (Fig 7)

$$\text{Ratio} = \frac{\text{Driver}}{\text{Driven}} = \frac{\text{Lead of work}}{\text{Lead of lead Screw}}$$

$$= \frac{2.5}{5} = \frac{2.5 \times 20}{5 \times 20}$$

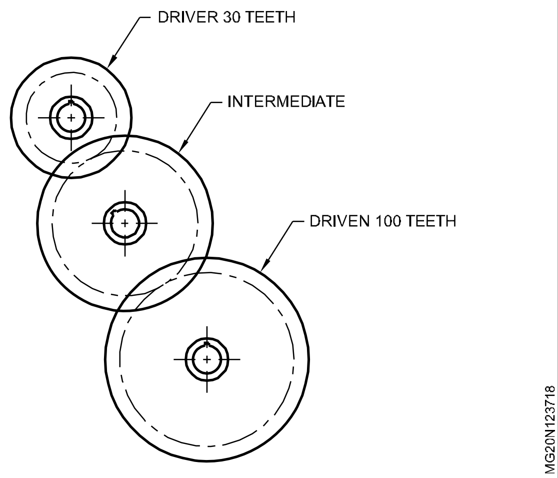
$$= \frac{50 \text{ (Driver)}}{100 \text{ (Driven)}}$$

3 Calculate the gears required to cut a 1.5 mm pitch in a lathe having a lead screw of 5 mm pitch. (Fig 8)

$$= \frac{1.5}{5} = \frac{3}{10} = \frac{3 \times 10}{10 \times 10}$$

$$= \frac{30 \text{ (Driver)}}{100 \text{ (Driven)}}$$

Fig 8



Application and use of pedestal grinder

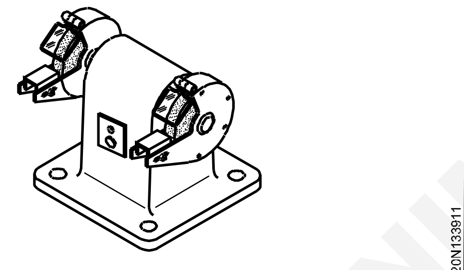
Objectives: At the end of this lesson you shall be able to
- **state the purposes of off-hand grinding**
- **name the machines with which off-hand grinding is done**
- **state the features of bench and pedestal grinders.**

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.

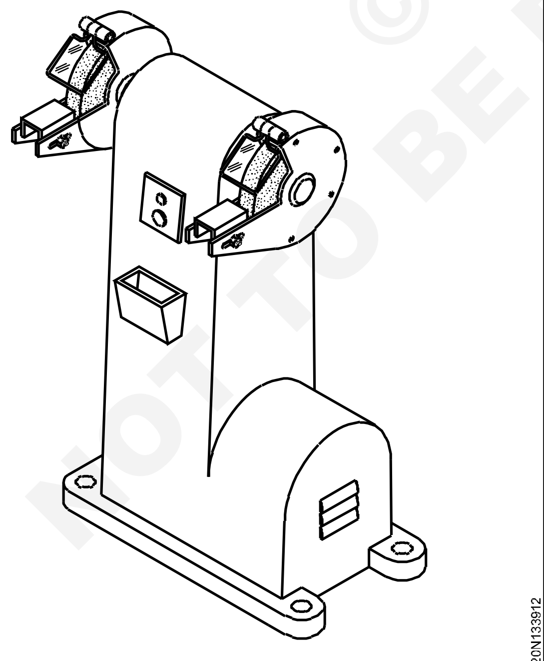
Off-hand grinders are fitted to a bench or a pedestal (Figs 1 ,2)

Fig 1



BENCH GRINDER

Fig 2



PEDESTAL GRINDER

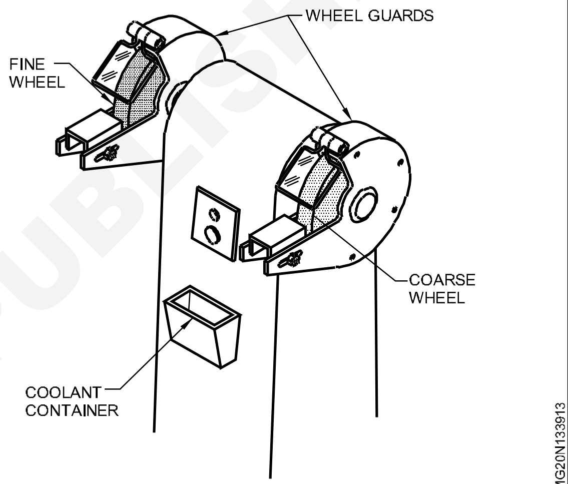
Bench grinders: Bench grinders are fitted to a bench or table, and are useful for light duty work.

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

These grinders consist of an electric motor and 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.

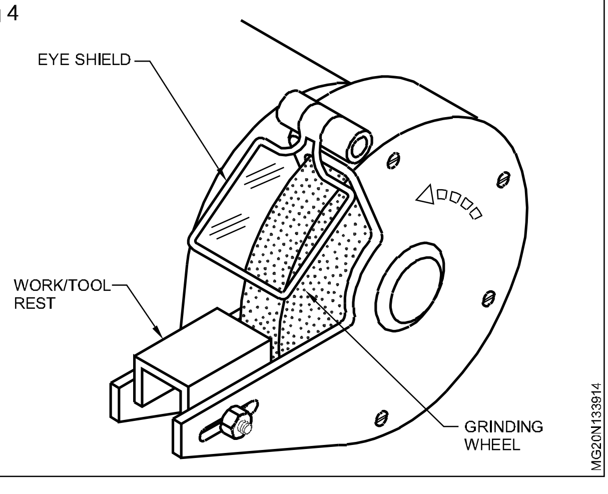
Fig 3



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

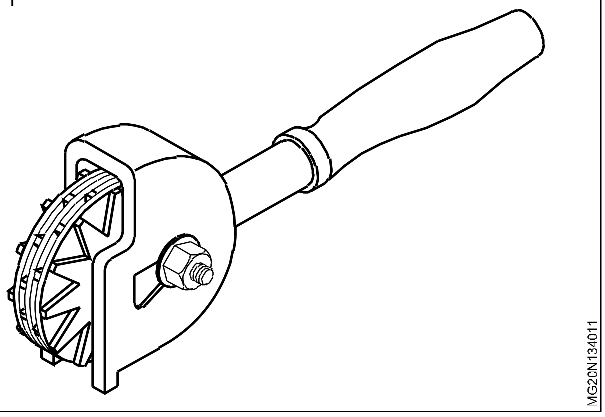


Dressing tools used in grinding section

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 dresser.**

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

Fig 1



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

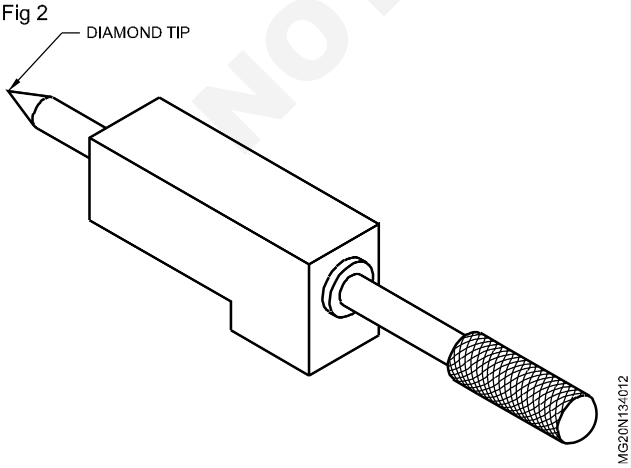
While dressing, the star wheel is pressed against the face of the revolving grinding wheel. The star wheel revolves and digs into the surface of the grinding wheel. This releases the wheel loading and dull grains, exposing sharp new abrasive grains.

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

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

Diamond dressers (Fig 2)

Fig 2



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

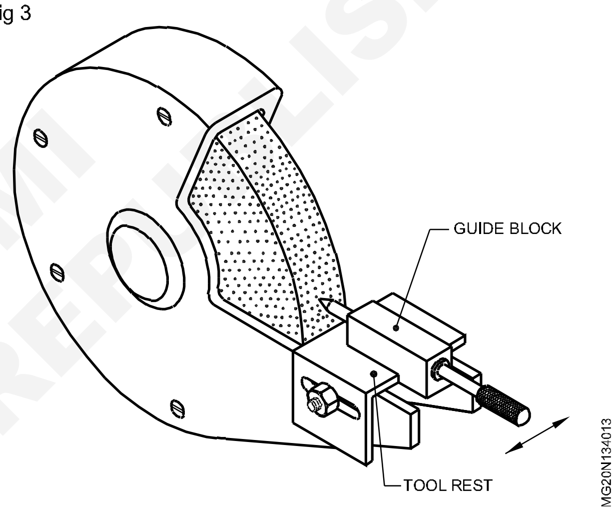
These wheels are dressed and trued with diamond dressers.

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

How to use a wheel dresser (Fig 3)

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

Fig 3



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

For roughing, the dresser is moved faster.

For fine finish, the dresser is moved slowly.

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

Abrasive stick

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

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

Outside micrometer

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

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

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

The parts of a micrometer are listed here.

Frame

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

Barrel/Sleeve

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

Thimble

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

Spindle

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

Anvil

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

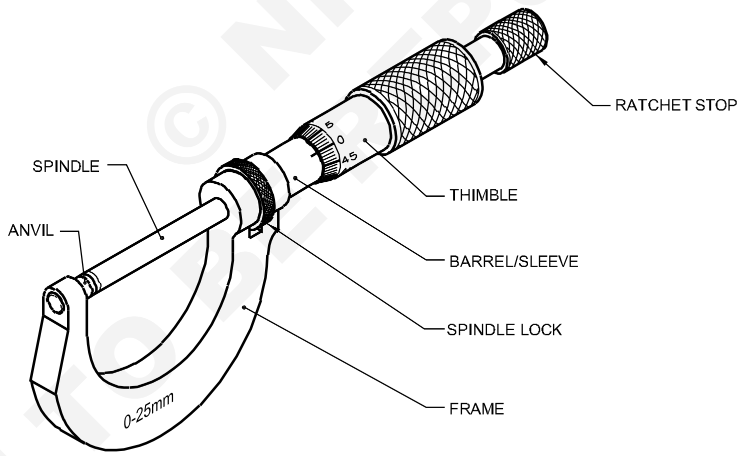
Spindle lock nut

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

Ratchet stop

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

Fig 1



Graduations of metric outside micrometer

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

Working principle

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

Graduations (Fig 1)

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

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

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

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

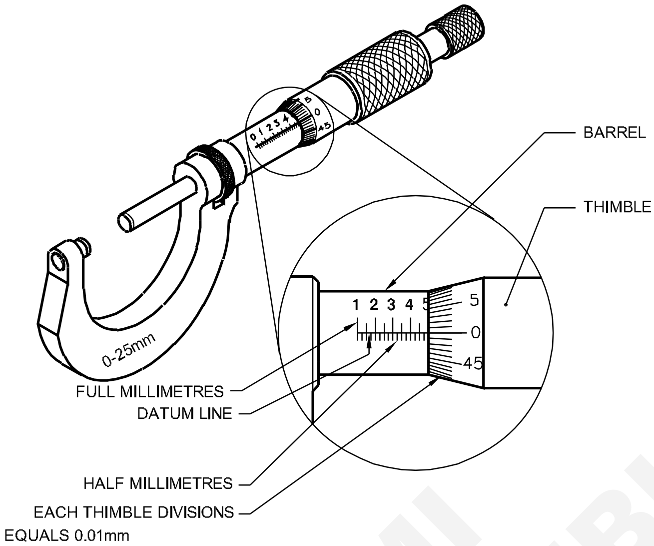
The distance moved by the spindle during one rotation of the thimble is 0.5 mm.

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

= 0.01 mm

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

Fig 1



OUTSIDE MICROMETER

MG20N134121

Reading dimensions with outside micrometer

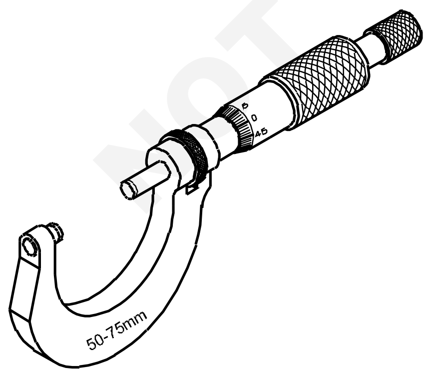
Objectives: At the end of this lesson you shall be able to
- **select the required range of a micrometer**
- **read micrometer measurements.**

Ranges of outside micrometer

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

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

Fig 1

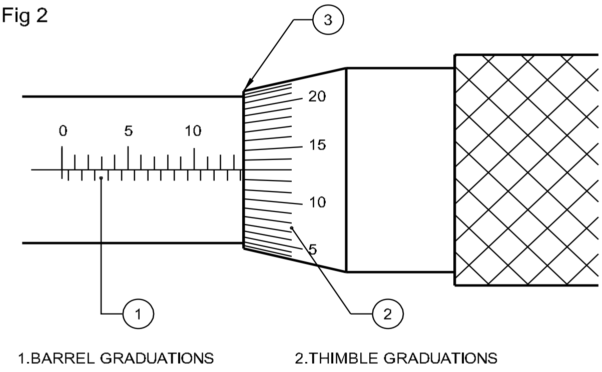


MG20N134131

Reading micrometer measurements

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

Fig 2



MG20N134132

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 barral)

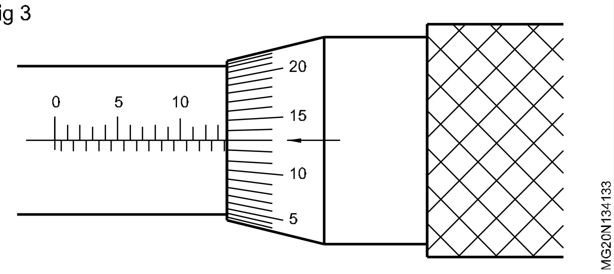
+ 00.50 mm (Sub division reading on barral)

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 3)

Fig 3



Multiply this value with 0.01 mm (least count).

13 x 0.01 mm = 0.13 mm.

Add

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

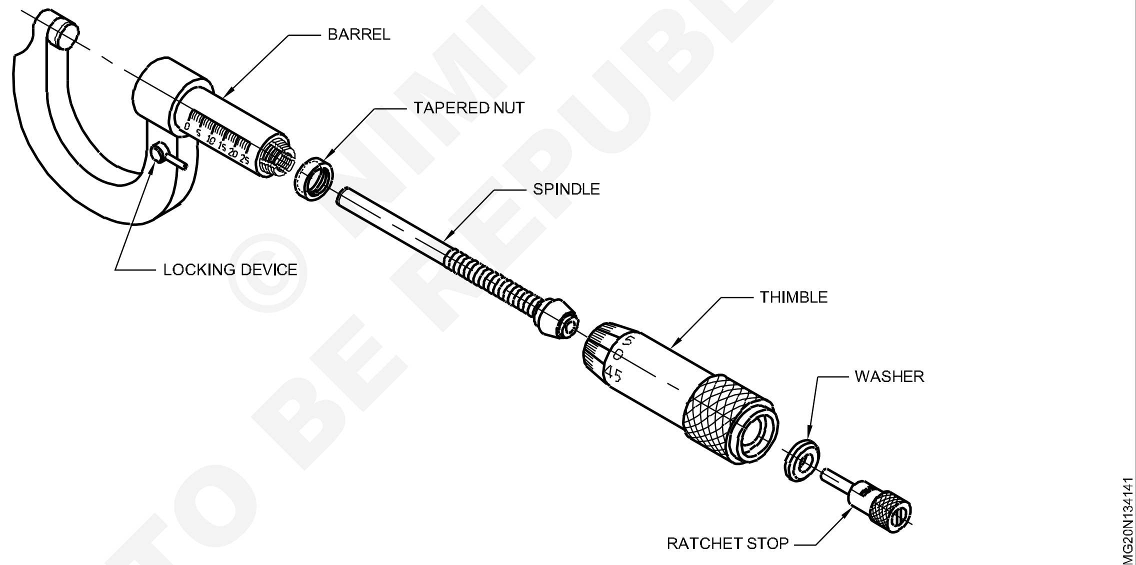
The micrometer reading is 63.63 mm.

Constructional features of outside micrometer

Objectives: At the end of this lesson you shall be able to
- **name the internal parts of a micrometer**
- **state the functions of the various parts of a micrometer**
- **state the precautions to be observed while dismantling and assembling micrometers.**

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 1)

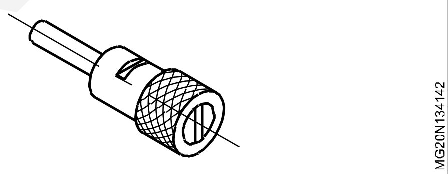
Fig 1



Ratchet stop (Fig 2)

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

Fig 2

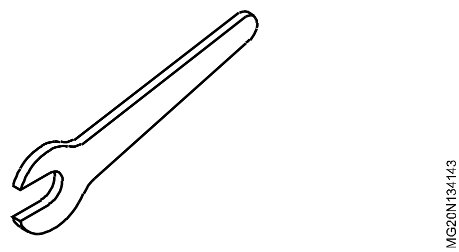


The ratchet stop will slip beyond certain pressure, thus preventing further advancement of the spindle when excessive pressure is used.

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 3)

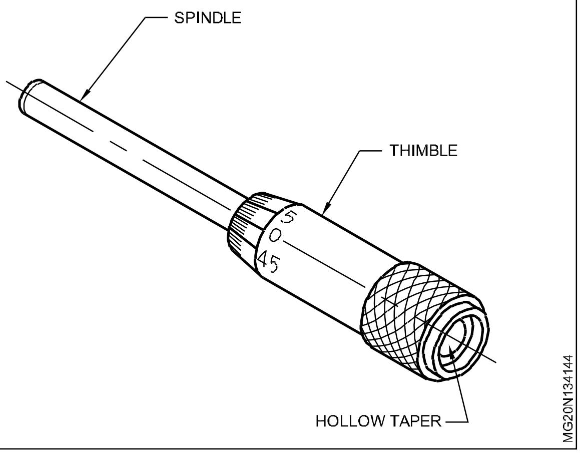
Fig 3



Thimble

The thimble has a hollow taper (Fig 4) to match with the taper nose fitted on the spindle.

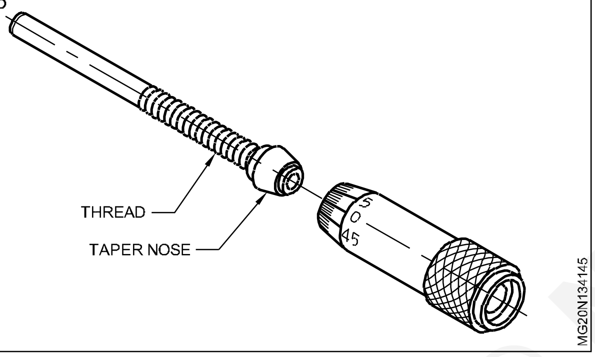
Fig 4



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 5)

Fig 5

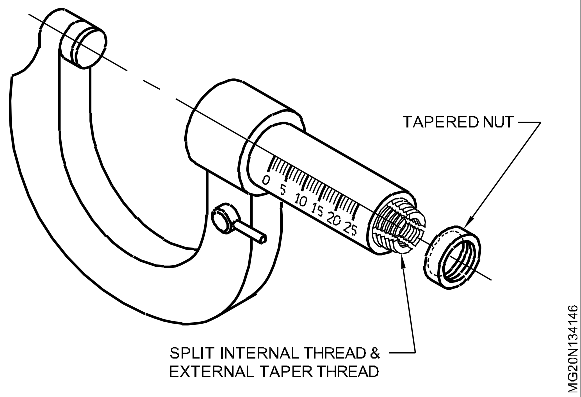


The taper nose is very accurately finished for axial alignment and it also permits postioning of the thimble in any required place during the adjustment of zero error.

The spindle passes through a split internal thread (Fig 6) 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.

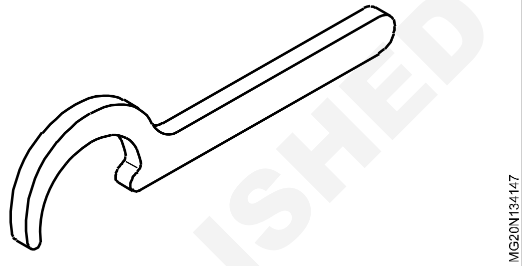
Tightening and loosening of this nut enables the spilt internal thread to close or open. This permits the wear adjustment. in the mating threads.

Fig 6



A special spanner is provided for this purpose. (Fig 7)

Fig 7



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.

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 enamelled tray is preferable.

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

Avoid frequent dismantling and assembling.

Inside micrometer

Objectives : At the end of this lesson you shall be able to
- **list the purposes of an inside micrometer**
- **identify the parts of an inside micrometer**
- **state the safety precautions to be followed while using an inside micrometer.**

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

Purpose

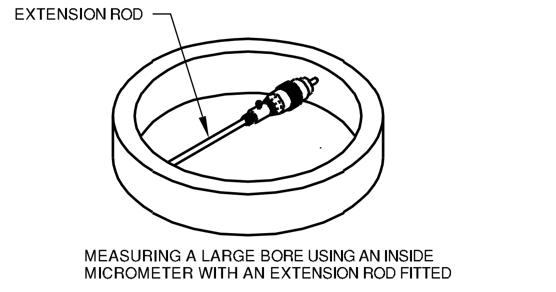
An inside micrometer is used to measure the diameter of holes. (Fig 1)

To measure the distance between internal parallel surfaces like slots (Fig 2)

Parts (Fig 3)

The following are the parts of an inside micrometer

Fig 1



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

Fig 2

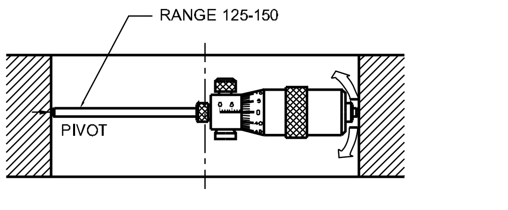
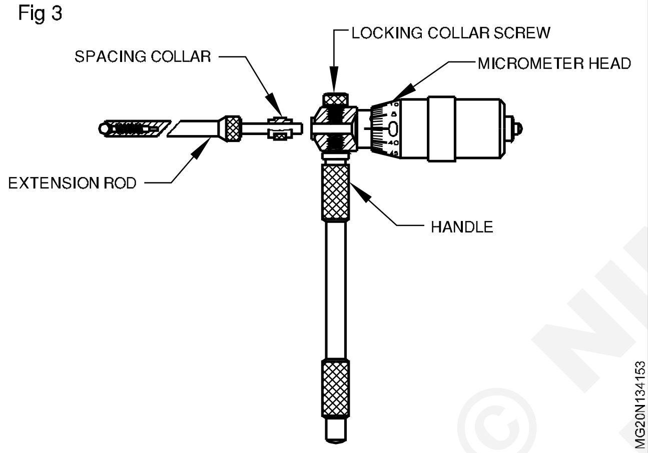


Fig 3



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

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

Locking Screw It is used to lock the extension rods.

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

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

The range of inside micrometer

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

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

Inside micrometer

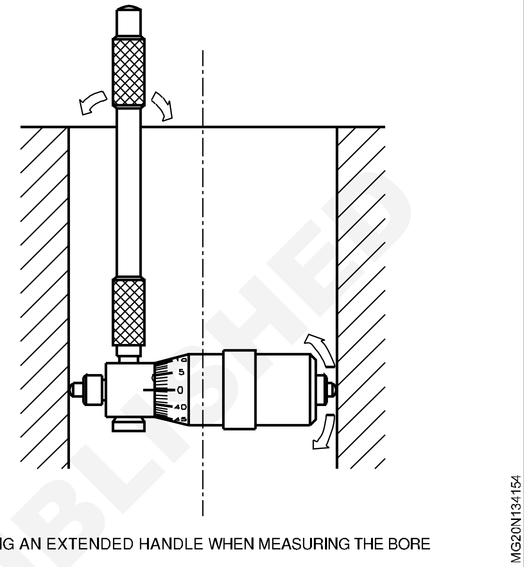
Ranges of extension rod for (50 - 200mm) Inside micrometer

Checking parallelism of surfaces of deep bores

An extended handle can be used while measuring deep bores. (Fig 4) for checking the parallelism of surfaces of the bore.

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

Fig 4



USING AN EXTENDED HANDLE WHEN MEASURING THE BORE

Precautions

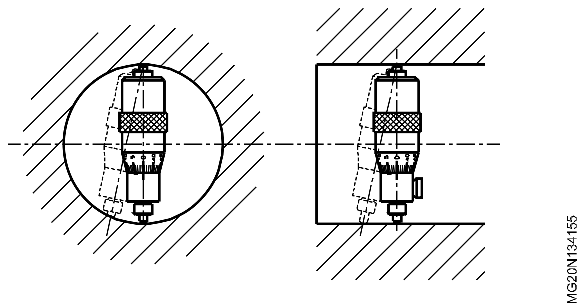
Ensure that the extension rod/spacing collar are fitted correctly.

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.

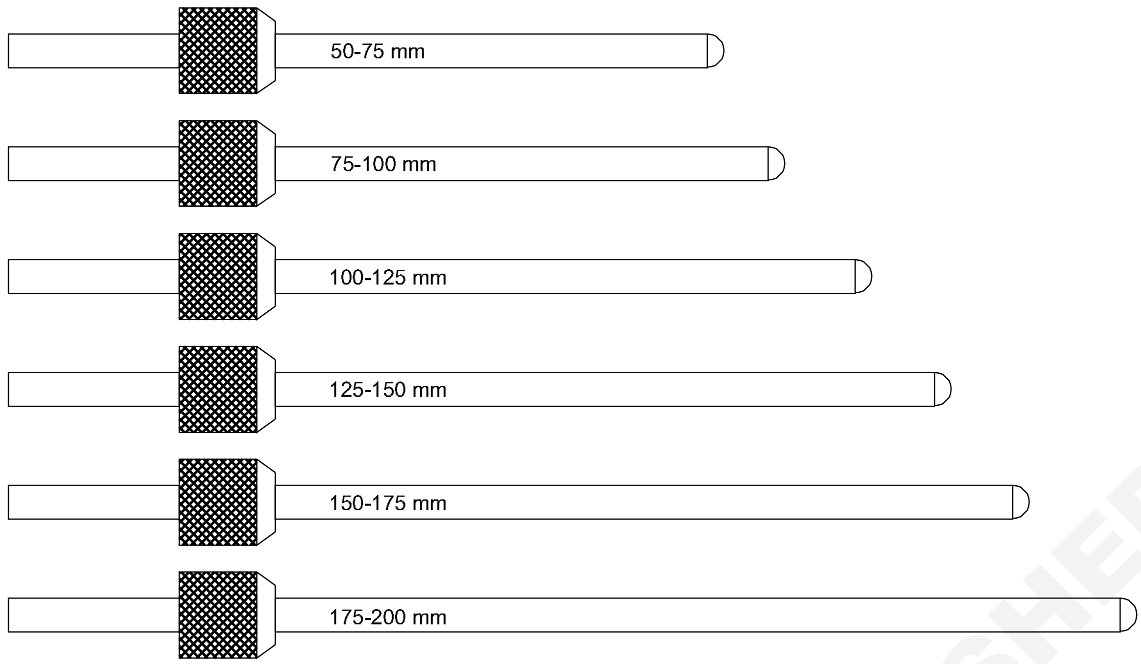
When measuring bores the micrometer must be set for the largest value. While measuring between flat surfaces, the micrometer should be set for the smallest value. (Fig 5)

Fig 5



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 6).

Fig 6



EXTENSION RODS

Digital micrometers

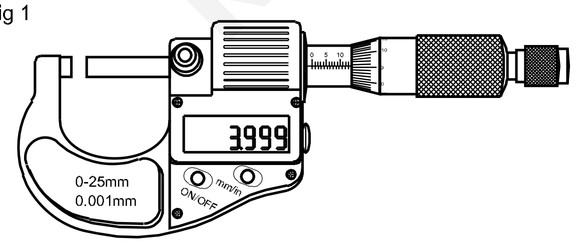
Objectives: At the end of this lesson you shall be able to
- **state the uses of digital micrometer**
- **list the parts of digital micrometer**
- **read the reading from LED display and thimble and barrel**
- **brief the maintenance, maintenance of digital micrometers.**

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

Feature of digital micrometers (Fig 1)

- 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

Fig 1



FEATURE OF DIGITAL MICROMETERS

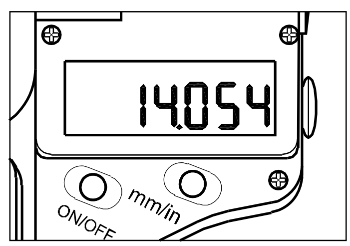
Accuracy of digital micrometers

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

Reading of the digital micrometer

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

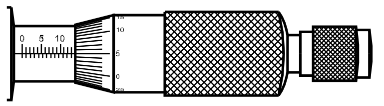
Fig 2



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 3)

Fig 3



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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 micrometer graduation and reading

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

Vernier micrometer

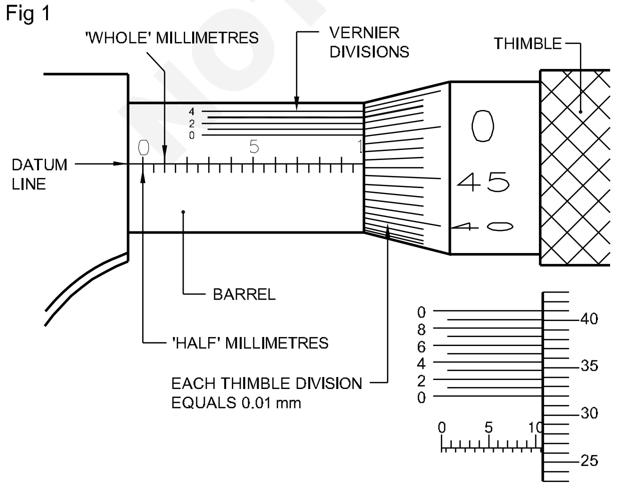
Ordinary metric micrometers can measure only to an accuracy of ±.01mm.

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

Construction and graduation

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

Fig 1



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The value of 10 vernier divisions is

0.0 1 mm X 9 = 0.09 mm

The value of a vernier division

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

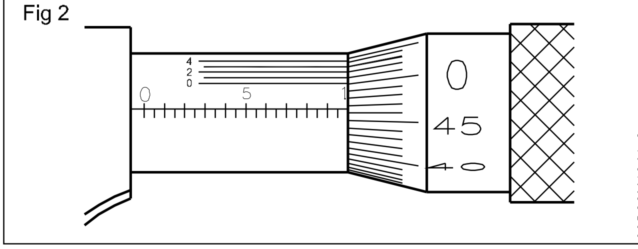
The least count =

1 thimble division – 1 Vernier division

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

Reading a vernier micrometer (Fig 2)

Fig 2



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Example

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

9 full divisions	9 mm

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

1 half division	0.5 mm

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

46 divisions	0.46 mm

Note the vernier division coinciding with the thimble division.

3 divisions	0.003 mm

Add up all the readings together.

Calculation

The range of micrometer is 0 to 25 mm.

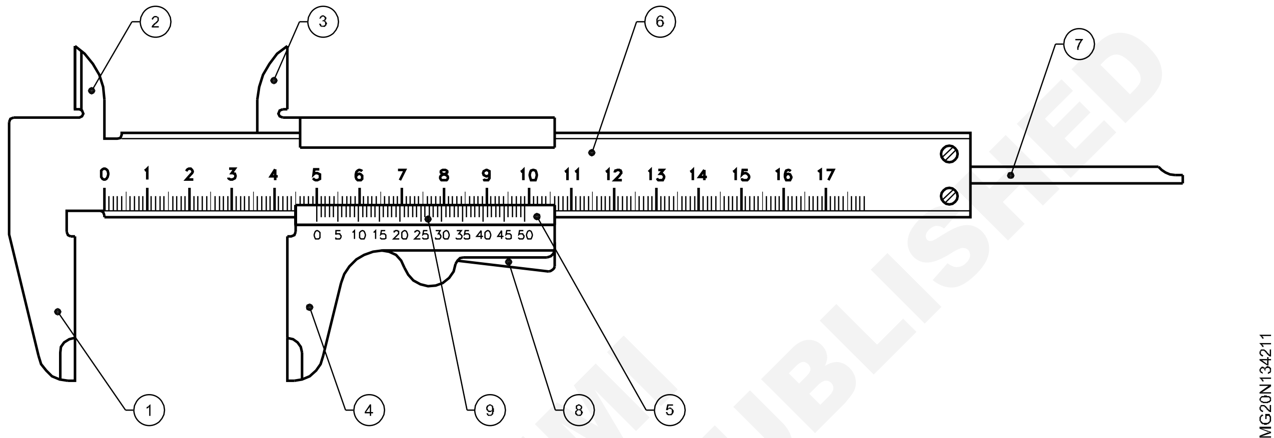
1	Full mm division visible before the thimble edge	9	=	9.000 mm
2	Half mm division visible after the full mm division on thimble	1	=	0.500 mm
3	Thimble division below the index line	46	=	0.460 mm
4	Vernier division coinciding with thimble division	3	=	0.003 mm
	Reading			9.963 mm

Precision measuring instruments vernier caliper

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

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

Fig 1



Fixed jaws (1 and 2)

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

Fig 2

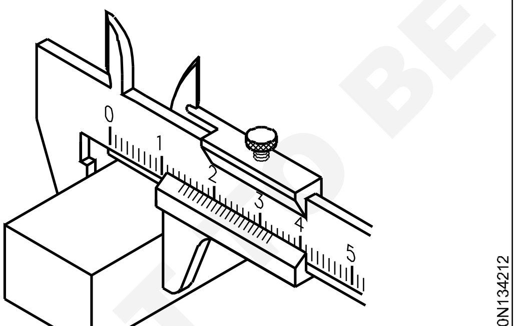
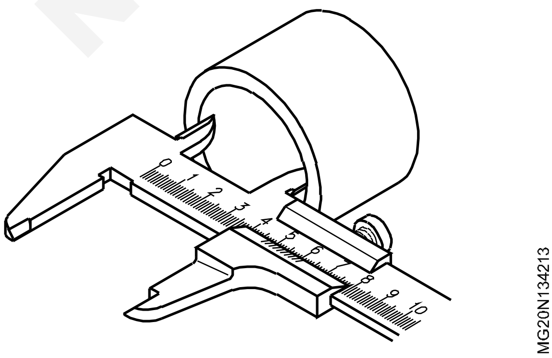


Fig 3



Parts of a vernier caliper (Numbers as per Fig 1)

Movable jaws (3 and 4)

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

Vernier slide (5)

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

Beam (6)

The vernier slide and the depth bar attached to it slide over the beam. The graduations on the beam are called the main scale divisions.

Depth bar (7)

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

Thumb lever (8)

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

Vernier scale (9)

The vernier scale is graduated and marked on the vernier slide. The divisions of this scale are called vernier divisions.

Main scale

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

Sizes

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

Never use a vernier caliper for any purpose other than measuring. Vernier calipers should be used only to measure machined or filed surfaces.

They should never be mixed with any other tools.

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

Graduations and reading of vernier calipers

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

Vernier calipers

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

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

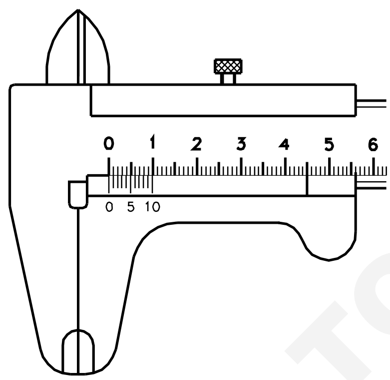
Vernier Principle

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

Determining the least count of vernier calipers

In the vernier caliper shown in Fig 1 the main scale divisions (9 mm) are divided into 10 equal parts in the vernier scale.

Fig 1



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

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

Least count = 1 MSD – 1 VSD

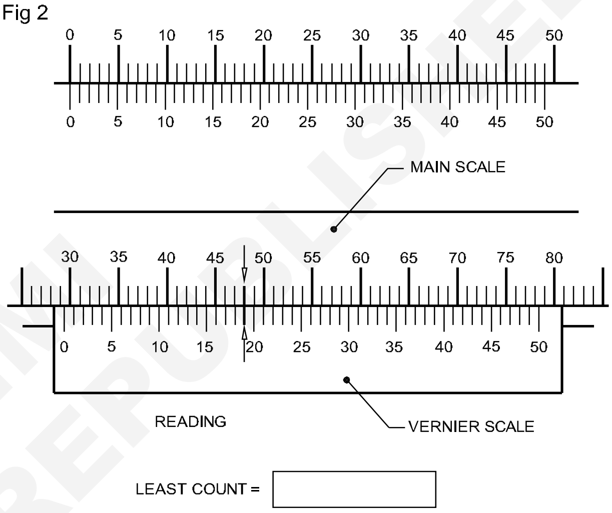
= 1 mm – 9/10 mm = 0.1 mm.

The difference between one MSD and one VSD = 0.1 mm.

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

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

Fig 2



Example

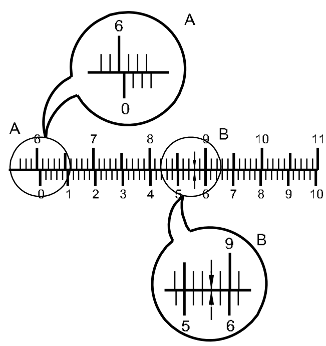
Calculate the least count of the vernier given in Figure 3.

Least count = 1 mm – 49/50 mm

= 1/50 mm

= 0.02 mm.

Fig 3



Example for reading vernier caliper (Fig 3)

Main scale reading = 60 mm

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

= 0.56 mm

Reading = 60 + 0.56 = 60.56 mm.

The British system of measurement

Objectives: At the end of this lesson you shall be able to
- **name the different units and multiples of liner measurements in the British System**
- **state the metric equivalent of the unit in the inch system**

The metric system for measurement is most widely used for industrial measurements. But in certain industries, the British system of measurement is still being used.

In this system of measurement, the inch, its multiples and sub-divisions are used to represent length measurements.

36 inches or 3 feet make 1 yard. 5280 feet or 1760 yards make 1 mile.

Conversions from inch to metric and vice versa		
CONVERSION FACTORS		
1"	=	25.4 mm or 2.54 cm
1 yard	=	36" or 0.9144 m
1 mm	=	0.03937"
1 metre	=	1000 mm or 39.37"

FRACTIONS/DECIMALS EQUIVALENT

1/64"	=	0.015625"
1/32"	=	0.03125"
1/16"	=	0.0625"
1/8"	=	0.125"
1/4"	=	0.25"
1/2"	=	0.5"

1.00 unit inch
0.1 one tenth
0.01 one hundredth
0.001 one thousandth
0.0001 one ten thousandth
0.00001 one hundred thousand

0.000001 one millionth (one micro inch)

Example of conversion (Metric to inch)

1) .05mm = .00196 inch (.05x03937 = 0.0019685 inch)
2) 1.25m = 49.215 inch (1.25x39.37 = 49.215 inches)

Example of conversion (Inch to Metric)

1) 3/4" = .75" = 19.05 mm (.75x 25.4 = 19.05 mm)
2) 1/1000" = 0.001 = 0.0254 mm (.001x25.4 = 0.0254mm)

(One thousandth of an inch = 25 micrometre approx)

ASSIGNMENT

Convert the following.

1) 38.1mm = _______ inches
2) 300 mm = _______ inches
3) 8" = _______ mm
4) 40" = _______ mm.

5) Express the tolerance ± .05" in metric terms to the nearest mm. _______________________

6) Express the tolerance ± .02 mm in terms of inches to the nearest 1/10,000". ___________________

Reading vernier caliper and micrometer with inch graduations

Objectives : At the end of this lesson you shall be able to
- **state the graduations of vernier calipers in the inch system**
- **state the graduations of micrometers in the inch system**
- **read the measurement of vernier calipers and micrometers with inch graduations.**

Reading vernier caliper and micrometer

The universal vernier calipers generally used in machine shop will have graduations in both metric units and inches.

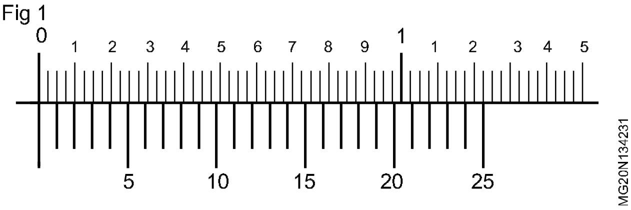
The vernier caliper with inch graduation will have a least count of 0.001".

The vernier scales for these calipers have graduation with 25 division or 50 divisions.

Vernier caliper with 25 divisions in vernier scale. (Fig.1)

One inch of the main scale is divided into 10 major divisions, and each of these is further divided into 4 equal parts. The value of each sub-division is 0.025 inch. Such 49 divisions of the main scale are equal to 25 divisions of the vernier scale.

Fig 1



Least count

25 vernier scale divisions = 49 x 0.025 = 1.225"

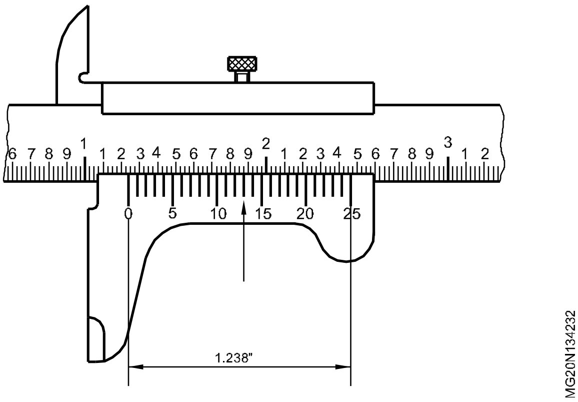
Value of vernier scale division = 0.049"

Value of 2 main scale divisions = 0.025 x 2 = 0.50"
Least count = Value of main scale divison - value of 1 vernier scale division

= 0.05" - 0.049" = 0.001" or 1/1000"

Example of reading (Fig 2)

Fig 2

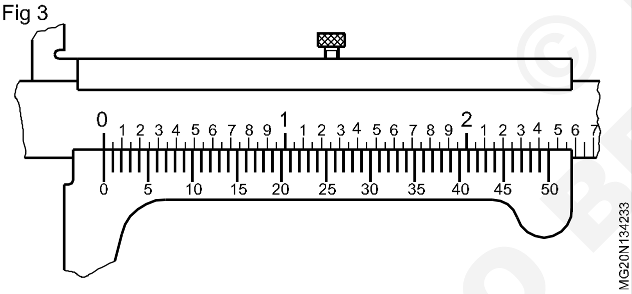


In Figure 2 the vernier '0' line is after 1" on the scale

Full inch		= 1.000"
2 main scale divisions		= .200"
Value of 1 subdivision		= .025"
coinciding	(13 x 001")	= .013"
	Reading	1.238"

In the vernier caliper given in fig 3 (50 divisions vernier scale), each inch of the main scale is divided into 10 major divisions, and they are further ssub - divided into two equal parts. The value of each subdivision is 0.05". 50 divisions of the vernier scale are equal to 49 sub divisions of the main scale.

Fig 3



Least count

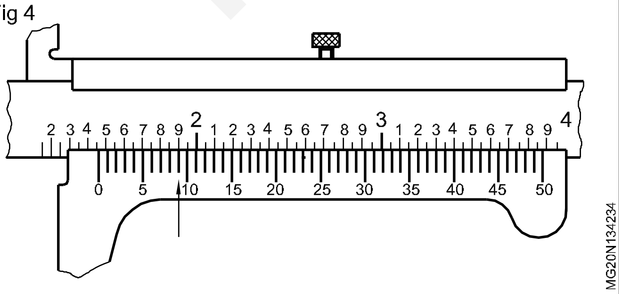
Value of 50 V.S.D.	= 49 x 0.05	= 2.45"
1.V.S.D.	= 2.45"/50	= 0.049"

Least count = Value of 1 MSD - Value of 1 VSD

= 0.05" - 0.049 = 0.001"

Example of reading (Fig 4)

Fig 4



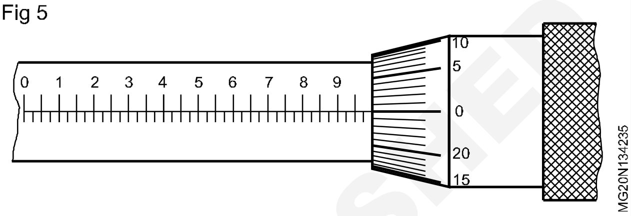
Vernier '0' line is after 1" on the main scale

Full inch	= 1.000"	
The value of 4 major divisions	(4 x 0.1") =	.400"
The value of 1 subdivision	(1 x 0.05") =	.050"
The value of 9th vernier division coinciding	(9 x 0.001") =	.009"
Reading		1.459"

Micrometer with graduations in inches

On micrometers with graduations in the inch system, the datum line on the barrel of the micrometer is graduated to a distance of 1 inch. This one inch is divided into 10 equal parts, and each of this is further subdivided into 4 equal parts. (Fig 5)

Fig 5

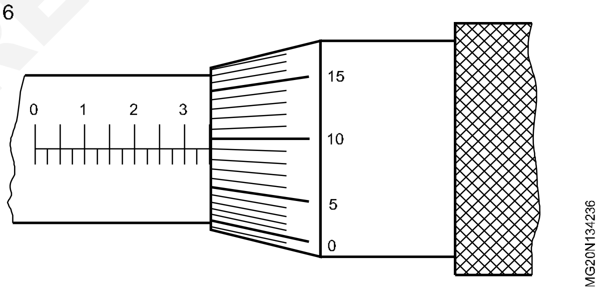


The value of each subdivision = 1/40" or 0.025". The thimble had 25 equal divisions marked on the circumference. The least counet is = 1/40"x1/25 = 1/1000" =.001'.

When the spindle of the micrometer advances by one division on the thimble, the actual value of the linear movement is = .001".

Example of reading (Fig 6)

Fig 6



Main divisions	3 x .1	= .300"
Subdivisions	2 x .025	= .05"
Thimble divisions	9 x .001	= .009"
Reading		= .359"

The barrel is graduated into 10 equal divisions each of which is further subdivided into 4 smaller divisions. The length of the sleeve graduations is 1". It is the distance the thimble travels in 40 complete revolutions.

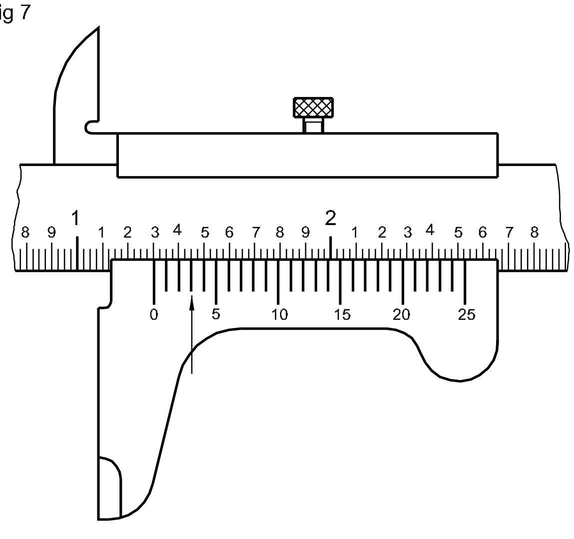
Barrel main divisions = 1/10 of an inch or 0.100" the distance the thimble moves in four complete revolutions. The thimble has 25 equal graduations on its circumference. Each graduation of the thimble is equal to 1/25 of 1/40 or 0.001".

Barrel subdivision 1/40 or 0.025 of an inch is equal to the distance the thimble moves in one complete revolution. The spindle screw has 40 TPI.

Assignment

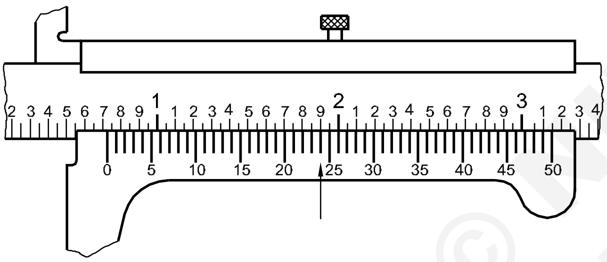
1 Read the vernier caliper measurement as shown in Figures 7 and 8.

Fig 7



Answer ....inch.

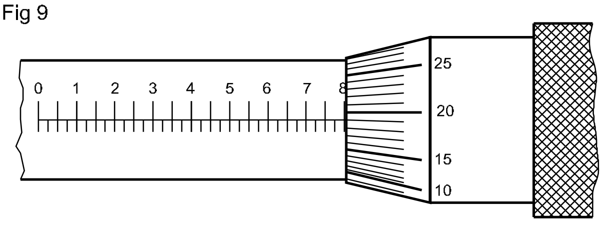
Fig 8



Answer ....inch.

2 Read and record the measurements of an outside micrometer shown in the Figures 9 and 10.

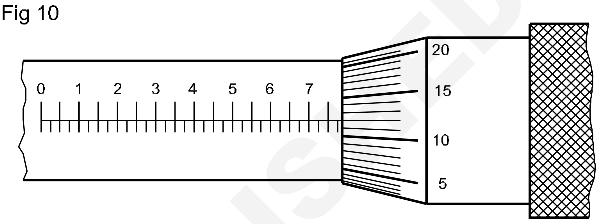
Fig 9



Answer ....inch.

Answer ....inch.

Fig 10



Vernier height gauge

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

Parts of a vernier height gauge (Fig 1)

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

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

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

The vernier scale is attached to the main slide which has been graduated, to read metric dimensions as well as the inch dimensions. The main slide is attached with the finer adjusting slide. The movable jaw is most widely used with

Fig 1

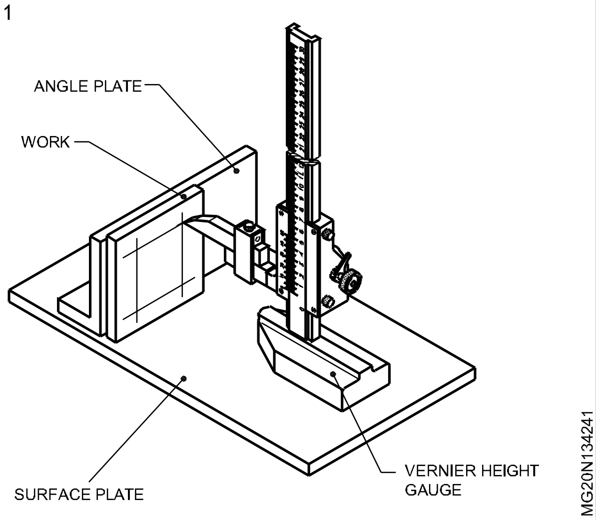
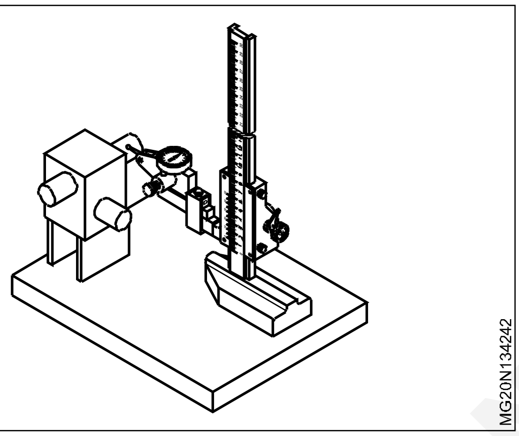


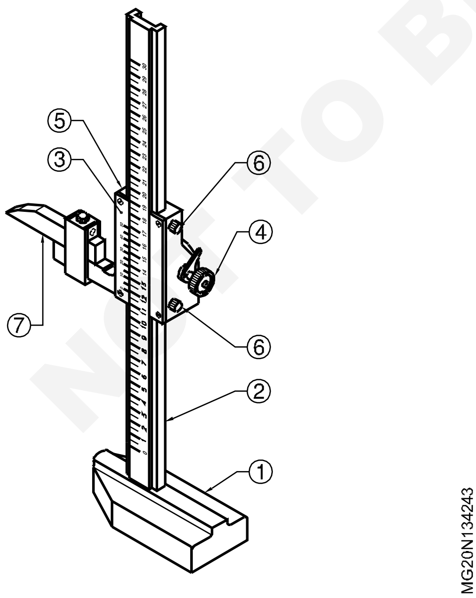
Fig 2



Parts of a vernier height gauge and their functions

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

Fig 3



Base (1)

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

Beam (2)

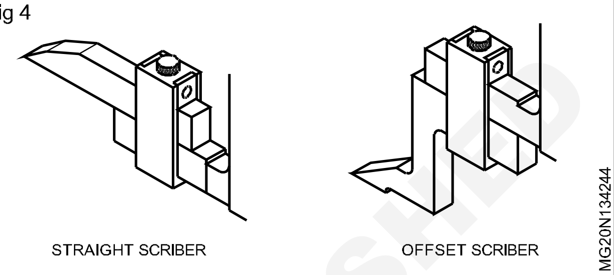
This is similar to the beam scale of a vernier caliper and is attached to the base.

Vernier slide (3)

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

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

Fig 4



Zero setting of the vernier height gauge.

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

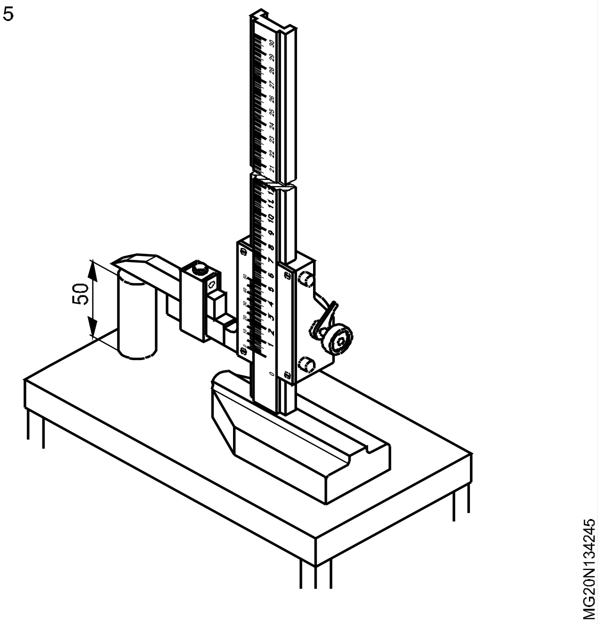
While using a straight scriber, the zero setting of the instrument is at a level above the datum surface. In this case the zero setting is to be checked using the precision round block, supplied along with the instrument.

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

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

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

Fig 5

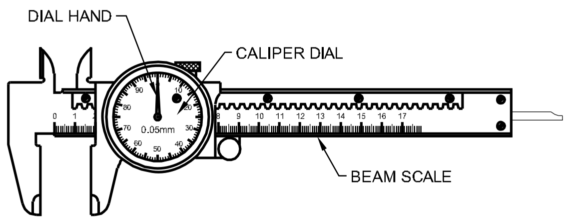


Dial Caliper

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)

Fig 1



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

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 graudation represents 1/100th of 5mm or 0.05 mm.

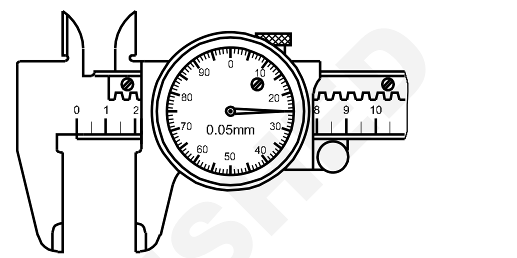
The dial hand is operated by a pinion that engages a rack on the beam.

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.

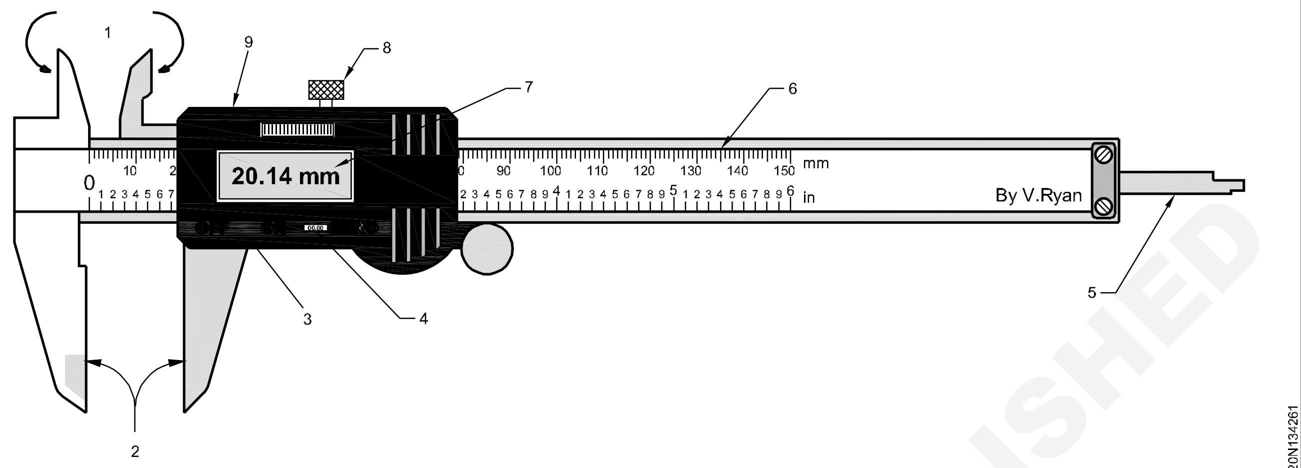
The digital caliper requires a small battery whereas the manual version does not need any power source. The digital calipers are easier to use as the measurement is clearly displayed and also, by pressing inch/mm button the distance can be read as metric or inch.

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 untill 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

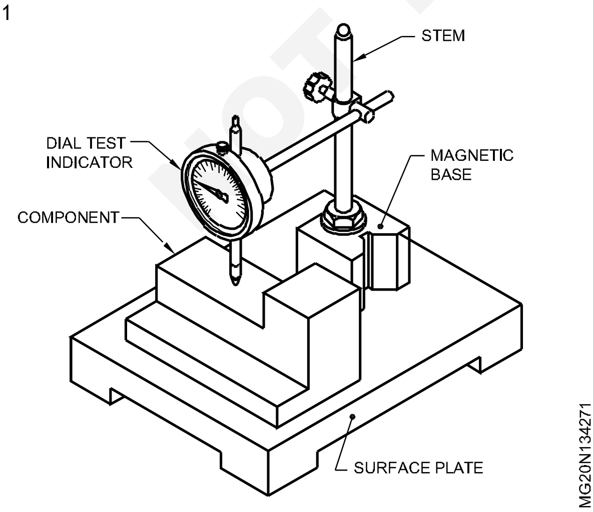


Dial test indicators

Objectives: At the end of this lesson you shall be able to
- **state the principle of a dial test indicator**
- **state the parts of a dial test indicator**
- **state the important features of a dial test indicator**
- **state the functions of a dial test indicator**
- **explain the different types of stands.**

Dial test indicators are instruments of high precision, used for comparing and determining the variation in the sizes of a component. (Fig 1) These instruments cannot give the direct reading of the sizes like micrometers and vernier calipers. A dial test indicator magnifies small variations in sizes by means of a pointer on a graduated dial. This direct reading of the deviations gives an accurate picture of the conditions of the parts being tested.

Fig 1



Principle of working

The magnification of the small movement of the plunger or stylus is converted into a rotary motion of the pointer on a circular scale. (Fig 2)

Types

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

- plunger type (Fig 3)

Fig 3

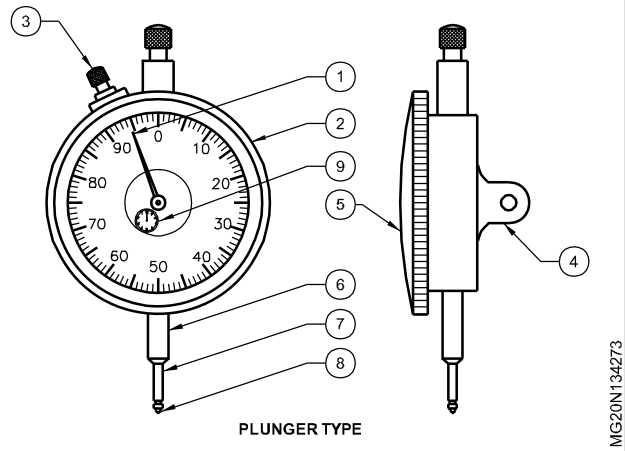
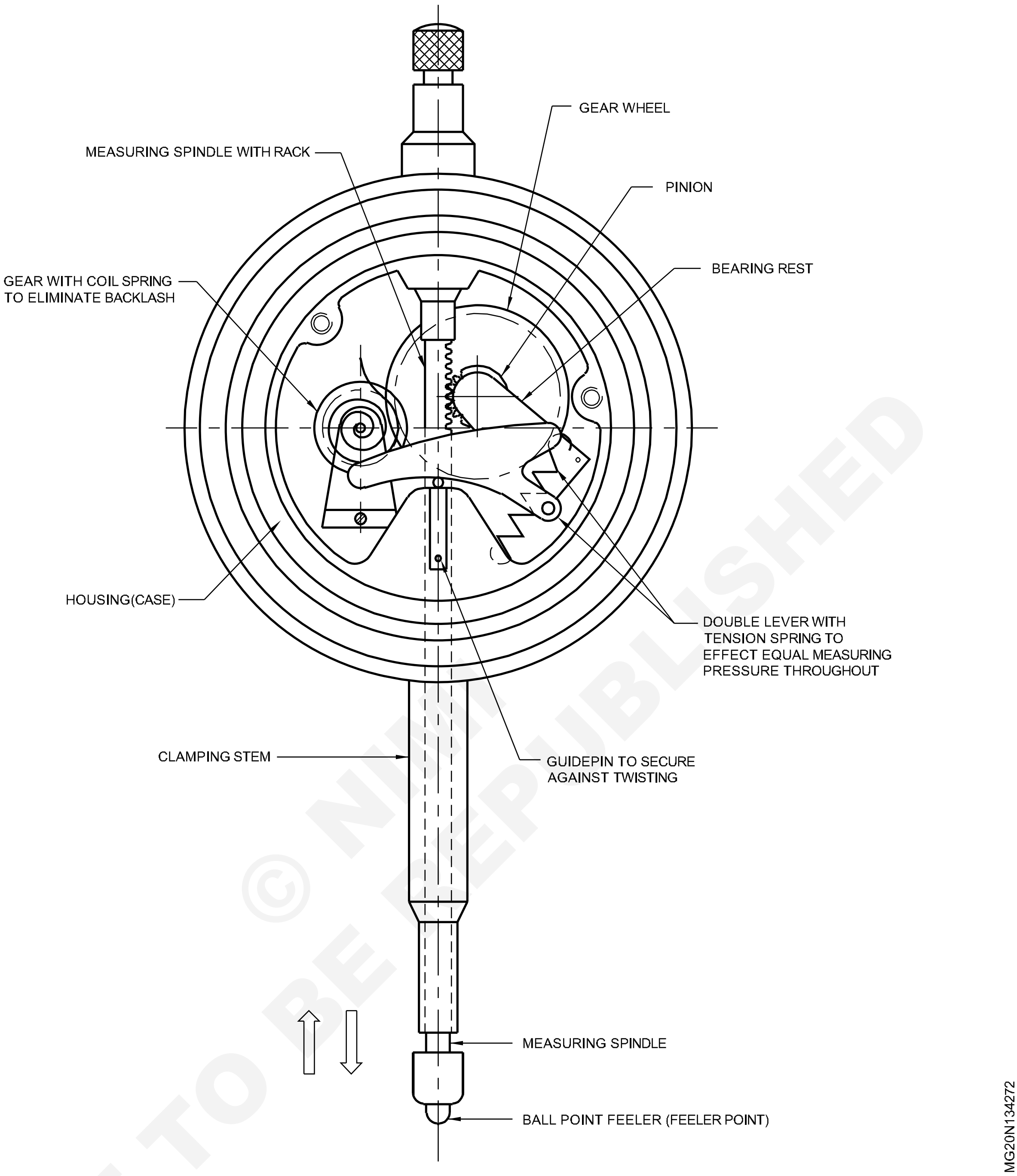


Fig 2



- lever type. (Fig 4)

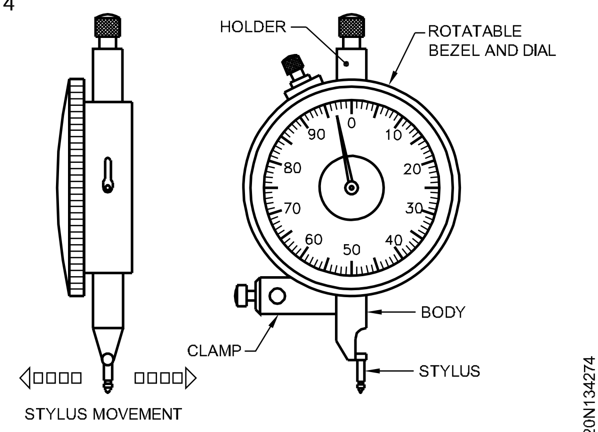
The plunger type dial test indicator

The external parts and features of a dial test indicator areas shown in figure 3.

1	Pointer	2	Rotatable bezel
3	Bezel clamp	4	Back lug
5	Transparent dial cover	6	Stem
7	Plunger	8	Anvil
9	Revolution counter		

For converting the linear motion of the plunger, a rack and pinion mechanism is used.

Fig 4

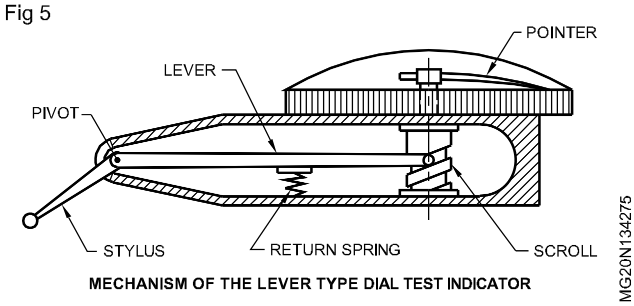


LEVER TYPE DIAL TEST INDICATOR

The lever type dial test indicator (Fig 4)

In the case of this type of dial test indicators, the magnification of the movement is obtained by the mechanism of the lever and scroll. (Fig 5)

Fig 5

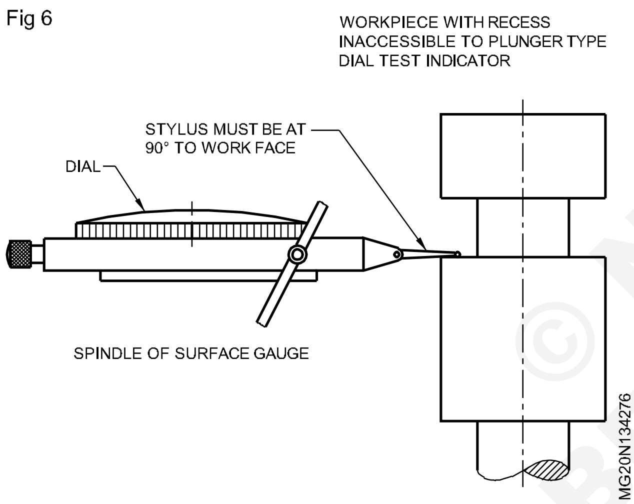


MECHANISM OF THE LEVER TYPE DIAL TEST INDICATOR

It has a stylus with a ball- type contact, operating in the horizontal plane.

This can be conveniently mounted on a surface gauge stand, and can be used in places where the plunger type dial test indicator application is difficult. (Fig 6)

Fig 6



Important features of dial test indicators

An important feature of the dial test indicator is that the scale can be rotated by a ring bezel, enabling it to be set readily to zero.

Many dial test indicators read plus in a clockwise direction from zero, and minus in the anticlockwise directions so as to give plus and minus indications.

Uses (Figure 7 shows a few applications.)

- To compare the dimensions of a workpiece against a known standard, eg.slip gauges.
- To check plane surfaces for parallelism and flatness.
- To check parallelism of shafts and bars.
- To check concentricity of holes and shafts.

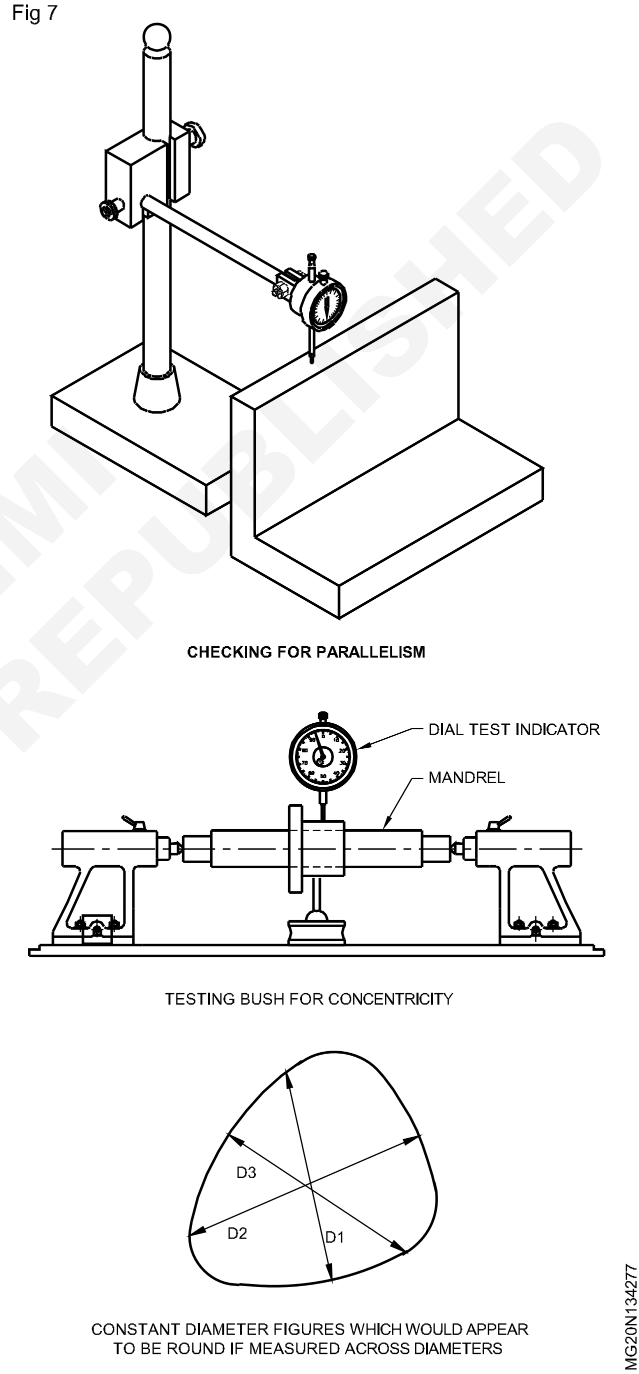
Indicator stands

Dial test indicators are used in conjunction with stands for holding them so that the stand itself may be placed on a datum surface or machine tools.

The different types of stands are

- magnetic stand with universal clamp
- magnetic stand with flexible post
- general purpose holder with cast iron base.

Fig 7



The arrows indicate the provisions in the clamps for insertion of the dial test indicator.

Vernier bevel protractor

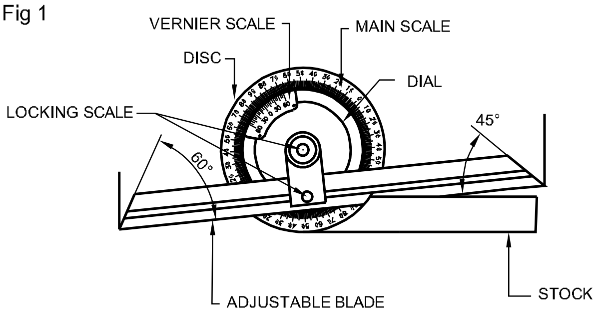
Objectives: At the end of this lesson you shall be able to
- **identify the parts of a universal bevel protractor**
- **state the functions of each part**
- **list out the uses of a vernier bevel protractor.**

The vernier bevel protractor is a precision instrument meant for measuring angles precisely 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 surface from which the inclination is measured.

Disc

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

Dial

It is pivoted to the disc and can be rotated through 360°. The vernier scale of the instrument is attached to the dial. The dial is locked to the disc during reading the measurement.

Blade

This is the other contacting surface of the instrument that contacts the work during measurement, preferably the inclined surfaces. 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 alloy 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

The vernier bevel protractor is used to measure acute angles, i.e. less than 90° (Fig 2) obtuse angles i.e more than 90° (Fig 3) for setting work-holding devices to angles on machine tools, work-tables etc. (Figs 4 & 5)

Fig 2

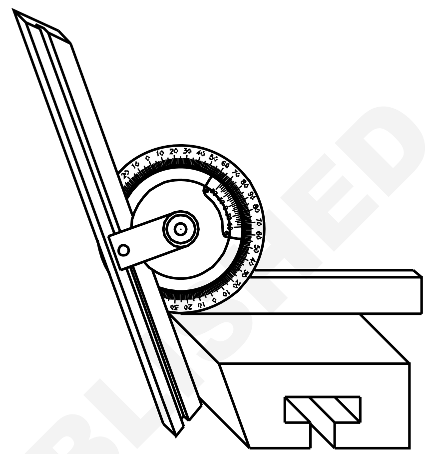


Fig 3

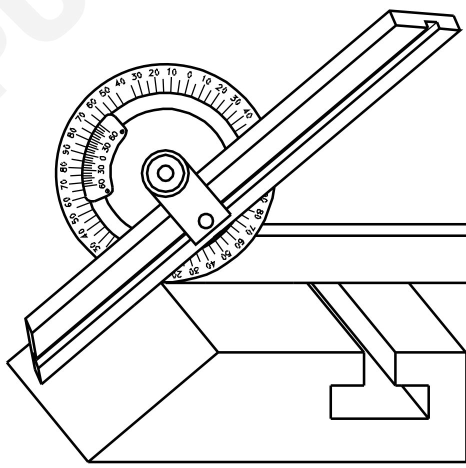


Fig 4

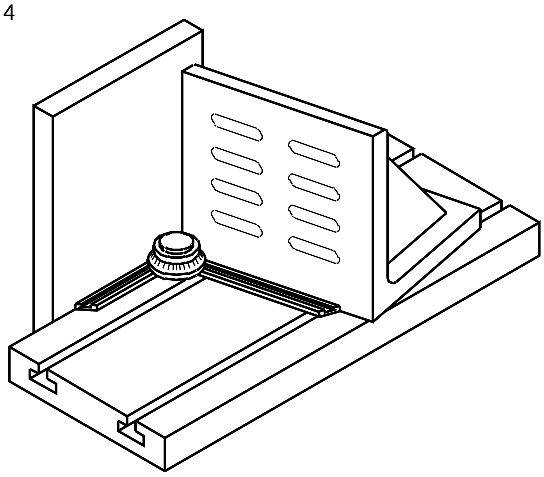
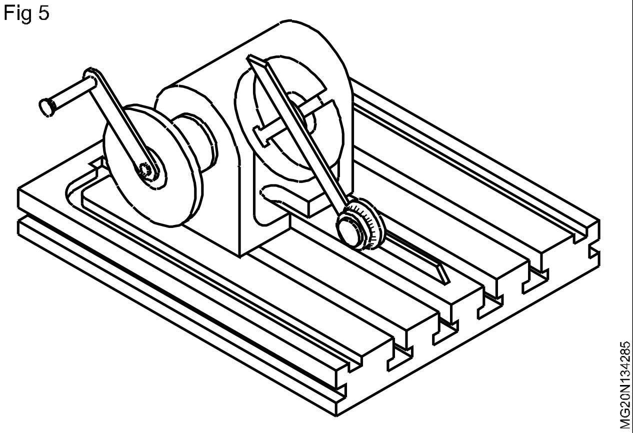


Fig 5



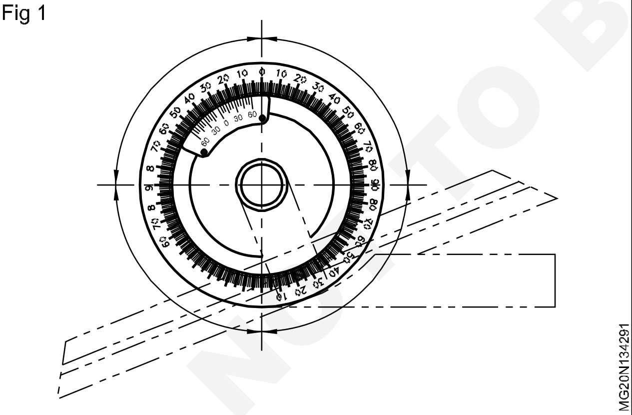
Graduations on universal bevel protractor

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

The main scale graduations

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

Fig 1



One vernier scale division (VSD) (Fig 2)

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

The least count of the vernier bevel protractor

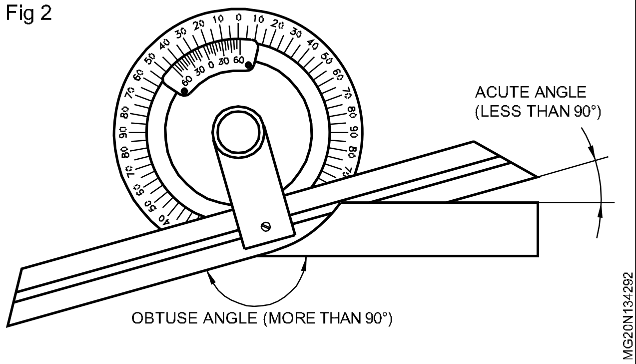
When the zero of the vernier scale coincides with the zero of the main scale, the first division of the vernier scale will be very close to the 2nd main scale division. (Fig 2)

2 MSD - 1 VSD

$$\text{i.e. the least count} = 2^\circ - \frac{23}{12} = \frac{1^\circ}{12} = 5'.$$

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

Fig 2



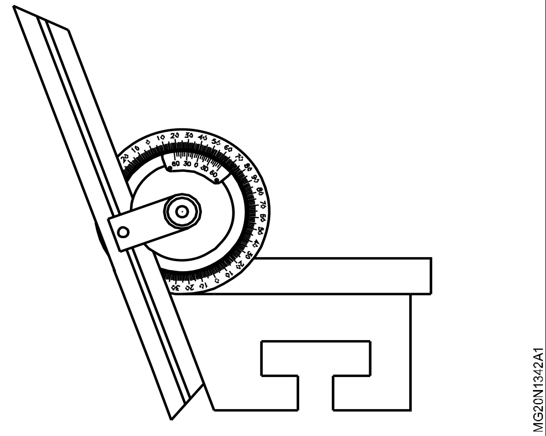
Reading of universal bevel protractor

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

For reading acute angle set up (Fig 1)

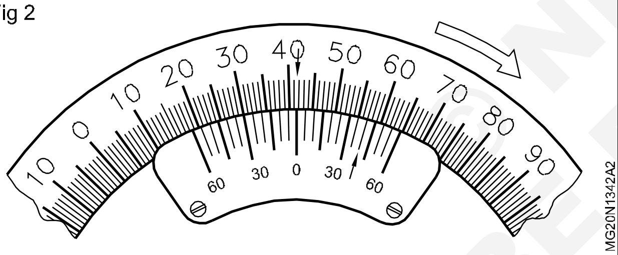
First read the number of whole degrees between zero of the main scale and zero of the vernier scale.

Fig 1



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

Fig 2



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

Example: 10 x 5' = 50'

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

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

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

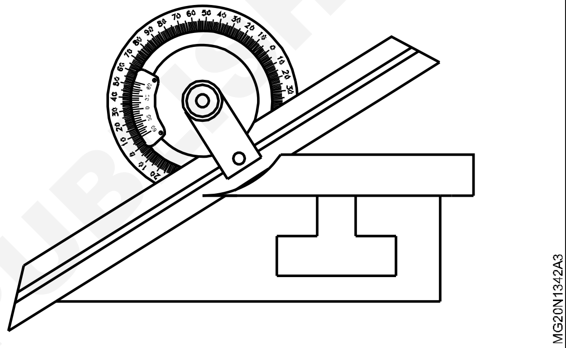
For obtuse angle set up (Fig 3)

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

Reading 22 30'

Measurement 180° - 22°30' = 157°30'

Fig 3



Different types of abrasive, manufacture of grinding wheels, their grades

Objectives: At the end of this lesson you shall be able to
- **explain grinding wheel**
- **state the types of abrasives**
- **explain grain and grade**
- **state the types of bonds.**

Grinding wheel

A grinding wheel is multipoint cutting tool made up of many hard particles known as abrasive. The abrasive grains are held together with adhesive substance known as bond.

The wheel may consist of one piece or segments of abrasive blocks built up to a solid wheel.

Abrasives

An abrasives are hard, tough, sharp edge and resistance to fracture used for cutting other materials.

There are two types of abrasives

Natural abrasive

Artificial abrasive

Natural abrasives

The natural abrasives are emery, corundum, sandstone or solid quartz and diamond.

Emery is a natural aluminium oxide. It contains aluminium iron oxide and other impurities.

Corundum also natural aluminium oxide it contains upto 95% and remainder is impurities.

Sand stone or quartz is one of the natural abrasive stones from which grind stones are shaped.

Diamond is less than quality of gem are crushed to produce abrasive grains for making grinding wheels and lapping compound.

Artificial abrasive

The artificial abrasive are silicon carbide and aluminium oxide.

Silicon carbide (SiC)

Silicon carbide abrasives are manufactured from silica sand. Silicon carbide is hard and brittle. It is used for grinding low tensile material like brass, copper, grey cast iron, aluminium. Silicon carbide is represented by letter 'S'.

Aluminium oxide (Al_2O_3)

This is manufactured from mineral bauxite. Aluminium oxide is tough and less brittle. It is used for grinding high tensile strength material like steels. Carbon steels, malleable iron, high speed steel and wrought iron. Aluminium oxide is represented letter 'A'.

The abrasives are selected depending upon the material being ground.

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

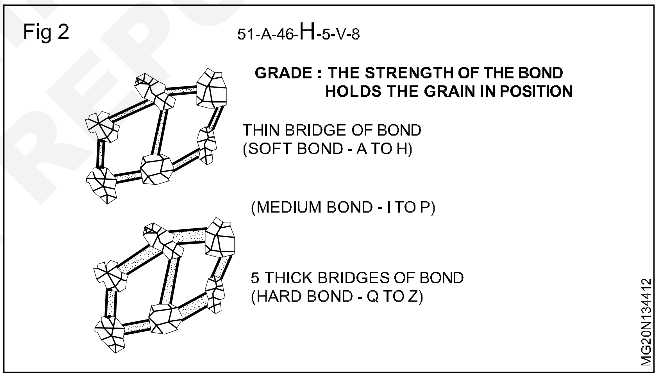
'Brown' aluminium oxide is used for general purpose grinding of tough materials.

Aluminium oxide is used for grinding die steels.

Grade (Fig 1)

Grade indicates the strength of the bond and, therefore, the 'hardness' of the wheel. In a hard wheel the bond is strong and it securely anothers the grit in place, and therefore, reduce the rate of wear. In a soft wheel, the bond is weak and the grit is easily detached resulting in a high rate of wear.

Fig 2



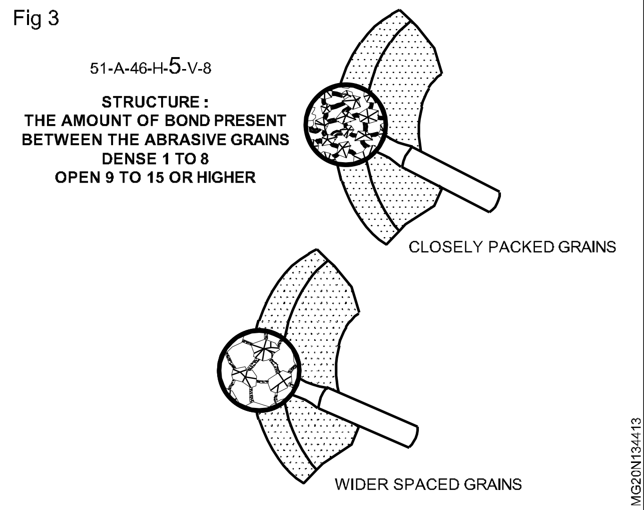
Alphate letters are used to indicate the grade of wheel

A	to	H	- Soft
I	to	P	- Medium
Q	to	Z	- Hard

Structure (Fig 2)

This indicates the amount of bond present between the individual abrasive grains, and the closeness of the individual grains to each other. An open structured wheel will cut more freely. That is, it will remove more metal in a given time and produce less heat. It will not produce such a good finish as a close structured wheel.

Fig 3



The structure is specified by number from 1 to 15.1 is indicating dense structure 15 indicates most wider structure. 1 to 8 dense and 9 to 15 and above indicates open structure.

Open structure wheel is used for grinding soft tough and ductile metal and used rough grinding.

A closed structure wheel is used for finish grinding of hard and brittle metal.

Principle and value of grinding in finishing process

Objectives: At the end of this exercise you shall be able to
- **explain the type and names of different shapes of grinding wheels**
- **state the application of each type of grinding wheel.**

A grinding machine uses an abrasive product - usually a rotating wheel - to shape and finish a workpiece by removing metal and generating a surface within a given tolerance. A grinding wheel is made with abrasive grains bonded together. Each grain acts as a cutting tool, removing tiny chips from the workpiece.

Value of grinding

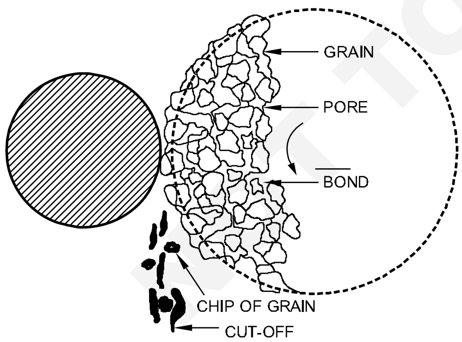
Grinding is a machining process specially indicated for finishing operations in hard materials, in order to obtain low surface roughness (Ra 0.1 μm to 2μm) and tight tolerances. The cutting tool is the grinding wheel which is formed by abrasive particles attached in a bond

Types of Grinding Wheels

- Straight Grinding Wheels. You see them all the time....
- Large Diameter Grinding Wheels. Large diameter wheels are like straight wheels, but they are much larger
- Grinding Cup Wheel
- Grinding Dish Wheel
- Segmented Grinding Wheel
- Cutting Face Grinding Wheel.

Grinding wheels are generally composed of the 3 elements "abrasive grains (grains)", "bond" and "pores" as shown in Fig 1, and each of these plays the following roles. These 3 elements are closely related to the grinding wheel specs.

Fig 1



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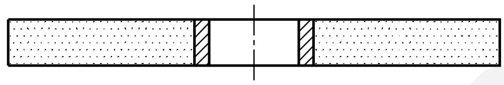
Grinding wheels are made in different shapes and sizes for grinding different jobs and for use in different machines. The size may differ in diameter, face width and bore dia.

The following are the standard shapes of grinding wheels.

Straight wheel: Type 1 (Fig 1)

This type of wheels is used on cylindrical, surface and centreless grinders for grinding cylindrical and flat surfaces. Sometimes this type of wheel is used on rough grinders for off hand grinding.

Fig 1



STRAIGHT

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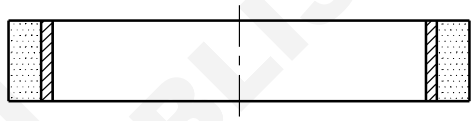
Cylinder: Type 2 (Fig 2)

This type of wheel is used on both horizontal and vertical spindle surface grinders for the surface grinding operations.

Fig 2



CYLINDER

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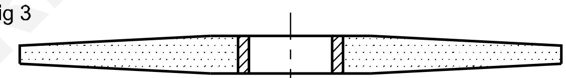
Tapered (both sides) Type 4 (Fig 3)

It is mainly used for rough grinding. The tapered sides reduce the chance of breaking.

Fig 3



TAPERED TWO SIDES

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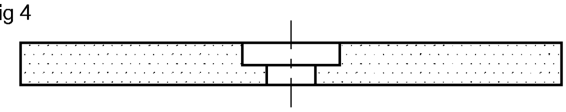
Recessed one side: Type 5 (Fig 4)

It is used for cylindrical, surface and centreless grinding. The recess provides clearance for the flange.

Fig 4



RECESSED ONE SIDE

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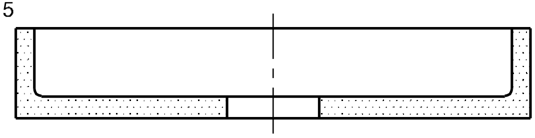
Straight cup: Type 6 (Fig 5)

It is used on surface grinders and on tool and cutter grinders to grind flat surfaces.

Fig 5

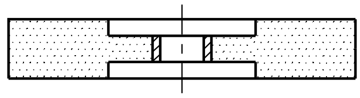


STRAIGHT CUP

MG20N134725

Recessed both sides: Type 7 (Fig 6): Used on cylindrical, surface and centreless grinders. The recesses provide clearance for both flanges.

Fig 6

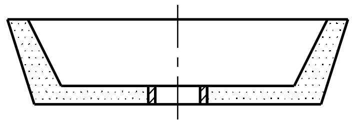


RECESSED TWO SIDES

Flaring cup: Type 11 (Fig 7)

It is used on tool and cutter grinders mainly to sharpen milling cutters and reamers.

Fig 7

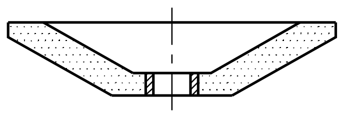


FLARING CUP

Dish: Type 12 (Fig 8)

Used on tool and cutter grinders to sharpen milling cutters with narrow slots like formed relieved cutters, hobs etc.

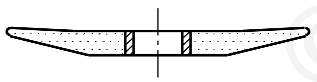
Fig 8



DISC WHEEL

Saucer: Type 13 (Fig 9): It is used for sharpening circular and handsaws. It is also used for gashing milling cutter teeth.

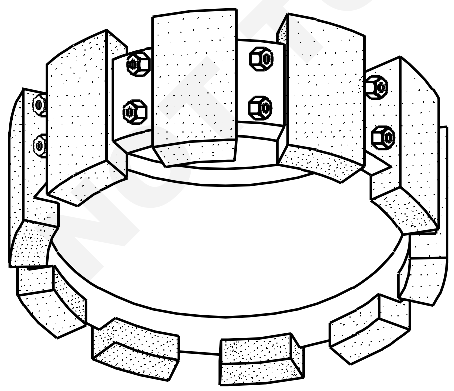
Fig 9



SAUCER WHEEL

Segmented wheels (Fig 10): This type of wheels is formed by holding segments of abrasives using a metal holder. This is mainly used on a vertical spindle surface grinder.

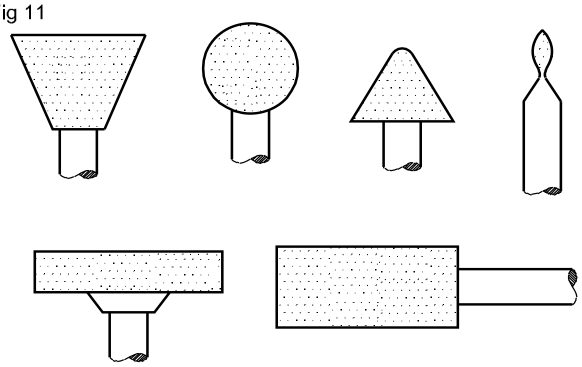
Fig 10



SEGMENTED WHEEL

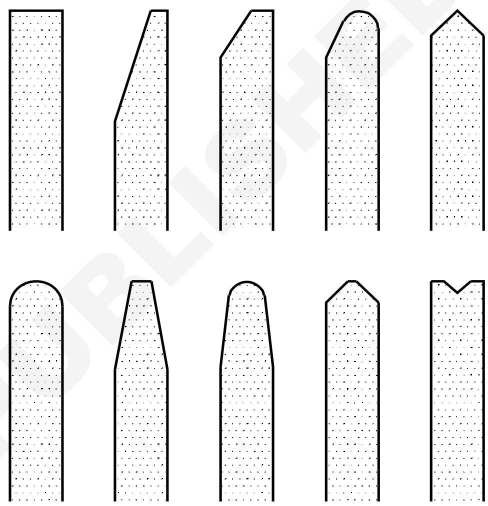
Mounted wheels (Fig 11)**:** These are wheels with less than 50 mm dia. formed on a steel shank to various shapes. Mounted wheels are mainly used for die grinding, deburring and for finishing operations. Used on pneumatic or electric grinders.

Fig 11



Types of wheel faces; To do different operations different types of wheel faces are produced by manufacturers. (Fig 12)

Fig 12

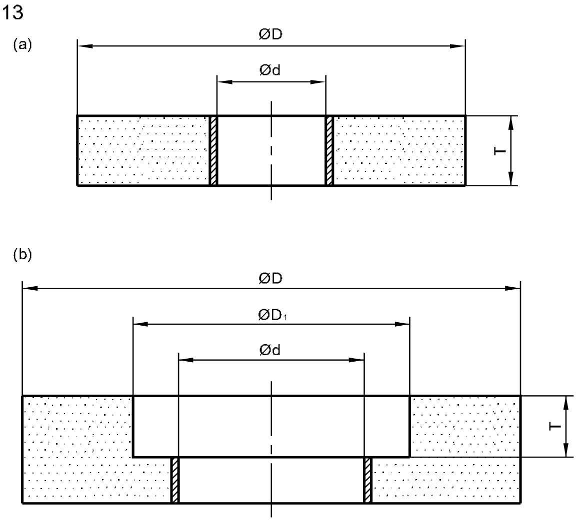


Grinding wheel specification (Fig 13)

A grinding wheel is specified by its marking, shape, outside dia. bore dia. thickness etc. (Fig 13a)

A recessed wheel is specified with all the above given particulars plus the dia. of the recess and the depth of the recess. (Fig 13b)

Fig 13



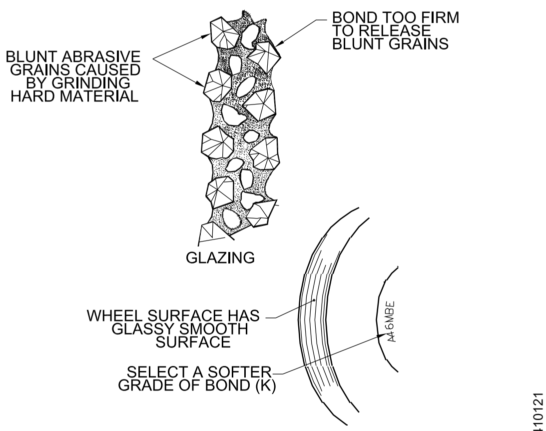
Glazing and loading

Objectives: At the end of this lesson you shall be able to
- **differentiate between glazing and loading of a grinding wheel**
- **state the effects of a glazed and loaded wheel while grinding**
- **state the causes and remedies for glazing**
- **state the causes and remedies for loading.**

Glazing

When the surface of a grinding wheel develops a smooth and shining appearance, it is said to be glazed. (Fig 1) This indicates the abrasive particles on the wheel face are not sharp. These are worned down to bond level.

Fig 1

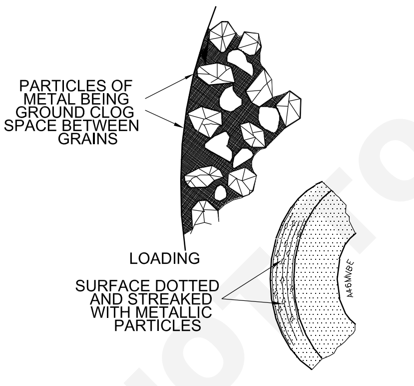


GLAZED WHEEL

Loading

When soft materials like aluminium, copper, lead, etc. are ground the metal particles get clogged between the abrasive particles. This condition is called loading. (Fig 2)

Fig 2



LOADED WHEEL

The effects of a glazed or a loaded grinding wheel are almost the same. They are:

- excessive cutting pressure between wheel and work
- more heat generation
- burning of the ground surface
- poor surface finish
- inaccuracies in the size and shape of the workpiece
- wheel breakage (sometimes)

A dull or glazed wheel should be dressed for the following reasons

To reduce heat generated between the work surfaces and the grinding wheel.

To reduce the strain on the grinding wheel and the machine

To improve the surface finish and accuracy of the work

To increase the rate of metal removal

Cause and remedies of glazing

Wrong selection of glazing

> **Wrong selection of grinding wheels means hard grade wheel in place of soft wheel and fine grain size in place of medium grain size.**

Select a grinding wheel of the right grade and size.

High wheel speed

Set the wheel to the recommended speed.

Feed too fine

Set the feed rate correctly.

Dirty coolant

Change the coolant

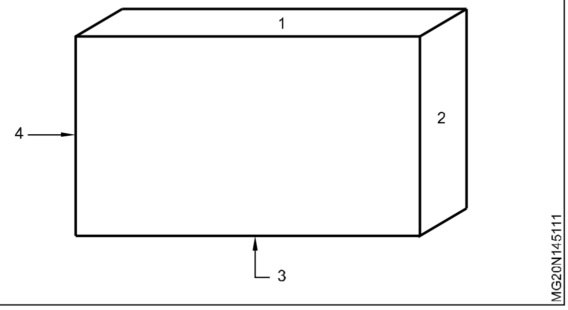
A glazed or a loaded grinding wheel can be reused after removing the glazed or loaded particles from the grinding wheel face.

Square up a workpiece using an angle plate

Objectives: At the end of this lesson you shall be able to
- **setting job on angle plate**
- **grinding surface at right angle**
- **checking the job for squareness.**

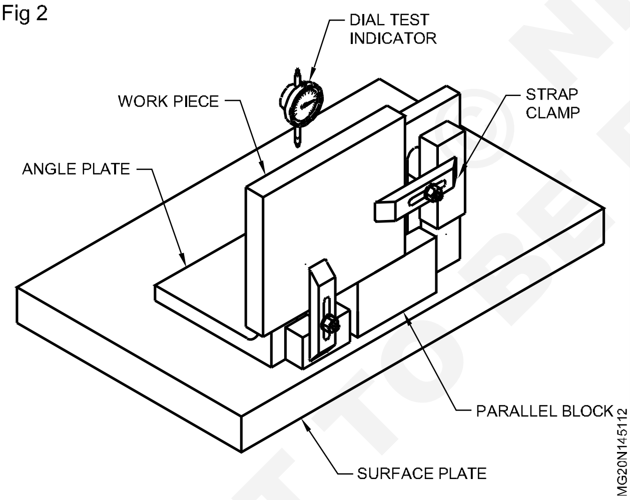
Clean and remove all burrs from the workpiece, the angle plate and the magnetic chuck. All the four sides are to be ground parallel and perpendicular to each other. (Fig 1)

Fig 1



Place the angle plate end the surface plate and set the workpiece using strap clamp. Top and edge of the workpiece project 3mm or 4mm about edge of the angle plate. (Fig 2)

Fig 2



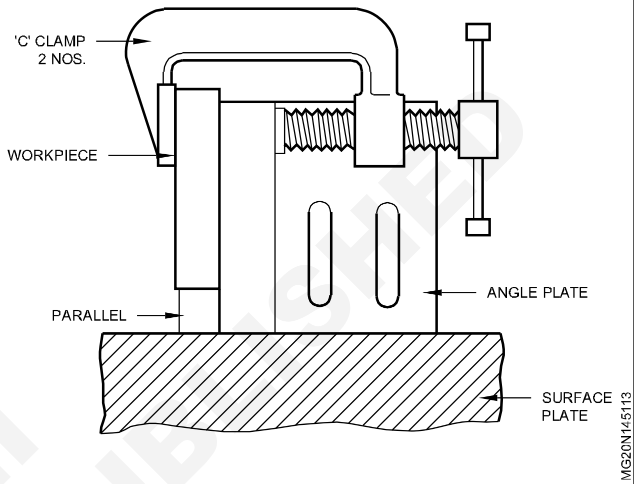
Be sure that the edge of the work does not project beyond the base of the angle plate.

If the work piece is smaller than the angle plate length, a suitable parallel must be used to being the top surfaces beyond the end of the angle plate. (Fig 3)

If the workpiee is convenient enough height and clearance from the angle plate edge and align with dial test indicator reference to the surface plate.

Carefully place the base of the angle plate on the magnetic chuck and switch 'ON'. Magnetic chuck of the grinding machine.

Fig 3

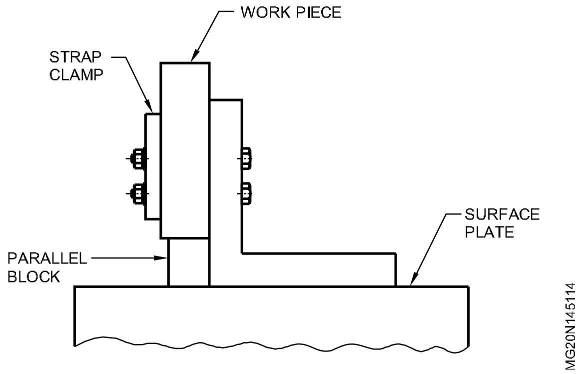


After the work has been properly set up on the magnetic chuck the following steps are to be followed for grinding the edges of work piece.

Raise the wheel head so that it is about 12mm above the surface of the job.

Adjust the table reverse dogs so that each end of the work clears the grinding wheel by about 25mm with the work under the centre of tile wheel tum the cross feed handle until about 3mm of the wheel overlaps the edge of the work. (Fig 4)

Fig 4



Start the machine and lower the wheel head until the wheel just sparks the work (It makes depth of cut)

Don't touch the wheel on the job when the wheel is stationary.

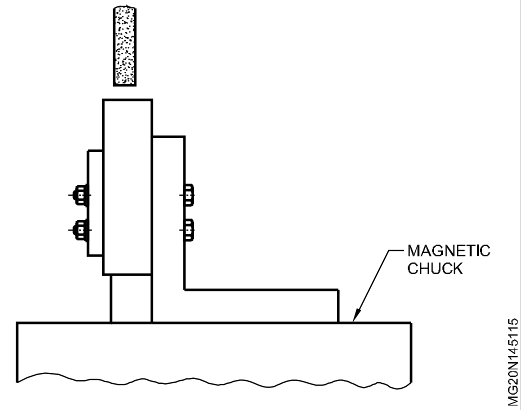
Move the work clear of the wheel with the cross feed handle.

Check for further high spots by feeding the table by hand so that the entire length of the workpiece under the wheel.

The depth of cut should be 0.03 to 0.15mm for the roughing cuts and 0.01 to 0.02mm for the finishing cuts.

Turn off the magnetic and remove the angle plate. Keep vertical position of angle plate for grinding surface (46mm) (2) (Fig 5) repeat the above steps.

Fig 5



Be careful not to be disturb the work set up for above process.

Turn off the magnetic chuck adn move the angle plate and workpiece clean the chuck angle plate.

Rearrange the job with angle plate and repeat the above steps. When two adjacent sides have been ground they are then used as reference surface to grind the sides (3) and (4) right angle and parallel.

If the workpiece is at-least 25mm thick and long enough to span three magnetic poles on the chuck no angle plate is required.

Factors affecting the selection of grinding wheel

Objective: At the end of this lesson you shall be able to
- **state the tractors affect the selection of grinding wheel.**

For grinding a job the right grinding wheel is to be selected. Theselection of a grinding wheel will depend on the following factors.

1 Factors affecting the selection of abrasive

a Materials of high tensile strength, viz. alloy steel, hard bronzes steel and wrought iron.

- Aluminium oxide

b Hardened tool steel high speed steel drills cutters and for cool and precision grinding.

- White Aluminium oxide

c Materials of low tensile strength, viz., Aluminium, copper, cast-iron, stone ad marble.

- Silicon carbide.

d Tungsten arbide tipped tools

- Green silicon carbide.

2 Factors affecting the selection of grit.

a Great amount of stock to remove - Course grain.

b Soft and tough materials - Course grain.

c Fine finish - Fine grain.

3 Factors affecting the selection of grade

a Hard materials - Soft wheel.

b Soft materials - Hard wheel

c Great area of contact - Soft wheel

d Low wheel surface speed - Hard wheel.

e Unstable and shaky foundation of grinding machine. - Hard wheel.

f Off-hand grinding - Hard wheel.

4 Factors affecting the selection of structure

a Soft and tough material - Open structure.

b Fine finish - Dense structure.

c Cylindrical and tool grinding - medium structure

d External grinding - Dense structure.

5 **Factors affecting the selection of bond**

a General purpose and maximum cutting efficiency - vitrified

b Wheels of very large diameter and wheels required quickly to special order. - silicate

c Very thin wheel - shellac or rubber.

d Very high finish where rapid cutting is not important - shellac or rubber

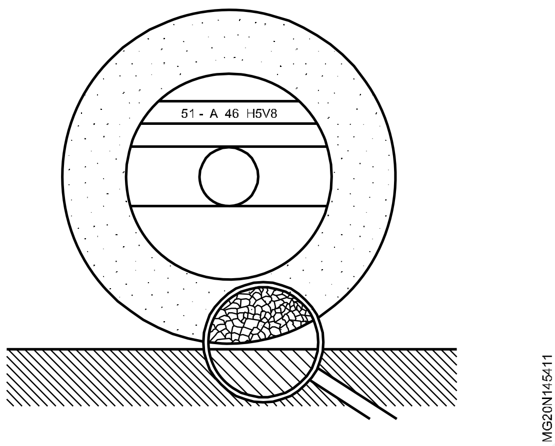
Marking system and selection of grinding wheel

Objectives: At the end of this lesson you shall be able to
- **explain marking system of grinding wheel**
- **identification of grinding wheel.**

Introduction

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

Fig 1



Example

Marking system

51 - A46 H5V8

Specification of grinding wheels

A grinding wheel is specified by the:

standard wheel marking

outer diameter of the wheel

bore diameter of the wheel

thickness of the wheel

type (shape) of the wheel

Example

32 A46 H8V 15

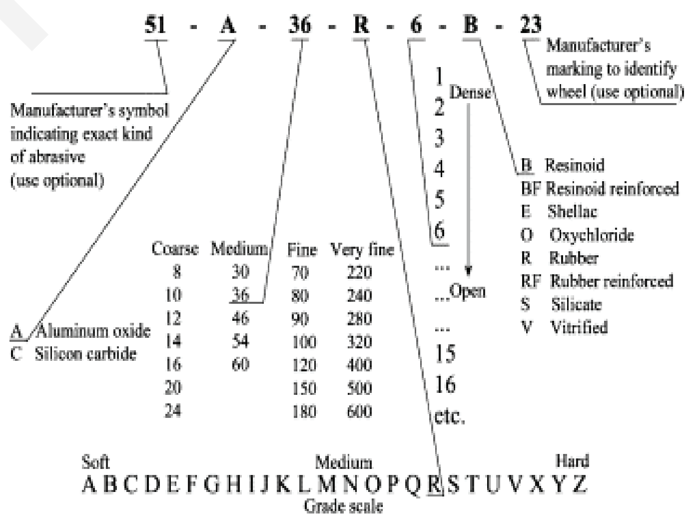
250 x 20 x 32

Straight wheel

Table 1

Position 0	Position 1	Position 2	Position 3	Position 4	Position 5	Position 6
Manufacture's symbol for abrasive (optional)	Type of abrasive	Grain size	Grade	Structure (optional)	Type of bond (optional)	Manufacture's own mark
51	A	46	H	5	V	8

Identification



grit and different types of bonds

Objectives: At the end of this lesson you shall be able to
- **state the different grain sizes and their uses**
- **state the type of bonds.**

Grain Size (Grit size) (Fig. 1)

The grit or grain size refer to the actual size of the abrasive particles. The grains size is denoted by a number. The sieve used to size the grain.

The larger the grit size number the finer the grit and the smaller the grit size number the larger the grit.

Bond

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

Types of bonds and their uses

Vitrified bond (V)

This is the most widely used bond. It has high porosity and strength which makes this type of wheel suitable for high rate of stock removal. It is not adversely affected by water, acid, oils at ordinary temperature conditions.

Silicate bond (S)

Silicate wheels have a milder action and cut with less harshness than vitrified wheels. For this reason they are suitable for grinding fine edge tools, cutlery etc.

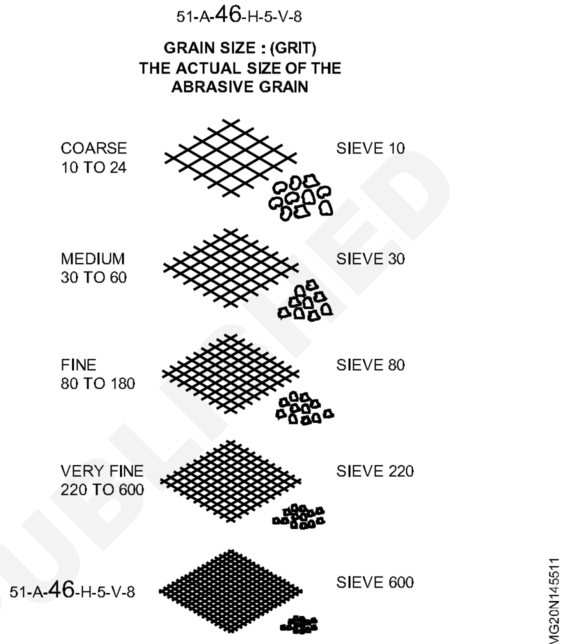
Shellac bond (E)

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

Rubber bond (B)

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

Fig 1



Resinoid bond (B)

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

Oxychloride bond (O)

The abrasive grains are mixed with magnesium chloride and magnesium oxide. This bond is used for making disc shaped wheels.

The bond ensures a cool cutting action so best for dry grinding operation.

Cutting speed, feed and depth of cut

Objectives: At the end of this lesson you shall be able to
- **state the is wheel speed, work speed, table traverse, and depth of cut**
- **explain machining time**
- **state grinding allowance.**

Cutting speeds and feeds

Wheel speed, work speed and table traverse required consideration when setting up a grinding machine.

Wheel speed

The faster a wheel is run, the more efficient it cuts but if it runs too fast, it will fly apart. Other adverse effects of using higher speeds are - clogging of wheels, smoothing of wheels (they will, then, not grind any more), overheating of workpiece, inaccuracy of surface and danger of accidents. On the other hand, if the speed is low, the abrasive is wasted without much work being done. It is best to run the wheel at the speed recommended by the manufacturer.

Recommended circumferential speed (cutting speed) of the grinding wheel (metres / second) is given in the table below.

Grinding method	Material			
	Steel	cast iron	cemented carbide	zinc alloys light metals
Internal grinding	25 m/s	20 m/s	8 m/s	25 m/s
External grinding	30 m/s	25 m/s	8 m/s	35 m/s
Surface grinding	25 m/s	25 m/s	8 m/s	20 m/s

R.P.M of the grinding wheel is calculated by the following formula:

$$h = \frac{V3 \times 1000 \times 60}{\pi D}$$

Where,

V3 = Circumferential speed of the grinding wheel in m/s

D = Diameter of the grinding wheel in mm

n = R.P.M of the grinding wheel.

Work speed

Work speed is chosen based on the surface finished desired and to obtain highest rate of production. Table below gives the normal work speeds in m/min. For grinding of work that is out of balance, lower surface speeds are used. Rough grinding of automatic cams is done at about 5-10 m/min and finish grinding is done at half of that speed.

Grinding of non-ferrous and light metals is done at higher work speeds. Plunge grinding requires very low speed. For thread grinding extremely low work speed is used.

The slower the workpiece revolves the harder will be the wheel action. The work speed should not be lower than the minimum or above the maximum speed recommended. Too high speed may cause accidents and is also likely to damage the machine.

Method of Grinding	Materials to be ground			
	Soft steel	Hardened steel	Cast iron	Light metals
Internal grinding	18-20 m/min	20-24 m/min	20-24 m/min	28-32 m/min
External grinding rough	12-18 m/min	14-18 m/min	12-15 m/min	25-40 m/min
Finish	10-15 m/min	10-12 m/min	10-12 m/min	20-30 m/min
Surface grinding	8-14 m/min	8-14 m/min	8-14 m/min	8-14 m/min

R.P.M of the workpiece,

Where,

$$\eta w = \frac{V_w \times 1000}{\pi d}$$

V_W = Circumferential speed of the workpiece in m/min

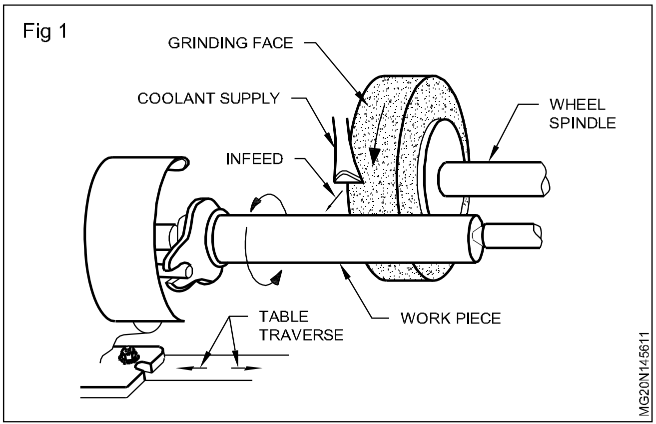
d = diameter of workpiece in mm

Table traverse (Fig 1)

It depends upon the width of the wheel and the accuracy of finish required. For rough grinding, table travel should be about 2/3 of the width of the wheel per revolution of the workpiece. For finish grinding it should be 1/3 or even less of the width of the wheel face. For very smooth finish, very low table travel say 1/8 of the width of the wheel face may be used.

Traverse should not be such as may allow the wheel to extend fully beyond the work. The wheel should over run the end of the work about $1/4^{th}$ to $1/3^{rd}$ the width of the wheel face. This is done so that wheel may finish the cut. If there is no over-run of the wheel at all, the work will be over size at the end. Momentary stoppage of the wheel at the end of each traverse is important as it permits the wheel to grind the work to size.

Fig 1



Depth of cut

Infeed or depth of the cut depends upon the following factors:

Amount of metal to be removed.

Type of finish required.

Power and rigidity of the machine.

Coolant used.

Provision of work support (Steady rest)

Depth of cut used for roughing is 0.01-0.03 mm, and for finishing 0.0025-0.005 mm. The shower of sparks thrown off by grinding wheel is a convenient and sensitive indication of the depth of cut being taken. An experienced operator can judge the depth of the cut within close limits by seeing the shower of sparks.

Feeding of the grinding to the work may be by hand or automatic. But it is advisable to use automatic feed except for bringing the wheel upto the work and to remove it away or when taking very fine cuts. The automatic feed takes 0.006 to 0.10 mm for each traverse of the machine table.

Machining time for cylindrical grinding

Where

l = Length of the workpiece in mm ; L = Grinding length in mm ; f = Feed in mm/revolution of workpiece ; n_W = R.P.M of workpiece ; i = no.of cuts ; = f x n_W

Machining time:

(i) With feed adjustment at every stroke of the table

(ii) With feed adjustment at every cycle

$$(i) = \frac{L x i}{f x n_w} \qquad (ii) = \frac{2 x L x i}{f x n_w}$$

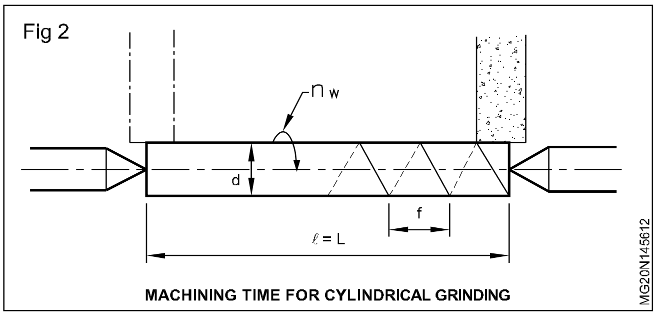
Example:

A steels shaft θ 50.3 mm, 500 mm long is to be ground to θ 50 mm, width of grinding wheel = 40 mm, feed adjustment per stroke = .005 mm circumferential work speed = 12 m/min feed = 1/2 width of grinding wheel per revolution of workpiece.

Then, grinding allowance = 50.3 - 50 = 0.3 mm

Grinding allowance applied to 0.3/2 = 0.15 mm

Fig 2



radius

Feed, f = 40 mm x 1/2= 20 mm per revolution of work

$$\text{No.of cuts (i)} = \frac{\text{Grinding allowance}}{\text{Infeed adjustment}}, i = \frac{0.15}{0.005} = 30$$

R.P.M of workpiece,

$$n_w = \frac{v_w x 1000}{\pi x d}$$

$$= \frac{12 x 1000}{\pi x 50}$$

=76 R.P.M

Grinding allowances

The amount of stock to be left on the work for removal by grinding in case of cylindrical work depend upon:

Diameter of work.

Length of work

The usual practice is to leave from 0.25 mm to 0.75 mm for grinding. The allowance on short, thick pieces of work is 0.25m. For larger and thinner pieces of work, the grinding allowance is correspondingly increased. For example for a 12 mm diameter shaft of 150 mm length, grinding allowance will be about 0.25 mm, while for a 900 mm long shaft, it will be 0.50 mm. Grinding allowance for a 300 mm long shaft of different diameters will be as follows:

Diameter	Grinding allowance
12 mm	0.25 mm
25-50 mm	0.375 mm
75-100 mm	0.50 mm
125-200 mm	0.625 mm
250-300 mm	0.75 mm

Other factors which need to be considered in deciding the allowance to be left for grinding are:

The finish of the work before grinding

The condition of the work when being ground, whether hardened or not.

If the work has been case hardened, the depth of penetration of case.

Depth micrometers

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

Constructional features

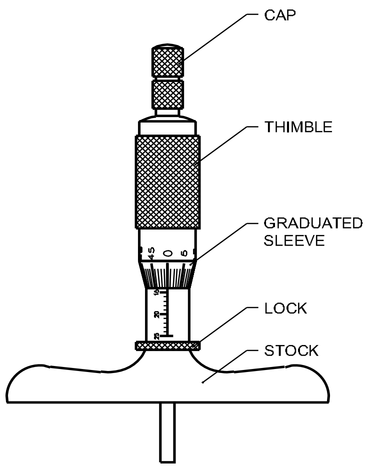
The depth micrometer consists of a stock on which a graduated sleeve is fitted.

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

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

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

Fig 1



DEPTH MICROMETER

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

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

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

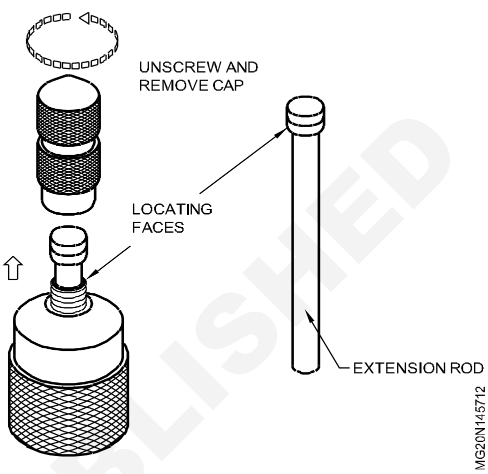
The measuring faces of the stock and the rods are hardened, tempered and ground. The measuring face of the stock is perfectly machined flat.

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 25mm. 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

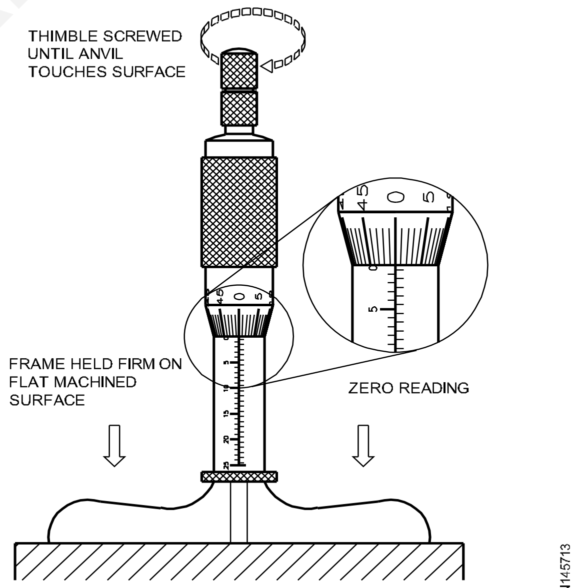
Fig 2



1 mm is further subdivided into two equal parts. Hence each sub-division represents 0.5 mm. (Fig 3)

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

Fig 3

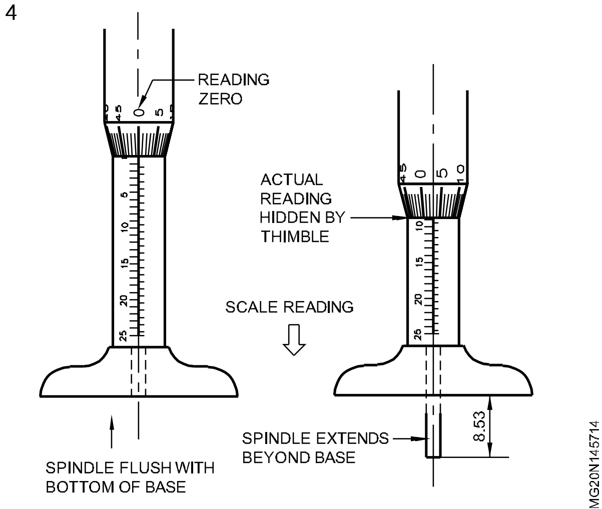


CHECKING THE ZERO SETTING

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

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

Fig 4



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

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

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

Uses of depth micrometer

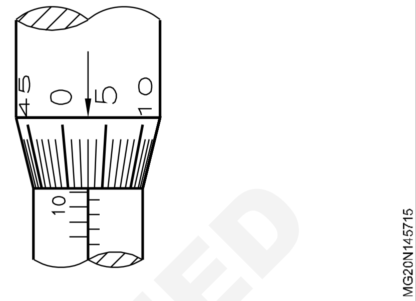
Depth micrometers are special micrometers used to measure

the depth of holes.

the depth of grooves and recesses

the heights of shoulders or projections.

Fig 5



Surface grinder

Objectives: At the end of this lesson you shall be able to
- **state the types and parts of surface grinding**
- **describe the construction of surface grinder**
- **state the methods of surface grinding.**

Surface grinding machine

It is a precision grinding machine to produce flat surfaces on a workpiece. It is a more economical and more practical method of accurately finishing flat surfaces than filing and scraping.

Types of surface grinders

There are four types of surface grinders.

- Horizontal spindle reciprocating table (Fig 1)
- Horizontal spindle rotary table (Fig 2)
- Vertical spindle reciprocating table (Fig 3)
- Vertical spindle rotary table (Fig 4)

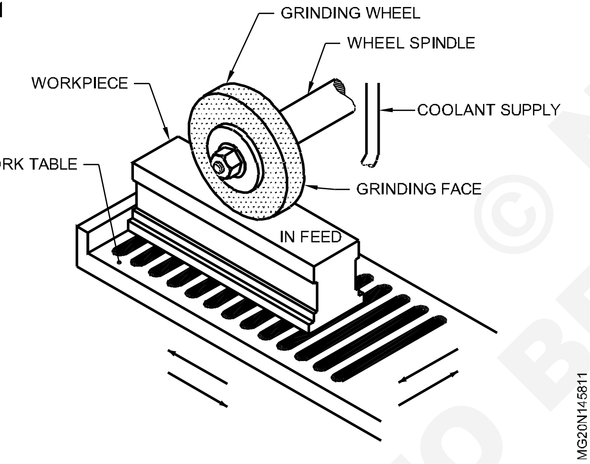
Fig 1


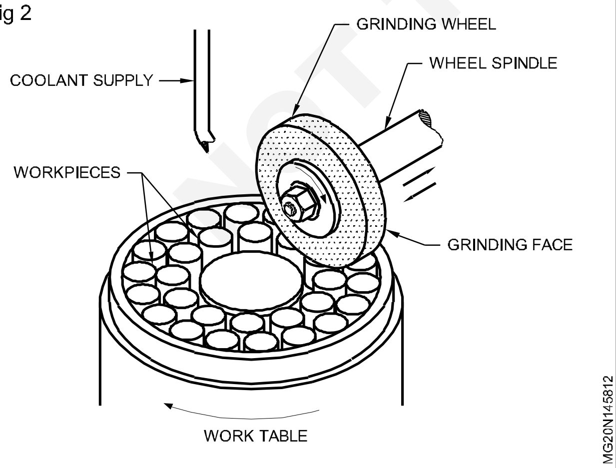
Fig 2


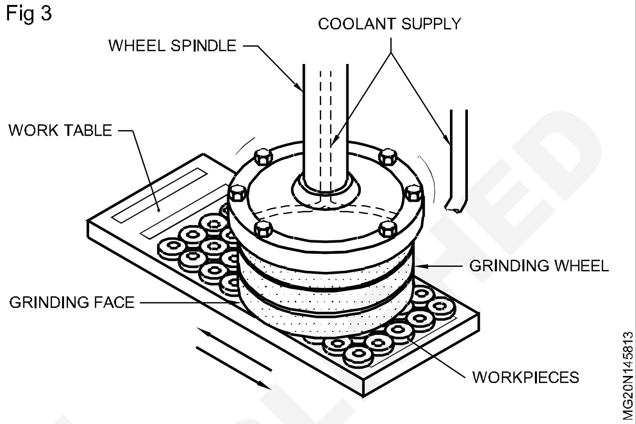
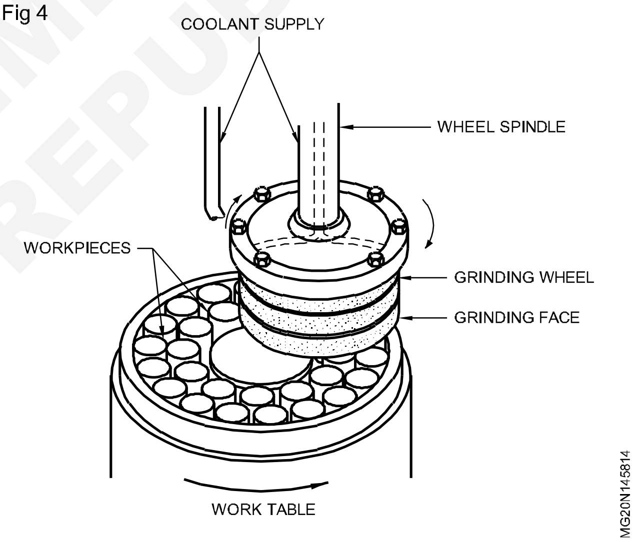
Fig 3


Fig 4


Parts

Horizontal spindle reciprocating table surface grinder main parts (Fig 5).

- Base
- Saddle
- Table
- Wheel head

Base

It is a rigid rectangular box contains the driving mechanism (hydraulic device tank and motor). It has a column at the back for supporting the wheel head on the top of the base provide precision guide ways for moving saddle.

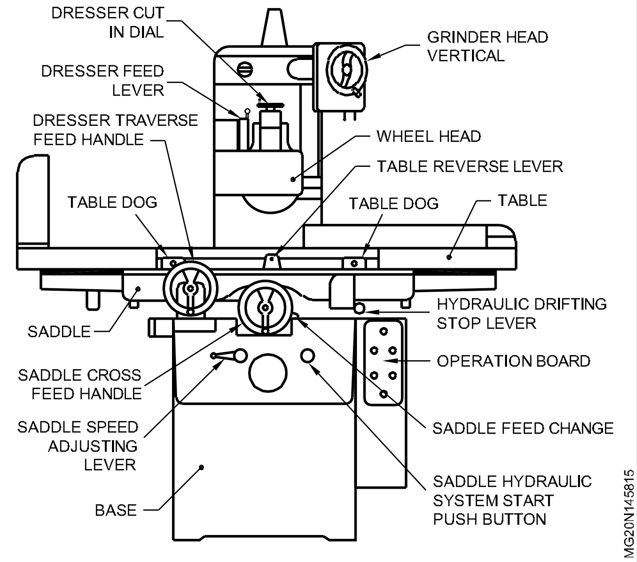


Fig 5

Saddle

It is a frame. It contains the table in its cross wise movement. It is used to give cross feed to the work. It can be removed by hand or auto feed.

Table

It is fitted on the saddle. It is reciprocating along the guide ways to provide the longitudinal feed to the work. The surface is accurately machined and T-slots are provided for clamping of workpieces directly on the table or for clamping magnetic chuck and grinding fixtures. It is moved by hand or auto feed.

Wheel head

It is mounted on the column secured to the base. It can be moved vertically up and down to by rotating a hand wheel accommodate work piece of different height and set the wheel for depth of cut. The wheel rotates at a constant wheel speed. (1500 rpm)

Some surface grinding machines the dressing unit mounted on the top of the wheel head and slide for dressing the wheel with help of rotating micrometer collar handle. Dress the wheel 0.015 mm to 0.025 mm giving feed.

Method of grinding taper

Objectives: At the end of this lesson you shall be able to
- **explain the taper cylindrical grinding**
- **explain the different methods of taper grinding.**

Grinding an exterior taper

Several methods are in use for grind tapers on the cylindrical grinder.

1 The work head, work table or wheel head may be swivelled.

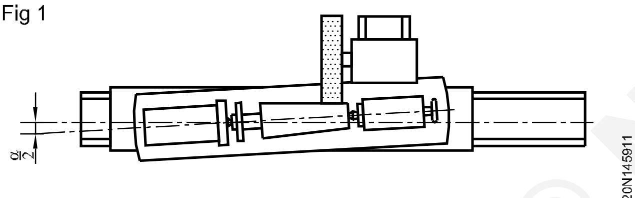
2 The grinding wheel may be dressed at an angle.

The machine may be set for slight or steep tapers. If possible, the set up should be such that the wheel pressure is towards the headstock.

Grinding slight tapers: Grinding of tapers upto 8° is usually done by swivelling the swivel table. (Fig 1)

1 Swivel the table to an angle as required and clamp it in position.

Fig 1



GRINDING SLIGHT TAPERS BY SWIVELLING THE TABLE

2 Choose the correct type and size of the wheel, secure it in position True it, if required

3 Check, clean and oil both the centres of the work. Mount the workpiece between the centres making sure that the centres are properly seated

4 Chose and set the correct work and wheel speeds.

5 Adjust the table feed dogs in the normal manner.

6 Make sure that the wheel guard is properly in position. Take necessary precautions for personal safety.

7 Adjust the coolant piping and nozzle and turn on the coolant.

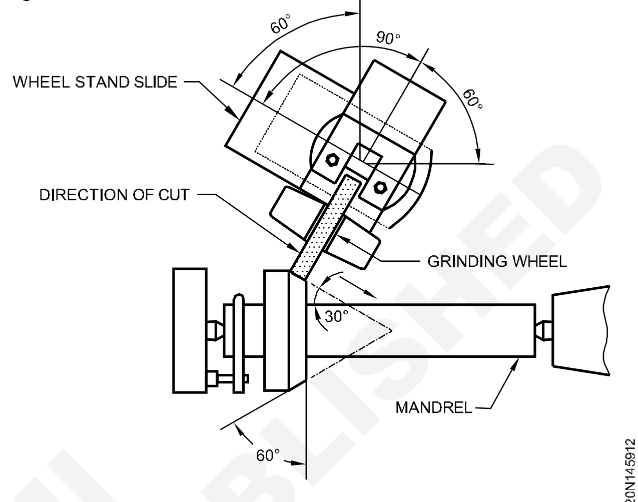
8 Start the machine and carry out grinding in the normal manner.

9 After completing the job, clean and restore the machine to the normal working condition.

Grinding steep or sharp exterior tapers

1 Say the angle of the taper is 300. Swivel and set the slide at 600(900-300) Fig 2 shows the wheel set in position for grinding 300 taper. Turn the platen to bring the spindle parallel to the slide.

Fig 2



GRINDING A STEEP TAPER

2 Choose the correct type and size of the wheel, secure it in position. Turn it, if necessary.

3 Use chuck or other suitable device for mounting the work.

4 Find out recommended work and wheel speeds. Make necessary adjustments.

5 Make sure that the wheel guard is properly in position. Take necessary precautions for personal safety.

6 Adjust the coolant piping and nozzle. Turn the coolant on.

7 Start the machine. Using hand feed bring the work in contact with the revolving wheel. Move the wheel across the face of the work. If the face of the wheel happens to be of the same width or wider than the surface to be ground, movement of the cross feed is not necessary.

8 Advance the wheel a pre-determined distance depending upon the amount of stock to be removed after every cut by moving the sliding table forward.

9 Take repeated cuts till the work is completed.

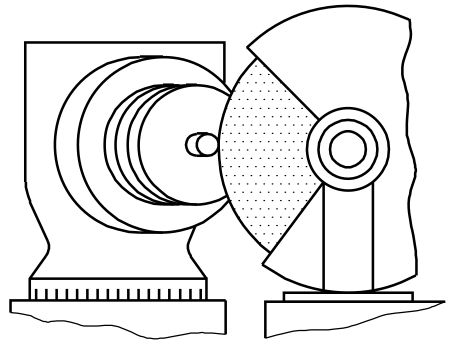
10 After completion of operation, clean and restore the machine to the normal position.

If the taper grinding is to be done by dressing the wheel at an angle, see that the diamond is set on the exact centre line of the wheel. If this is not done, the wheel will not be dressed at the correct angle.

Fig 3 shows the set up for grinding a 60° machine centre. The work head has been swivelled to 30°. After dressing the wheel a trial cut is taken. In case, the trial doesn't follow the original point, the point is checked with the flat centre gauge, Fig 4, or the cone centre gauge and necessary arrangements are made to insure accurate results.

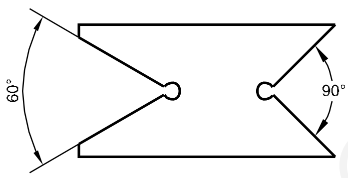
After adjustments, grinding operation is proceeded further, Due to the steep taper, a change in work speed takes place which may cause burning of the centre. It is, therefore, necessary to take light cuts, Use a slow work speed, plenty of coolant and take the cut from the point back to large diameter of the centre.

Fig 3



GRINDING A 60° MACHINE CENTRE

Fig 4

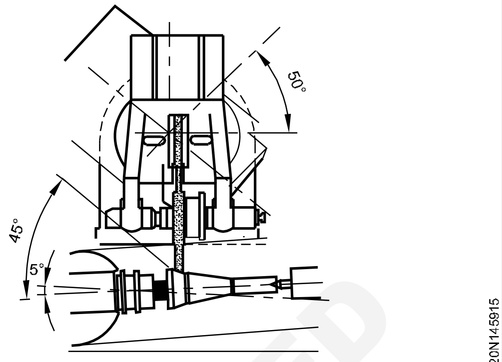


FLAT CENTRE GAUGE

Grinding double or compound tapers

Grinding of double or compound tapers can be done in one setting provided one of the tapers is within the range of the swivel table. Swivel table is adjusted to the smaller angle and the wheel slide to the large angle. (Fig 7)

Fig 5



GRINDING DOUBLE TAPER

The wheel is adjusted perpendicular to the longest surface and one corner is, then, bevelled correctly to suit the other surface. Grinding of one part is done by traversing the table and the other by movement of the wheel slide. In such cases, the wheel base is adjusted at an angle equal to the sum of the angles of both tapers as measured from the axis. In the set up shown, the sum of both the angles equal 50^0.

Grinding shoulders

If it is required to grind a work to a shoulder, the grinding wheel is located up against the shoulder before starting to grind. Then by the method of plunge cut, the surface is ground to the required diameter. By this method, the finished diameter is left with a corner at the shoulder that is fairly sharp and square. After grinding the workpiece to size at the shoulder, the rest of it is ground by traversing the table.

Common types of grinding machines

Objectives: At the end of this lesson you shall be able to
- **define grinding machines**
- **name the common types of grinding machines.**

Grinding machines

Grinding machines are precision machine tools, designed to remove metal from a workpiece to close tolerances (up to 0.0025mm) and to produce high quality surface finish (up to N4).

There are two major groups of grinding machines.

Off hand or rough grinders

Precision grinders

The common types of precision grinder are:

Surface grinders

Surface grinders are used to grind flat parallel surfaces or stepped surfaces. The surface produced by a surface grinder is more economical and more accurate than the surface obtained by filling or scraping

Cylindrical grinder

Cylindrical grinders are used to grind external and internal cylind Cylindrical surfaces. The cylindrical surfaces produced may be plain, tapered or stepped.

Tool and cutter grinder

A tool and cutter grinder is mainly used to sharpen single point cutting tools, milling cutters etc. it also can be used as a surface and cylindrical grinder along with some attachments

Plain cylindrical grinders

Objectives: At the end of this lesson you shall be able to
- **state the purpose of a cylindrical grinder**
- **name the four types of cylindrical grinder**
- **state the main parts and function of a plain cylindrical centre type**
- **specify a cylindrical grinder.**

The cylindrical grinder is a precision grinding machine. It is used to grind the external and internal surfaces of a cylindrical work pieces.

By cylindrical grinding the diameter of a workpiece can be maintained to a close tolerance (upto 0.002mm) and a high quality surface finish can be obtained upto 0.2mm (N4)

The four types of cylindrical grinders are

- external cylindrical grinders
- internal cylindrical grinders
- universal cylindrical grinders
- centreless grinders

Plain centre type cylindrical grinder

It is mainly used to grind and produce the plain, stepped, formed external cylindrical surfaces.

Parts (Fig. 1)

The main parts of cylindrical grinder are the

A base

B table

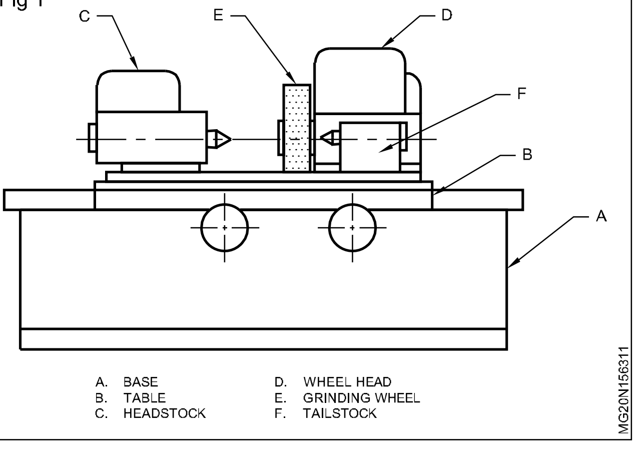
C head stock

D wheel head

E grinding wheel

F Tailstock

Fig 1



Function

Base (A) is made out of cast - iron. It is heavy and provided rigidity to the machine. All parts of the machine are mounted on the base. Table drive mechanism is housed in the base of the machine.

The table (B) is mounted on the bed ways. There are two types of tables provided on base 1. lower table 2. upper table . The tables can be operated by hand or automatic power. Upper table rests on the lower table.

In the upper table is provided with 'T' slots.

Tables can be swivelled up 10^o to grind taper.

The reversing dogs are provided to control the table reciprocation.

The head stock (C) is mounted on the table at the left side of the machine. It has a motor with 2 or 4 speed steps to drive the work. A dead centre (plain) is mounted in the spindle of this head stock to support the workpiece between centres.

The wheel head (D) is mounted on the cross slide. It moves perpendicular to give depth of cut. The grinding wheel (E) is mounted on main spindle.

It removes excess material of the workpiece. It can be moved to and from by grinding wheel (E) cylindrical grinder wheel is used for recessed both side wheel.

Hand or powerfeed

The tailstock or footstock (F) is mounted on the table at the right hand side of the machine. It can be moved and locked at any position along the table length to hold different length of work. The spindle is spring loaded and carries a half centre to support the work.

Specification of cylindrical grinder

- maximum diameter of workpiece which can be held.
- the breadth of the table
- maximum table traverse movement
- maximum diameter of grinding wheel.
- capacity of the machine
- H.P of the spindle motor.
- weight of the machine.

Types of cylindrical grinders

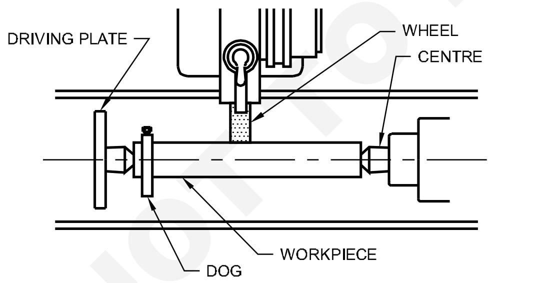
Objective: At the end of this lesson you shall be able to
- **state the four types of cylindrical grinders.**

Plain cylindrical grinders or Centre type grinder (Fig. 1)

This machine is designed the most simple types of external grinding. Plain cylindrical grinders the workpiece is usually held between centres.

The work is rotated by a dog with its own centre holes on two dead centres. It is used for grinding cylindrical parts, counter cylinders; fillets, cams and crank shafts.

Fig 1



PLAIN CYLINDRICAL GRINDER

Internal cylindrical grinders (Fig 2)

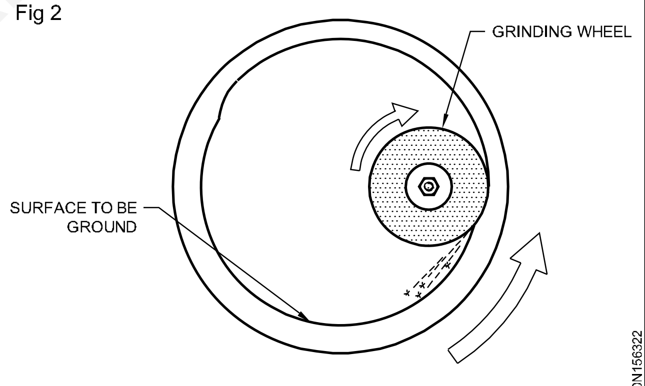
It is used to finish plain, step, taper and formed holes for correct size, shape and finish.

The depth of cut of the diameter of hole ground from 0.02 to 0.05mm for rough grinding and from 0.002 to 0.01mm in finish grinding.

There are three types

- Chucking
- Planetary
- Centreless

Fig 2



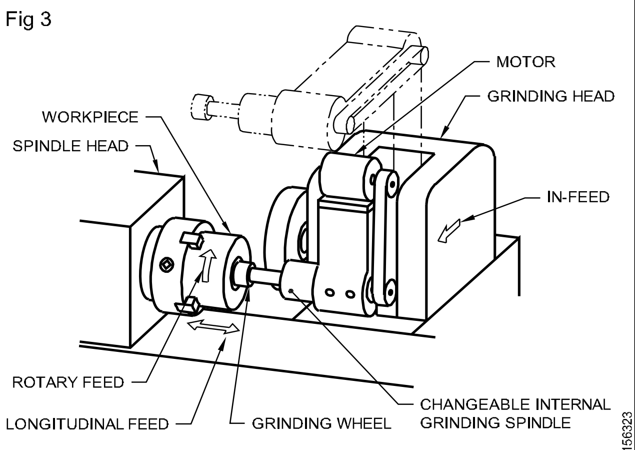
INTERNAL GRINDER

Universal cylindrical grinders (Fig 3)

This machine differs from the plain cylindrical grinding machine only in that an internal grinding attachment is mounted on wheel head. It has swivel arm. A small electric drive motor drives the internal grinding spindle by means of a belt. The workpiece is mounted in check or between centres.

Universal grinders are widely used for tool room works.

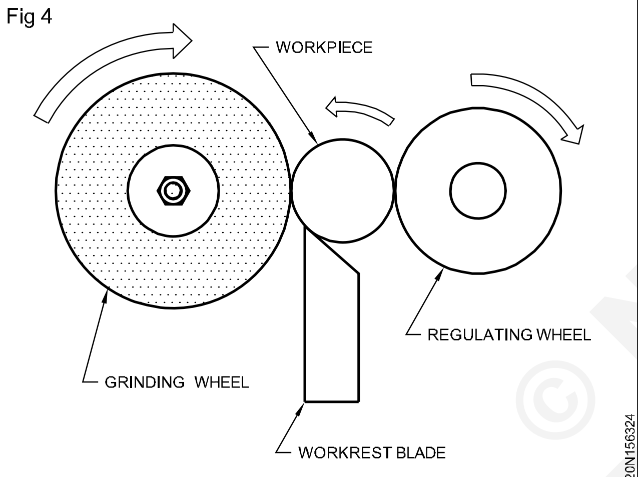
The head stock, wheel head and table can be swivelled at an angle.



INTERNAL CYLINDRICAL GRINDING ATTACHMENT OF A UNIVERSAL CYLINDRICAL GRINDING MACHINE

Centreless grinders (Fig 4)

In this type of grinding the workpiece is not held in between centres. So it is called as 'centerless grinding'.



CENTRELESS GRINDER

It is used for mass production of similar object for unskilled workers.

The workpiece is supported on a workrest with blade. Both wheels are mounted in machine. One is grinding wheel and another one is regulating wheel. Both wheels are rotated in same direction.

Types

- External centreless
- Internal centreless

It is also used for grinding long plain cylindrical shaft, taper cylindrical and formed surfaces.

The workrest is holding the work and grinding wheel is remove the metal from workpiece. The regulating wheel is rotate the job and giving the depth of cut. Regulating wheel is made of rubber bond.

Test for alignment and checking

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

Wheel inspection

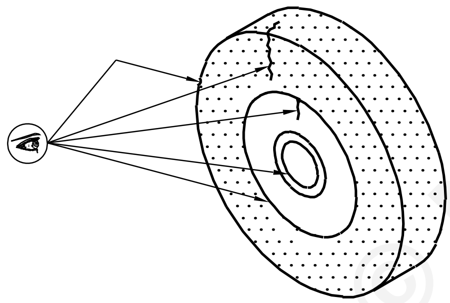
The wheel selected may have been damaged during transport or storage and must be carefully inspected before use.

Visual inspection (Fig. 1)

Look for

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

Fig 1



CHECK FOR FAULTS

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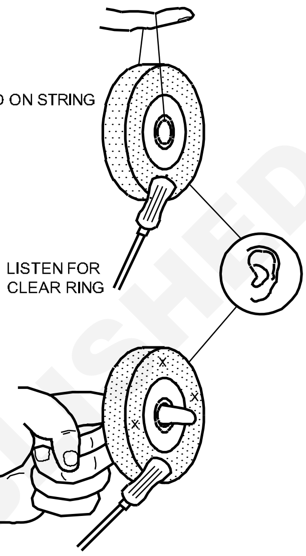
Testing for cracks (Fig 2)

Test a small 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 2



TESTING A SMALL WHEEL

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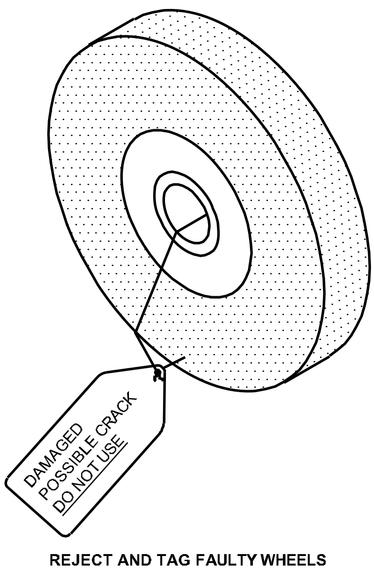
Fig 3



REJECT AND TAG FAULTY WHEELS

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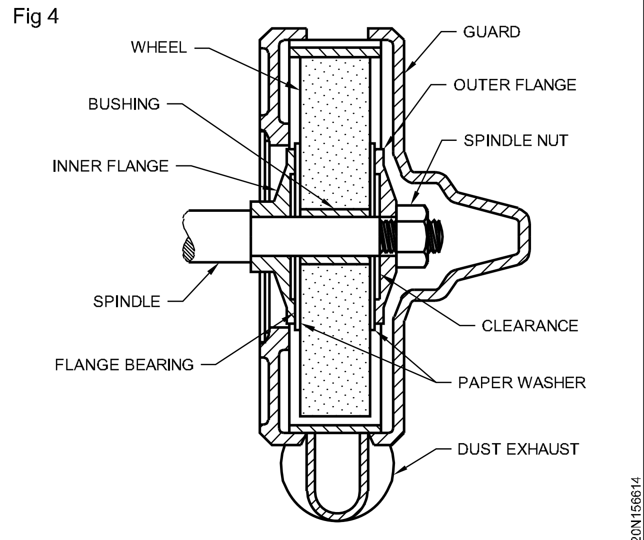
Mounting the grinding wheel (Fig 4)

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.



GRINDING WHEEL CORRECTLY MOUNTED

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.

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.

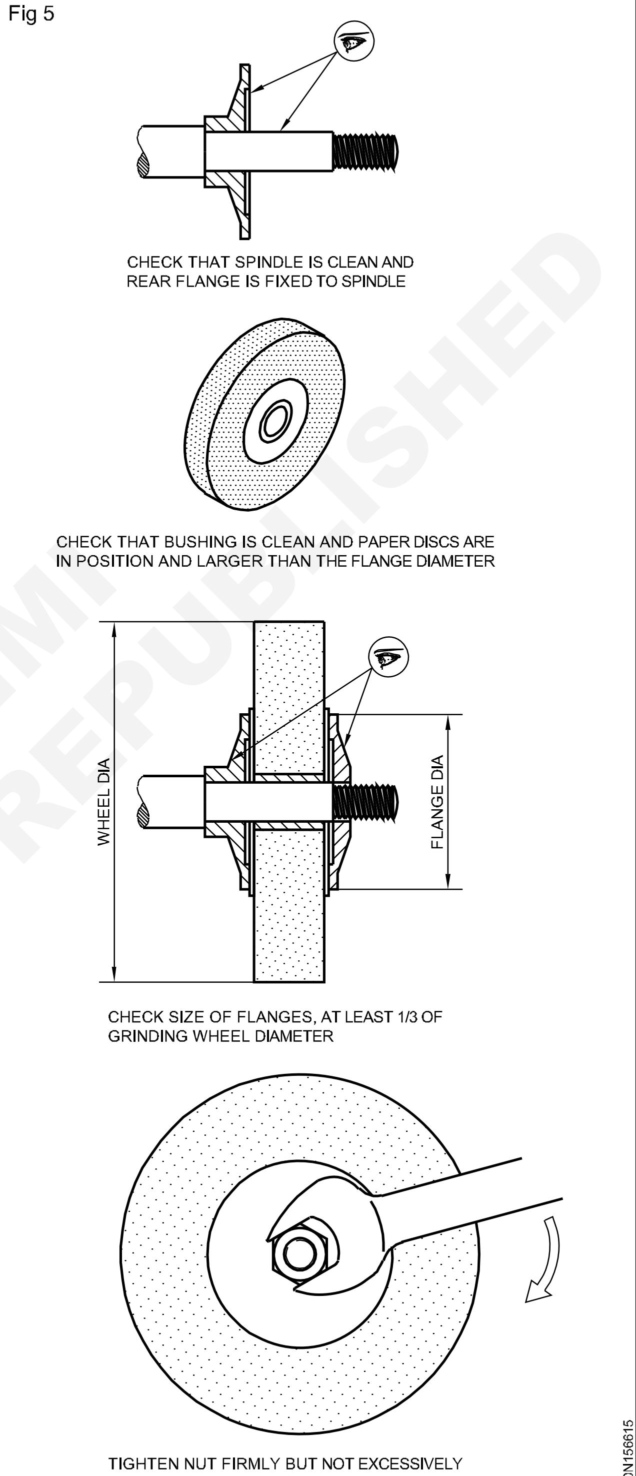
Replace the wheel guard correctly

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.



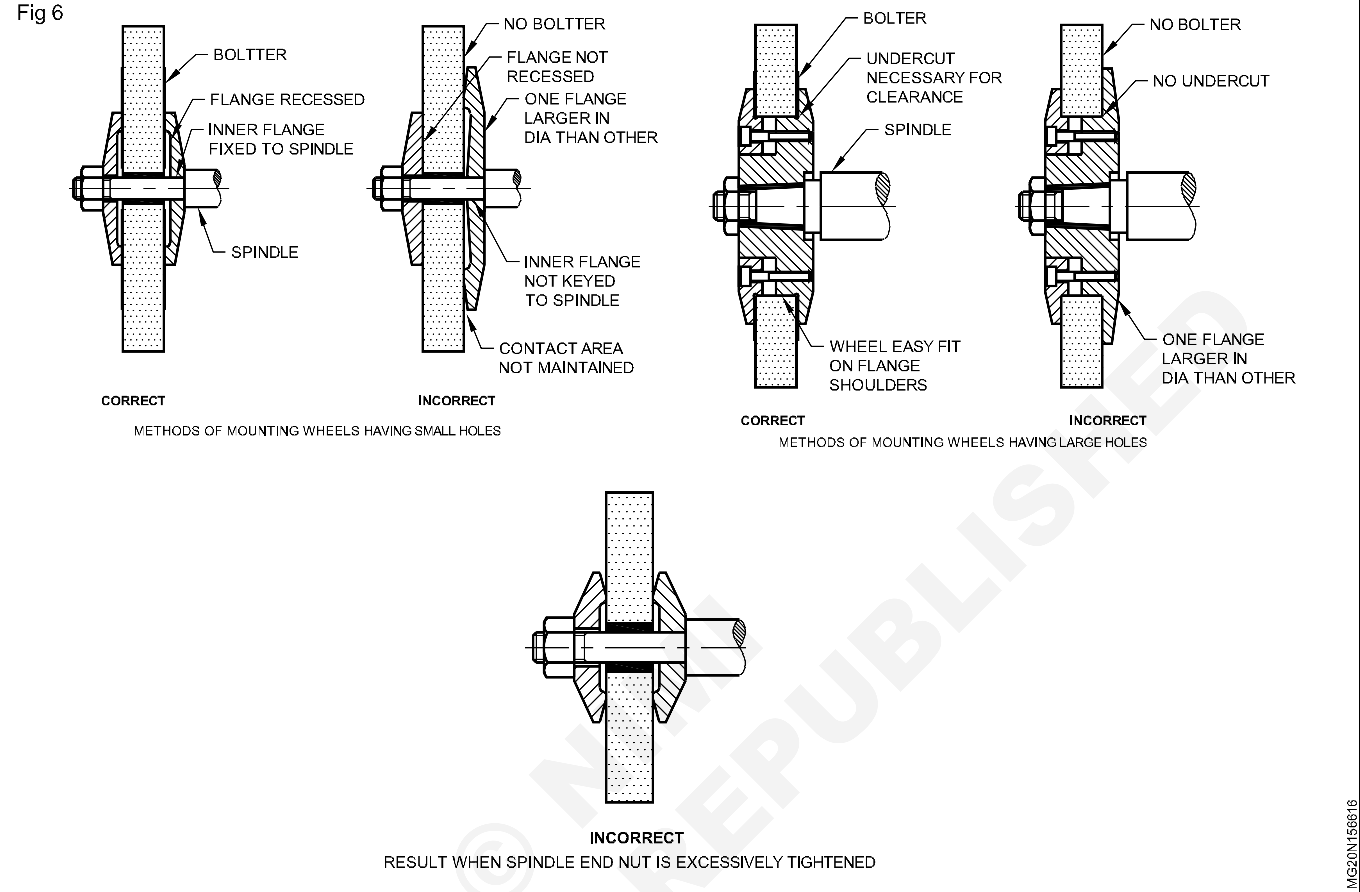
MOUNTING A GRINDING WHEEL ON A GRINDING MACHINE SPINDLE

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 6



Grinding wheel dressing

Objective: At the end of this lesson you shall be able to
- **list types of wheel dressers and their uses.**

Turning and dressing wheels

For precision cylindrical grinding the cutting face of an abrasive wheel must be brought concentric with the axis of rotation and must retain its shape. If good work is to be consistently produced, an abrasive wheel needs regular attention, as the portion making contact with the workpiece must bear uniformly, with the many abrasive particles expose, in such a manner as to ensure effective cutting. On continuous production, therefore, it is standard practice to dress the wheel after a predetermined number of articles have been ground. By adopting this procedure the wheel face is maintained in good condition, wheel wear is held to a minimum, the specified surface finish obtained and dimensional accuracy economically achieved.

Types of dressers

In general practice there are five means by which an abrasive wheel may be dressed:

- Using a suitably mounted set of steel discs or wheels.
- With an abrasive stick.
- With a small abrasive wheel, suitably mounted.
- With a diamond.
- Using a crush dressing fixture.

Wheel Dressers

The wheel dressers are of four types, as roughly described below.

The star dresser - The star wheel dresser has a number of pointed discs loosely mounted upon a pin, and plain discs are used as separators. It uses is practically confined to dressing of coarse grit wheels by hand, or segmental surface-grinding wheels. That is, on wheels as chosen for rough grinding articles in the forge, foundry and welding shops.

Corrugated disc-type - A dresser having cast corrugated discs, mounted without spacers, is chosen when the operating conditions do not require the extreme open wheel structure produced by the star dresser. As the corrugated discs have the tendency to shear through the grains, instead of dislodging them from the bond, this class of dresser is used to smooth wheels chosen for rough-grinding operations.

Locked wheel dresser - The locked disc wheel dresser consists of a number of cut steel discs with elongated teeth, or cast discs with serrated or zig-zag edges. Either type of wheel is locked in sets and rigidly mounted, without spacers, upon a pin; the latter is supported in suitable bearings. The function of the locked disc dresser is to bring the abrasive particles down to the common level and slightly open the bond. Its range of usefulness is restricted to dressing wheels used for rough cylindrical grinding of such articles as crankshafts and camshafts, and rough grinding on the centreless type of machine.

Cylinder dresser - A precision cylinder type of wheel dresser is, on occasions, chosen in place of the diamond. It consists of a cylinder or solid steel shell mounted on accurate bearings. The cylinders have helical grooves running in one or both directions, or a series of evenly spaced holes or openings. The single handed grooved dresser is chosen to dress wheels when grinding cast-iron components. The dressing cylinders having both right and left-hand helical grooves, or with holes, are used when engaged in many forms of cylindrical grinding.

Abrasive sticks

Abrasive dressing sticks are of two shapes; one is square, for hand dressing, and the other has a circular cross-section for magazine mounting. The hand dressing stick is chiefly used in the tool room and, in action, it shears the abrasive grain rather than penetrates the bond. The stick may be used when dressing thin wheels, as when engaged in cutter grinding, and for taking the rough-dressing cuts prior to using the diamond.

The round magazine mounted stick is useful for producing various shapes on the cutting portion of a wheel, also for truing or dressing thin wheels. The stick may, on be used for rough dressing prior to final dressing with a diamond.

Abrasive wheels

An abrasive wheel dresser consists of silicon carbide abrasive particles in a vitrified bond mounted in a suitable holder. They are, generally, of two designs (1) hand-operated; (2) clamped to the machine. When in use, the axis of the dresser makes an angle with the grinding wheel so as to create a combination of crushing, wiping and shearing. A wheel dresser of this type will leave a smooth clean free-cutting face, clear of any dressing or diamond marks. When dressing with an abrasive wheel, the grinding wheel may need slowing down but, because of the wheel surface obtained, it is a favorite means of dressing wheels, when pistons, crankshafts, camshafts, and kindred items are being ground on cylindrical and centreless grinding machine.

Diamonds

Diamonds are the chief means of dressing truing the abrasive wheels, as are used for precision grinding.

Types - There are two types of diamond used for truing abrasive wheels, the black diamond proper, and bort. The black diamond is harder and more expensive than bort, and because of its all-round efficiency, it is the best stone for general purposes. Yet, due to its high cost it should be used only by skilled and careful operators; the brown or grey bort may be used by the less skilled and, sometimes, more careless operators. It has been suggested that the grey bort is more firmly held in the solder, will do more work between each resetting and will last longer.

Sharpness - When dressing a wheel for cylindrical grinding, the diamond should be sharp and free from flats. The harder the wheel grade the greater the need for sharpness, so that the passage of the diamond across the wheel will produce a surface that will retain its cutting properties for a long period. A dull or worn diamond should be restricted to dressing the soft wheels which are chosen for surface grinding.

Grinding wheel balancing

Objectives: At the end of this lesson you shall be able to
- **state what is a wheel balancing**
- **name the method of balancing**
- **state the procedure of balancing**
- **state the causes of breakage of the grinding wheel**
- **state the method of storage of grinding wheels.**

Wheel balancing

Wheel balancing is an action of bringing the grinding wheel to rotate concentric to its axis and the weight and density of wheel are uniform throughout its circumference.

Before testing the balance of the wheel it is true.

Necessary of wheel balancing

- A good surface finish is possible to the work surface.
- Prevents wheel vibration and breakage.
- Prevents chatter marks on the work surface.
- Improves the dimensional accuracy of the work.
- Considerably increases the life of grinding wheel.
- Prevents the damage of the spindle /bearings.

Small wheel normally do not require any balancing, but larger diameters of the wheel important is the balancing.

Similar equipment used to balance the wheels of motor cars.

Method of balancing

- Static balancing
- Dynamic balancing

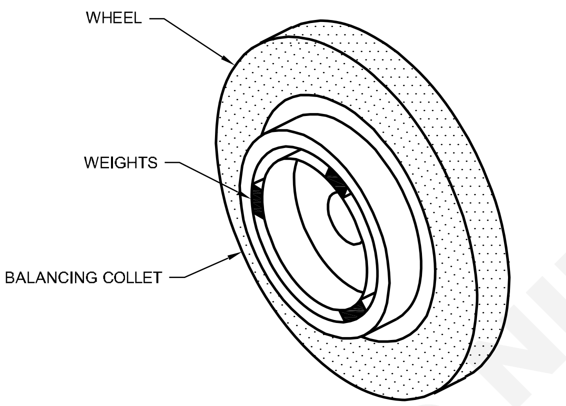
Static balancing means that when the wheel is centered in balancing mandrel and placed on a balancing stand.

Dynamic balancing means that when the wheel can be balanced while it is running on the machine, for getting still better result.

Wheel mounted on a balancing collet (Figs 1&2)

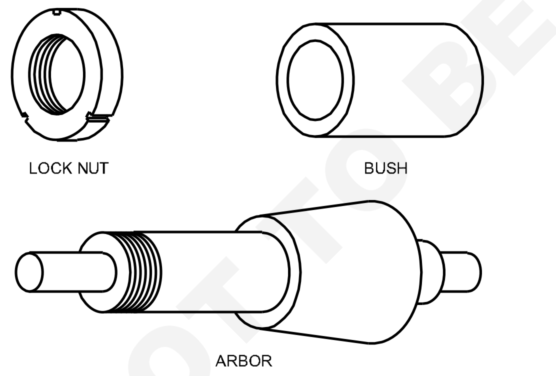
Large grinding wheels must be mounted on a balancing collet and balanced before being fitted to the grinding machine. The collect remains fitted to the wheel during use.

Fig 1



GRINDING WHEEL MOUNTED ON A BALANCING COLLET

Fig 2

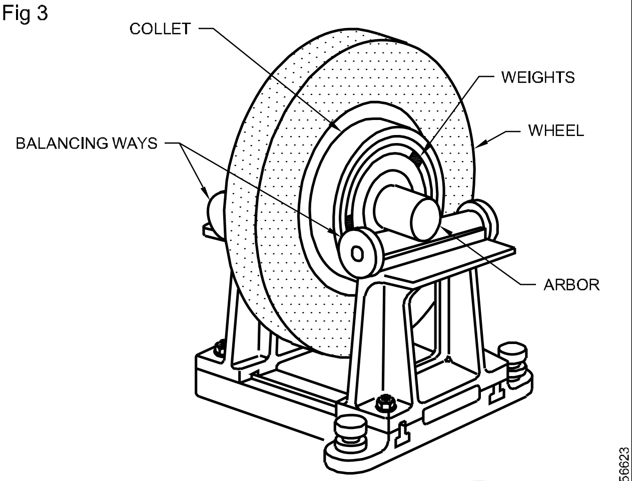


BALANCING ARBOR COMPONENTS

To balance a wheel proceed as follows (Fig 3)

- Mount the wheel on a balancing collect.
- Fit a balancing arbor to the collet.
- Remove the adjustable weight from the collet.
- Place the arbor collet and wheel assembly on a pair of balancing ways in a position near the centre of the ways.

Fig 3



GRINDING WHEEL MOUNTED ON BALANCING COLLET AND ARBOR PLACED ON BALANCING WAYS

- Ensure that the ways are perfectly horizontal.
  - Use are accurate spirit level for this if none is mounted on the ways.
- Allow the wheel to roll slowly on the ways by a very gentle push until it comes to rest. In this rest position the heavy spot of the wheel will be on the lower part of the wheel.
  - Do not push so hard that the wheel rolls off the ways.
- Make a chalk mark on the wheel at the point opposite to the heavy spot. This will be the uppermost position of the wheel when it is at rest. (Fig.4)
- Mount the balancing weights on either side of the chalk mark.
- Test as before by allowing the wheel to rotate slowly on the balancing ways, each time moving the weights a little further back from the chalk mark after the wheel comes to rest until a perfect balance is obtained.
  - The wheel is balanced when it gently comes to a stop with no tendency to roll back regardless of which portion of the wheel was the lowest at the start of the roll.
- Fix the weights in the balance position by tightening the weight set screws.
- Remove the arbor from the collect.
  - The balanced wheel with its collet assembly is now ready for mounting on the grinding machine spindle.

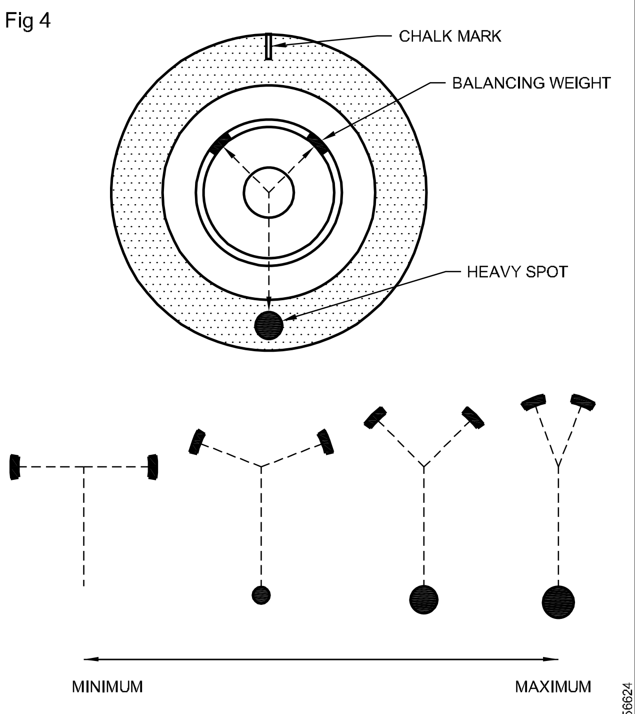
Wheels in use should be re-balanced at intervals since the balance may change with wear of the wheel.

Caution:

If a wheel is re-dressed during service, it must be re-balanced after the dressing operation.

Reasons for wheel breakage

- Increased wheel speed.



ADJUSTING BALANCING WEIGHTS TO OBTAIN MAXIMUM AND MINIMUM COUNTERBALANCE

- In correct size of bolts, nut.
- More depth of cut.
- Insufficient coolant.
- Wheel getting jammed on work.
- Wheel force fitted on spindle.
- Wheels are not checked for crack by light tapping before fitting.
- Workpiece is not hold properly (rigidly).
- Unbalanced grinding wheel is used for grinding.

Wheel storage

Grinding wheel is properly stored on edge or piled flat as per recommendations of the manufacture.

- They should be kept in dry place.
- Racks in which wheels are stored have no tendency to roll off.

Work - holding devices

Objectives: At the end of this lesson you shall be able to
- **name the work - holding devices used in grinding**
- **state the uses of each work - holding device**
- **state the purpose of a de- magnetizer.**

In grinding, different work-holding devices are used to keep the workpiece in position.

The work-holding devices used in grinding are

- magnetic chuck
- vice
- angle plates
- 'V' blocks
- sine table
- clamps and special devices (Jigs and fixtures)

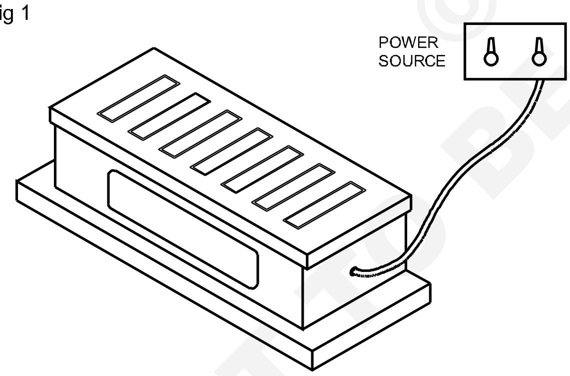
Magnetic chuck

Surface grinding work mainly used device is magnetic chuck. It can be varied according to size of the work.

Magnetic chucks are of two types

- Electromagnetic chuck
- Permanent magnetic chuck

Fig 1



Electromagnetic chuck (Fig 1)

The electromagnetic chuck is built supply of power from machine power source. There are two shapes of chucks are rectangular and circular shape. Switch on the chuck, magnetic force act and pulling power to hold the jobs.

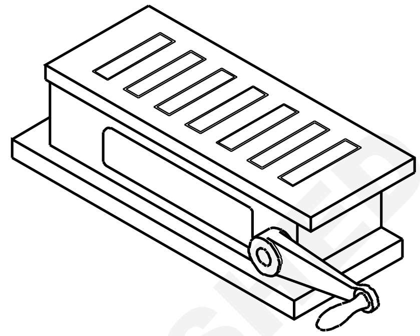
Permanent magnetic chuck (Fig 2)

This type of chuck holds the work in place by exerting a magnetic force on it. The magnetic poles of the chuck are placed nearer together so that it is possible to hold very small piece of work.

Uses

Magnetic chuck is commonly used work holding device. It hold ferrous workpiece and small workpiece also can be mounted on it.

Fig 2



MAGNETIC CHUCK

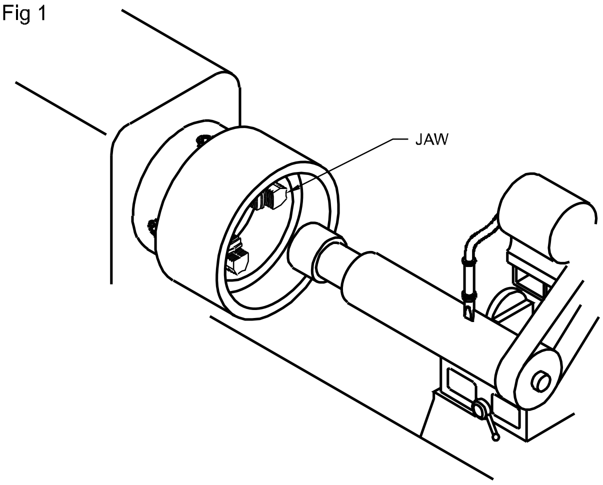
Mechanical chucks

These are used for holding short workpieces not suitable for supporting between centres. Centring of the workpiece is carried out by adjustment of the position of the radial jaws.

The jaws also clamp the workpiece in position. In a three-jaw self-centring chuck, the jaws are moved in unison by operating a key.

Three or four jaw self-centring or independent jaws may be provided. The most accurate centring of the workpiece is obtained using a four-jaw independent chuck. (Fig 2)

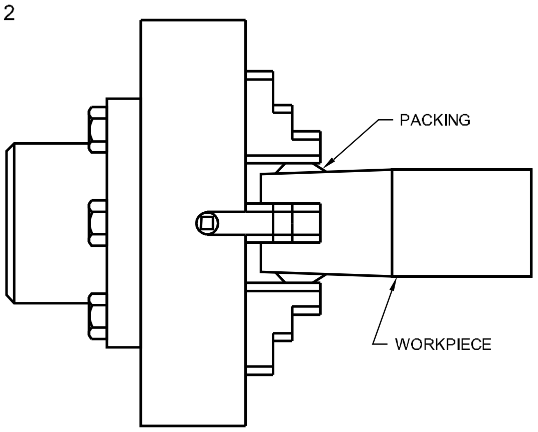
Fig 1



WORKPIECE IN A FOUR JAW MECHANICAL CHUCK
FOR AN INTERNAL GRINDING OPERATION

To protect the workpiece from damage by the jaws, or when holding tapered workpieces, packing pieces of soft metal are used. (Fig 3)

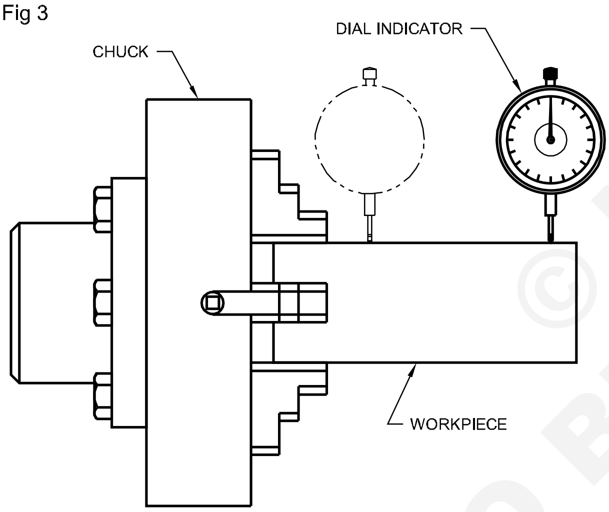
Fig 2



PACKING PIECES USED TO SECURE A TAPERED SHAFT IN A MECHANICAL CHUCK

The workpiece is set in a four-jaw chuck using a dial indicator. The dial indicator is placed in position as shown (Fig 4) and the jaws adjusted individually for minimum eccentricity, or out of true, of the workpiece. The indicator is then moved to position B as shown and the position of the workpiece in the chuck adjusted again. This process is repeated until the required accuracy is obtained.

Fig 3



SETTING CYLINDRICAL WORKPIECE IN CHUCK USING A DIAL INDICATOR

Holding in a magnetic chuck (Fig 5)

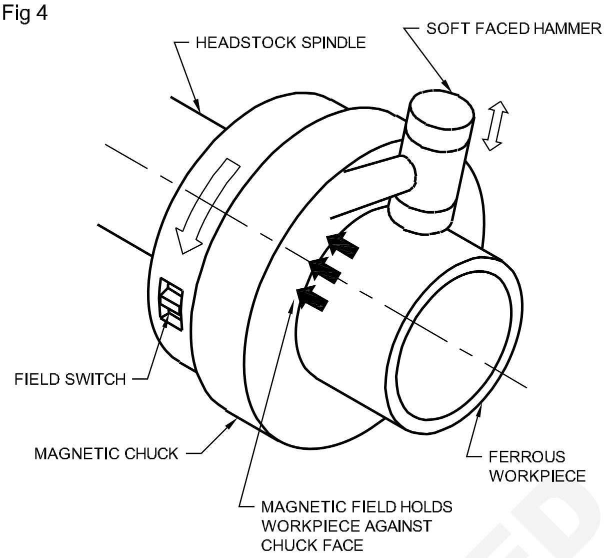
A magnetic chuck may be used to hold ferrous workpieces during cylindrical grinding operations. some magnetic chucks are designed to screw onto the headstock spindle and some to be clamped to a face plate.

The field generated by permanent magnets in the body of the chuck holds the work firmly on the chuck face.

This force is sufficient to make centring of the work difficult. A soft faced hammer may be used to carefully tap the workpiece and adjust its position as the chuck is rotated.

Holding the workpiece in a magnetic chuck is also useful where the workpiece has an unusual shape not suited to other mounting methods.

Fig 4



The face of the chuck will attract metal particles. These must be cleaned off to prevent damage to the face of the chuck and faulty centring of the workpiece.

Caution

Turn the field off before locating the workpiece. The magnetic field action is quite strong and may snatch the workpiece from your hand as you approach the chuck. Do not forget to turn the field on again before releasing the workpiece.

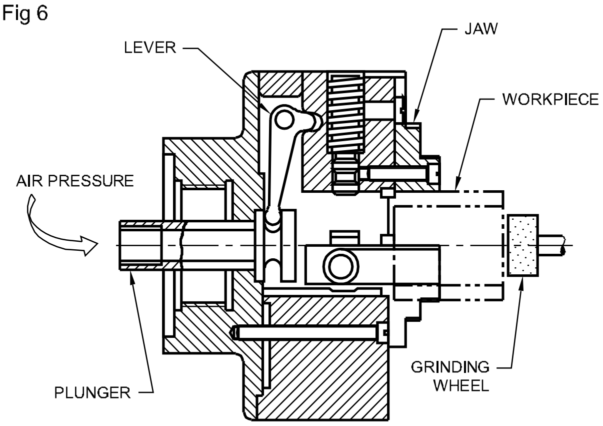
Pneumatic chucks (Fig 6)

These are similar to mechanical chucks, but movement of the jaws is controlled by air pressure. They are used with workpieces of material hard enough to withstand the high jaw pressure produced.

The pressure on each jaw is constant and setting up can be performed quickly.

The chuck jaws are moved by levers within the chuck. The levers are moved in turn by a plunger which is operated by air pressure from a source remote from the machine.

Fig 6



PNEUMATIC CHUCK HOLDING WORKPIECE FOR INTERNAL GRINDING

Spring collets

Spring collets are similar to chucks.

They are used for holding small parts where only light grinding loads are applied.

The collet has a split sleeve with a tapered conical end fitting in a similarly tapered seat. Lengthwise movement of the collet causes expansion or contraction of the workpiece gripping surfaces. This movement is made by rotating a handwheel and drawbar fitted to the collet.

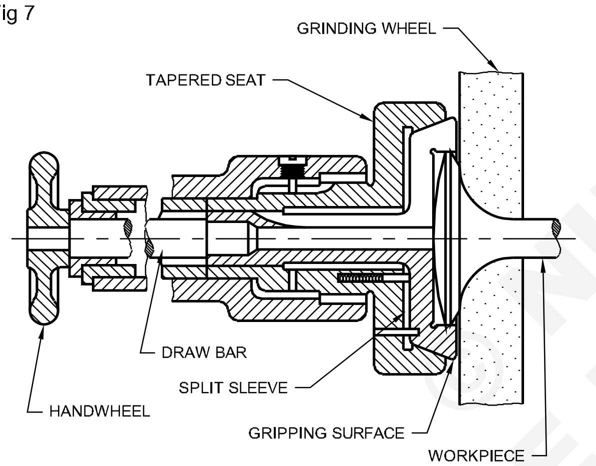
There are two types of spring collet.

- External spring collets.
- Internal spring collets.

External spring collets (Fig 7)

The workpiece gripping surfaces are arranged to grip the external surface of a workpiece in response to movement of the collet. The workpiece gripping surfaces of an external spring collet may be shaped to suit a particular workpiece.

Fig 7

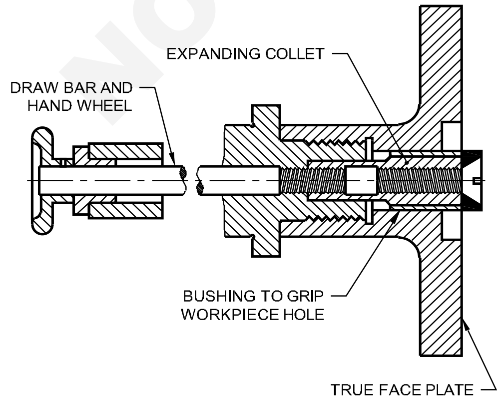


CROSS SECTIONAL VIEW OF EXTERNAL SPRING COLLET GRIPPING AN ENGINE VALVE. THE GRIPPING SURFACE HAS BEEN SHAPED FOR THIS SPECIFIC OPERATION

Internal spring collets (Fig 8)

The workpiece gripping surfaces of internal collects are arranged to grip the internal surface of a hollow workpiece. Their operation is otherwise the same as that of external spring collets.

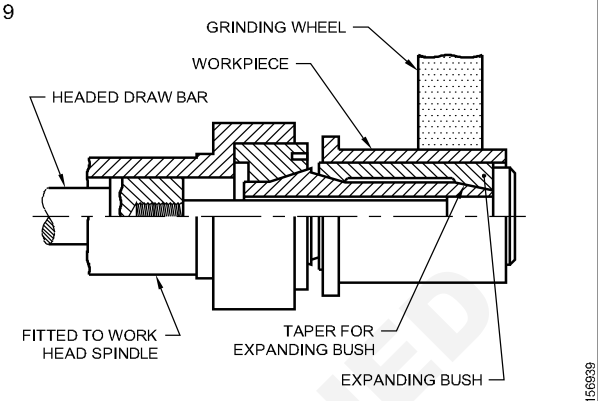
Fig 8



DRAW-IN SPLIT COLLET FOR HOLDING THIN CIRCULAR WORKPIECES

In a modified internal collet, an expansion bushing is included to grip the hole is washers, saw blades or other circular cutters. By operation of the handwheel the gripped workpiece is drawn workpiece for grinding. The bushing is removable to permit fitting of different sized bushing to the collet. (Fig 9)

Fig 9

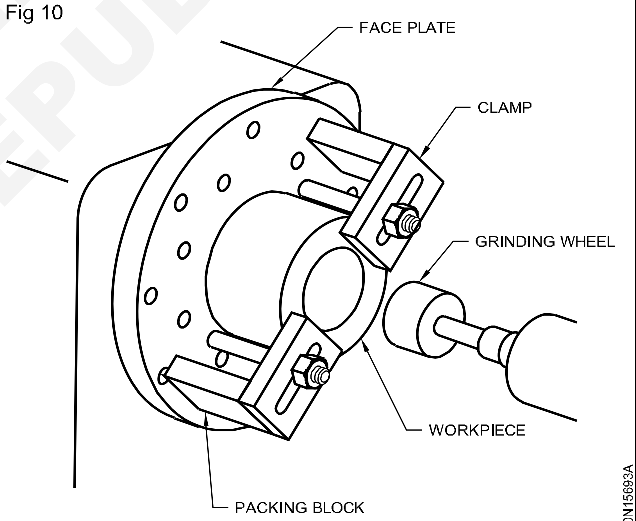


PART SECTIONAL VIEW OF INTERNAL SPRING COLLET GRIPPING HOLLOW WORKPIECE

Holding workpieces in a fixture (Fig 10)

This method is commonly used for internal grinding operations. It also has limited use in other grinding operations.

Fig 10



USE OF A FIXTURE FOR AN INTERNAL GRINDING OPERATION

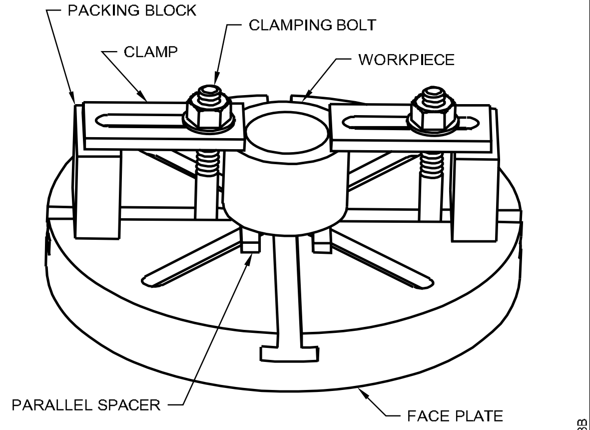
The workpiece is fixed to a machine faceplate using packing blocks and clamps. The clamps are fixed by bolts passing through the faceplate. The workpiece is centred accurately on the plate before the bolts are firmly clamped.

Caution (Fig 11)

Use the correct method of clamping. This will avoid damage to the workpiece, inaccurate grinding, machine damage and personal injury.

- **The clamp must be parallel to the face plate. Select packing blocks of the correct height.**
- **The bolts must be fixed close to the workpiece to secure it firmly.**
- **If parallel clearance blocks are used, position them clear of the path of the grinding wheel.**

Fig 11



CLAMPING WORKPIECE TO A FACE PLATE

External grinding operational steps

Objectives: At the end of this lesson you shall be able to
- **state the operational steps for external cylindrical grinding**
- **state the precaution to be taken while cylindrical grinding.**

Sl. No.	Steps	Tools used	Equipments used	Instrument / Gauges used
1	Cleaning	Banian cloth SAE 40 oil	Plain cylindrical grinder	---
2	Grinding allowance checking in workpiece	---	---	Outside micrometer
3	Table aligning at 0°	Test bar allen keys	Plain cylindrical grinder	Dial test indicator
4	Dressing (Rough grinding)	Single point diamond dresser	Grinding Wheel	----
5	Work holding	---	Plain cylindrical grinder	----
6	Stroke setting	Double ended Despanner and allen keys	Plain cylindrical grinder	----
7	Selection of speed, feed and depth of cut	---	Plain cylindrical grinder	---
8	Rough grinding	Grinding wheel	Plain cylindrical grinder	Outside micrometer
9	Dressing (Finish grinding)	Single point diamond dresser.	Grinding wheel	---
10	Finish grinding	Grinding wheel	Plain cylindrical grinder	Outside micrometer
11	Deburring	Fine abrasive oil stone	Plain cylindrical grinder	---
12	Measuring and checking	----	----	Outside micrometer and DTI

Precaution to be taken while grinding

- Always wear safety goggles.
- Ensure the safety guards properly placed.
- Before starting the machine the wheel must be inspected
- Ensure the holding devices are sufficient tightened.
- Besure to allowable clearance between hand and grindign wheel.
- Before starting of hydraulic system donot hold the job in between centre.
- If the work is heavy shut the machine down when placing the work between centers.

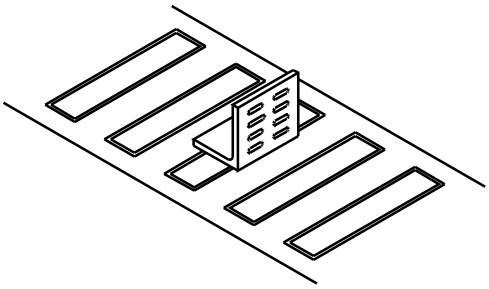
Work-holding devices jig and fixture angle plates 'V' blocks

Objectives: At the end of this lesson you shall be able to
- **name the work - holding devices used in grinding**
- **state the uses of each work-holding device**
- **state the purpose of a de-magnetizer.**

Angle plate

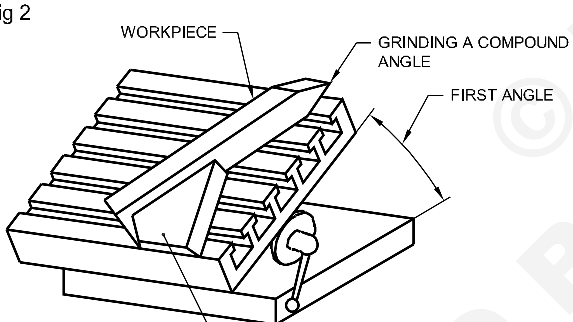
Angle plates are used to hold the workpiece while grinding, one surface perpendicular to another surface (plain type, Fig 1) or while grinding one surface at an angle to another surface (adjustable type, Fig 2)

Fig 1



ANGLE PLATE MOUNTED ON MAGNETIC CHUCK

Fig 2

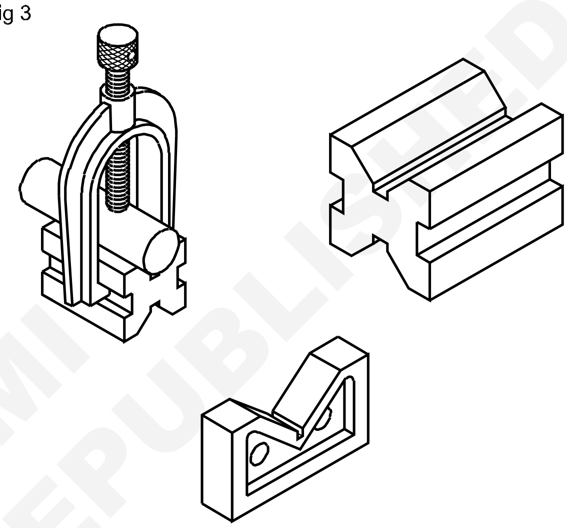


WORKPIECE SUPPORTED ON ADJUSTABLE ANGLE PLATE

'V' block (Fig 3)

'V' block are used to hold the round workpieces while grinding a flat on the workpiece.

Fig 3



'V' BLOCKS

These are used for holding tube or bar workpieces for grinding flat surfaces on the exterior. Square workpieces may also be supported in Vee blocks for grinding the external corners of the work.

Vee blocks may be attached to the work table by clamps or be set on a magnetic chuck.

Magnetic Vee blocks can be used in combination with other mounting devices, such as angle plates which themselves can be clamped to the work table or held in position on a magnetic chuck.

Jigs and fixtures

Objectives: At the end of this lesson you shall be able to
- **state the advantages of using jigs and fixtures**
- **distinguish between the functions of jigs and fixtures.**

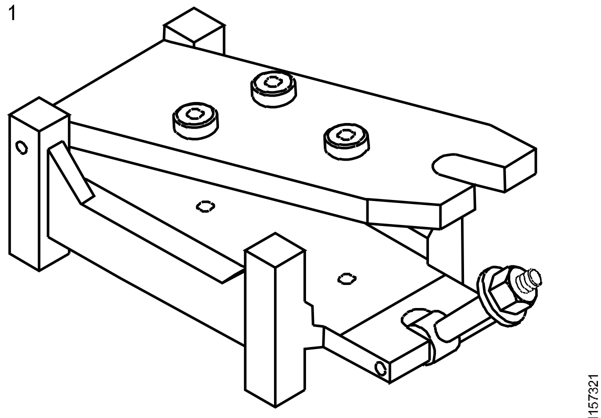
Great deal of importance is placed today on improving productivity in manufacturing processes. Application of jigs and fixtures has contributed a lot towards this direction.

Jigs and fixtures (Fig 1 and Fig 2) are devices used in manufacturing or assembling. They are facilitating in carrying out special operations accurately.

Advantages of using jigs and fixtures

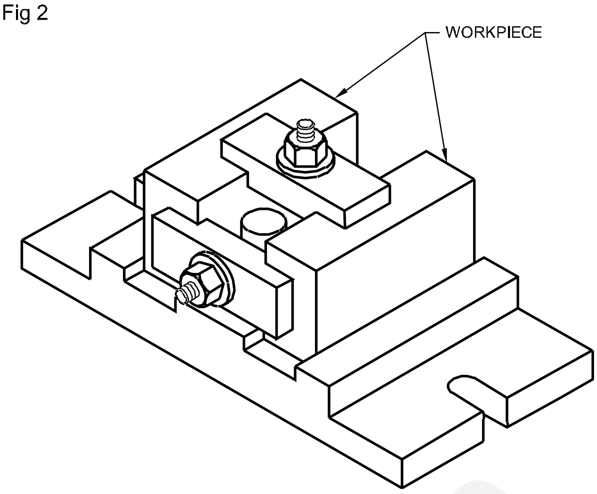
- Faster rate of production.
- Easy to perform the operations even by unskilled workers.
- Layout and marking on individual parts eliminated.

Fig 1



JIG

Fig 2



FIXTURE

Operational steps for internal grinding

Objectives: At the end of this lesson you shall be able to
- **state the operational steps for internal grinding**
- **state the out of roundness**
- **state the measuring diameters**
- **state the precautions to be taken while internal grinding.**

Operational step for internal grinding

- Check internal diameter for sufficient grind stock.
- Mount a four jaw chuck on the head strock and set the work in the chuck so that it run true
- Select the proper quill (spindle) and grinding wheel mount on the spindle unit.
- Dress the grinding wheel.
- Set the length of strock setting.
- Take trail cut removing as little strock material.
- Check the hole for straightness and make necessary table adjustment.
- Dress the grinding wheel for finishing operation.
- Finish grind to internal diameter to required size and deburr.
- Check the internal dimension with proper gauge and also check bell mouthing and out of roundness.
- Measuring the internal dimension.

Precaution to be taken while internal grinding

- Mount all internal grinding wheels with either paper or brass washers.
- Do not use internal grinding wheel without safety guard.
- Always use goggles.
- Do not use wheels in excess of 60mm diameter for internal grinding work.
- Do not try to wipe out the hole that is to be ground while the work head is in motion.
- Heavy work in grinding, the work is properly clamped.
- Clean the machine with brush.
- When setting the work table for automatic traverse, allow the wheel to over travel the workpiece in each direction.
- When starting a grinding operation make light cuts only.

State the out of roundness of the work may be grinding operations

Out of roundness - causes

– improper supporting of the work.

– Overheating of the work.

– Loose workhead spindle

– Improper clamping of work holding devices.

– Worktable, headstock wheel head not aligning.

– Using unbalanced grinding wheel.

Remedies

– Rigid the workpiece.

– Use sufficient coolant

– Tight the workhead spindle.

– Proper select and clamp the work holding devices.

– Table headstock, wheel heads are aligning at 0^{o}.

– Using balanced grinding wheel.

Measuring diameters: During precision grinding operations a constant watch must be kept to ensure that the workpiece is kept within the specified dimensional tolerances.

In cylindrical grinding operations the most important dimension is the workpiece diameter. Various devices are available for use in measuring the diameter. Selection is made according to the nature of the work and the accuracy required.

> **Warning**
>
> **Do not attempt to measure the diameter of a rotating of workpiece. This will damage the measuring instrument and could cause personal injury.**

Always allow workpiece to cool before measuring

- Checking diameters with ring gauges.
- They are used to check the external diameter of shafts rods.
- Checking diameters with plug gauges.

They are used to check internal diameters

Checking diameters with caliper gauges.

These are limit gauges also used to check diameters.

Measuring the micrometers

This is used where accuracy is required.

- Outside micrometers 0.01mm
- Vernier micrometer 0.001mm accuracy
- Inside micrometer 0.01mm accuracy

Measuring tapers

There are several ways of measuring tapers

The most common are

- Vernier bevel protractor
- Taper ring gauge
- Sine bar
- Roller with slip gauges

Indian standard system of limits & fits - terminology as per ISI: 919-1963

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

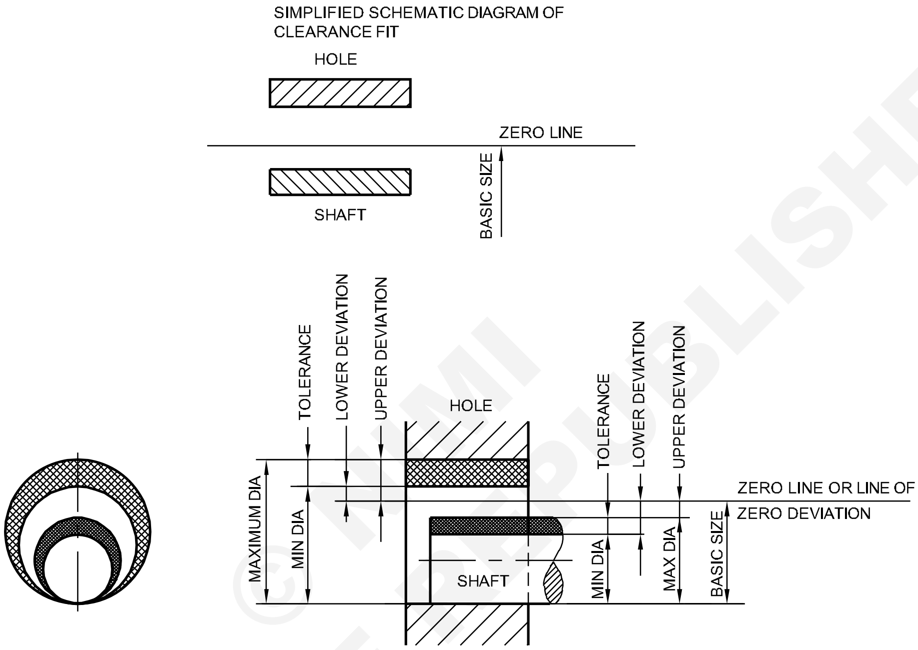
Size

It is a number expressed in a particular unit in the measurement of length.

Basic size

It is the size based on which the dimensional deviations are given. (Fig 1)

Fig 1



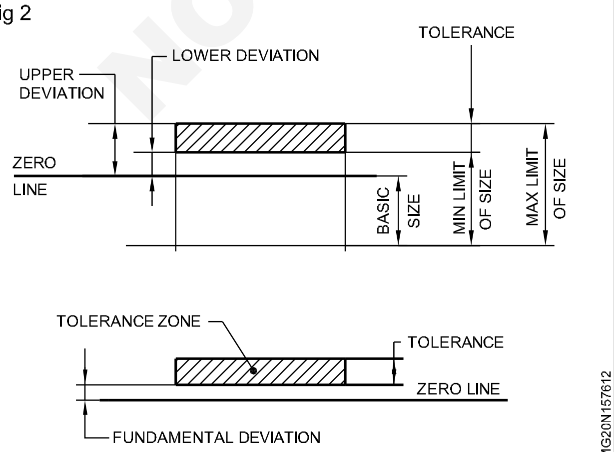
Actual size

It is the size of the component by actual measurement after it is manufactured. It should lie between the two limits of size if the component is to be accepted.

Limits of size

These are the extreme permissible sizes within which the operator is expected to make the component. (Maximum and minimum limits) (Fig 2)

Fig 2



Maximum limit of size

It is the greater of the two limits of sizes. (Fig 2) (Table 1)

Minimum limit of size

It is the smaller of the two limits of size. (Fig 2) (Table 1)

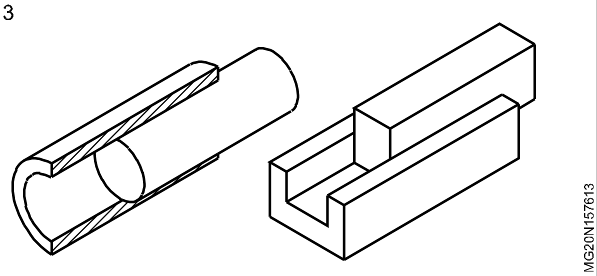
Table 1
(Examples)

S.I No.	Size of Component	Upper deviation	Lower deviation	Max.limit of size	Min,limit of size
1	+.008 -.005 20	+ 0.008	- 0.005	20.008	19.995
2	+.028 +.007 20	+ 0.028	+ 0.007	20.028	20.007
3	-.012 -.021 20	- 0.012	- 0.021	19.988	19.979

Hole

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

Fig 3



Shaft

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

Deviation

It is the algebraic difference between a size and its corresponding basic size. It may be positive, negative or zero. (Fig 2)

Upper deviation

It is the algebraic difference between the maximum limit of size and its corresponding basic size. (Fig 2) (Table1)

Lower deviation

It is the algebraic difference between the minimum limit of size and its corresponding basic size. (Fig 2) (Table 1)

Upper deviation is the deviation which gives the maximum limit of size. Lower deviation is the deviation which gives the minimum limit of size.

Actual deviation

It is the algebraic difference between the actual size and its corresponding basic size. (Fig 2)

Tolerance

It is the difference between the maximum limit of size and the minimum limit of size. It is always positive and is expressed only as a number without a sign. (Fig 2)

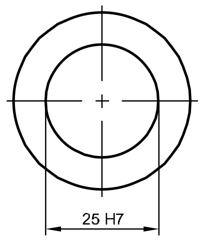
Zero line

In the graphical representation of the above terms, the zero line represents the basic size. This line is also called the line of zero deviation. (Fig 1 and 2)

Fundamental deviation

There are 25 fundamental deviations in the BIS system represented by letter symbols (capital letters for holes and small letters for shafts), i.e. for holes-ABCD....Z excluding I,L,O,Q and W. (Fig 4)

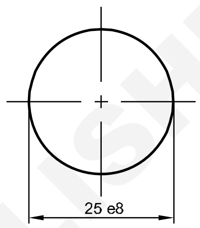
Fig 4



In addition to the above, four sets of letters JS,ZA,ZB and ZC are included.

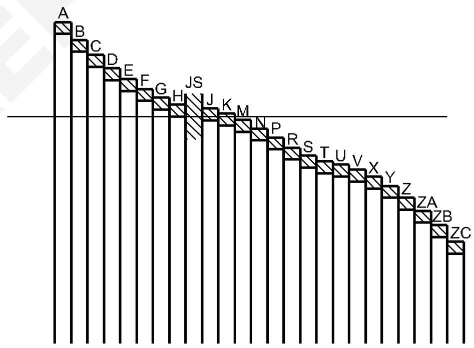
For shafts, the same 25 letter symbols but in small letters are used. (Fig 5)

Fig 5



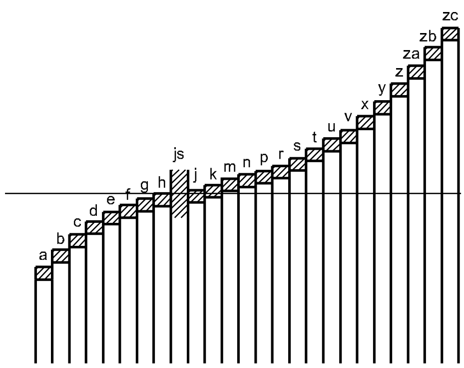
The position of tolerance zone with respect to the zero line is shown in Fig 6 and 7.

Fig 6



CAPITAL LETTERS INDICATE FUNDAMENTAL DEVIATION OF HOLES

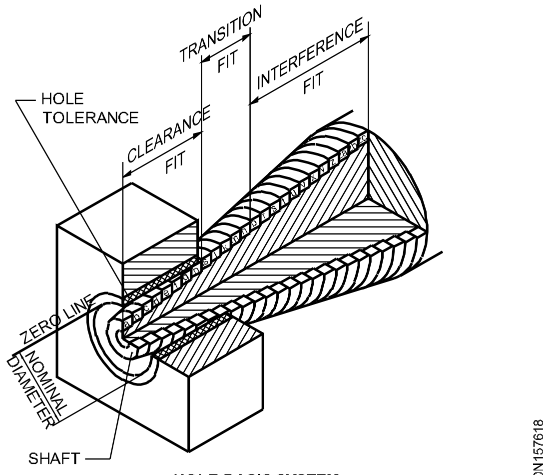
Fig 7



SMALL LETTER INDICATE FUNDAMENTAL DEVIATION OF SHAFTS

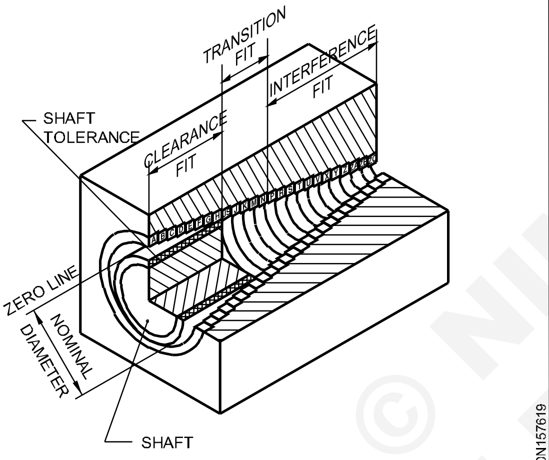
The fundamental deviations are for achieving the different classes of fits. (Fig 8 and 9)

Fig 8



HOLE BASIS SYSTEM

Fig 9

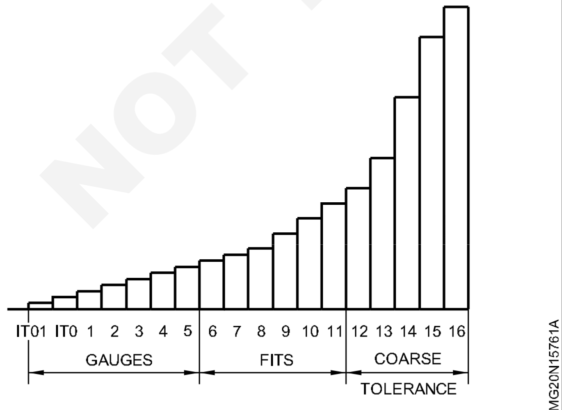


SHAFT BASIS SYSTEM

Fundamental tolerance

This is also called 'grade of tolerance'. In the B.I.S. system, there are 18 grades of tolerances represented by number symbols both for hole and shaft, denoted as IT01, IT0, IT1, IT2 .... IT16 (Fig 10)

Fig 10



A higher number gives a larger tolerance.

> **Grade of tolerance refers to the accuracy of man facture.**

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.) An extract upto 120mm is given in Table.

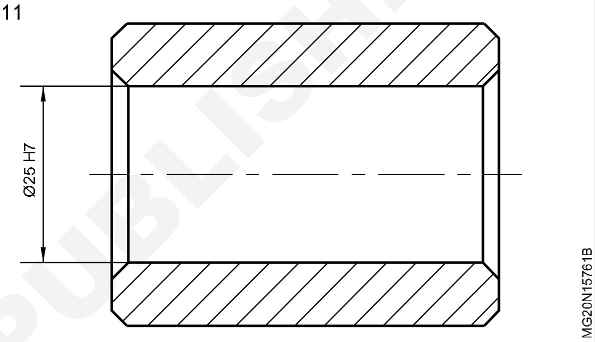
Tolerance size

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

Examples

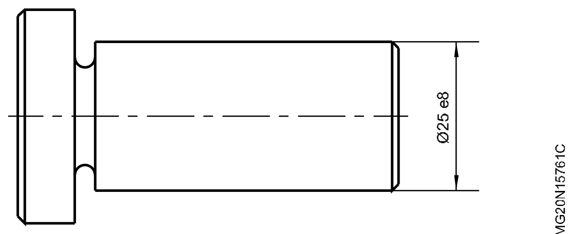
25 H7 - is the tolerance size of a hole whose basic size is 25. The fundamental deviation is represented by the letter symbol H and the grade of tolerance is represented by the number symbol 7. (Fig 11)

Fig 11



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

Fig 12



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

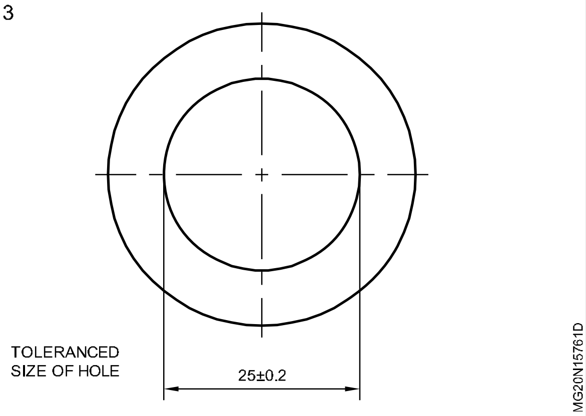
Example

In Fig 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 dimensions.

Fig 13



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

$$25 + 0.2 = 25.2 \text{ mm}$$

$$\text{or } 25 - 0.2 = 24.8 \text{ mm.}$$

25.2 mm is the maximum limit. (Fig 14)

24.8 mm is the minimum limit. (Fig 15)

Fig 14

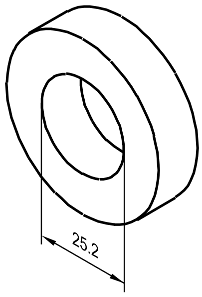
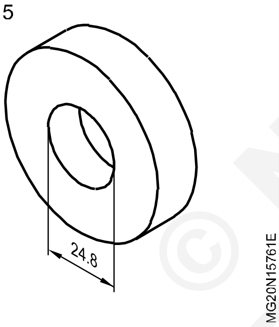
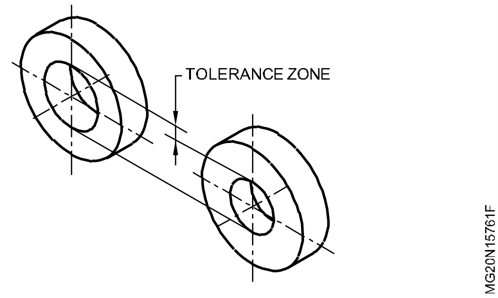


Fig 15



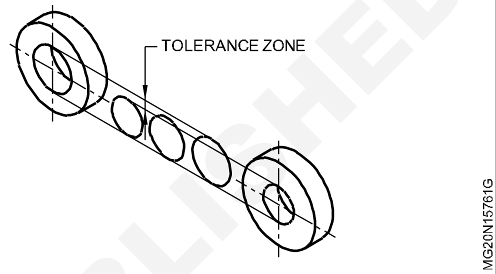
The difference between the maximum and minimum limits is the TOLERANCE. Tolerance here is 0.4 mm. (Fig 16)

Fig 15



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

Fig 16



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

Fits and their classification as per the Indian standard

Objectives: At the end of this lesson you shall be able to
- **define 'fit' as per the Indian standard**
- **list out the terms used in limits and fits as per the Indian standard**
- **state examples for each class of fit**
- **interpret the graphical representation of different classes of fits.**

Fit

It is the relationship that exists between two mating parts, a hole and a shaft, with respect to their dimensional differences before assembly.

Expression of a fit

A fit is expressed by writing the basic size of the fit first, (the basic size which is common to both the hole and the shaft) followed by the symbol for the hole, and the symbol for the shaft.

Example

30 H7/g6 or 30H7 - 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, when the hole is bigger than the shaft.

Clearance fit

It is a fit which always provides clearance. Here the tolerance zone of the hole will be above the tolerance zone of the shaft. (Fig 1)

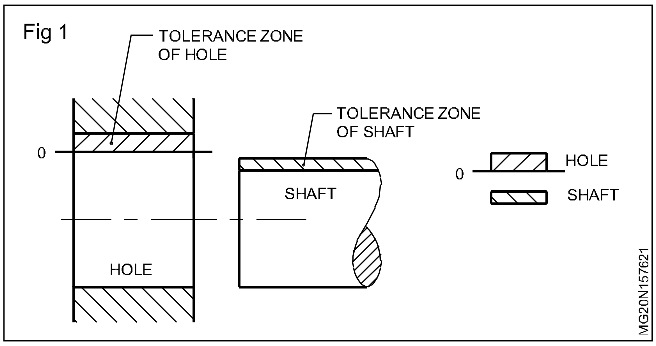


Fig 1

Example

20 H7/g6

With the fit given, we can find the deviations from the chart.

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

These numbers indicate the deviations in microns. (1 micrometer = 0.001 mm)

The limits of the hole are 20 + 0.021 = 20.021 mm and 20 + 0 = 20.000 mm. (Fig 2)

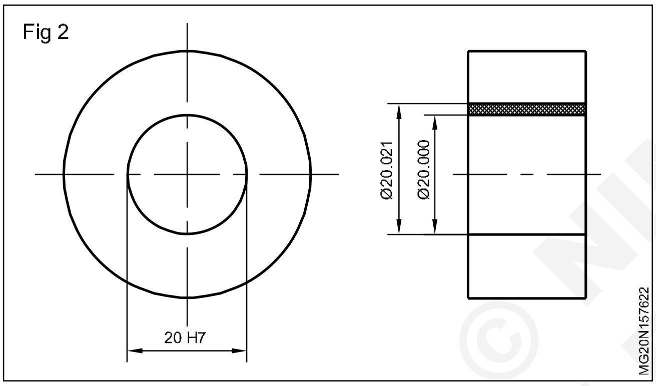


Fig 2

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 = 19.980 mm. (Fig 3)

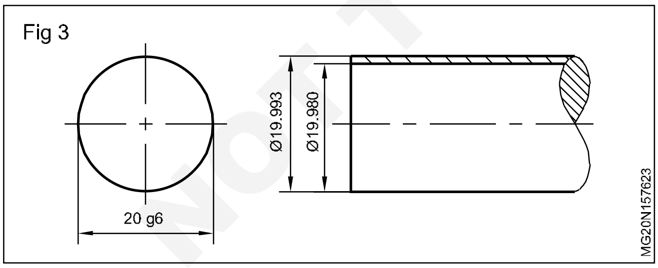


Fig 3

Maximum clearance

In a clearance fit or transition fit, the maximum clearance is the difference between the maximum size hole and the minimum size shaft. (Fig 4)

Minimum clearance

In a clearance fit, the minimum clearance is the difference between the minimum hole and the maximum shaft. Fig 4

The minimum clearance is 20.000 – 19.993 = 0.007 mm. (Fig 4)

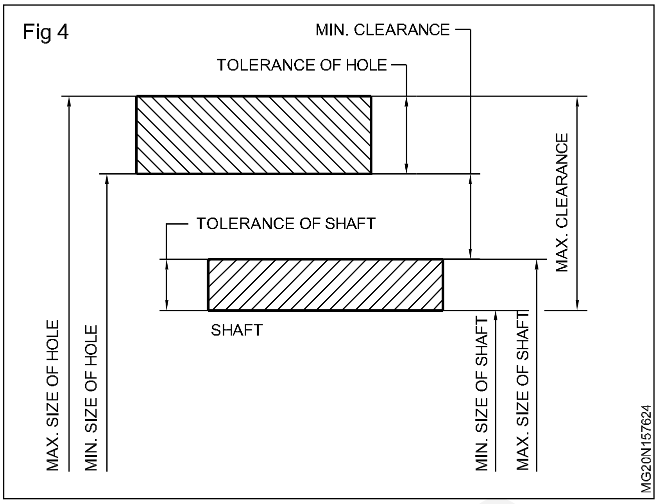


Fig 4

The maximum clearance is 20.021 – 19.980 = 0.041 mm. (Fig 4)

There is always a clearance between the hole and the shaft. This is the clearance fit.

Interference

It is the difference between the size of the hole and the shaft before assembly, and this is negative. In this case, the shaft is always larger than the hole size.

Interference fit

It is a fit which always provides interference. Here the tolerance zone of the hole will be below the tolerance zone of the shaft. (Fig 5)

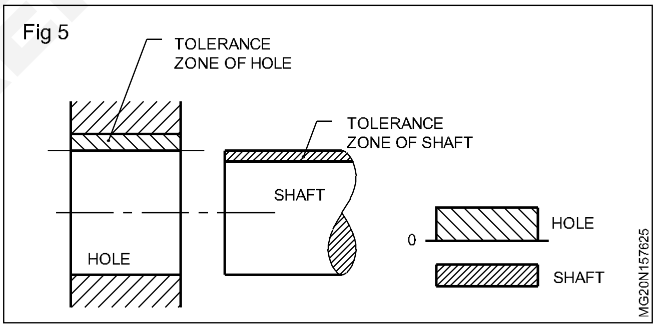


Fig 5

Example

Fit 25 H7/p6 (Fig 6)

The limits of the hole are 25.000 and 25.035 mm. and the limits of the shaft are 25.022 and 25.035. The shaft is always bigger than the hole. This is an interference fit.

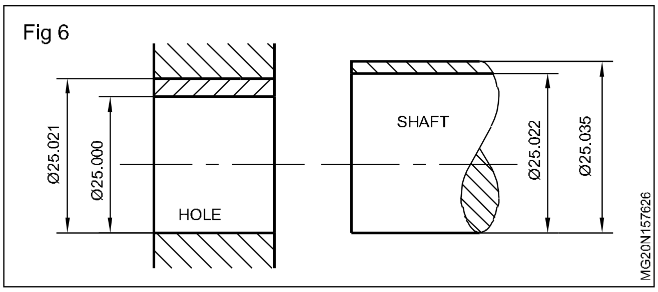
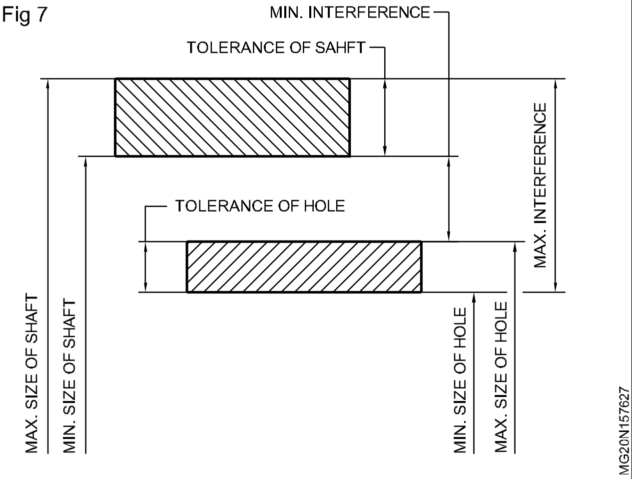


Fig 6

Maximum interference

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

Fig 7



Minimum interference

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

In the example shown in figure 6,

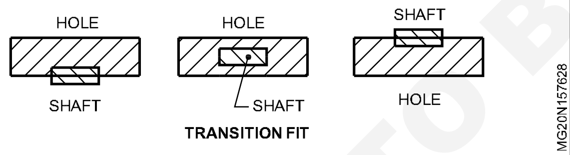
the maximum interference is = 25.035 - 25.000
= 0.035.

the minimum interference is = 25.022 - 25.021
= 0.001.

Transition fit

It is a fit which may sometimes provide clearance, and sometimes interference. When this class of fit is represented graphically, the tolerance zones of the hole and shaft will overlap each other. (Fig 8)

Fig 8



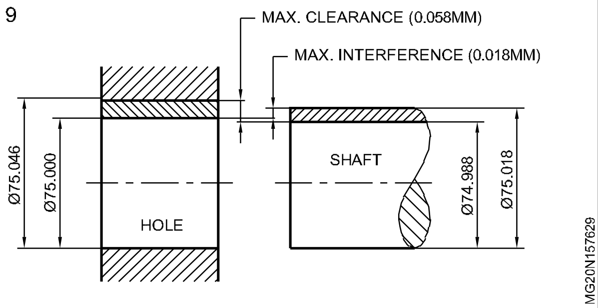
Example

Fit 75 H8/J7 (Fig 9)

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

Maximum clearnace = 75.046 - 74.988
= 0.058 mm.

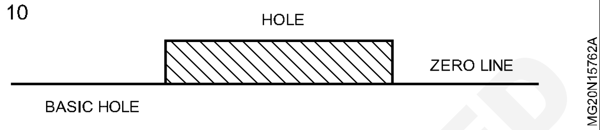
Fig 9



If the hole is 75.000 and the shaft 75.018 mm, the shaft is 0.018 mm bigger than the hole. This results in interference. This is a transition fit because it can result in a clearance fit or an interference fit.

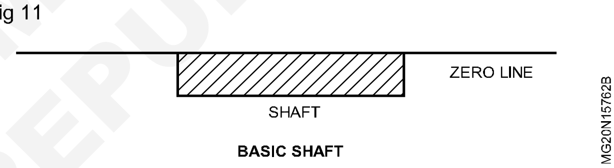
Hole basis system: In a standard system of limits and fits, where the size of the hole is kept constant and the size of the shaft is varied to get the different classes of fits, it is known as the hole basis system. The fundamental deviation symbol 'H' is chosen for the holes, when the hole basis system is followed. This is because the lower deviation of the 'H' hole is zero. It is known as the 'basic hole'. (Fig 10)

Fig 10



Shaft basis system: In a standard system of limits and fits, where the size of the shaft is kept constant and the variations are given to the hole for obtaining different classes of fits, then it is known as shaft basis system. The fundamental deviation symbol 'h' is chosen for the shaft when the shaft basis is followed. This is because the upper deviation of the 'h' shaft is zero. It is known as the 'basic shaft'. (Fig 11)

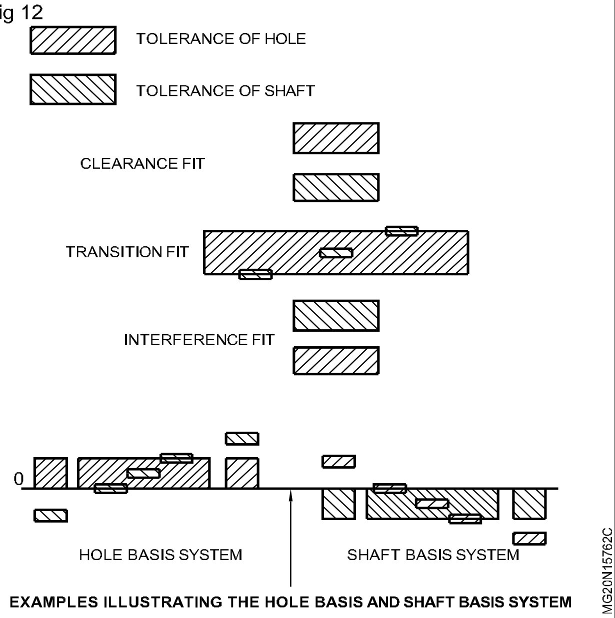
Fig 11



The hole basis system is followed mostly. This is because, depending upon the class of fit, it will be always easier to alter the size of the shaft as it is external, but it is difficult to do minor alterations to a hole. Moreover the hole can be produced by using standard tooling's.

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

Fig 12



The B.I.S system of limits and fits - reading the standard chart

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

- **refer to the standard limit system chart and determine the limits of sizes.**

The standard chart covers sizes up to 500 mm (I.S.919 of 1963) for both holes and shafts. It specifies the upper and lower deviations for a certain range of sizes for all combinations of the 25 fundamental deviations, and 18 fundamental tolerances.

The upper deviation of the hole is denoted as ES and the lower deviation of the hole is denoted as EI. The upper deviation of the shaft is denoted as `es' and the lower deviation of shaft is denoted as `ei'.

es is expanded as ECART SUPERIOR and ei as ECART INFERIOR.

Determining the limits from the chart

Note whether it is an internal measurement or an external measurement.

Note the basic size.

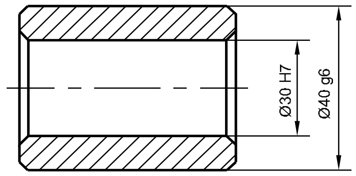
Note the combination of the fundamental deviation and the grade of tolerance.

Then refer to the chart and note the upper and lower deviations which are given in microns, with the sign. Accordingly add or subtract from the basic size and determine the limits of size of the components.

Example

30H7 (Fig 1)

Fig 1



It is an internal measurement. So we must refer to the chart for 'holes'.

The basic size is 30 mm. So see the range 30 to 40.

Look for es, and ei values in microns for H7 combination for 30 mm basic size.

It is given as +0.025
+0.000

Therefore, the maximum limit of the hole is 30 + 0.025 = 30.025 mm.

The minimum limit of the hole is 30 + 0.000 = 30.000 mm.

Refer to the chart and note the values of 40 g6.

The table for tolerance zones and limits as per IS2709 is attached.

TABLE FOR TOLERANCE ZONES & LIMITS (DIMENSIONS IN µ m)

NOMINAL SIZE RANGE mm		s6	r6	p6	n6	k6	js6	h6	h7	h9	h11	g6	f7	e8	d9	c11	b11	a11
From upto	1 3	+20 +14	+16 +10	+12 +6	+10 +4	+6 0	+3 -3	0 -6	0 -10	0 -25	0 -60	-2 -8	-6 -16	-14 -28	-20 -45	-60 -120	-140 -200	-270 -330
Over upto	3 6	+27 +19	+23 +15	+20 +12	+16 +8	+9 +1	+4 -4	0 -8	0 -12	0 -30	0 -75	-4 -12	-10 -22	-20 -28	-30 -60	-70 -145	-140 -215	-270 -345
Over upto	6 10	+32 +23	+28 +19	+24 +15	+19 +10	+10 +1	+4.5 -4.5	0 -9	0 -15	0 -36	0 -90	-5 -14	-13 -28	-25 -47	-40 -76	-80 -170	-150 -240	-280 -370
Over upto	10 14	+39	+34	+29	+23	+12	+5.5	0	0	0	0	-6	-16	-32	-50	-95	-150	-290
Over upto	14 18	+28	+23	+18	+12	+1	-5.5	-11	-18	-43	-110	-17	-34	-59	-93	-205	-260	-400
Over upto	18 24	+48	+41	+35	+28	+15	+6.5	0	0	0	0	-7	-20	-40	-65	-110	-160	-300
Over upto	24 30	+35	+28	+22	+15	+2	-6.5	-13	-21	-52	-130	-20	-41	-73	-117	-240	-290	-430
Over upto	30 40	+59	+50	+42	+33	+18	+8	0	0	0	0	-9	-25	-50	-80	-120 -280	-170 -330	-310 -470
Over upto	40 50	+43	+34	+26	+17	+2	-8	-16	-25	-62	-160	-25	-50	-89	-142	-130 -290	-180 -340	-320 -480
Over upto	50 65	+72 +53	+60 +41	+51	+39	+21	+9.5	0	0	0	0	-10	-30	-60	-100	-140 -330	-190 -380	-340 -530
Over upto	65 80	+78 +59	+62 +43	+32	+20	+2	-9.5	-19	-30	-74	-190	-29	-60	-106	-174	-150 -340	-200 -390	-360 -550
Over upto	80 100	+93 +71	+73 +51	+59	+45	+25	+11	0	0	0	0	-12	-36	-72	-120	-170 -390	-220 -440	-380 -600
Over upto	100 120	+101 +79	+76 +54	+37	+23	+3	-11	-22	-35	-87	-220	-34	-71	-126	-207	-180 -400	-240 -460	-410 -630
Over upto	120 140	+117 +92	+88 +63													-200 -450	-260 -510	-460 -710
Over upto	140 160	+125 +100	+90 +65	+68 +43	+52 +27	+28 +3	+12.5 -12.5	0 -25	0 -40	0 -100	0 -250	-14 -39	-43 -83	-85 -148	-145 -245	-210 -460	-280 -530	-520 -770
Over upto	160 180	+133 +108	+93 +68													-230 -480	-310 -560	-580 -830
Over upto	180 200	+151 +122	+106 +77													-240 -530	-340 -630	-660 -950
Over upto	200 225	+159 +130	+109 +80	+79 +50	+60 +31	+33 +4	+14.5 -14.5	0 -29	0 -46	0 -115	0 -290	-15 -44	-50 -96	-100 -172	-170 -285	-260 -550	-380 -670	-740 -1030
Over upto	225 250	+169 +140	+113 +84													-280 -570	-420 -710	-820 -1110
Over upto	250 280	+190 +158	+126 +94	+88	+66	+36	+16	0	0	0	0	-17	-56	-110	-190	-300 -620	-480 -800	-920 -1240
Over upto	280 315	+202 +170	+130 +98	+56	+34	+4	-16	-32	-52	-130	-320	-49	-108	-191	-320	-330 -650	-540 -860	-1050 -1370
Over upto	315 355	+226 +190	+144 +108	+98	+73	+40	+18	0	0	0	0	-18	-62	-125	-210	-360 -720	-600 -960	-1200 -1560
Over upto	355 400	+244 +208	+150 +114	+62	+37	+4	-18	-36	-57	-140	-360	-54	-119	-214	-350	-400 -760	-680 -1040	-1350 -1710
Over upto	400 450	+272 +232	+166 +126	+108	+80	+45	+20	0	0	0	0	-20	-68	-135	-230	-440 -840	-760 -1160	-1500 -1900
Over upto	450 500	+292 +252	+172 +132	+68	+40	+5	-20	-40	-63	-155	-400	-60	-131	-232	-385	-480 -880	-840 -1240	-1650 -2050

NOMINAL SIZE RANGE mm		S7	R7	P7	N7	K7	JS7	H7	H8	H9	H11	G7	F8	E9	D10	C11	B11	A11
From upto	1 3	-14 -24	-10 -20	-6 -16	-4 -14	0 -10	+5 -5	+10 0	+14 0	+25 0	+60 0	+12 +2	+20 +6	+39 +14	+60 +20	+120 +60	+200 +140	+330 + 270
Over upto	3 6	-15 -27	-11 -23	-8 -20	-4 -16	+3 -9	+6 -6	+12 0	+18 0	+30 0	+75 0	+16 +4	+28 +10	+50 +20	+78 +30	+145 +70	+215 +140	+345 +270
Over upto	6 10	-17 -32	-13 -28	-9 -24	-4 -19	+5 -10	+7.5 -7.5	+15 0	+22 0	+36 0	+90 0	+20 +5	+35 +13	+61 +25	+98 +40	+170 +80	+240 +150	+370 +280
Over upto	10 14	-21	-16	-11	-5	+6	+9	+18	+27	+43	+110	+24	+43	+75	+120	+205	+260	+400
Over upto	14 18	-39	-34	-29	-23	-12	-9	0	0	0	0	+7	+16	+32	+50	+95	+150	+290
Over upto	18 24	-27	-20	-14	-7	+6	+10.5	+21	+33	+52	+130	+28	+53	+92	+149	+240	+290	+430
Over upto	24 30	-48	-41	-35	-28	-15	-10.5	0	0	0	0	+7	+20	+40	+65	+110	+160	+300
Over upto	30 40	-34	-25	-17	-8	+7	+12.5	+25	+39	+62	+160	+34	+64	+112	+180	+280 +120	+330 +170	+470 +310
Over upto	40 50	-59	-50	-42	-33	-18	-12.5	0	0	0	0	+9	+25	+50	+80	+290 +130	+340 +180	+480 +320
Over upto	50 65	-42 -72	-30 -60	-21	-9	+9	+15	+30	+46	+74	+190	+40	+76	+134	+220	+330 +140	+380 +190	+530 +340
Over upto	65 80	-48 -78	-32 -62	-51	-39	-21	-15	0	0	0	0	+10	+30	+60	+100	+340 +150	+390 +200	+550 +360
Over upto	80 100	-58 -93	-38 -73	-24	-10	+10	+17.5	+35	+54	+87	+220	+47	+90	+159	+260	+390 +170	+440 +220	+600 +380
Over upto	100 120	-66 -101	-41 -76	-59	-45	-25	-17.5	0	0	0	0	+12	+36	+72	+120	+400 +180	+460 +240	+630 +410
Over upto	120 140	-77 -117	-48 -88													+450 +200	+510 +260	+710 +460
Over upto	140 160	-85 -125	-50 -90	-28 -68	-12 -52	+12 -28	+20 -20	+40 0	+63 0	+100 0	+250 0	+54 +14	+106 +43	+185 +85	+305 +145	+460 +210	+530 +280	+770 +520
Over upto	160 180	-93 -133	-53 -93													+480 +230	+560 +310	+830 +580
Over upto	180 200	-105 -151	-60 -106													+530 +240	+630 +340	+950 +660
Over upto	200 225	-113 -159	-63 -109	-33 -79	-14 -60	+13 -33	+23 -23	+46 0	+72 0	+115 0	+290 0	+61 +15	+122 +50	+215 +100	+355 +170	+550 +260	+670 +380	+1030 +740
Over upto	225 250	-123 -169	-67 -113													+570 +280	+710 +420	+1110 +820
Over upto	250 280	-138 -190	-74 -126	-36	-14	+16	+26	+52	+81	+130	+320	+69	+137	+240	+400	+620 +300	+800 +480	+1240 +920
Over upto	280 315	-150 -202	-78 -130	-88	-66	-36	-26	0	0	0	0	+17	+56	+110	+190	+650 +330	+860 +540	+1370 +1050
Over upto	315 355	-169 -226	-87 -144	-41	-16	+17	+28.5	+57	+89	+140	+360	+75	+151	+265	+440	+720 +360	+960 +600	+1500 +1200
Over upto	355 400	-187 -244	-93 -150	-98	-73	-40	-28.5	0	0	0	0	+18	+69	+125	+210	+760 +400	+1040 +680	+1710 +1350
Over upto	400 450	-209 -272	-103 -166	-45	-17	+18	31.5	+63	+97	+155	+400	+83	+165	+290	+480	+840 +440	+1160 +760	+1900 +1500
Over upto	450 500	-229 -292	-109 -172	-108	-80	-45	-31.5	0	0	0	0	+20	+68	+135	+230	+880 +480	+1240 +840	+2050 +1650

Interchangeability system

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

Mass production

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

Advantages of mass production

Time for the manufacture of components is reduced.

The cost of a piece is reduced.

Spare parts can be quickly made available.

Disadvantages of mass production

Special purpose machines are necessary.

Jigs and fixtures are needed.

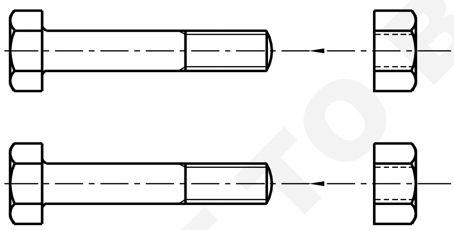
Gauges are to be used instead of conventional precision instruments.

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

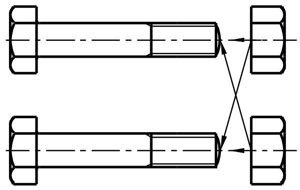
MG20N157641

Non-selective assembly

Any nut fits any bolt of the same size and thread type. Such an assembly is rapid, and costs are reduced. Maintenance is simpler because spares are easily available. (Fig 2)

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

Fig 2



NON-SELECTIVE ASSEMBLY
INTERCHANGEAB ILITY

MG20N157642

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)

Dry and wet grinding use of coolant

Objectives: At the end of this exercise you shall be able to
- **state the wet and dry grinding**
- **state difference between wet and dry grinding.**

Wet grinding

This grinding process heat generated by the friction of the wheel and work. To maintain uniform temperature of work to supply of cutting fluid continuously that the grinding method is called wet grinding.

Precision grinders like cylindrical surface centerless and internal grinders are adopted by wet grinding method.

Dry grinding

A considerable amount of metal removing by grinding without cutting fluid is called dry grinding.

Dry grinding method involves rough (Bench, pedestal flexible) tool and cutter grinders

Differentiate between wet and dry grinding

Wet grinding	Dry grinding
Coolant used	Coolant not used
Increase the depth of cut	Minimize the depth of cut
Suitable for precision grinders	Suitable for tool and cutter grinder
Good surface finish cab be possible	Rough surface possible
Closed dimensional accuracy possible	Wider dimensional accuracy possible
Chances of burning effect is less	Chances of burning effect is more
Not possible for any changes in structure.	Possible for changes of structure of the job.

Cutting fluid

Objectives: At the end of this lesson you shall be able to
- **state the purpose, advantages and characteristics of a cutting fluid**
- **state the types, functions and application of a cutting fluid.**

Purpose

During the machining process, considerable heat and friction is created. This heat and friction may result in the breakdown of the tool, poor finish and inaccurate work. In order to overcome this defect, it is essential to use cutting fluids in most machining processes. Initially tallow was used. It had only lubricating property but did not cool. Later lard oil was used because it had both lubricating and cooling properties.

Advantages

Correct selection and application of cutting fluid can have the following advantages.

- Reduces the tool wear; the tools last longer which results in reduction of tool cost.
- Helps to reduce heat and friction. Due to this, higher cutting speeds are possible for increasing the production and reducing the production cost.
- Cutting tools last longer and require less grinding. Therefore there is less stoppage of production which helps in reducing the labour cost.

Characteristics

A good cutting fluid should possess the following characteristics.

Cooling capacity

This will help in reducing the cutting temperature, increase tool life, dimensional accuracy and production.

Lubricating quality

The cutting fluid should help in preventing the metal from adhering to the cutting edge resulting in a poor surface finish.

Rust resistance

It should not cause stain, rust or corrosion to the workpiece or machine.

Relatively low viscosity

Should possess low viscosity to permit the chips and dirt

to settle quickly.

Non-inflammable

It should not burn easily, should be preferably non-combustible.

Resistance to rancidity

It should not become rancid easily.

Types

Cutting fluids generally fall into three categories. (1) Cutting oils

(2) Emulsifiable oils and

(3) Chemical (synthetic) cutting fluids.

Cutting oils

These are further classified as

(a) active

(b) inactive cutting oils.

An active cutting oil is defined as that oil which will darken a copper strip immersed in it for three hours at a temperature of 100°C.

Given below is the classification of active cutting oils and their applications.

Sulpharised mineral oils

- Good cooling and lubricating quality.
- Suitable for low carbon steels and tough and ductile metals.

Sulpho-chlorinated mineral oils

- Prevent excessive built up edges and prolong cutting tool life.
- Effective for low carbon and chrome nickel alloy steels.

Sulpho-chlorinated fatty oil blends

- Effective for heavy duty machining.

An effective cutting oil is defined as that oil which will not darken the copper strip immersed in it.

They are further classified as under according to their qualities and applications.

Straight mineral oils

- Low viscosity, faster cutting and penetrating.
- Machining of non-ferrous metals.

Fatty and mineral oil blends

- Lubricates but low cooling property.
- Severe cutting operation on non-ferrous metals.

Sulphurised mineral and fatty oil blends

- Excellent lubricity.
- Machining of non-ferrous metals to produce high surface finish.

Emulsifiable oils

Also known as soluble oils, there are mineral oils containing a soap like material which makes them soluble in water. These oils are supplied in a concentrated form. They are used when machining is done at high cutting speeds at low cutting pressure and when considerable heat is generated.

Soluble oils are available in three types for various machining conditions.

Emulifiable mineral oils

- Good tooling and lubricating quality.
- Low in cost, used for general cutting operation.

Super-fatted emulsifiable oils

- Better lubricating quality.
- Used in tougher machining operations.

Extreme pressure emulsifiable oils

- Added lubrication quality.
- Used for tough machining operations.

Chemical cutting fluids

This type of cutting fluid has been widely accepted for use. They are stable, preformed emulsions which contain very little oil, and mix easily with water.

Chemical cutting fluids are available in three types.

True solution fluids

- Rust-preventive and rapid heat dissipators.

Wetting agent type

- More uniform heat dissipation.
- Excellent lubricating quality.
- Used in machining with high speed or carbide cutting tools.

Wetting agent type with extreme pressure lubricants

- Provide boundary lubrication effect.
- Used for tough machining jobs with high speed or carbide cutting tools.

Though chemical cutting fluids have been widely used for many types of metal cutting operations, there are certain precautions which should be observed regarding their use. It is advisable to contact the supplier for the right cutting fluid for a particular machining operation and the metal being cut.

Functions

The important functions of a cutting fluid are to provide:

- cooling effect
- lubrication.

In addition, good cutting fluids increase the cutting tool life, control rust etc.

Cooling

Heat is produced during machining which results in the reduction of cutting tool life. Cooling is done for reducing the heat generated during machining. Soluble oil or chemicals which prevent rust and provide other essential qualities are added to make it a good cutting fluid.

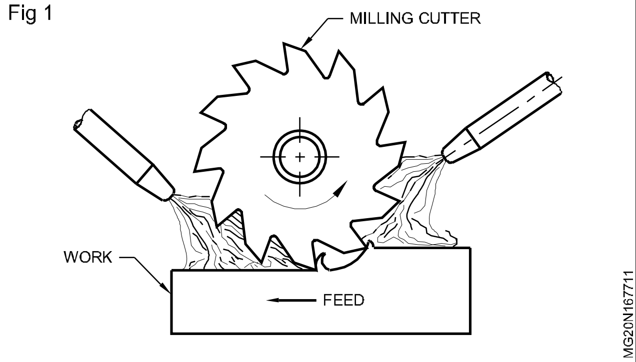
Lubrication

The lubricating function of a cutting fluid is as important as its cooling function. Lubrication helps in reducing the heat that is generated during the machining process.

Application of cutting fluids

Cutting tool life and the machining operation are generally influenced by the way the cutting fluid is applied. It should be applied under low pressure so that the work and cutting tool are well covered. The inside diameter of the supply nozzle should be about three quarters the width of the cutting tool. The fluid should be directed to the area where the chip is being formed to reduce the heat created during the machining process. (Fig 1)

Fig 1



Application of cutting fluid to milling cutters

During milling operation the cutting fluid is flooded to each side of the cutter as shown in Fig 2. A still better way of applying the fluid is to supply the fluid to both the incoming and outgoing sides of the cutters as shown in Fig 3. This serves the purpose of flushing as well as cooling.

Fig 2

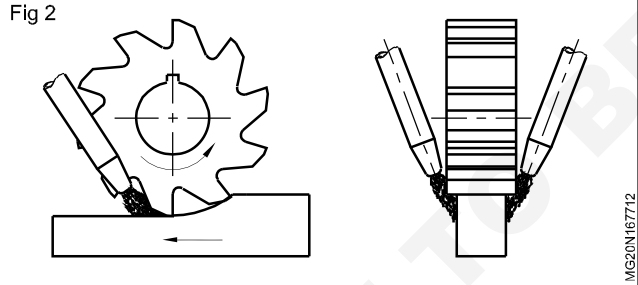
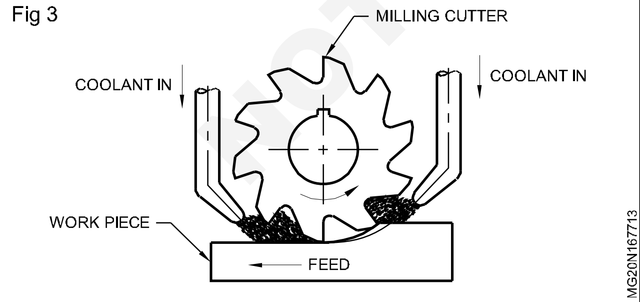
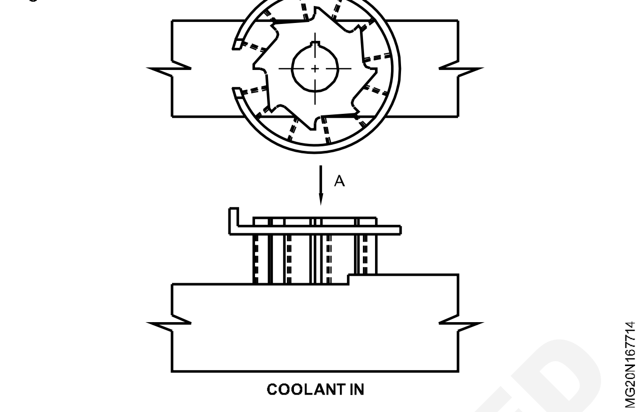


Fig 3



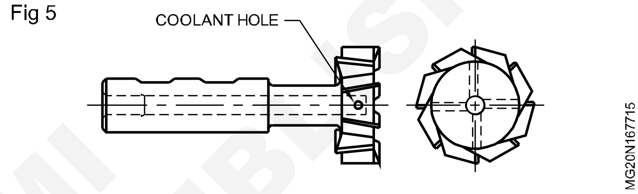
For face milling the fluid is directed at all the cutting edges by means of a ring distributor as shown in Fig 4 to ensure uniform cooling.

Fig 4



Coolant feed tools have oil holes in the shank as shown in Fig 5.

Fig 5



`T' slot milling cutter

Though these tools are not generally used on conventional milling machines, they are widely used on numerically controlled machines to facilitate optimum use of the tool and the machine.

A general guidance to the selection of cutting fluids and recommended cutting fluids for various materials are given in Table 1 and 2 respectively.

Table 1

General guidance to the selection of cutting fluids

Sl. No.	Machining process	Free machining-low carbonsteel cast iron, cast steel	Medium carbon alloy steel	High carbon alloy steel	Stainless and resistant alloys	Non-ferrous, easy machining, magnesium, zinc and aluminium alloys	Non-ferrous, tough machining, aluminium, bronze, gun-metal, nickel, copper, etc.
1	Broaching	4	5	5	5	2	2
2	Tapping and threading	3,4	4,3	4	4	6,1	6,1
3	Gear cutting	3	3	4	4	6,1	6,1
4	Thread and form grinding	3,4	4,3	4	4	-	-
5	Reaming	3,4	4,3	4	4	6	6
6	Drilling deep holes	5	5	5	5	9	9
7	Drilling,boring, turning and milling	7	7	9,7	9,7	7	8
8	Sawing	7	7	7	7	7	7
9	Grinding	7,8	7,8	8,7	8,7	7	7
10	Honing	1,2	1,2	2	2	6	6
11	Automats	1,2	1,2	2,1	2,4	6,1	6,1

1 Mild sulphurized oil

2 Mild sulpho-chlorinated oil

3 Medium sulphurised fatty oil

4 High sulpurized fatty chlorinated oil

5 High chlorinated mild sulphurised oil

6 Fatty mineral oil

7 Soluble oil

8 Translucent soluble oil

9 Heavy duty soluble oil

TABLE 2

Recommended cutting fluids for various metals

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	Dry Soluble oil Lard oil Mineral oil
Brass	Dry Soluble oil Kerosene & lard oil	Dry Soluble oil	Soluble oil Lard oil	Soluble oil	Dry Soluble oil
Bronze	Dry Soluble oil Mineral oil Lard oil	Dry Soluble oil Mineral oil Lard oil	Soluble oil Lard oil	Soluble oil	Dry Soluble oil Mineral oil Lard oil
Cast iron	Dry Air jet Soluble oil	Dry Soluble oil Mineral lard oil	Dry Sulphurized oil Mineral lard oil	Dry Soluble oil	Dry Soluble oil
Copper	Dry Soluble oil Mineral oil Lard oil Kerosene	Soluble oil Lard oil	Soluble oil Lard oil	Soluble oil	Dry Soluble oil
Malleable iron	Dry Soda water	Dry Soda water	Lard oil Soda water	Soluble oil	Dry Soda water
Monel metal	Soluble oil Lard oil	Soluble oil Lard oil	Lard oil	Soluble oil	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 lard oil
Steel (machine)	Soluble oil Sulphurised oil Lard oil Mineral lard oil	Soluble oil Mineral lard oil	Soluble oil Mineral lard oil	Soluble oil	Soluble oil Mineral lard oil
Steel (tool)	Soluble oil Sulphurized oil Mineral lard oil	Soluble oil Sulphurized oil Lard oil	Sulphurized oil Lard oil	Soluble oil	Soluble oil Lard oil

Chemical cutting fluids can be used successfully for most of the above cutting operations. When using chemical cutting fluids, it is advisable to follow the manufacturer's recommendations for use and mixture.

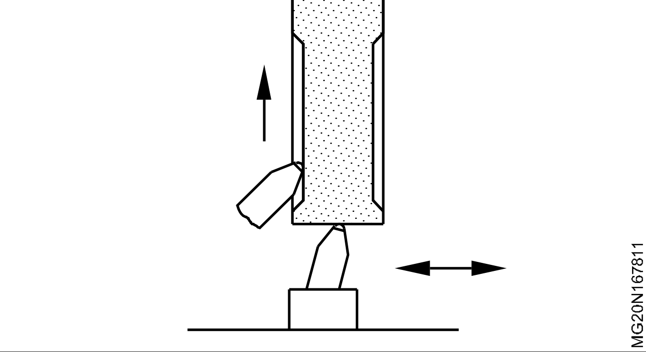
Grinding angular surface

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

- **state the procedure to grind angular surfaces using a universal vice.**

Dress the grinding wheel on the sides for relief and on the face for trueness. (Fig 1)

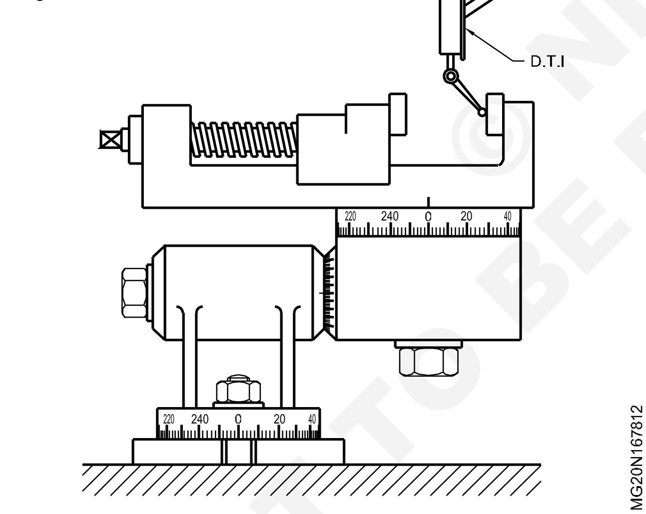
Fig 1



Clean the machine table and mount the universal vice.

Align the fixed jaws of the vice perpendicular to the axis of the spindle. (Fig 2)

Fig 2



Ensure that all the swivel base graduation coincides with 'O' degree dead mark before aligning.

Tilt the vice to 45° with reference to the graduated plate at the bottom of the vice. (Fig 3)

Clean the job and measure it to determine the grinding allowance. (Ask your instructor for help in determining the allowance).

Hold the job in the vice such that the horizontal surface to be ground is aligned parallel to the surface of the table using a dial test indicator. (Fig 4)

Position the stop dogs for longitudinal traverse.

Start the wheel and lower the wheel head until the wheel just sparks the highest spot of the job.

Fig 3

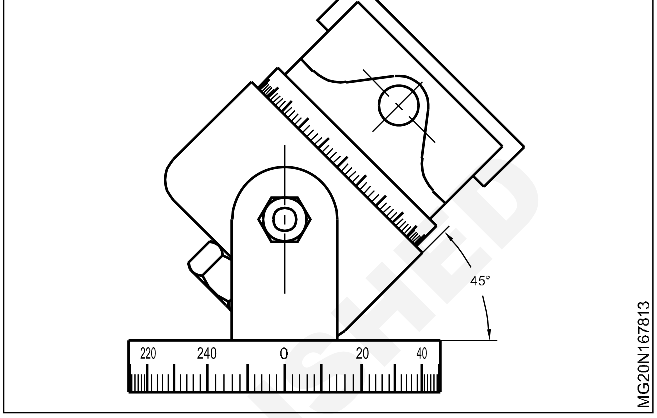
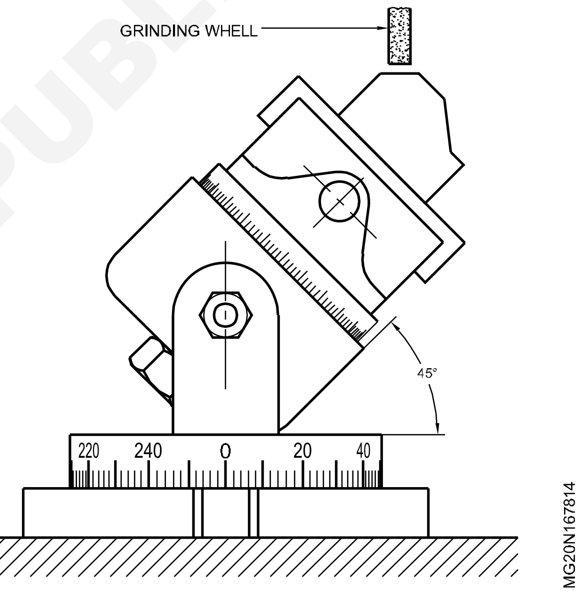


Fig 4



Start the table travelling automatically and feed the entire length of the job and clear off the job from the wheel.

Give depth and grind.

Give the cross feed manually.

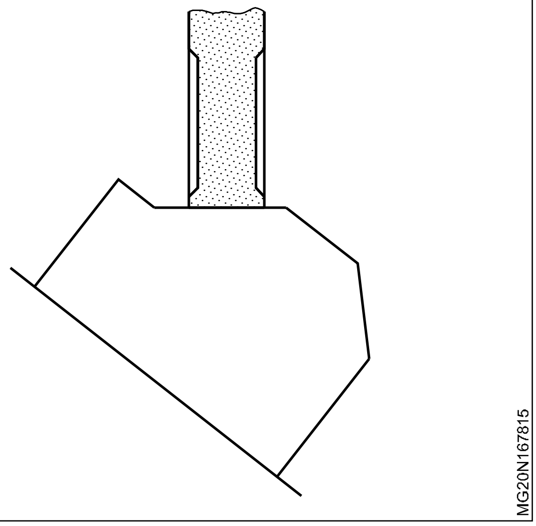
Grind the longitudinal surface up to the corner relief.

Remove only that much of material pre-determined as grinding allowance and record the amount of material removed.

Lower the wheel head to 0.20mm and without releasing the wheel, plunge the wheel little by little against the vertical surface of the job to be ground to the depth equal to the horizontal surface.

Lower the wheel gradually to finish grind the angle surface. (Fig 5)

Fig 5



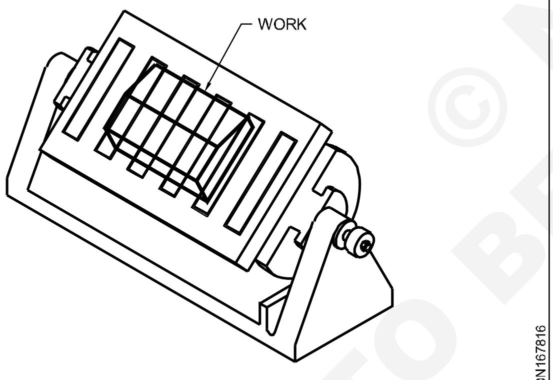
Grinding angular surface using difference methods

To grind angular surfaces it is necessary to mount the work in tilting support such as

- A sine table
- A perma sine
- A tilting vice
- A tilting table

Alternatively the wheel may be dressed to the required angle to produce the angular surface.

Fig 6



MAGNETIC CHUCK TILTED TO REQUIRED ANGLE

Using a Tilted table support.

The sine table and perma sine may be readily set to any required angle.

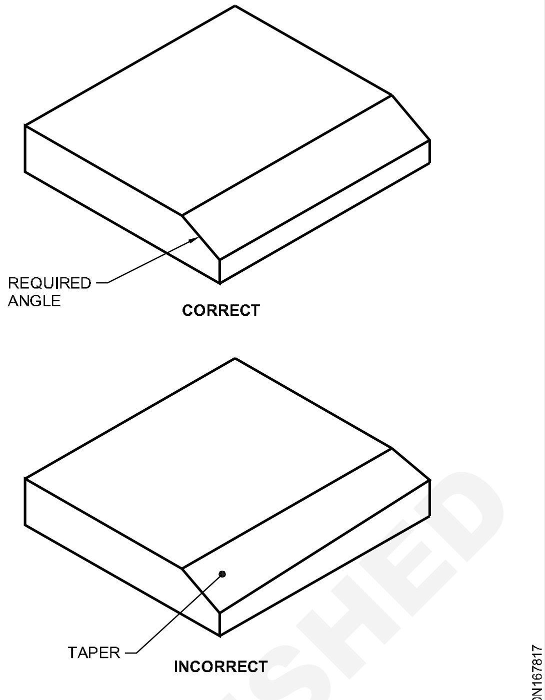
Care must be taken to ensure accuracy when setting the angle of tilt. Both the work support and workpiece must be carefully aligned on the work table.

> **Workpiece must be carefully aligned on the work table otherwise unwanted tapers may be produced. (Fig 7)**

Forming an angular surface on a grinding wheel

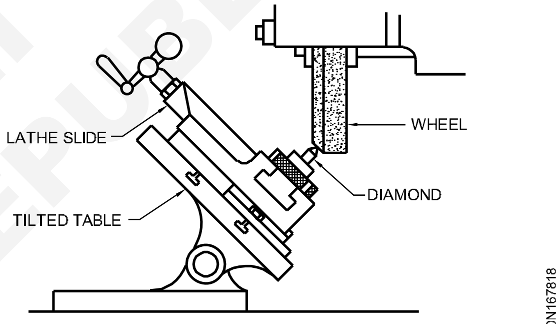
An angle may be ground using a grinding wheel which has been angle dressed to the required angle. (Fig 8&9)

Fig 7



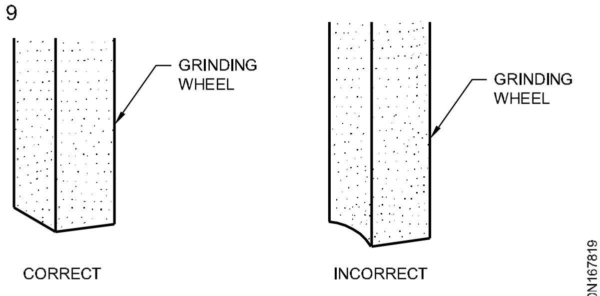
TAPER PRODUCED BY MISALIGNMENT OF WORK OF SUPPORT

Fig 8



FORM DRESSING AN ANGULAR WHEEL SURFACE

Fig 9



FACE OF WHEEL DRESSED TO AN ANGLE

The diamond dressing tool must be moved in a straight path to avoid producing a radius on the wheel surface.

Set a tilting table to the desired angle.

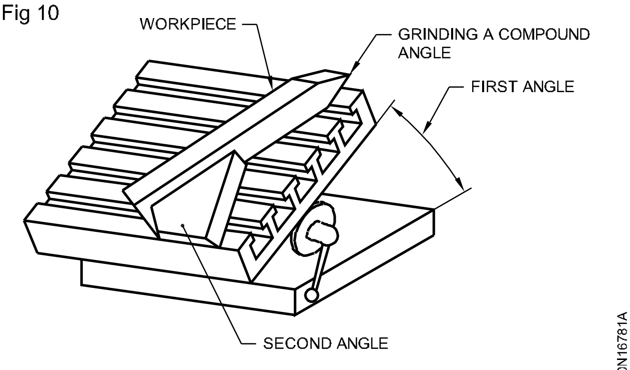
With the diamond mounted in a lathe slide on the table, carefully traverse the wheel surface to produce the required angular face.

> **Wheels are expensive and angular dressing should only be used where there is an appropriate number of workpieces to be grind or where there is no practical alternative.**

Grinding compound angle surface (Fig 10): Sometimes a taper is ground intentionally. For example, cutting tools may require tapered or compound angled faces. One of the angles is set by adjusting the support table.

The other angle is set by angling the workpiece on the table surface using standard angle pieces, or by setting and clamping.

Fig 10



WORKPIECE SUPPORTED ON ADJUSTABLE ANGLE PLATE

Glazing and loading, their effects, causes and remedies

Objectives: At the end of this lesson you shall be able to
- **state the effects of a glazed and loaded wheel while grinding**
- **state the causes and remedies for glazing**
- **state the causes and remedies for loading.**

Wheel loading

Fault	Cause	Means of rectification
Metal lodged in chip spaces of wheel or rigidly fixed on the abrasive particles	Wheel incorrect	Use a coarser grit or a more open structure to ensure sufficient chip clearance. Choose abrasive that will fracture readily. Increase the coolant supply
	Faulty wheel dressing	Use a sharper dresser, i.e. diamond; pass the tool quickly across the wheel face; wash the freshly dressed wheel with a good flow of coolant before commencing grinding.
	Coolant faulty	Increase the flow coolant. Use a cleaner coolant, also consider the use of a thinner liquid.
	Faulty operation	Alter the process technique so as to create a softer cutting wheel. Reduce the infeed.

Wheel glazing

Surface appearance	Cause	Means of rectification
Shiny appearance of the work surface	Incorrect choice of wheel	Use a coarser grit and softer grade; operate so as to give the effects of using a softer wheel
	Incorrect dressing	Keep wheel sharp, using a sharp diamond; use a fast traverse and a greater depth of infeed.
Shiny appearance of the work surface	Coolant unsatisfactory	Use a coolant containing less oil or use a greater flow of coolant.
	Faulty operation	Increase the infeed.
	Coolant oxidising or becoming gummy	Increase the soda content when using hard water Refrain from using soluble oils in hard water.

Common defects (faults) in surface grinding and their remedies

Objectives: At the end of this lesson you shall be able to
- **list out the common faults and their causes in grinding**
- **state the remedies for the faults.**

Fault	Symptom	Caused by	Remedies
Work tapered (faces not parallel)		Work not supported accurately or tightly	Check for burrs or particles between table and holding device or between device and work. Tighten.
		Work out of alignment	Align
		Face of wheel not true. Wheel glazed.	Redress wheel
Curved work surface		Work not supported firmly	Eliminate spring or movement of piece.
		Incorrect traverse setting	Adjust table traverse to allow wheel to clear at each pass
Chatter marks.	Intermittent sparking. Uneven sound.	Wheel out of balance.	Re-balance the wheel.
	Glazing of wheel.	Incorrect grade of wheel.	Change the wheel.
		Workpiece (or) workhold device loose.	Secure both properly.
		Wheel incorretly dressed.	Re-dress the wheel.
		Loose pulley on spindle.	Tighten the pulley.
	Uneven cutting and irregular sparking.	Feed too coarse.	Decrease the feed rate.
	Machine vibration.	Improper bedding down.	Report to your supervisor.
Poor surface finish.	Scratched surface.	Incorrect grain size of wheel.	Change to correct grain size.
		Dirty coolant.	Clean the tank and replace.
	Surface burnished.	Incorrect wheel grade.	Fit a correct wheel.
		Feed too coarse.	Reduce the feed.
		Cut too deep.	Decrease the depth of cut.
		Insufficient coolant.	Increase the supply of the coolant.
	Ridges.	Wheel damaged/not	Change the wheel if necessary or dress the whee

Fault	Symptom	Caused by	Remedies
Wheel wearing out too fast.	Wheel size reduced.	Wheel is too soft.	Use harder wheel.
		Grinding wheel speed lower than that recommended.	Increase the wheel speed to the recommended speed.
		Wrong rate of traverse or work speed.	Reduce the rate of traverse and work speed and decrease slightly the depth of cut.
Faces not square	Upon checking with measuring tools	Machine table out of alignment	Check alignment
		Faulty measuring devices	Check measuring equipment
Wheel spindle seems hot	---	Insufficient oil	Oil bearings

Grinding faults

Objective: At the end of this lesson you shall be able to
- **state the grinding defects and correction for cylindrical and internal grinding.**

Grinding defects for cylindrical and internal grinding

Fault	Symptom	Caused by	Correction
Chatter	Intermittent sparks uneven cutting sound.	Wheel out of balance or out of true.	Re-balance and redress wheel. True wheel before and after balancing.
	Glazed wheel	Wheel too hard fault dressing.	Check grade/Replace wheel check diamond for wear and ensure it is securely held during dressing.
	Uneven cutting sound, intermittent sparks, vibration.	Work support or rotation faulty.	Check work rests / adjust. Check centres/adjust. (Check angles, wear and fit in spindles).
	Traverse or infeed erratic	Faulty traverse.	Check hydraulic oil level.
		Incorrect operation.	Reduce wheel feed rate.
		Work vibrating.	Reduce work speed. Check workpiece balance and tightness.

Fault	Symptom	Caused by	Correction
Poor work finish	Uneven cuts. ridges on wheel	Damaged wheel.	Dress and true wheel.
	Scratches on work	Incorrect grain size. (Too coarse) Dirty coolant.	Check/change wheel. Clean tank, refile with new coolant.
	Workpiece burnishing	Wheel grade incorrect. Incorrect operation.	Check / change. Decrease in-feed. Workpiece should not be stopped when in contact with wheel.
	Work surface burned	Glazed wheel	Dress wheel
		Work speed too low	Increase
		Cut too heavy	Reduce
		Incorrect wheel	Check / Change
		Insufficient cooling	Increase supply
	Cracked work surface	Wheel to hard	Change to correct wheel
		Wheel speed too high	Reduce speed.
Inaccuracies in workpiece	Work out of round	Centres in work or in machine out of round	Re-centre work / grind centres / oil.
		Work out of balance	Re-balance
		Work springing due to excessive wheel pressure	Decrease pressure
		Worn out bearings	Have replaced
	Work tapered	Wheel face not true	True face
		Table misaligned	Reset work table
		Wheel glazed	Dress wheel
		Headstock misaligned	Align
		Tailstock misaligned	Align
		Centres inaccurate, maladjusted, dirty	Check / Adjust / Clean
		Traverse overrun	Adjust traverse. Wheel should not clear work.
		Incorrect or no supports	Check / Adjust. Use supports.

Fault	Symptom	Caused by	Correction
Rapid centre wear	Run hot, poor work finish	Rough centres. Not oiled Too tight	Clean / grind / oil and adjust.
Wheel spindle runs not or	----	Insufficient / wrong oil. Feed too heavy driving belt too tight	Check / oil reduce feed adjust / replace.
Tapered bore	Change in spark density at begin and end of bore.	Bell mouthing	Allow wheel spark out decrease size of cut or use stronger spindle.
	––	Wheel not allowed to spark out	Allow spark out before next cut.
		Work head misaligned	Check / adjust
		Table misaligned	Check / adjust
Incorrect taper	––	Work head angle incorrect	Check / adjust
	––	Table angle incorrect	Check / adjust

Tool and cutter grinder their description

Objectives: At the end of this lesson you shall be able to
- **state the purpose of a tool and cutter grinder**
- **list the types of tool and cutter grinder**
- **explain the parts and function of a tool and cutter grinder**
- **specify a tool and cutter grinder.**

In a machine shop the tool and cutter grinders are used mainly to sharpen and recondition of single point cutting tolls or multipoint cutting tools like milling cutters reamers drills, taps, wobs, dies and punches.

The cutting tools become blunt due to contain use and need re-sharpening for continued production.

Such re-sharpening is done in tool rooms where a tool and cutter grinder is used for this purpose.

Types

They are classified according to the purpose of grinding into two groups.

1 Single purpose tool and cutter grinder.

2 Universal tool and cutter grinder.

Single purpose tool and cutter grinder

This type of machine is used for re-sharpening of cutting tools such as single point tools chisels, punches, drills etc.

Universal tool and cutter grinder

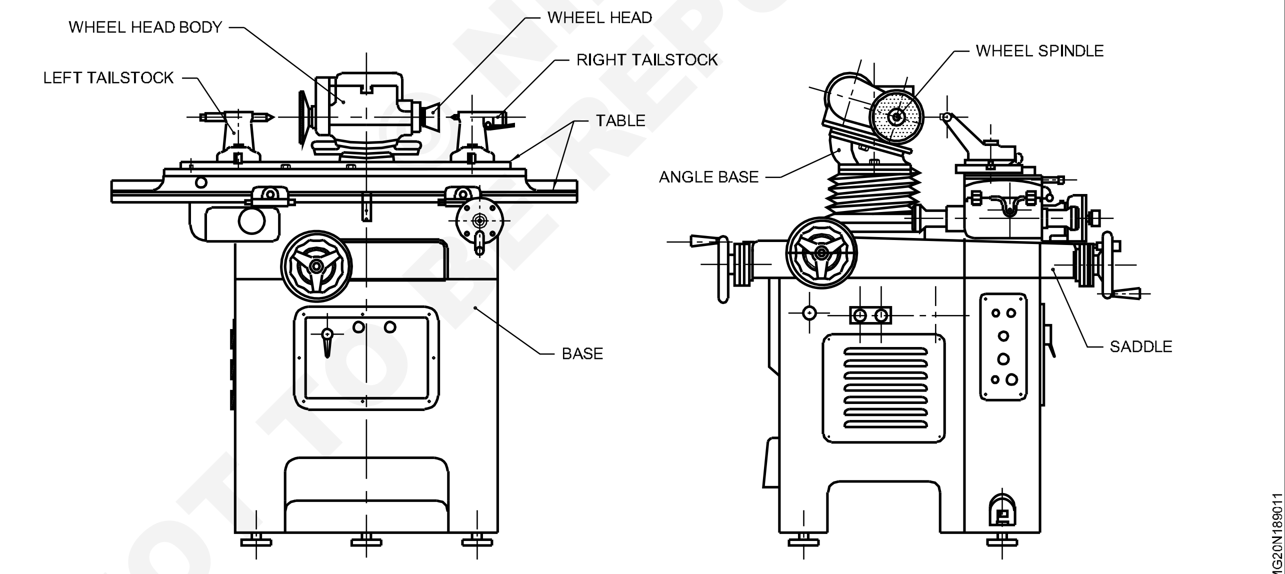
It is a precision grinder and it can be set up for a various grinding operations like surface grinding, cylindrical grinding and internal grinding as well as sharpening of all types of milling cutters.

Parts and construction of a tool and cutter grinder (Fig.1)

Base

The base is rigidity and stability to the machine it is heavy box type.

Fig 1



It supports all the other parts of the machine. The driving mechanism are filled in the body. It is made up closed grey cast iron.

Saddle

The saddle is mounted directly on the top of the base. It carries the table and traverse crosswise to the table movement.

Table

The table rests and moves on a top on the saddle, the rack and pinion mechanism which control the table movement.

The work table is mounted on the sub table which has T-slot for mounting the work and attachments used on the machines.

The work and attachments used on the machines.

The work table can be swivelled to the required angle for grinding tapers.

Column

It is on the back of the machine and it carries wheel head and moves up and down for giving the depth of cut.

Wheel head (Fig. 2)

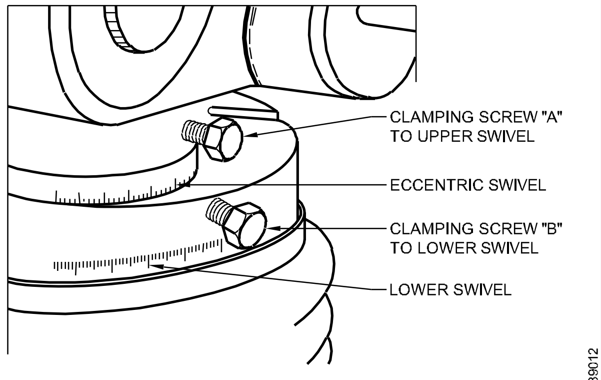
The wheel head is mounted on a double swivel able column behind the table and spindle is driven by built in individual motor through tooth grip belt.

The wheel used may be swivelled and tilting the 360°. It can be moved up and down by means of hand or power.

Specification of tool and cutter grinder

- Maximum dia. of the wheel that can be held in the spindle.
- Maximum height of the job that can be ground.
- Maximum length of the job that can be ground.
- Maximum breath of the job that can be ground.
- Type of drive
  - hydraulic
  - electrical
- Number of attachments.

Fig 2



ARRANGEMENTS OF 360° ECCENTRIC WHEEL-HEAD TO CINCINNATI No. 2 MACHINE

Factors affecting the selection of grinding wheel

Objective: At the end of this lesson you shall be able to
- **state the factors which affect the selection of grinding wheel.**

For grinding a job the right grinding wheel is to be selected. The selection of a grinding wheel will depend on the following factors.

A Factors affecting the selection of abrasive

a) Materials of high tensile strength, viz. alloy steel, hard bronzes steel and wrought iron.
 - Aluminium oxide

b) Hardened tool steel high speed steel drills cutters and for cool and precision grinding.
 - White Aluminium oxide

c) Materials of low tensile strength, viz., Aluminium, copper, cast-iron, stone ad marble.
 - Silicon carbide.

d) Tungsten arbide tipped tools
 - Green silicon carbide.

B Factors affecting the selection of grit.

a) Great amount of stock to remove - Course grain.

b) Soft and tough materials - Course grain.

c) Fine finish - Fine grain.

C Factors affecting the selection of grade

a) Hard materials - Soft wheel.

b) Soft materials - Hard wheel.

c) Great area of contact - Soft wheel.

d) Low wheel surface speed - Hard wheel.

e) Unstable and shaky foundation of grinding machine. - Hard wheel.

f) Off-hand grinding - Hard wheel.

D Factors affecting the selection of structure

a) Soft and tough material - Open structure.

b) Fine finish - dense structure.

c) Cylindrical and tool grinding - medium structure

d) External grinding - dense structure.

E Factors affecting the selection of bond.

a) General purpose and maximum cutting efficiency - vitrified

b) Wheels of very large diameter and wheels required quickly to special order.
 - silicate

c) Very thin wheel - shellac or rubber.

d) Very high finish where rapid cutting is not important - shellac or rubber

Snap gauges and sine bar

Objectives: At the end of this lesson you shall be able to
- **state what is snap gauge and list their uses**
- **state what is sine bar and list their uses**
- **explain the principle of sine bar**
- **brief the steps in checking the angles**
- **describe the slip gauges and its various sets**
- **determine the slip gauges for different sizes.**

Snap gauges are generally C-shaped and are adjustable to the maximum and minimum limits of the part being checked. When in use, the work should slide into the 'GO' gauge but not into the 'NO-GO' gauge.

Snap gauges (Figs 1& 2)

Fig 1

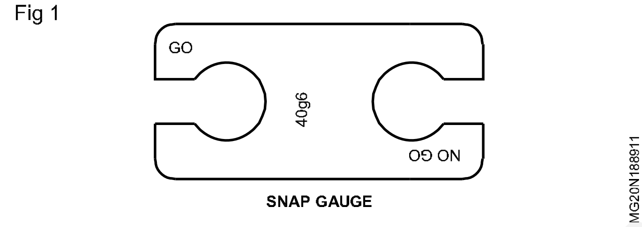
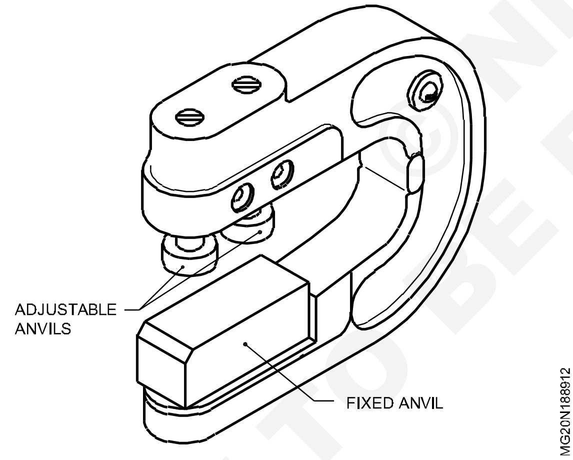


Fig 2



Snap gauges are a quick means of checking diameters and thickness within certain limits by comparing the part size, to the dimension of the snap gauge.

Sine bar

A sine bar is a precision measuring instrument for checking and setting of angles. (Fig 3)

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 4)

It may be noted that for setting the sine bar to different angles, slip gauges are used.

Fig 3

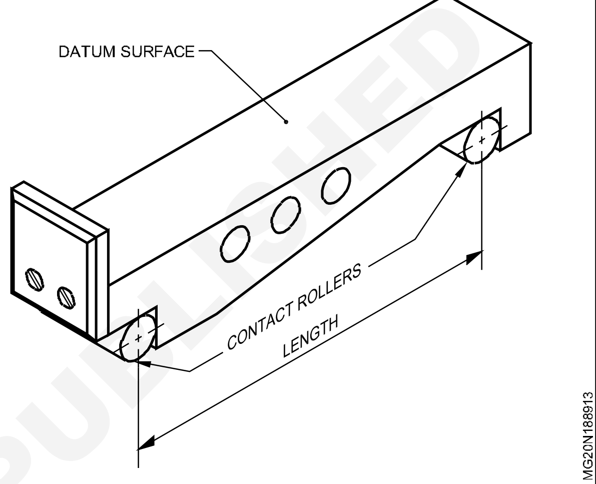
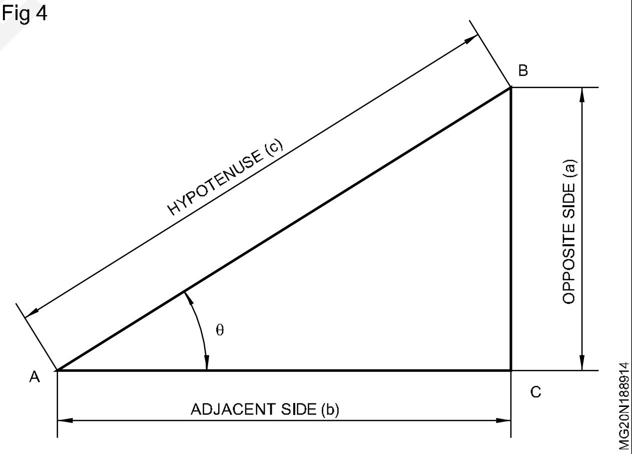


Fig 4



A surface plate or marking table provides the datum surface for the set up.

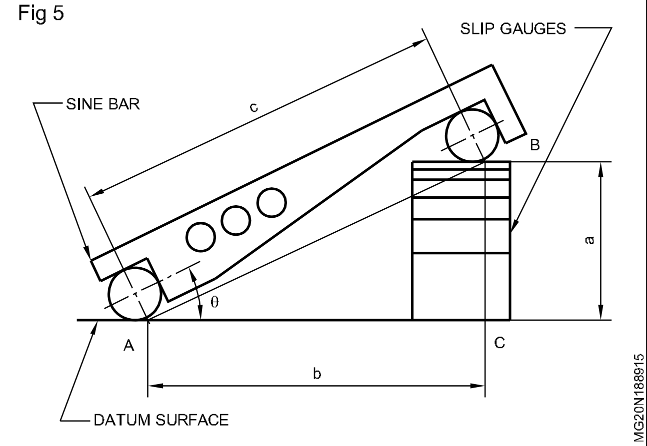
The sine bar, the slip gauges and the datum surface upon which they are set form a right angled triangle. (Fig 5)

The sine bar forms the hypotenuse (c) and the slip gauge stack forms the side opposite (a).

$$\text{Sine of the angle } \theta = \frac{\text{Opposite side}}{\text{Hypotenuse}}$$

$$\text{Sine } \theta = \frac{a}{c}$$

Fig 5



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.

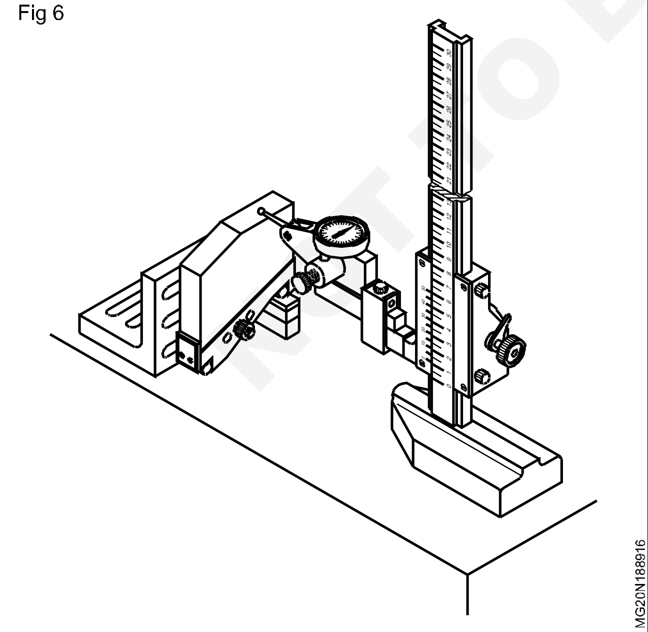
There are holes drilled across the bar. This helps in reducing the weight, and also it facilitates clamping of sine bar on angle plate.

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

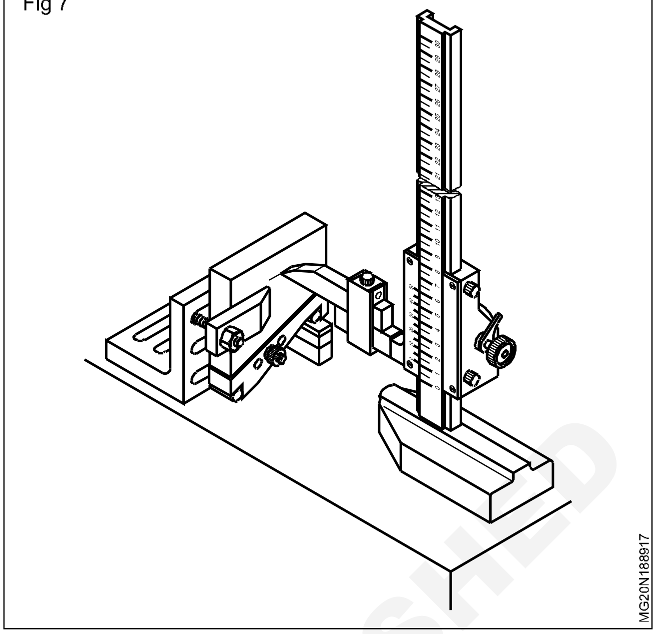
Sine bars are used when a high degree of accuracy to less than one minute is needed for

Fig 6



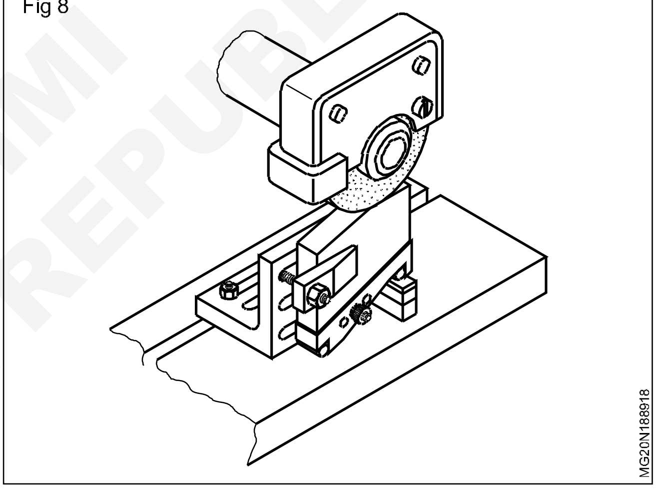
– measuring angles (Fig 4)

Fig 7



– marking out (Fig 5)

Fig 8



– setting up for machining. (Fig 6)

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 9

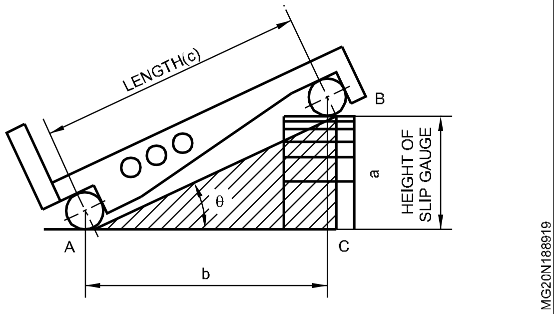
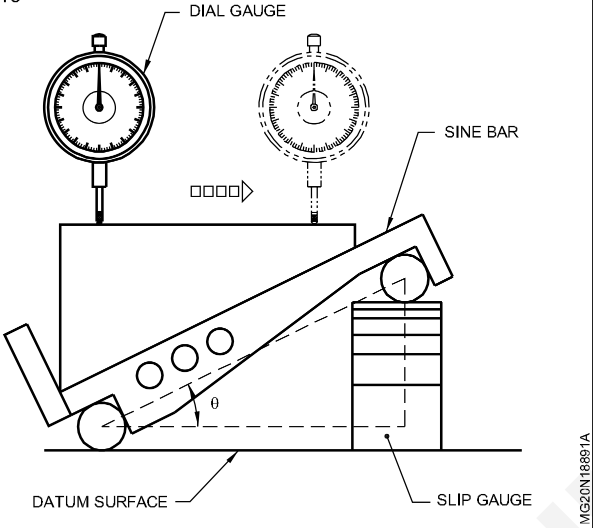


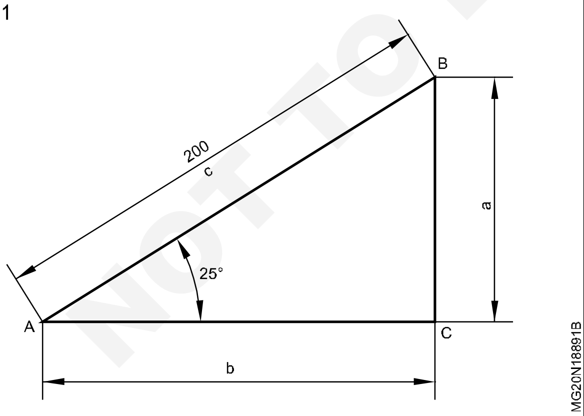
Fig 10



A dial test indicator is mounted on a suitable stand or vernier height gauge. Fig 2 The dial test indicator is then set in first position as in the figure and the dial is set to zero.

Move the dial to the other end of the component (second position). If there is any difference then the angle is incorrect. The height of the slip gauge pack can be adjusted until the dial test indicator reads zero on both ends. The

Fig 11



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)

Exercise 1

To determine the height of slip gauges for an angle of 25° using a sine bar of 200 mm long.

$$\text{Sine } \theta = \frac{a}{c}$$

$\theta = 25^0$

a = C Sine θ

= 200 x 0.4226

a = 84.52 mm

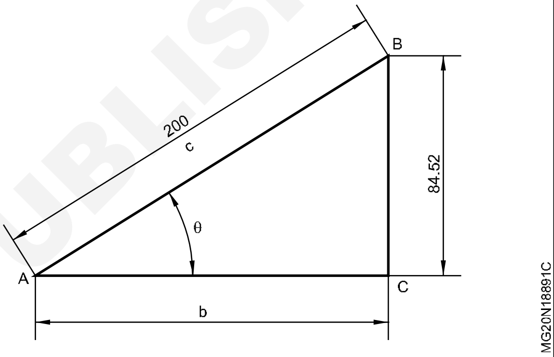
The height of the slip gauge required is 84.52 mm.

The value of sine θ can be obtained from mathematical tables. (Natural trigonometrical functions)

Tables are also available with readily worked out sine bar constants for standard sine bar lengths.

Calculating the angle for tapered components

Fig 12



Exercise 2 (Fig 4)

The height of the slip gauge used is 84.52 mm. The length of the sine bar used is 200 mm.

What will be the angle of the component? (Fig 4)

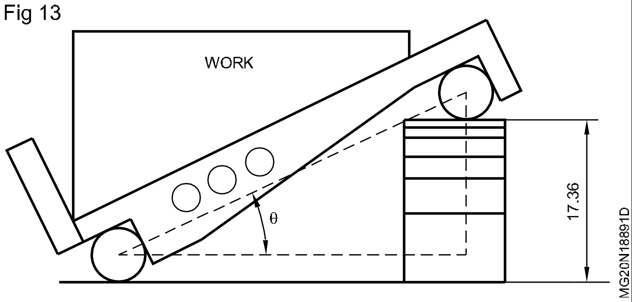
$$\text{Sine}\theta = \frac{a}{c}$$

$$= \frac{84.52}{200}$$

$$\text{Sine}\theta = 0.4226$$

The angle whose sine value is 0.4226 is 25^0. Hence the

Fig 13



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 ________________________

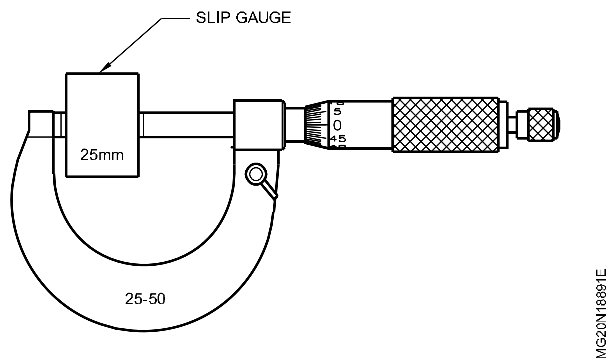
2 Calculate the height of the slip gauge pack to raise a 100 mm sine bar to an angle of 3^0 35'.

Answer ________________________

Slip gauge

Slip gauge or gauge blocks are used as standards for precision length measurement. Fig 1 These are made in sets and consist of a number of hardened blocks, made of high grade steel with very 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 14



These slip gauges are available in various sets with different numbers. (Fig 2) (Ref. Table 1)

Fig 15

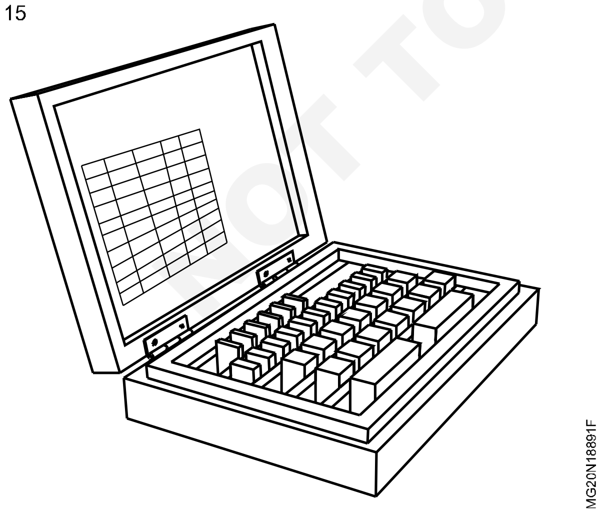


Table 1

Different sets of slip gauges

Set of 112 pieces (M112)

Range(mm)	Step(mm)	No. of pieces
Special piece 1.0005		1
1st series 1.001 to 1.009	0.001	9
2nd series 1.01 to 1.49	0.01	49
3rd series 0.5 to 24.5	0.5	49
4th series 25.0 to 100.0	25.0	4
Total pieces		112

Set of 103 pieces (M 103)

Range (mm)	Step(mm)	No. of pieces
Special piece 1.0005	–	1
1st series 1.001 to 1.49	0.01	49
2nd series 0.5 to 24.5	0.5	49
3rd series 25.0 to 100.0	25.0	4
Total pieces		103

Set of 78 pieces (M78)

Range (mm)	Steps (mm)	No. of pieces
1.0025	–	1
1.005	–	1
1.0075	–	1
1.01 to 1.49	0.01	49
0.5 to 9.5	0.5	19
10.0 to 50.0	10.0	5
75.0 & 100.0	–	5
	Total pieces	78

Set of 47 pieces (M47)		
Range (mm)	Step(mm)	No. of pieces
1st series 1.005	–	1
2nd series 1.01 to 1.09	0.01	9
3rd series 1.1 to 1.9	0.1	9
4th series 1.0 to 24.0	1.0	24
5th series 25.0 to 100.0	25.0	4
Total pieces		47

Set of 87 pieces (M87)

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	49
3rd series 0.5 to 9.5	0.5	19
4th series 1.0 to 100.0	10.0	10
Total pieces		87

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 1.1 to 1.9	0.1	9
4th series 1.0 to 9.0	1.0	9
5th series 10.0 to 100	10.0	10
Total pieces	46	

Even though there are a number of sets of slip gauges available, the popularly recommended are: M112, M87, M46, M38 and M9.

Set of 38 pieces (M38)

Range (mm)	Steps(mm)	No. of pieces
1.005	---	1
1st series 1.01 to 1.09	0.01	9
2nd series 1.1 to 1.9	0.1	9
3rd series 1 to 9.0	1.0	9
4th series 10.0 to 100	10.0	10
Total pieces	38	

Set of 86 pieces (M86)

Range (mm)	Steps(mm)	No. of pieces
1st series 1.001 to 1.009	0.001	9
2nd series 1.01 to 1.49	0.01	49
3rd series 0.5 to 9.5	0.5	19
4th series 10.0 to 100	10.0	9
Total pieces	86	

A particular size can be built up by wringing individual slip gauges together. (Fig 3 & Fig 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 made to standard thickness from higher wear-resistant steel or tungsten carbide. These are used for protecting the exposed faces of the slip gauge pack from damage while in use.

Fig 16

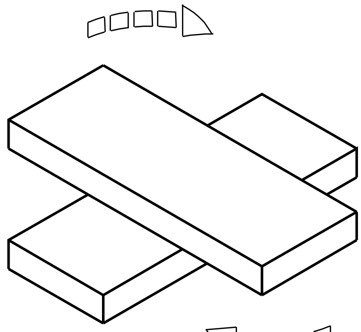
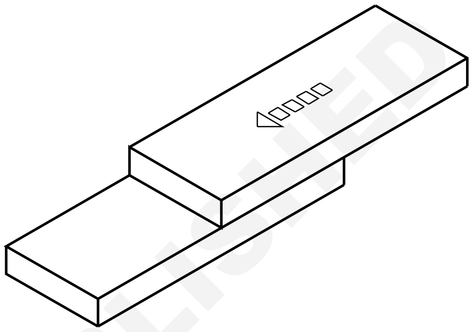


Fig 17



Grades

The following four grades of slip gauges are recommended as per IS 2984-1981.

Grade '00', grade'0'. Grade '1' & Grade '2'.

Grade '00' shall normally be used for calibration purposes. It shall not be used in combination.

Grade 0,1 and 2 are intended for general use.

Grade '0' is used only for calibration of Inspection grade '1'. Grade '1' is used in tool room and standards room. It is also used for calibration of Grade '2'.

Grade '2' is used on machines for setting purposes and on surface plate for inspection purposes in shop floor. It is also used for zero setting of precision measuring instruments in shop floor. **For further details refer IS 2984-1981.**

BIS recommendations

Three grades of slip gauges are recommended as per IS-2984. They are:

Grade '00' Grade '0'

Grade '1' Grade '2'

Care and maintenance points to be remembered while using slip gauges

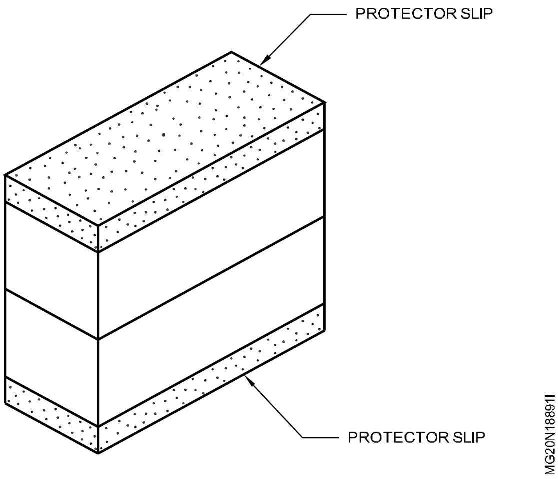
- Avoid handling the slip gauges with bear hands, since this affects the size of them due to heating.
- Use a minimum number of blocks as far as possible while building up a particular dimension.
- While building the slip gauges, start wringing with the largest slip gauges and finish with the smallest.

While holding the slip gauges do not touch the lapped surfaces.

If available use protector slips on exposed faces. Fig 5 After use, clean the slips with carbon tetrachloride and apply petroleum jelly for protection against rust.

Before use, remove the petroleum jelly with carbon tetrachloride. Use chamois leather to wipe the lapped surfaces.

Fig 18



Selection of 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.

Example (Without using protector slips) (Fig 1)

Building up a size of 44.8725mm with the help of 112 piece set. (Table 1)

Table 1

Set of 112 pieces

Range (mm)	Steps (mm)	No. of pieces
1.005	–	1
1.001 to 1.009	0.001	9
1.01 to 1.49	0.01	49
0.5 to 24.5	0.5	49
25.0 to 100.0	25.5	4
	Total pieces	112

Procedure	Slip pack	Calculation
a First write the required dimension		44.8725
b Select the slip gauge having the 4th decimal place	1.0005 subtract	1.0005

		43.872
c Select 1st series slip that has the same last figure	1.0002 subtract	1.002

		42.87
d Select the 2nd series slip that has the same last figure and that will leave .0 or 0.5 as the last figure	1.37 subtract	1.37

		41.5
e Select a 3rd series slip that will leave the nearest 4th series slip (41.5-25=16.5)	16.5 subtract	16.5

		25.00
f Select a slip that eliminates the final figure	25.0 subtract	25.00
Add	44.8725	0

Fig 1

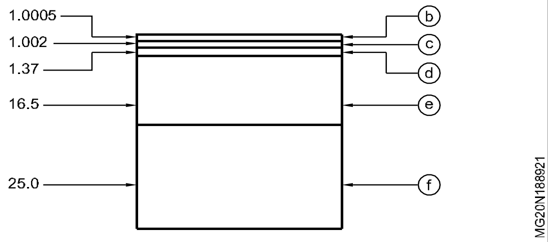
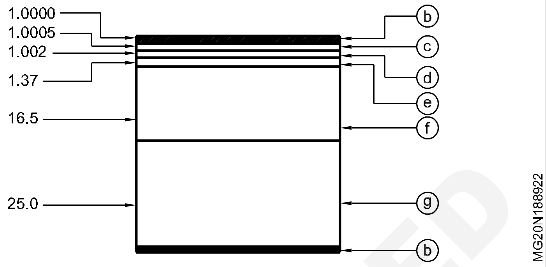


Fig 2



Example (using protector slips of 1mm thickness). The selection of slip gauges are as follows: (Fig 2)

Procedure	Slip gauge pack	Calculation
a First write the required dimension		44.8725
b Two numbers of protector slips of 1mm each	2.000 subtract	2.0000

		42.8725
c Select the slip gauge having the 4th decimal place	1.0005 subtract	1.0005

		41.8720

d	Select 1st series slip that has the same last figure	1.002 subtract	1.0020 ------- 40.8700
e	Select the 2nd series slip that has the same last figure and that will leave .0 or 0.5 as the last figure.	1.3700 subtract	1.3700 --------- 39.5000
f	Select a 3rd series slip that will leave the nearest 4th slip	16.5000 subtract	16.50000 ----------- 23.0000
g	Select a slip that eliminates the final figure	23.0000 subtract	23.0000 ---------- 0

Care and maintenance of slip gauges & sine bar

Precision measuring instruments play an important role in maintaining the quality of the products. Measuring instruments are also very expensive. It is important that the instruments are well looked after and maintained by the person who uses it.

Protection against corrosion

High atmospheric humidity and sweat from hands can cause corrosion to instruments. Avoid this.

Acid-free vaseline (petroleum jelly) applied lightly on the instruments can give protection against corrosion. (Fig 1)

Be sure that the instruments are thoroughly cleaned and free from water or moisture before applying vaseine.

Use chamois leather for giving a light coating of vaseline.

Always clean the slip gauges with carbon tetrachloride and apply petroleum jolly after use.

Polishing:

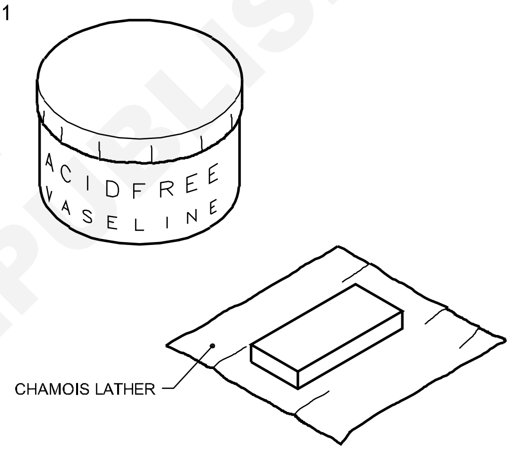
Polishing is finishing process for smoothing a workpieces surface using an abrasive and a work wheel or a leather strop.

Polishing is used to create a flat, defect-free surface for examination of a metals microstructure under a microscope. silicon based polishing pads or a diamond solution can be used in the polishing process. polishing stainless steel can also increase the sanitary benefits of it.

Polishing wheel attached to high speed polishing machines, or electric drills. Lubricants like wax and kerosene may be used as lubricating and cooling media during these operations.

The removel of oxidization (tarnish) from metal objects is accomplished using a metal polish or tarnish remover this is also called polishing.

Fig 1



Surface finishing methods

Objectives: At the end of this lesson you shall be able to
- **describe the polishing and buffing**
- **state what is lapping and brief lapping process**
- **list the various types of lapping abrassives and its uses**
- **state what is lapping vechicles and commonly used vehicles**
- **brief the emery sheet and emery cloth and uses.**

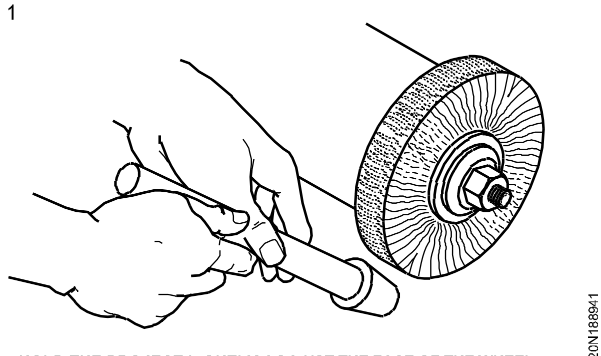
Machine Polishing and Buffing

Polishing is usually undertaken to make metals smoother or to produce a more uniform surface (Fig 1)

On the other hand, the function of the buffing operation Polishing and buffing compounds are usually divided into two broad categories is to produce a smooth, uniform surface with a high brilliant lusture.

The butting machines (Fig 2) carry a series of polishing and buffing wheels which can be adjusted to different positions so that all surfaces of the part can either be polished or buffed as required. The compounds and wheels selected are governed by the shape of the part. the material of which

Fig 1



HOLD THE PROJECT LIGHTLY AGAINST THE FACE OF THE WHEEL it is fabricated, and the required surface quality of the end product. For ordinary polishing and buffing operations, polishing and buffing wheels are mounted on floor polishing lathes.

The commonly used polishing wheels (Fig 3a & b) are constructed of canvas, muslin, felt and leather, while the buffs are flexible wheels made of cotton cloth linen flannel or wood discs.

Fig 2

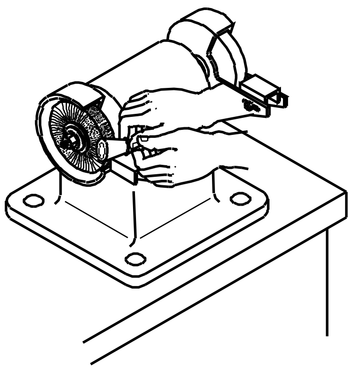
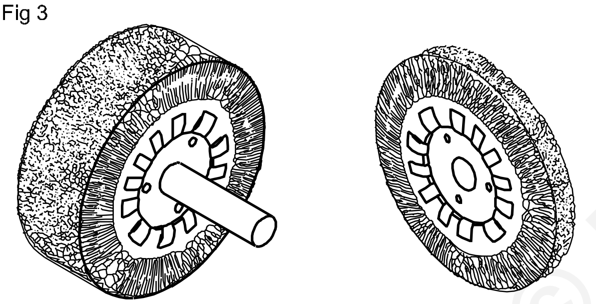


Fig 3



a) SATIN FINISH

b) TYPICAL SCRATCH-BRUSH WIRE WHEELS

Polishing and buffing compounds are usually divided into two broad categories.

- Compounds for removal of scratches and grain lines from
  previous operations, either fully or partially.
- Compounds for colouring which give the product the final bright deep and lustrous appearance.

Buffing coumpounds can either br greaseless or have a grease base.

- A greaseless compound is a mixture of glue base, a softening agent, and a mineral.
- A greaseless based compound is a mixture of oil, tallow and other bonds.

Lapping

Lapping is a precision finishing operation carried out using fine abrasive materials.

Purpose

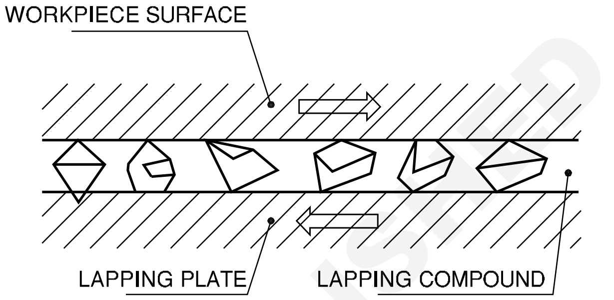
This process

- improves geometrical accuracy
- refines surface finish
- assists in achieving a high degree of dimensional
- accuracy
- improves the quality of fit between the mating components

Lapping process

In the lapping process smail amounts of material are removed by rubbing the work against a lap charged with a tapping compound (Fig 1).

Fig 1



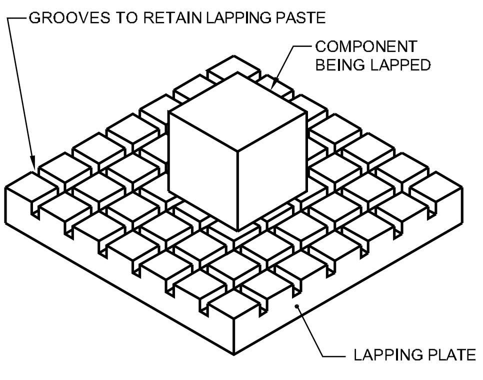
The lapping compound consists of fine abrasive particles suspended in a vehicle' such as oil, paraffin, grease etc.

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 plates 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.

These grooves are usually about 12 mm apart.

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 grey 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 abrasives 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 cared out either wet or dry.

In wet tapping there is surplus oil and abrasives on the surface of the tap As the workpiece, which is being lapped, is moved on the lap, there is movement of the abrasive particles also.

In the 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 tapped are moved over the surface with light pressure However, while lapping, the surface being lapped is kept moistened with kerosene or petrol Sur faces 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.

Lap Materials and Lapping Compounds

Objectives: At the end of this lesson you shall be able to
- **name the different types of tap materials**
- **state the qualities of different lap materials**
- **name the different types of abrasive materials used for lapping**
- **distinguish between the application of different abrasives**
- **state the function of lapping vehicles**
- **name the different lapping vehicles**
- **name the solvents used in lapping.**

The material used for making laps should be softer than the workpiece being lapped. This helps to charge the abrasives on the lap It the lap is harder than the workpiece, the workpiece will get charged with the abra sives and cut the lap instead of the workpiece being lapped.

Laps are usually made of

- close grained iron
- copper
- brass or lead

The best material used for making tap is cast iron, but this cannot be used for all applications.

When there is excessive lapping allowance, copper and brass laps are preferred as they can be charged more easily and cut more rapidly than cast iron.

Lead is an inexpensive form of lap commonly used for holes Lead is cast to the required size on steel arbor These laps can be expanded when they are worn out. Charging the lap is much quicker.

Lapping abrasives

Abrasives of different types are used for lapping

The commonly used abrasives are

- silicon carbide
- aluminium oxide
- boron carbide and
- diamond

Silicon carbide

This is an extremely hard abrasive. Its grit is sharp and brittle. While lapping, the sharp cutting edges continuously break down exposing new cutting edges. Due to this reason this is considered as very ideal for lapping hardened steel and cast iron, particularly where heavy stock removal is required.

Aluminium oxide

Aluminium oxide is sharp but tougher than silicon carbide. Aluminium oxide is used in un-tused and fused forms. Unfused alumina (aluminium oxide) removes stock ef fectively and is capable of obtaining high quality finish.

Fused alumina is used for lapping soft steels and non-ferrous metals.

Boron carbide

This is an expensive abrasive material which is next to diamond in hardness While it has excellent cutting properties, it is used because of the high cost only in specialized application like dies and gauges.

Diamond

This being the hardest of allmaterials, it is used for tapping tungsten carbide Rotary diamond taps are also prepared for accurately finishing very small holes which cannot be ground.

Lapping vehicles

In the preparation of lapping compounds the abrasive particles are suspended in vehicles. This helps to prevent concentration of abrasives on the tapping surfaces and regulates the cutting action and lubricates the surfaces.

The commonly used vehicles are

- Water soluble cutting oils
- Vegetable oils
- Machine oils
- Petroleum jelly or grease
- Vehicles with oil or grease base used for lapping ferrous metals.

Metals like copper and its alloys and other non-ferrous metals are lapped using soluble oil, bentomite etc.

Fig 1

In addition to the vehicles used in making the lapping compound, solvents like water, kerosene, etc are also used at the time of lapping.

Abrasives of varying grain sizes from 50 to 800 are used for lapping, depending on the surface finish required on the component.

Emery Clothes

Emery clothes is a fabric that is covered with a range of grades of abrasive material and is used for sanding down to eigther smooth a surface, remove deep scratches, remove and oxidised layer, or form a shape or angle.

It is manufactures Emery cloth roll (Fig 1) and Emery cloth sheet (Fig 1)

Grades

Emery is rated on the average grit size, glued to the backing. Common sizes are from course to fine.40,46,54,60,70,80,90,100,120,180,220,320 F and FF. A46 or 54 grade cloth is used on roughly filled work.While 220 to 320 grit cloth will give a good polish.

Fig 2

Special types of grinding machines

Objectives: At the end of this lesson you shall be able to
- **state centreless grinding processes/methods**
- **state the advantages of centreless grinding**
- **state the effect of setting work above and below the wheel centre.**

Methods of centreless grinding and its advantages

Through feed and infeed are the two basic methods of centreless grinding. The fundamental difference between these methods lies in the type of feeding method employed when grinding is in progress. To grind a work using the through feed method, the work is axially fed through automatically between the two wheels, kept ready set (Fig 1a) whereas in the infeed method (Fig 1b), one of the two wheels is fed against the work, which does not move

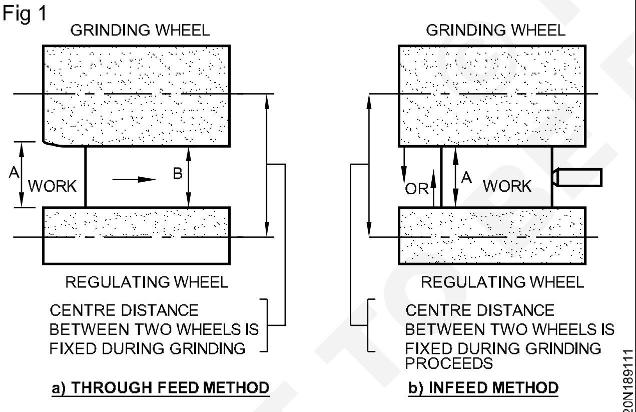
A initial diameter of the work

B Finished diameter of the work

-> Feed motion during grinding

axially during grinding. Besides through feed and infeed, there are two other methods; one of these can be said to be neither through feed not infeed, which is known as 'Endfeed' and the other one is a combination of both the through feed and infeed methods.

Fig 1



METHODS OF CENTRELESS GRINDING

Thus, there are the following four main methods of centreless grinding:

- Through feed
- Infeed
  - Plain infeed
  - Profile infeed
- End feed (neither through feed nor infeed)
- Combination of through feed and infeed

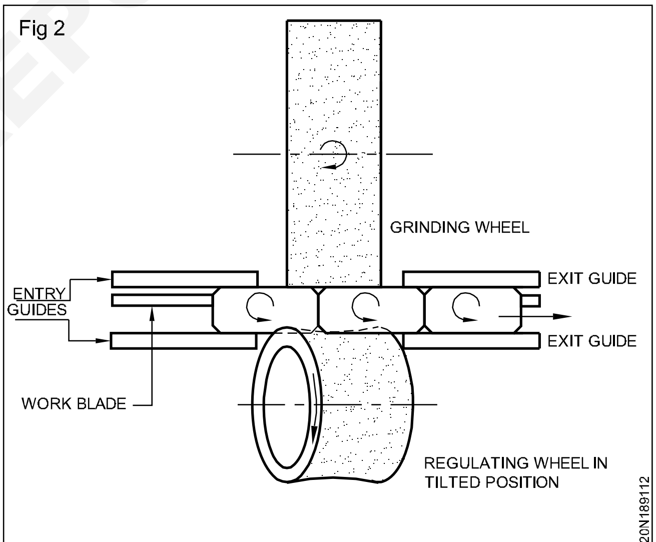
Through feed method

In the throughfeed type of grinding, the work is 'automatically' fed 'through' continuously between the grinding and the regulating wheels which have already been set with a particular gap, During its axial travel, it remains supported on the vee formed by the inclined top surface of the work blade and the regulating wheel.

Since the work has to remain or guides are necessary at the entry and exit sides of the wheel in order to support or guide the work while entering as well as while leaving the wheels. Figs 2 and 3 illustrate the set-up for throughfeed grinding. The words 'through' and 'automatic' have definite significance in expressing the following two special features of through feed grinding:

- The grinding starts as soon as the work starts entering between the already set grinding wheel and regulating wheel. The grinding operation is complete only when the work is completely 'through', i.e., when the entire work comes out of the wheels.

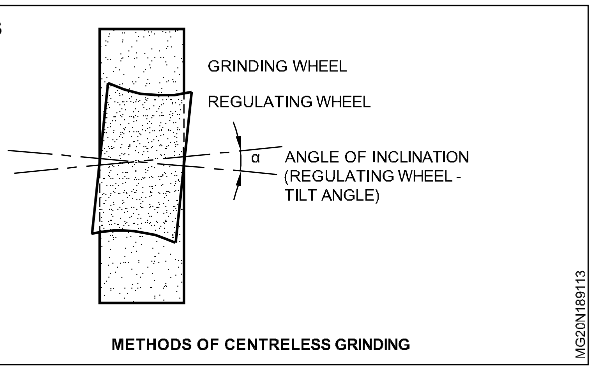
Fig 2



METHODS OF CENTRELESS GRINDING (THROUGH FEED)

- Axial feed, i.e., axial movement of the work is 'automatic' in the sense that, normally, no additional feeding mechanism is employed for this purpose. The regulating wheel, which otherwise is essential for controlling the rotation of the work, is also used for feeding the work axially by diverting a part of its rotational power for feeding purpose, by tilting it at a certain angle, called the angle of inclination (Fig 3). This will give rise to a horizontal component of rotational velocity.

Fig 3



METHODS OF CENTRELESS GRINDING

Work feed rate (Work traverse rate) F = Horizontal component of peripheral velocity at the point of contact between regulating wheel and work.

F = π d N Sin a*__________(1)

Where d = Diameter of the regulating wheel

N = Speed of the regulating wheel in RPM

a = Angle of inclination of the regulating wheel, i.e., regulating wheel tilt angle in degrees. (If d is expressed in mm, the work feed rate F will be in mm per minute). (Table 1)

TABLE 1

***Values of Sin a**

a	0°	2°	4°	5°	6°	8°
0°	.0000	.0035	.0070	.0087	.0105	.0140
1°	.0175	.0209	.0244	.0262	.0279	.0314
2°	.0349	.0384	.0419	.0436	.0454	.0488
3°	.0523	.0558	.0593	.0610	.0628	.0663
4°	.0698	.0732	.0767	.0785	.0802	.0837
5°	.0872	.0906	.0941	.0958	.0976	.1011

It can be seen from equation (1) that the work feed rate can be either increased by increasing the regulating wheel speed or by increasing the angle of inclination of the regulating wheel.

All grinding machines are either so designed that while viewed from the front, i.e., the work feeding side, when the regulating wheel is on the right hand side, it is supposed to rotate in a clock-wise direction (Fig 2), or when the regulating wheel is on the left hand side, it is designed to rotate in an anti-clockwise direction. Thus, with any one of these set -ups, the regulating wheel axis is always tilted in a vertical plane in such a way that it slopes down towards the rear so that the work travel is always from the front to the rear. Sometimes, this automatic feeding action due to a tilted regulating wheel may not be effective, if the work is very heavy. In such cases, additional feeding devices are employed.

Once set, the through feed method offers a great advantage of grinding continuously one work piece after another, requiring practically no attention as long as the work pieces coming out are within the required tolerance limits of size and surface finish.

The through feed is thus the quickest method of production it is most widely used in preference to other methods of grinding.

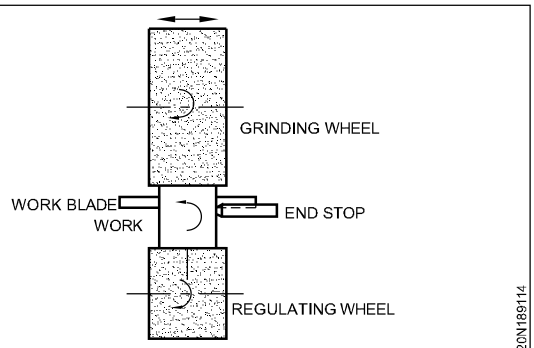
Through feed grinding limitations

- The use of the through feed method of centreless grinding is normally limited to grinding of plain cylindrical work. However, by using a special loading attachment and a specially formedregulating wheel, taper rollers can be ground quite satisfactorily on a production basis by utilising the through feed principles.
- If stock removal-required is high then it may not be possible to remove all the stock in a single pass, because in the through feed set-up the amount of cut is fixed for a particular pass; and for any additional cuts, additional through feed passes will be necessary. Thus, for a limited number of work pieces requiring heavy stock removal, the through feed method .

Infeed (plunge cut) method

In this type of grinding, the work does not move axially as in the through feed method, but it is kept supported against an end stop In a fixed position and resting in the vee formed by the inclined top surface of the work blade and the regulating wheel, as shown in Figs 4 and 5b. Grinding action is affected by feeding gradually either the regulating wheel or the grinding wheel on to the work.

Fig 4



METHODS OF CENTRELESS GRINDING (INDEED)

When the work diameter approaches the required diameter, the feeding movement of the wheel is stopped. After allowing the work to be ground for a short time in this fixed set-up, one or both of the wheels are withdrawn to facilitate unloading of the ground work by pushing it backward or forward or by lifting it up or dropping it sideways. The next work piece is then placed in position against the end stop and the same cycle of operation is repeated for grinding it.

Because the work does not require axial feeding while using the infeed method, it is not necessary to tilt the regulating wheel from the theoretical point of view. However, in practice, even in Infeed grinding, the regulating wheel is given a certain tilt angle, not exceeding I/4°, to keep the work always pressed against the fixed end stop.

Sometimes, to obtain a better surface finish, an oscillating attachment is provided on the machine which gives an axial oscillating motion to the grinding wheel during the infeed grinding. The amplitude of the grinding wheel oscillation may be about 2 mm to 6 mm.

Depending upon the wheel motions available on a particular machine, the type of work and the type of loading and unloading devices employed, different sequences of operations are followed for infeed grinding.

Sequence of infeed grinding operations on a machine where grinding wheel is fixed and only regulating wheel is moveable.

Many makes of machines, such as, the Cincinnati, Churchill, Wickman-Scrivener, efc., have their grinding wheel headstock rigidly fixed to the bed and only the regulating wheel headstock is moveable. In such cases, the regulating wheel headstock is mounted on two moveable slides, the upper and the lower. The work rest and the upper slide carrying the regulating wheel headstock are fitted to the lower slide, as shown in Fig 5a. The sequence of infeed grinding operations on such machine is described below.

- Fig 5a shows the work set in position before grinding. The upper slide carrying the regulating wheel headstock is locked by means of lever M to the lower slide carrying the work rest. Thus, the regulating wheel, the work and the work rest can all be moved as one unit on the machine bed by operating the hand wheel of the regulating wheel with lever L in unlocked position.

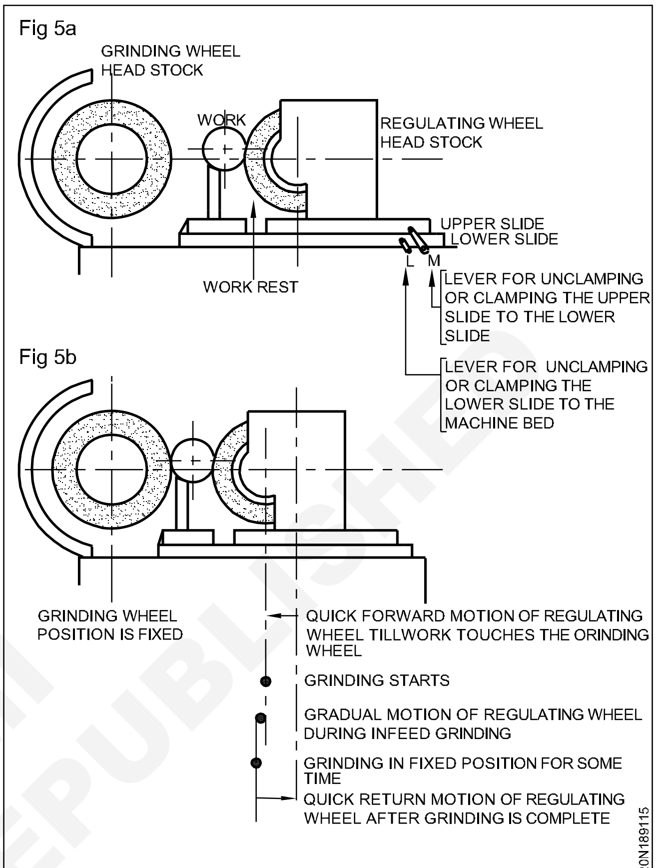
- The regulating wheel together with the work and the work rest, as one unit, are quickly moved forward, so that the work just touches the grinding wheel as shown in Fig 5b and faint sparks appear.

- The feeding of the regulating wheel together with the work and the work rest is continued but at a slower rate for infeed grinding.

- When the work diameter approaches the required diameter, the feeding motion of the regulating wheel is stopped and the work is allowed to be ground a little longer in this fixed set-up.

- After grinding is complete, the regulating wheel is quickly returned backward to its original position and the finish ground work is unloaded by lifting up or pushing. The next work piece is then placed in position and the same sequence of operations is repeated for grinding it.

Sequence of infeed grinding operations on a machine where grinding wheel as well as regulating wheel both are moveable, and work rest position is permanently fixed.



METHODS OF CENTRELESS GRINDING

- Such a type of wheel and work rest arrangement is provided on many makes of machines, such as, Linkoping, Norton, Hartex, Landis, etc. For this type of machines, the sequence of infeed grinding operations depends upon the type of the unloading arrangement. Two cases differing in the type of unloading arrangement have been dealt with below:

(A) Work unloading by pushing or lifting

- The work is set in position, supported by the work blade and the regulating wheel; the grinding wheel is kept away from the work as shown in Fig 6a.

- The grinding wheel is then moved forward so that it just touches the work, as shown in Fig 6b, and faint sparks appear.

- The forward motion of the grinding wheel is continued but at a slower rate. During the whole of the grinding cycle, the regulating wheel remains stationary.

- When the work diameter approaches the required diameter, the feeding motion of the grinding wheel is stopped and the work is allowed to be ground for a little longer time in this fixed set-up.

- After grinding is complete, the grinding wheel is quickly returned backward to its original position and the finish ground work is pushed out or lifted up.

Fig 6a

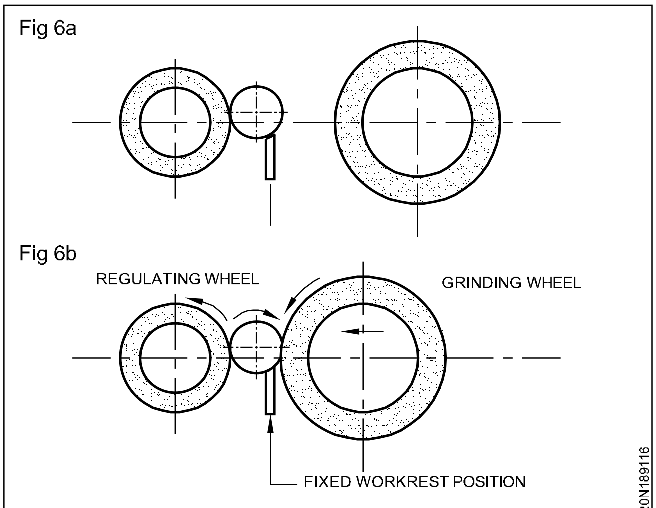


Fig 6b

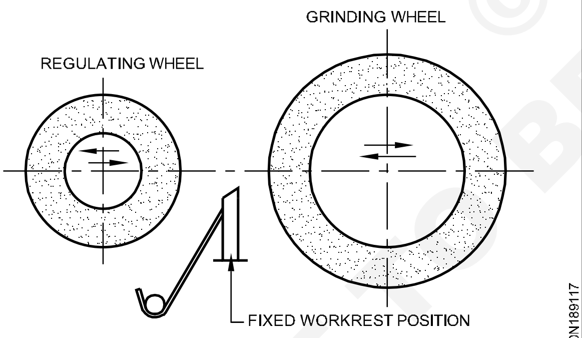
METHODS OF CENTRELESS GRINDING

The next work piece is then placed in position and the same sequence of operations is repeated for grinding it.

(B) Work unloading by gravity ejection chute

The sequence of operations of from No. I to No. 4 are the same as described in the preceding case. After grinding is complete, the grinding wheel as well as the regulating wheel are quickly returned backward and the finish ground work is allowed to fall into the ejection chute shown in Fig 7. The regulating wheel is then quickly moved forward to permit loading of the next work piece. Till then the grinding wheel stays in the original position. After loading of the next work piece is complete, the same sequence of operations is repeated for grinding it.

Fig 7



METHODS OF CENTRELESS GRINDING

Limitations of infeed grinding method

- A work of a length greater than the width of the grinding wheel cannot be ground by this method because the work remains stationary during infeed grinding.
- Because it is not a continuous operation, only one work piece can be ground at a time.

Though the infeed method can be satisfactorily used for grinding cylindrical work yet because of the above two limitations this method is usually not employed in preference to through feed.

However, modern centreless grinding machines are equipped with automatic infeed grinding mechanisms which can perform a complete sequence of operations, e.g., loading, grinding, unloading, etc., automatically.

Also the complete sequence can be repeated automatically to grind subsequent work pieces. Thus, for certain types of work, particularly where the grinding allowance is high, automatic infeed grinding can give better production rate than through feed grinding.

Infeed grinding in general is primarily used for grinding work other than a plain cylindrical one, such as, stepped, headed Shouldered, tapered, spherical, intricate shaped, etc.

Different types of infeed methods

Basically, there are two types of infeed methods—Plain and Profile.

1 Plain infeed grinding

This is the method for grinding plain cylindrical work using infeed principles.

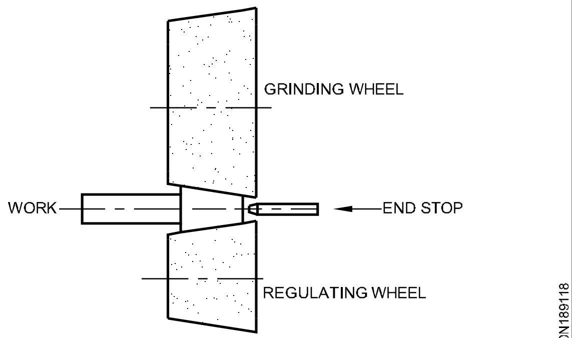
2 Profile grinding

Many types of profiled work places can be ground by the centreless grinding method using infeed principles; but since the grinding wheel has to be shaped to the profile corresponding to the work profile, it is called 'profile' or 'form' grinding.

End feed method

The end feed method is used only for grinding taper work. In this method, taper work is fed in between tapered grinding and regulating wheels, the centre distance of which has been already set. It resembles the through feed method in the respect than the work is fed between fixed positioned grinding and regulating wheels; but it does not satisfy the other requirement of the through feed method, in which case the grinding process is said to be complete only when the entire work comes our of the wheels on exit side. In this end feed method the work does not come out at all, but is stopped by a fixed stop and at that moment, the grinding operation is supposed to be over and the work is taken out either by lifting it up or by moving one of the wheels back. Further, in through feed grinding, the axial feed of the work is obtained by tilting the regulating wheel, whereas in end feed grinding, the regulating wheel is not tilted for feeding the work but manual or mechanical feeding is employed. Fig 8 shows the work being ground by the end feed method.

Fig 8



METHODS OF CENTRELESS GRINDING (END FEED)

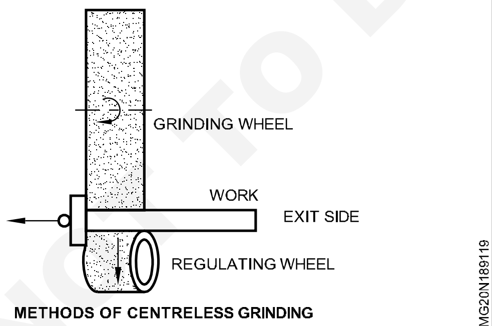
Combination of through feed and infeed methods

Both the through feed as well as the infeed methods have their own limitations and advantages with regard to each other. For certain types of work, both the methods can best be utilised so as to benefit from their respective advantages and to over-come their limitations. Two such applications have been dealt with below.

- For a two-diameter work, such as, a headed pin where only the smaller diameter portion of a length than the grinding wheel width is required to be ground, a pure through-feed method cannot be applied because of its other portion, being of greater diameter, cannot be passed through. Also the pure infeed method cannot be employed as the length of the work portion to be ground is greater than the width of the grinding wheel. However, both the methods can be partially utilised to their good advantage in the following manner:

  The work is set for conventional infeed grinding except that the regulating wheel is tilted and trued for negative through-feed goading. Negative means that the tilt angle is kept negative and truing is also done accordingly so that the work, instead of moving forward from the entry to the exit side, moves from the exit side to the entry side while through-feed grinding. However, with this set-up, as shown in Fig 9, in the first step of grinding, the through feed action is not allowed by using an end stop while the portion of the work between the wheels is infeed ground. When the required size is obtained during infeed grinding, the end stop is removed; now the work starts travelling through the wheels towards the front to the machine and the rest of the work is, thus, through feed ground to the size set at the end of infeed grinding. A special work blade is required to support the head of the pin as it feeds backward during the second step of the grinding operation.

Fig 9



METHODS OF CENTRELESS GRINDING

- A work of comparatively short length requiring heavy stock removal can be ground in a single pass by utilising both the methods. The regulating wheel is tilted for through feed operation, but the distance between the wheel is set for infeed operation. The work is placed between the two wheels with its one end as near to the entry side as possible. After starting grinding, the infeed cut is gradually increased, while the work is travelling, the infeed cut is gradually increased, while the work is travelling. This increase in cut should be so adjusted that when the rear end of the work comes close to the exit side, the gap between the wheels corre-sponds to the finished diameter of the work. At this stage, the infeed cut is stopped so that the rest of the grinding takes place as through feed. This method is, however, not recommended on a full production basis as it gives rise to uneven wheel wear, necessitation constant attention.

Advantages of centreless grinding

The advantages of the centreless type of grinding process for the appropriate type of work are many:

- Work chucking and its centering or its placing on a mandrel is not necessary, thereby the setting time for subsequent identical work pieces is saved once the setting is done for the first work piece.
- As the work is not positively gripped during the grinding operation, true floating conditions exist, so that the errors associated with centering are absent, and thus grinding allowance can be reduced.
- Since the work is adequately supported on the vee formed by the inclined surface of the blade and the regulating wheel, no deflection takes place during the grinding operation. This allows heavier cuts to be taken, if necessary.
- Errors in setting of the work or due to grinding wheel wear are reduced by half because stock removal is measured on the diameter of the work and not on its radius, unlike other grinding operations.
- Excellent accuracy and fine surface finish can be achieved.
- Work pieces of a wide range of dimensions can be finished by this method. Work diameters approaching zero to 600 mm and lengths from 1 mm to 15000 mm have been successfully ground.
- Centreless grinding is applicable to external grinding not only of cylindrical work, but stepped, tapered, spherical, and even ovel and intricate profiled work can be centreless ground economically. Internal centreless grinding is also possible.
- A wide variety of materials can be ground.
- The grinding process is practically continuous, especially if through feed type of centreless grinding process is adopted. Even with infeed grinding, the idle machine time required for unloading and loading of the work generally represents a very small part of the total time.
- Centreless grinding lends itself extremely well to fully automatic operation with regard to loading, grinding and unloading and thus very high rates of production can be achieved. The highest output claimed by Lidkoping on their machine is 60,000 work pieces per hour using the single pass through feed grinding method.
- Centreless grinding machines are usually simple yet robust in design, incorporating an automatic lubrication system for spindle bearings and for other moveable

parts. Thus, the machine maintenance cost is comparatively low.

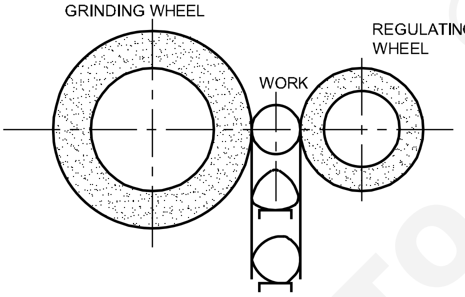
- Unskilled labour with little training can operate the machine. In short, centreless grinding is a highly productive method of finishing work requiring accurate size control and superior finish.

Theoretical explanation for raising or lowering the work centre height

The following principles of geometry can be applied explain the effect of the work centre height:

'Any rotating curve touching two crossing lines and at the same time passing through a fixed point, must be a circle'. Whereas, 'any rotating curve touching two parallel lines and at the same time passing through a fixed point, need not necessarily be a circle'. In case of centreless grinding, the two lines correspond to the tangents passing through the points of contact between the work and the two wheels and the fixed point corresponds to the work blade. If the work centre and the wheel axis are at the same height, the two tangents are parallel. Therefore, the body generated after grinding need not be circular but may be triangular (Fig 10) if originally there is one high spot on the work; otherwise it may be multiangular in the case of a work with many high spots. If the work centre is kept above (Fig 11a) or below (Fig 11b) the line joining the wheel centres, the tangents passing through the points of contact will cross each other and the work also will be constantly kept supported on a fixed point, i.e., the point of contact between work and work blade; therefore a circle will be generated.

Fig 10



METHODS OF CENTRELESS GRINDING

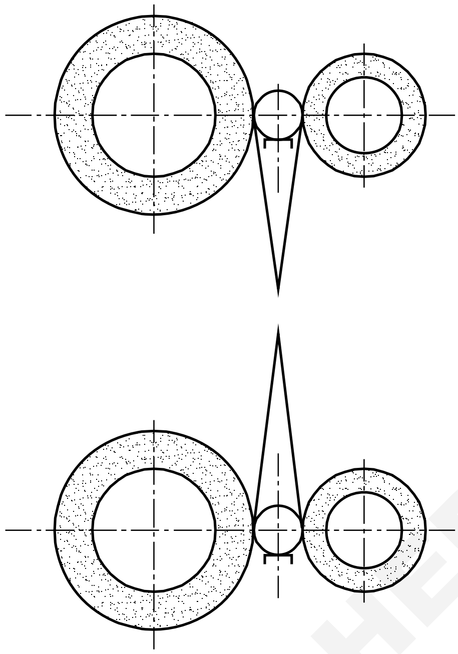
Work centre height

The work centre height is defined as the height of the centre of the work above the line joining the centres of the grinding and regulating wheels.

The work centre height has a definite influence on the accuracy of roundness produced. The higher the work is placed between the wheels, the better is the rounding action on an out-of-round work but at the same time, there is a limit to the increase of the work centre height. The higher the work, is placed, the greater is the tendency of the wheels to squeeze the work upward due to increased vertical component of cutting contact pressure. In such a condition, the work for a moment loses its contact with the wheels and is pushed upwards and then falls back into the grinding position due to gravity and again it is

Fig 11a

Fig 11b



METHODS OF CENTRELESS GRINDING

pushed up. This process is repeated, the action being very rapid and continuous, resulting in spoiling of the surface finish of the work. This difficulty can be overcome by one or more of the following methods.

- By reducing the cutting contact pressure between the grinding wheel and the work. This can be done by one or more of the following ways:
  a) Use of softer wheel
  b) Reduction of depth of cut
  c) Increase of grinding wheel speed, if it is lower that the permissible
  d) reduction of work speed
- By reducing the vertical component of cutting contact pressure between the grinding wheel and the work by one of the following methods.
  a) reduction of work centre height
  b) Increase in blade angle
  c) Increase of grinding wheel diameter
- By partially neutralising the effect of the vertical component of cutting pressure by increasing the weight of the work. However, this is not practical proposition.
- By using an overhead guide.

Methods, reduction of centre height and by using an overhead guide are normally recommended to prevent jumping of the work.

Amount of work centre height

Since there are many variable are causing the work centre height there is a definite formula available for finding out the optimum value for work centre height which can give the best grinding results. However, it has been found that the rounding action is effective when the sum of angles subtended by the work centre with respect to the grinding wheel and regulating wheel centres is between 5° to I5°.

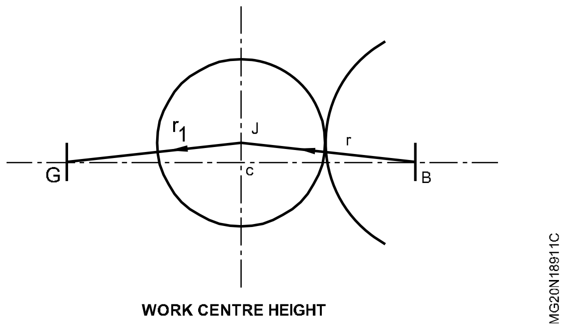
Referring to Fig 12 let
R = Grinding wheel radius
r = Regulating wheel radius
r_1 = Work radius
H = Work centre height

Considering triangles JGC and JCB

$$\sin a_1 = \frac{H}{R + r_1}$$

$$\sin a_2 = \frac{H}{r + r_1}$$

Fig 12



WORK CENTRE HEIGHT

Thus, having chosen an arbitrary value for H and knowing the grinding wheel, the regulating wheel and work radii, we can find one the values of a_1 and a_2. If the sum of a_1 and a_2 comes out between 5^0 to 15^0, then the arbitrary value of H chosen may be satisfactory

Usual ly the work centre height between 3/16th to 5/16th of the work diameter has proved quite satisfactory. For a shouldered or multi-diameter work, the determination of the work centre height should be based on the greatest diameter available.

For small diameter work, particularly tubes and rings, the work height may have to be increased to obtain a proper rounding from experience or trials with the help of good measuring can determine the best centre height for a particular and under the prevailing conditions of the grinding operation.

Work centre below the centre and of the wheels

Long but work particularly of small diameter and with slight bend of is often ground with the work centre below the line of the wheels. This position is contrary to be usual of keeping the work centre height above, but it is necessary by whipping or chattering of the work by holding it down the blade and in between the wheel.

Internal centreless grinding

Objectives: At the end of this lesson you shall be able to
- **state internal centreless grinding and holding/grinding set-up of job**
- **explain the selection of wheels.**

Internal centreless grinding

The basic centreless principle can also be used for internal grinding of bores. Thus, in internal centreless grinding, the work is not positively gripped and, therefore, does not have any fixed centre, but rolls on its own outside diameter in a centreless workhead. The grinding of the bore takes place with the outside diameter of the work as a reference and not the centre line of the bore or of the work as reference.

Internal centreless grinding has proved to be successful for finish grinding of a bore, parallel as well as tapered, whether through or blind, in cylindrical work.

Elements of internal centreless grinding machine

An internal centreless grinding machine incorporates the following basic elements.

- **Grinding wheel**

  It is connected with an electric motor and has a provision for axial movement so that it can be taken into the work for the internal grinding cut.

- **Regulating wheel**

  It is connected to a separate motor which is responsible for rotating the work at the desired speed, It is adjustable transversely to accommodate work of different outside diameters.

- **Work support**

  For smaller diameter work, say upto 30mm, the work support is usually in the form of a work blade, where as for larger diameter work, it is in the form of a roller called a 'support roll'.

- **Pressure roller**

  This is usually spring loaded with mechanism for adjusting The pressure, It is mounted in a swinging bracket and holds the work against the regulating wheel and the work support.

Where the accurate endwise location of a work is essential, as when grinding taper bores, a rotating backing plate is also necessary to hold the end face square with the axis. To hold the work against the backing plate, the rolls are inclined at a slight angle, the effect being the same as that obtained by inclining the regulating wheel when grinding the work externally by the infeed method.

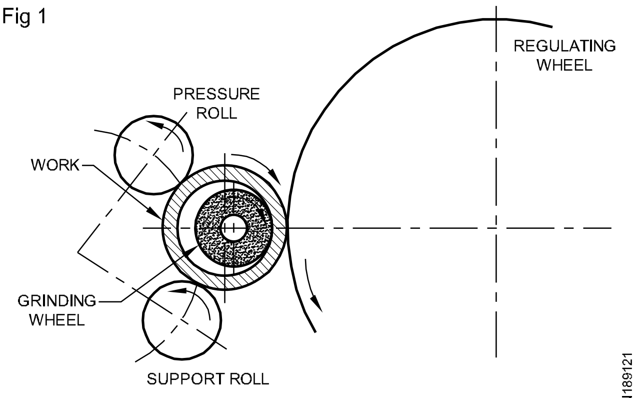
Grinding set-up

The basic element s of an internal centreless grinding machine described above can be set in one of the following two ways.

1 On-centre arrangement

In this arrangement (Fig 1), the work, grinding wheel and regulating wheel are all on the same horizontal centre line. This arrangement gives the maximum support to the work which makes it possible to grinding accurately without distortion, particularly work having a thin wall section.

Fig 1

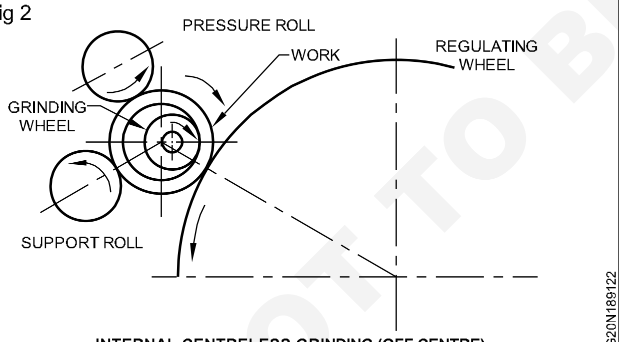


INTERNAL CENTRELESS GRINDING (ON CENTRE)

2 Off-centre arrangement

In this arrangement (Fig 2), the work-wheel centre line is above that of the regulating wheel, the angular relationship of the support and the regulating wheel being such that successively loaded work pieces, even with considerable variation of the out-side diameter, remain on the same vertical centre line. As a result, it is possible to grind such work piecestoclose limits. The off-centre method also permits the grinding of multiple work simultaneously, all to the same tolerance.

Fig 2



INTERNAL CENTRELESS GRINDING (OFF CENTRE)

Advantages of internal centreless grinding

- Accurate concentricity of the internal and external diameters together with uniform wall thickness is ensured.
- High production rates can be achieved as the internal centreless grinding operation can be made full automatic with regard to loading, grinding and unloading.

Limitations of internal centreless grinding

- Since the grinding of the bore takes place with the outside diameter of the work as a reference, this limits its field of application. Work with an inaccurate outside diameter cannot be internally ground accurately. Accuracy of the finished bore depends upon the accuracy of the outside surface. As such, it is necessary that the outside diameter of the work should be finished to close limits for roundness and size before proceeding to internal grinding.
- Only those bores which are required to be concentric with the outside diameter can be ground. It does not matter whether the required hole is cylindrical or taper as long as it is concentric with the outside diameter of the work, However, for internal centreless grinding of taper holes, some provision for inclining the grinding wheel spindle should exist on the machine.

Internal centreless grinding is not much in use now a days, as other types of internal grinding methods have been developed which, being more productive, are preferable.

Selection of wheels for centreless grinding

The proper selection of the grinding wheel is very important for a successful grinding operation on a particular work under the prevailing circumstances and conditions. The following are the wheel specifications that require careful consideration, as they govern the cutting behaviour of the grinding wheel, which ultimately affects the economics of production.

- Wheel shape
- Wheel size
- Wheel characteristics
  - abrasive
  - grain or grit
  - grade or hardness
  - structure
  - bond

Wheel shape

For centreless grinding, a plain cylindrical wheel is normally needed. However, it may require to be dressed to a certain profile to suit the grinding of a profiled work.

Wheel size

Every centreless grinding machine has a limitation as to the size of grinding wheel which it can accommodate. In general, a grinding wheel of the maximum permissible diameter and width should be selected. A grinding wheel of the maximum diameter is to be preferred from the operational point of view, as a smaller wheel well be consumed faster, involving frequent replacement, frequent setting, etc., which will decrease the production rate.

As regards the width of the grinding wheel, it depends upon the type of grinding operation and the length of the work. In case of throughfeed grinding, maximum output is generally obtained by using as wide a grinding wheel as the machine permits. With wider wheels the grinding load is distributed and a greater cut can be taken, particularly by truing the wheel slightly tapered. Also better results are ob tained with regard to accuracy and finish as a greater length of the work is gripped at any time during grinding. In case of infeed grinding, longer work can be handled with a wider wheel. However, the width of the grinding wheel for infeed grinding should not be abnormally greater than the length of the work as extra width does not serve any purpose; on the contrary it necessitates a longer end stop, which may produce vibrations resulting in poor finish.

Having decided on the proper shape and size of the grinding wheel, the proper wheel characteristics should be selected to specify a wheel completely. The various wheel characteristics and their selection criteria are discussed below.

Ideal grinding wheel

An ideal grinding wheel should possess the following qualities:

- It should wear the minimum possible so as to :-
- Maintain the abrasive particles of the grinding wheel sharp for rapid stock removal and thus produce the maximum number of work pieces per unit time
- keep the cost of the grinding wheel consumption per ground work to minimum.
- It should be 'self-sharpening' at 'optimum speed'.The latter action is called 'self-sharpening', which means that the grinding wheel should retain abrasive particles as long as they are sharp, and as soon as they become seriously dull, the grinding pressure, developed at that stage, should be sufficient to fracture the dull particles, bringing in front fresh sharp particles. This type of self-sharpening action should be repetitive to maintain the wheel's sharpness and to avoid frequent dressing. Further, the optimum speed is also an important criterion, because the wheel can be made to act self-sharpening if the grinding wheel speed is reduced. But reduction in speed will reduce the grinding efficiency; hence, the self-sharpening action at optimum speed only is one of the qualities of an ideal grinding wheel.
- An ideal grinding wheel should also give the desired finish at all times.
- An ideal grinding wheel should be cool cutting. Coolness of cut minimises the deformation of the work piece from grinding heat and allows close tolerances to be produced quickly and continuously.

Selection of regulating wheel

The regulating wheel is primarily used to regulate the speed of rotation of the work. During through feed grinding, it also serves to provide longitudinal feed to the work. The regulating wheel is subject to high pressures as it acts as one of the supports during grinding This wheel should, therefore, be strong and coarse enough to produce sufficient inaction against the work without scratching it, to control its speed. For most grinding work, an aluminium oxide fine grained, hard with a close structure and rubber bonded wheel has proved quite satisfactory. Vitrified and retinoid bended wheels can some times be used as regulating wheels.

Diamond Wheel and Applications of diamond wheel in grinding

Objectives: At the end of this lesson you shall be able to
- **state centreless grinding processes/methods**
- **state the advantages of centreless grinding**
- **state the effect of setting work above and below the wheel centre.**

Nowadays diamond wheels have become the accepted type of abrasive wheel for off-hand finish grinding of carbide single point tools. And for all precision grinding operations on cemented carbide multi-tooth cutters and chip-breaker grinding, these wheels are found to be more advantageous ue to their exceptionally fast and cool cutting action and remely low rate of wear, as compared with silicon varbide grinding wheels.

These properties of diamond wheels ultimately result in low grinding cost.

They are available with either natural or man-n:a_de diamonds. Resinoid and vitrified bonded wheels containing the man-made diamond, in the 100 grit and finer range, have proved to be very satisfactory for the grinding of cemented tungsten carbides.

Bond types

Three types of bonds are used in the manuf ctu:e of diamond wheels to suit the various fields of applications.

Resinoid bond

Resinoid bonded diamond wheels have exceptionally fast and coolcutting action and are more suitable for sharpening of multi-tooth cutters, reamers etc. for grinding chip breaker, and precision grinding operations on carbide dies, gauges, rolls etc.

Vitrified bond

Vitrified bonded diamond wheel has

- rigidity that gives dimensional accuracy to the work being ground
- a porous structure to promote faster and cooler cutting, and
- positive adhesion betweer;i the bond and the diamond particles, whic!Jensures a long, useful wheel life.

Vitrified bonded diamond wheels are particularly suitable for reconditioning excessively dull single point tools end for ordinary re-sharpening or finish grinding operations.

Vitrified bonded diamond wheels are available in straight wheels, flaring cup, dish and mounted wheels for various precision and tool and cutter grinding operations.

Metal bond

Metal-bonded diamond wheels are also used for off-hand grinding of single point tools, particularly where durability, long life and resistance to grooving are of primary considerations. When compared with other bonds, these wheels are slower in cutting.

Standard grit sizes as per IS 3264-1985

Diamond wheels (of any bond type) are supplied in the following standard grit sizes for grinding carbide tools & cutters.

Selection of Grit Size

The selection of grit size is based on the surface finish requirements and rate of material removal.

Surface finish	IS grit designation	
	Diamond	CBN*
Very coarse	D 181	B 181
medium - coarse	D 151	B 151
Medium	D 126	B 126
Mdium fine	D 107	B 107
Fine	D 91	B 91
Very fine	D 76	D 76
Extra fine	D 54	B 54
Superfine	D 46	B 46

Diamond Concentration

It represents the quantity of diamond with one unit of mass of wheel. Basically in grinding wheels, diamond concentration of 100 is equivalent to 4.4 carats per cubic centimetre (0.88g/cm3). This figure corresponds to 25 percent by volume, taking the density of diamond as 3.52 g/cm3. Standard concentration will be 125, 100,75 and 50.

When to use "125" concentration

Used for machine grinding operations on cemented carbides, such as chip breaker grinding, cutter grinding, cylindrical, surface and internal grinding. This is also b.est suited for thin cutting-off wheels, mounted wheels and hand hones.

When to use "100" concentration

Wheels of"100" concentration are recommended for the same class of precision grinding operations as"125" concentration wheels. These wheels are generally more economical to use.

When to use "75" concentration

Wheels of "75" concentration are recommended for both vitrified and metal bonded cup wheels, which are used for off-hand grinding.

When to use "50" concentration

Diamond wheels of"50" concentration and metal-bonded are used primarily in the cutting of soft stone. They are not considered economical for grinding carbides.

Depth of diamond

It depends upon the type of bond and wheel size.

Plain disc wheels -1.6 or 3.2or 6.3mmdepth of diamond measured radially. Cup or recessed wheels (for grinding on the side or mm)-1.6 or 3.2mm in the case of resinoid or vitrified bonded wheels, for metal-bonded wheels the thickness is 0.8 mm. With specific reference to cost per toogl round,wheel with a relatively large depthof diamond are more economical.

Marking - All diamond grinding wheels shall be marked legibly on the core, with the following formation.

Designation

Diamond concentration

Diamond grit size with a suffix as D for diamond andB for cubic boron nitride

Depth of diamond impregnation

Manufacturer's serial number, and

Manufacturer's name or Trade Mark.

Method of ordering - Forordering diamond grinding wheels, quote the following information in addition to the bore

diameter. (Fig 1)

Type of grinding wheel Designation

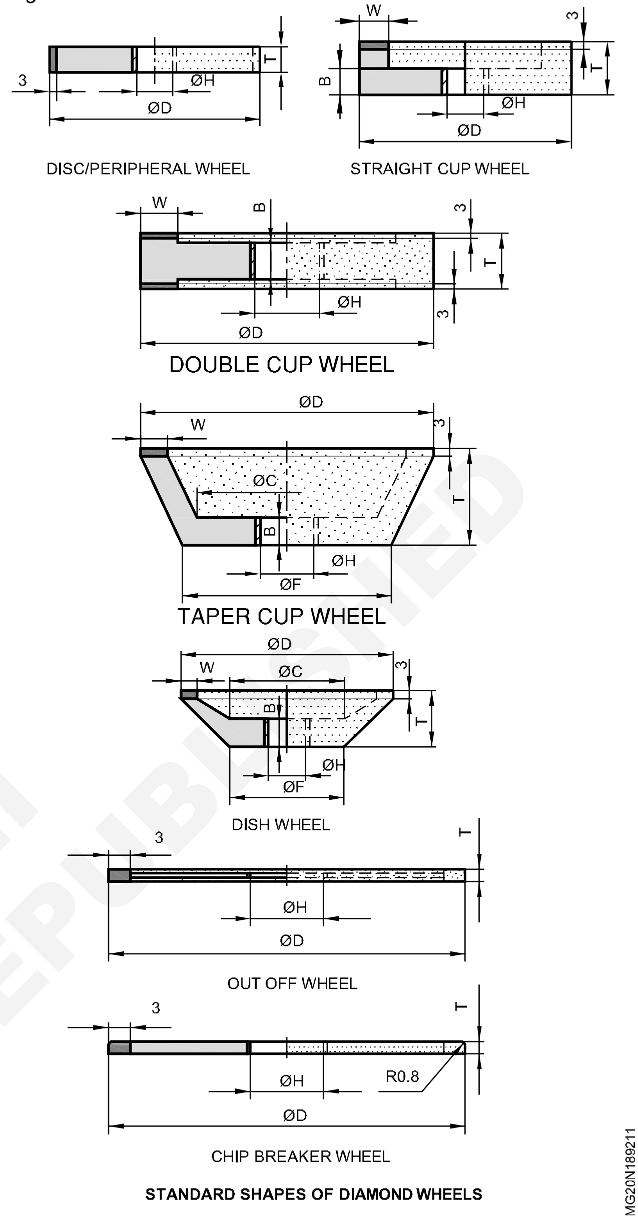
Diamond concentration

Diamond grit size

Type of bond (resin or me!al) and

Type of grinding (wet or dry).

Fig 1



STANDARD SHAPES OF DIAMOND WHEELS

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 equipments 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 equipments to uncover conditions leading to production breakdowns or harmful depreciation
- Upkeep of machines and equipments 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 equipments as per the 'Check- lists'. (Annexure I)
- Lubrication of machines and equipments 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 equipments.

Periodic inspection of machines and equipments as per the check-list

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.

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 equipments

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.

The manufacturer's manual contains all the necessary details like grade of oil, grease, oiling and greasing points and also indicates the time intervals of lubrication.

Maintenance records (Annexure III)

Keep a detailed record of faults, failures, repairs and replacements done for machines. It is useful to analyse

Keep a detailed record of faults, failures, repairs and replacements done for machines. It is useful to analyse the cause of a fault and rectification.

Maintenance records analysis

Systematic review and regular analysis of the equipment records will help to:

- Re-design the weak part which gives repetitive trouble
- Substitute with better material for high cost items
- Minimise frequent breakdowns
- Reduce the cost of production.

Preventive Maintenance Programme

Name of the Machine : Location of the machine :

Machine Number :

Model No. & Make :

Annexure I

CHECK-LIST FOR MACHINE INSPECTION

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 gaurds			

Inspected by

Signature

Name :

Date : Signature of in-charge

EQUIPMENT RECORD

Annexure II

History sheet of machinery & equipment

Description of equipment:				
Manufacturers' address:				
Supplier's address:				
Order No. and date:				
Date on which received:				
Date on which installed and placed:				
Date of commissioning:				
Size: Length X Width X Height				
Weight:				
Cost:				
Motor particulars:	Watts:	r.p.m:	Phase:	Volts
Bearings/Spares record:				
Belt specification:				
Lubrication details:				
Major repairs and overhauls carried out with dates.				

Annexure III

MAINTENANCE RECORDS

Sl.No	Name of the machine	Nature of fault rectified	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 LE products
- Application methods
- Drain or lube intervals
- Special remarks

The materal 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.

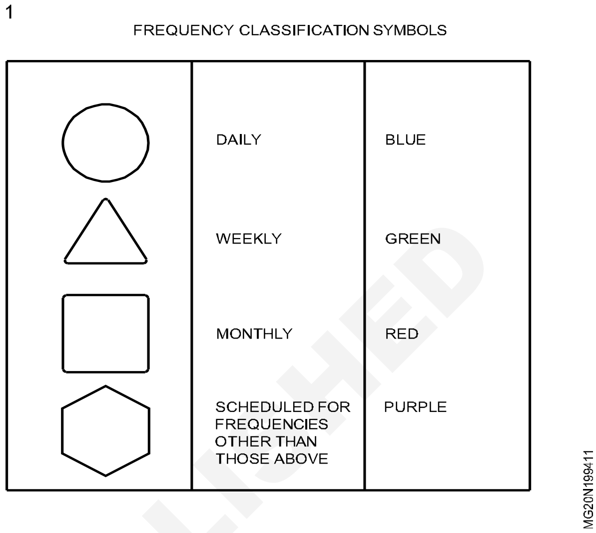
Hints for lubricating machines

- 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.

Hand box 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 disctionary defines as "any book giving information such as facts on a particular subject, guidence 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 cheorikal engineers hand book, mark standard hand book for machine engineer and the CRC hand book of chemistry and physics.

Reference table

A refereance 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.

Total productive maintenance

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

ESTIMATION SHEET - FORMAT-4

Part Name: Base plate Assembly: Shearing machine Assembly No.: MA2WOAO1	Part No.: 1 Material: Fe310.0 Stock size: 305 x 227 x 20	Insert Part Drawing

Operation No.	Operation description	Machine	Estimated time	Rate / piece per hr.	Tools
01	Setting and aligning job on table	Milling	10 min		
02	Mount arbor and cutter	Milling	10 min		
03	Set speed and feed	Milling	2 min		
04	Align cutter in position	Milling	2 min		
05	Mill four sides	Milling	50 min		
06	Mark 45º angle corner	-	8 min		vernier bevel protractor vernier height gauge
07	Set and clamp the job	-	10 min		
08	Mill 45º on opposite sides	-	10 min		
09	Set clamp on other sides	-	20 min		
10	Mill 45º on other sides	-	20 min		
11	Deburr and mark drill position	-	10 min		
12	Set and align for drilling	Drilling	10 min		
13	Mount drill chuck and drill	Drilling	03 min		
14	Set drill rpm	Drilling	02 min		
15	Drill pilot and holes	Drilling	30 min		
16	Counter bore holes	Drilling	15 min		
17	Place job on magnetic chuck on surface grinder	Surface grinder	03 min		
18	Grind the surface as per drawing	Surface grinder	10 min		
19	Deburr sharp edges	-	02 min		Abrasive stick

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 manfacturing 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 performace part of the equation measures the running speed of the operation compared to its maximum capability often called the rated sppe. 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 preventionof 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.

- Understanding the equipment functions and safety risks.

The seven steps of Autonomous Maintenance

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 tentaive 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.

Cylindrical grinders

Objectives: At the end of this lesson you shall be able to
- **state the purpose of a cylindrical grinder**
- **state the types of cylindrical grinders**
- **list the parts and functions of a plain centre type cylindrical grinder**
- **state the specification of a cylindrical grinder.**

Cylindrical grinders are used to grind the external or internal surfaces of a cylindrical workpiece.

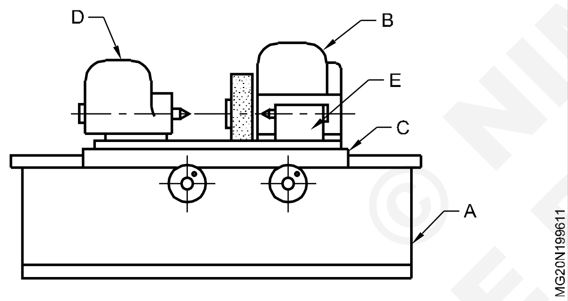
By cylindrical grinding the diameter of a workpiece can be maintained to a close tolerance (upto 0.0025 mm), and high quality surface finish can be obtained (upto N4).

The four types of cylindrical grinders are:

- external cylindrical grinders
- Internal cylindrical grinders
- universal cylindrical grinders
- centreless grinders

Plain centre type cylindrical grinder (Fig 1)

Fig 1



It is mainly intended to produce plain, stepped or tapered

Parts

The main parts of this type of a cylindrical grinder are the:

base

wheel head

table

headstock

foot-stock

Functions

Base (A) is made out of cast iron. It is heavy and provides rigidity to the machine. The top surface is machined to form guideway to the table.

The wheel head (B) is mounted on the cross-slide. It moves perpendicular to give depth of cut.

The table (C) is mounted on the bed-ways. It reciprocates past the wheel. It can be swivelled to grind taper. Trip dogs are provided to control reciprocation.

The headstock (D) is mounted on the table at the left end. It has a motor with 2 or 4 speed steps to drive the work. A dead centre is mounted in the spindle of this head to support the workpiece between centres.

The foot-stock (E) is mounted on the table at the right hand side. It can be moved and locked at any place along the table is spring-loaded and carries a dead centre to support the work.

The spring tension provides even, stiff support

Specification of cylindrical grinder

maximum diameter of workpiece which can be held

the breadth of the table

maximum table traverse movement

maximum diameters of the grinding wheel

H.P of the spindle motor

weight of the machine

Safety

Always wear safety goggles

Ensure the safety guards properly placed

Before starting the machine the wheel must be inspected

Ensure the holding devices are sufficiently tightened

Besure to allowable clearance between hand and grinding wheel

Before starting of hydraulic system donot hold the job in between centre.

If the work is heavy shut the machine down when placing the work between centres.

Surface grinding machine its parts

Main parts (Fig 2)

Base

Saddle

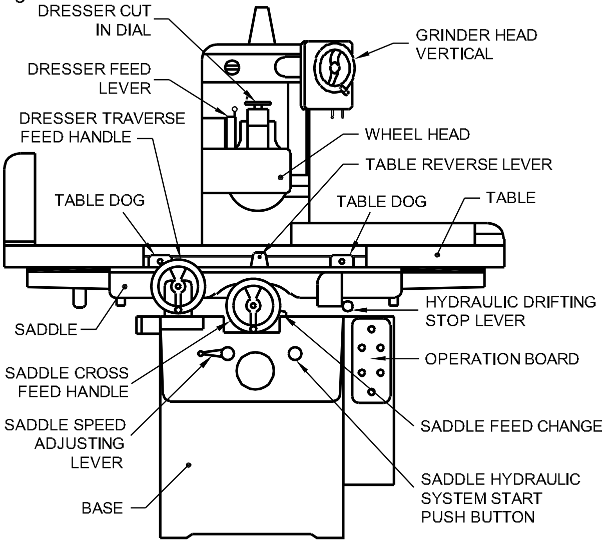
Table

Wheel head

Base

It is a rigid rectangular box contains the driving mechanism (hydraulic device tank and motor). It has a column at the back for supporting the wheel head on the top of the base provide precision guid ways for moving saddle.

Fig 2



Saddle

It is a frame. It contains the table in its cross wise movement. It is used to give cross feed to the work. It can be moved by hand or auto feed.

Table

It is fitted on the saddle. It is recirocates along the guide ways toprovide the longitudinal feed to the work. The surface is accurately machined and T-slots are provided for clamping of workpieces directly on the table or for clamping magnetic chuck and grinding fixtures. It is moved by hand or auto feed.

Wheel head

It is mounted on the column secured to the base. It can be moved vertically up and down to by rotating a hand wheel accommodate work piece of different height and set the wheel for depth of cut. The wheel rotates at a constant wheel speed. (1500 rpm)

Some surface grinding machines the dressign unit mounted top of the wheel head and slide to dressing the wheel with help of rotating micrometer collar handle. Dress the wheel 0.015mm to 0.025mm to giving a feed.

Specification of surface grinder

- Maximum dia of the wheel that can be held on the spindle.
- Working surface of table (length & wide)
- Vertical traverse of wheel head (height)
- Table cross and traverse (movement) feed rate.
- Speed of wheel.
- HP of wheel head motor.
- Types of drive (Incase of hydraulic drive hydraulic pump HP)
- Floor space required.
- Net weight of the machine.

Eg. Praga, 175mm wheel 400mm stroke, hydraulic surface grinder. Model 451.

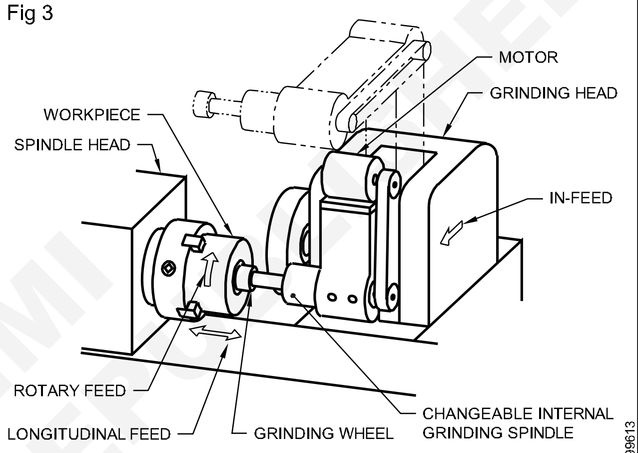
Detailed specifications and dimensions of a surface grinder are furnished by the manufacturer in the operator's instructional manual. Refer to one such manual of your sectio with the help of your instructor.

Use of surface grinding machine

It is a precision grinding machine to produce flat surface, Parallel surface or stepped surface. It is a move economical and more practical method of accurately finishing flat surface than filing and scraping. The abrasive wheel is used as a cutting tool. It has more number of cutting edges than single point cutting tool, hence removes metal fastly and accurately.

Universal cylindrical grinder (Fig 3)

Fig 3



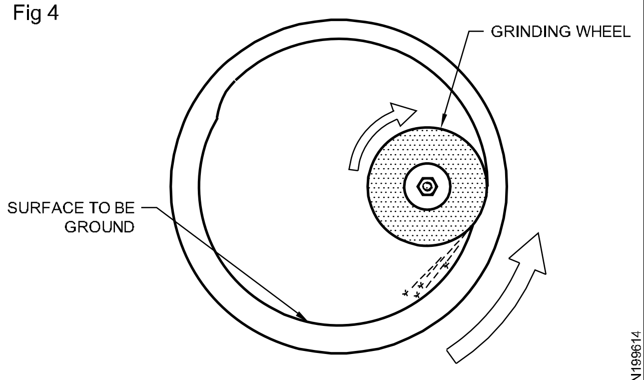
INTERNAL CYLINDRICAL GRINDING ATTACHMENT OF A UNIVERSAL CYLINDRICAL GRINDING MACHINE

This machine differs from the plain cylindrical grinding machine only in that an internal grinding attachment is mounted on wheel head. It has swivel arm. A small electric drive motor drives the internal grinding spindle by means of a belt. The workpiece is mounted in check or between centres.

Universal grinders are widely used for tool room works. The head stock, wheen head and table can be swivelled at an angle.

Internal cylindrical grinders (Fig 4)

Fig 4



INTERNAL GRINDER

It is used to finish plain, step, taper and formed holes for correct size, shape and finish.

The depth of cut of the diameter of hole ground from 0.02 to 0.05mm for rough grinding and from 0.002 to 0.01mm in finish grinding.

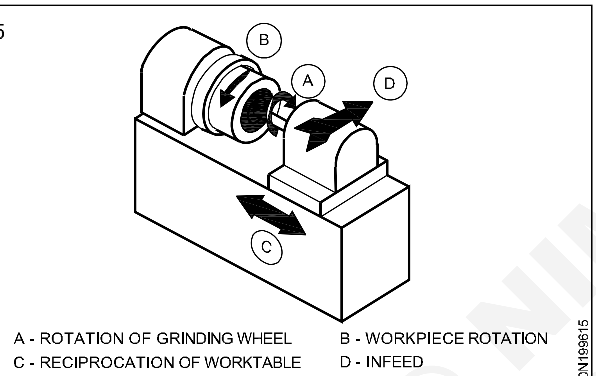
There are three types

- Chuncking
- Planetary
- Centreless

Chucking type internal grinder

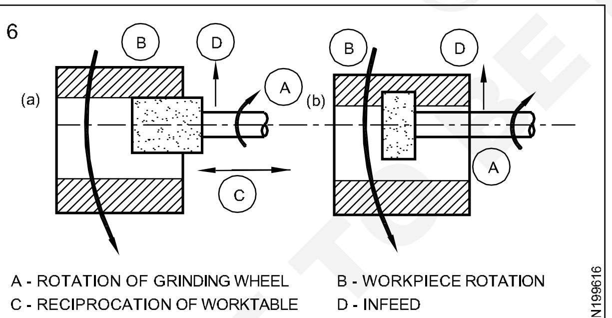
Figure 5 illustrates schematically this machine and various motions required for grinding action. The workpiece is usually mounted in a chuck. A magnetic face plate can also be used. A small grinding wheel performs the necessary grinding with its peripheral surface. Both transverse and plunge grinding can be carried out in this machine as shown in Fig 6.

Fig 5



INTERNEL CENTRELESS GRINDER

Fig 6

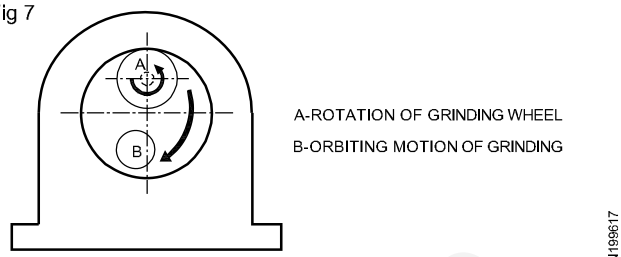


INTERNEL (a)TRAVERSE GRINDING AND (b)PLUNGE GRINDING

Chucking type internal grinder

Planetary internal grinder is used where the workpiece is of irregular shape and can not be rotated conveniently as shown in Fig 7. In this machine the workpiece does not rotate. Instead, the grinding wheel orbits the axis of the hole in the workpiece.

Fig 7

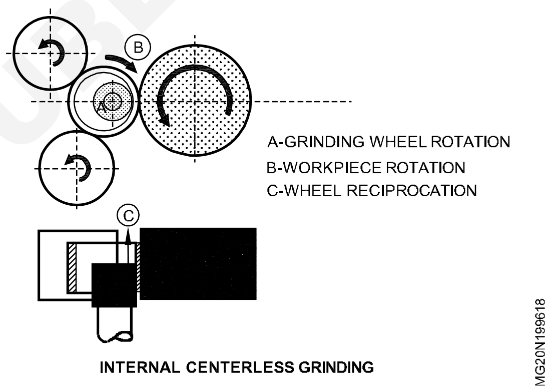


PLANETARY INTERNAL GRINDER

Centreless internal grinder

This machine is used for grinding cylindrical and tapered holes in cylindrical parts (e.g. cylindrical liners, various bushings etc). The workpiece is rotated between supporting roll, pressure roll and regulating wheel and is ground by the grinding wheel as illustrated in Fig 8.

Fig 8



INTERNAL CENTERLESS GRINDING

Care and maintenance of grinding machine

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

Machine and maintenance: In the design and manufacture of a grinding machine great care is taken to ensure that the alignment of the machine frame, its bed, work head, and wheel head parts, will be retained over a long period of time.

When lifting with slings, care should be taken to follow the manufacturer's recommendations. Moreover, one should take full advantage of any assistance the makers may render during the period the machine is being brought into service.

Usually the base of the machine is provided with three feet and the machine should rest only upon these, in order that the three-point support may be maintained. When the machine has been correctly designed it is highly advisable, after the final inspectional check, to grout, it using cement. It is however, important that no wedges or packing (apart from the grounting) should be placed between the feet.

The object of grouting is to absorb any vibration that may arise from outside sources, and to carry it to the foundation the grouting is not to ensure alignment.

Foundations: A grinding machine, being a precision tool, requires a sound foundation. For this purpose a concrete bed of adequate size is the best medium. A small machine requires a minimum depth of say 2 ft. more if the soil is loose and of the made-up type.

The area dimensions should be equal to the machine base plus about 2 ft. each way. With the larger machines the depth of the concrete base should be a 3 ft. minimum more when the safe bearing load of the soil is very low.

In order to carry the load effectively it may be essential to use a grillage and spread the loading over a wide area. When choosing a site for a grinding machine a careful study should be made of the possibility of vibration from machines in the neighbourhood, or from heavy traffic passing along roads in the vicinity of the factory.

If vibrations are found to exist, and arise from the use of heavy forging presses, or drop stamps in the vicinity, or from the passage of heavy motor traffic in the adjacent roads, the wisdom of using that particular site for a precision grinding machine is open to doubt.

Tests: With the machine in position an alignment test should be made using a precision level or optical instruments to ensure that the bed is truly level in both the longitudinal and traverse directions. Adjustments should be made as and when necessary.

When using the level or the optical instrument, the checking positions should be well place and numerous; it is insufficient to take only one or two readings, particularly when the machine has a long bed.

Belts: All the belts used on a grinding machine should be of the endless type, and be such that it does not favour the creation of vibration on any portion of the machine, otherwise there is a risk that chatter marks may be found on the workpiece. A belt drive must be smooth and free from any impact loading upon the pulleys over which it must pass.

As the belt is required to be endless, then a leather, rubber, or canvas belt with a cemented lap joint may be chosen; alternatively, and according to circumstances, one may use the endless cotton woven or rubber vee-belts. The use of metal belt fasteners on grinding machines is to be avoided.

Lubrication: No grinding machine can operated successfully if due attention is not given to its cleanliness and lubrication. Each operator should acquaint himself or herself with the lubricating points on the machine he or she operates, and ensure that all sliding and rotating parts are thoroughly lubricated several times each shift. In this manner, a few minutes a day are well spent and amply repay the trouble taken.

Daily attention should als be given to the pumps, so that the oil levels are maintained. Inattention in this direction soon leads to machine troubles, poor work, and the inability to achieve the output in a reasonable time.

Cleanliness: When received from the makers, each machine should be thoroughly cleaned and the slushing grease removed; oil ways should be checked to ensure that they are free from obstruction.

With the machine working, the greatest care should be taken to keep the working surfaces clean and well lubricated. Moreover, it is necessary to keep the grinding grit out of the lubricating system, and all the oil cans used in the grinding section should be of the dust-proof variety.

The nature of the metal cutting performed on a grinding machine carries with it special hazards as regards the maintenance of accuracy.

The extremely small metal chips, tiny particles of abrasive, and the dust from the bonding material, all have a destructive influence when in contact with any machine slide or bearing, whilst the dressing of the wheel and the grinding operation itself tend to spread the particles over a wide area.

Then again the grinding fluid forms a film over the machine table and other parts and thus carries the small metal and other particles in all directions. The need for wiping down the machine at frequent intervals during the day, and at the end of the shift is imperative. Once a week at least, the machine should be given a thorough cleaning.

In order to avoid undue wear at one position on the machine table it is desirable to move the headstock, as operating conditions permit, from one position to another. It is unwise to clamp the headstock at, say, the end of the table, and never move it into a new position such practice only leads to excessive localised table wear.

Coolant bosh: Every two or three days the coolant bosh should be cleaned out and the mud removed. Good work cannot be done when the liquid is carrying, in suspension, a large amount of the grinding grit.

What is required is an adequate stream of the coolant or lubricant free from any suspended matter; hence the need for a clarifier. When conditions permit, it is wise to consider one large coolant tank and clarifier for all machines in the grinding section. Then the clean liquid is supplied to each machine at a standard temperature.

Machine centres: The machine centres should always be maintained in first class order, by regrinding as circumstances require.

Wheel slide: The wheel slide must be maintained in a clean well-oiled condition so that it will work smoothly. If allowed to become dry, stiff, and dirty, it loses that responsiveness which is essential to accurate sizing, for the slide on finishing cuts may be called to move only 0.0001 in. per pass of the wheel. 'Slide-stick' cannot be tolerated.

Wheel head: The wheel head is usually fitted with a forced lubrication system and card should be taken to ensure that this is always working satisfactorily. The following remarks apply to the successful operating of the machine.

No running adjustment should be made to the bearings until the machine has reached the normal operating temperature, which is around 120°F.

With the passing of time all lubricating oils lose some of their properties, and the bearing oil sump on a grinding machine should be drained at frequent intervals, well swilled with paraffin or petrol, and then refilled with new oil.

When the machine has been standing idle for a long period, the lubricators should be well primed with oil before setting the machine in motion, and oiling should continue until the pump commences to operate.

Machine overhaul: At times it becomes essential to have each grinding machine thoroughly overhauled. Perhaps the best conditions are when the machine is given a periodic examinatiion once a year. If, as is very unlikely, the machine is sent back to the makers, little can be said, as normally they will do the job effectively.

When, however, the work has to be done by the machine tool fitters attached to the establishment, it is vital to see that the work is done and inspected to the same high standards as those of the makers.

In this direction it may be that the final alignment charts for the machine, taken during its erection, are available. Then they should form the basis of the work performed in the repair section, and be used by the inspection department.

When this important information is not available, then one should use the alignment charts produced by, and obtainable from, the institution of mechanical engineers or the institution of production engineers.