

FITTER

NSQF LEVEL - 5

3rd Semester

TRADE THEORY

SECTOR: Production & Manufacturing



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 : Production & Manufacturing
Duration : 2 - Years
Trade : Fitter 3rd Semester - Trade Theory

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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 Mentor Councils comprising various stakeholder's 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 **Fitter 3rd Semester Trade Theory NSQF Level - 5 in Production & Manufacturing Sector under Semester Pattern**. The NSQF Level - 5 Trade Theory will help the trainees to get an international equivalency standard where their skill proficiency and competency will be duly recognized across the globe and this will also increase the scope of recognition of prior learning. NSQF Level - 5 trainees will also get the opportunities to promote life long learning and skill development. I have no doubt that with NSQF Level - 5 the trainers and trainees of ITIs, and all stakeholders will derive maximum benefits from these 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

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RAJESH AGGARWAL

Director General/ Addl. Secretary
Ministry of Skill Development & Entrepreneurship,
Government of India.

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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 Ministry of Skill Development and Entrepreneurship) Government of India, with technical assistance from the Govt. of the Federal Republic of Germany. The prime objective of this institute is to develop and provide instructional materials for various trades as per the prescribed syllabi under the Craftsman and Apprenticeship Training Schemes.

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

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

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

R. P. DHINGRA
EXECUTIVE DIRECTOR

ACKNOWLEDGEMENT

National Instructional Media Institute (NIMI) sincerely acknowledges with thanks for the co-operation and contribution extended by the following Media Developers and their sponsoring organisations to bring out this Instructional Material (**Trade Theory**) for the trade of **Fitter** under Production & Manufacturing Sector for ITIs.

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

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

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

INTRODUCTION

TRADE THEORY

The manual of trade theory consists of theoretical information for the Third Semester Course of the Fitter Trade. The contents are sequenced according to the practical exercise contained in NSQF LEVEL - 5 syllabus on Trade Practical. 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 perceptual 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 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.

TRADE PRACTICAL

The trade practical manual is intended to be used in practical workshop. It consists of a series of practical exercises to be completed by the trainees during the Third Semester Course of Fitter 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 - 5 syllabus are covered.

The manual is divided into three modules. The distribution of time for the practical in the three modules are given below:

Module 1	Assembly 1	325 Hrs
Module 2	Gauges	125 Hrs
Module 3	Pipe & pipe fittings	75 Hrs
	Total	<u>525 Hrs</u>

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

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

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LEARNING / ASSESSABLE OUTCOME

On completion of this book you shall be able to

- **Make & assemble components of different mating surfaces as per required tolerance by different surface finishing operations using different fastening components, tools and check functionality. [Different mating surfaces - Dovetail fitting, Radius fitting, Combined fitting, Different surface finishing operations- Scraping, Lapping and Honing. Different fastening components - Dowel pins, Screws, Bolts, Keys and Cotters. Different fastening tools - Hand operated & Power tools, Required tolerance - ± 0.02 mm, angular tolerance ± 10 min].**
- **Make different gauges by using standard tools & equipment and check it for specified accuracy. [Different gauges - Snap gauge, Gap gauge; specified accuracy ± 0.02 mm].**
- **Apply a range of skills to execute pipe joints, dismantle and assemble valves & fittings with pipes and test for leakages. [Range of skills - Cutting, Threading, Flaring, Bending and Joining].**

SYLLABUS

Third Semester

Duration: Six Month

Week No.	Ref. Learning Outcome	Professional Skills (Trade Practical) with Indicative hours	Professional Knowledge (Trade Theory)
53	<p>Make & assemble components of different mating surfaces as per required tolerance by different surface finishing operations using different fastening components, tools and check functionality.</p> <p><i>[Different Mating Surfaces – Dovetail fitting, Radius fitting, Combined fitting; Different surface finishing operations – Scraping, Lapping and Honing; Different fastening components – Dowel pins, screws, bolts, keys and cotters; Different fastening tools-hand operated & power tools, Required tolerance - $\pm 0.02\text{mm}$, angular tolerance $\pm 10\text{ min.}$]</i></p>	<p>117. Make „H. fitting.(17 hrs.)</p> <p>118. Power tools: Practice operation of power tool for fastening.(5 hrs.)</p> <p>119.Tightening of bolt/ screw with specified torque.(2 hrs.)</p> <p>120. Selection of right tool as for Tightening or loosening of screw/bolt as per accessibility (1 hrs.)</p>	<p>Screws: material, designation, specifications, Property classes (e.g. 9.8 on screw head), Tools for tightening/ loosening of screw or bolts, Torque wrench, screw joint calculation uses.</p> <p>Power tools: its constructional features, uses & maintenance.</p>
54	-do-	<p>121. Assembly sliding for using keys, dowel pin and screw, $\pm 0.02\text{ mm}$ accuracy on plain surface and testing of sliding fitting job. (25 hrs.)</p>	<p>Locking device: Nuts- types (lock nut castle nut, slotted nuts, swam nut, grooved nut) Description and use.</p>
55	-do-	<p>122. File & fit angular mating surface within an accuracy of $\pm 0.02\text{ mm}$ & 10 minutes angular fitting.(25 hrs.)</p>	<p>Various types of keys, allowable clearances & tapers, types, uses of key pullers.</p>
56	-do-	<p>123. Drill through and blind holes at an angle using swivel table of drilling machine.(10 hrs.)</p> <p>124. Precision drilling, reaming and tapping and Test- Job.(15 hrs.)</p>	<p>Special files: types (pillar, Dread naught,Barrow, warding) description & their uses.</p> <p>Testing scraped surfaces: ordinary surfaces without a master plate.</p>

57	-do-	125. Make Dovetailed fitting and radius fitting.(25 hrs.)	Templates and gauges- Introduction, necessity, types. Limit gauge: Ring gauge, snap gauge, plug gauge, description and uses. Description and uses of gauge-types (feeler, screw, pitch, radius, wire gauge)
58	-do-	126. File and fit, combined fit with straight, angular surface with ± 0.02 mm accuracy and check adherence to specification and quality standards using equipment like Vernier calipers, micrometers etc.(25 hrs.)	Slip gauge: Necessity of using, classification & accuracy, set of blocks (English and Metric). Details of slip gauge. Metric sets 46: 103: 112. Wringing and building up of slip gauge and care and maintenance.
59	-do-	127. Drilling and reaming, small dia. holes to accuracy & correct location for fitting.(4 hrs.) 128. Perform drilling using „V. block and a clamp.(1 hrs.) 129. Make male and female fitting parts, drill and ream holes not less than 12.7 mm.(20 hrs.)	Application of slip gauges for measuring, Sine bar-Principle, application & specification. Procedure to check adherence to specification and quality standards.
60	-do-	130. Make Sliding Diamond fitting.(20 hrs.) 131. Lap flat surfaces using lapping plate. (5 hrs.)	Lapping: Application of lapping, material for lapping tools, lapping abrasives, charging of lapping tool. Surface finish importance, equipment for testing-terms relation to surface finish. Equipment for testing surfaces quality – dimensional tolerances of surface finish.
61	-do-	132. Prepare Stepped keyed fitting and test job. (20 hrs.) 133. Lapping holes and cylindrical surfaces.(5 hrs.)	Honing: Application of honing, material for honing, tools shapes, grades, honing abrasives. Frosting- its aim and the methods of performance.
62	-do-	134. Dovetail and Dowel pin assembly.(20 hrs.) 135. Scrape cylindrical bore.(5 hrs.)	Metallurgical and metal working processes such as Heat treatment, various heat treatment methods - normalizing, annealing, hardening and tempering, purpose of each method, tempering colour chart.
63	-do-	136. Scrapping cylindrical bore and to make a fit-(15 hrs.) 137. Scrapping cylindrical taper bore and check taper angle with sine bar.(10 hrs.)	Annealing and normalizing, Case hardening and carburising and its methods, process of carburising (solid, liquid and gas).

64	-do-	138. Make a cotter jib assembly.(25 hrs.)	Tapers on keys and cotters permissible by various standards.
65	-do-	139. Hand reams and fit taper pin. (15 hrs.) 140. Drilling and reaming holes in correct location, fitting dowel pins, stud, and bolts.(10 hrs.)	The various coatings used to protect metals, protection coat by heat and electrical deposit treatments. Treatments to provide a pleasing finish such as chromium silver plating, nickel plating and galvanizing.
66	Make different gauges by using standard tools & equipment and checks for specified accuracy. [Different Gauges – Snap gauge, Gap gauge; Specified Accuracy - $\pm 0.02\text{mm}$]	141. Making a snap gauge for checking a dia of 10 ± 0.02 mm.(25 hrs.)	Gauges and types of gauge commonly used in gauging finished product-Method of selective assembly „Go. system of gauges, hole plug basis of standardization.
67	-do-	142. Scrape external angular mating surface and check angle with sine bar.(15 hrs.) 143. Scrape on internal surface and check.(10 hrs.)	Bearing-Introduction, classification (Journal and Thrust), Description of each, ball bearing: Single row, double row, description of each, and advantages of double row.
68	-do-	144. Practice in dovetail fitting assembly and dowel pins and cap screws assembly.(20 hrs.) 145. Industrial visit.(5 hrs.)	Roller and needle bearings: Types of roller bearing. Description & use of each. Method of fitting ball and roller bearings Industrial visit.
69	-do-	146. Preparation of gap gauges.(15 hrs.) 147. Perform lapping of gauges (hand lapping only)(10 hrs.)	Bearing metals – types, composition and uses. Synthetic materials for bearing: The plastic laminate materials, their properties and uses in bearings such as phenolic, teflon polyamide (nylon).
70	-do-	148. Preparation of drill gauges. (10 hrs.) 149. File and fit straight and angular surfaces internally.(13 hrs.) 150. Identify different ferrous metals by spark test(2 hrs.)	, the importance of keeping the work free from rust and corrosion.

19 - 21	Apply a range of skills to execute pipe joints, dismantle and assemble valves & fittings with pipes and test for leakages. <i>[Range of skills – Cutting, Threading, Flaring, Bending and Joining]</i>	151. Flaring of pipes and pipe joints. (3 hrs.) 152. Cutting & Threading of pipe length.(3 hrs.) 153. Fitting of pipes as per sketch observing conditions used for pipe work. (12 hrs.) 154. Bending of pipes- cold and hot.(7 hrs.)	Pipes and pipe fitting- commonly used pipes. Pipe schedule and standard sizes. Pipe bending methods. Use of bending fixture, pipe threads-Std. Pipe threads Die and Tap, pipe vices.
72	-do-	155. Dismantling & assembling – globe valves, sluice valves, stop cocks, seat valves and non-return valve. (25 hrs.)	Use of tools such as pipe cutters, pipe wrenches, pipe dies , and tap, pipe bending machine etc.
73	-do-	156. Fit & assemble pipes, valves and test for leakage & functionality of valves.(22 hrs.) 157. Visual inspection for visual defects e.g. dents, surface finish.(1 hrs.) 158. Measuring, checking and recording in control chart.(2 hrs.)	Standard pipefitting- Methods of fitting or replacing the above fitting, repairs and erection on rainwater drainage pipes and house hold taps and pipe work. Inspection & Quality control -Basic SPC -Visual Inspection
74-75		In-plant training / Project work 1. Key Way Fitting 2. Lathe Dog 3. Different Test Piece For Fitter 4. Radius Form Gauge/ Form Gauge/ Snap Gauge 5. Square Fitting Alignment 6. Universal Fitting 7. Hand Press 8. Setup assembly of pipes and valves and test for leakage/ functionality	
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Screws

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

- state the results of poor selection of fasteners
- state the various types of fasteners in industrial use
- state the types of thread fasteners and their uses - machine bolts, machine screws, cap screws and set screws.

In the industrial field much depends on the proper choice of fasteners to be used in each job.

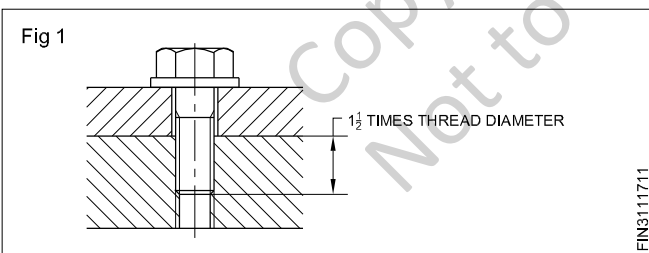
- A poorly selected fasteners might greatly lead to unsafe condition.
- Increase the assembly cost.
- Products are inferior quality.

Various types of fasteners

- Threaded fasteners
- Rivets
- Pins
- Retaining ring or circlips
- Keys
- Staples
- Adhesives.

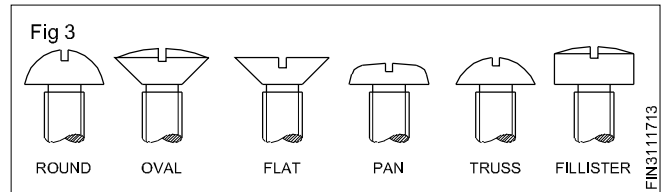
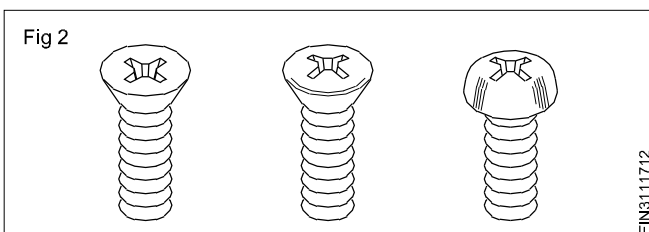
Threaded fasteners

Fasteners: Fasteners that fall into category utilise the wedging action of screw thread for clamping pressures. To achieve maximum strength, a threaded fasteners should screw into its mating part a distance equal to 1.5 times (minimum) the diameter of thread. (Fig 1)

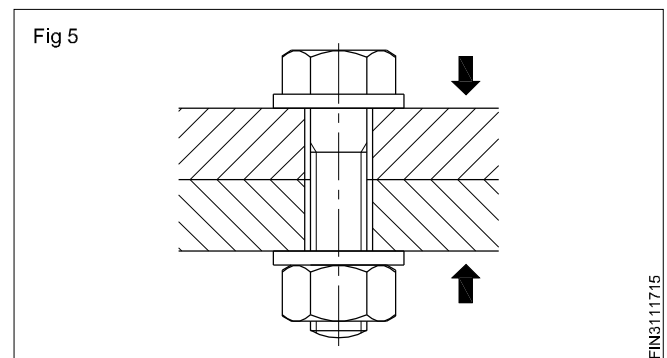
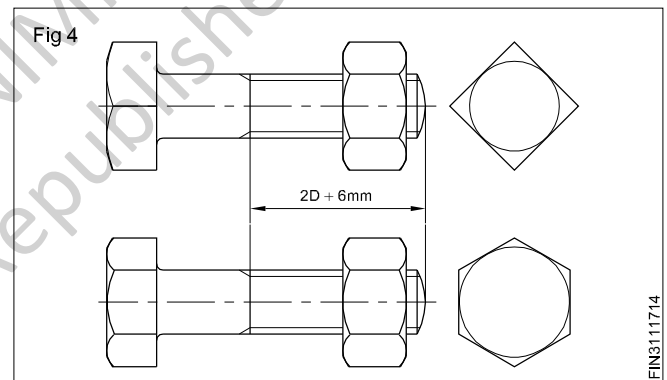


Machine screws: Machine screws are used for general assembly work. (Fig 2) It is manufactured in both COARSE and FINE series, fitted with either a slotted or recessed head. (Fig 3)

Sizes vary in diameter from 1.5 mm to 12 mm and in length 2 mm to 75 mm.



Machine bolts: Machine bolts (Fig 4) are manufactured with square and hexagonal heads. They are used where a close tolerance assembly is not required. Available in diameter 6 mm to 75 mm and in length 12 mm to 300 mm. Tightening the nut on machine bolt (Fig 5) produce clamping action.

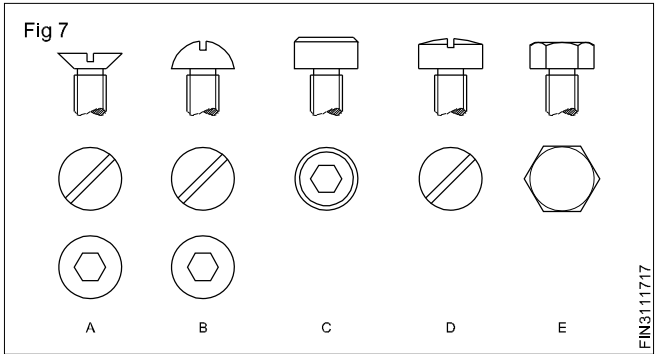
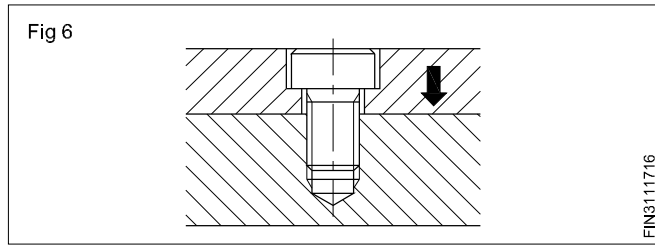


Cap screws: Cap screws are used when assembly requires a stronger, more precise and better appearing fastener. A cap screw is fitted through a clearance hole in one of the piece and screws into a threaded hole.

A clamping action is developed by tightening the cap screws. (Fig 6)

Cap screws are manufactured to closer tolerance than machine bolts and produced with semi-finished bearing surface. They stocked in aluminium, brass, bronze, mild

steel, alloy steel (Heat treated), stainless steel and titanium and in coarse in fine and special thread series (Fig 7).



Cap screws are available in diameter from 6 mm to 50 mm and in length from 10 mm to 200 mm. Nuts are not included with cap screws.

Set screws: Set screws are used to prevent pulleys from slipping on shafts, positioning and holding collars in place, on shafts and holding shafts in place in assemblies. (Fig 8)

Headless set screws have either a slotted or socket head and threaded entire length. Screw points are available in various styles and their recommended use. (Fig 9)

Types of screws

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

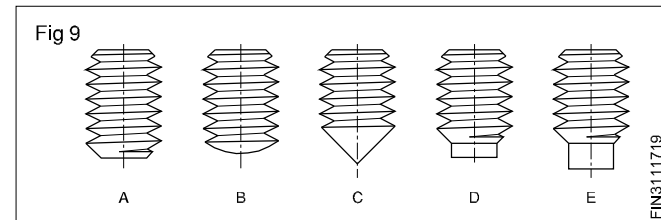
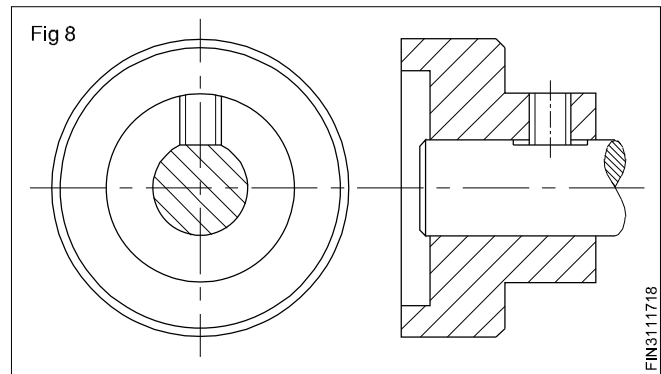
- state the various types of fastening screws and their uses
- state the various types of nuts and their uses
- state the various types of washers and their specific applications.

Self tapping screw: To eliminate the cost of tapping, a thread forming screw has been derived. These are designed to form a thread as they are driven. (Fig 1)

Thread cutting screws: Thread cutting screws which are hardened, actually cut rather than form threads.

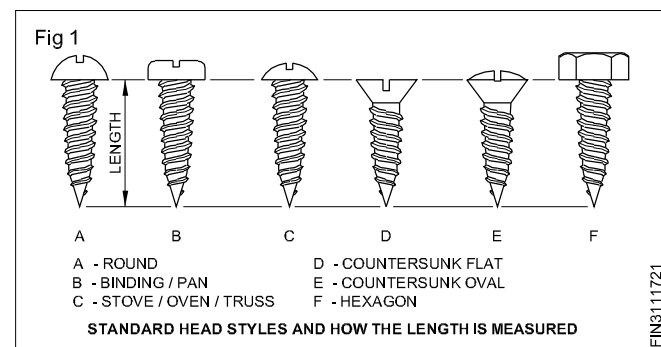
Type F: Cuts a standard machine thread used in castings and forgings. (Fig 2)

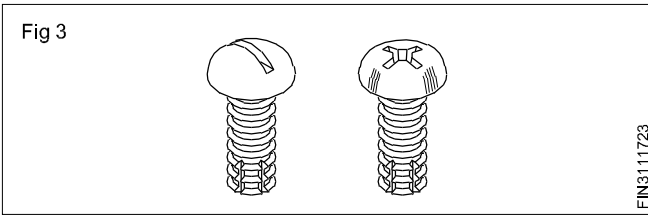
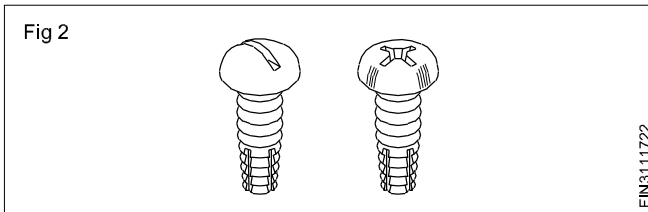
Type BF: This screw is recommended for die castings and plastics. (Fig 3)



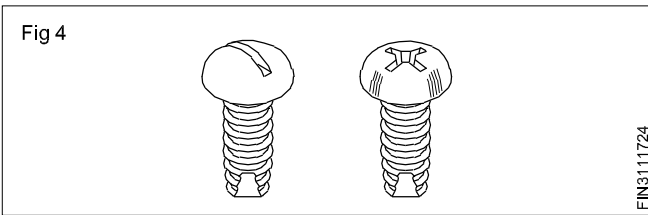
Uses

- A Flat point set screw is used on parts requiring frequent adjustment.
- B Oval point set screw is used against a shaft that has been spotted to receive it.
- C Cone point set screw is used for setting machine parts permanently on shaft and it is used as a pivot or hanger and for adjustment.
- D The half dog point set screws is probably one of the most useful and it can be used as a dowel. A hole is drilled to receive the point.
- E The full dog point set screw is suitable for use as a key that slides in a key way.

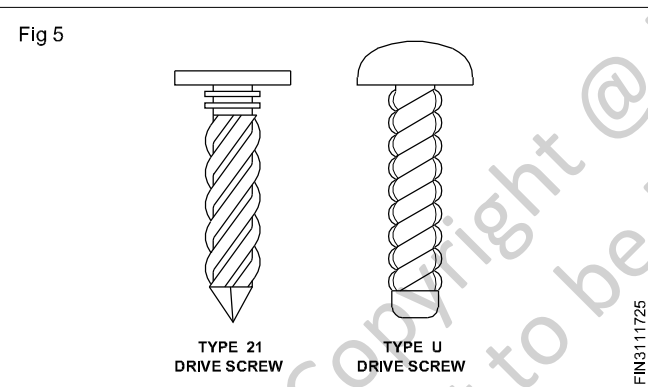




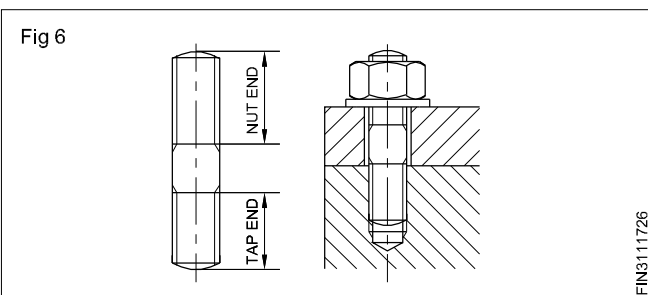
Type L: Widely used with plastics. (Fig 4)



Driver screws: Driver screws are simply hammered into a drilled hole or punched hole of the proper size. They make a permanent joints. (Fig 5)

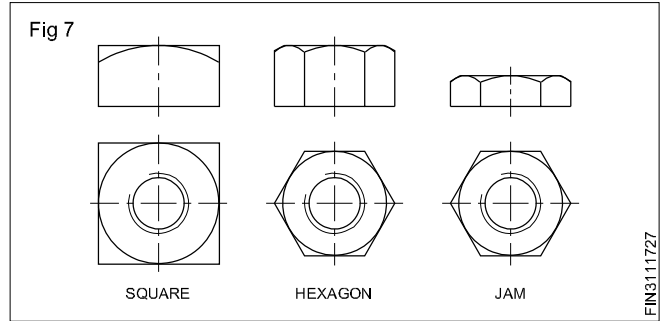


Stud bolts: Stud bolts are threaded on both ends. One threaded end is designated for semi-permanent installation in a tapped hole while the other end threaded for standard nut assembly to clamp the pieces together. (Fig.6)

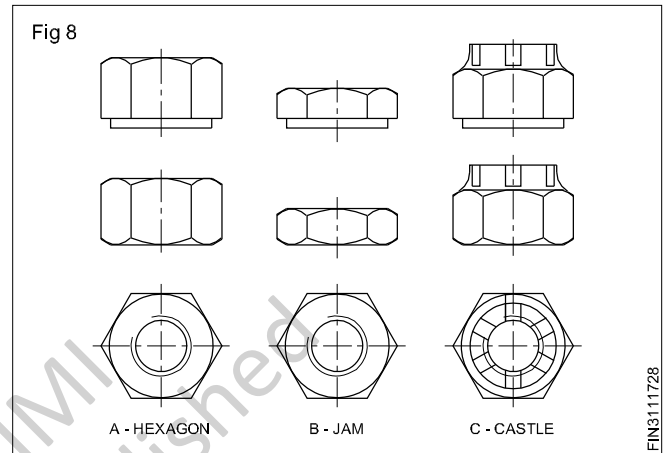


Nuts: Nut utilise a hexagonal or square head and are used with bolts with the some head shapes. They are available in various finish.

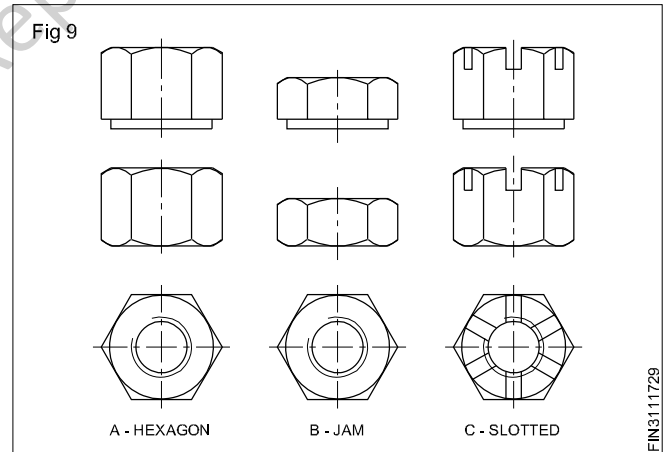
Regular is unfinished (not machined) except on the thread. (Fig 7)



Regular semifinished is machined on the bearing face to provide a truer surface for the washers. (Fig 8)



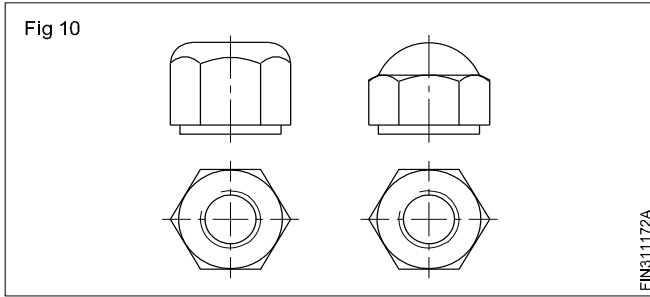
Heavy semifinished are identical in finish to the regular semi-finished nut, however, the body is thicker for additional strength. (Fig 9)



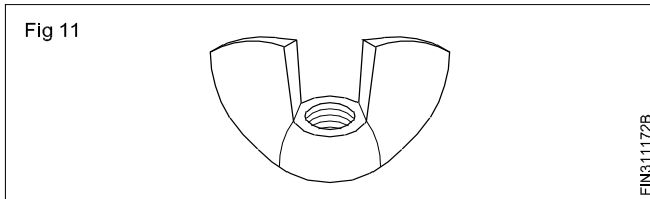
The jam nut/check nut is used where the strength of the full nut is not needed. They are frequently used in pairs or with standard nuts for locking action. (Fig 8B, 9B)

Castle and slotted nut have milled slots across the flats. So that can be locked with a cotter pin/split pin or safety wire that is inserted through the slot and a hole drilled in the bolt to prevent the nut from turning loose. (Fig 8C, 9C)

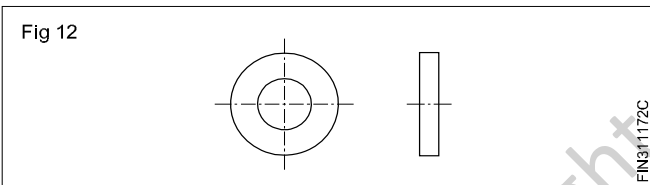
A corn nut/Cap nut are used when appearance is of primary importance or where projecting threads must be protected. They are available in low or high crown styles. (Fig 10)



The wing nut is used where frequent adjustment or removal is necessary. It can be loosened or tightened rapidly without the need of a wrench. Nut are manufactured in the same material as the bolts. (Fig 11)

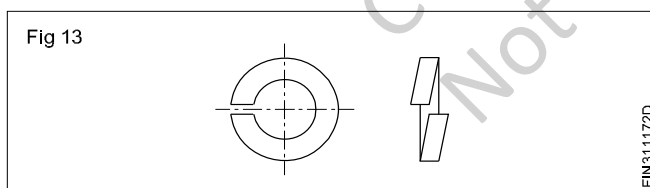


Washers: Washers are used to distribute the clamping pressure over a larger area, and prevent the surface damaged (marking). They also provide an increased bearing surface for bolt heads and nuts. Washers are manufactured in light, medium, heavy and extra heavy series. (Fig 12)



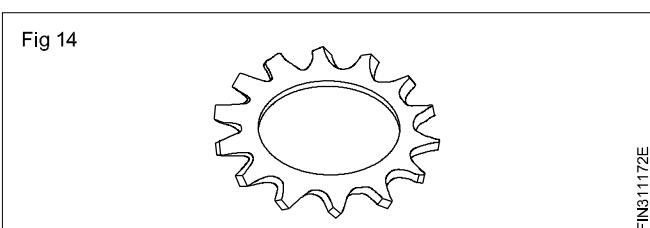
Lock washers: A lock washer is used to prevent a bolt or nut from loosening under vibration.

The split ring lock washer is being rapidly replaced by lock washers designed for specific applications. (Fig 13)

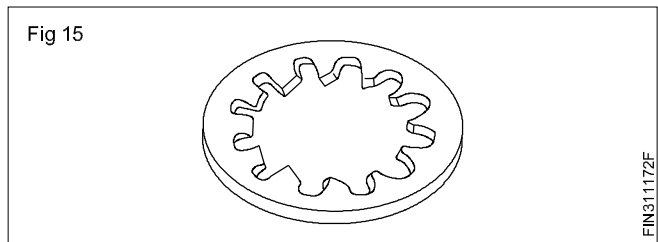


Tooth type lock washers: These washers have teeth that bite deep into both screw head and work surface. Their design is such that they actually lock tighter as vibrations increase.

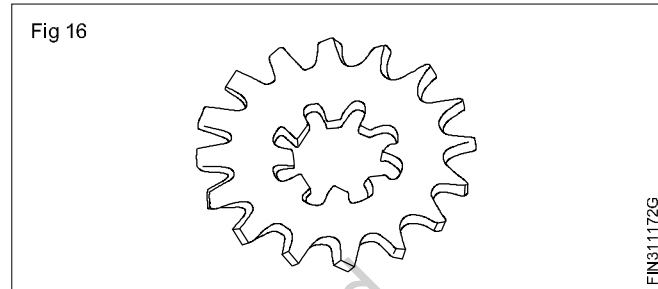
External type: Should be used where possible as it provides the greatest resistance. (Fig 14)



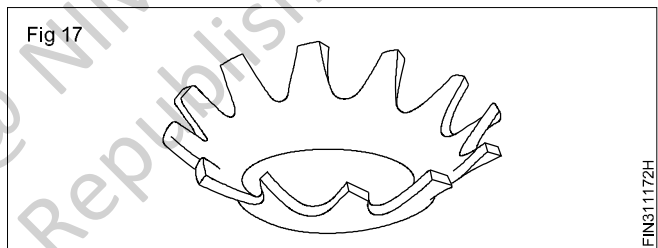
Internal type: Used with small head screws and where it is desirable to hide the teeth either for appearance or to prevent snagging. (Fig 15)



Internal and external type: Used when the mounting holes are over size. (Fig 16)



Countersunk type: For use with flat or oval type head screws (Fig 17).



Non threaded fastening devices

Dowel pins: Dowel pins are made of heat treated alloy steel and are used in assemblies where a parts must be accurately positioned and held in absolute relation to one another. They assure perfect alignment and facilitate quicker disassembly of parts and reassembly in exact relationship.

Property classes (as per IS/ISO) IS: 1367

The symbol for the property classes of bolts, screws and studs consists of two numbers separated by a point. The first number, when multiplied by one hundred, indicates the nominal tensile strength in newtons per square millimeter. The second figure, multiplied by ten, states the ratio between the lower yield stress and the nominal tensile strength (yield stress ratio) as a percentage. The multiplication of these two figures will give one tenth of the yield stress in newtons per square millimeter.

Example of a screw in property class 5.8

Nominal tensile strength

$$5 \ 100 = 500 \text{ N/mm}^2 \text{ (MPa)}$$

Yield stress ratio

$$8 \ 10 = 80\%$$

Yield stress

80% of 500 = 400 N/mm² (MPa)

The designation consists of two figures:

- The first figure indicates 1/100 of the nominal tensile strength in N/mm² and
- The second figure indicates 1/10 of the ratio, expressed as a percentage, between nominal yield stress and nominal tensile strength.

The multiplication of these two figures will give 1/10 of the nominal yield stress in N/mm².

Designation: Metric thread bolts, screws are identified by a letter M for the thread profile form. The letter M is followed by the value of nominal diameter expressed in millimeters and nominal length separated by the sign "x". (Example: M 8 x 35)

Materials: The table below specifies steel for the different property class of bolts, screws and studs. The minimum tempering temperature is mandatory for property classes 8.8 to 12.9 in all cases.

Chemical composition

Property Class	Material and Treatment	Chemical composition limits %				Tempering Temperature RE° C Min
		C		P	S	
		min.	max.	max.	max.	
4.6, 4.8, 5.8, 6.8*	Low or medium carbon steel	-	0.55	0.05	0.06	-
8.8	Medium carbon steel quenched, tempered	0.25	0.55	0.04	0.05	425
9.8	medium carbon steel quenched, tempered	0.25	0.55	0.04	0.05	425
10.9	Medium carbon steel additives e.g. boron, Mn, Cr or Alloy steel-quenched, tempered	0.20	0.55	0.04	0.05	425
12.9	Alloy steel-quenched, tempered	0.20	0.50	0.035	0.035	380

* Free cutting steel is allowed for these classes with the following maximum sulphur, phosphorus and lead content:

S-0.34% P- 0.11% Lead - 0.35%

** Alloy steel shall contain one or more of chromium, nickel, molybdenum or vanadium

* For size M20 and larger a temperature of 425° C may be used.

Note:

Property class 9.8 applies only to sizes up to 16 mm thread diameter and is included for information only and manufacture of products with this property class is to be discouraged.

The minimum tempering temperatures listed in above table are mandatory for property classes 8.8 to 12.9 in all cases.

Mating screws and nuts

Property classes bolts, screws, studs	3.6	4.6	4.8	5.6	5.8	6.8	8.8	9.8	10.9	12.9	14.9
Property classes nuts	5					6	8	9	10	12	14

Nuts of a higher property class can normally to be used in the place of nuts of a lower property classes.

* Property classes 14.9 are not ISO or ANSI standard = quenched and tempered

Screw drivers

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

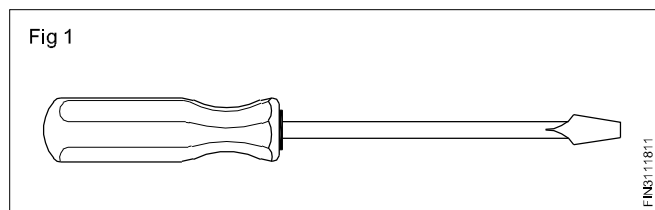
- state different types of screw drivers and their uses
- specify a screw driver
- list the precautions to be observed while using screw driver.

Screwdrivers are used to tighten or loosen screws and are available in various lengths.

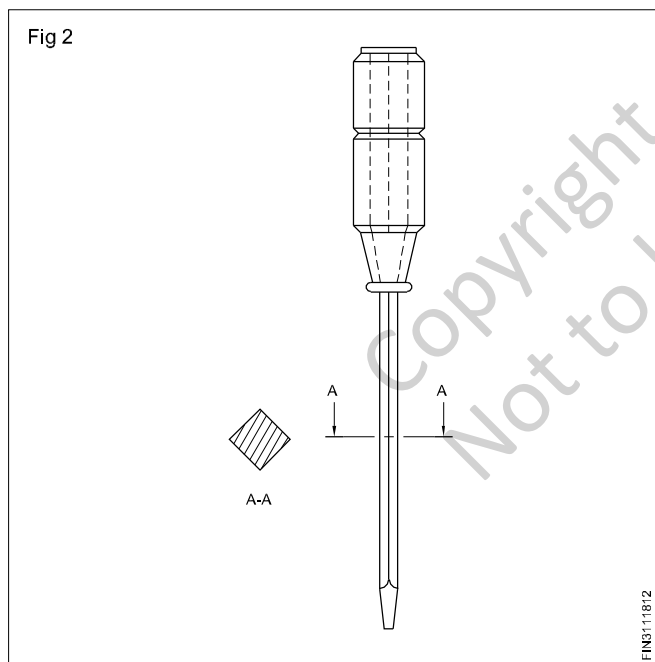
Hand-held screwdrivers are of the following types.

Standard screwdriver (Light duty) (Fig 1)

It is of round shank/blade with metal, wood or moulded, insulated material handle.



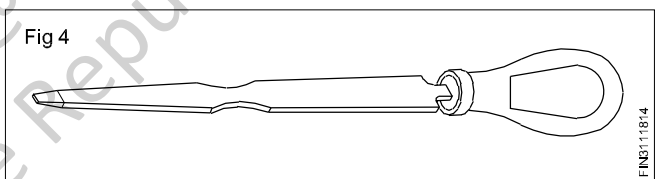
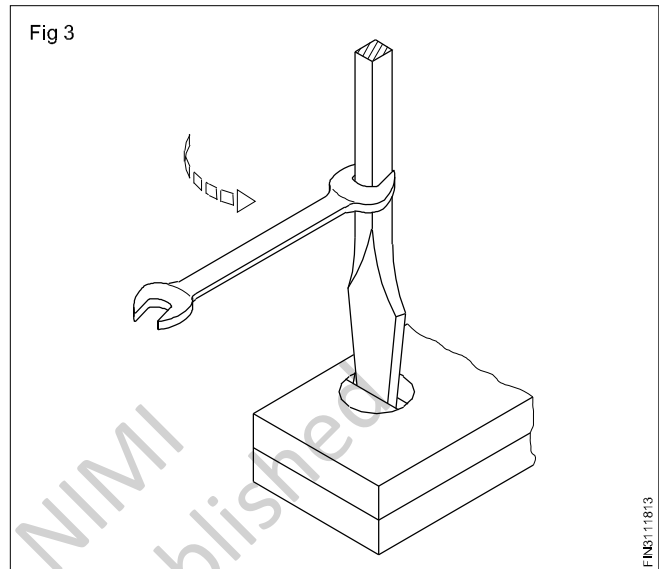
Standard screwdriver (Heavy duty) (Fig 2)



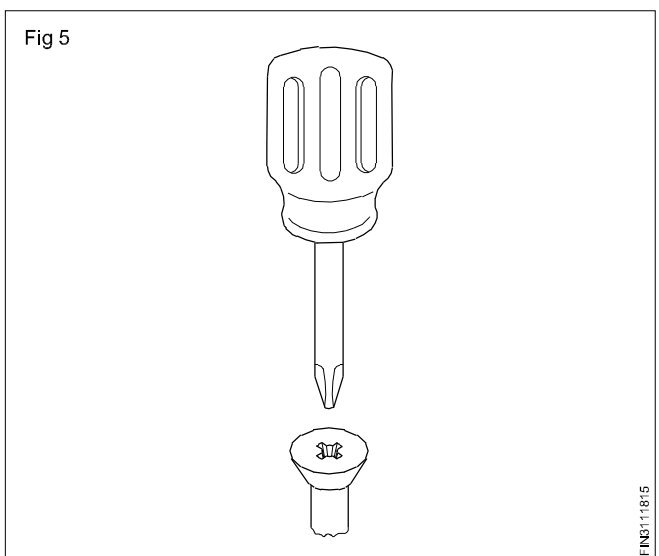
It has a square blade. The shank is also of square section for applying extra twisting force with the end of a spanner. (Fig 3)

Heavy duty screwdriver (London pattern) (Fig 4)

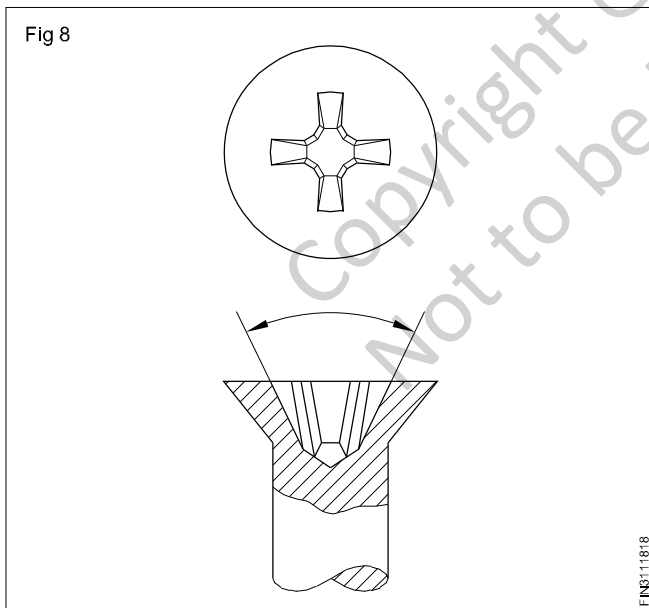
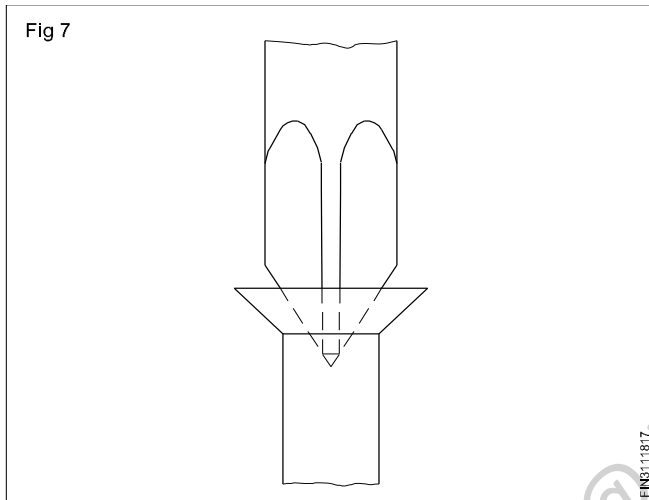
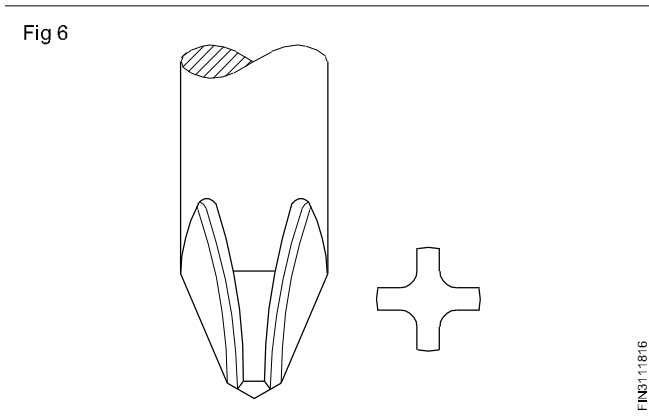
It has a flat blade and is mostly used by carpenters for fixing and removing wood screws.



Philips screwdriver (Fig 5)



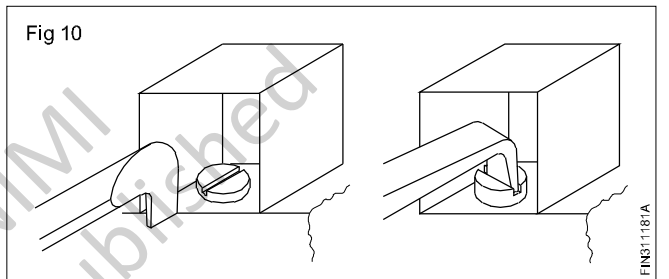
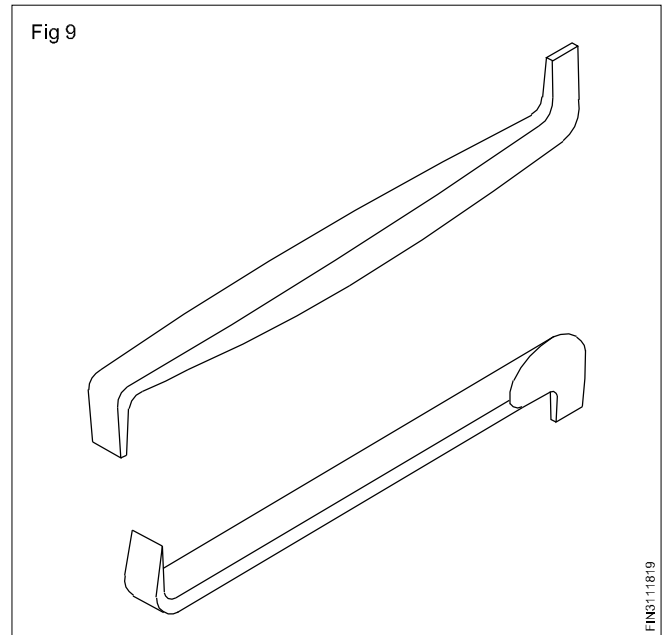
These are made with cruciform (Fig 6) tips that are unlikely to slip from the matching slots. (Fig 7) Philips recess head screws are shown in Fig 8.



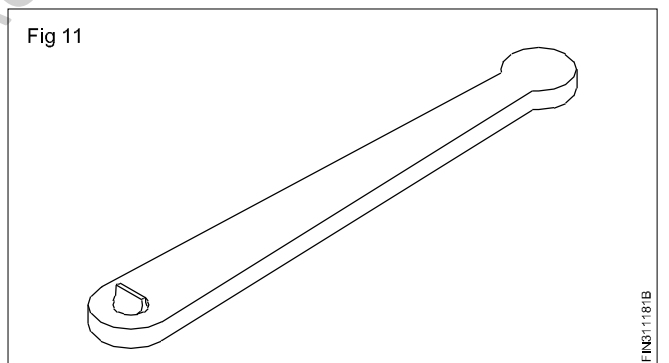
The sizes of Philips screwdrivers are specified by point size 1, 2, 3 and 4.

Offset screwdrivers (Fig 9)

These are useful in some situations (Fig 10) where the normal screwdriver cannot be used because of the length of the handle. They are also useful for applying greater turning force.



For quicker application ratchet offset screwdrivers are also available with renewable tips. (Fig 11)



Specification

Screwdrivers (Fig 12) are specified according to the

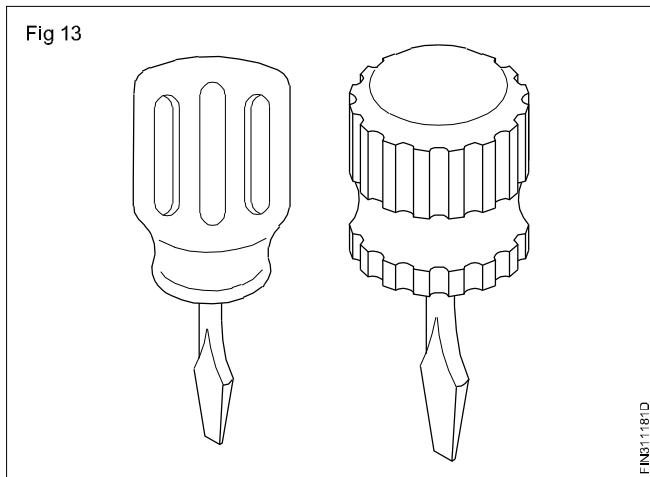
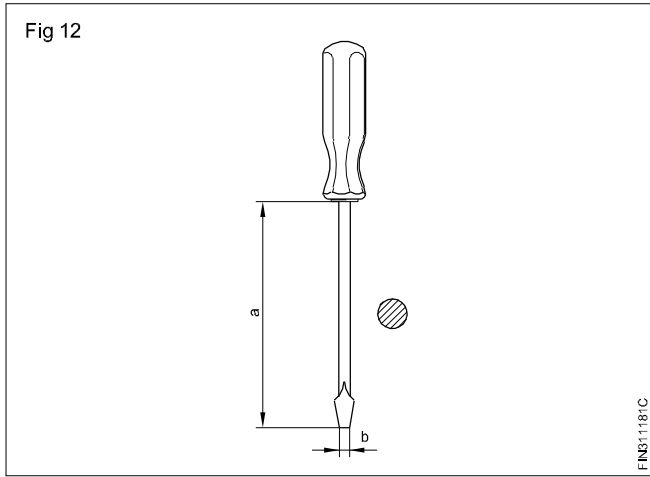
- length of the blade
- width of the tip.

Normal blade length: 45 to 300mm. Width of blade : 3 to 10mm.

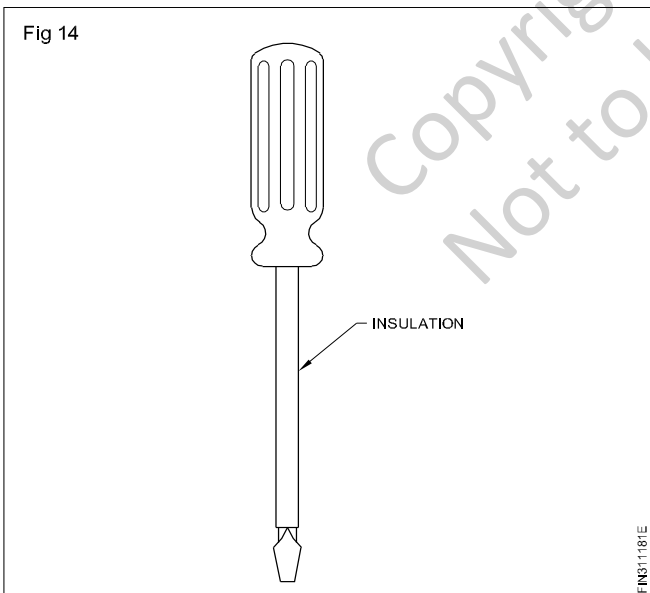
The blades of screwdrivers are made of carbon steel or alloy steel, hardened and tempered.

Screwdrivers for special uses

Small sturdy screwdrivers are available for use where there is limited space. (Fig 13)



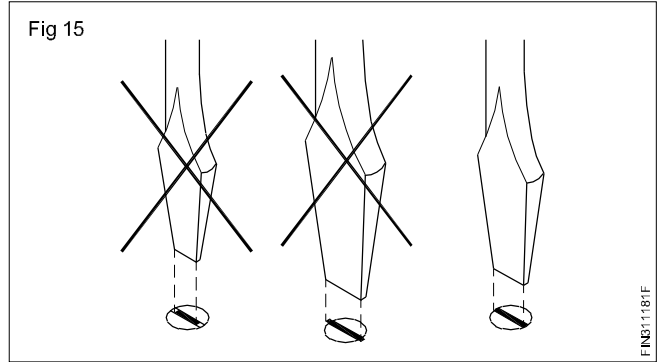
Screwdrivers with blades sheathed in insulation are available for the use of electricians. (Fig 14)



Precautions

Use screwdrivers with tips correctly fitting into the screw slot. (Fig 15)

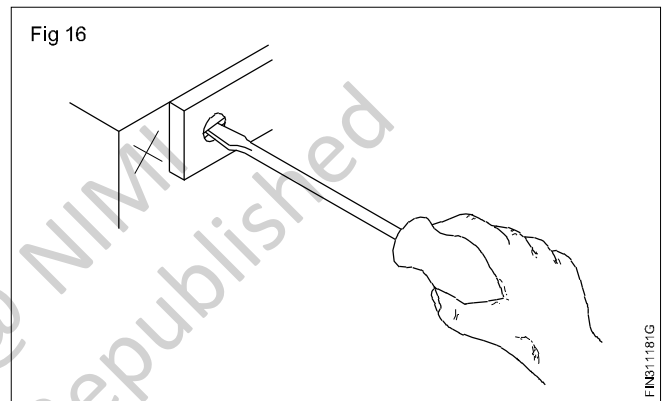
Make sure your hand and the handle are dry.



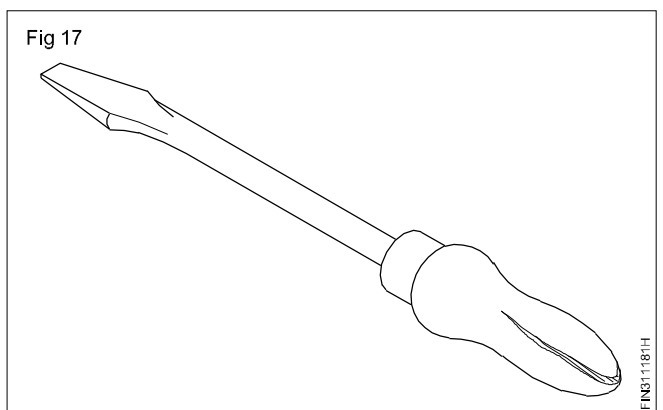
Hold the screwdriver with its axis in line with the axis of the screw.

While using a Philips screwdriver apply more downward pressure.

Keep your hand away to avoid injury due to slipping of screwdriver. (Fig 16)



Do not use screwdrivers with split or defective handles. (Fig 17)



In the case of damaged screwdrivers, the blades can be ground (the faces will be parallel with the sides of the screw slot) and used. While grinding ensure the end of the tip is as thick as the slot of the screw.

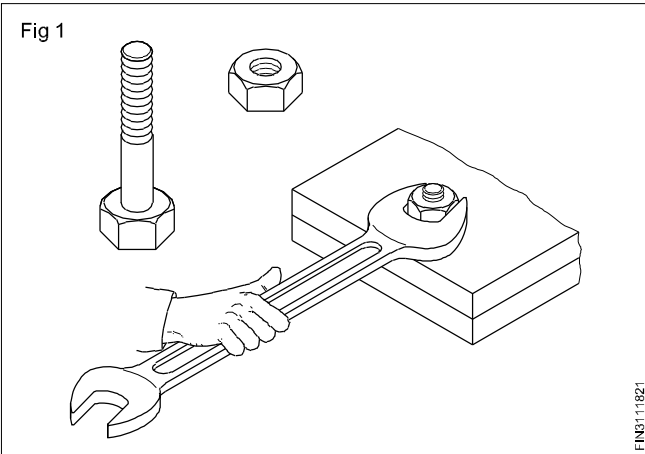
While using screwdrivers on small jobs, place the jobs on the bench or hold them in a vice.

Spanners

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

- state the uses of different sizes of spanners
- identify the size of a spanner.

A spanner is a hand tool with jaws or opening or a ring at one end or at both ends for tightening or slackening nuts and bolts and screw heads. (Fig 1) It is made of drop-forged, high tensile or alloy steel and heat treated for strength.



Types of spanners

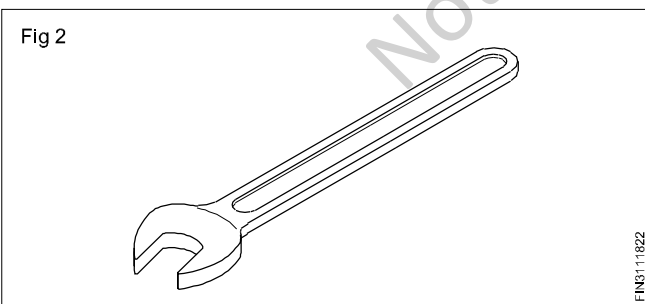
- Open end spanners
- Ring spanners

Open end spanners

They can be single ended or double ended.

Single-ended spanners

These are general purpose spanners. Single-ended spanners are mostly supplied with machine tools for a specific purpose. (Fig 2)



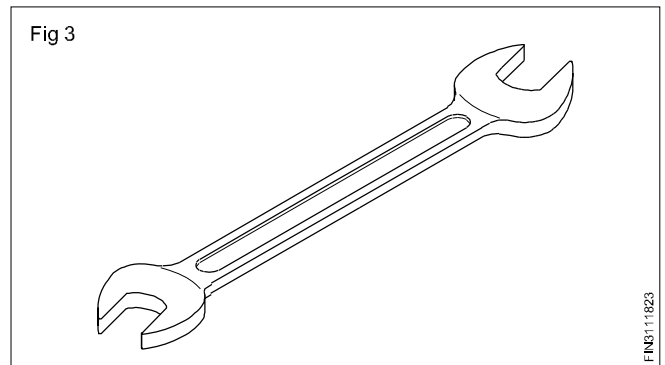
Double-ended spanners

Double-ended spanners are standard spanners having two different size openings. Some spanners are made of chrome vanadium steel.

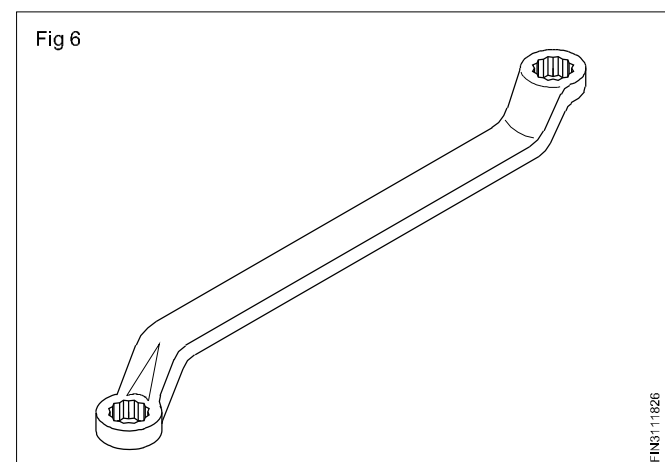
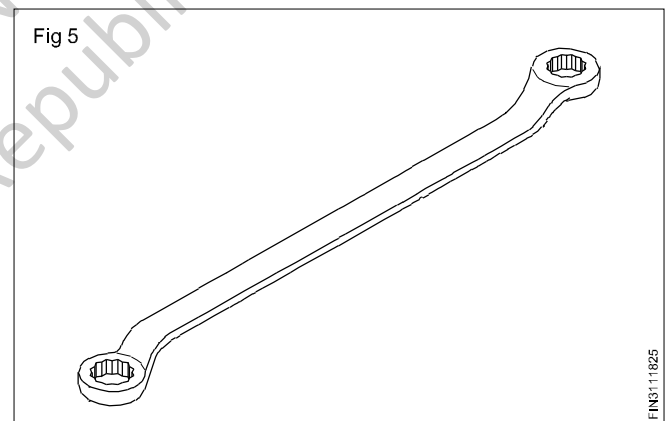
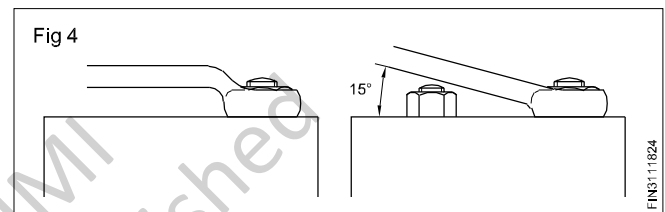
They are available in a set of 8, Nos 8 to 27 mm. (Fig 3)

8x10, 9x11, 12x13, 14x15, 16x17, 18x19, 20x22 and 24x27 mm.

Bigger than 27 mm size open end spanners are also available.



Ring spanners (Figs 4,5 & 6)



These types of spanners are used where obstruction close to the side of a nut prevails (Fig 4) and application of open-ended spanners is not possible.

These are available in a set of 8 Nos. (8 to 27 mm)

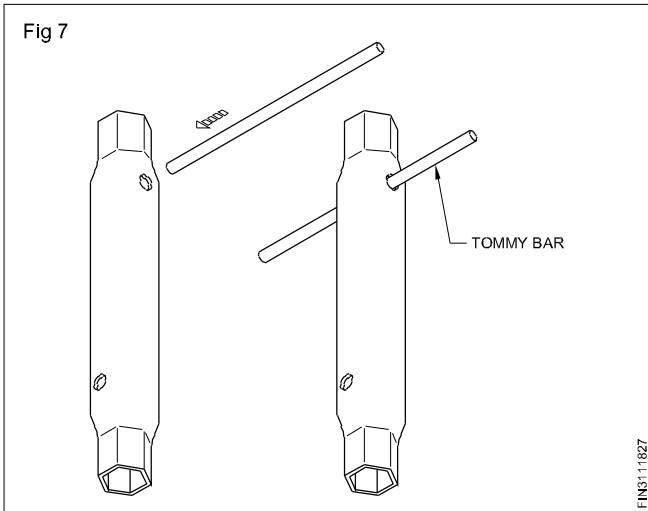
8x9, 10x11, 12x13, 14x15, 16x17, 18x19, 20x22 and 24x27 mm.

Sizes and identification of spanners

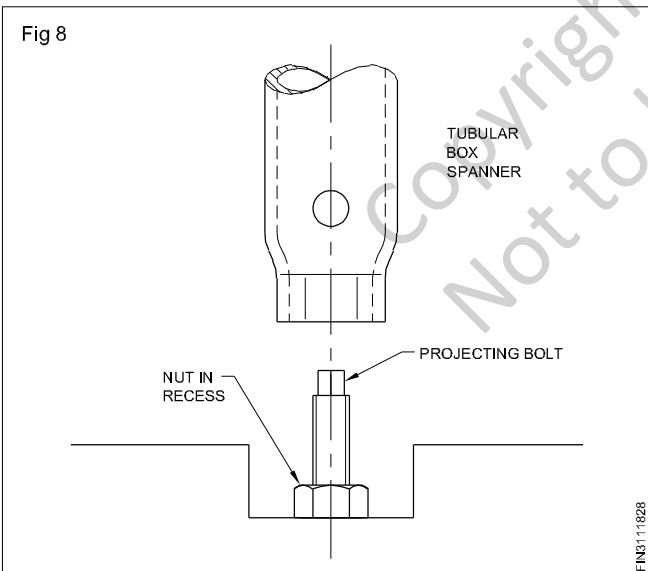
Spanners for metric bolts, nuts and screws are marked with the size across the jaw opening in mm.

Special purpose spanners

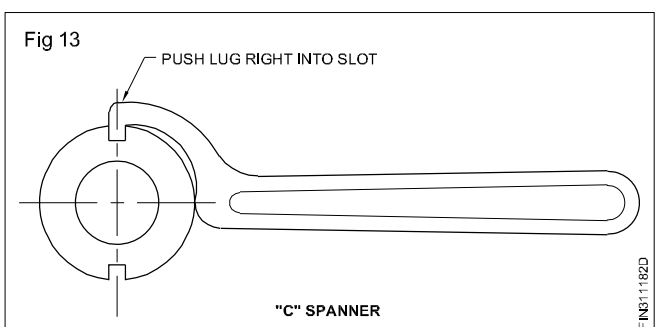
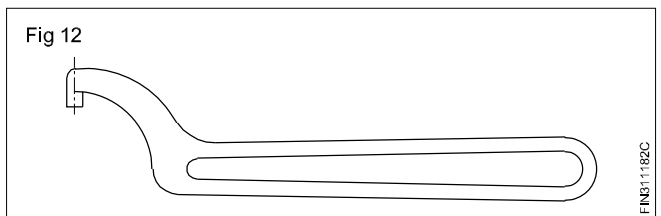
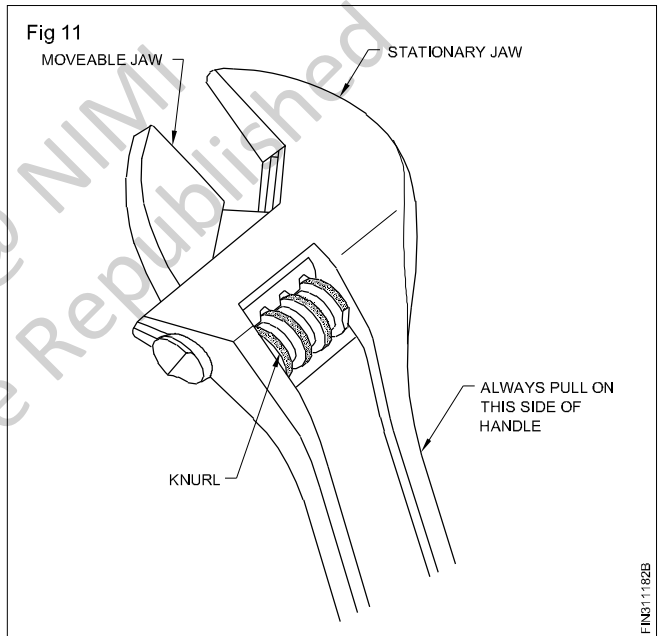
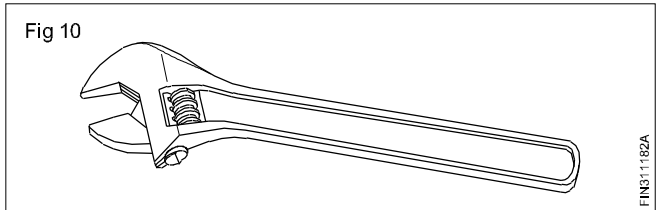
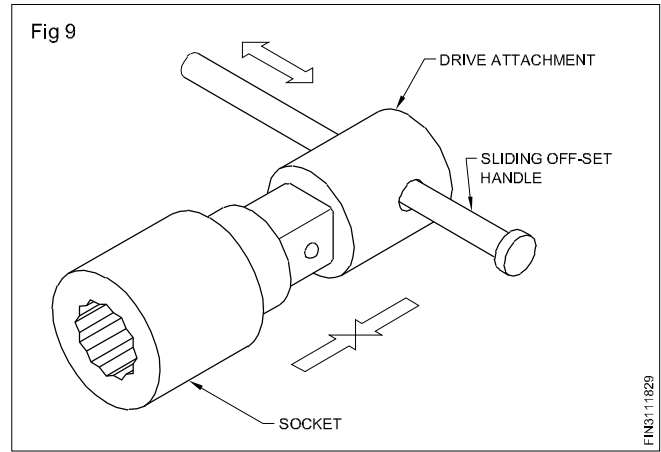
- Tube or tubular box spanners (Figs 7 & 8)



- Socket spanners (Fig 9)



- Adjustable spanners (Figs 10 & 11)
- Hook spanners (C-spanner) (Figs 12 & 13)



Power tools

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

- define power tool, torque and torque wrench
- state care and maintenance of power tools.

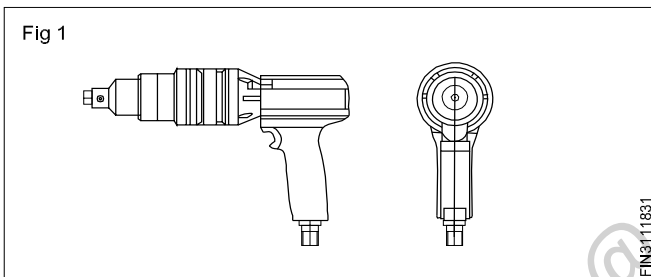
Definition

A power tool is a tool actuated by power source and mechanism other than manual labour used with hand tools for fastening bolts and nuts.

Power wrench

A power wrench is type of wrench that is powered by other means than human force. A typical power source is compressed air. There are two main types of power wrenches:

- 1 Impact wrenches and
- 2 Air ratchet or pneumatic ratchet wrenches

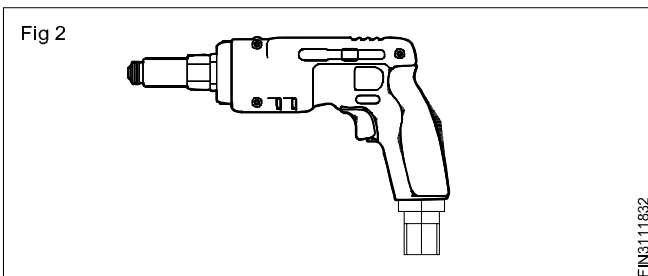


Air ratchet wrench

An air ratchet wrench is very similar to hand powered ratchet wrenches in that it has the same square drive, but an air motor is attached to turn the socket drive. Pulling the trigger activates the motor which turns the socket drive. A switch is provided to change the direction of socket drive.

This type of power wrench is designed more for speed and less for torque. If high levels of torque are desired an impact wrench should be used.

Pneumatic torque wrench



Pneumatic torque wrench setting torque on bolts.

A pneumatic torque wrench is a primary torque multiplier or a gear box that is mated to a pneumatic air motor. At the end of the gear box is a reaction device that is used to absorb the torque and allows the tool operator to use

it with very little effort. The torque output is adjusted by controlling the air pressure.

These planetary torque multiplier gearboxes have multiplication ratios up to 125:1 and are primarily used anywhere accurate torque is required on a nut and bolt, or where a stubborn nut needs to be removed.

The pneumatic torque wrench is sometimes confused with a standard impact wrench due to their similar appearance. A pneumatic torque wrench is driven by continuous gearing and not by the hammers of an impacting wrench. A pneumatic torque wrench has very little vibration and excellent repeatability and accuracy.

The pneumatic torque wrench was first invented in Germany in the early 1980's.

Torque capabilities of pneumatic torque wrenches range from 118Nm, up to a maximum of 47,600Nm.

Air requirements

A pneumatic motor using compressed air is the most common source of power for pneumatic torque wrenches. CFM requirements are usually 20-25 CFM of air consumption per tool.

CFM - Cubic feet/minute (or) PSI - Pounds/square inch.

Torque wrenches

Screwdrivers are available - manual, electric and pneumatic with a clutch that slips at a preset torque. This helps the user tighten screws to a specified torque without damage or over-tightening. Cordless drills designed to use as screwdrivers often have such a clutch.

Torque

- Torque is the application of a force acting at a radial distance and tending to cause rotation
- Torque is used to create tension in thread fasteners
- When the nut and bolt are tightened the two plates are clamped together. The thread converts the applied torque into tension in the bolt shank. This turn is converted into clamping force. The amount of tension created in the bolt is critical.

Torque wrench

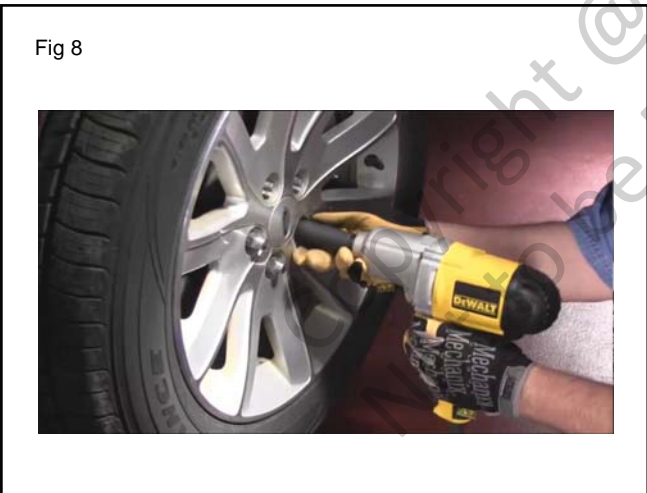
A tool for setting and adjusting the tightness of nuts and bolts to a desired value is called torque wrench.

Fastener tightening

- Always use a torque wrench to tighten fasteners, and use a slow, smooth, even pull on the wrench.

torque to save the head of the screw or any mishaps of snapping.

Uses of power screwdrivers will really depend on the person and project out there, but are less versatile since the attachments are as of variety when compared to drills. We know many who have both a power screwdriver and drill for more versatility in their work flow. They can also help is in hard-to-reach spots and corners since they are usually smaller than drills and only take one hand to use.



Explanation on the creation of a clamping force

The tension in the bolt creates a clamping force (generally referred to as the preload) between the two parts

If the clamping force is too low, the fasteners can work loose due to vibrations or movement between the component parts

If a clamping force is too high, the fastener may permanently stretch and no longer apply the required clamping force

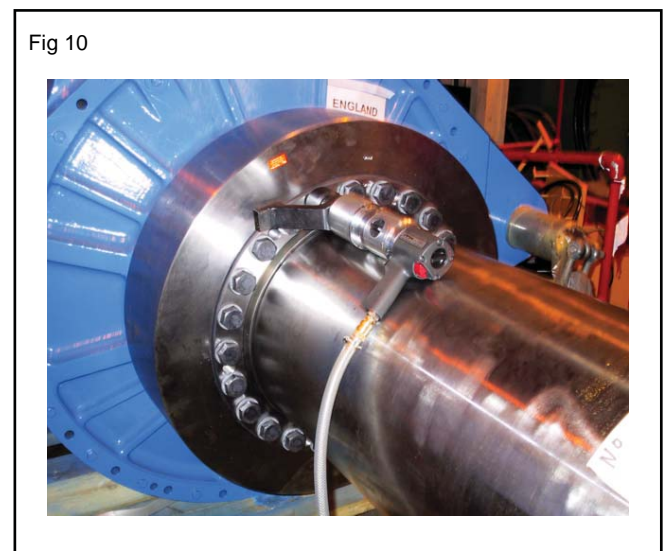
In severe cases the fastener may fail in assembly or during use when under loaded

How to calculate torque

Torque is the result of multiplying the value of force applied by the distance from the point of application

Comparing the two examples below (A and B) it will be noted that the same resultant torque can be achieved with a lower force if the distance from the nut/bolt is increased

It should also be realised that some torque wrenches are length dependent which means that the actual torque applied to the fastener varies if the hand position on the wrench is varied - even with the wrench preset. This occurs if the pivot point of the wrench mechanism is not coincidental with the point of application of torque



Maintenance of power tools

Power tools and other machines are designe for long life, but each requires some care and maintenance to meet its life expectancy. Properly storing power tools, performing maintenance as needed, and replacing machine parts will extend a tool's life to its full potential and deliver more value to its owner.

Proper storage

Our three guidelines for tool storage are:

1. Store tools in an area protected from the elements (like moisture).
2. Store tools in a clean and organized space.
3. Store tools in a well-ventilated area.

Keeping tools out of the elements protects them from damage and wear. A clean and organized storage space will promote safety, and keeping tools well-ventilated will help them run smoothly when it's time to pull them out of storage.

It might take a little extra time to put everything back in place at the end of the day or completion of a project, but storing tools the right way will always be worth the effort.

Care and maintenance

Before being stored, most power tools can use a little cleaning and a couple of quick checks for damage or other problems. Here's some maintenance tips for keeping those tools in good shape.

- Use a tooth brush and a soft cloth to wipe debris from power tool casings before storage.
- If available, use an air compressor to clean out power tool vents. A little air will go a long way. When a machine or tool can breathe more, it will run cooler and wear more slowly. For an "Air compressors 101" article -click here,

- Lubricate power tool parts that need to be lubricated. Following instructions in the tool's user manual will be help here.
- Check the parts that hold a tool together, screws and other fasteners. Tighten up anything that might have been shaken loose during operation.
- Electrical cords should be checked with each use of a power tool.
- A bad power cord can be dangerous and should be replaced before the tool is used again. For more information about power cords - click here.
- Keep blades and other cutting accessories sharp. Check bits and other accessories for wear and damage.
- Follow any other maintenance guidelines for a tool or machine explained in its user manual.

Replacing parts

Like cars and other machinery, many power tool parts are designed for wear and replacement. The expected service life of a power tool takes the replacement of certain parts into account.

Some examples of parts that commonly need to be replaced on power tools are : Carbon brushes, switch assemblies, power cords, accessories, bearings, and tires. Performing the checks and maintenance suggested in the section above is important for catching tool performance issues right when they start acting up.

Making tool repairs at the first sign of performance trouble can prevent damage to other parts of machine or tool.

Locking devices - Types of lock nut

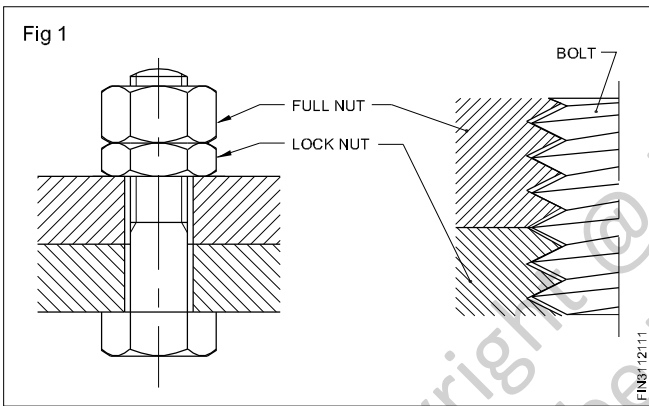
Objectives : At the end of this lesson you shall be able to

- state the different types of locking devices
- state the uses of locking devices.

Nuts used along with bolts in assembly may loosen due to vibration. Different types of nut-locking devices are used depending on the severity of the condition in which the fastener is used. The following are the most commonly used types.

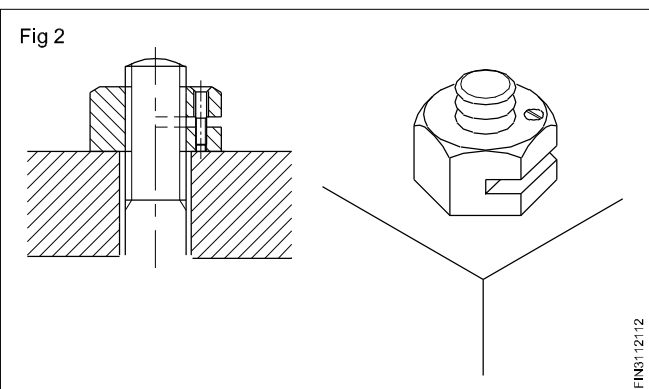
Lock-nut

A thin nut with both faces machined is placed below a nut in the assembly. (Fig 1) Both nuts are tightened over the bolt one after the other. Then using two spanners pressure is exerted on both nuts by turning in opposite directions. Both nuts are held together by friction.



Sawn nut (Wiles nut)

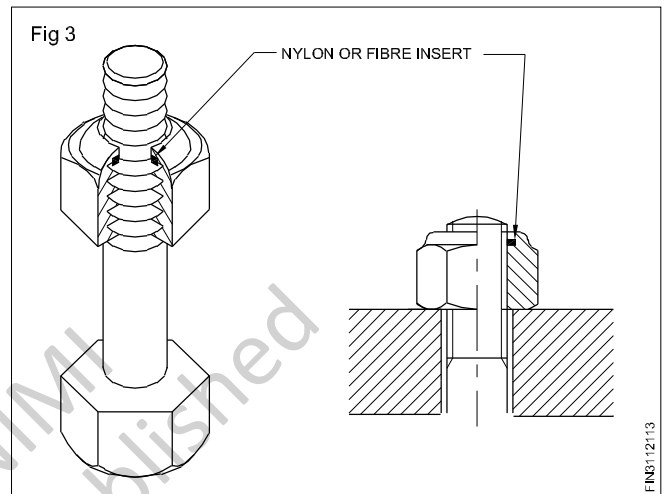
In this type of locking, a slot is cut half way across the nut. A screw is fitted with a clearance hole on the top part and matching thread on the lower part of the nut. (Fig 2) Tightening of the nut provides positive locking for the nut.



Self-locking nut (Simmonds nut)

This is a special nut with a nylon or fibre ring insert placed in the upper part of the nut. The internal diameter of the ring is smaller than the core diameter of the bolt thread.

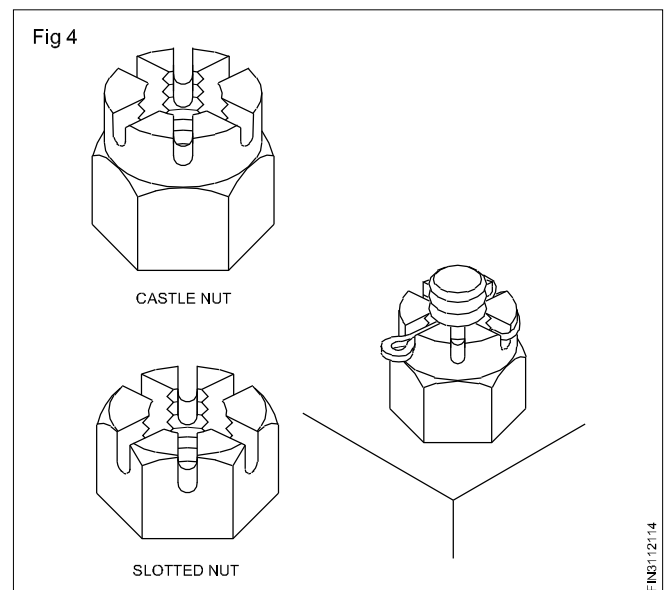
The nut while tightening cuts its own thread on the nylon insert. This provides a positive grip and prevents the nut from loosening due to vibration. (Fig 3)



Slotted and castle nuts

These nuts have special provision in the form of slots for fixing split pins for locking the nuts.

Slotted nuts are hexagonal shaped throughout. (Fig 4) in the case of castle nuts, the top part of the nut is cylindrical in shape.



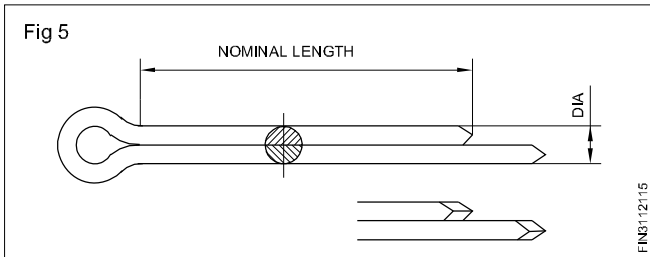
Slotted and castle nut with split pin

The position of the nut can be locked using a split pin.

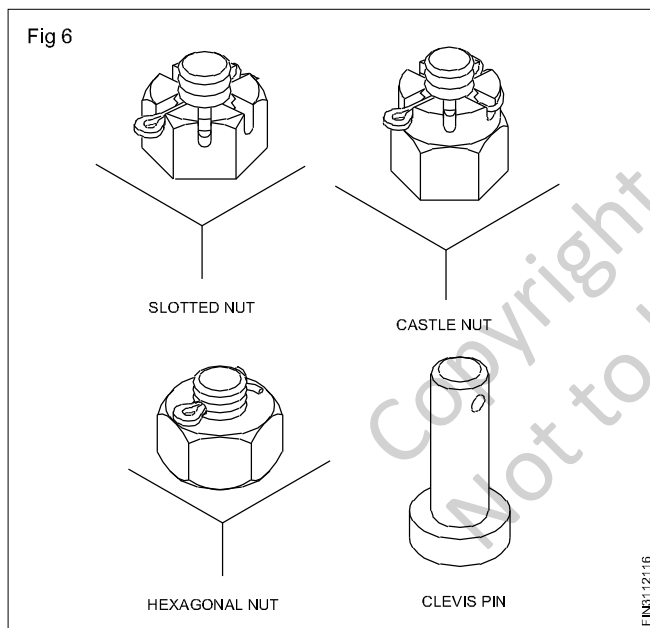
Split pins are designated by the nominal size, nominal length, the number of the Indian Standard and the materials (for materials other than steel only).

The nominal size is the diameter of the hole for receiving the split pins.

The nominal length is the distance from the underside of the eye to the end of the short leg. (Fig 5)



Split pins are used for locking slotted nuts, castle nuts, hexagonal nuts, clevis pins etc. and are used in different ways. (Fig 6)

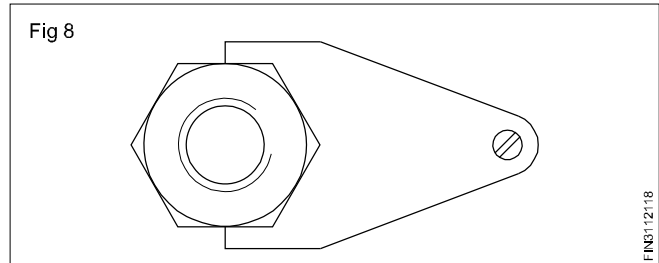
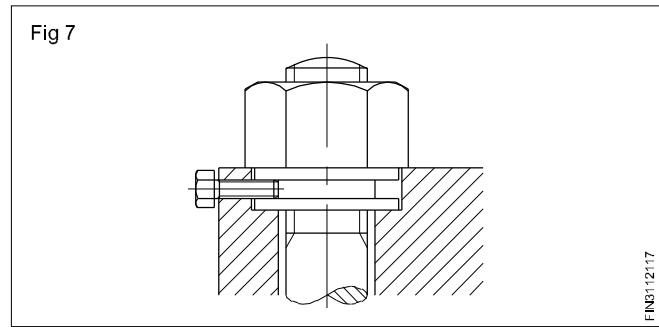


Grooved nut (Penning nut)

This is a hexagonal nut with the lower part made cylindrical on the cylindrical surface. There is a recessed groove in which a set screw is used to lock the nut. (Fig 7)

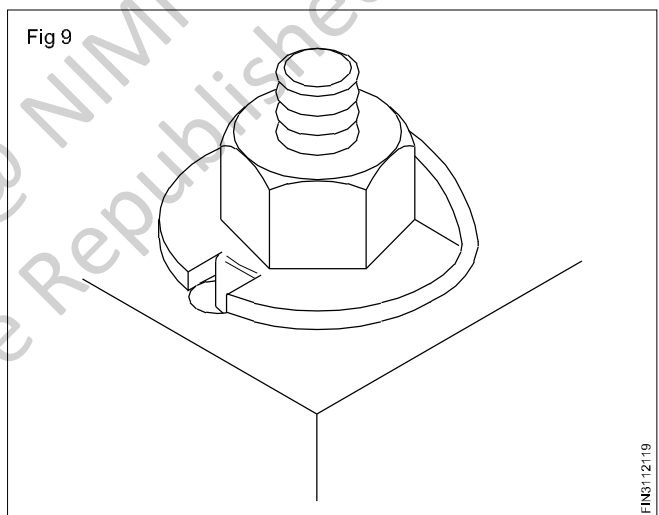
Locking plate

For preventing the nut from loosening locking plates are fixed on the outside of the hexagonal nut. (Fig 8)



Lock-washers with lug

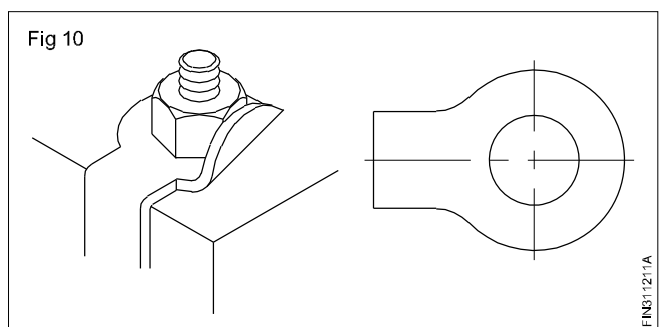
In this arrangement of locking a hole is drilled for accommodating the lug. (Fig 9)



The movement of the nut is prevented by folding the washer against the nut.

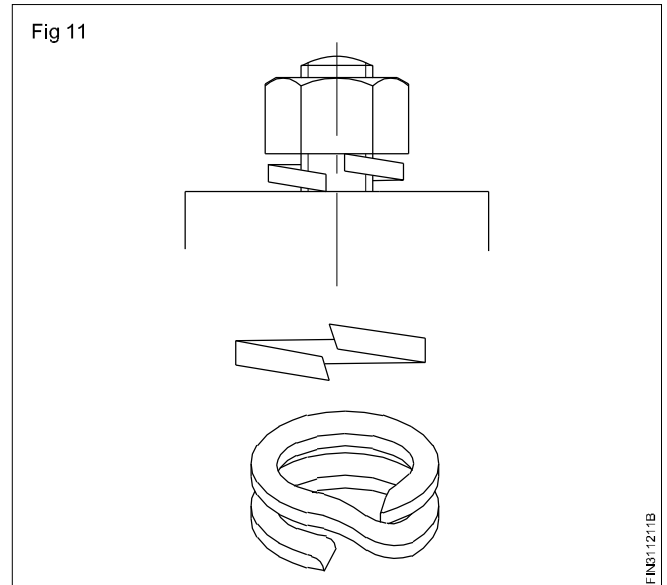
Tab washers (Fig 10)

Tab washers can be used for locking the nuts which are located near an edge or corner.



Spring washers (Fig 11)

Spring washers are available with a single or a double coil. These are placed under a nut in the assembly as washers. The stiff resistance offered by the washer against the surface of the nuts serves to prevent loosening.



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Various types of keys

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

- list the types of keys
- state the specification of keys
- state the standard taper of key
- state the uses of key pullers.

Key

Key is a metallic piece of wedge inserted between a shaft and hub, parallel to the axis of shaft. It is proportionate to the shaft dia.

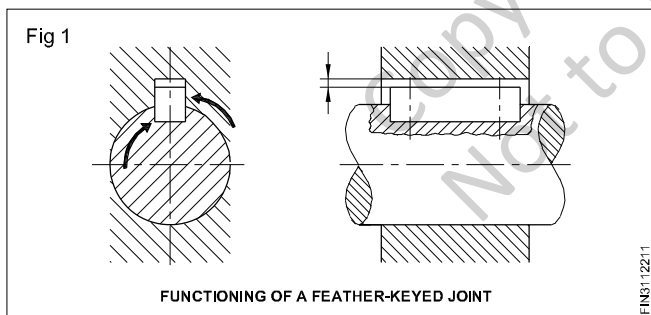
Purpose

A key is an insert which is housed in the keyway to fit together a hub or a pulley to transmit torque. A keyway is provided on the shaft and also on the hub or on a pulley to connect together the conjugate parts by inserting the key in between. The key can be withdrawn at will to disengage the mating components.

Common types

Parallel key or feather key (Fig 1)

This is the most commonly used key, used for transmitting unidirectional torque. A hub or a pulley is engaged to the shaft by a key which prevents relative motion. The functioning of the feather key assembly is shown in Fig 1.



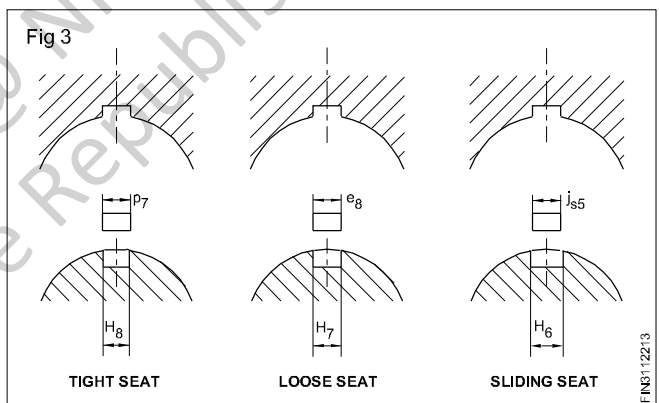
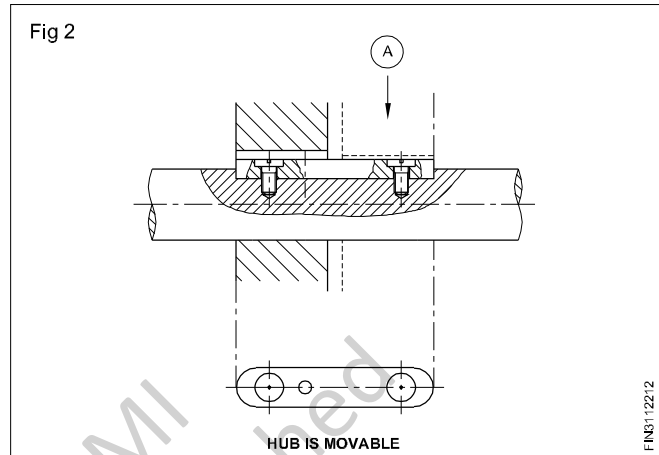
In many cases the key is screwed to the shaft keyway. (Fig 2)

Where axial movement of the hub is required, a clearance fit is provided between the hub and the shaft and the hub and the key. Three types of fits are shown for feather key in Fig 3.

Approximate proportion of parallel or taper keys.

If D is the dia. of the shaft, width of the key $W = 1/4D + 2$ mm.

Nominal thickness $T = 2/3 w$.



Example

Diameter of shaft = 40 mm

$$\text{Width} = \frac{1}{4} \times 40 + 2 = 12 \text{ mm}$$

$$\text{Thickness} = \frac{2}{3} \times 12 = 8 \text{ mm}$$

Thickness at the large end is the nominal thickness of the taper key.

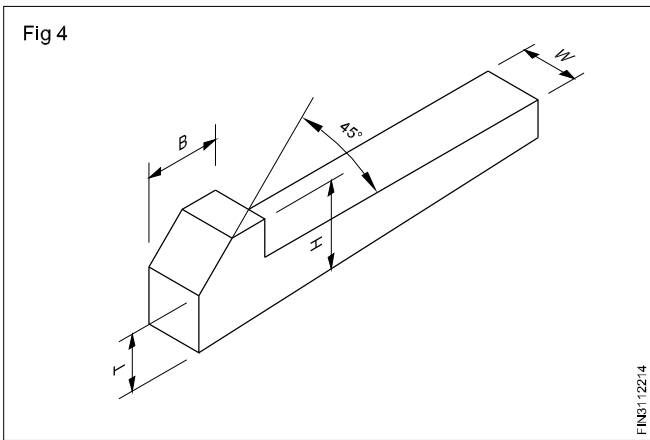
Taper is 1 in 100 on the top face only.

Taper and jib-headed key (Fig 4 & 5)

The key is having a jib-head with a taper (1 in 100) on the top face. It is driven on to the keyway by hammering

on the jib to have a tight fit. The taper rectangular key without a jib-head is also in use. A jib-headed key can be withdrawn easily and used for transmitting more torque. It is not good for high speed applications.

Approximate proportion of jib-headed key (Fig 4)



$$H = 1.75T$$

$$B = 1.5 T$$

$$W = \frac{1}{4} D + 2$$

$$\text{Nominal thickness } T = \frac{2}{3} W$$

$$\text{Angle of chamfer} = 45^\circ$$

Example

Diameter shaft = 46 mm

$$\text{Width}(w) = \frac{1}{4} \times 46 + 2 = 11.5 + 2$$

$$= 13.5 \text{ rounded off to } 14 \text{ mm.}$$

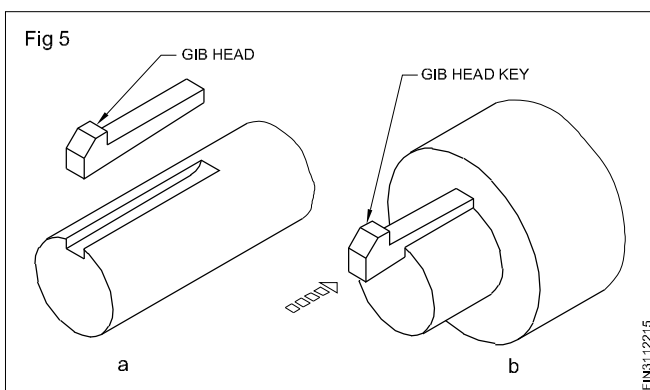
$$\text{Thickness}(T) = \frac{2}{3} \times 13.5 = 9 \text{ mm}$$

$$H = 1.75 \times 9 = 15.75$$

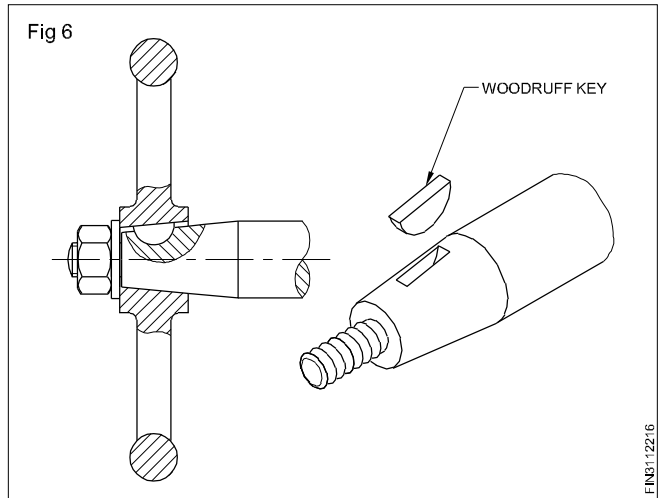
say 16 mm

$$B = 1.5 \times 9 = 13.5 \text{ mm.}$$

Woodruff key (Fig 5)

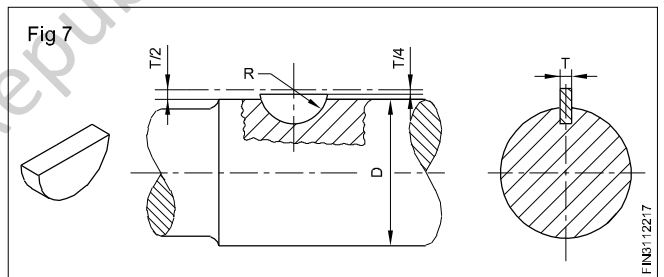


It is a semicircular key used for transmitting light torque. It fits on to the shaft on which matching recesses are cut. The top portion of the key projects out and fits in the keyway cut on the hub. (Fig 6)



This key is particularly useful on tapered fittings or shafts. Its key way is milled to the profile of the key on the shaft which tends to weaken the shaft. This type of key positions itself in the keyway to accommodate the hub to have an easy assembly.

Approximate proportion of woodruff key (Fig 7)



$$\text{Radius of the key } (R) = \frac{D}{3}$$

$$\text{Thickness}(T) = \frac{D}{6}$$

Example

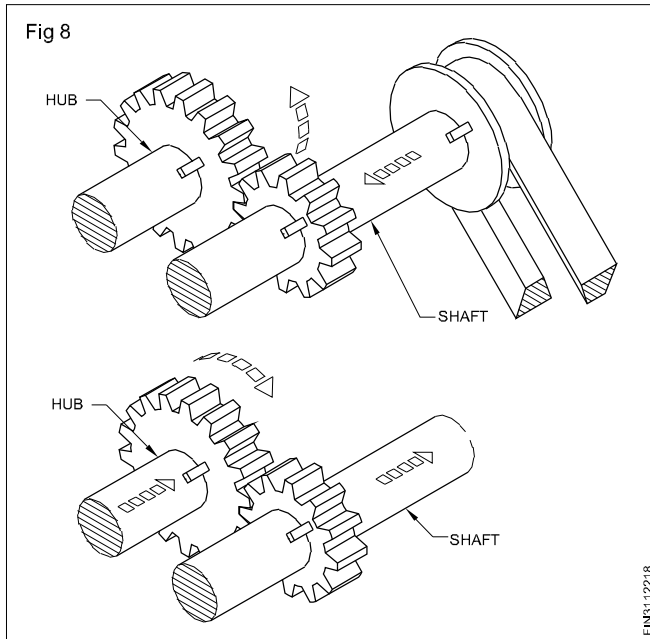
For shaft $\phi 30$.

$$R = 30/3 = 10 \text{ mm}$$

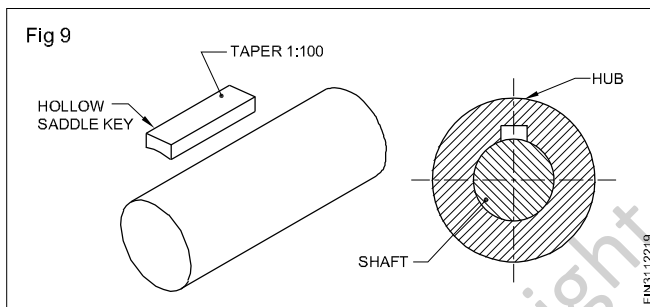
$$T = 30/6 = 5 \text{ mm}$$

Keys and splines: Keys and splines are used for transmitting torque from a rotating shaft to a hub/wheel or from a hub/wheel to the shaft. (Fig 8)

Keys of different types and splines are used depending on the requirements of transmission.



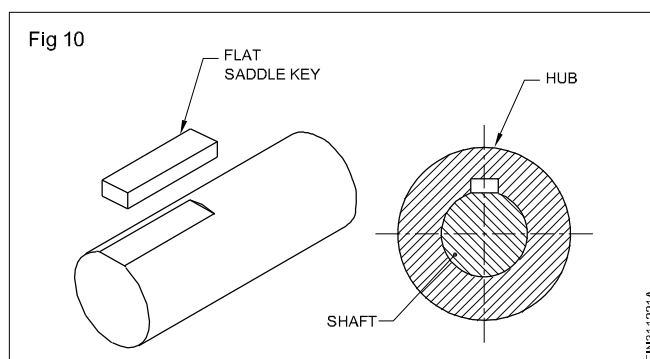
Hollow saddle key: One face of this key has a curvature to match with that of the shaft surface. It has a taper of 1 in 100 and is driven in through the keyway. (Fig 9)



The hub is held on the shaft due to friction. This key is useful only for light duty transmission.

Flat saddle key: This key has a rectangular cross-section.

For fitting this key in the assembly a flat surface is machined on the shaft. (Fig 10) The key is placed between the flat surface of the shaft and the keyway on the hub. This is considered to be stronger than the hollow saddle key. This is not suitable for heavy duty transmission.



Approximate proportion

If D is the diameter of the shaft,

$$\text{width of the key } (W) = \frac{1}{4}D + 2 \text{ mm}$$

$$\text{nominal thickness } (T) = \frac{1}{3}W.$$

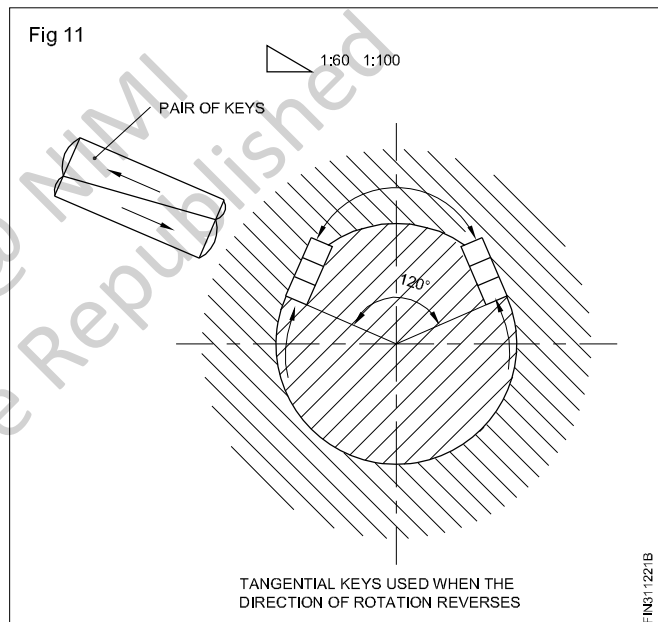
Example

diameter shaft = 24 mm

$$W = \frac{1}{4} \times 24 + 2 = 8 \text{ mm}$$

$$T = \frac{1}{3} \times 8 = 2.7 \text{ or } 3 \text{ mm.}$$

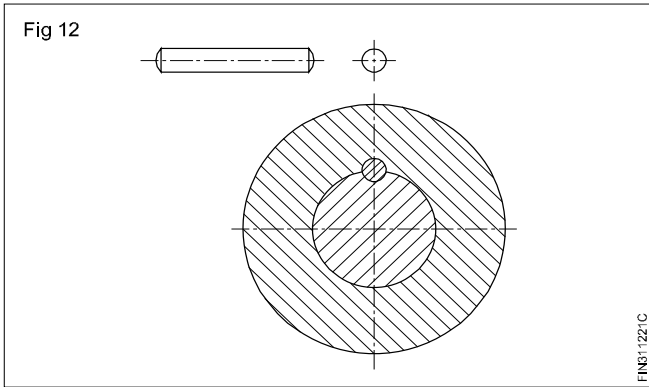
Tangential key (Fig 11)



These keys are used when very high torque of impact type is to be transmitted in both directions of rotation. Common applications are found in flywheels, rolling mills etc. A tangential key consists of two taper rectangular wedges, positioned one over the other in opposite directions. Two sets of keys are fixed at 120° angle as shown in Fig 11 and should be such that the broad side is directed along a tangent to the shaft circle while the narrow side sits along the radius of the shaft.

Round key (Fig 12)

It is of cylindrical cross-section and is used in assemblies to secure the mating components where the torque is light. The key is fitted parallel to the shaft into the drilled hole made partly on to the shaft and partly on to the mating part.



Approximate proportion of round key

If dia. of the shaft = D

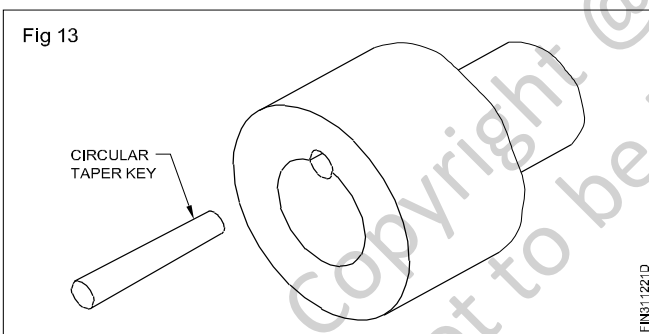
$$\text{Dia. of the key (d)} = \frac{1}{6} D$$

Example

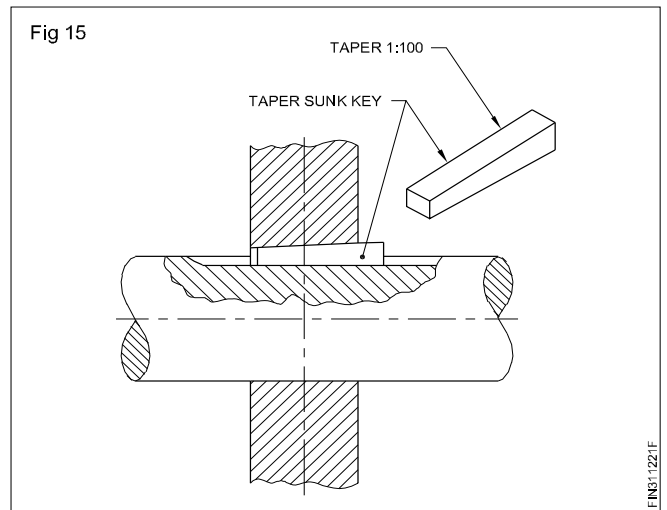
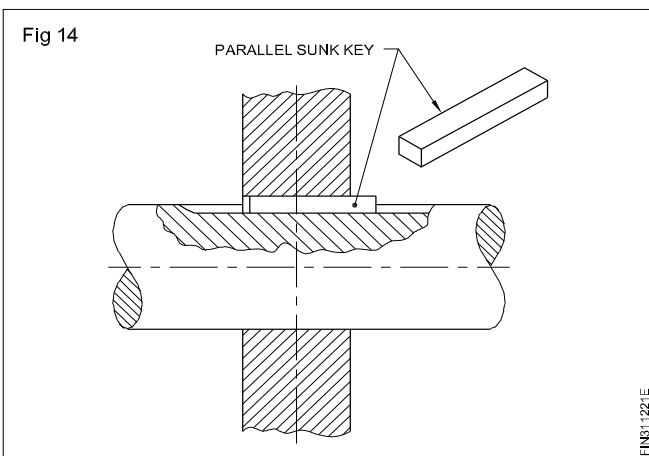
Dia. of shaft = 30 mm

$$\text{Dia of key} = \frac{1}{6} \times 30 = 5 \text{ mm}$$

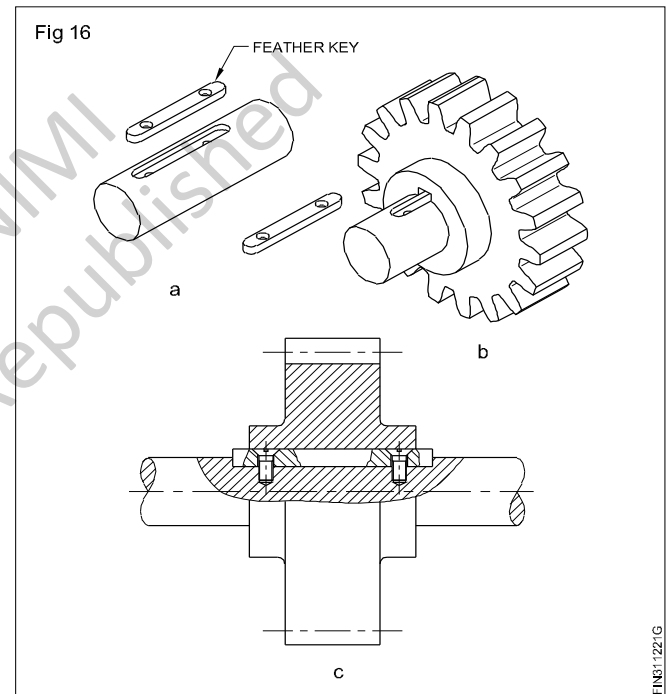
Circular taper key: In this case both the shaft and the hub have semicircular keyways cut on them. (Fig 13) The taper key is driven in while assembling. This key is suitable only for light transmission.



Sunk key: This key has a rectangular cross-section and it fits into the keyway cut on both the shaft and the hub. Sunk keys are either parallel or tapered. (Figs 14 and 15)



Feather key: This is parallel key with rounded ends. This is useful when the hub/pulley has to slide axially on the shaft to some distance. (Figs 16a, b and c) This key may be either tightly fitted in the keyway or screwed in.



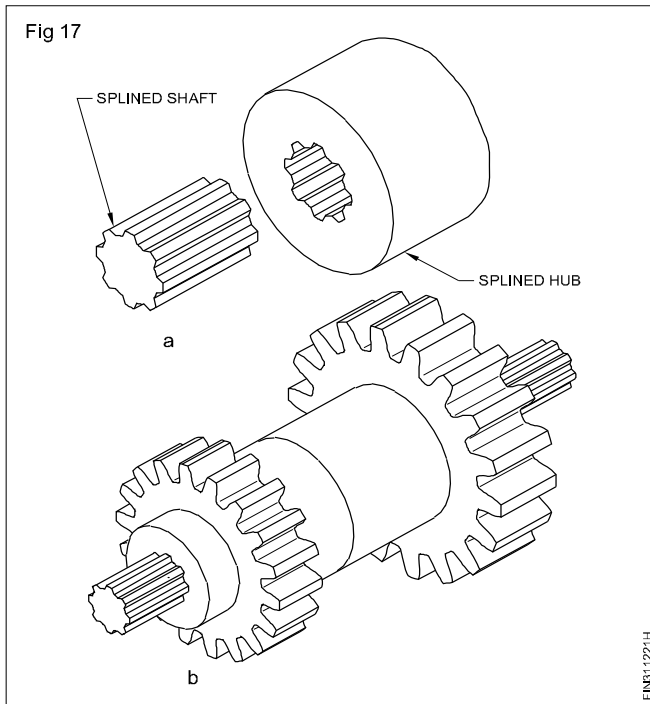
Splines: Splines are ridges (or) teeth on a drive shaft that mesh with grooves in a mating piece and transfer torque to it, maintaining the angular correspondence between them.

An alternative to spline is a key way and key

Splined shaft and serrated shaft: Splined shafts along with splined hubs are used particularly in the motor industry. The splined hub can also slide along the shaft, wherever necessary (Figs 17a and b) used while fixing change gears in a lathe and heavy duty drilling machine.

In certain assemblies, serrated shafts are also used for transmission. (Fig 18)

Peg feather key: It is a parallel rectangular key having a round peg at the centre or one edge of the key face. (Fig 19)



when the spindle in rotation.

Some of the key dimensions as per IS is given in table 1, 2, 3 & 4.

Key puller

Key puller is used for the safe removal of keys from the shaft of any type of machine, motor, blower, compressor, etc.

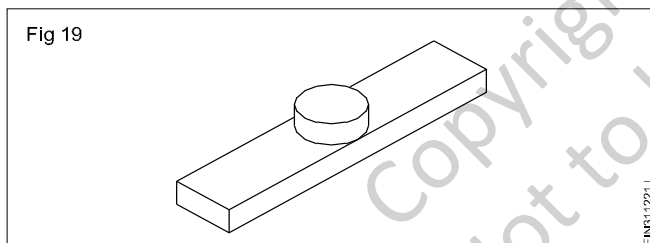
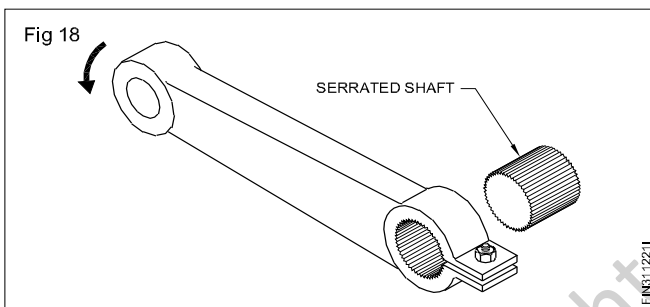
It is generally used for the keys from 5mm to 35mm width.

Advantages

- Safe and fast removal
- Perpendicular removal
- No damage to shafts & keys
- Saves time & labour costs & costs

Easy-to-use

- 1 Turn wheel (A) to move the jaws (1) up or down so that they are aligned with housing (2)
- 2 Turn wheel (B) to fit the size of the key allowing ± 1 mm space.
- 3 Turn wheel (B) hand tight to secure the key with the jaws.
4. Then turn wheel (A) to extract the key perpendicularly.
5. Turn wheel (A) to move the jaws down, turn wheel (B) to open the jaws and free



The peg will fits into the hole of the shaft or stationary member of a unit assembly to prevent the sliding of the key.

A peg feather key is used at the bottom of the tail stock barrel to prevent the barrel from rotation. It is also used in a drilling machine spindle while moves along with quill

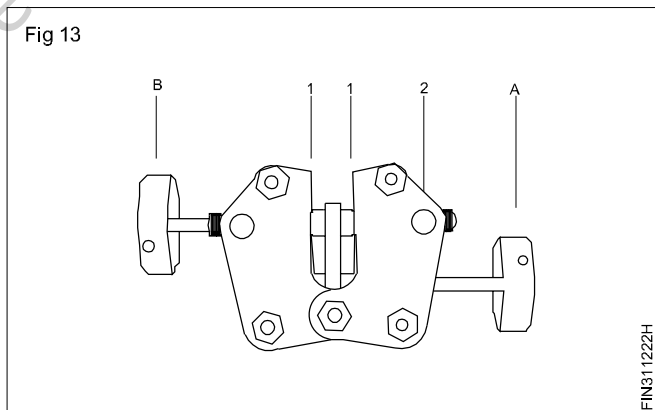


Table 1**Dimensions for keys**

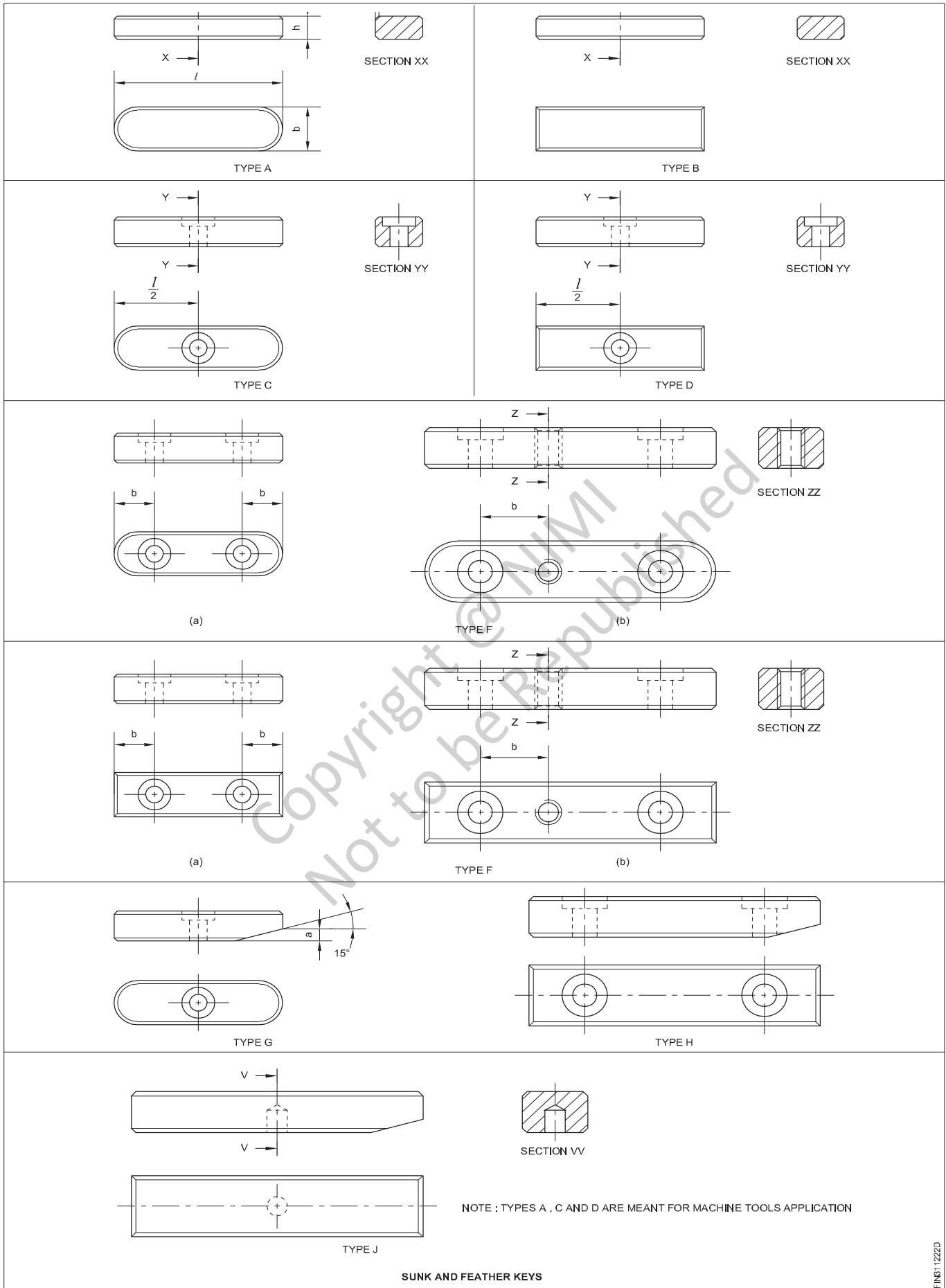
(IS 2048 - 1983)

All dimensions in millimetres

b	Tol on b h9	h	Tol on h*	s		Range of Key Length l		Range of Key Length (for Machine tools only)	
				Min	Max	Min	Max	Min	Max
4	0	4	0	0.16	0.25	8	45	10	45
5	-0.030	5	-0.030	0.25	0.40	10	56	12	56
6		6		0.25	0.40	14	70	16	70
8		7		0.25	0.40	18	90	20	90
10	-0.036	8		0.40	0.60	22	110	25	110
12	0	8	-0.090	0.40	0.60	28	140	32	140
14		9		0.40	0.60	36	160	40	160
16	-0.043	10		0.40	0.60	45	180	45	180

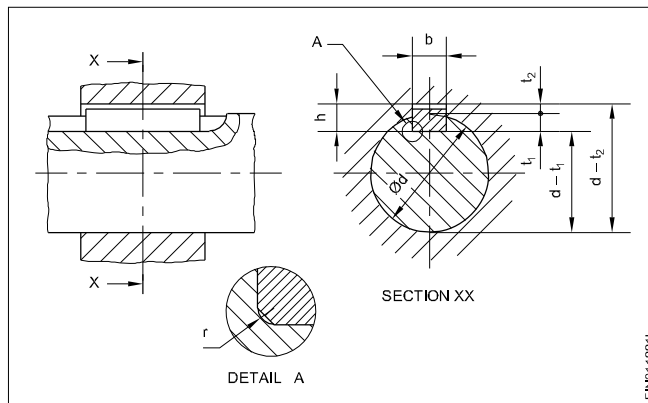
Note - Keys with b = 4 to 40 are meant for machine tools application also.

* Tol on h: Square section h9; Rectangular Section h11.



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Table 2
Dimensions for keyways

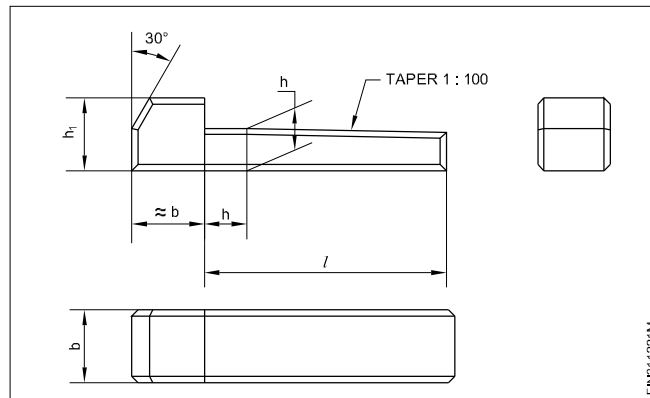


Range of shaft dia d		Key		Keyway									Range of shaft dia d		Keyway for Machine Tools Application			
Above	Upto	b x h	b	Tol on b					t1	Tol	t2 on t1	Tol on t2	Above	Upto	t1	Tol on t2	t2	Tol on t2
				Running fit		Light drive fit		Force fit										
				Shaft H9	Hub D10	Shaft N9	Hub Js9	Shaft & Hub P9										
22	30	8 x 7	8	+ 0.036	+ 0.098	0	+ 0.018.0	- 0.015	4.0		3.3		22	30	5.4 -		1.7 -	
30	38	10 x 8	10	0	+ 0.040	- 0.036	- 0.018.0	- 0.051	5.0		3.3		30	33	6		2.1	
38	44	12 x 8	12	+ 0.043	+ 0.120	0	- 0.021.5	- 0.018	5.0		3.3		38	44	6	+ 0.2	2.1	
44	50	14 x 9	14	0	+ 0.050	- 0.43	- 0.021.5	- 0.061	5.5	0	3.8	0	44	50	6.5	0	2.6	
50	58	16 x 10	16						6.0	+ 0.2	4.3	+ 0.2	50	58	7.5		2.6	

Table 3

Indian Standard specification for GIB Head keys and keyways

All dimensions in millimetres

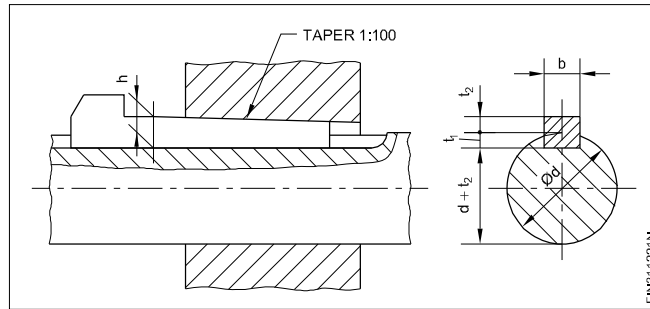


b	Tol on b h9	h	Tol on h*	s		Range of Key length, l		h1
				Min	Max	Min	Max	
4		4		0.16	0.25	14	45	7
5	0	5	0	0.25	0.40	14	56	8
6	-0.030	6	-0.030	0.25	0.40	16	70	10
8	0	7		0.25	0.40	20	90	11
10	-0.036	8		0.40	0.60	25	110	12
12		8	0 -0.090	0.40	0.60	32	140	12
14		9		0.40	0.60	40	160	14
16	0 -0.043	10		0.40	0.60	45	180	16

Table 4

Details of keyway and key

All dimensions in millimetres



Range of Shaft Dia d		Key b x h	Keyway						r		
			b	Tol on b D10	t1	Tol on t1	t2	Tol on t2	Min	Max	
Above	Upto										
22	30	8 x 7	8	+ 0.098 + 0.040	4.0	0	+ 0.2	2.4	0	0.16	0.25
30	38	10 x 8	10		5.0			2.4		0.25	0.40
38	44	12 x 8	12	+ 0.120 + 0.050	5.0	0	+ 0.2	2.4	0	0.25	0.40
44	50	14 x 9	14		5.5			2.9		0.25	0.40
50	58	16 x 10	16		6.0			3.4		0.25	0.40

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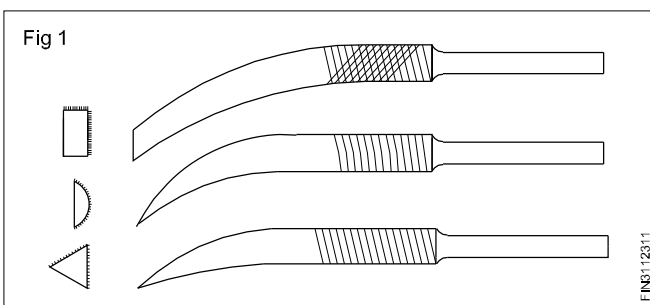
Special Files

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

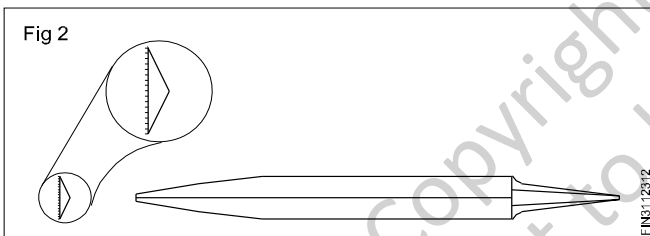
- describe the different types of special files
- state the uses of special file.

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

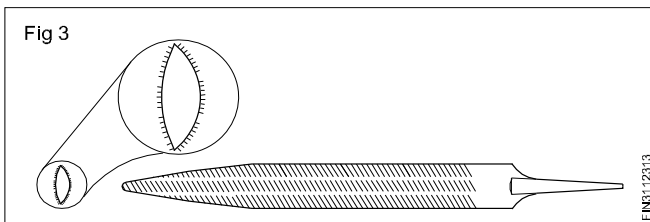
Riffler files (Fig 1): These files are used for die-sinking, engraving and in silversmith's work. They are made in different shapes and sizes and are made with standard cuts of teeth.



Barrette file (Fig 2): This file has a flat, triangular face with teeth on the wide face only. It is used for finishing sharp corners.

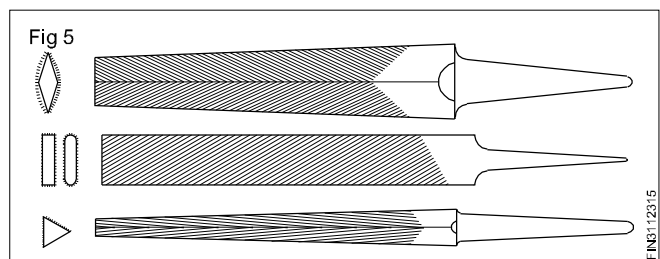
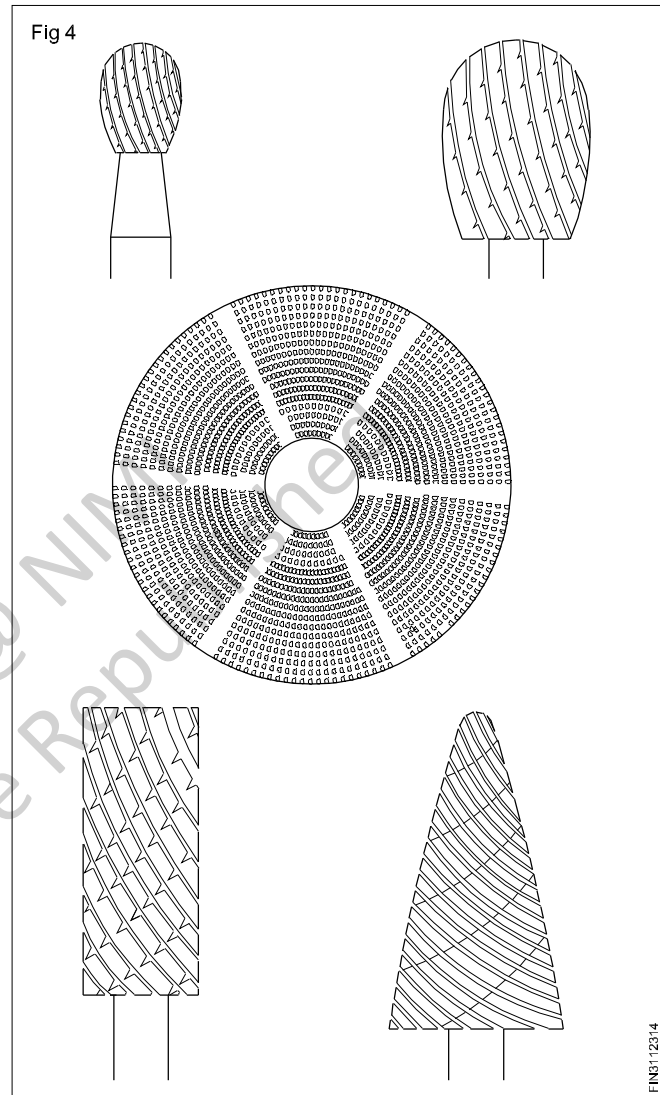


Crossing file (Fig 3): This file is used in the place of a half round file. Each side of the file has different curves. It is also known as "fish back" file.

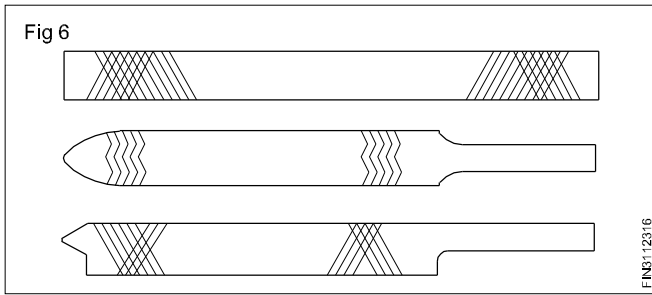


Rotary files (Fig 4): These files are available with a round shank. They are driven by a special machine with a portable motor and flexible shaft. These are used in diesinking and mould-making work.

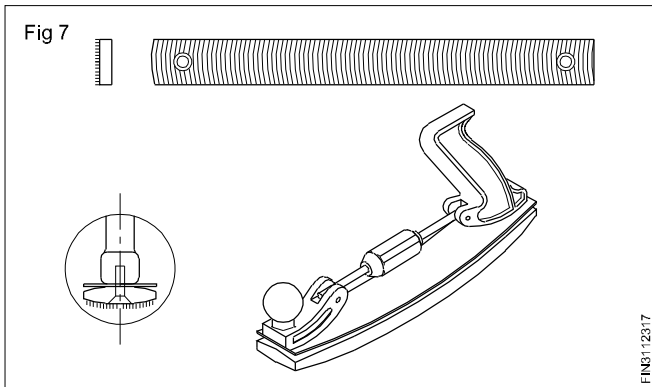
Mill saw files (Fig 5): Mill saw files are usually flat and have square or rounded edges. These are used for sharpening teeth of wood-working saws, and are available in single cut.



Machine files for hand filing machine (Fig 6): 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 diesinking and other tool-room work.

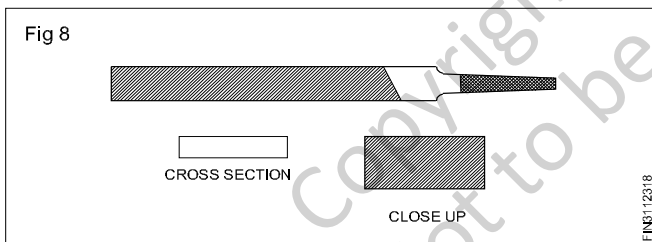


Tinker's file (Fig 7): This file has a rectangular shape with teeth only at the bottom face. A handle is provided on the top. This file is used for finishing automobile bodies after tinkering.



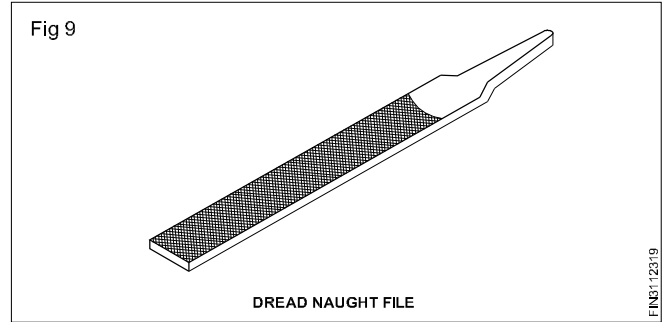
Pillar file (Fig 8)

A usually double-cut file that is rectangular in section, parallel in width with one safe edge, and tapered in thickness from the middle both ways and that is especially suitable for narrow work.



Dread naught file (Fig 9)

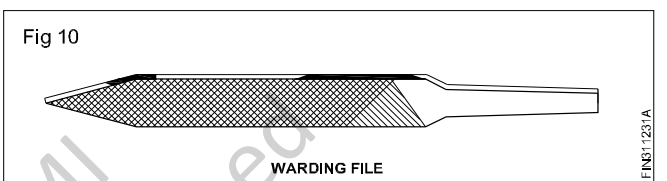
A file is a metalworking, wood working and plastic working tool used to cut fine amounts of material from a work piece. It most commonly refers to the hand tool style, which takes the form of a steel bar with a case hardened surface and a series of sharp, parallel teeth. Most files have a narrow, pointed tang at one end to which a handle can be fitted.



A similar tool is the rasp. This is an older form, with simpler teeth. As they have larger clearance between teeth, these are usually used on softer, non-metallic materials.

Related tools have been developed with abrasive surfaces, such as diamond abrasives or silicon carbide.

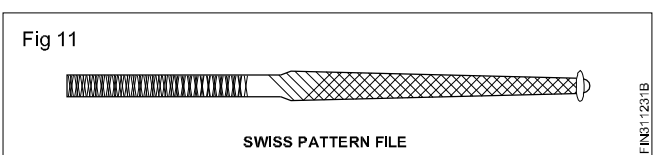
Warding files (Fig 10)



Warding files are tapered to a point for narrow space filing. They have double cut faces and single cut edges. Warding files are used for lock repair or for filling wardnotches in keys.

Swiss pattern files (Fig 11)

Swiss pattern files are made to more exact measurements than American pattern files. They are primarily finishing tools used on all sorts of delicate and intricate parts. Swiss pattern files come in a variety of styles, shapes, sizes, and double and single cuts to insure precision smoothness.



Testing scraped surfaces

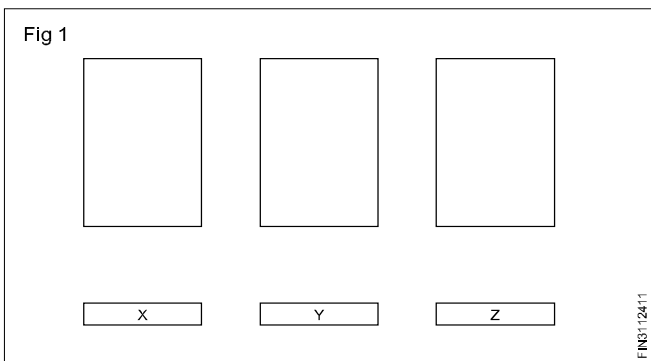
Objective: At the end of this lesson you shall be able to

- testing a scraped surface by 3 plate method. (with worth principle).

How does one obtain a flat surface?

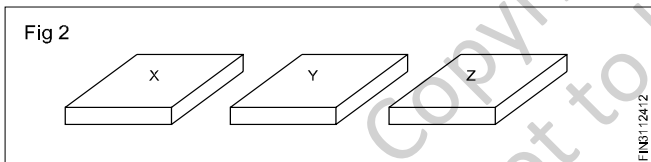
It is easy to say that it is scraped but how does one know where to take off the high points.

If three plates are compared with one another in alternate pairs, they will only mate perfectly in all positions when they are absolutely flat. (Fig 1)



Procedure

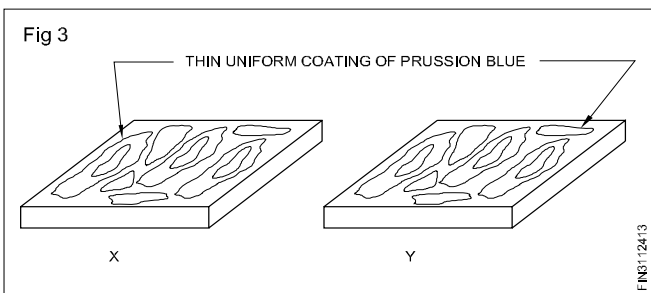
File and ensure that all the three plates are finished to size and square. (Fig 2)



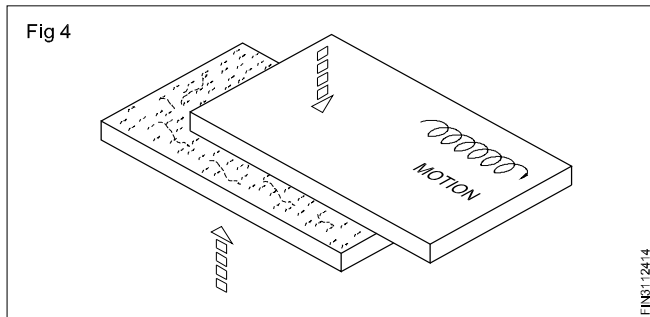
Check the level with the knife edge/straight edge.

Stamp the plates X, Y and Z with a letter punch.

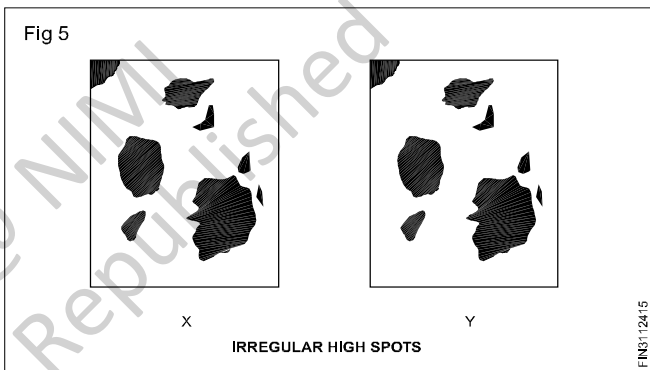
Apply a very thin uniform coating of prussian blue on the faces of plates X and Y which are to be scraped. (Fig 3)



Keep both the pieces together and rub the plates back and forth against each other. (Fig 4)



Observe the high spots on the plates X and Y and remove by scraping. (Fig 5)



Clean the faces with knitted cotton cloth,

Apply an oilstone gently to remove the burrs and again clean with knitted cotton cloth.

Repeat the same procedure till both the faces are mating with good bearing surfaces.

Apply a very thin uniform coating of prussian blue on the face of the plate Z which is to be scraped.

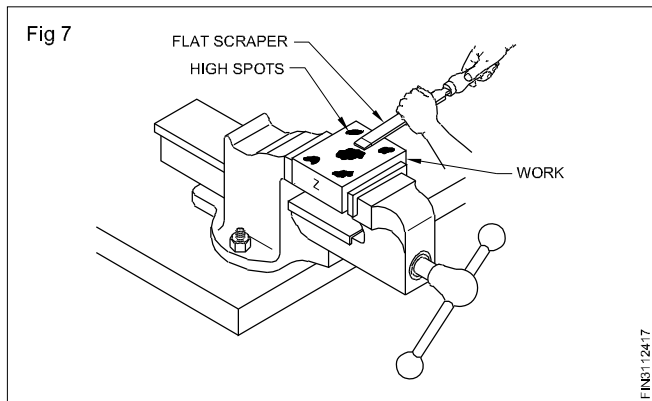
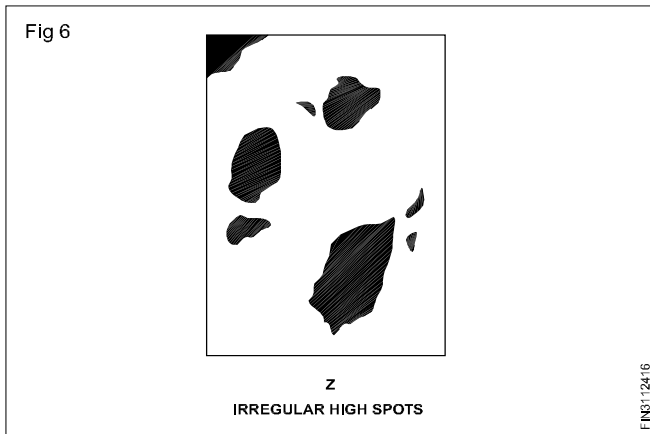
Keep the faces of the plates X and Z together and rub the plates back and forth against each other.

Observe the high spots on the plate Z and remove by scraping. (Figs 6 and 7)

Do not scrape plate X. This is taken as a reference surface.

Repeat the same procedure till both the faces of the plates X and Z are mating with good bearing surfaces.

Repeat the procedure till the faces of plates Y and Z are mating with good bearing surfaces.



Now one cycle of operation is completed

Note

Plate X will mate with plates Y and Z but Y and Z will not mate. All the three plates mate only when all the three are flat.

Testing scraped surfaces, ordinary surfaces without a master plate

The prussion blue technique is a colour transfer test associated with hand scraping of cast iron plates and machine ways, although well known but less used in recent years.

Sharpening a flat scraper

Objective: This shall help you to

- sharpen a flat scraper by grinding and honing.

Flat scrapers are sharpened by grinding the cutting edge and honing both faces.

To avoid overheating while grinding, use wet wheel grinding or ensure that there is a cooling arrangement for the pedestal/bench grinder.

Select a grinding wheel with fine grain. (Fig 1)

Soft grade aluminium oxide grinding wheel with large diameter gives best results.

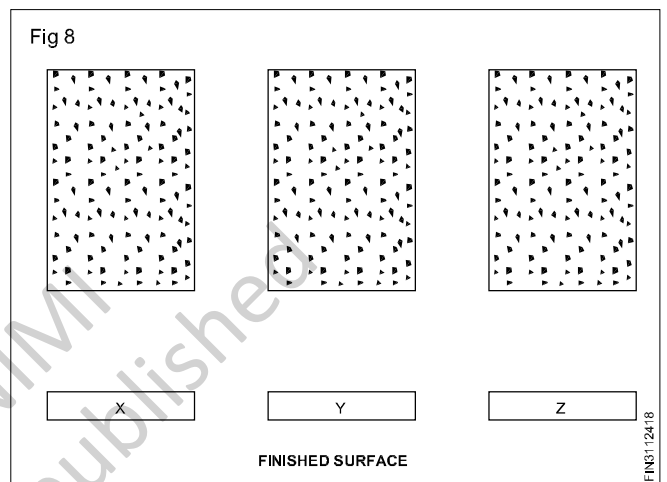
In this test a contour difference is observed between the surfaces of the work and the master plate by the transfer to one surface of a visible colour applied as a thin oil film on the other surface.

Repeat the cycle a number of times till interchangeable, flat, good bearing surfaces are achieved.

Clean all the plates with kerosene.

Use knitted cotton cloth for cleaning

A good bearing surface is achieved when 5 to 10 points are visible and uniformly distributed per cm² on the workpiece surfaces after finishing. (Fig 8)



Three trainees will work in a group for this exercise.

Each trainee will be given one plate for scrapping.

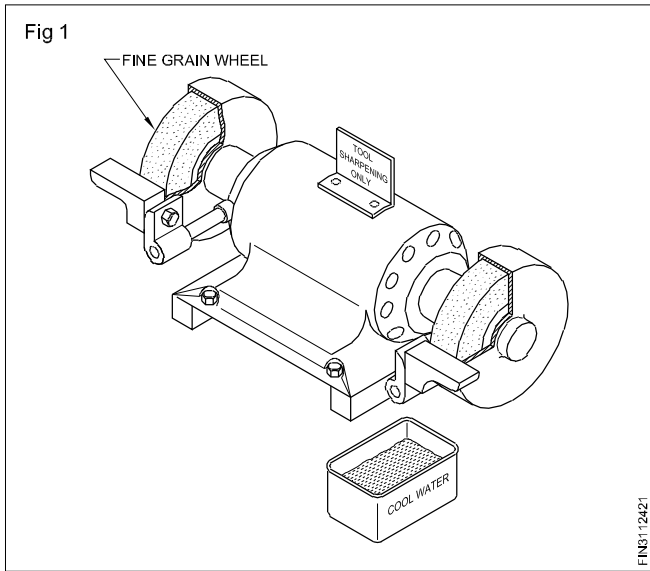
Each trainee will compare his plate with those of the other trainees as per the above procedure and generate flat surfaces by the three-plate method.

Check for gap between the work-rest and the grinding wheel, and adjust, if necessary.

For grinding the cutting edges, hold the scraper horizontal and flat on the tool rest. (Fig 2)

Move the scraper in an arc to provide a slightly concave surface on the cutting edge. (Fig 3)

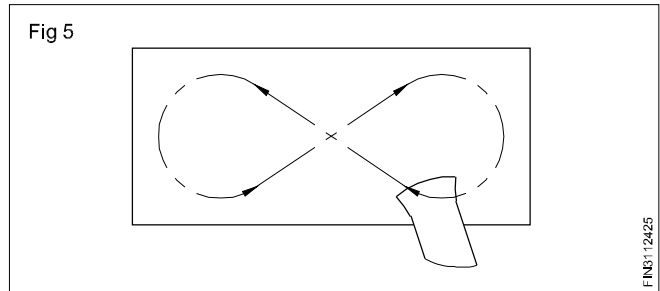
If the scraper is carbide -tipped use silicon carbide or diamond wheels. (Fig 4)



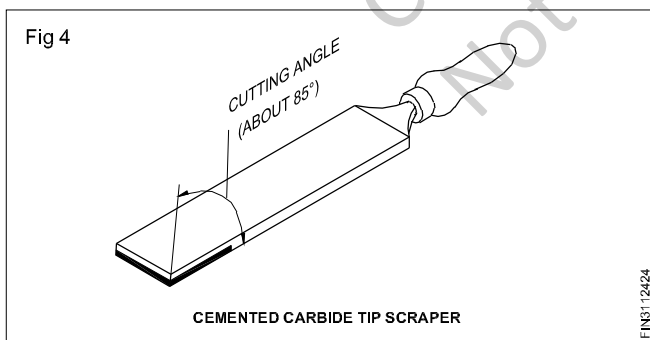
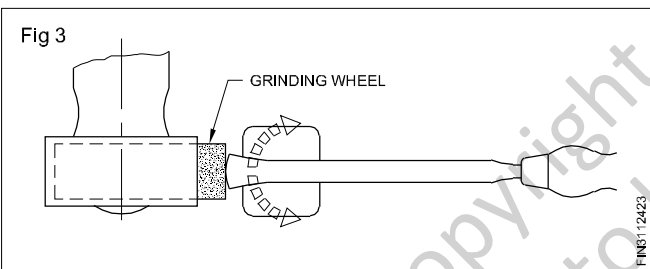
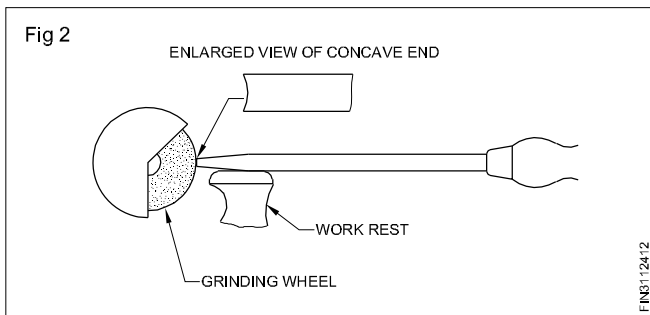
While honing use a lubricant.

Mix light mineral oil with kerosene for preparing the lubricant.

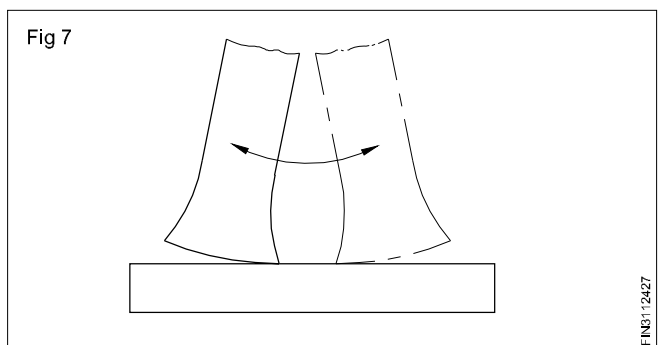
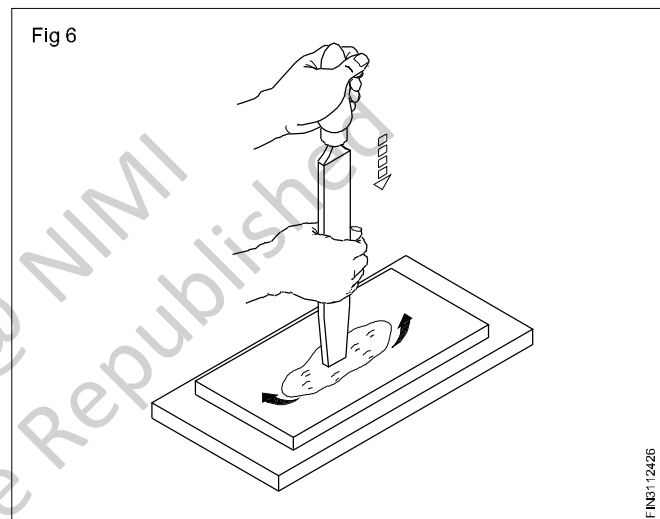
Hone the faces first with a movement as shown in Fig 5.



Then hone the cutting end by placing the scraper in an upright position on the oilstone with a rocking movement. (Figs 6 and 7)



The cutting edges sharpened by grinding should be honed. Honing removes grinding marks and provides keen cutting edges.



What should be the cutting angle? it should be

- for rough scraping - 60°
- for final scraping - 90°

Template and gauges

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

- define template with its uses and advantages
- define gauges their necessity and types.

Templates: Templates are used to check the contour of the profile of a workpiece for conformance to shape or form templates are made from steel sheet. They are also called profile gauge.

Benefits of templates

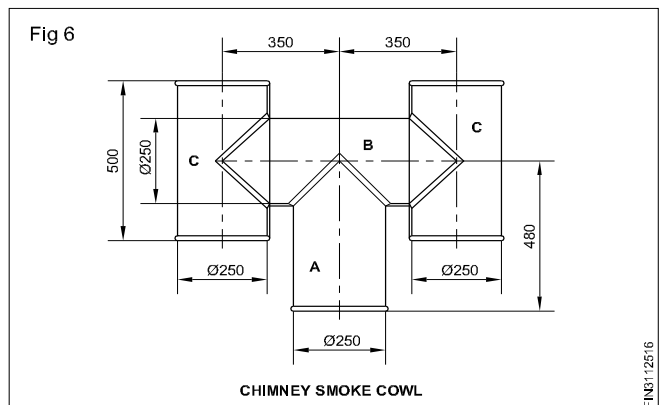
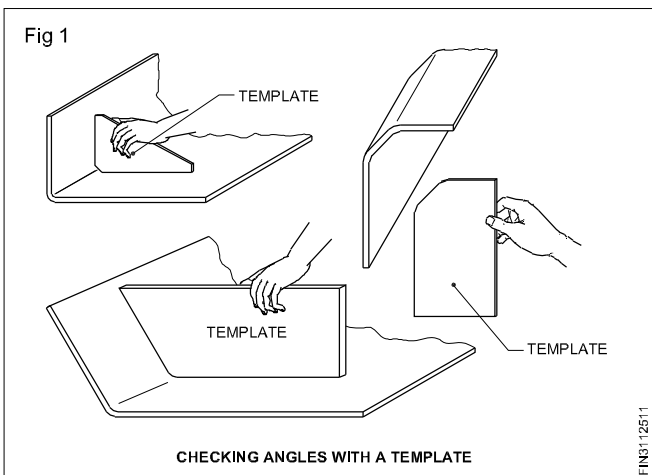
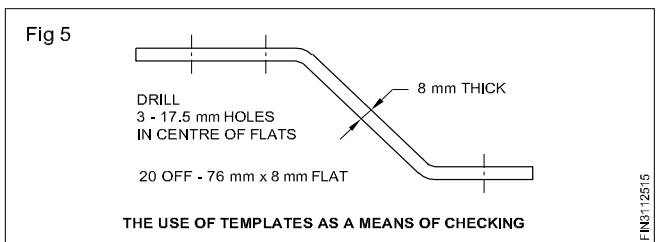
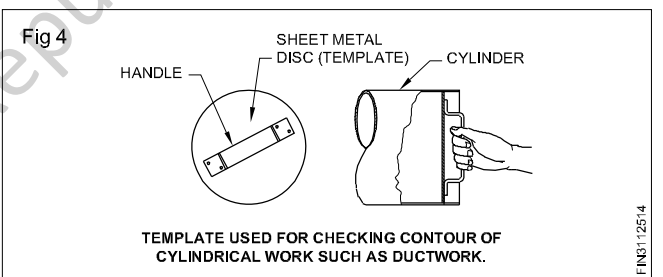
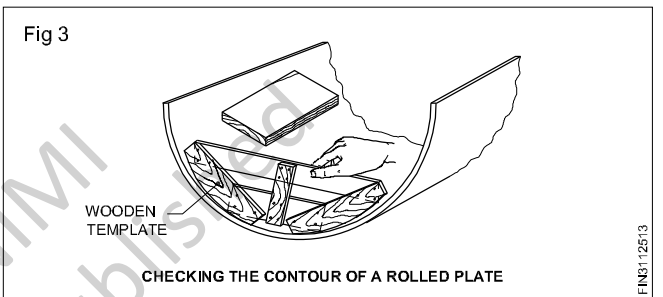
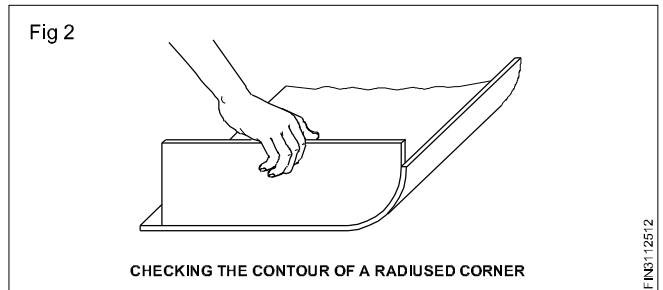
- 1 To avoid repetitive measuring and marking the same dimension, and where many identical parts are required.
- 2 To avoid unnecessary wastage of material and from information given on drawing, it is almost impossible to anticipate exactly where to begin in order that the complete layout can be economically accommodated.
- 3 To act as a guide for cutting processes.
- 4 As a simple means of checking bend angles and contours.

Information given on templates

Written on templates may be as follows:

- 1 Job or contract number
- 2 Size and thickness of plate
- 3 Quantity required
- 4 Bending or folding instructions
- 5 Drilling requirement
- 6 Cutting instructions
- 7 Assembly reference mark.

Templates as a means of checking is shown in Fig 1 to 6



Templates for setting out sheet metal fabrications:

For economy reasons, many patterns are made for marking out the sheet metal prior to cutting and forming operations. Fig 7,8 show a smoke cowl. Here a template is required to check and to mark out the contours of the intersection joint lines for the parts A,B & C whose developed sizes are marked out in the flat with the appropriate datum lines.

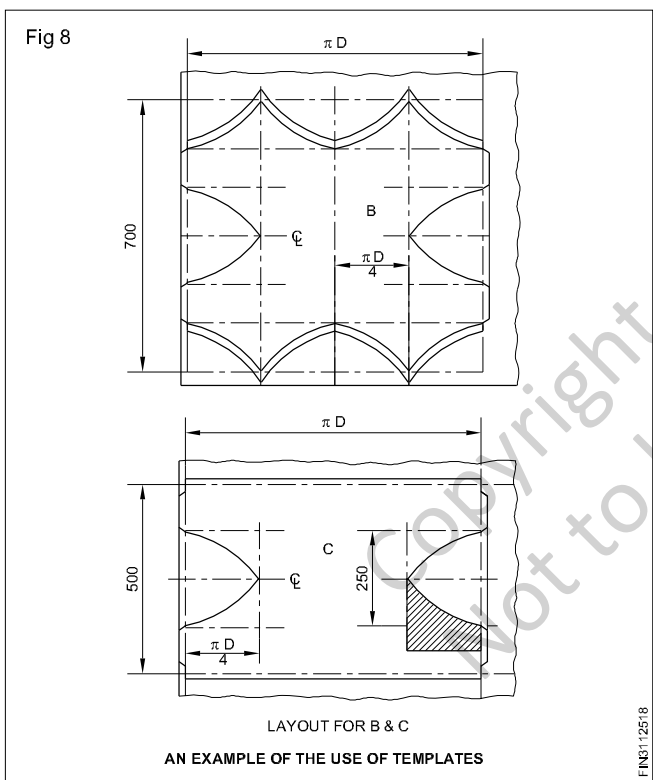
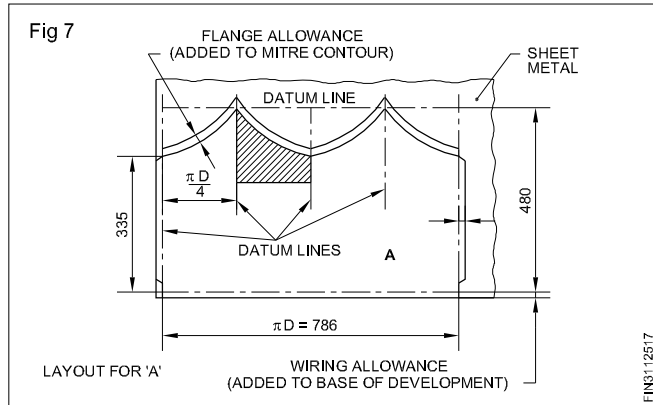


Fig 9 shows a square to round transformer is an isometric view of the sheet metal transforming piece which is used to connect a circular duct to a square duct of equal area of cross section. In this example the dia of the round duct is 860 mm and length of one side of the square duct is 762 mm and the distance between the two ducts is 458 mm and sheet thickness is 1.2 mm.

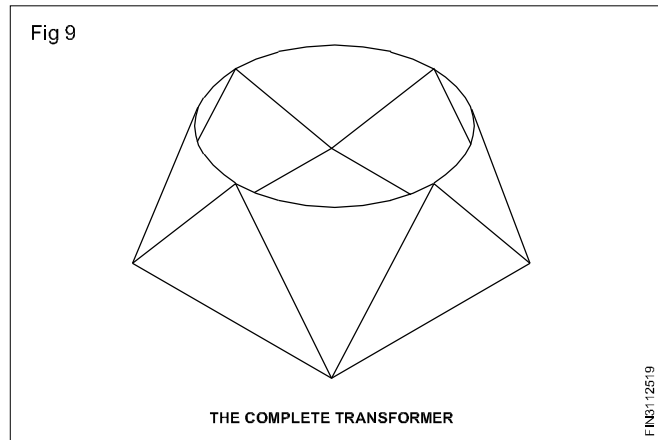
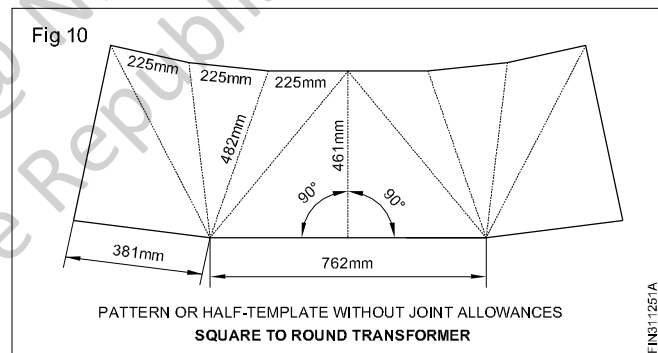


Fig 10 shows a scale development pattern on which are marked the full size dimensions. This type of drawings are supplied by the drawing office for marking out purposes. Allowances for the seams and the joints must be added to the layout.



Screw pitch gauge

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

- state the purpose of a screw pitch gauge
- state the features of a screw pitch gauge.

Purpose

A screw pitch gauge is used to determine the pitch of a thread.

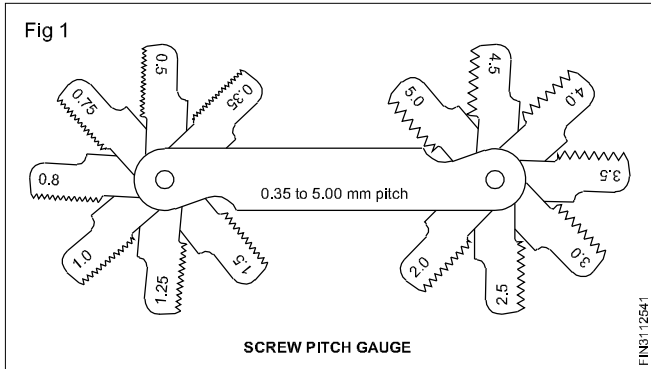
It is also used to compare the profile of threads.

Constructional features

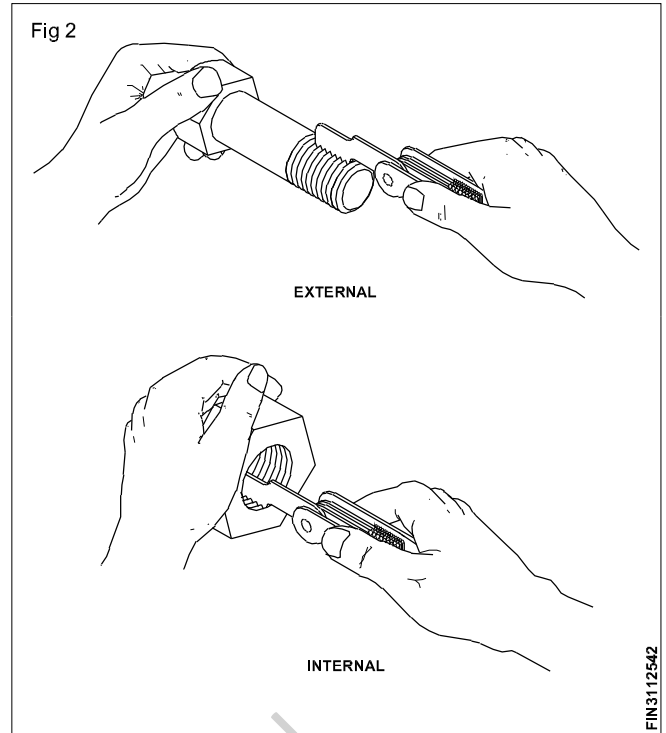
Pitch gauges are available with a number of blades assembled as a set. Each blade is meant for checking a particular standard thread pitch. The blades are made of thin spring steel sheets, and are hardened.

Some screw pitch gauge sets will have blades provided for checking British Standards threads (BSW, BSF etc.) at one end and the metric standard at the other end.

The thread profile on each blade is cut for about 25 mm to 30 mm. The pitch of the blade is stamped on each blade. The standard and range of the pitches are marked on the case. (Fig 1)



For obtaining accurate results while using the screw pitch gauge, the full length of the blade should be placed on the threads. (Fig 2)



Simple and standard workshop gauges

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

- state what is radius and fillet gauge
- mention the sizes and uses of feeler gauge
- brief the drill gauge and drill grinding gauge
- state the function centre gauge
- state the uses of acme threading tool grinding gauge & tool setting gauge
- describe the construction and uses of wire gauge.

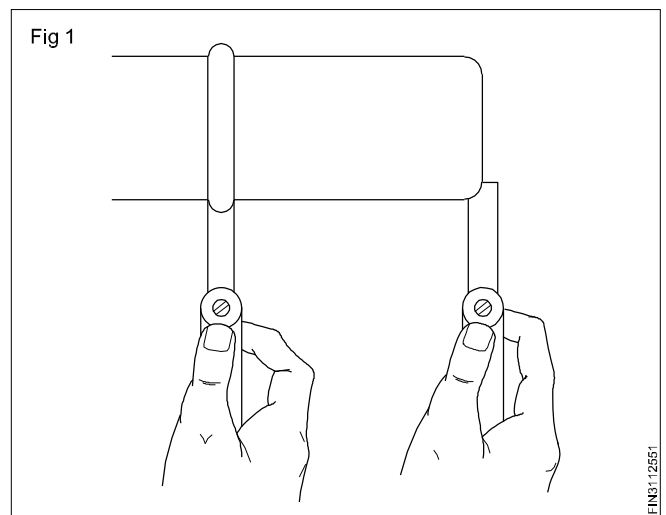
Radius and fillet gauges: Components are machined to have curved formation on the edges or at the junction of two steps. Accordingly they are called radius and fillets. The size of the radius and radius is normally provided on a drawing. The gauges used to check the radius formed on the edges of diameters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

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

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

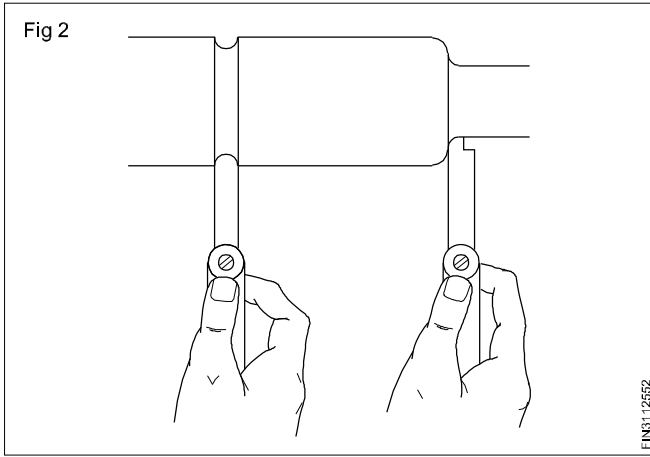
- Checking the corner radius of a part being filed to shape. (Fig 3)
- Checking a radius formed by a milling cutter. (Fig 4)

The radius and fillet gauges are available in sets of several blades which fold into a holder when not in use. (Fig 5)

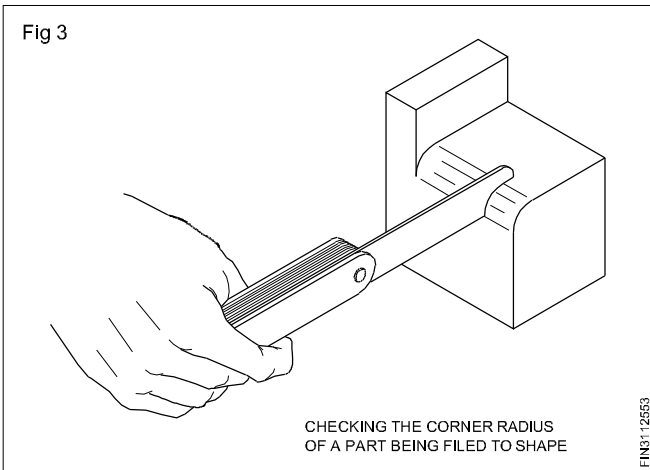


Some sets have provisions to check the radius and fillet on each blade. (Fig 6)

And some sets have separate sets of blades to check the radius and fillet. (Fig 7)

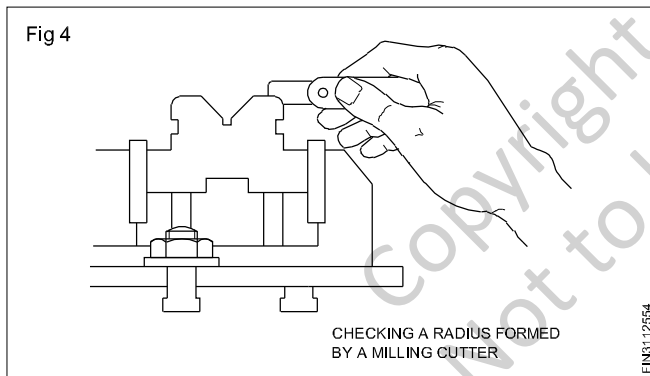


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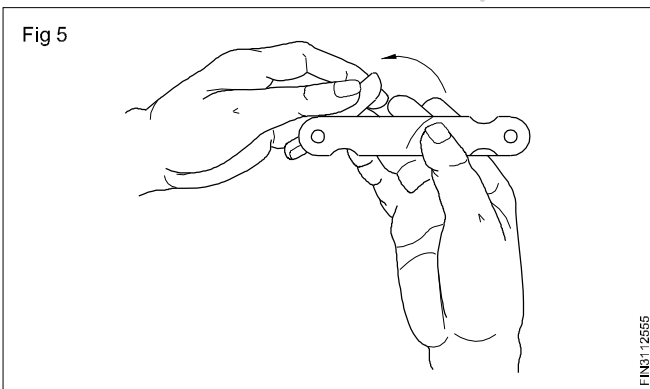
CHECKING THE CORNER RADIUS OF A PART BEING FILED TO SHAPE

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CHECKING A RADIUS FORMED BY A MILLING CUTTER

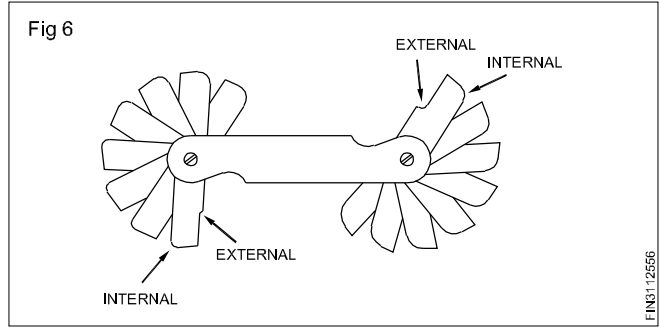
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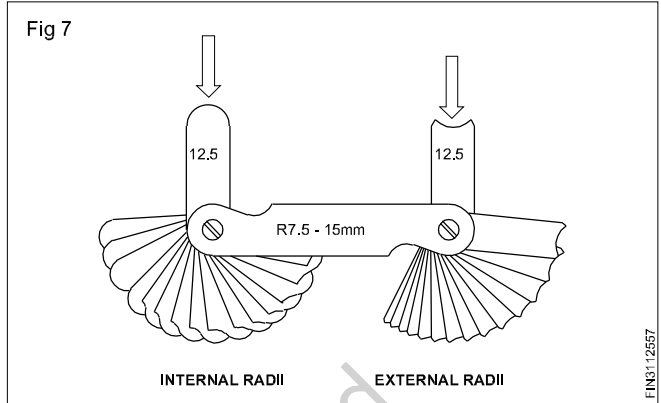
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Each blade can be swung out of the holder separately, and has its size engraved on it. (Fig 8)

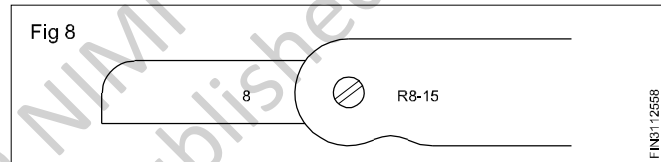
Fillet gauges are available in sets to check the radii and fillets from:



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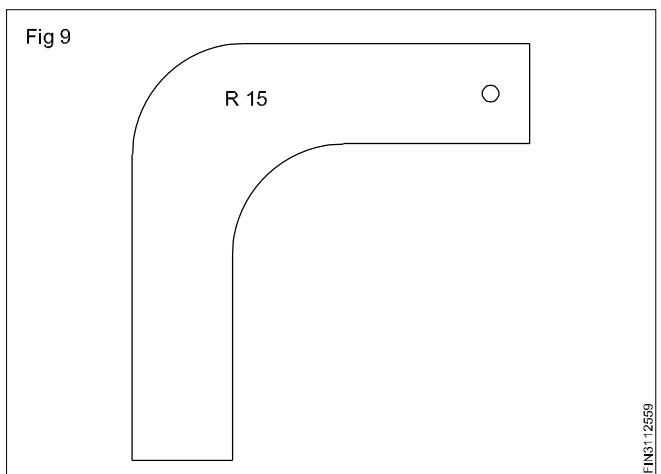
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1 to 7 mm in steps of 0.5 mm

7.5 to 15 mm in steps of 0.5 mm

15.5 to 25 mm in steps 0.5 mm.

Individual gauges are also available. They usually have internal and external radii on each gauge and are made in sizes from 1 to 100 mm in steps of 1 mm. (Fig 9)



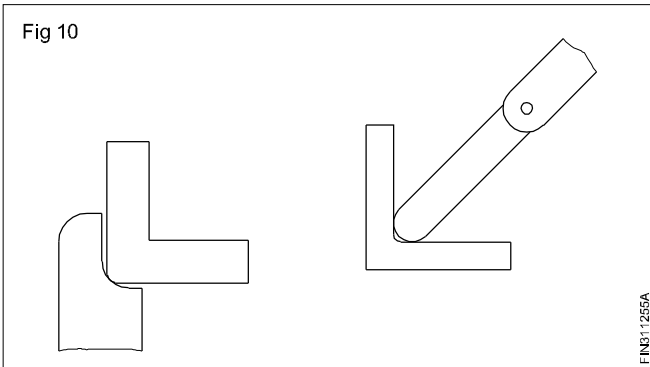
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Before using the radius gauge, check that it is clean and undamaged.

Remove burrs from the workpiece.

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

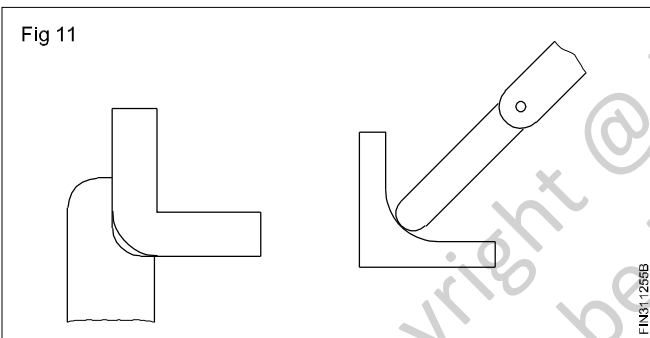
Fig 10 shows that the radius of the fillet and that of the external radius are smaller than the gauge.



Try a smaller gauge to determine the radius dimension.

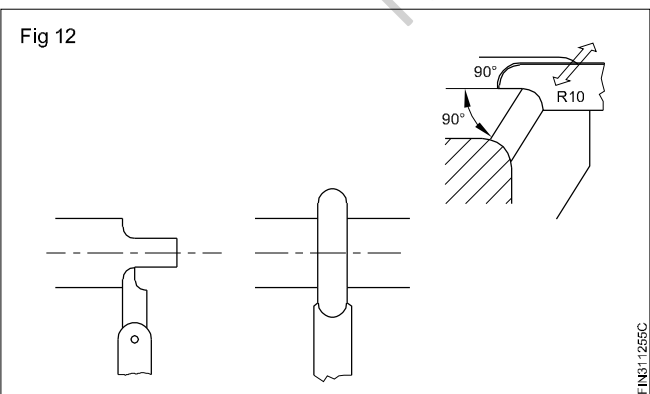
File or machine the workpiece if it has to be of the radius of the gauge.

Figure 11 shows that the radius of the fillet and that of the external radius are larger than the gauge.



Try a larger gauge if you need to find the radius dimension.

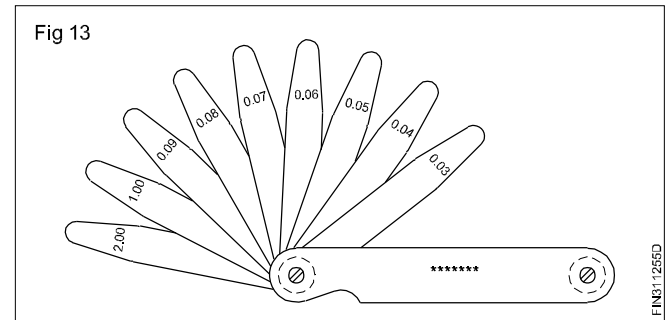
Fig 12 shows the workpiece having the same radius as that of the gauge that is being used for checking.



Feeler gauge and uses

Features: A feeler gauge consists of a number of hardened and tempered steel blades of various thicknesses mounted in a steel case. (Fig 13)

The thickness of individual leaves is marked on it. (Fig 13)



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

Example

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

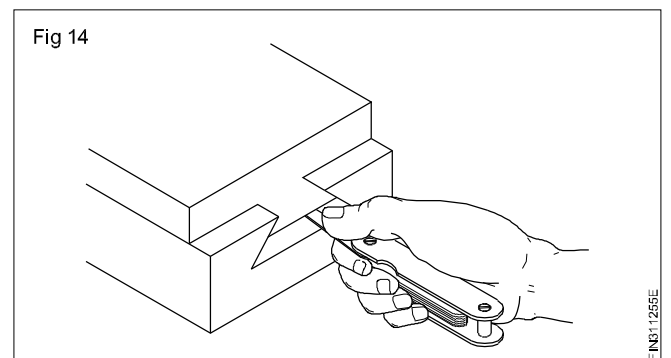
0.03, 0.04, 0.05, 0.06, 0.07, 0.08, 0.09, 0.10, 0.15, 0.20, 0.30, 0.40, 0.50.

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

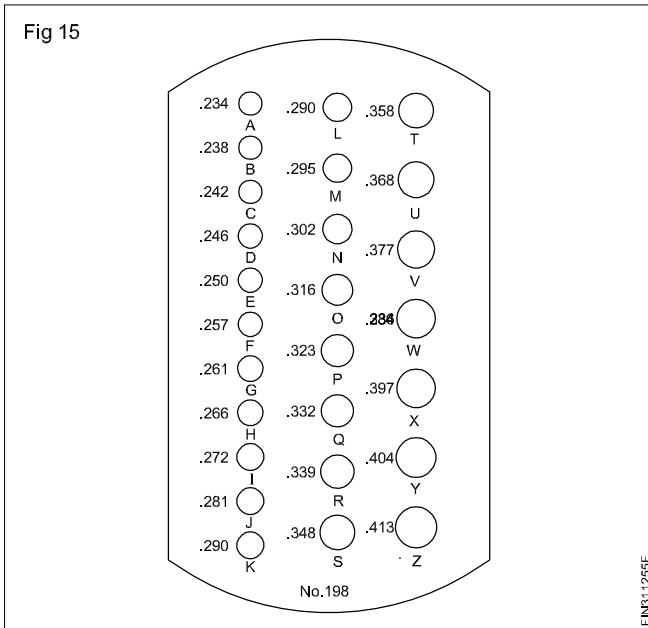
The dimension being tested is judged to be equal to the thickness of the leaves used, when a slight pull is felt while withdrawing them. Accuracy in using these gauge requires a good sense of feel.

Feeler gauges are used:

- To check the gap between the mating parts
- To check and set the spark plug gaps
- To set the clearance between the fixture (setting block) and the cutter/tool for machining the jobs
- To check and measure the bearing clearance, and for many other purposes where a specified clearance must be maintained. (Fig 14)

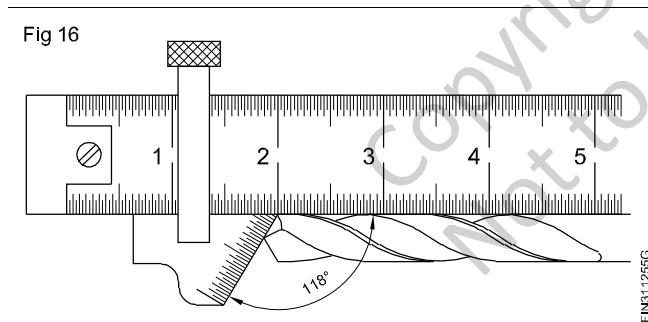


Drill gauge: A drill gauge is a rectangular or square shaped metal piece containing a number of different diameter holes. The size of the hole is stamped against each hole. (Fig 15)



In the number drill and letter drill series, the diameter of the drill is gauged with the help of the respective drill gauge.

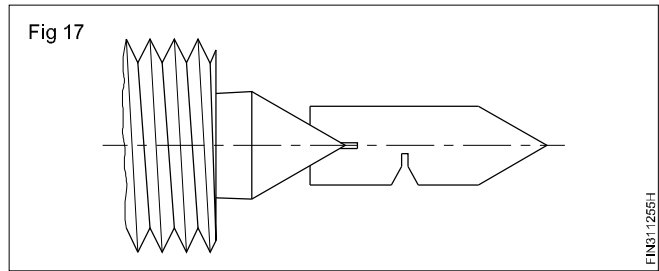
Drill point grinding gauge: Drill point grinding gauge having an angle 118° . In the 118° angle/side/0.5 graduations are marked to check the length of the cutting edge. In inches version this tool is calibrated with $1/32$ parts of an inch. (Fig 16)



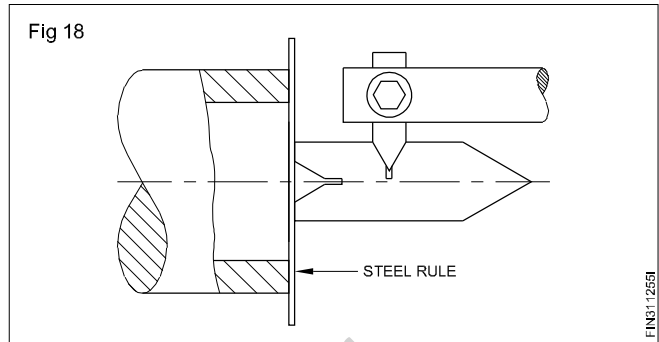
It consists of a sliding head mounted on a steel rule. The head may be positioned on the rule and clamped by a knurled nut.

This gauge is used to check the correctness of the cutting angle 118° , of the twist drill after re-sharpening by hand.

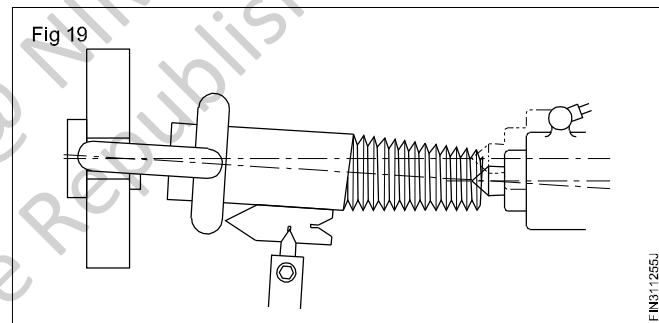
Centre gauge: A centre gauge is made up of spring steel hardened and tempered and is used mainly for grinding and setting single point thread cutting tool. These gauges have graduation for checking the number of threads per inch. Some gauges have a table giving the double depth of various threads and also used to check the included angle 60° of ground lathe centres. (Fig 17)



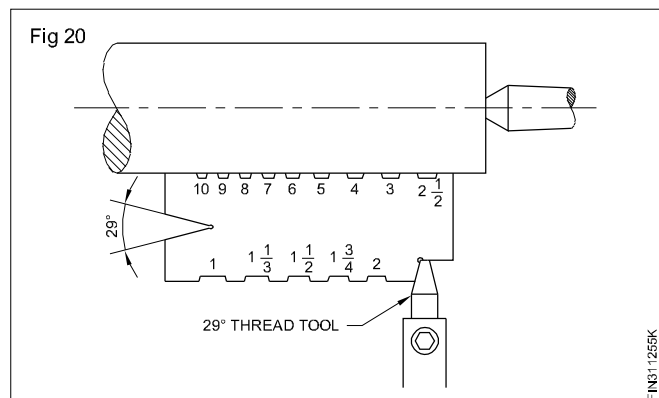
For internal threading, the cutting tool is set to square with the help of centre gauge and steel rule. (Fig 18)



When cutting tapered threads the centre gauge is used to set the cutting tool square with the axis of the workpiece. (Fig 19)

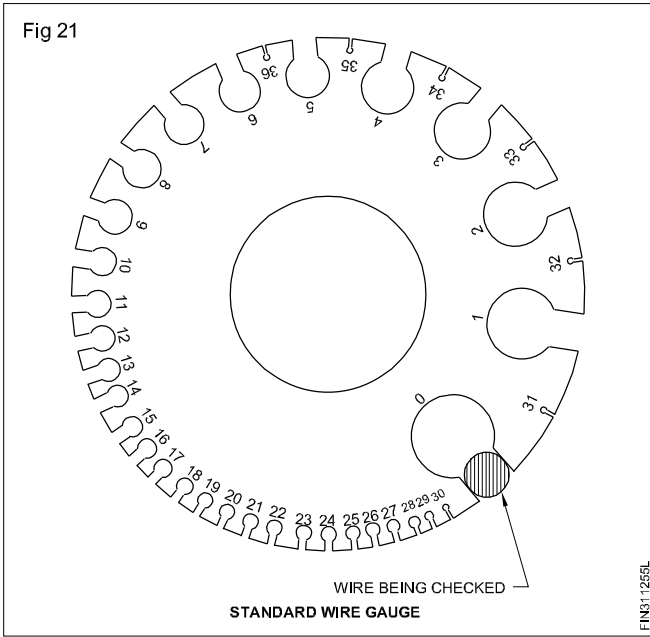


Acme thread gauge: An Acme thread gauge is used when grinding thread cutting tool and also for setting the tool square with the work. (Fig 20)



The notches on the edge of the gauge are for checking the correct width of point of the tool according to the number of threads per inch specified for acme thread. It is made of spring steel and hardened. Similarly, a metric thread gauge is also available.

Standard Wire Gauge (SWG): It is used to measure the size of a wire and thickness of sheet shown in Fig.21



The standard wire gauge is a circular metal disc with varying hole and slot size on its circumference. Each slot size corresponds to a gauge number which is written just below the hole.

The gauge numbers specify the size of a round wire in terms of its diameter.

As the gauge number increase from 0 to 36, the dia size decrease.

The thickness of sheet metal and the diameter of wires confirm to various gauging numbers and the following Table 1 give the decimal equivalents of the different gauge numbers for the diameter of wires, and the thickness of sheets.

Table 1
Standard wire gauge number and equivalent value in mm
as per IS 5049-1969

Wire No. according to SWG	Wire Dia according to IS:280-1962 in mm	Wire No. according to SWG	Wire Dia according to IS:280-1962 in mm
0	8.00	19	1.00
2	7.10	20	0.90
3	6.30	21	0.80
4	6.00	22	0.710
5	5.60	23	0.630
6	5.00	24	0.560
7	4.50	25	0.500
8	4.00	26	0.450
9	3.55	27	0.400
10	3.15	29	0.355
11	2.80	30	0.315
12	2.50	32	0.280
13	2.24	33	0.250
14	2.00	34	0.224
15	1.80	36	0.200
16	1.60	37	0.180
17	1.40	38	0.160
18	1.25	39	0.140
-	1.12	40	0.125

Gauges and types of gauges

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

- define template with its uses and advantages
- define gauges their necessity and types.

Gauge

Gauge is an inspection tool used to check product dimension with reference to its maximum and minimum acceptable limits. It is, generally, used to segregate acceptable and non-acceptable products in mass production, without the exact dimensions. It is made of tool steel and is heat treated.

Advantages of gauging

Faster checking of the product is within the specified limits.

Less dependence on operator skill and getting affected by operator judgement.

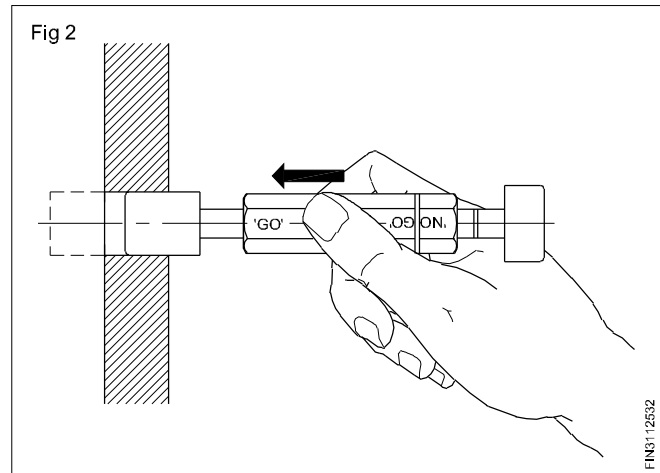
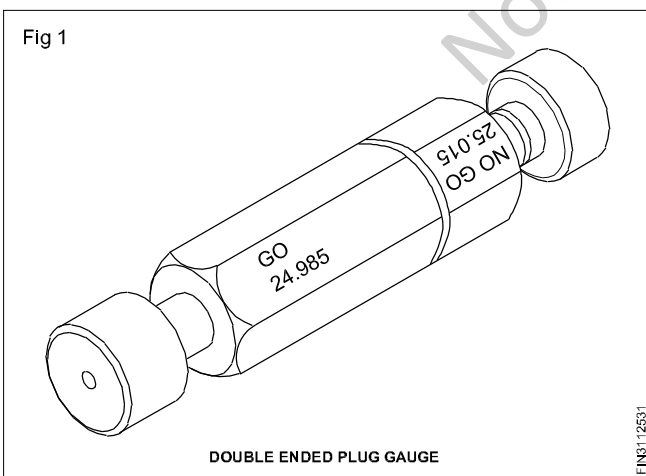
Gauges are economical when compared to measuring instruments.

Instrument used for gauging

- 1 Snap and ring gauge
- 2 Combined gauge
- 3 Plug gauge
- 4 Screw pitch gauge
- 5 Template and form gauge
- 6 Taper gauge

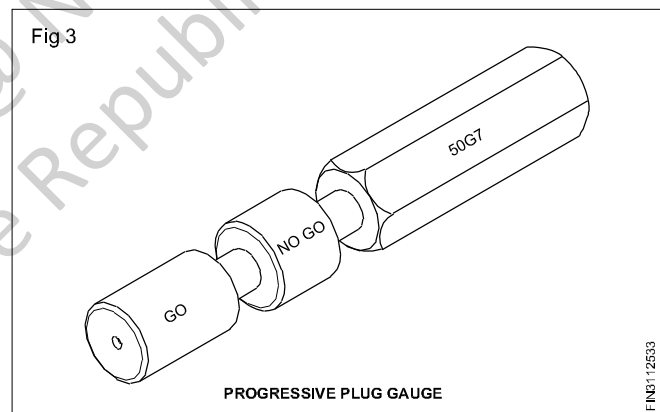
Types of cylindrical plug gauges

Double-ended plug gauge (Fig 1 and 2)

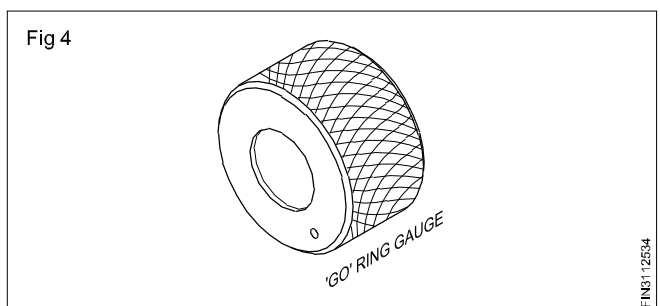


Progressive plug gauge (Fig 3)

Plain cylindrical gauges are used for checking the inside diameter of a straight hole. The 'Go' gauge checks the lower limit of the hole and the 'No-Go' gauge checks the upper limit. The plugs are ground and lapped. (Fig 3)

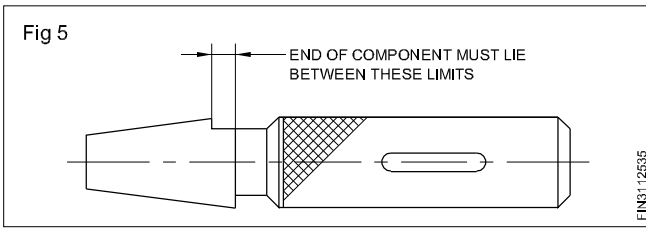


Plain ring gauge (Fig 4)



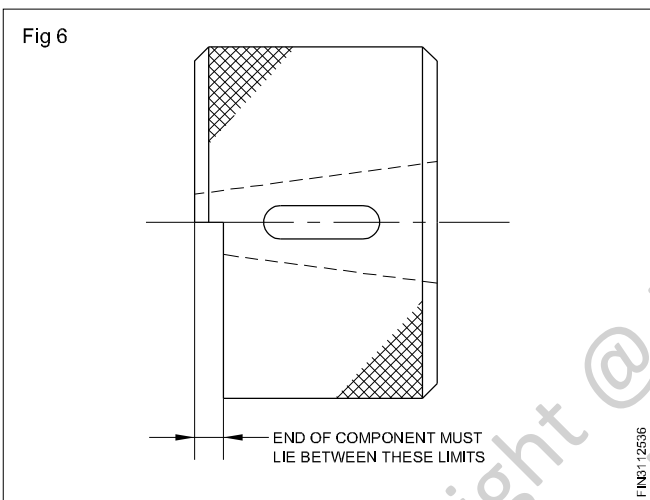
Plain ring gauges are used to check the outside diameter of pieces. Separate gauges are used for checking 'Go' and 'No-Go' sizes. A 'No-Go' gauge is identified by an annular groove on the knurled surface.

Taper plug gauges (Fig 5)



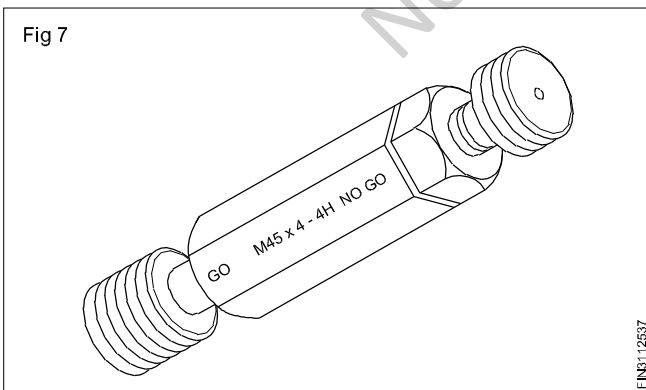
These gauges made with standard or special tapers are used to check the size of the hole and the accuracy of the taper. The gauge must slide into the hole for a prescribed depth and fit perfectly. An incorrect taper is evidenced by a wobble between the plug gauge and the hole.

Taper ring gauges (Fig 6)

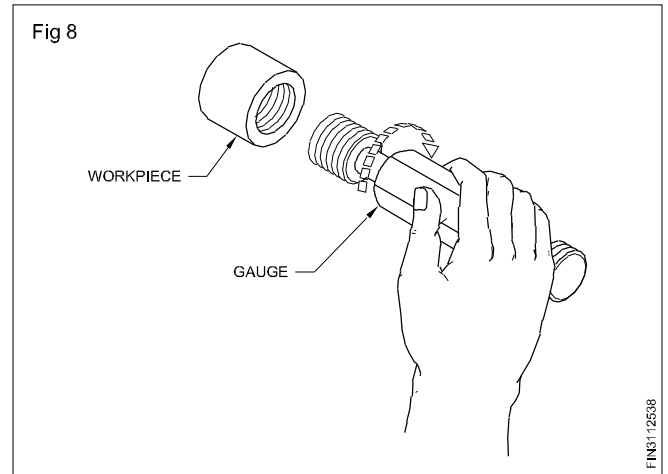


They are used to check both the accuracy and the outside diameter of a taper. Ring gauges often have scribed lines or a step ground on the small end to indicate the 'Go' and 'No-Go' dimensions.

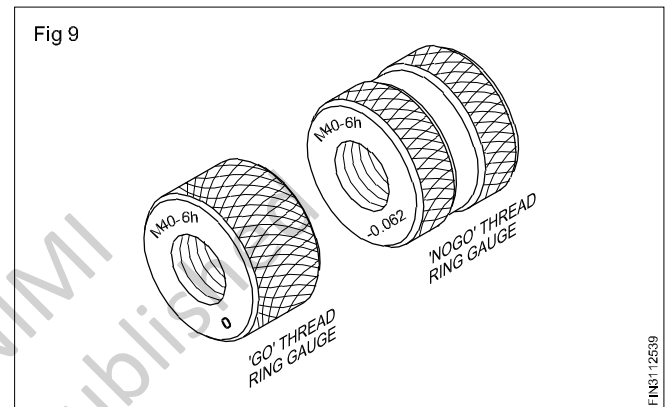
Thread plug gauges (Figs 7 and 8)



Internal threads are checked with thread plug gauges of 'Go' and 'No-Go' variety which employ the same principle as cylindrical plug gauges.

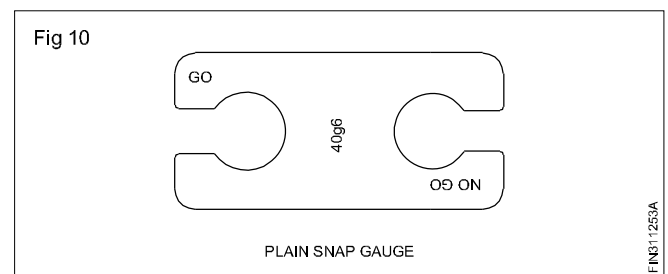


Thread ring gauges (Fig 9)



These gauges are used to check the accuracy of an external thread. They have a threaded hole in the centre with three radial slots and a set screw to permit small adjustments.

Snap gauges (Figs 10, 11, 12 and 13)



Snap gauges are a quick means of checking diameters and threads to within certain limits by comparing the part's size to the present dimension of the snap gauge.

Snap gauges are generally C-shaped and are adjustable to the maximum and minimum limits of the part being checked. When in use, the work should slide into the 'Go' gauge but not into the 'No-Go' gauging end.

Fig 12

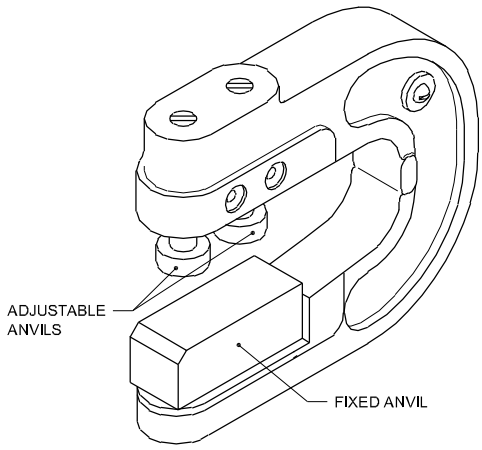


Fig 13

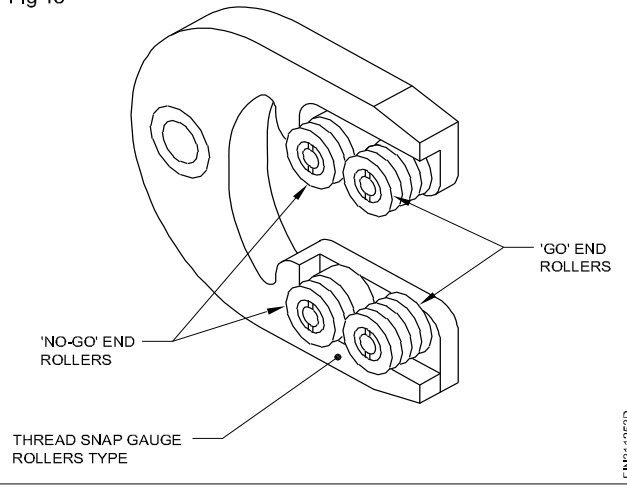
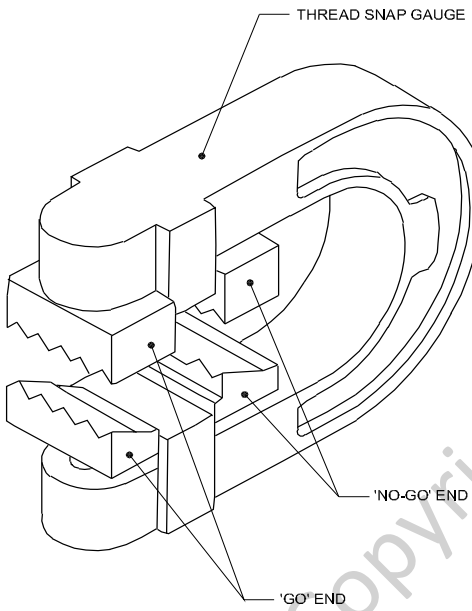


Fig 12



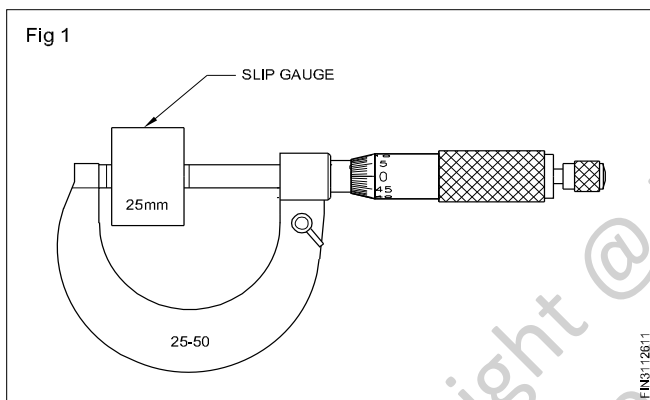
Slip Gauges

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

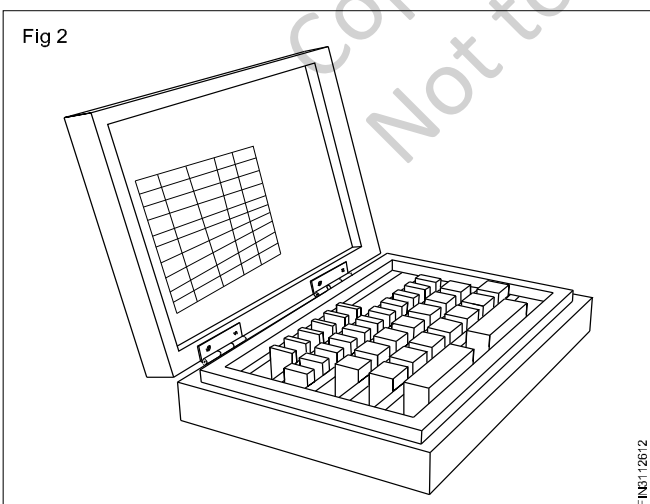
- **define the features of slip gauges**
- **state the different grades of slip gauges**
- **state the number of slips in standard**
- **state the precautions and application of slip gauges.**

Slip gauges

Slip gauges are gauge blocks used as standards for precision length measurement. (Fig 1) These are made in sets and consist of a number of hardened blocks, made of high grade steel with low thermal expansion. They are hardened throughout, and heat treated further for stabilization. The two opposite measuring faces of each block are lapped flat and parallel to a definite size within extremely close tolerances.

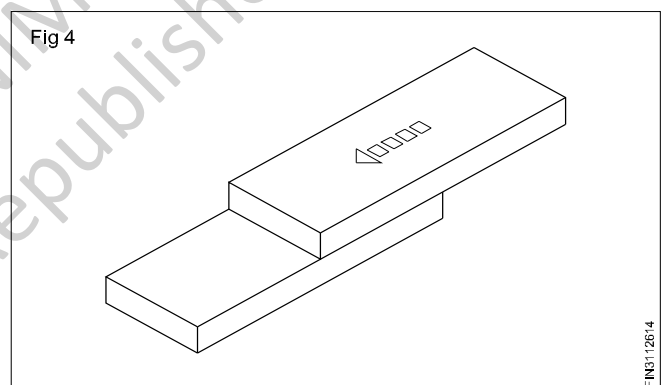
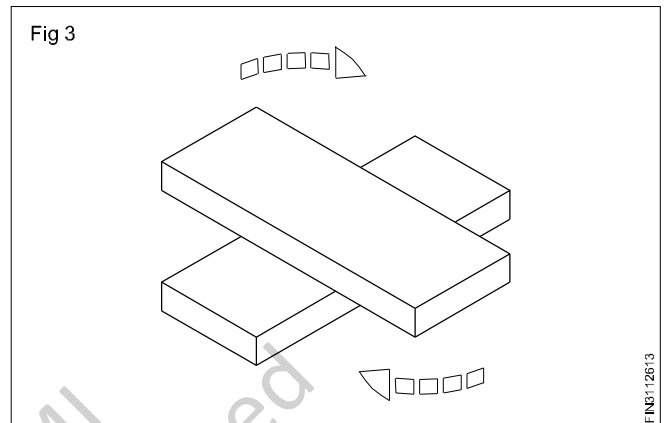


These slip gauges are available in various sets with different numbers. (Fig 2) (Ref. Table 1)



A particular size can be built up by wringing individual slip gauges together. (Figs 3 & 4)

Wringing is the act of joining the slip gauges together while building up to sizes.



Some sets of slip gauges also contain protector slips of some standard thickness made from higher wear-resistant steel or tungsten carbide. These are used for protecting the exposed faces of the slip gauge pack from damage.

Grades

Grade '00' accuracy

It is a calibration grade used as a standard for reference to test all the other grades.

Grade '0' accuracy

It is an inspection grade meant for inspection purposes.

Grade I accuracy

Workshop grade for precision tool room applications.

Grade II accuracy

For general workshop applications.

B.I.S. recommendations

Three grades of slip gauges are recommended as per IS 2984. They are:

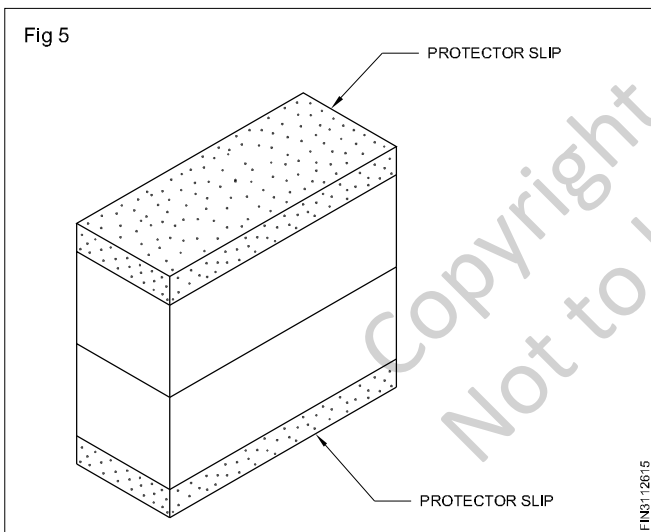
- Grade '0'
- Grade I
- Grade II.

Care and maintenance points to be remembered while using slip gauges.

- Use a minimum number of blocks as far as possible while building up a particular dimension.
- While building the slip gauges, start wringing with the largest slip gauges and finish with the smallest.

While holding the slip gauges do not touch the lapped surfaces.

If available use protector slips on exposed faces. (Fig 5) After use, clean the slips with carbon tetrachloride and apply petroleum jelly for protection against rust.



Before use, remove petroleum jelly with carbon tetrachloride. Use chamois leather to wipe the surfaces.

TABLE 1

Different sets of slip gauges

Set of 112 pieces (M112)

Range (mm)	Steps (mm)	No.of pieces
Special piece	1.0005	1
1 st series 1.001 to 1.009	0.001	9
2 nd series 1.01 to 1.49	0.01	49
3 rd series 0.5 to 24.5	0.5	49
4 th series 25.0 to 100.0	25.0	4
Total pieces		112

Set of 103 pieces (M103)

Range (mm)	Steps (mm)	No.of pieces
1 st series 1.005	-	1
2 nd series 1.01 to 1.49	0.01	49
3 rd series 0.5 to 24.5	0.5	49
4 th series 25 to 100	25.0	4
Total pieces		103

Set of 46 pieces (M46)

Range (mm)	Steps (mm)	No.of pieces
1 st series 1.001 to 1.009	0.001	9
2 nd series 1.01 to 1.09	0.01	9
3 rd series 1.10 to 1.90	0.10	9
4 th series 1.00 to 9.00	1.00	9
5 th series 10.00 to 100.00	10.00	10
Total pieces		46

Selection and determination of slip gauges for different sizes

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

- determine slip gauges for different sizes.

For determining a particular size, in most cases a number of slip gauges are to be selected and stacked one over the other by wringing the slip gauges.

While selecting slip gauges for a particular size using the available set of slip gauges, first consider the last digit of the size to be built up. Then consider the last or the last two digits of the subsequent value and continue to select the pieces until the required size is available.

Example (Without using protector slips)

Building up a size of 44.8725mm with the help of 112 piece set. (Table 1)

Set of 112 pieces (M112)

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

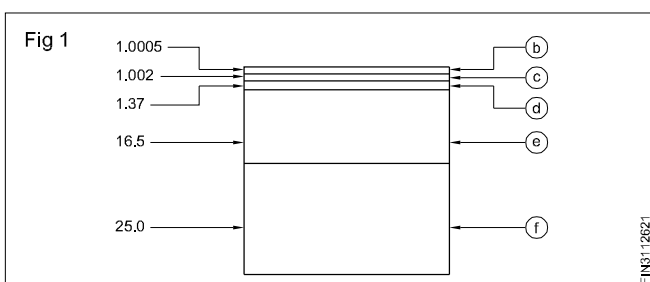


TABLE 1

Procedure	Slip pack	Calculation
a First write the required dimension		44.8725
b Select the slip gauge having the 4 th decimal place	1.005 subtract	$\begin{array}{r} 1.0005 \\ \hline 43.872 \end{array}$
c Select 1 st series slip that has the same last figure	1.002 subtract	$\begin{array}{r} 1.002 \\ \hline 42.870 \end{array}$
d Select the 2 nd series slip that has the same last figure and that will leave 0.0 or 0.5 as the last figure	1.37 subtract	$\begin{array}{r} 1.37 \\ \hline 41.5 \end{array}$
e Select a 3 rd series slip that will leave the nearest 4th series slip	16.5 subtract	$\begin{array}{r} 16.5 \\ \hline 25.0 \end{array}$
	(41.5 - 25 = 16.5)	25.00
f Select a slip that eliminates the final figure Add	25.0 subtract	25.00
		$\begin{array}{r} 25.00 \\ \hline 0 \end{array}$
	44.8725	0

Maintenance of measuring instruments

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

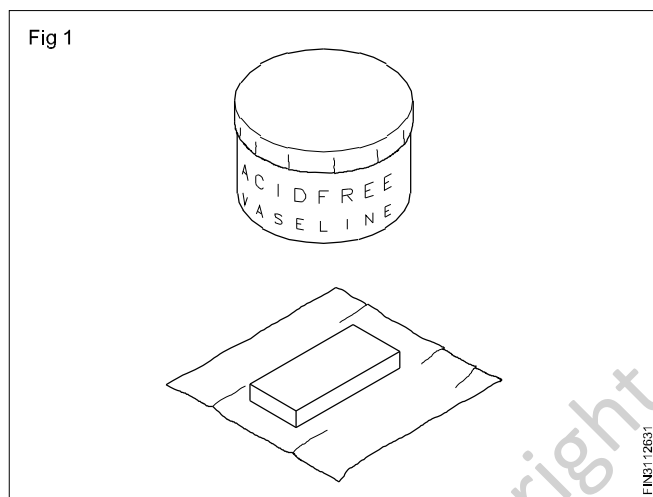
- state the preventive measures to be taken for protecting precision measuring instruments.

Precision measuring instruments play an important role in maintaining the quality of the products. Measuring instruments are also very expensive. It is important that the instruments are well looked after and maintained by the person who uses it.

Protection against corrosion

High atmospheric humidity and sweat from hands can cause corrosion to instruments. Avoid this.

Acid-free vaseline (petroleum jelly) applied lightly on the instruments can give protection against corrosion. (Fig 1)



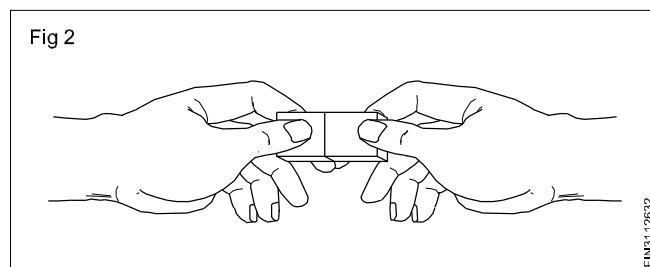
Be sure that the instruments are thoroughly cleaned and free from water or moisture before applying vaseline.

Use chamois leather for giving a light coating of vaseline.

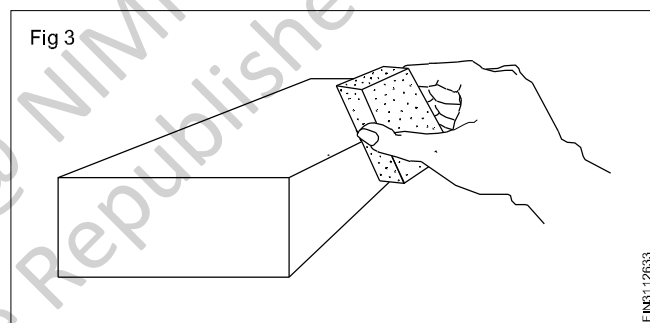
Always clean the slip gauges with carbon tetrachloride and apply petroleum jelly after use.

Remove burrs and metal particles. Burrs on workpieces can cause scratches and damages to measuring equipment. They can also damage other workpieces.

Metal or other particles between the measuring faces of slip gauges will make it impossible for them to adhere to each other. (Fig 2)



Remove burrs from the workpieces with an oilstone. (Fig 3)



Use chamois leather to wipe the carbon tetrachloride after cleaning.

Use a felt pad or rubber mat for placing the instruments while working.

Handle the instruments with care and do not allow them to mix up with other tools.

Slip gauge accessories

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

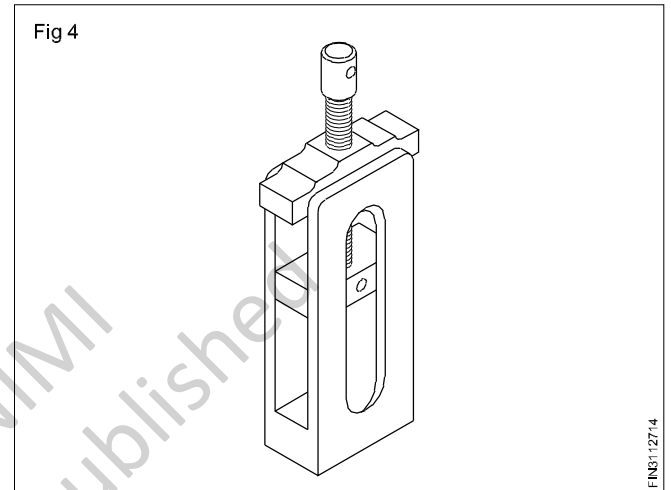
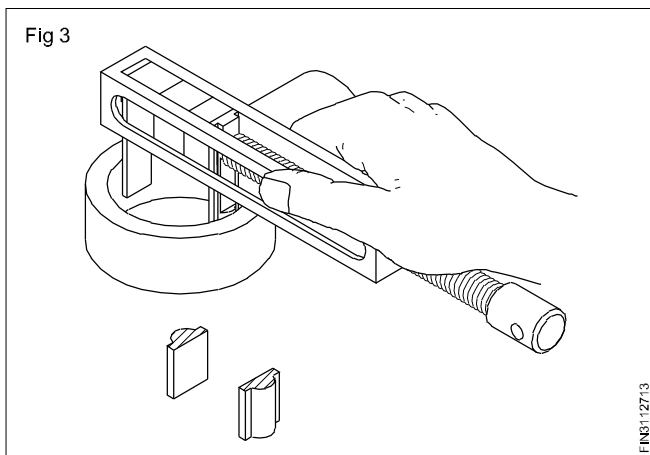
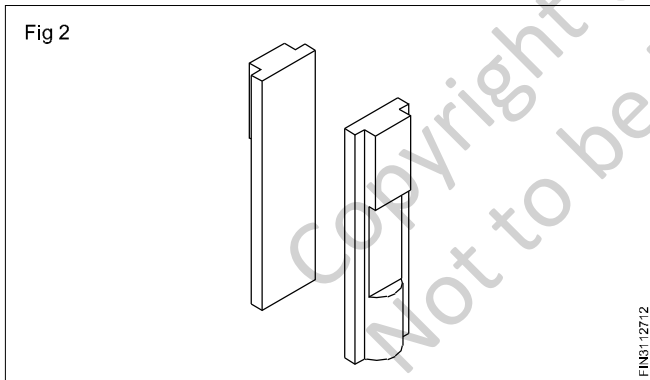
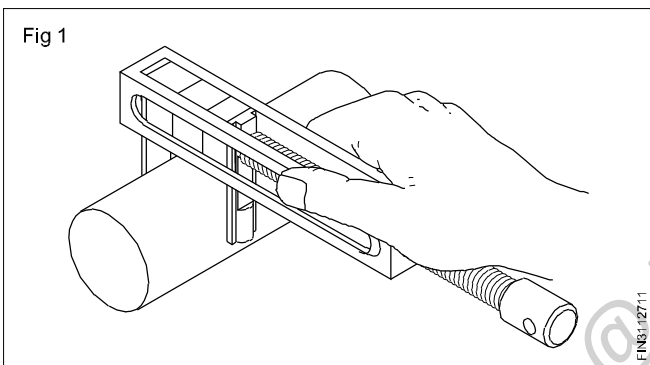
- name the different accessories used along with slip gauges
- state the uses of different accessories.

Slip gauges can be put to a variety of precision work when used along with certain special accessories.

Measuring external and internal sizes

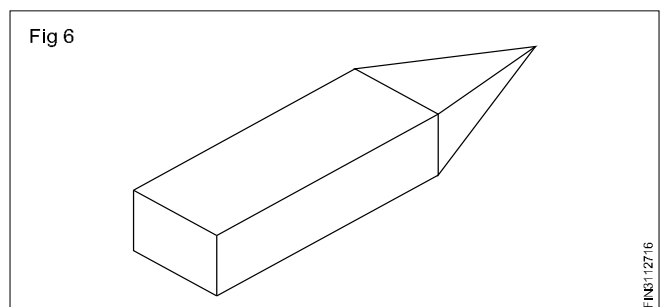
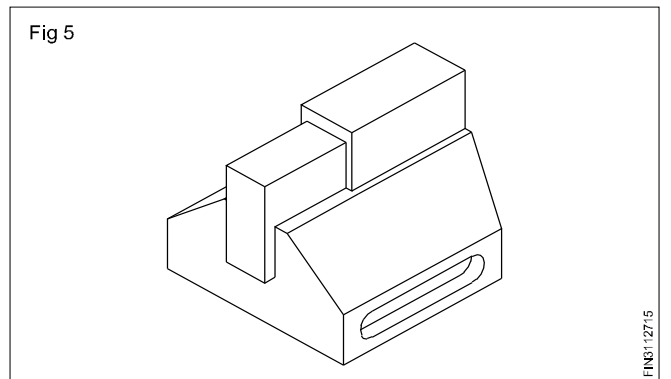
Slip gauges can be used for checking external and internal measurements. For this purpose a set of high precision special jaws are used along with a holder. (Figs 1,2 & 3)

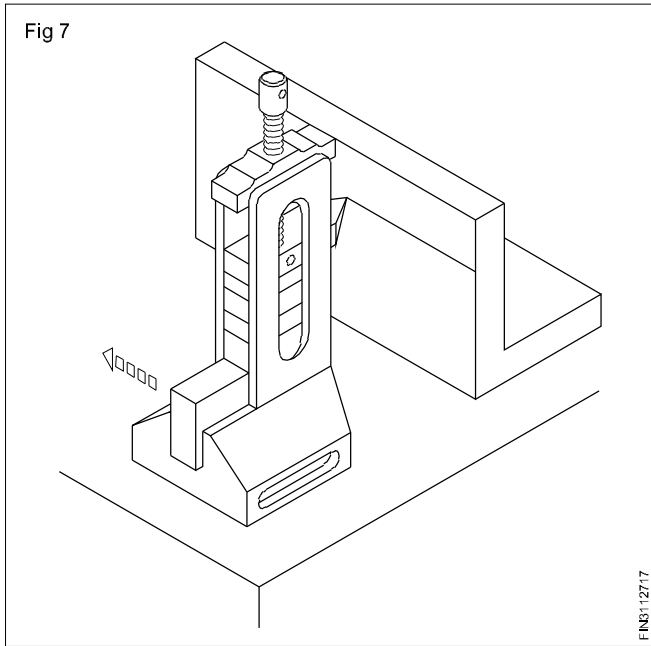
The pair of special jaws (Fig 2) will have a flat surface at one end and a curved surface at the other end to facilitate external and internal measurements. The slip gauge holder can be used for a variety of applications. (Fig 4)



Using as a height gauge

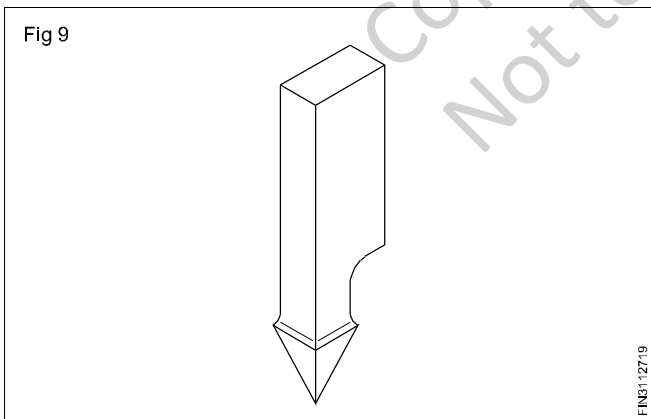
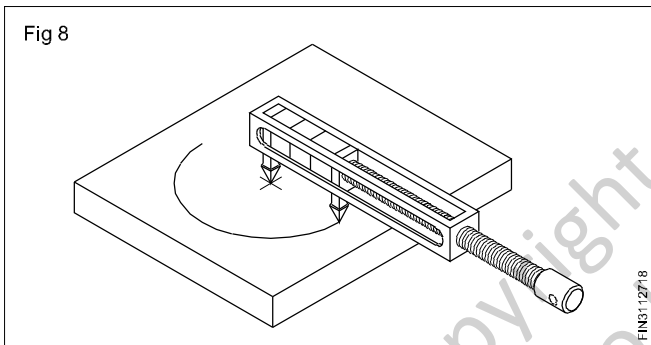
A height gauge can be built up by using a base block, (Fig 5) slip gauge holder, scriber point (Fig 6) and the required slip gauges. The height gauge (Fig 7) built up with these accessories can be used for very accurate layout work.





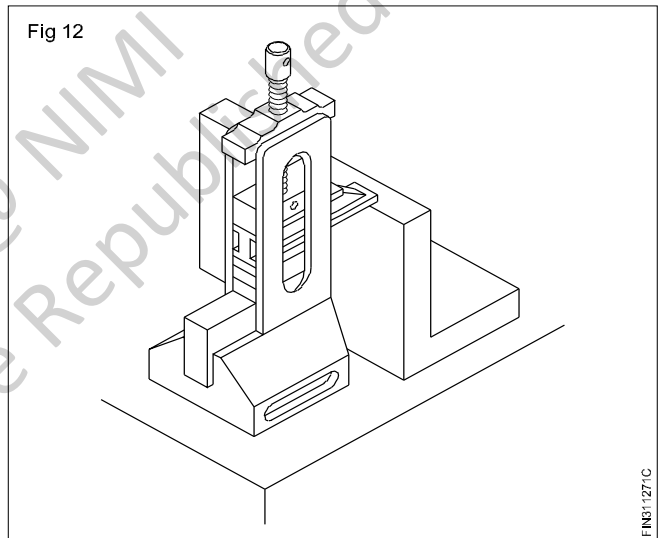
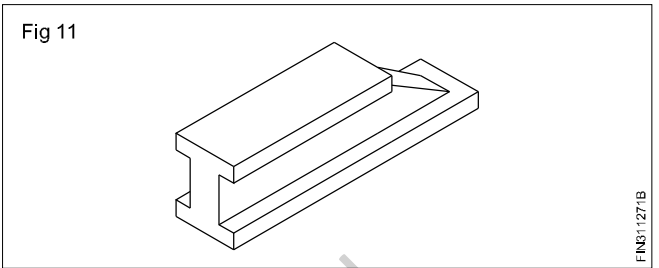
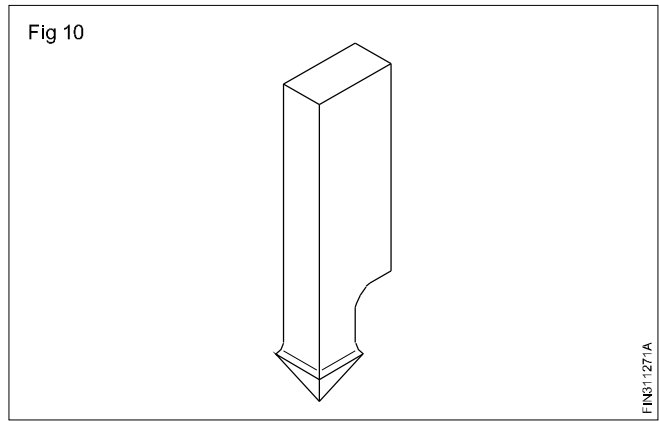
For drawing circles

Compasses (Fig 8) of different lengths can be built up using the slip gauge holder, radii scriber (Fig 9) and a centre point. (Fig 10)



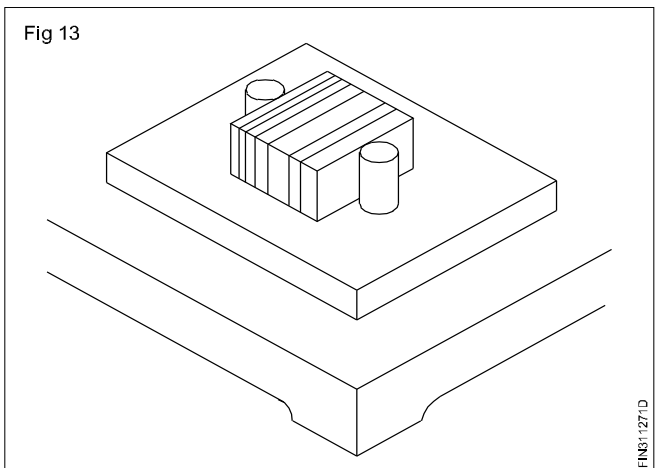
Checking height

The height of surfaces can be checked by the use of a flat jaw (Figs 11 & 12) along with a base and a slip gauge holder.



Checking centre distance of holes

With the help of precision cylindrical pins, the centre distance between holes can be accurately measured. (Fig.13)

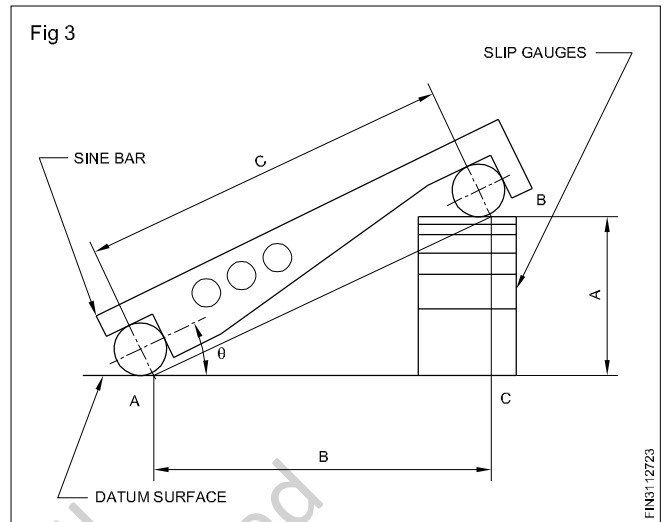
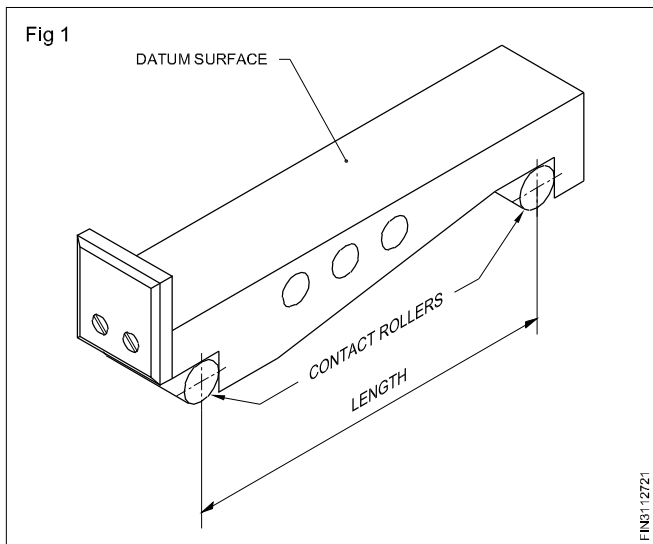


Sine bar principle application and specification

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

- state the principle of a sine bar
- specify the sizes of sine bar
- state the features of sine bars
- state the different uses of sine bar using slip gauges.

A sine bar is a precision measuring instrument for checking and setting of angles. (Fig 1)



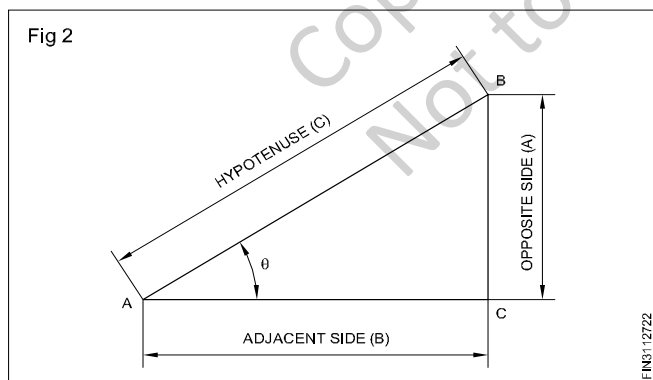
$$\text{Sine of the angle } \theta = \frac{\text{Opposite side}}{\text{Hypotenuse}}$$

$$\text{Sine } \theta = \frac{A}{C}$$

The principle of a sine bar

The principle of a sine bar is based on the trigonometrical function.

In a right angled triangle the function known as Sine of the angles is the relationship existing between the opposite side to the angle and the hypotenuse. (Fig 2)



It may be noted that for setting the sine bar to different angles, slip gauges are used.

A surface plate or marking table provides the datum surface for the set up.

The sine bar, the slip gauges and the datum surface upon which they are set form a right angled triangle. (Fig 3) The sine bar forms the hypotenuse (c) and the slip gauge stack forms the side opposite (a).

Features

This is a rectangular bar made of stabilized chromium steel.

The surfaces are accurately finished by grinding and lapping.

Two precision rollers of the same diameter are mounted on either end of the bar. The centre line of the rollers is parallel to the top face of the sine bar.

There are holes drilled across the bar. This helps in reducing the weight, and also it facilitates clamping of sine bar on angle plate.

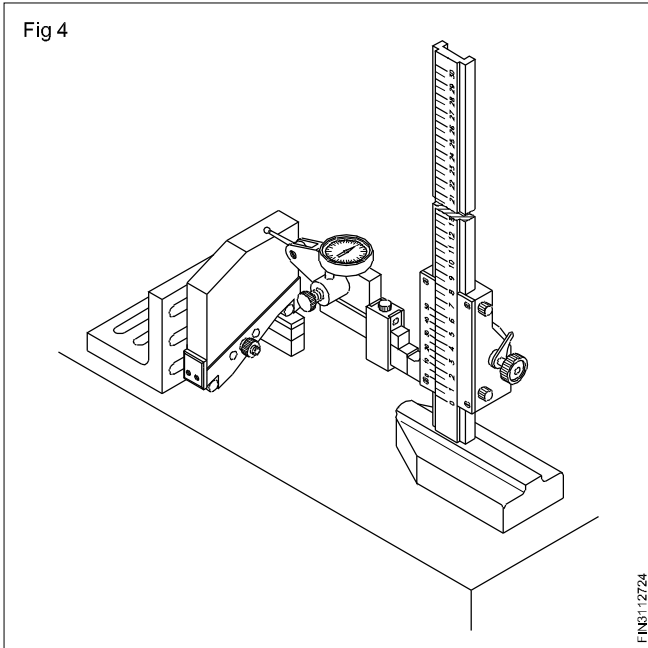
The length of the sine bar is the distance between the centres of the rollers. The commonly available sizes are 100 mm, 200 mm, 250 mm and 500 mm. The size of a sine bar is specified by its length.

Uses

Sine bars are used when a high degree of accuracy to less than one minute is needed for

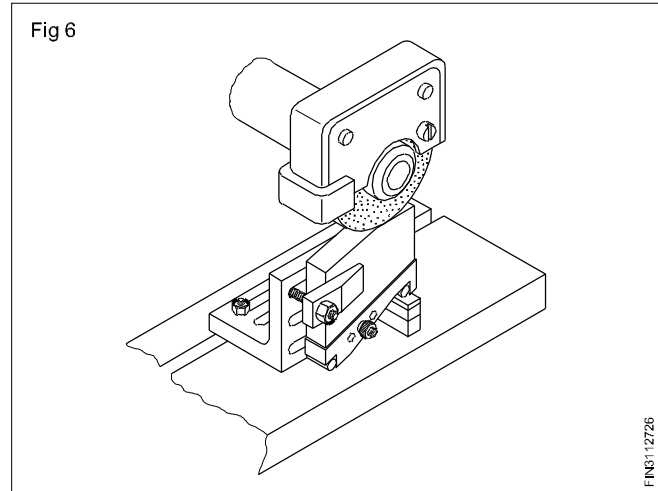
- measuring angles (Fig 4)
- marking out (Fig 5)
- setting up for machining. (Fig 6)

Fig 4



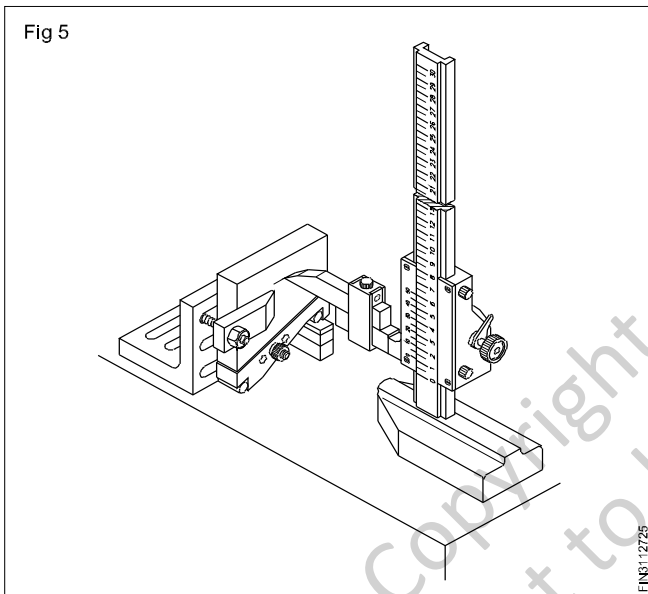
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Fig 6



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Fig 5



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Determining taper using sine bar and slip gauges

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

- determine correctness of a known angle
- calculate the height of slip gauges to a known angle.

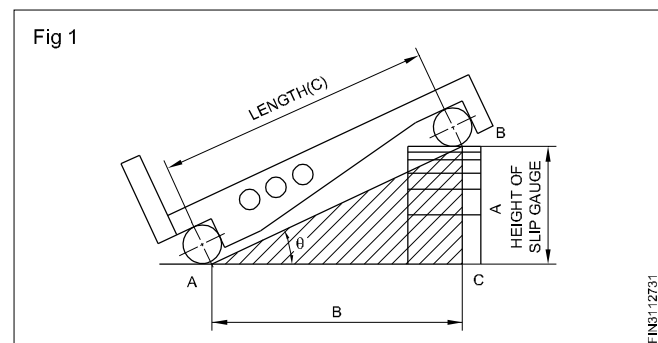
Sine bars provide a simple means of checking angles to a high degree of accuracy of not less than one minute upto 45° .

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.

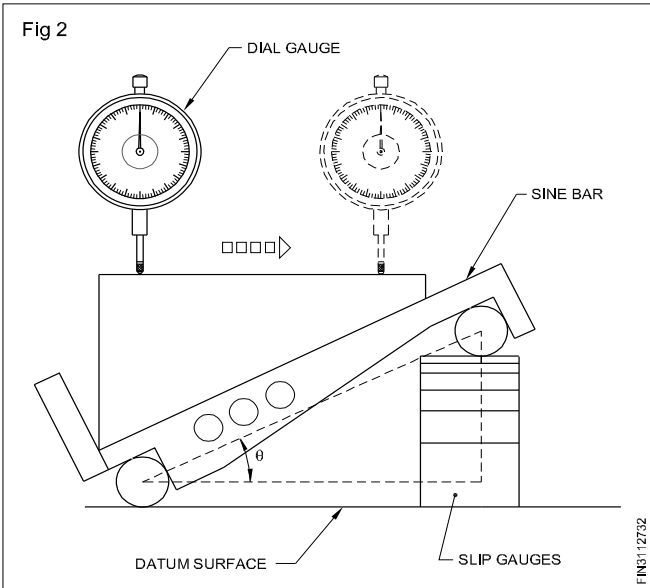
Fig 1



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The component to be checked should be mounted on the sine bar after placing the selected slip gauges under the roller. (Fig 1)

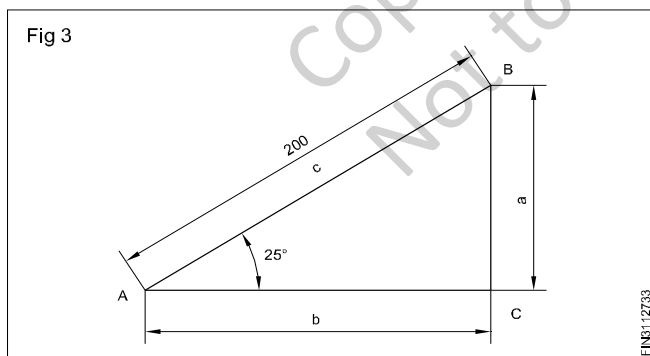
A dial test indicator is mounted on a suitable stand or vernier height gauge. (Fig 2) The dial test indicator is then set in first position as in the figure and the dial is set to zero.



Move the dial to the other end of the component (second position). If there is any difference then the angle is incorrect. The height of the slip gauge pack can be adjusted until the dial test indicator reads zero on both ends. The actual angle can then be calculated and the deviation, if any, will be the error.

Method of calculating the slip gauge height

Example (Fig 3)



Exercise 1

To determine the height of slip gauges for an angle of 25° using a sine bar of 200 mm long.

$$\text{Sine } \theta = \frac{a}{c}$$

$$\begin{aligned} \theta &= 25^\circ \\ a &= c \text{ Sine } \theta \\ &= 200 \times 0.4226 \\ a &= 84.52 \text{ mm} \end{aligned}$$

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)

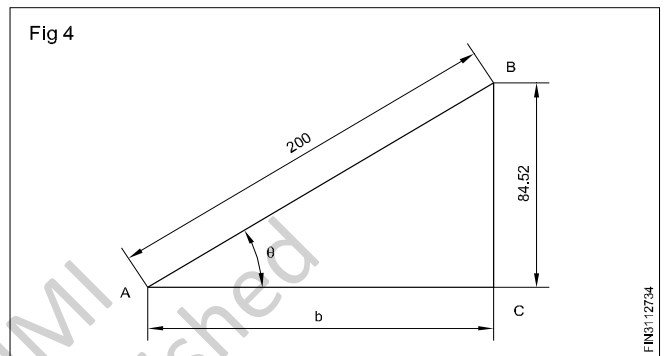
Tables are also available with readily worked out sine bar constants for standard sine bar lengths.

Calculating the angle for tapered components

Exercise 2

The height of the slip gauge used is 84.52 mm. The length of the sine bar used is 200 mm.

What will be the angle of the component? (Fig 4)



The angle whose sine value is 0.4226 is 25°. Hence the angle of tapered component is 25°.

$$\begin{aligned} \text{Sine } \theta &= \frac{a}{c} \\ &= \frac{84.52}{200} \end{aligned}$$

$$\text{sine } \theta = 0.4226$$

The angle whose sine value is 0.4226 is 25°. Hence the angle of tapered component is 25°.

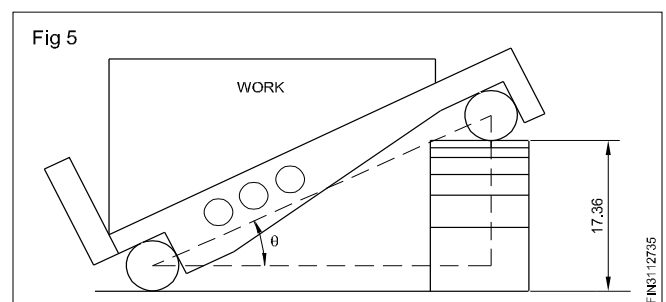
Classroom Assignment

1 What will be the angle of the workpiece if the slip gauge pack height is 17.36 mm and the size of the sine bar used is 100 mm? (Fig 5)

Answer _____

2 Calculate the height of the slip gauge pack to raise a 100 mm sine bar to an angle of 3° 35'.

Answer _____



Lapping

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

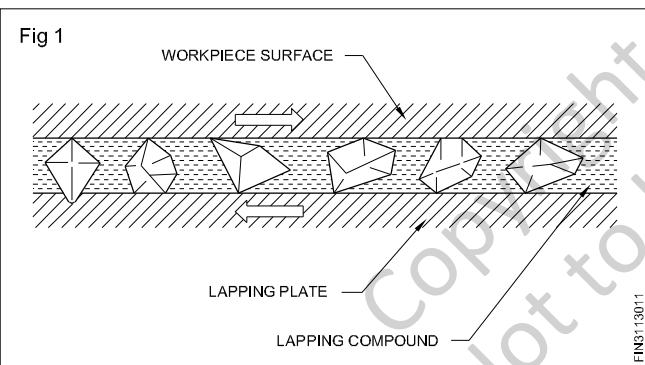
- state the purpose of lapping
- state the features of a flat lapping plate
- state the use of charging a flat lapping plate
- state the method of charging a cast iron plate
- distinguish between wet lapping and dry lapping.

Lapping is a precision finishing operation carried out using fine abrasive materials.

Purpose: This process:

- improves geometrical accuracy
- refines surface finish
- assists in achieving a high degree of dimensional accuracy
- improve the quality of fit between the mating components.

Lapping process: In the lapping process small amount of material are removed by rubbing the work against a lap charged with a lapping compound. (Fig 1)

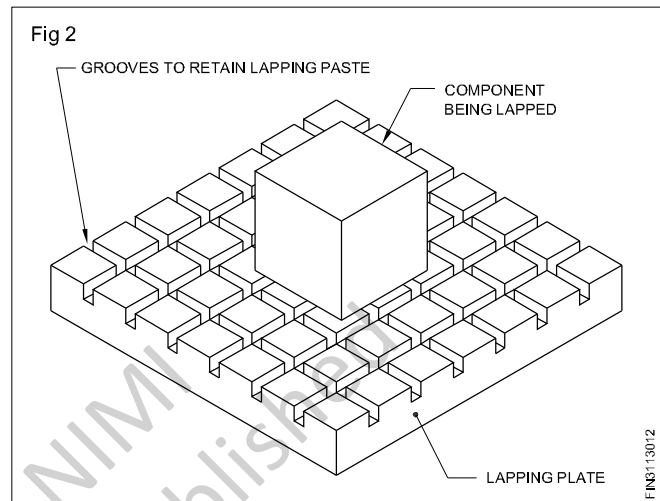


The lapping compound consists of fine abrasive particles suspended in a 'vehicle' such as oil, paraffin, grease etc.

The lapping compound which is introduced between the workpiece and the lap chips away the material from the workpiece. Light pressure is applied when both are moved against each other. The lapping can be carried out manually or by machine.

Hand lapping of flat surfaces: Flat surfaces are hand-lapped using lapping plate made out of close grained cast iron. (Fig 2) The surface of the plate should be in a true plane for accurate results in lapping.

The lapping plate generally used in tool rooms will have narrow grooves cut on its surface both lengthwise and crosswise forming a series of squares.



While lapping, the lapping compound collects in the serrations and rolls in and out as the work is moved.

Before commencing lapping of the component, the cast iron plate should be CHARGED with abrasive particles.

This is a process by which the abrasive particles are embedded on to the surfaces of the laps which are comparatively softer than the component being lapped. For charging the cast iron lap, apply a thin coating of the abrasive compound over the surface of the lapping plate.

Use a finished hard steel block and press the cutting particles into the lap. While doing so, rubbing should be kept to the minimum. When the entire surface of the lapping plate is charged, the surface will have a uniform gray appearance. If the surface is not fully charged, bright spots will be visible here and there.

Excessive application of the abrasive compound will result in the rolling action of the abrasive between the work and the plate developing inaccuracies.

The surface of the flat lap should be finished true by scraping before charging. After charging the plate, wash off all the loose abrasive using kerosene.

Then place the workpiece on the plate and move along and across, covering the entire surface area of the plate.

When carrying out fine lapping, the surface should be kept moist with the help of kerosene.

Wet and dry lapping: Lapping can be carried out either wet or dry.

In wet lapping there is surplus oil and abrasives on the surface of the lap. As the workpiece, which is being lapped, is moved on the lap, there is movement of the abrasive particles also.

In dry method the lap is first charged by rubbing the abrasives on the surface of the lap. The surplus oil and

abrasives are then washed off. The abrasives embedded on the surface of the lap will only be remaining. The embedded abrasives act like a fine oilstone when metal pins to be lapped are moved over the surface with light pressure. However, while lapping, the surface being lapped is kept moistened with kerosene or petrol. Surfaces finished by the dry method will have better finish and appearance. Some prefer to do rough lapping by wet method and finish by dry lapping.

Lap materials and lapping compounds

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

- name the different types of lap materials
 - state the qualities of different lap materials
 - name the different types of abrasive materials used for lapping
 - distinguish between the application of different lapping 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. If the lap is harder than the workpiece, the workpiece will get charged with the abrasives 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 lap 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 and tougher than silicon carbide. Aluminium oxide is used in un-fused and fused forms. Un-fused alumina (aluminium oxide) removes stock effectively 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. It has excellent cutting properties. Because of the high cost, it is used only in specialised application like dies and gauges.

Diamond: This being the hardest of all materials, it is used for lapping tungsten carbide. Rotary diamond laps 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 lapping surfaces and regulates the cutting action and lubricates the surfaces.

The commonly used vehicles are:

- water soluble cutting oils
- vegetable oil

- 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, bentonite etc.

In addition to the vehicles used in making the lapping compound, solvents like water, kerosene, etc. are also used at the time of lapping.

Abrasive of varying grain sizes from 50 to 800 are used for lapping, depending on the surface finish required on the component.

Lap external and internal cylindrical surfaces

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

- state the features of external and internal cylindrical laps
- identify the different types of laps used for cylindrical surfaces
- state the method of charging the cylindrical laps
- state the precautions to be observed while lapping cylindrical surfaces.

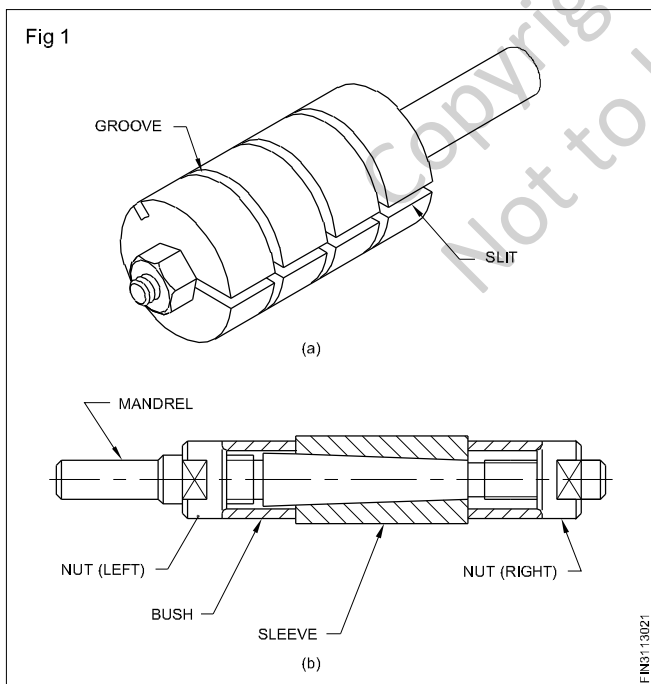
In manufacturing processes where a very high degree of accuracy is required as in the case of jigs and fixtures etc. lapping becomes necessary. For finishing holes, which are hardened, lapping is very essential.

Lapping internal cylindrical surfaces

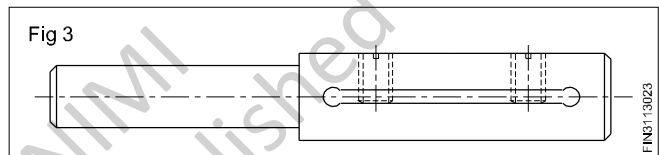
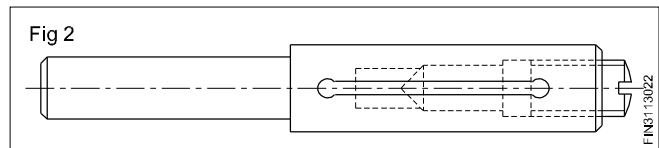
Solid or adjustable types of laps are used for lapping internal cylindrical surfaces/holes. (Fig 1a)

Laps of larger sizes are made of cast iron. Small diameter laps are made of copper or brass as cast iron is brittle. Laps for holes are commercially available.

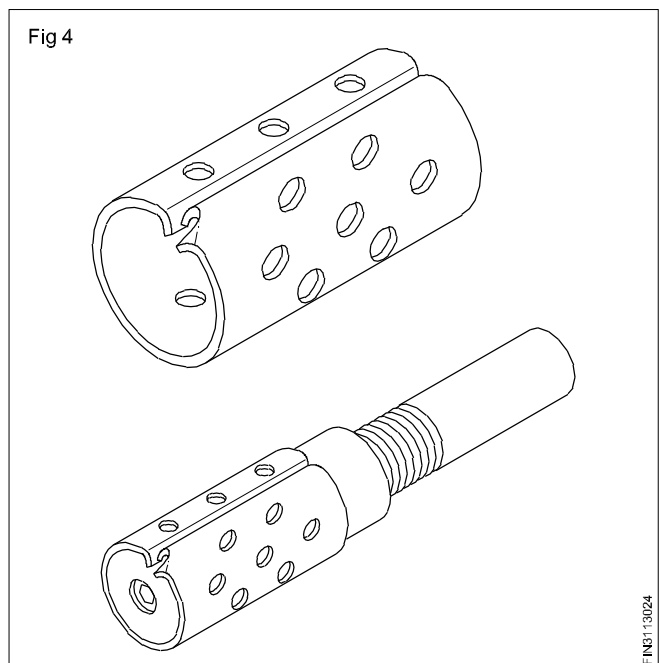
They are adjustable and have interchangeable sleeves made of copper. (Fig 1b)



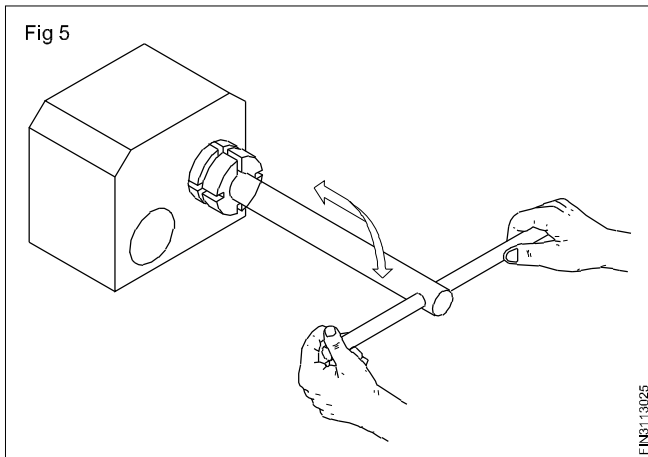
Laps with a capability of slight adjustment in size can also be prepared in the shop floor. (Figs 2 & 3)



Grooves cut on the surfaces of the lap help in retaining the abrasive compound (Fig 1a) and the slits cut provide for expansion. Commercially available laps are sometimes provided with holes which can hold the lapping compound. (Fig 4). Holes can be lapped manually or by using special lapping machines. A sensitive drill press can also be used for rotating the laps. While lapping, the lap should fill the hole and kept tight. Use of adjustable laps is very helpful for this. The length of the lap should be longer than the hole being lapped to ensure straightness of the hole throughout.



The lap should not be removed from the hole while lapping, and should travel the full length of the bore. (Fig 5)

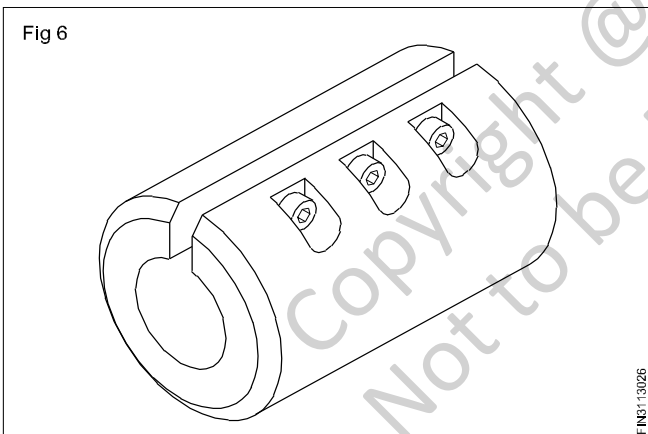


While lapping, the lap should be pushed forward in the bore giving a clockwise movement at the same time.

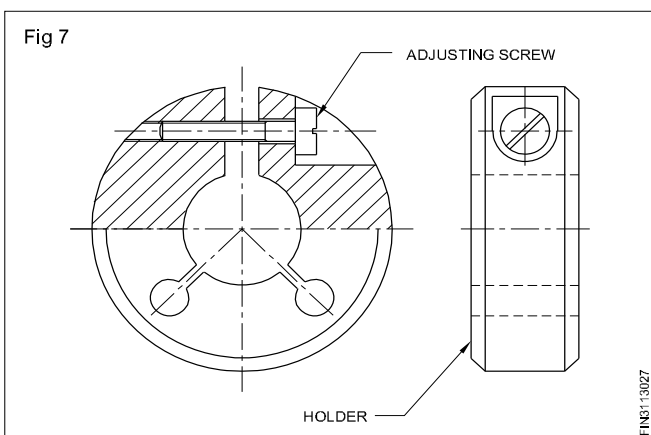
Lapping external cylindrical surfaces

Adjustable ring laps of various designs are available for lapping external cylindrical surfaces.

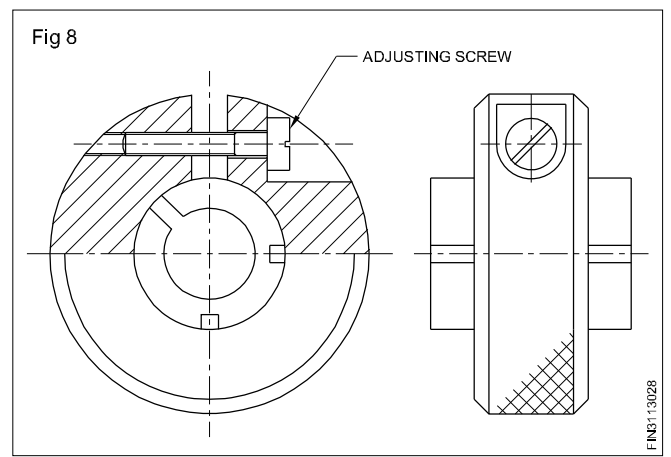
The simplest form is a split bush with clamping screws, which permits some adjustment of sizes. (Fig 6)



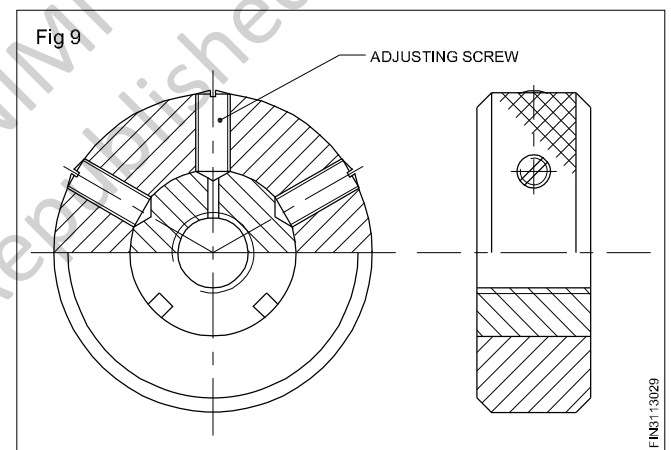
The adjustable ring lap will have slots cut on it which permit the feeding of the lapping compound and adjustment of sizes. (Fig 7)



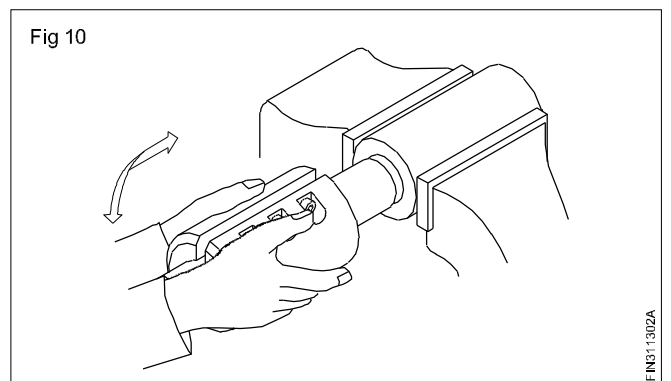
Another type of ring lap with interchangeable bushes is also available. In a single holder different sizes of bushes can be used. (Fig 8)



External threads can also be lapped using ring laps. (Fig 9) This usually consists of interchangeable threaded bushes corresponding to the external thread to be lapped. A slight adjustment of sizes is also possible. Ring laps are usually made of closely grained cast iron.



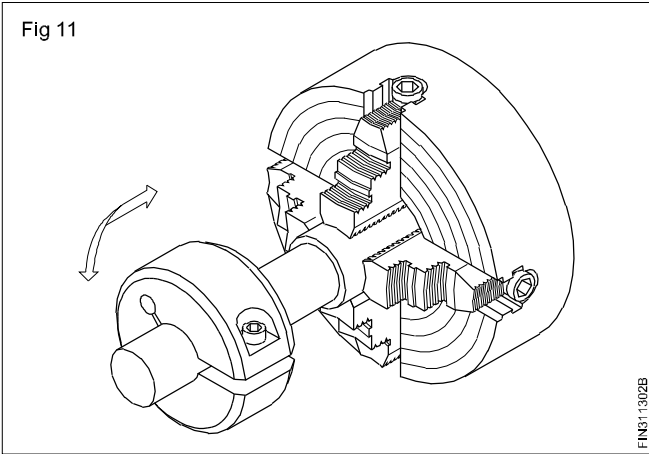
Ring lapping can be done manually (Fig 10) or by holding the work on the lathe while the split ring is moved over the cylindrical surface. (Fig 11)



While lapping, the ring lap should slide forward and backward along the workpiece rotating the lap at the same time in alternate directions.

For lapping large diameters, special laps can be prepared and used. (Fig 12)

Fig 11



FIN311302B

Charging cylindrical laps

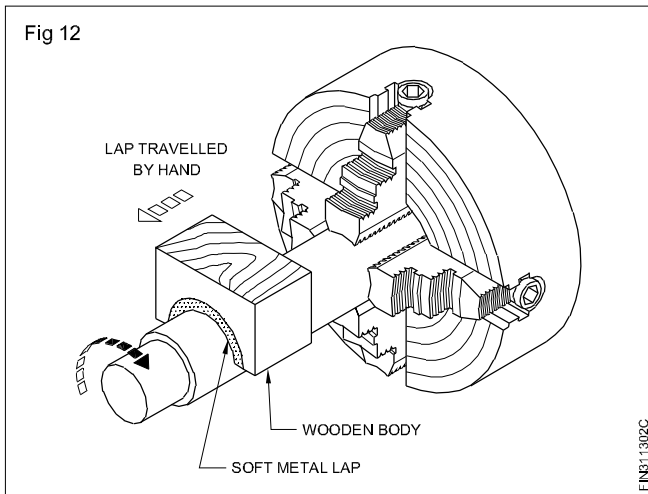
For charging cylindrical laps for internal work, a thin coating of prepared abrasive compound is spread over the surface of a hard steel block. The lapping compound is then rubbed with a cast iron or copper block. The lap is rolled over the cast iron block by pressing it down firmly so that the abrasive grains will be firmly embedded on the surface of the lap.

The external cylindrical laps can be charged by pressing the abrasive inside the bore with the help of hard steel rollers which are slightly smaller than the diameter of the lap.

Precautions to be observed while lapping

- Do not dwell in the same place while lapping.
- Keep the lap moist always.
- Do not add fresh abrasive during lapping; recharge if necessary.
- Do not apply excessive pressure while lapping.

Fig 12



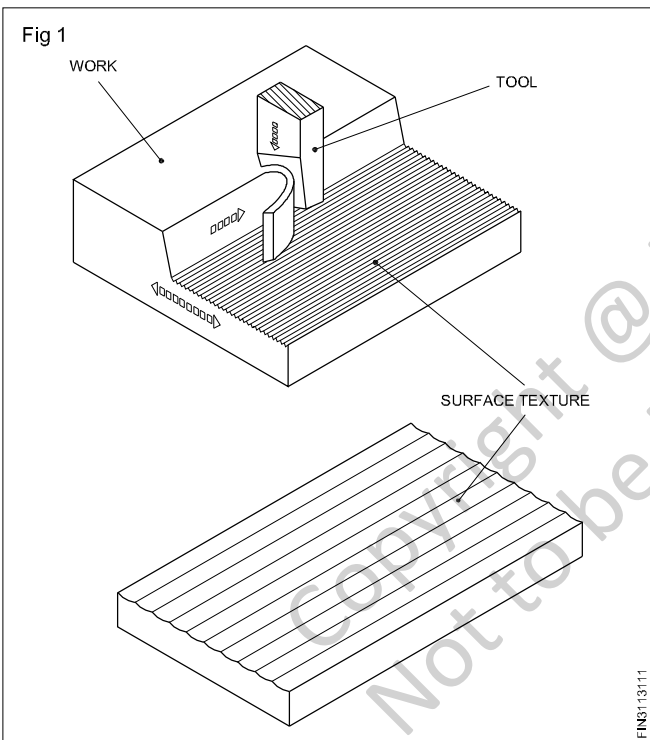
FIN311302C

Surface finish importance

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

- state the meaning of surface texture
- distinguish between roughness and waviness
- state the need for different quality surface textures
- state the meaning of 'Ra' value
- interpret 'Ra' and roughness grade number in drawings.

When components are produced either by machining or by hand processes, the movement of the cutting tool leaves certain lines or patterns on the work surface. This is known as surface texture. These are, in fact, irregularities, caused by the production process with regular or irregular spacing which tend to form a pattern on the workpiece. (Fig 1)



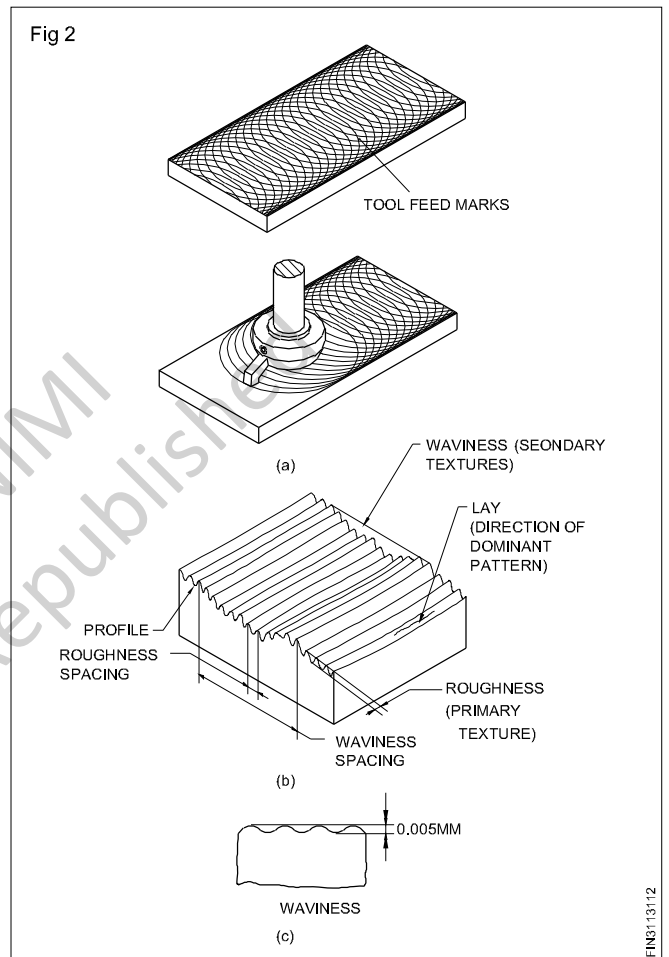
The components of surface texture

Roughness (Primary texture)

The irregularities in the surface texture result from the inherent action of the production process. These will include traverse feed marks and irregularities within them. (Fig 2a)

Waviness (Fig 2b & 2c)

This is the component of the surface texture upon which roughness is superimposed. Waviness may result from machine or work deflections, vibrations, chatter, heat treatment or warping strain.



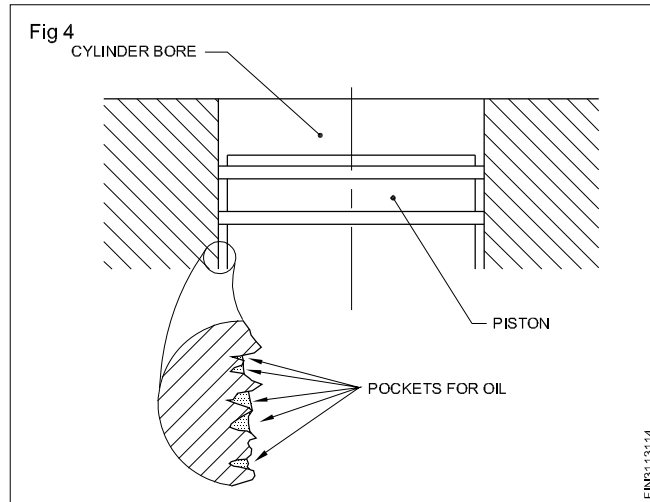
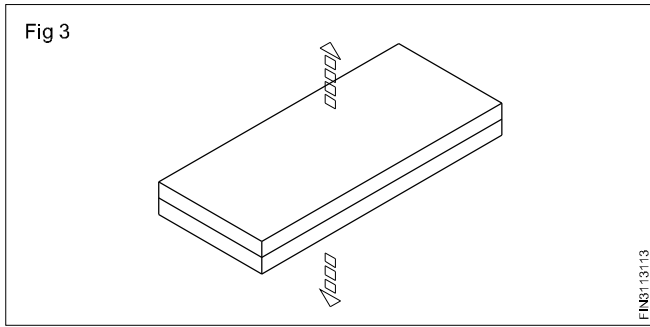
The requirement of surface quality depends on the actual use to which the component is put.

Examples

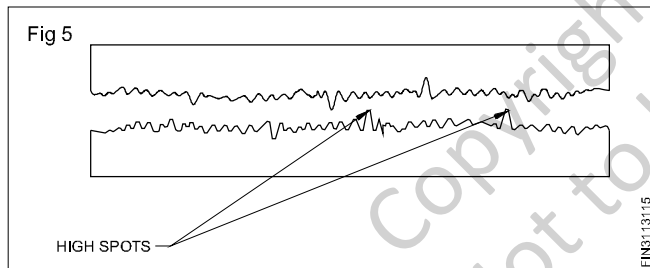
In the case of slip gauges (Fig 3) the surface texture has to be extremely fine with practically no waviness. This will help the slip gauges to adhere to each other firmly when wrung together.

The cylinder bore of an engine (Fig 4) may require a certain degree of roughness for assisting lubrication needed for the movement of the piston.

For sliding surfaces the quality of surface texture is very important.



When two sliding surfaces are placed one over the other initially the contact will be only on the high spots. (Fig 5) These high spots will wear away gradually. This wearing away depends on the quality of the surface texture.



Due to this reason it is important to indicate the surface quality of components to be manufactured.

The surface texture quality can be expressed and assessed numerically.

Surface texture measuring instruments

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

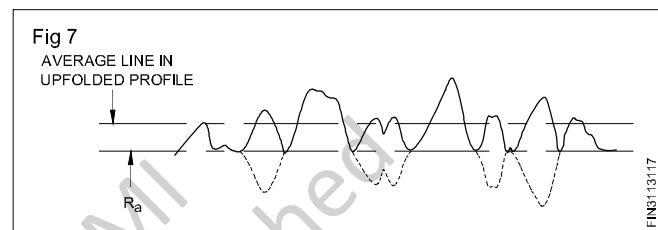
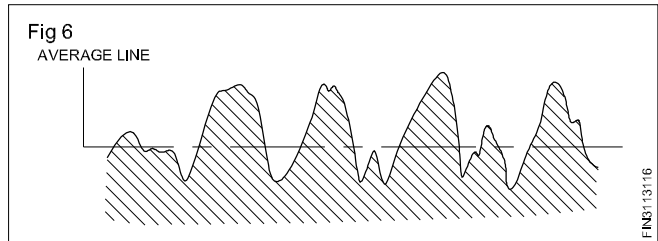
- distinguish the features of mechanical and electronic surface indicators
- name the parts of a mechanical surface indicator
- identify the features of electronic surface indicators (tay-surf)
- state the functions of the different features of electronic surface indicators.

The use of surface finish standards which we have seen earlier is only a method of comparing and determining the quality of surface. The result of such measurement very much depends on the sense of touch and cannot be used when a higher degree of accuracy is needed.

'Ra' Values (Dimensional therome)

The most commonly used method of expressing the surface texture quality numerically is by using Ra value. This is also known as centre line average (CLA).

The graphical representation of Ra value is shown in Figures 6 & 7. In Figure 6 a mean line is placed cutting through the surface profile making the cavities below and the material above equal.



The profile curve is then drawn along the average line so that the profile below this is brought above.

A new mean line (Fig 7) is then calculated for the curve obtained after folding the bottom half of the original profile.

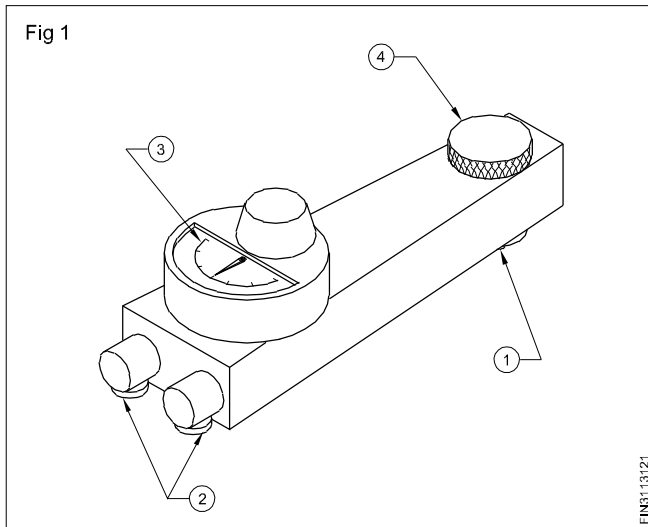
The distance between the two lines is the 'Ra' value of the surface.

The 'Ra' value is expressed in terms of micrometre (0.000001) or (m), this also can be indicated in the corresponding roughness grade number, ranging from N_1 to N_{12} .

When only one 'Ra' value is specified, it represents the maximum permissible value of surface roughness.

Mechanical surface indicator

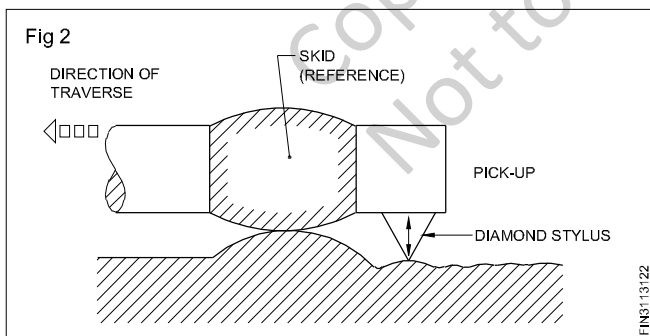
This instrument consists of the following features. (Fig 1)



- 1 Measuring stylus
- 2 Skids
- 3 Indicator scale
- 4 Adjustment screw

The stylus is made of diamond, and its contact point will have a light radius.

When the stylus is slowly traversed across the test surface the stylus moves upward or downward depending on the profile of the surface. (Fig 2) This movement is amplified and transferred to the dial of the surface indicator. The pointer movement indicates the surface irregularities.



Surface quality

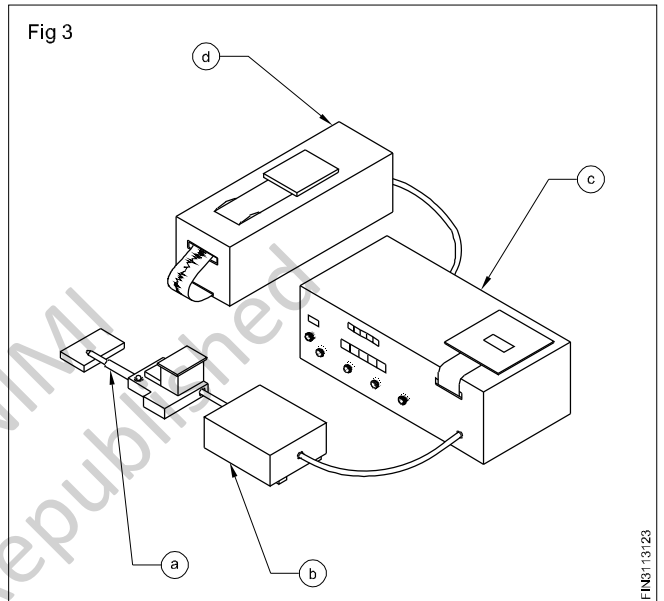
Various components are manufactured by different machining processes. The surfaces of the components differ in their appearance as well as 'feel' when we move our hand over the surface. (Fig 1)

When using a mechanical surface indicator, measurement must be read as it is moved over the surface, and then a profile curve is drawn manually to compute the mean value.

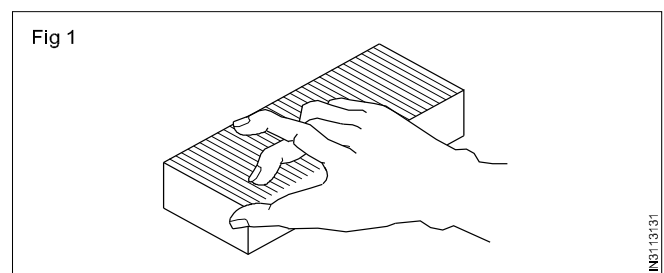
There are different types of electronic surface measuring devices; one type of such an instrument used in workshops is the taly-surf.

Taly-surf (Electronic surface indicator)

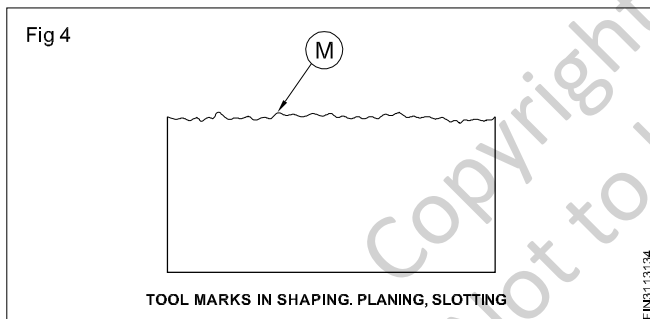
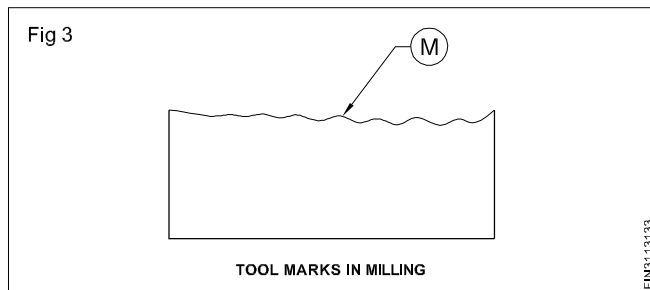
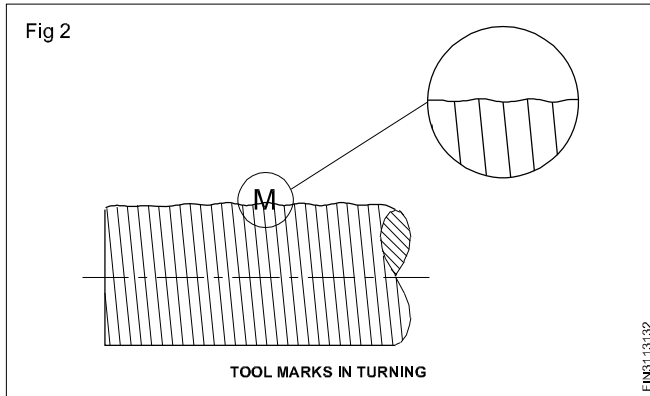
This is an electronic instrument for measuring surface texture. This instrument can be used for factory and laboratory use. (Fig 3)



The measuring head of this unit consists of a stylus (a) and a motor race (b) which controls the movement of the instrument head across the surface. The movement of the stylus is converted to electrical signals. These signals are amplified in the surface analyser/amplifier (c) which calculates the surface parameter and presents the result on a digital display or in the form of a diagram through a recorder (d).



The surface will have ups and downs. These ups and downs are due to the tool marks. The pattern of these tool marks depends on the machining processes. The irregular patterns of tool marks depend on the feed, speed, tool angles, depth of cut etc. So all the machined surfaces are rough due to the inherent tool marks left in the machining processes. The surface appearance of components is shown in Figs 2 to 4.



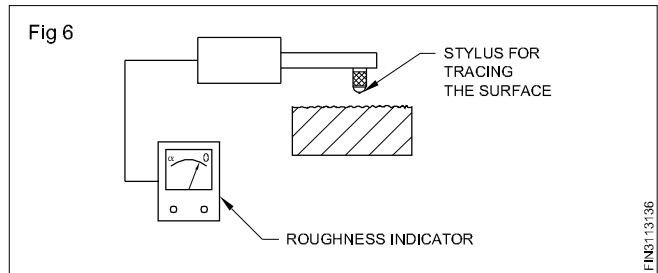
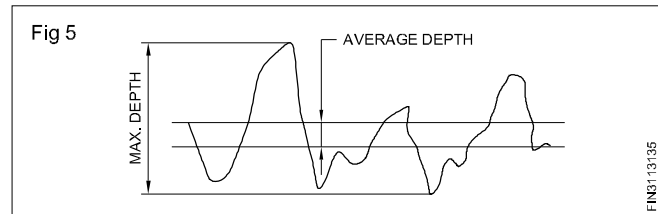
In other words, the selection process and setting of machining parameters are dictated by the type of surfaces quality demanded in the drawing of the part.

Surface roughness measurement

To control the roughness of a surface precisely, we need to define and establish a measuring system for it.

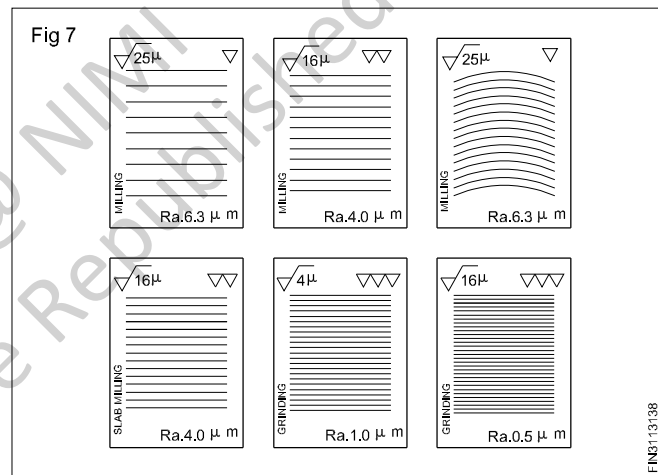
Roughness is defined as the average height or depth from the hill to the valley of a surface pattern (Fig 5) and it is possible to measure this by instruments specially designed for this purpose.

This instrument has a very sharp stylus. (Fig 6) This stylus is moved across the surface to be measured mechanically over a short distance and during this time the instrument calculates the average depth and displays the value as a roughness number.



Surface finish standard

One method of determining the surface roughness is by using a surface finish standard. (Fig 7) This is a box which consists of 20 blocks of a specific surface finish obtained by a specific machining operation.



The type of machining operation is marked on each block together with the surface roughness number for height and width. Using the surface finish standard, we can make comparisons between the machined surface and the standard surface using our sense of touch.

However, this method is sometimes not accurate enough and the individual must be very sensitive to the different surface roughness.

If the degree of accuracy of checking is high, then the application of a sensitive instrument is inevitable.

In order to obtain the required surface quality, it is necessary to choose the appropriate manufacturing process. Table-1 appended here gives an idea about the different processes and range of surface quality attainable.

For more detailed information on surface texture, symbols and their representations refer to IS:10719.

TABLE 1

Surface roughness expected from manufacturing processes		IS : 3073 - 1967													
Manufacturing process	Surface roughness (µm)														
	0.012	0.025	0.050	0.10	0.20	0.40	0.80	1.6	3.2	6.3	12.5	25	50	100	200
Flame cutting, sawing and chipping										6.3					100
Hot rolling								2.5						50	
Planing								1.6						50	
Sand casting									5					50	
Turning and milling						0.32								25	
Filing					0.25									25	
Disc grinding								1.6						25	
Hand grinding										6.3				25	
Drilling								1.6						20	
Boring								1.6						6.3	
Radial cut-off sawing								1						6.3	
Permanent mould casting							0.8							6.3	
Surface and cylindrical grinding			0.063											5	
Extrusion					0.16									5	
Reaming, broaching and jobbing						0.4								3.2	
Die casing							0.8							3.2	
High pressure casting						0.32								2	
Burnishing			0.04											0.8	
Honing		0.025												0.4	
Super finishing		0.016												0.32	
Lapping	0.012							0.16							
polishing		0.04						0.16							

Honing

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

- define honing
- state the principle of honing
- name the various applications of honing
- state the methods of honing
- compare the features of the honing tools used in manual and power stroking
- name the different honing stones(abrasive) and state their uses
- list the cutting fluid used in honing.

Honing

Honing is a super finishing process carried out using abrasive sticks for the removal of stock from metallic and non-metallic surfaces.

This process:

- produces high surface finish
- corrects the profiles of cylindrical surfaces
- removes taper.

Working principle

The honing tool with abrasives mounted on it is held on the spindle of a machine which can be rotated in its axis.

As the spindle rotates, a reciprocating motion is also given to the tool. The surface produced will have a cross hatched pattern. (Figs 1 & 2) This pattern of the surface texture provides better lubrication in cylindrical bores.

Application

Honing is used for finishing of bores in ferrous and non-ferrous materials.

Honing can be done in hardened or un-hardened state.

Bores of any size, length, blind or through, tandem or interrupted surfaces can also be honed.

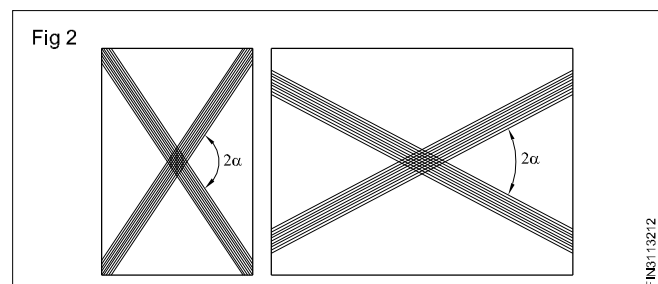
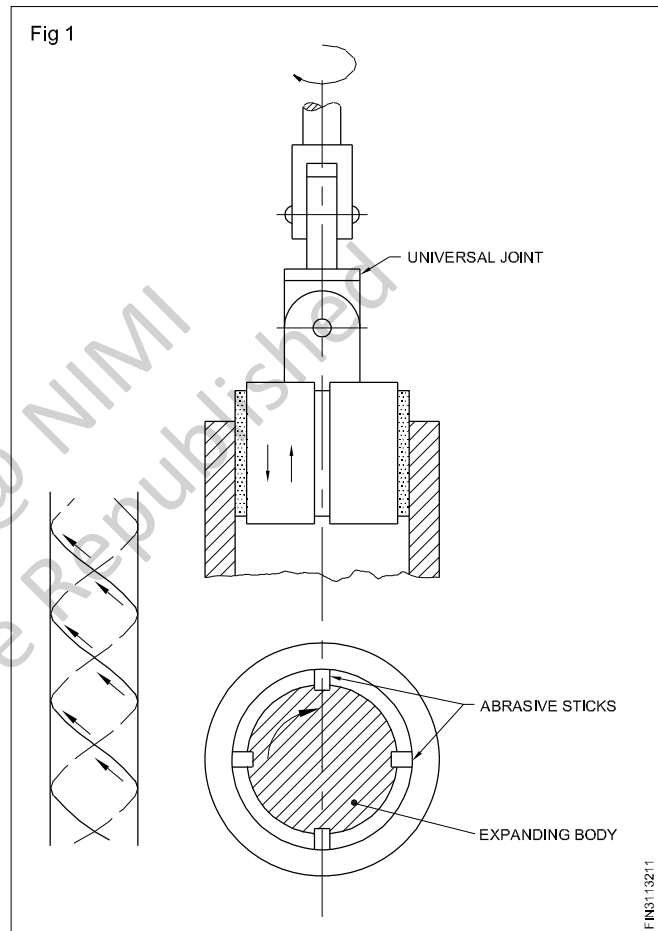
Honing can be carried out on drilling or other machines which have arrangement for rotary and reciprocating motion simultaneously.

A rotary motion can be given by the spindle and the reciprocating motion can be either manual or by power depending on the type of machine used.

For mass production special honing machines are used.

Methods of honing

Manual stroking/Power stroking



Manual stroking is preferred for large quantities when tolerances are extremely close.

Many operators prefer this because of the flexibility in operation.

This eliminates the use of expensive fixtures to hold the work.

Jobs can be quickly changed from one type to another.

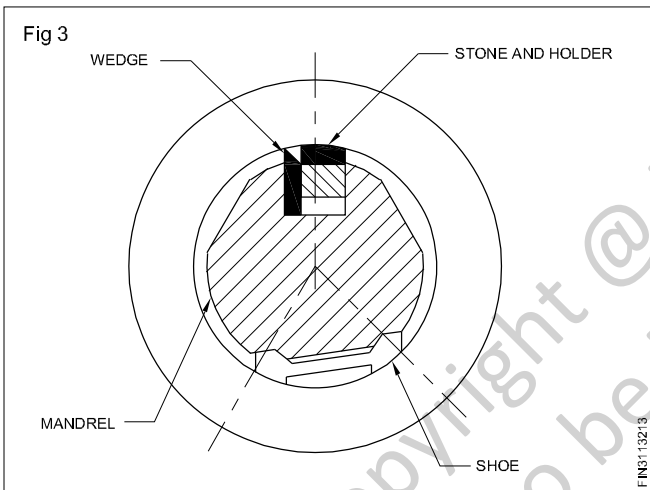
Jobs can be reversed from end to end for accurate honing and correction. The stroke length can be altered depending on the actual requirement of the individual workpiece.

Power stroking is used for honing all types of workpieces. Power stroking may prove to be economical particularly in the case of small parts.

Note

Sometimes for final finishing, manual stroking is employed after power stroking.

The tools used for manual stroking consist of a mandrel, an abrasive stone with holder and a pair of shoes made of wear resistant material with respect to workpiece materials. (Fig 3)



The wedge controls the feeding of the abrasive stone. The shoes stabilize and guide the tool in the workpiece.

Power stroke tools will have abrasive stones at equal distance all around the circumference of the tool. For feeding the abrasive stones, expanding cones are provided. The tools are usually of a self-aligning type with a double universal joint.

Honing stones

Honing stones consist of particles of aluminium oxide, silicon carbide or diamond bonded together with vitrified clay, cork, carbon or metal. The honing stones have a

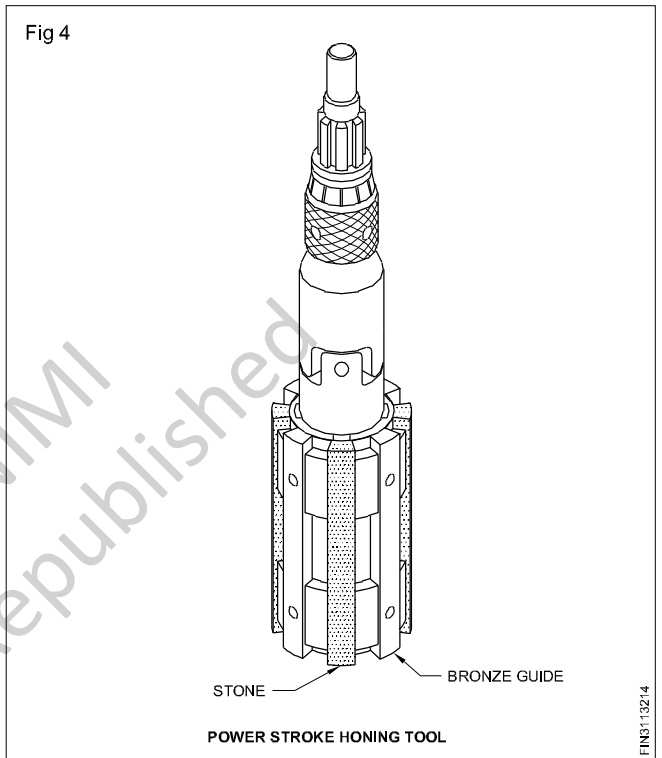
porous structure and this helps for chip clearance.

The grit size of abrasives used ranges from 36 to 600 but the most commonly used sizes are 120 to 320.

Uses of different abrasives

Aluminium oxide	Steel
Silicon carbide	Cast iron & non-ferrous metals
Diamond	Tungsten, ceramics etc.

Power stroke honing tool shown in Fig 4.



Cutting fluids

Cutting fluids are used while honing. The mineral oil commonly used in machining operations is diluted in proportion of one part of oil with four parts of kerosene before it is used for honing.

Frosting

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

- define frosting
- state the aim of frosting
- describe the method of frosting.

Frosting

Frosting is a process in which scraped metal surface is decorated with the use of hand scraper.

Frosting can also be called as flaking

When a patterned finish is formed on a polished or scraped flat surface

Why frosting is used

Frosting used as a way of increasing oil retention on scraped or polished surfaces.

This is important with machine parts in order to keep them lubricated and moving smoothly instead sticky and jerky movement.

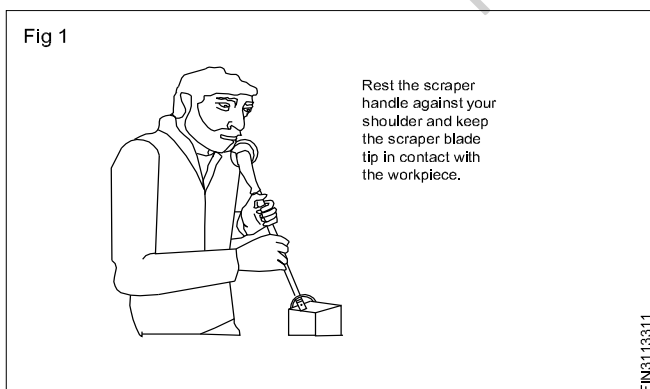
Without the frosting, the oil would runway, leaving just the two metal surfaces in contact with each other, which is likely to cause seizure of the machine.

How to carry out frosting or flaking with an engineer's scraper

Engineer's scraper frosting technique

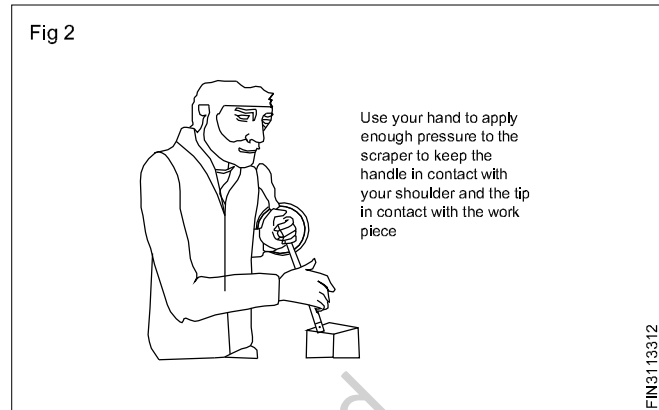
Step 1 - Stand comfortably

Stand with the end of the scraper handle resting just beneath your shoulder, and contact with the workpiece.



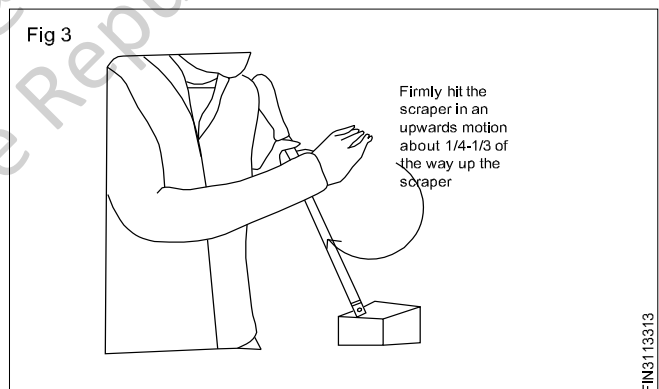
Step 2 - Position your hands

Use your non-dominant hand to hold the scraper about 1/2 - 3/4 of the way up the scraper and apply enough pressure to keep the handle in contact with your body and the tip in contact with workpiece.



Step 3 - Hit scraper

Using an upwards motion with your dominant hand, firmly hit the scraper towards you, striking the scraper at between 1/4 - 1/3 of the way up the scraper.



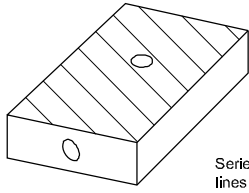
Step 4 - Repeat hitting motion

Repeat step 3 to produce a straight, frosted line across the workpiece at an angle of approximately 45 degree of the edge of the workpiece. Then repeat this to produce a series of parallel frosted lines across the workpiece.

Step 5 - Repeat at right angles

Repeat step 4 at a right angle to your original frosted lines.

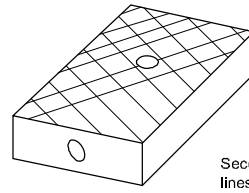
Fig 4



Series of parallel frosted lines at 45° to the edge of the workpiece

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Fig 5



Second set of frosting lines at right angle to first

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Heat treatment of plain carbon steels

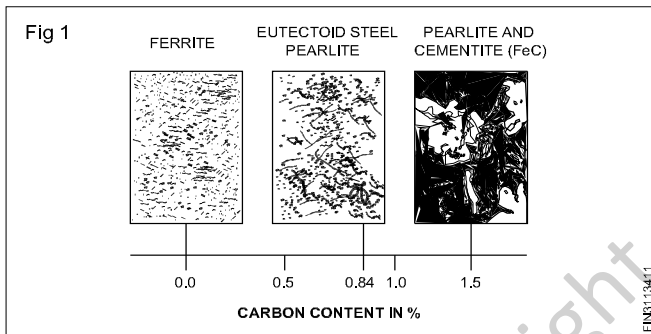
Objectives: At the end of this lesson you shall be able to

- 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.

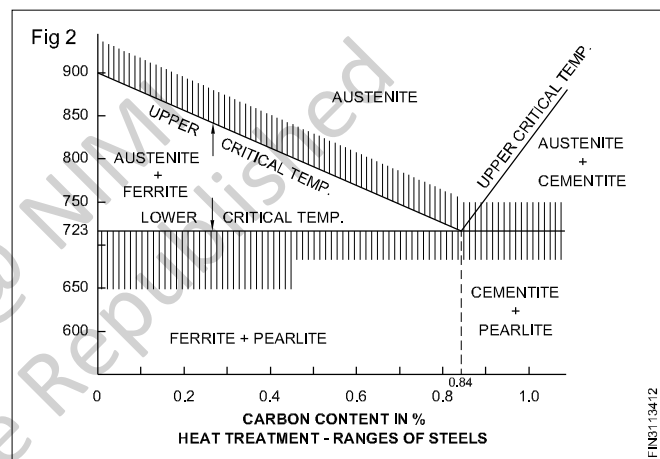
Hypereutectoid steel

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

Hypoeutectoid steel

Less than 0.84% carbon steel or hypoeutectoid 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 machinable.

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 heat-ing 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.

To improve machinability.

To soften the steel.

Annealing: To relieve strain and stress.
To eliminate strain/hardness.

Normalising: To refine the grain structure of the steel.

Heating and 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.

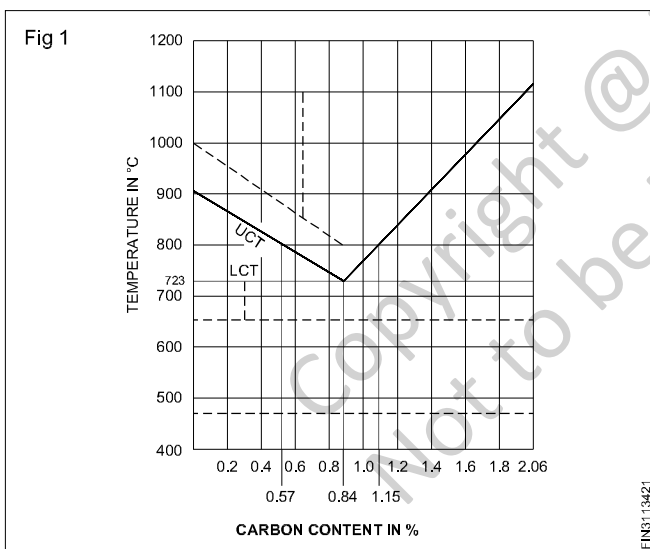
Critical temperatures

Lower critical temperature

The temperature, at which the change of structure to austenite starts - 723°C, is called the lower critical temperature for all plain carbon steels.

Upper critical temperature

The temperature at which the structure of steel completely changes to AUSTENITE is called the upper critical temperature. This varies depending on the percentage of carbon in the steel. (Fig 1)



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.

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.

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.

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

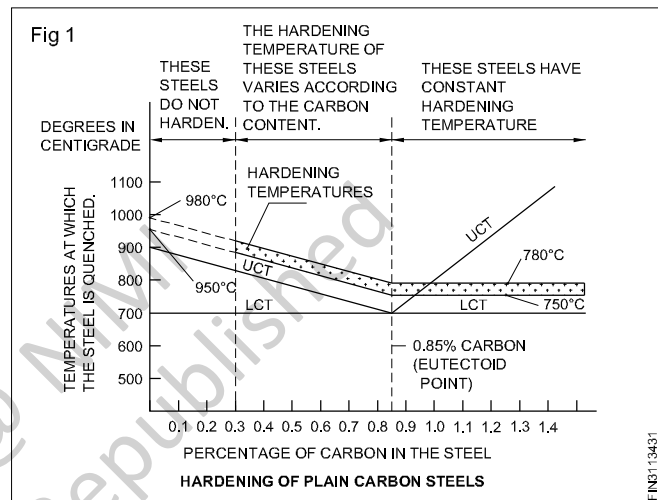
To develop high hardness and wear resistance properties.

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 5 mts. / 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	Temperature in degrees (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, screw drivers	300	Dark blue.
	320	Very dark blue.
	340	Greyish blue.
For toughening without undue hardness.	450-700	No colour.

Annealing of steel

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

- state the annealing of steel
- state the purpose of annealing
- state the process of annealing.

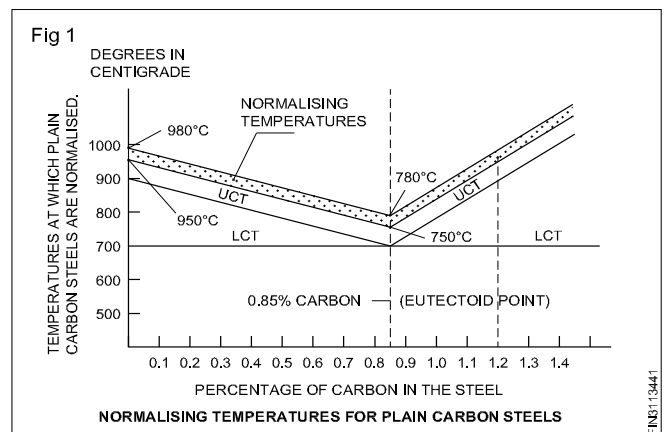
The annealing process is carried out by heating the steel above the critical range, soaking it for sufficient time to allow the necessary changes to occur, and cooling at a predetermined rate, usually very slowly, within the furnace.

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 hypoeutectoid steels to 30 to 50°C above the upper critical temperature and 50°C above the lower critical temperature for hypereutectoid steels. (Fig 1)



Soaking is holding at the heating temperature for 5 mts./ 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.

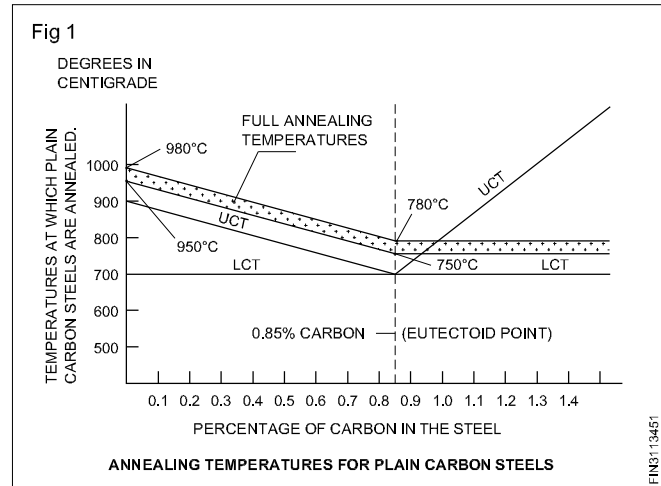
The process of removing the internal defects or to refine the structure of steel components is called normalising.

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

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 draught, to room temperature. Normalizing should be done in all forgings, castings and work-hardened pieces.



Precautions

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

Surface hardening of steel

- Objectives :** At the end of this lesson you shall be able to
- name four different types of surface hardening process
 - state 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 supported by a tough, shock-resisting core for service condition and longer life. This combination of different properties can be obtained in a single piece of steel by surface hardening. (Fig 1)

Types of surface hardening

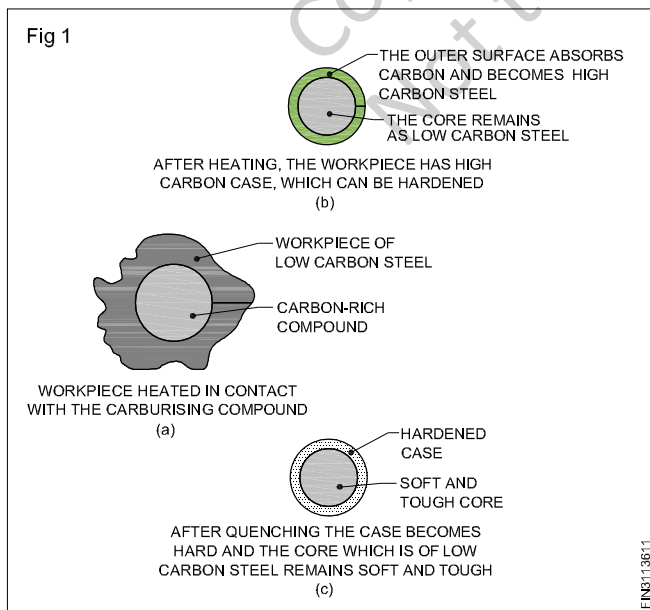
- Case hardening
- Nitriding
- Flame hardening
- Induction hardening

Case hardening

Parts to be hardened by this process are made from a steel with a carbon content of 0.15% so that they will not respond to direct hardening.

The steel is subjected to treatment in which the carbon content of the surface layer is increased to about 0.9%.

When the carburised steel is heated and quenched, only the surface layer will respond, and the core will remain soft and tough as required. (Fig 1)



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.

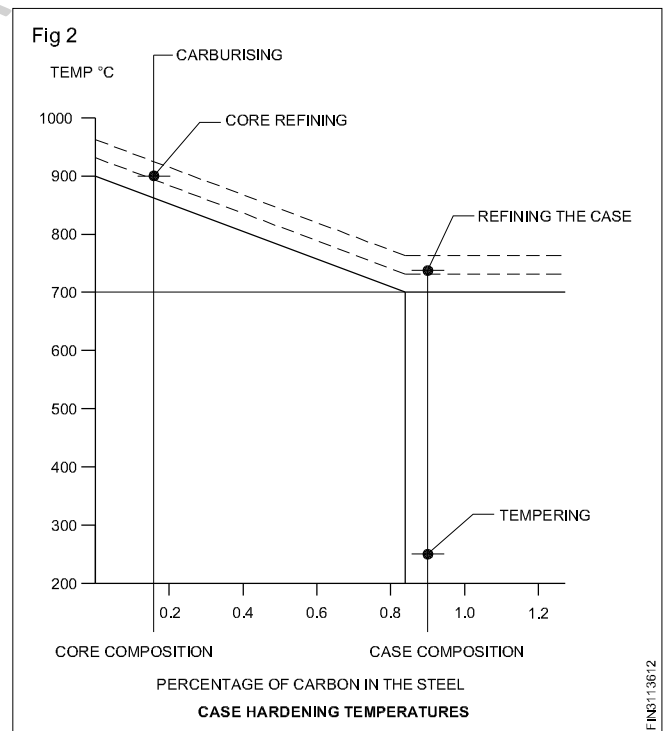
1. Carburising in which the carbon content of the surface is increased.
2. Heat treatment in which the core is refined and the surface hardened.

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.

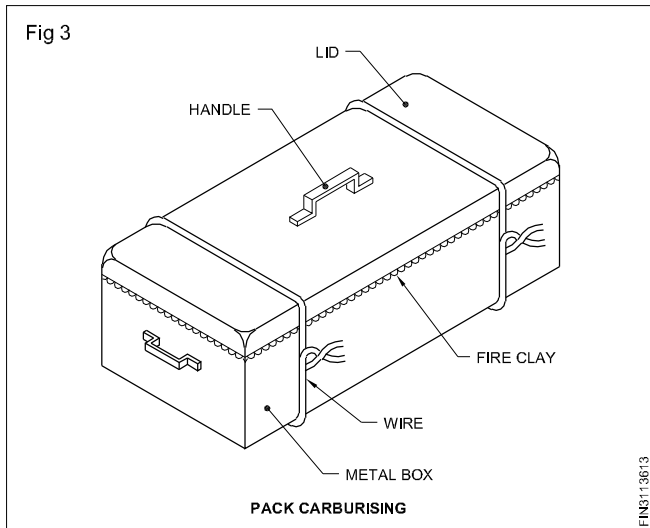
The carbon can be supplied as a solid, liquid or gas.

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 2)



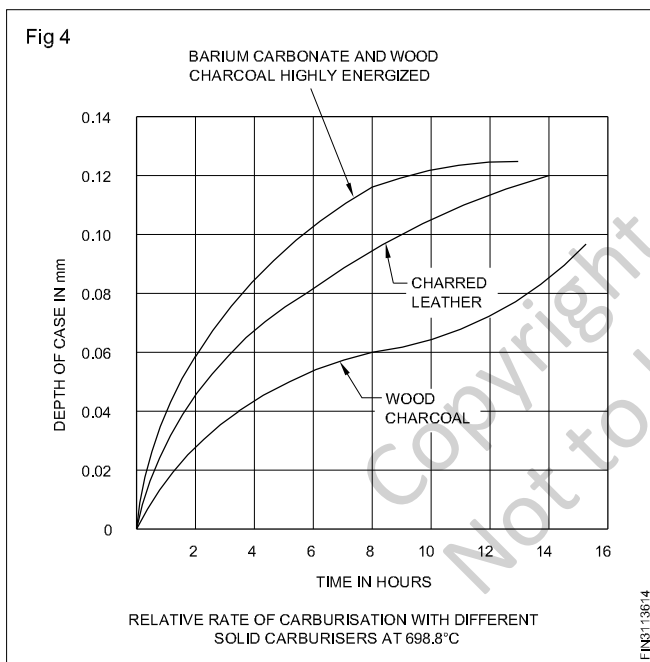
Pack carburising (Fig 3) (solid)

The parts are packed in a suitable metal box in which they are surrounded by the carburising medium.



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 decarburisation.

The carburising medium can be wood, bone, leather or charcoal, but an energiser, such as barium carbonate, is added to speed up the process. (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 carburisation, the depth of the case depends on the cyanide content.

Salt-bath carburising is very rapid, but is not always suitable because it produces an abrupt change in the carbon content from the surface to the core. This produces a tendency for the case to flake.

This is suitable for a thin case, about 0.25 mm deep. Its advantage is that heating is rapid and distortion is minimum.

Gas carburising

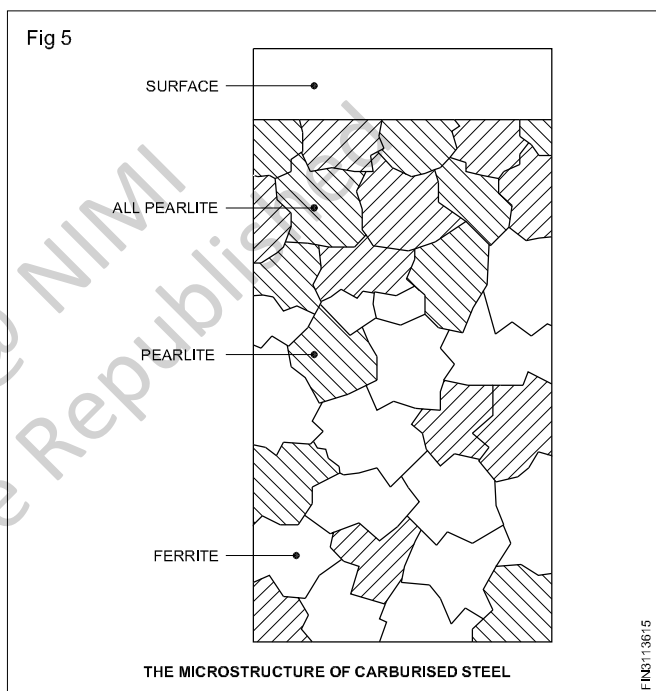
The work is placed in a gas tight container which can be heated in a suitable furnace, or the furnace itself may be the container.

The carburising gas is admitted to the container, and the exit gas is vented.

The gas such as methane or propane may be fed directly into the container in which the work is placed.

In a continuous gas carburising furnace, the carburising, quenching and tempering processes are carried out in sequence in the same closed furnace as they progress on a conveyer from one operation to the next.

Fig 5 illustrates the appearance of the structure across its section produced by carburising.



Heat treatment

After the carburising has been done, the case will contain about 0.9% carbon, and the core will still contain about 0.15% carbon. There will be a gradual transition of the carbon content between the case and the core. (Fig 2)

Owing to the prolonged heating, the core will be coarse, and in order to produce a reasonable toughness, it must be refined.

To refine the core, the carburised steel is reheated to about 870° C and held at that temperature long enough to produce a uniform structure, and is then cooled rapidly to prevent grain growth during cooling.

The temperature of this heating is much higher than that suitable for the case, (Fig 2) and, therefore, an extremely brittle martensite will be produced.

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

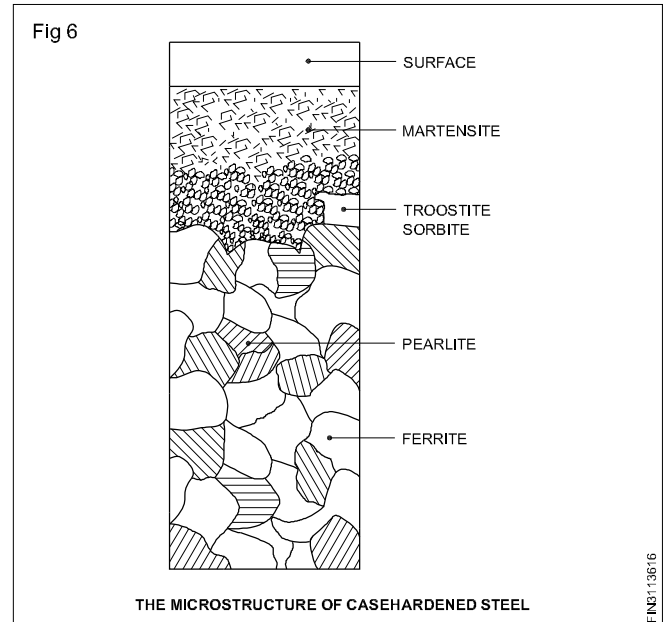
The refining is done by reheating the steel to about 760°C, to suit the case, and quenching it.

Tempering

Finally the case is tempered at about 200°C to relieve the quenching stresses.

If the part is not required to resist shock, it is unnecessary to carry out the core refining operation; in these conditions, a coarse martensite at the surface may not cause trouble, and so this part may be quenched directly after carburising.

Fig 6 illustrates the appearance of the structure across its section produced by case hardening.



Nitriding

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

- state the process of case hardening by gas nitriding
- state the process of case hardening by nitriding in a salt bath.

In the nitriding process, the surface is enriched not with carbon, but with nitrogen. There are two systems in common use, gas nitriding and salt bath nitriding.

Gas nitriding

The gas nitriding process consists of heating the parts at 500°C in a constant circulation of ammonia gas for up to 100 hours.

During the gas nitriding process, the parts are in an externally heated gas-tight box, fitted with inlet and outlet bores for the ammonia gas which supplies the nitrogen. At the completion of the 'soaking' the ammonia is still circulated until the temperature of the steel has fallen to about 150°C, when the box is opened, and the cooling completed in air. Nitriding causes a film to be produced on the surface but this can be removed by a light buffing.

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 pre-heated (about 400°C) before being put in the salt bath

(about 520-570°C). A layer 0.01 to 0.02 mm thick is formed on the surface which consists of a carbon and nitrogen compound. The duration of nitriding depends on the cross-section of the workpiece (half an hour to three hours). (It is much shorter than gas nitriding.) After being taken out of the bath, the workpieces are quenched and washed in water and dried.

Advantages

The parts can be final-machined before nitriding because no quenching is done after nitriding, and, therefore, they will not suffer from quenching distortion.

In this process, the parts are not heated above the critical temperature, and, hence warping or distortion does not occur.

The hardness and wear-resistance are exceptional. There is a slight improvement in corrosion-resistance as well.

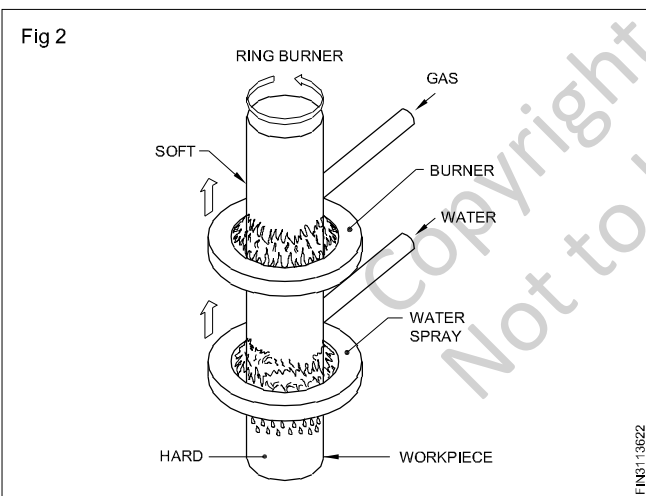
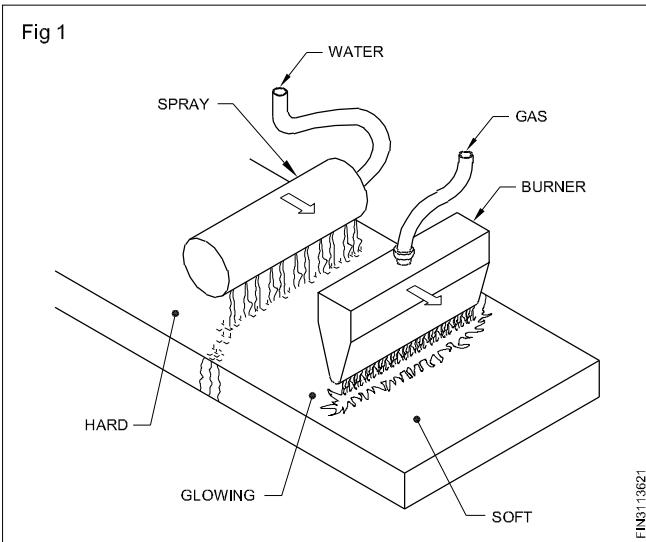
Since the alloy steels used are inherently strong when properly heat-treated, remarkable combinations of strength and wear-resistance are obtained.

Flame Hardening

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

- state the process of surface hardening using a flame
- state the advantages and disadvantages of flame.

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



The workpiece is maintained at the hardening temperature for a very short period only, so that the heat is not conducted more than necessary into the workpiece.

Steels used for surface-hardening will have a carbon content of 0.35% to 0.7%.

The following are the advantages of this type of hardening.

- The hardening devices are brought to the workpiece.
- It is advantageous for large workpieces.
- Short hardening time.
- Great depth of hardening.
- Small distortion.
- Low fuel consumption.

The following are the disadvantages.

- Not suitable for small workpieces because of the danger of hardening through.
- The workpieces must be stress-relieved before hardening.

Induction hardening

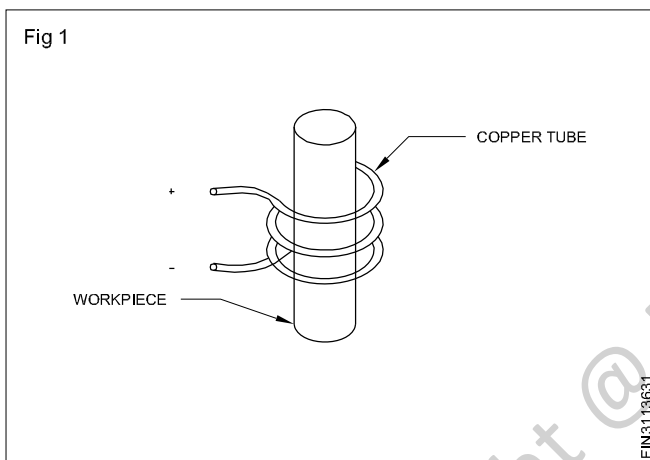
Objectives : At the end of this lesson you shall be able to

- **state the process of the induction hardening method**
- **state the advantage of the induction hardening process.**

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.

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 scale.
- This type of hardening can easily be incorporated in mass production.



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Tapers on keys and cotters

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

- define taper
- state the uses of tapers
- distinguish between features of self-holding and self-releasing tapers
- state the features of pin tapers & keyway tapers
- state why taper is provided on key and cotters.

Taper

Taper is a gradually narrowing (or) increasing from one end to other end of the object either in thickness (or) cylindrical.

Tapers on key

When key is drive through the keyways fit, tight due to wedge action. This ensure tightness of joint in operation and prevent lossening of the parts. Due to taper it is lasy to remove the key and dismantle the joint. The normal value of taper of key is 1:100.

Taper on cotter

When cotter is driven through slots, it fit, tight due to wedge action. This ensures tightness of joint in operation and prevent loosening of the parts. Due to taper it is easy to remove the cotter and dismantle the joint. The normal value of taper varies from 1:48 to 1:24.

Taper pins

Taper pins like round keys are used for locking collars on shafts and also between shaft and hub for transmission of motion. Taper is 1:50, small end as ref nominal dia. Its ends are spherical and radius equal to dia. of the pin.

Tapers are used for:

- self-alignment/location of components in an assembly
- assembling and dismantling parts easily
- transmitting drive through assembly.

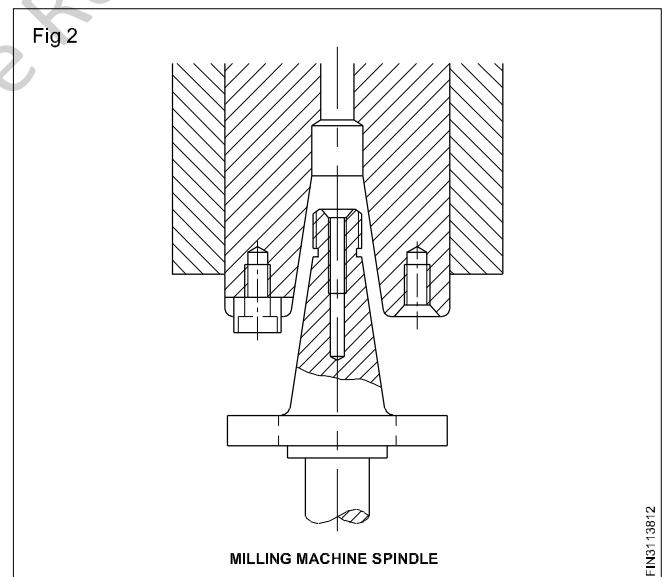
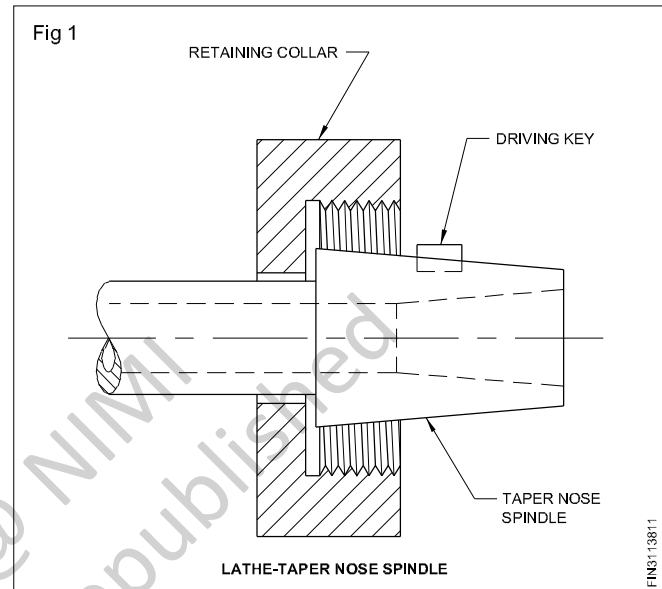
Tapers have a variety of applications in engineering assembly work.(Figs 1,2 & 3)

Tapers of components are expressed in two ways.

- Degree of arc (Fig 4)
- Gradient (Fig 5)

The method adopted for expressing tapers depends on:

- the steepness of the tapers

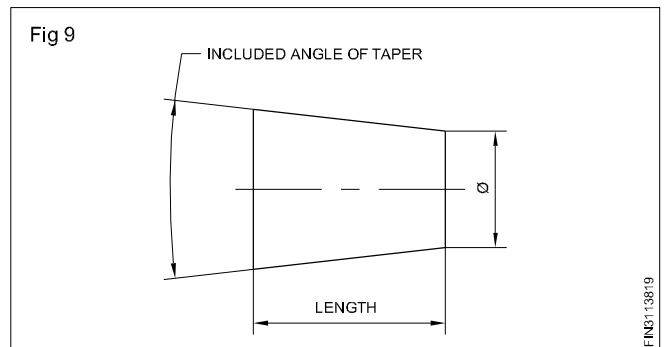
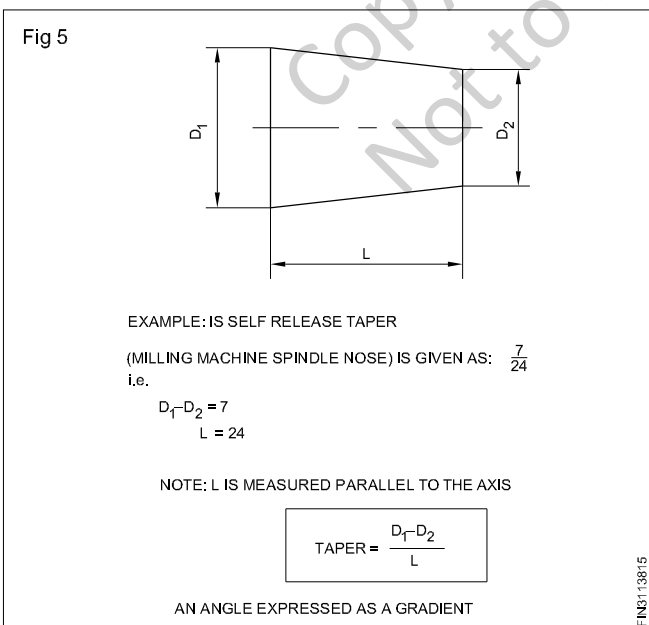
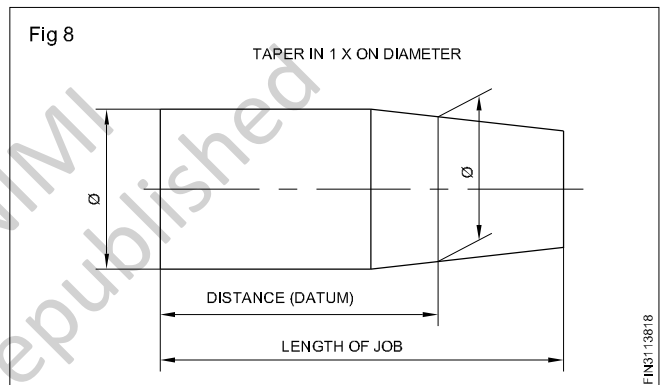
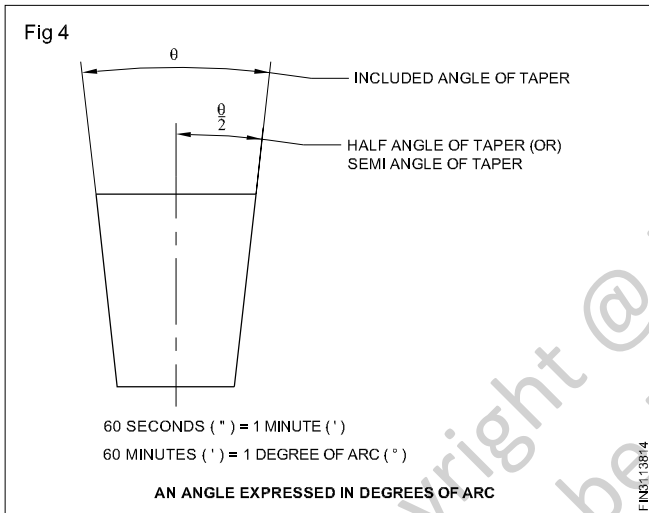
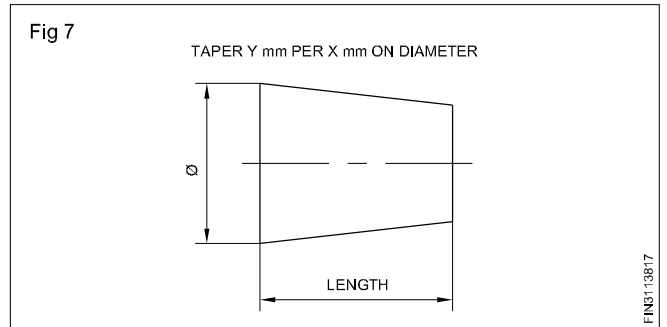
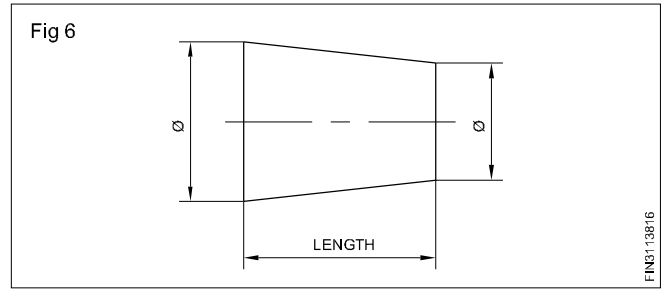
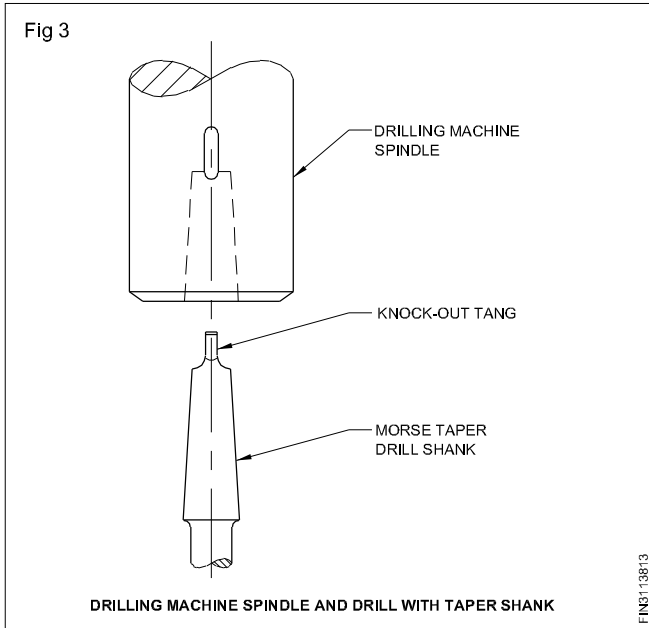


- the method adopted for measuring.

Specification of tapers

While specifying taper in drawings it should indicate the:

- angle of the taper
- size of the component. (Figs 6,7, 8 & 9)



Standard tapers

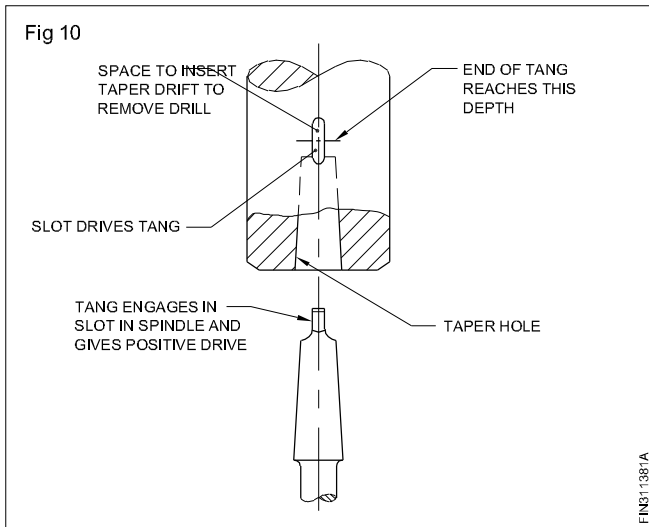
Tapers for tool-holding

Two types of tapers are used for tool-holding on machines.

- Self-holding tapers
- Self-releasing tapers

Self-holding tapers

Self-holding tapers have less taper angle. These are used for holding and driving cutting tools like drills, reamers etc. without any locking device. (Fig 10)



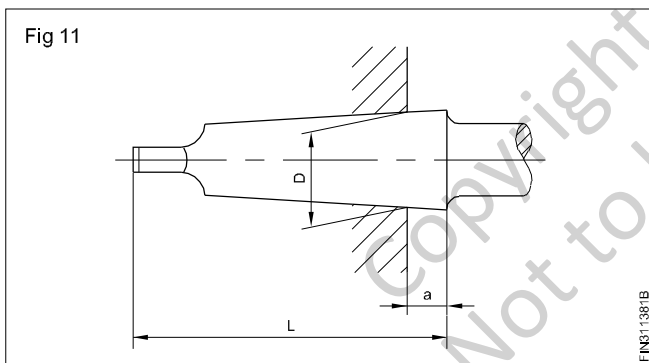
The standard tapers used for this are:

- the metric taper
- the Morse taper.

Metric taper

The taper on diameter is 1:20. The commonly used shank sizes in metric tapers are metric 4, 6, 80, 100, 120, 160 and 200.

The shank size indicating the metric taper is the diameter at D. (Fig 11)



Morse taper

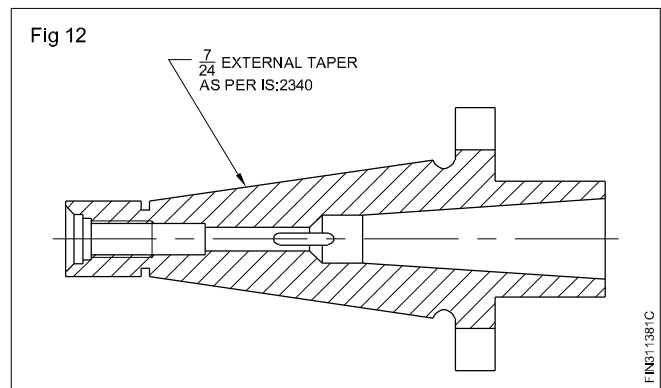
The commonly used taper shank sizes are:

- 0, 1, 2, 3, 4, 5 and 6.

The taper is varying according to the size of the Morse taper. It varies from 1:19.002 to 1:20.047.

Self-releasing 7/24 taper (Fig 12)

Spindle noses and arbors used on milling machines are usually provided with self-releasing tapers. The standard self-releasing taper is 7/24. This is a steep taper which helps in the correct location and release of the components in the assembly. This taper does not drive the mating component in the assembly. For the purpose of driving, additional features are provided.



The commonly used 7/24 taper sizes are: 30,40,45,50 and 60.

The taper of a 7/24 taper of No.30 will have a maximum diameter of (D) 31.75 mm and No.60, 107.950 mm. All other sizes fall within this range.

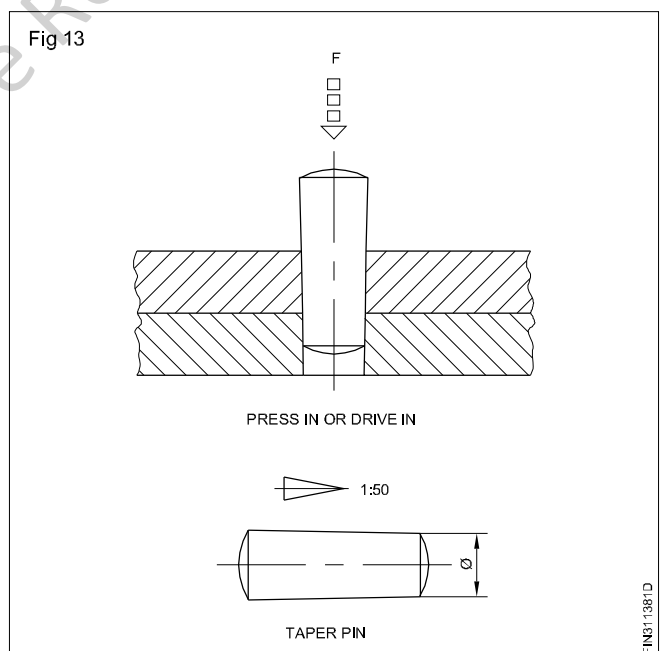
Tapers used in other assembly work

A variety of tapers are used in engineering assembly work. The most common ones are:

- pin taper
- key and keyway taper.

Pin taper

This is the taper used for taper pins used in assembly.(Fig 13)



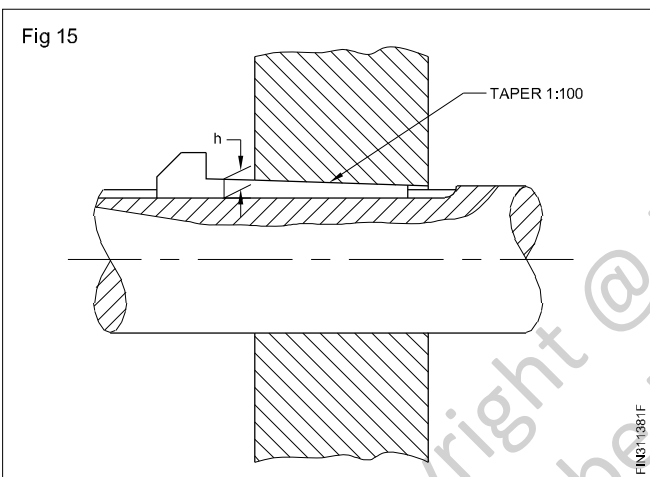
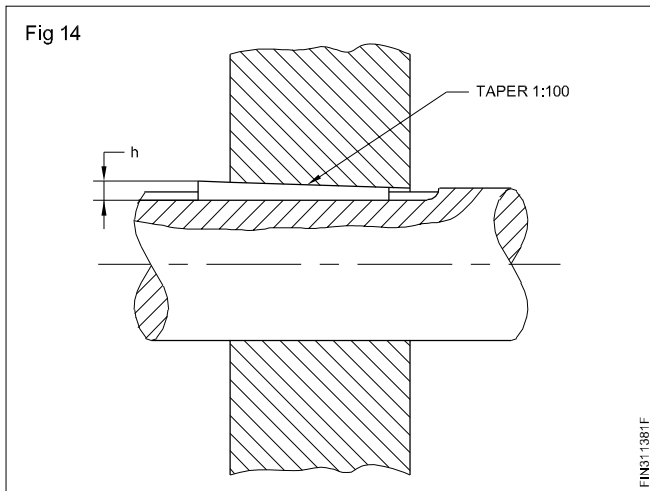
The taper is 1:50.

The diameter of taper pins is specified by the small diameter.

Taper pins help in assembling and dismantling of components without disturbing the location.

Key and keyway tapers

This taper is 1:100. This taper is used on keys and keyways. (Figs 14 and 15)



Note

For further information about the tapers used for special application refer to:

IS: 3458 - 1981.

Taper pins are three types:

Type A - pins ground with a surface finish N6

Type B - pins turned with a surface finish N7

Type C - split pins with a surface finish N7

The nominal dia range from 0.6 to 50 mm and of varying lengths 4 to 200 mm according to dia of pin.

Three types of taper pins

Designation: Taper pin shall be designated by name, type A,B or C, nominal dia, nominal length and BIS number.

Taper pin A 16 x 90 IS:6688

Taper pin B 20 x 60 IS:6688

Split taper pin C 5 x 40 IS:6688

General proportion: normal dia of pin = 1/6 (dia of shaft).

Cotter/cotter joint : Cotter is a rectangular wedge with taper on one side of the width, thickness being same. It is used to connect shafts, with reciprocating motion only. The ends of the shafts to be joined are formed into socket and spigot. A rectangular slot at right angle to the axis is made with taper on one side to suit the cotter. The socket and spigot are aligned and the cotter is driven in locking them together.

Two cotters are used to join shafts with a sleeve. The enlarged shaft ends with slots are placed facing each other in a sleeve with slots. On driving the cotters, with a bearing surface on the sleeve, the tapered or slope surface of the cotters pull the shafts closer. The clearance on the sleeve and shafts allow the variation of cotters width to certain extent.

Cotter joint: Is also used to connect square or rectangular members. A strap joint with a gib and cotter. One end of the member is made as fork end which takes the end of the other member to prevent the fork end getting bend while driving the cotter a gib is placed. The bending effect on the fork end and how the gibs are made use of. Single gib is used for cotter with slope on one side. Two gibs are used if the cotter has slope on both sides.

Use of pin in connecting shafts: Similar to the cotter, cylindrical pin is also used in connecting shafts. One end of the shaft is made as Fork (fork end) with holes and the end of the other shaft is formed as eye end. The eye end fits into the fork end, holes being in one line. A collared cylindrical pin with a small hole is inserted into the eye and fork. The pin is held in position using a collar and a small taper pin or split pin.

Various coatings for protection by heat & electrical deposits

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

- **state the need for prevention of corrosion**
 - **name the different methods of metallic coatings used for preventing corrosion**
 - **state the different cementation processes**
 - **state the application of different metallic protective coatings**
 - **state the treatments to provide pleasing finish.**
-

Most of the common non-ferrous metals and alloys form their own protective coating when exposed to the atmosphere. Corrosion prevention is largely relevant to iron and steel. For maximum life, accuracy and utility of a component, it is very essential that corrosion is controlled or prevented.

One method of corrosion-proofing is to protect the metallic material from the corroding influences by means of protective coats or deposits which prevent or limit corrosion to acceptable levels.

Protective treatment of metal surface

The type of protective treatment used depends upon:

- the material from which the component is made
- the purpose for which it is used
- the environment in which it is to operate.

Non-metallic coatings

Oil or grease is applied when parts must remain bright (vernier caliper). Grease and oil must be acid free; otherwise the parts will be corroded.

Metallic coatings

Molten metal bath

This is the coating of mild steel with zinc. There are two alternative processes, namely hot dip galvanising, in which the cleaned and fluxed work is dipped into a bath of molten zinc, and electrolytic galvanising where the zinc is deposited electrolytically on the sheet metal base.

Cladding

In this process a composite billet is made up of the base metal and the coating is done by rolling or drawing the layers of metal on to base metal. (eg. coins) More expensive metals can be saved in this way.

Spraying or coating with paint

Painting is widely used for the protection and decoration of metallic components and structures. Red lead forms an effective protective coat when used as a primer. High quality of paints (oil-bound paints or lacquers) are used according to the purpose.

Enamelling

This is carried out by spraying or sprinkling enamel powder on the surface and baking at a suitable temperature (80 to 100C). The coating is heat-resistant and resistant to chemicals as well. The enamel consists of glass powder, a mixture of quartz, felspar, alumina and

Plastic coatings

These are done for functional as well as for anti-corrosive and decorative purposes. These coatings are applied by immersion in molten plastic or by varnishing. The common oil paints are being replaced by synthetic resin paints, cellulose paints and chlorinated rubber paints.

Spraying

Metal spraying is used for a variety of purposes. The process consists of spraying molten or heated particles of metal on a prepared surface with compressed air, Eg. surfaces of shafts is done by depositing wear-resistant alloy steel or plain carbon steels.

Gauges

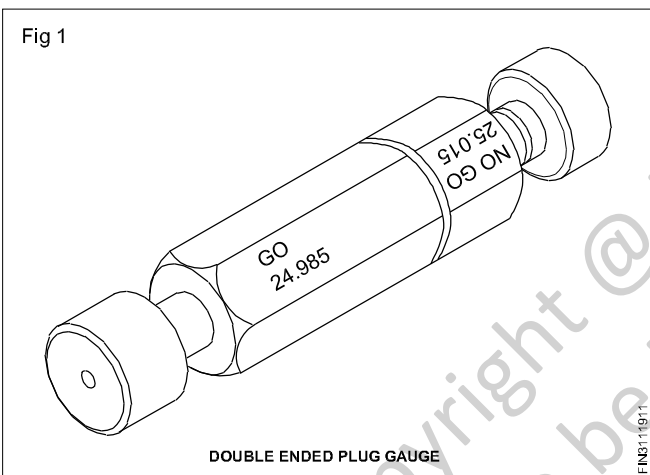
Objectives : At the end of this lesson you shall be able to

- state the features of Go and No - Go gauges
- list the types of gauges used in production
- explain about the selective and non - selective assembly
- state the hole basis and shaft basis system.

Features of Go and No- Go gauges

Components manufactured using mass production methods are checked only to ensure that the sizes are within the prescribed limits. The most economical method of checking such components is by using limit gauges. These gauges are used in inspection because they provide a quick means of checking.

Go and No - Go principle (Fig 1)



The Go and No -Go principle of gauging is that the Go -end of the gauge must go into the feature of the component being checked and the No - Go end must not go into the same feature. The dimensions of the Go and No - Go ends of gauges are determined from the limits stated on the dimension of the component to be gauged. The dimension of the Go -end is equal to the minimum permissible dimension and that of the No -Go end is equal to the maximum permissible dimension.

Essential Features

These gauges are easy to handle and are accurately finished. They are generally finished to one tenth of the tolerance they are designed to control. For example, if the tolerance to be maintained is at 0.02mm, then the gauge must be finished to within 0.002mm, of the required size.

These must be resistant to wear, corrosion and expansion due to temperature. The plugs of the gauges are ground and lapped.

The Go -end is made longer than the 'No -Go' end for easy identification. Sometimes a groove is cut on the handle near the 'No -Go' end to distinguish it from the 'Go' end.

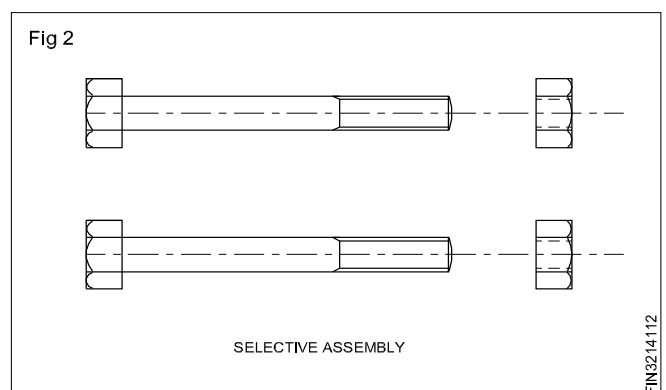
The dimension of these gauges are usually stamped on them.

Types of gauges used in production

- 1 Limit gauge
- 2 Radius gauge
- 3 Centre gauge
- 4 Drill gauge
- 5 Drill grinding gauge
- 6 Feeder gauge
- 7 Screw pitch gauge
- 8 Angle gauge
- 9 Wire gauge.

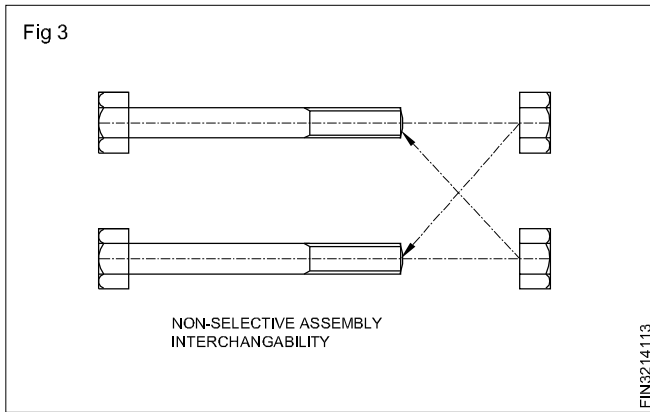
Selective assembly

The figure illustrates the difference between a selective assembly and a non-selective assembly. It will be seen in (Fig 2) that each nut fits only one bolt. Such an assembly is slow and costly, and maintenance is difficult because spares must be individually manufactured.



Non - selective assembly

Any nut fits bolts 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 3)



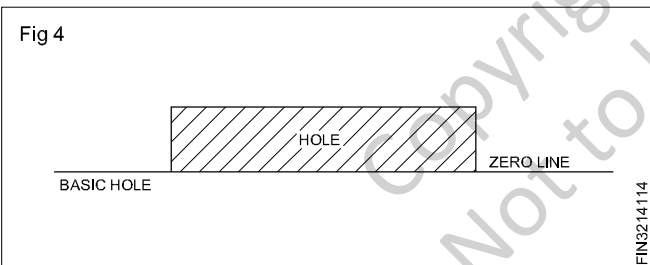
Non - selective assembly provides interchangeability between the components.

In modern engineering production, i.e. mass production, there is no room for selective assembly. However, under some special circumstances, selective assembly is still justified.

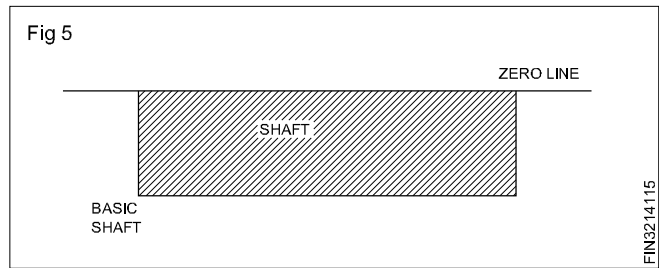
Hole basis system

In a standard system of limits and fits, where the size of the hole is kept constant and the size of the shaft is varied to get the different class of fits, then it is known as the hole basis system.

The fundamental deviation symbol 'H' is chosen for the holes, when the hole basis system is followed. This is because the lower deviation of the hole 'H' is zero. It is known as 'basic hole' (Fig 4).



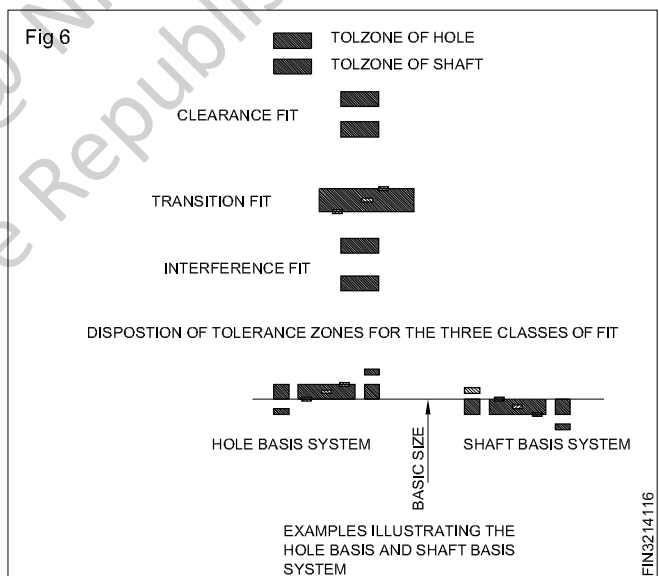
Shaft basis system (Fig 5)



In a standard system of limits and fits, where the size of the shaft is kept constant and the variations are given to the hole for obtaining different class of fits, then it is known as shaft basis. The fundamental deviation symbol 'h' is chosen for the shaft when the shaft basis is followed. This is because the upper deviation of the shaft 'h' is zero. It is known as 'basic shaft'.

The hole basis system is followed mostly. This is because, depending upon the class of fit, it will be always easier to alter the size of the shaft because, it is external but it is difficult to do minor alterations to a hole. Moreover the hole can be produced by using standard toolings.

The three classes of fits, both under hole basis and shaft basis, are illustrated in figure 6.



Bearings

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

- state the purpose of bearings
- state the characteristics of plain bearings
- describe journal bearing & thrust bearing
- describe ball bearing and its types

What are bearings?

Bearings are used in parts having relative motion. The motion may be rotational, reciprocating or a combination of these movements.

Bearings form part of an assembly or mechanism which supports or constrains another part in the assembly.

The need for bearings

A bearing is a part of an assembly, structure or mechanism which supports or acts as a constraint on another part of the assembly. The other part may be stationary but the word 'bearing' is usually used in connection with parts having relative motion which may be rotational, reciprocating or a combination of these movements.

A bearing material should have the following properties.

It should:

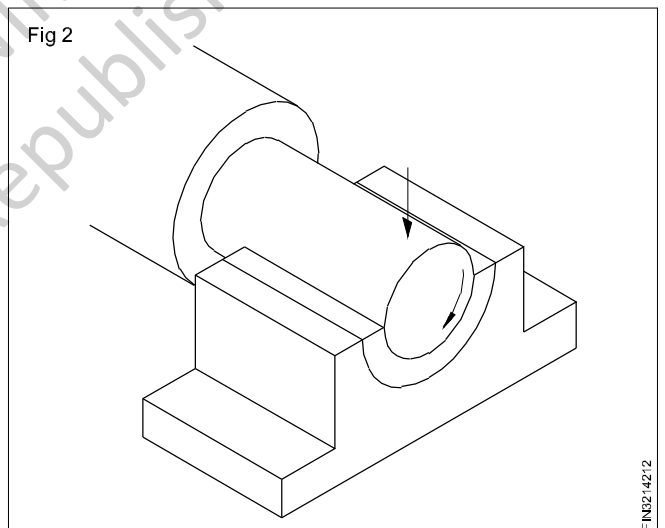
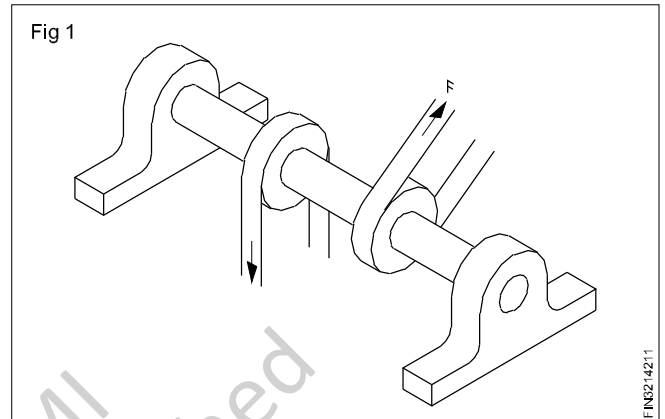
- offer the least possible resistance to motion
- have good wear resistance
- be able to absorb sudden loads
- be able to conduct heat away from the bearing surface
- resist corrosive conditions
- have a melting point lower than that of the shaft it supports, so that it runs before shaft seizure occurs.

These requirements may be met by the selection of suitable bearing materials and arrangements with adequate lubrication, where necessary.

Uses

Bearings are used to:

- support and hold the shaft in a fixed position (Figs 1 and 2)
- allow the shaft to run freely
- restrain moving elements
- minimise the rubbing action.



Bearings are generally grouped as:

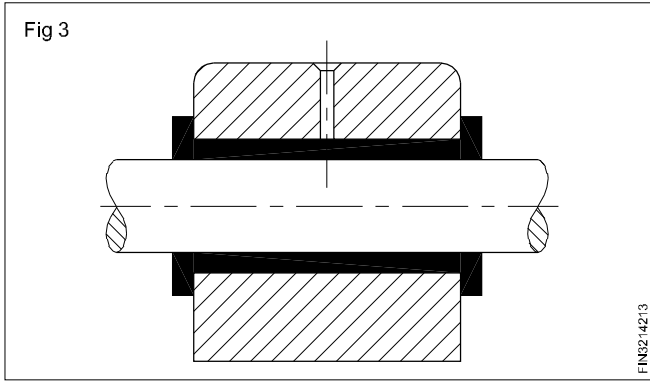
- plain bearings
- anti-friction bearings.

Plain bearings

Depending on the direction of load application they are called radial or journal bearings and thrust bearings.

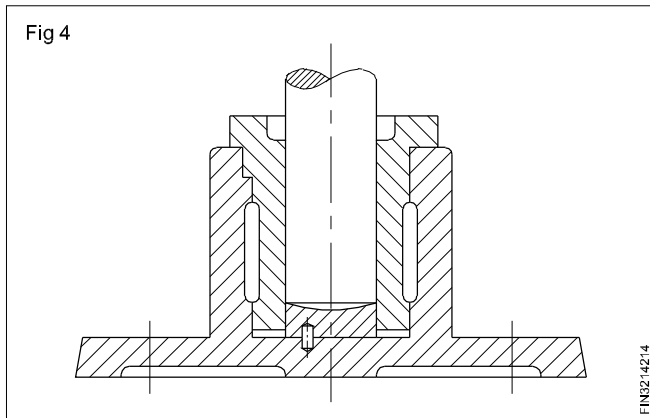
Radial or journal bearing

In this, the loading is at right angles to the bearing axis. (Fig 3)



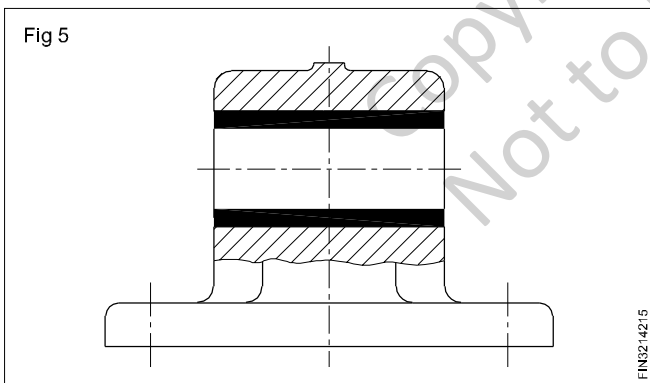
Thrust bearing

In this, the loading is parallel to the bearing axis. (Fig 4)



Characteristics of plain bearings

These bearings have a cylindrical shape (Figs 3 and 5) and are fitted in a housing.

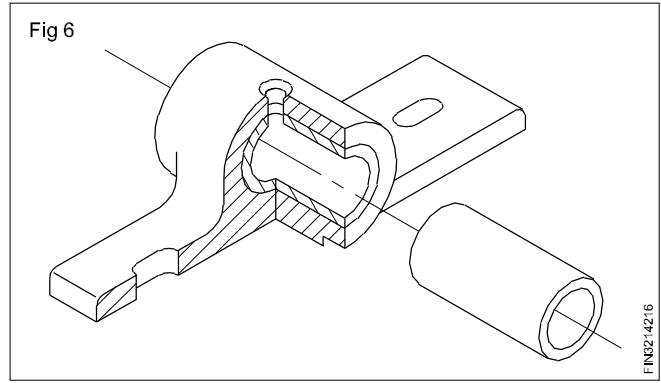


Plain bearings are kept in position without allowing them to rotate along with the shaft. For this purpose they are press fitted in the housing or provided with a key or screws. (Fig 5)

Types of plain bearings

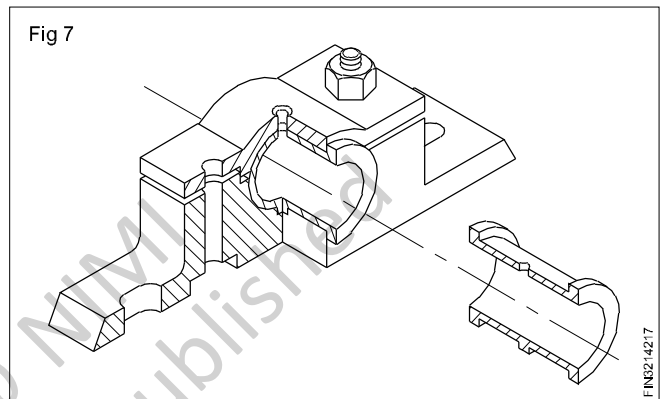
Solid bearings (Fig 6)

These are made of bearing materials in the form of bush and are press fitted in fabricated or cast iron housings.



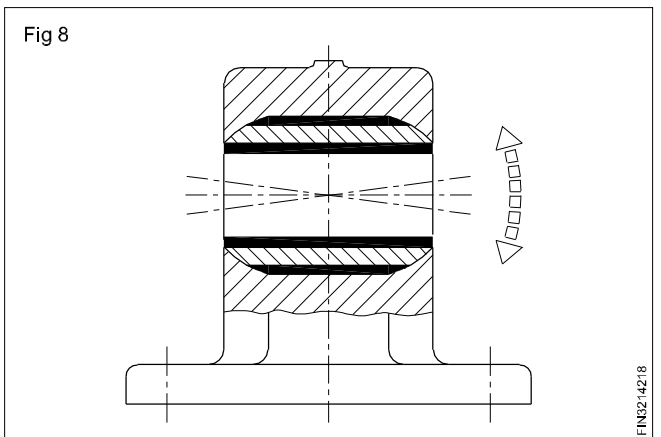
Split bearings (Fig 7)

These bearings are made in halves and assembled in special plumber blocks.



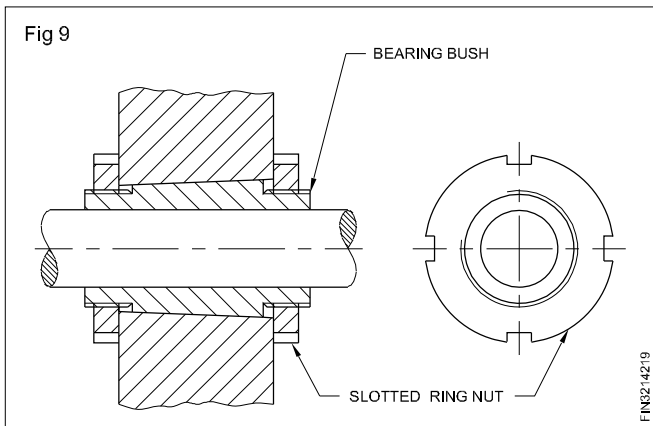
Self-aligning bush bearings (Fig 8)

In this type, the bearing bush is pressed into a special sleeve for self-aligning, in case slight angular misalignment or deflection due to the load between the bearing and the support points occurs.



Adjustable slide bearing (Fig 9)

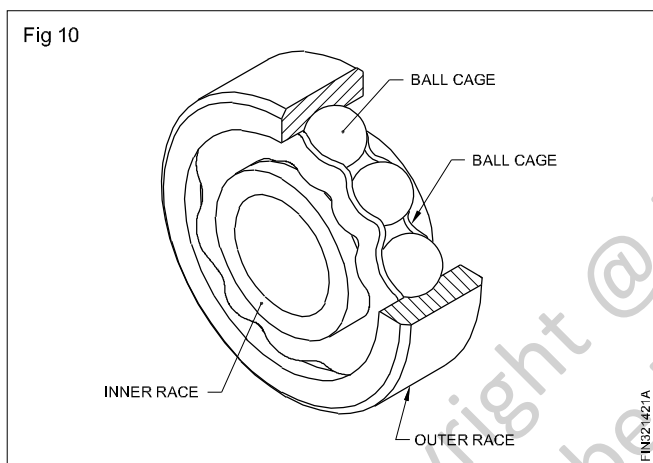
This type of bearing has provision for wear adjustment. The bearing is fitted in the tapered hole of the housing for adjustment of wear. The bearing is drawn inside by means of a nut.



Anti-friction bearing

General features of anti-friction bearings

This bearing consists of rolling elements, races and cage. (Fig 10)



Rolling elements

They are available in different shapes such as balls, parallel rollers, taper rollers, barrels and needles. They are made of chromium (or) chrome-nickel steel with a ground or polished surface. The load of the rotating member is carried by the rolling elements.

Races

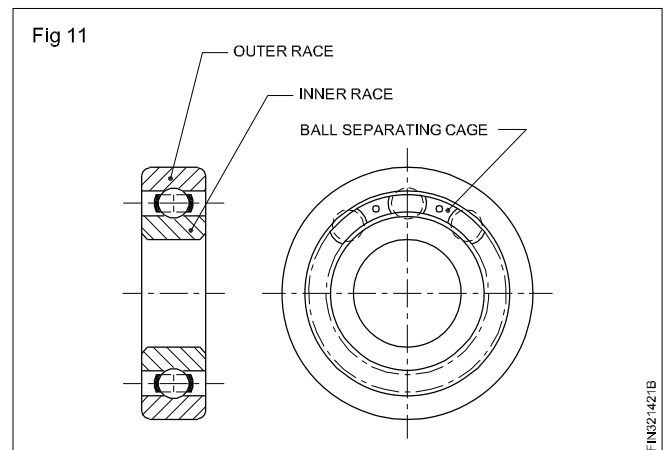
The inner and outer races are provided with grooves or race-ways which guide the rolling elements. They are made of high grade chromium steel or chrome-nickel steel. They are hardened, ground and polished.

Cage

Each rolling element is separated from the other by means of a 'cage' and it keeps the rolling elements from bunching up. The rolling elements and the cage are retained between the inner and outer races. The rolling elements are retained in the cages to ensure proper fits and equal spacing between the rolling elements. They are made out of brass, steel or plastics.

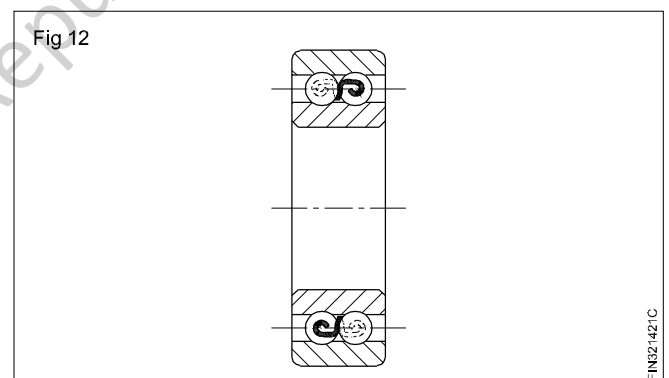
Ball-bearings

Ball-bearings are the most widely used of all the bearings. (Fig 11)



For any given bore diameter, there are usually two or three sizes of outside diameter width, and the load-carrying capacity. The width of these bearings is smaller than the bore diameter. The width (or length) to diameter ratio is much smaller than that of plain bearings. Although principally they are to carry journal loads, the deep groove type of ball races are capable of withstanding the axial thrust.

Self-aligning ball-bearings (Fig 12)



This type of bearings has a spherical bore on the outer race. This bearing can carry journal loads which are slightly inclined due to shaft misalignment.

Ball bearing types

The three most commonly used types of ball bearings are the radial bearing, the angular contact bearing, and the double row ball bearing. The radial ball bearing is designed to accommodate primarily radial loads but the deep groove type will support bidirectional thrust loads up to 35% of the radial load before bearing life becomes progressively shorter. The assembled radial bearing is inseparable and may be equipped with seals, shields, and/or snap rings

Single row ball bearing

Angular contact ball bearings are single row bearings designed so that the line of contact between the balls and inner and outer ring pathways is at an angle to a line 90° to the bearing axis of rotation. The angle between the two lines is called the contact angle. In angular contact ball bearing design, one of the pathway shoulders is removed to allow assembly of a maximum complement of balls for increased load carrying capacity. Angular contact ball bearing support both radial and high one-direction thrust loads.

Double row ball bearing (Fig 13)

This has two angular contact ball bearings mounted back-to-back. This type of mounting has good axial and radial rigidity and provide resistance to overturning moments and angular deflection of the shaft.

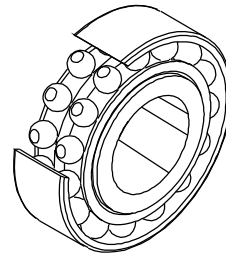
The two angular contact ball bearings mounted face-to-face. This type of mounting has the same axial and radial rigidity as back-to-back mounting but less resistance to overturning moments and more compliance to misalignment or bending of the shaft.

The depicts two angular contact ball bearings mounted in tandem (face-to-face). This mounting arrangement provides resistance to high one-direction thrust loading. The total thrust capacity of the pair is 1.62 times the thrust capacity of one bearing. For even higher thrust loading, three or more angular contact bearings can be mounted in tandem.

Advantages of double row ball bearings

- 1 Double row ball bearings support heavy radial loads, thrust loads from either direction, or combined radial and thrust loads. They are normally used in positions where radial loads exceed the capacity of a single row bearing with a comparable bore and OD.
- 2 Double row bearings are designed with the bore and outside diameter the same as single row bearing but are narrower than two single row bearing.

Fig 13



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- 3 Double row ball bearing may offer some economic benefits as well as handling and maintaining benefits versus single row ball bearings.

Double row angular contact ball bearings

Double row angular contact ball bearings have two rows of balls arranged back-to-back. The lines of action of the load at the contact between balls and raceways (load lines) diverge at the bearings axis and form an angle of 30° to the radial plane. In essence, they work similarly to having a matched pair of single row angular contact ball bearings either face-to-face or back-to-back. The difference is that double row angular contact ball bearing can take a bi-directional axial load in one bearing where it takes a matched pair otherwise. This means the bearings are particularly suitable for accommodating simultaneously acting radial load and axial load in both directions. They are also available with seals or shields.

Double row angular contact ball bearings are available in two numerical series:

- 5200 series - Light load, higher speed, more/smaller balls per bore diameter
- 5300 series - Heavier load, slower speed, fewer/larger balls per bore diameter.

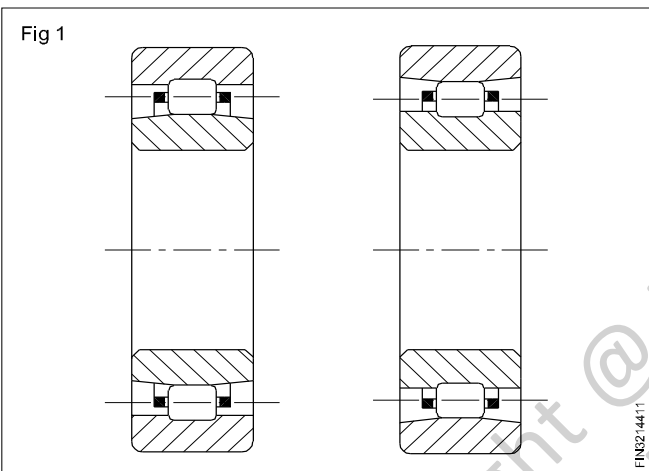
Roller & needle bearings

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

- describe roller & needle bearing
- state types of roller bearing
- state the method of fitting bearings.

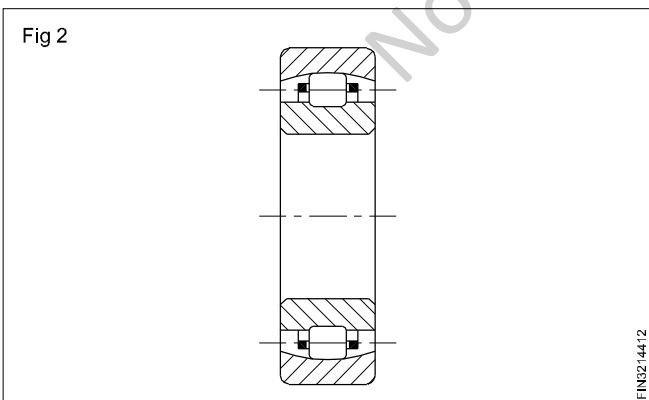
Roller bearings (Fig 1)

Roller bearings are available with the grooved race in the outer and inner members. Selection of this depends upon which race is required to be locked. Roller bearings are intended to carry radial journal loads and can carry greater radial loads than ball-bearings of the same size.



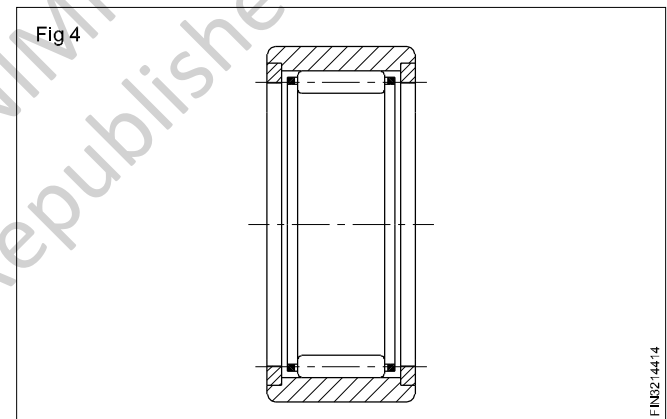
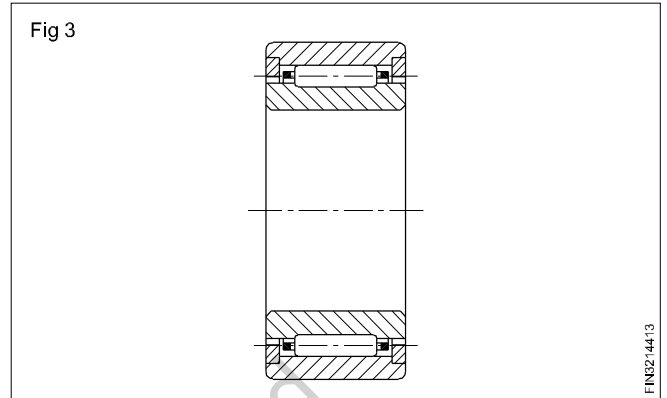
Self aligning roller bearings (Fig 2)

Self aligning roller bearings have barrel-shaped rollers and spherical bores in the outer race. For very heavy radial loads double row roller bearings are also available.



Needle bearings

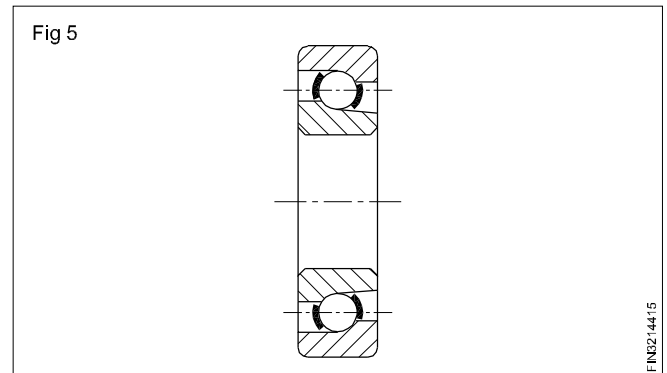
Rollers of very small diameter, called needle rollers, are shown in (Fig 3). This type of bearing is used where the outside diameter of the bearing is severely restricted because of the limited bearing space in the housing. Fig 4 shows the needles fitted in a circular cage which is push-fit in its housing.



In this design the needles are in contact with the shaft journal.

Angular contact ball-bearing

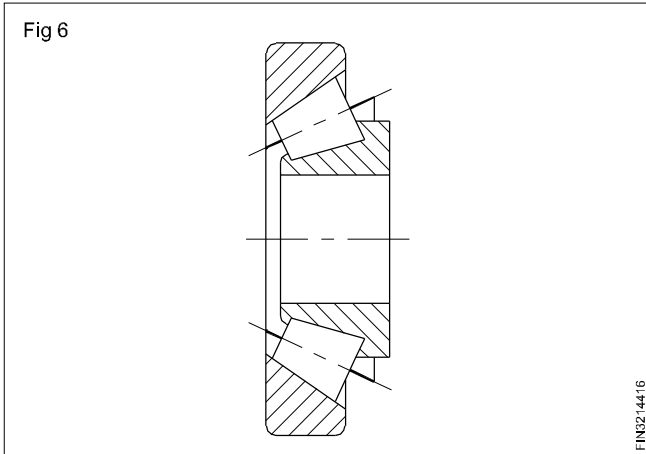
These bearings are designed to take an axial thrust as well as radial loads. (Fig 5) shows an angular contact ball-bearing (single row).



Tapered roller bearings (Fig 6)

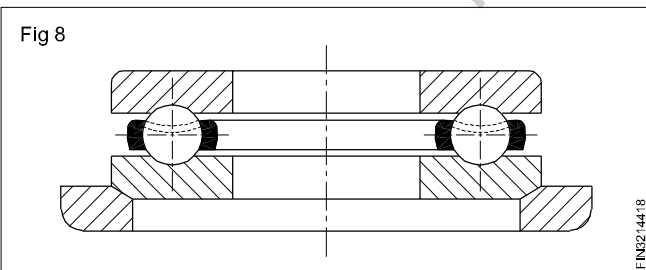
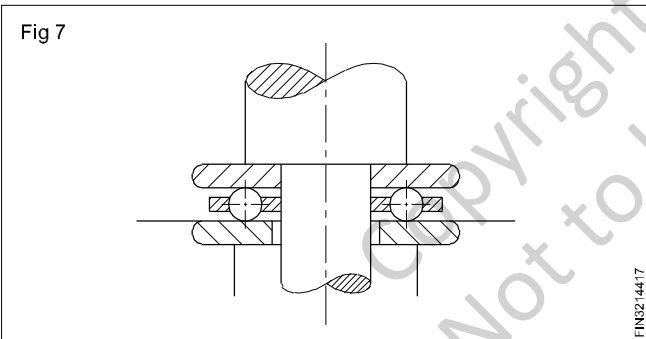
These are used for taking high axial thrust loads. Tapered roller bearings with slow tapered cones are used where the axial thrust is more than the radial load.

These bearings are made to take thrust from one direction only. Where there is opposing thrust then the bearings must be mounted as pairs in opposition.



Thrust ball-bearing

These bearings are useful for taking vertical thrust load (Fig 7) but cannot take any radial load. Special thrust bearings (Fig 8) are available which can also take horizontal end thrusts.



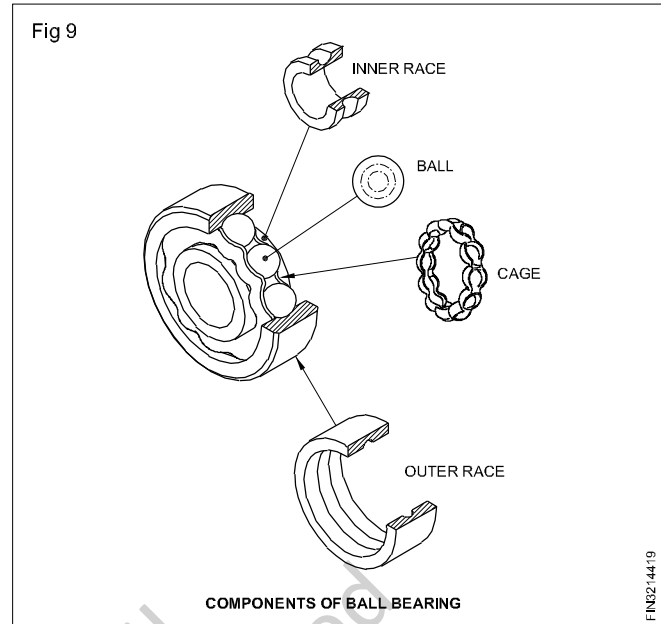
Bearings are the supporting members of a rotating shaft. They provide safe and reliable service when properly applied and maintained.

Rolling contact

Rolling contact bearing is also known as anti-frictional bearing. In this bearing, contracting elements have rolling friction which is much lesser than sliding friction. Bell

bearings have point contact while roller bearings have the contact.

Rolling elements (Fig 9)



A rolling element bearing consists of four basic parts.

- Inner race
- Outer race
- Balls or rollers
- Retainer or cage

The inner race, the outer race and the balls or rollers, support the bearing load. The fourth part, the bearing retainer, serves to position the rolling elements.

Materials

Selection of material and control of material quality are critical in the manufacturing of rolling element bearings.

Bearing steel must possess high strength, toughness, wear resistance, dimensional stability, excellent fatigue resistance and should be free from internal defects.

Importance of proper fit

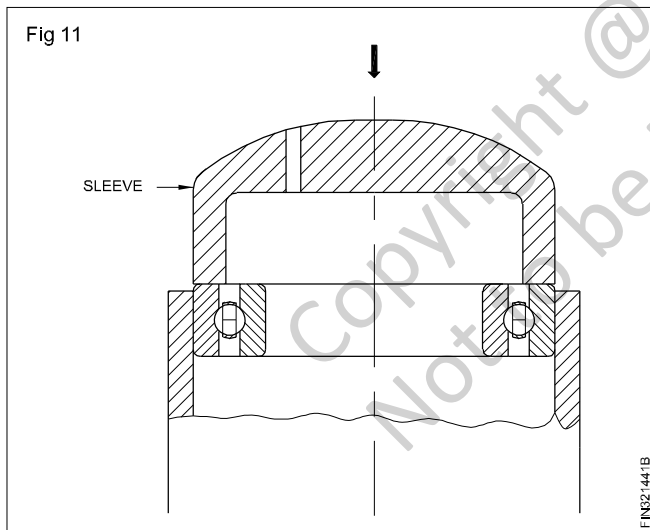
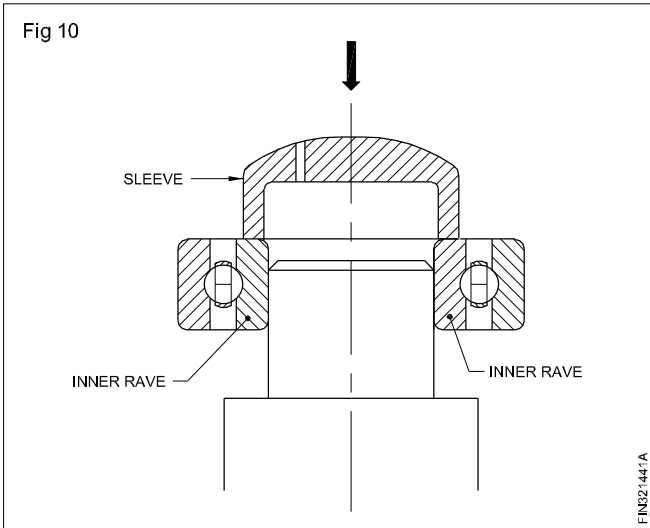
Proper fit in the rolling contact bearing ensures long services life. If the bearing is fitted too tight, the internal radial clearance will be reduced, and thereby, the rolling elements will get jammed. Consequently it will have premature failure. If the bearing is too loose, it will not take the load. So, a proper fit is very much essential.

In general applications, when the journal (spindle) is rotating, the inner face will have an interference fit with the journal and the outer race will have a close push fit. In the case of a stationary spindle, when the outer race is the rotating member, the interference fit will be with the outer race, and the hub and close push fit with the

inner race and spindle. The degree of tightness and looseness depends upon the load, speed, temperature and the type of the bearing.

Bearing mounting

Bearing mounting deserves great care. When the bearing is fitted tight into the spindle, pressure should be applied on to the inner race. (Fig 10) If the bearing is pressed into the housing, pressure must be applied on to the outer race. (Fig 11)

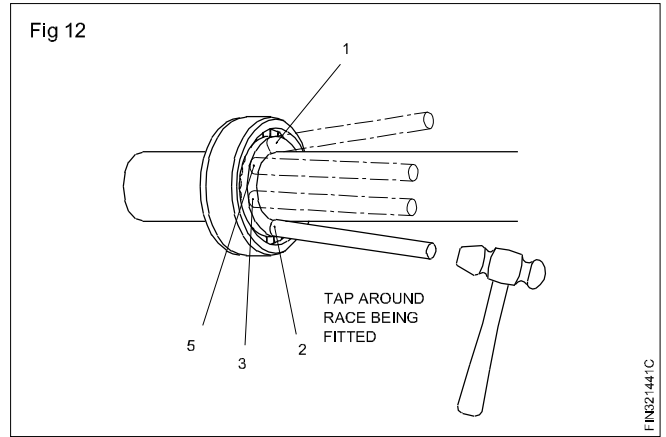


Smear thin lubricating oil on the shaft or housing where the bearing is to be fitted.

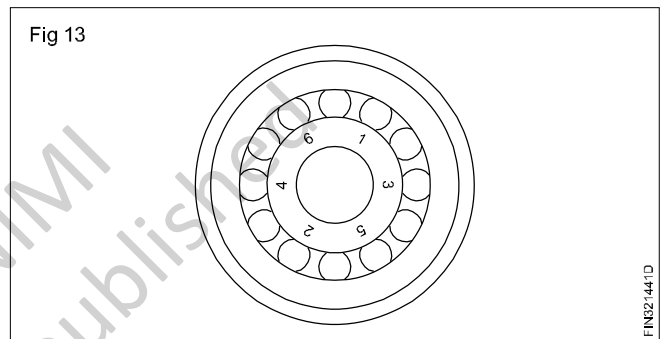
Small bearings can be fitted by using mounting sleeves and hammer (Fig 12) or using a copper drift and hammer.

The mounting sleeve should have its faces parallel and flat.

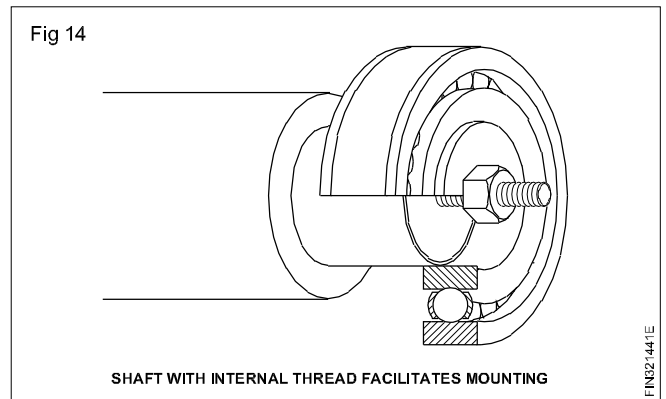
Check frequently that the bearing is driven parallel to the axis of the housing or at right angle to the axis of the shaft.



When a suitable bearing puller is not available, as soft metal drift may be used to drive the bearing into position. While striking the bearing on the inner race, it should be struck progressively on the opposite point of the race as shown in Fig 13.



If a shaft is having internal threads at the centre (Fig 14) or external threads, they can be utilised for mounting the bearings.

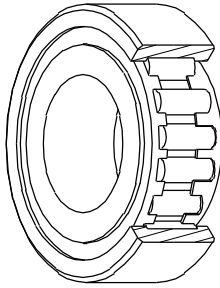


Separable parts of cylindrical roller bearing are more independently. Mount the inner ring first and the outer race with the roller and cage assembly after bit of oiling or greasing. (Fig 15)

When the shaft fit has more interference, one adopt shrinkage fit. For such a fit the inner race should heated up in an oil bath as shown in Fig 16 or by indicate heating process between 90° to 120°C depending the expansion requirement. (Fig 17)

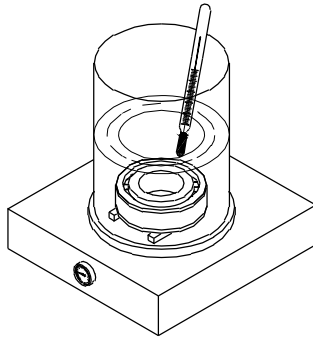
In no case should the rolling contact bearing be heated more than 140°C.

Fig 15



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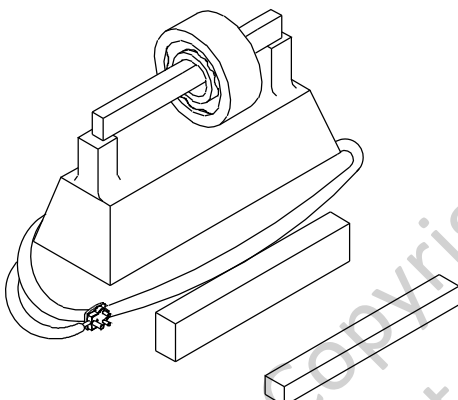
Fig 16



OIL HEATING OF BEARING

FIN321441G

Fig 17

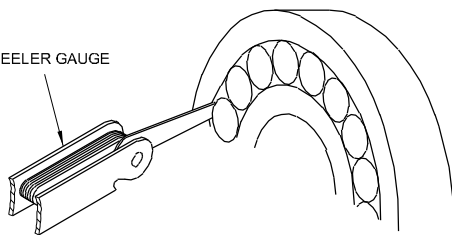


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Check the internal clearance of the bearing (Fig 18) after the bearing attains room temperature. When the bearing is having more interference in the housing, the bearing should be cooled in a freezing chamber (-5 to -20°C) and pushed inside the housing easily.

Fig 18

FEELER GAUGE



FIN321441I

The inner ring of bearings with the tapered bore is always mounted with an interference fit, usually on a taper adaptor sleeve or a withdrawal sleeve. When the bearing

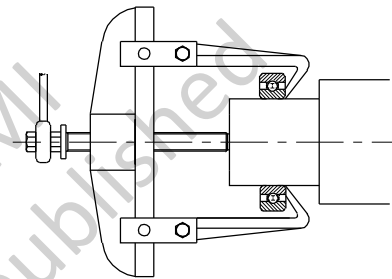
driven up the original radial, the internal clearance is reduced. The reduction in clearance required can be referred to in the table provided by the bearing manufacturer. The clearance is measured as shown in Fig 18.

Bearing dismounting

Dismounting of bearing should be done with proper care using proper tools. If proper tools are not used and right techniques are not adopted, the bearing is likely to be damaged and may lead to premature failure.

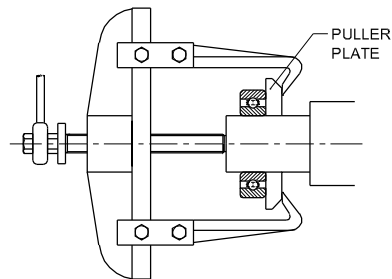
While using a puller, the pulling legs of the puller should be placed with the inner race. (Fig 19) In certain cases, we use a puller plate (Fig 20) to facilitate the placing of the pulling legs in position so that force is applied on the inner race. Special puller plates (Fig 21) are used along with a two-legged puller so that the pull is applied on the inner race alone.

Fig 19



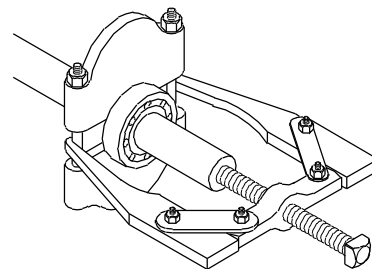
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Fig 20



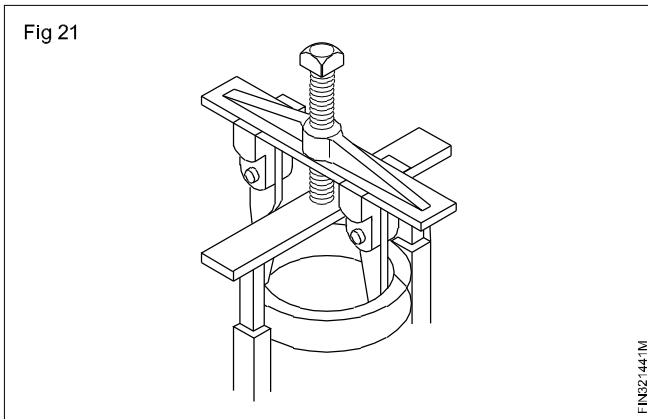
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Fig 21

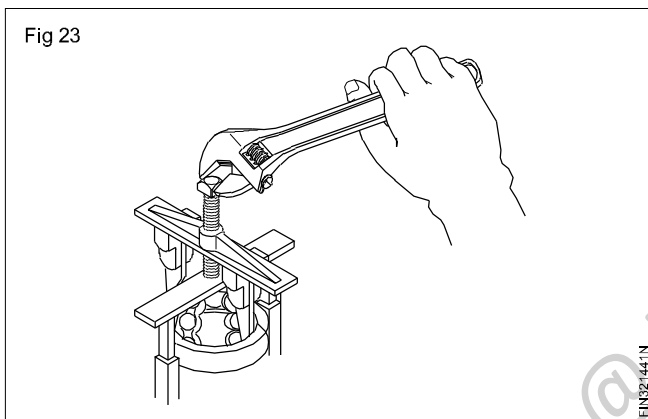


FIN321441L

For detachable inner ring type bearing, the puller legs can be placed with the outer ring as shown in Fig 22 for dismounting the bearing when the outer ring is having an interference fit in the housing.



A self aligning ball-bearing can be swivelled as shown in Fig 23 fixing the bearing puller to facilitate the dismantling process.



Care and maintenance

- A good bearing should not be dismantled unless otherwise it is absolutely necessary.
- Bearings should be handled in a dirt/dust free environment. Bearing housing on the shaft should be free from burns or scratches.
- Proper mounting and dismantling tools, and correct techniques should be adopted. Provide proper support for the bearing and shaft during disassembly.
- Direct blows should be not given to the bearing.
- Bearing should not be heated with a naked flame. Before heating ensure that any grease or lubricant does not start a fire.
- Use only the recommended grade and quantity of lubricant for the lubrication of bearing.

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Bearing materials

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

- **state the properties of plain bearing materials**
 - **name the different materials commonly used for making plain bearings**
 - **state the characteristics of different bearing materials.**
-

The materials used for plain bearings will have properties according to the operating conditions.

In general the bearing materials should have the following properties.

- Good thermal conductivity to carry away heat from the bearing.
- Resistance to corrosion from atmosphere or lubricants.
- Strength to carry the loading of the shaft or sliding member without permanent deformation.
- Ability to operate in the required temperature range.
- Ability for dirt and other foreign matters to embed on the surface and thus prevent seizing of the shaft or sliding member.
- Ability to resist wear.
- Ability to deform slightly for compensating minor mis-alignments and surface irregularities.

Bearing materials (Plain bearings)

White metal

White metals of different composition are used for a various applications.

White metals are either tin or lead-based. Tin-based white metals are often referred to as babbitt metals.

White metal bearing alloys also contain small amounts of copper and antimony in varying proportions.

White metal bearings have low load carrying capacity, when compared with other bearing materials. The strength of this metal decreases considerably with increasing temperature. To overcome these defects, a layer of high strength fatigue-resistant material is introduced between the thin white metal layer and a steel backing.

Cadmium based alloy

These alloys have greater resistance to fatigue than white metal bearings, but have poor resistance to corrosion. These alloys usually contain small amounts of nickel, copper and silver.

Bearings made out of these alloys can work at higher temperature and have higher load carrying capacity.

Copper lead alloys

This contains copper and lead. This has a higher load carrying capacity than cadmium based alloys and the operating temperature is higher than for white metal bearings. This alloy is used in heavy duty applications like main and connecting rod bearings and in moderate load and speed applications in turbine and electric motors.

Lead bronze and tin bronze

Lead bronze will contain approximately up to 25% lead and the tin bronze up to 10%. They can be used as single material without any overlay or steel backing.

These bearings find application for intermediate load and speed requirements.

Aluminium alloys

Aluminium, alloyed with small quantities of tin, silicon, cadmium, nickel or copper is also used as bearing metal. Aluminium alloy containing about 20 to 30% of tin and up to 3% of copper is capable of substituting bronze bearings for certain industrial applications.

It is best suited for hard journals. It is necessary to give extra clearance between the bearing and the journal to overcome the effects of high thermal expansion.

Aluminium alloys for bearings are available with special properties needed for higher load carrying, strength and thermal conductivity.

Cast iron

Cast iron is used as bearing metal for light loading and low speed applications.

Sintered alloys

Bearing metals such as plain or lead bronze, iron, stainless steel are also made by the sintering process providing porosity in the metal. The structure of the bearings made by the sintering process is spongy, and can absorb and hold considerable quantity of oil. These bearings in actual use will be of a self-lubricating type. These bearings are used in situations where lubrication is difficult.

Plastics

Plastics of different types are used as bearings because of the following reasons.

- Good resistance to corrosion.
- Silent operation.
- Ability to be moulded in different shapes easily
- Elimination of the need for lubrication.

The most commonly used types of plastic materials are

- laminated phenolics
- nylon
- teflon.

Laminated phenolics

This consists of cotton fabric, asbestos, or other materials bounded with phenolic resin. This material has high strength and shock-resisting properties. The thermal conductivity of this material is low. There should be adequate facilities for cooling the bearings made out of these materials.

Nylon

This is widely used for light loading applications. Nylon bearing needs no lubrication as it has self-lubricating properties.

Teflon

This material has self-lubricating properties, resistance to attack of chemicals, a low co-efficient of friction, and can withstand a wide temperature range. The cost of this material is high and the load-carrying capacity is low.

With the movement of two mating parts of the machine, heat is generated. If it is not controlled the temperature may rise resulting in total damage of the mating parts. Therefore a film of cooling medium with high viscosity is applied between the mating parts which is known as a 'lubricant'.

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

Prevention of corrosion

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

- **state the importance of keeping the work free from rust and corrosion**
- **state the need for prevention of corrosion**
- **name the different methods of metallic coatings used for preventing corrosion**
- **state the different cementation processes**
- **state the application of different metallic protective coatings**
- **state the treatments to provide pleasing finish.**

The importance of keeping the work free from rust and corrosion

Rusting is in the simplest form, the slow eating away of iron and its alloys. Rusting is the same as corrosion, but it is used to describe the corrosion of iron and its alloys only. Rusting is a chemical process in which ferrous reacts with oxygen in the presence of moisture or water, to produce ferric oxides and hydroxides (which are called rust). Rusting causes slow degradation of iron and its alloys. This results in the weakening of the material and ultimate failure. Since iron and its alloys are very widely used (Some examples are pipe lines for water and waste water flow structures like bridges, railway tracks, ships etc.) any degradation in the metal's quality will directly affect these structures our economy, our health and well-being. And thus the prevention of rusting is necessary. There are a number of ways of doing it, such as galvanization, paints, coating etc.

Most common non-ferrous metals and alloys form their own protective coating when exposed to the atmosphere. Corrosion prevention is largely applied to iron and steel. For maximum life, accuracy and utility of a component, it is very essential that corrosion is controlled or prevented. One method of corrosion proofing is to protect the metallic material from the corroding influence by means of protective coats or deposits which prevent or reduce corrosion to acceptable levels.

Protective treatment of metal surface

The type of protective treatment used depends upon:

- the material from which the component is made
- the purpose for which it is used
- the environment in which it is to operate.

There are more or less permanent methods for preventing corrosion. These methods can be grouped as metallic corrosion-resistant coating and non-metallic corrosion-resistant coating.

Commonly used metallic corrosion-resisting coatings

- Hot dipping (galvanising)
- Electroplating
- Cladding
- Metal spraying
- Cementation

Galvanizing

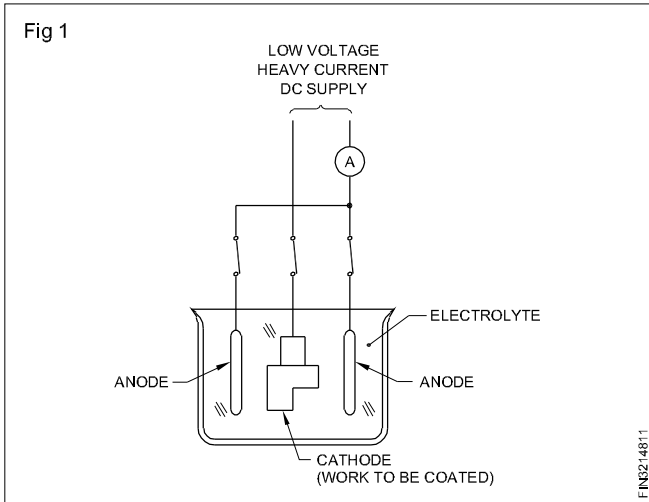
In this process mild steel is coated with zinc. For hot dip galvanizing, the workpieces are initially pickled in hot sulphuric or cold hydrochloric acid to clean the surface, and then fluxed with zinc chloride and ammonium chloride. After this they are dipped in molten zinc. Sometimes a small quantity of aluminium is added which gives a bright appearance and uniform thickness.

The temperature of the zinc bath is usually maintained between 450° and 465°C. The hot-dipped workpieces are then quenched in a water bath. Galvanizing is done for structural work, bolts and nuts, pipes and wires, which are exposed to different atmospheric conditions. This method is highly reliable. It can withstand severe working conditions and the cost is low.

Electroplating

Many metals can be plated on to workpieces electrically, and this process is called electroplating. In electroplating the surfaces of components are coated with another metallic coating for the purpose of obtaining decorative or protective surfaces.

In the electrolytic process the components to be plated are immersed in a solution called the electrolyte. The component to be plated is made as the cathode by connecting the negative pole of a low voltage, high current DC supply. (Fig 1) To complete the circuit, anodes connected to the positive pole of the supply are also immersed in the electrolyte.



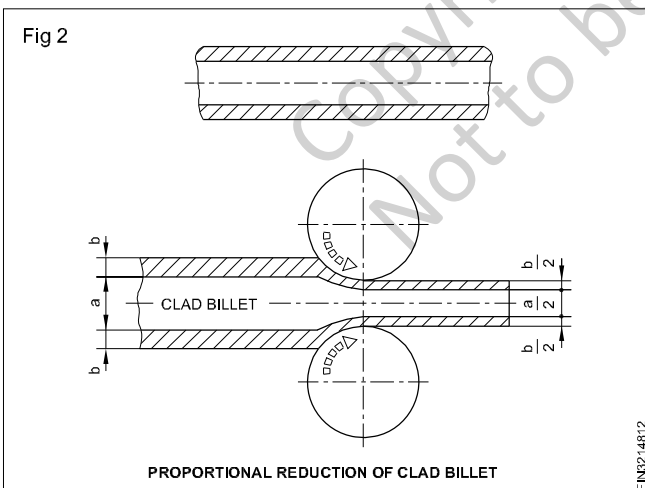
The electrolyte supplies the metal ions which are to be deposited on to the components (cathode). The anodes may be soluble and made of the same metal to be plated on the component surface i.e. nickel, copper or zinc.

Certain anodes are insoluble, for example - chromium. In such cases anodes are useful only to complete the circuit in the electrolytic process.

Metals like copper, chromium, cadmium, nickel, silver etc. are used for electroplating.

Cladding

This is a process in which composite billets consisting of a base metal and a coating of corrosion-resistant metal are rolled or drawn. The thickness of the base metal and the coating reduce proportionally. (Fig 2) An application of this is cladding of steel with aluminium.



Metal spraying

Ferrous metals are sprayed with metal coatings for preventing corrosion, building up worn out shafts, providing wear-resistant surfaces etc. In this process molten particles of metal are sprayed on surfaces which are properly degreased and grit-blasted. Common metals used for metal spraying are - copper, zinc, brass, carbon steel, stainless steel etc.

Cementation

There are three types of cementation process for protecting metal surfaces.

- Sherardising (Zinc coating)
- Calorising (Aluminium coating)
- Chromising (Chromium coating)

Sherardising

In this process the workpieces are initially prepared by acid pickling or grit-blasting. They are then placed in a rotating steel barrel containing zinc powder, and heated to a temperature around 370°C. The time taken for the coating depends on the thickness of the coat. The heated powder bonds to the ferrous workpiece by diffusion and forms a hard even layer of iron/zinc intermetallic compound. The surface of the sherardised components will be slightly rough which provides a good grip for subsequent painting.

Calorising

This process is very similar to sherardising but the powder used is aluminium, and the heating temperature is between 850°C and 1000°C. This is used to protect steel components from corrosion. This process requires a higher temperature and higher humidity than sherardising.

Chromising

This provides a chromium-rich surface. The work to be chromised is baked with aluminium oxide and chromium powder in a temperature of 1300° to 1400°C in an atmosphere of hydrogen to prevent oxidation of chromium. The process is expensive, and due to this reason, it is used only in places where extreme protection is required.

This coating caused by the action of the acids in the atmosphere protects the surface of the copper.

Zinc

A carbonate coating forms on the surface after a period of exposure, and this acts as a protective film that gradually strengthens with time. This coating is grey in colour like the colour of the parent metal itself.

This coating does not crack or peel off due to variation in temperature. For this reason zinc is an excellent exterior building material. It gives excellent protection when coated on steel.

Aluminium

Aluminium and its alloys have a great affinity for oxygen. Aluminium surfaces quickly develop a thin, transparent film of aluminium oxide or 'Alumina' which prevents

further oxidation and retains bright appearance. However exterior use of aluminium results in the thickening of the oxide film. This film becomes grey in colour and protects the parent metal from further attack. The oxide film on aluminium and its alloys can be artificially thickened by a process called anodising.

Lead

Lead is one of the most corrosion-resistant of all metals. A large quantity of lead is used as sheathing material for underground telephones and power cables. The WHITE OXIDE film resulting from exposure to the atmosphere prevents further attack.

Stainless steel

It has high structural strength as well as resistance to corrosion. Stainless steels are not confined to

applications requiring resistance to atmosphere corrosion. They are used extensively for chemical plant and food processing equipment where they combine corrosion resistance at elevated temperatures.

Nickel

Nickel is used extensively for 'NICKEL PLATING' as it has high resistance to chemical attack. When alloyed with copper in the proportion of 2:1 (Nickel two third) 'MONEY METAL' is produced which is extremely resistant to corrosion, particularly to sea water and acid.

Chromium

One of its most important uses is for electroplating metallic surfaces. It is highly resistant to the influence of corrosion and it retains its high polish and colour for a long period.

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Pipes and pipe fittings

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

- state the uses of pipes
- name the common types of pipes
- identify the standard pipe fittings and state their uses.

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

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

The common types of pipes classified according to material are:

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

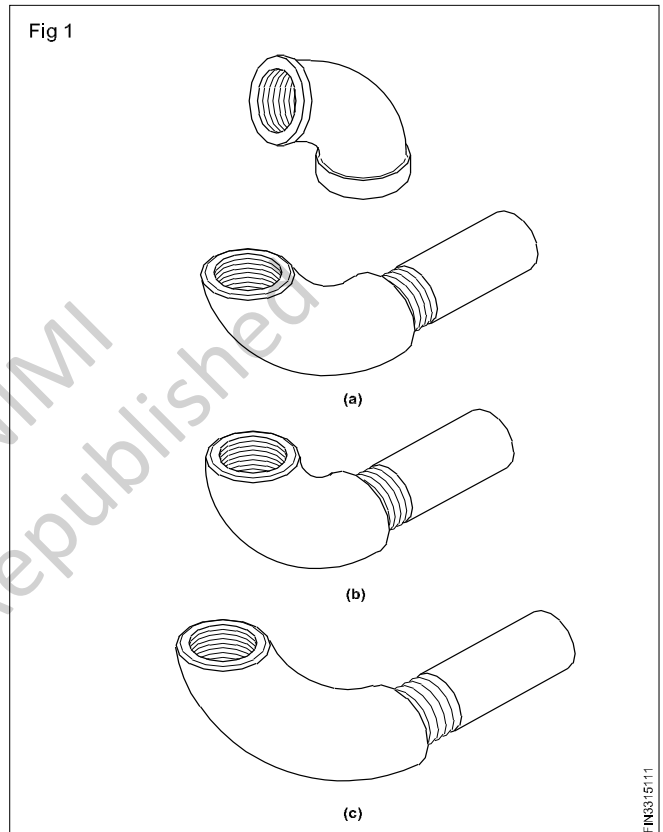
Standard pipe fitting

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

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

Standard pipe fittings

Elbows (Fig 1)



Elbows and bends provide deviations of 90° and 45° in pipe work systems.

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

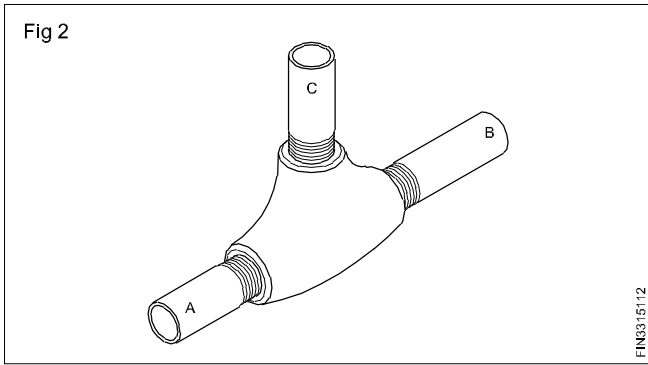
Short radius elbows have a radius equal to the bore of the pipe. (Fig 1b)

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

Tee branch

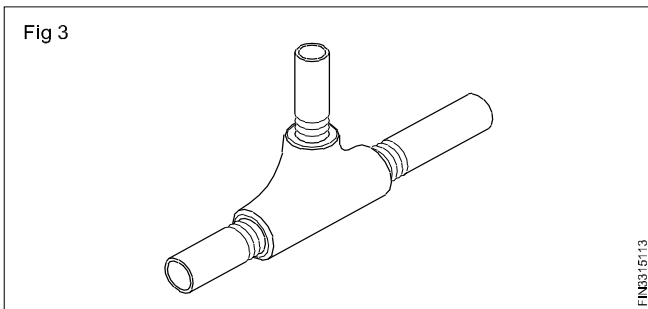
A tee joint helps the pipe line to branch off at 90°. The branches may be equal in diameter or there may be one reducing branch.

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



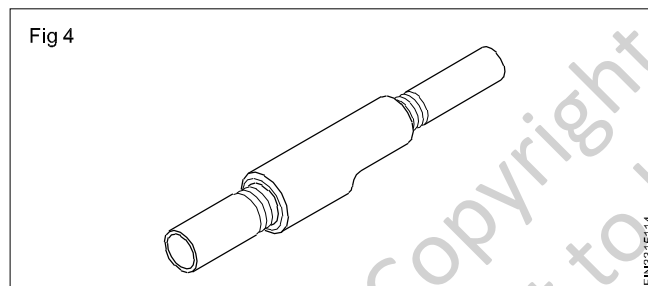
Reducing tee branch

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



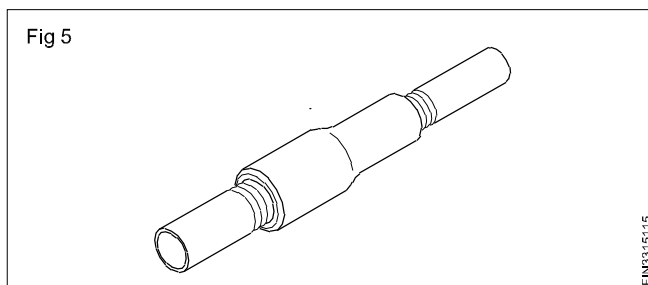
Eccentric reducer

Used mainly in horizontal position. (Fig 4)



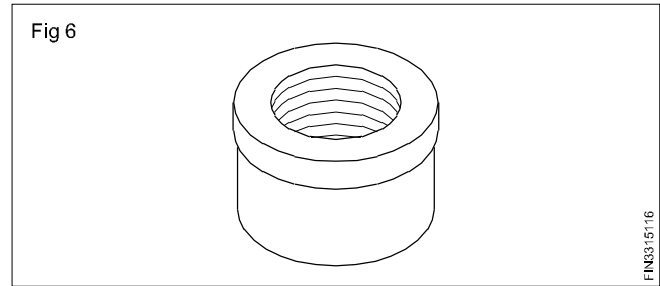
Concentric reducer

Used mainly in vertical position. (Fig 5)



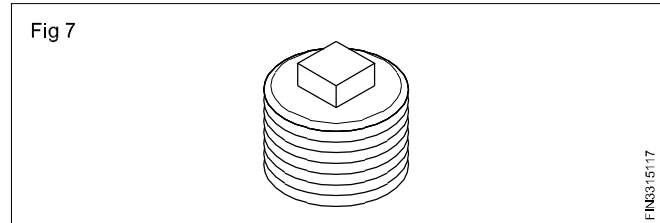
Caps

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



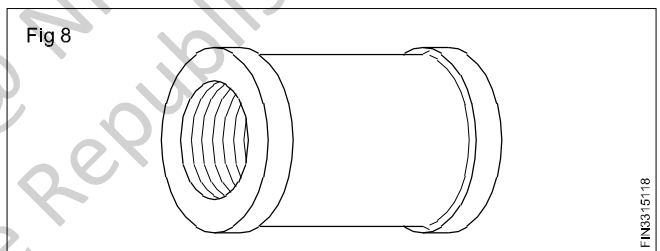
Plug

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



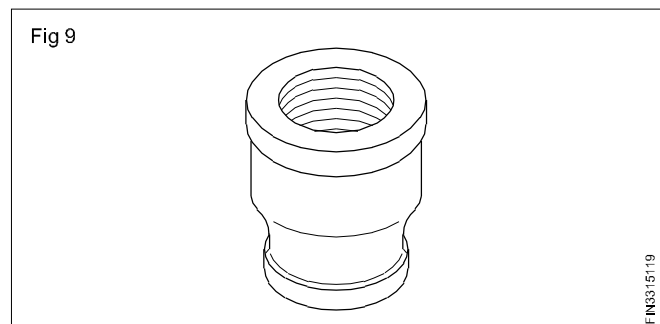
Coupling (Fig 8)

A coupling is used to connect two pipes. Couplings have internal threads at both ends to fit the external threads on pipes.



Reducer (Fig 9)

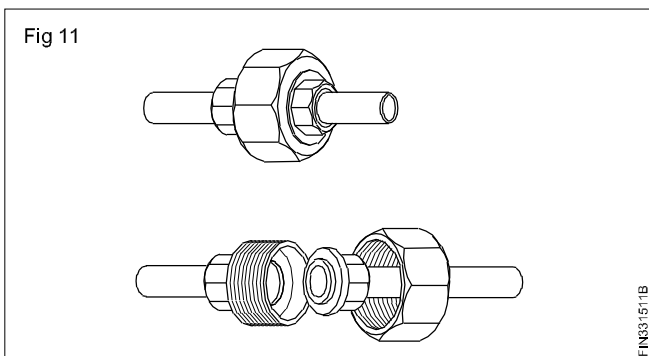
A reducer coupling is used to connect two pipes with different diameters.



Fitting	Symbol
Bend 90 degrees	
Bend 45 degrees	
Cross	
Elbow 90 degrees	
Elbow 45 degrees	
Tee	
Reducer concentric	
Union screwed	
Plug or cap	
Joint/socket	

Union

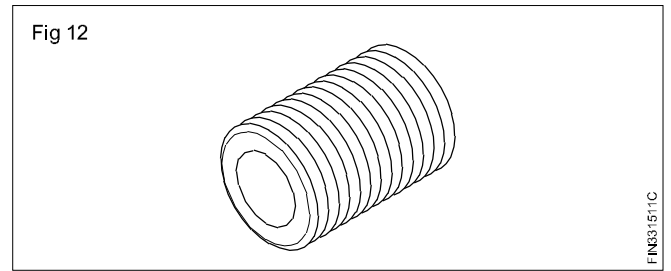
A device used to connect pipes. Unions are inserted in a pipe-line to permit connections with little change to the position of the pipe. (Fig 10)



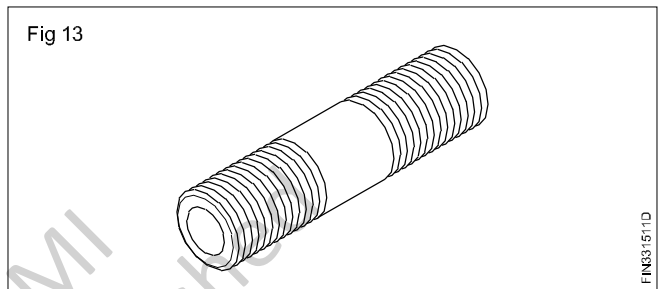
Pipe nipples

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

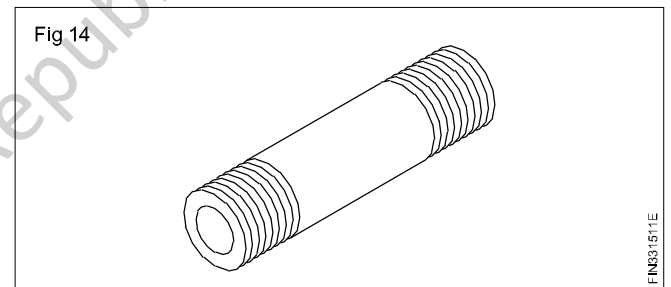
1 Close nipple (Fig 11)



2 Short nipple (Fig 12)

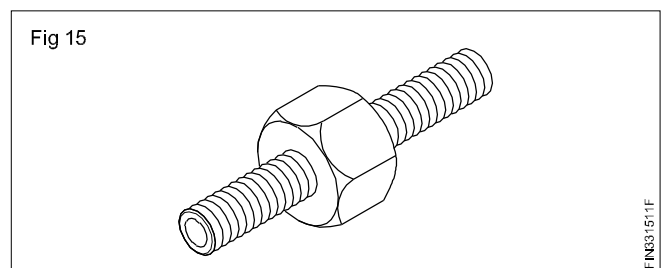


3 Long nipple (Fig 13)



The hexagonal nut

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



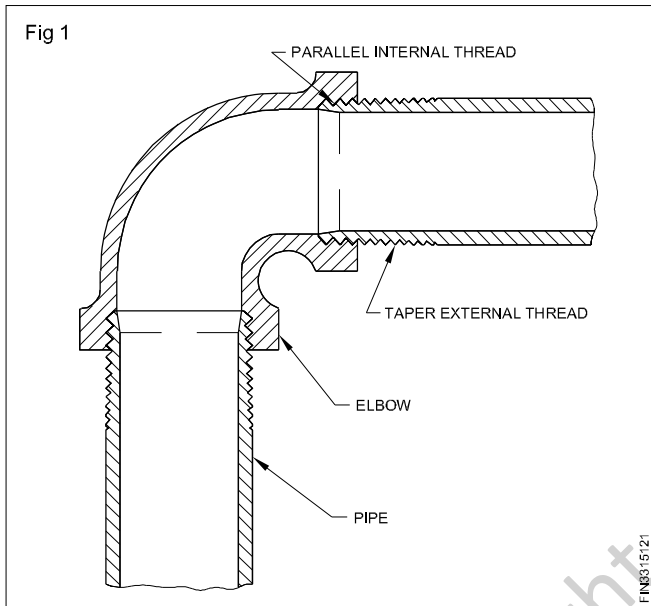
British standard pipe threads

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

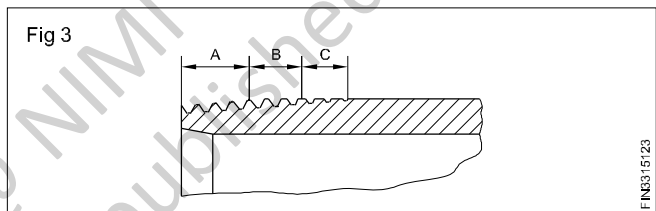
- state parallel and taper pipe threads
- determine the wall thickness and threads per inch TPI of BSP threads
- state the method of sealing pipe joints
- determine blank sizes for threading as per B.S 21-1973 and I.S.2643-1964.

Pipe threads

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



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



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

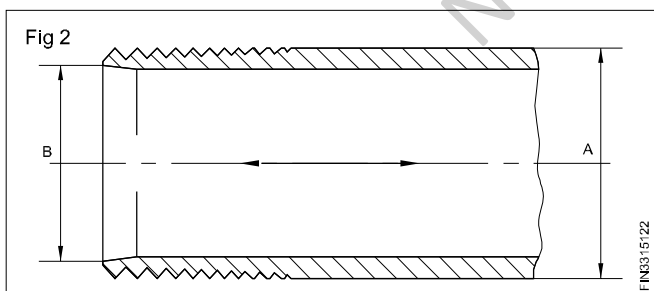
The pipe joint shown in Fig 4 consists of the following.

- 1 Parallel female thread
- 2 Tapered male thread
- 3 Hemp packing

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

B.S.P. threads

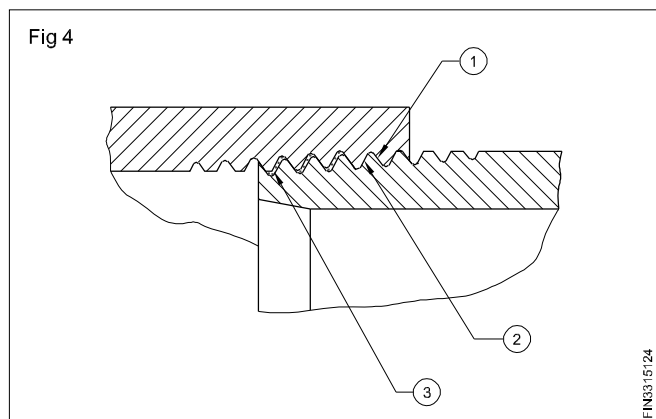
Galvanized iron pipes are available in sizes ranging from 1/2" to 6" in several different wall thicknesses. The table shows outside diameters and threads per inch from 1/2" to 4". (Fig 2)



Sealing pipe joint

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

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

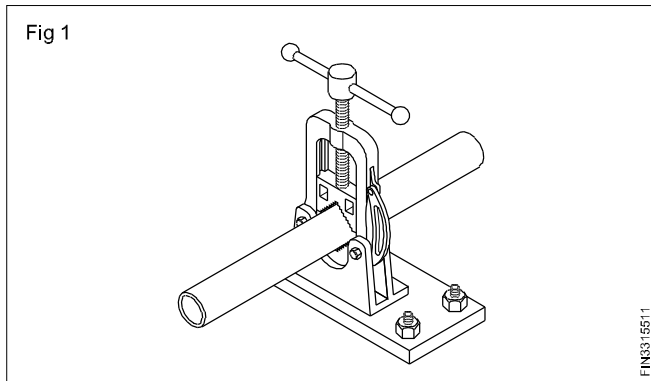


Uses of pipe fitting tools

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

- name the different types of pipe vices
- state the uses of pipe vices
- name the parts of a pipe cutter
- compare the constructional features of a pipe cutter and a multi-wheel chain pipe cutter
- state the care and maintenance aspects concerning pipe cutters.

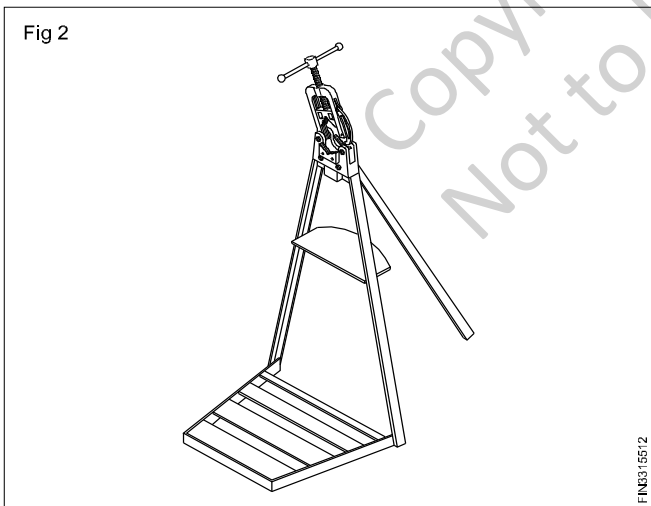
Pipe vice (Fig 1)



The pipe to be cut/bent/threaded must be held steadily and it must be prevented from rotating by holding it in a pipe vice.

It is a device used for holding and locating pipes. It can be used to hold pipes up to 63mm diameter.

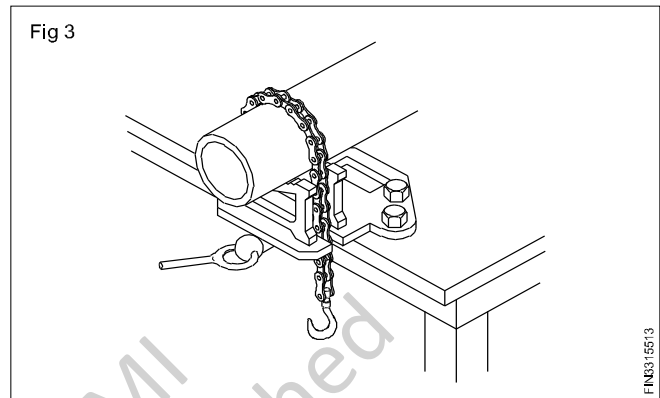
Portable folding pipe vice (Fig 2)



This vice can be folded and carried easily to any working place. This is similar to the quick-releasing type pipe vice.

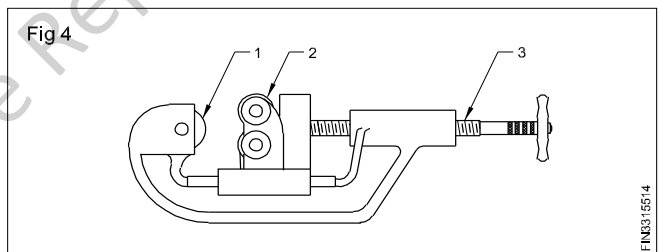
Chain pipe vice (Fig 3)

This vice is used to hold larger diameter pipes up to 200mm diameter. The pipe is gripped by means of a chain and the serrations provided on the vice jaws.



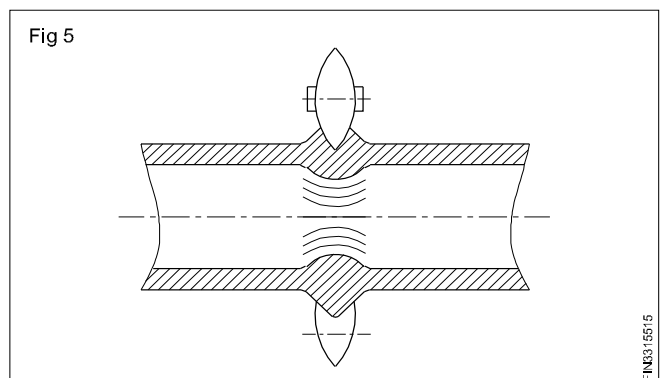
Pipe cutter

The wheel pipe cutter is used to make a square cut on the pipe. It consists of (1) a cutter wheel, (2) two guide rollers and (3) an adjusting screw. (Fig 4)

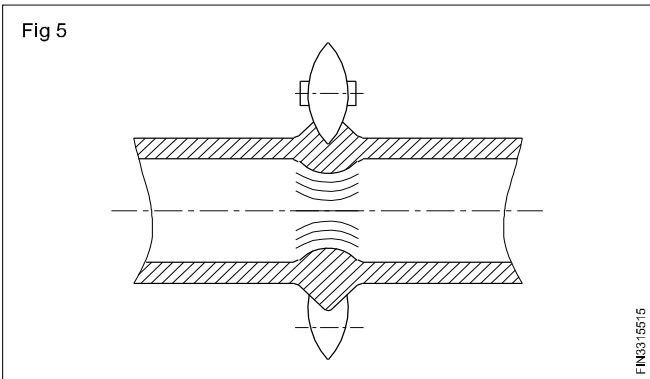


The cutter wheel tends to crush rather than cut the pipe. If it is blunt, it needs replacement.

This type of pipe cutter does not remove any materials but the cutter squeezes the metal and forces it ahead of the cutter until the pipe is cut through the wall thickness. (Fig 5)

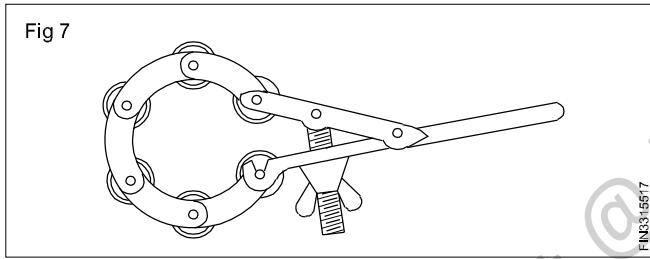


This type of cutting leaves a large ridge on the inside of the pipe which would obstruct the flow. (Fig 6) The pipe must be deburred or reamed by a pipe reamer.

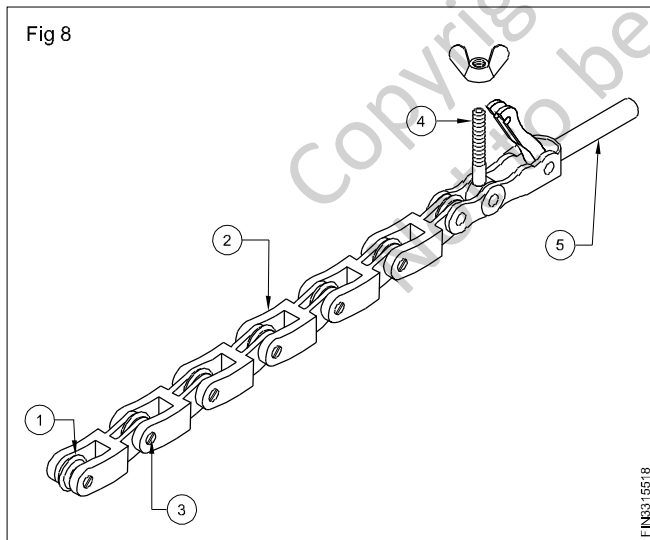


Multi-wheel chain pipe cutter

A multi-wheel chain pipe cutter can be adjusted to cut any diameter of pipe by adding on extra wheels and links. (Fig 7) The type and the size of the cutter is selected according to the diameter of pipe to be cut.



It consists of the following parts. (Fig 8)



- 1 Hardened cutting wheels
- 2 Links
- 3 Screw for joining links and wheels
- 4 Tension adjustment screw
- 5 Cutter handle

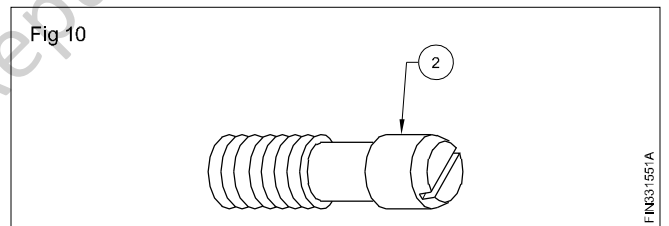
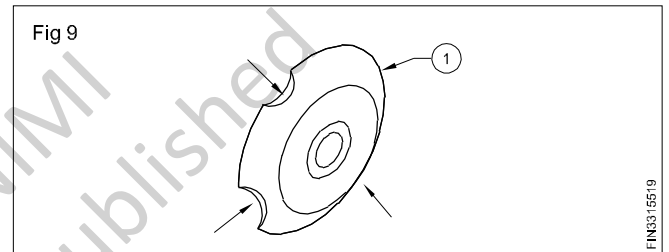
Care and maintenance of pipe cutters

Before using the cutter check the wheels, pins and links for any damage.

Replace the wheels, pins and links if damaged.

As the wheel revolves around the pin, any wear on the pin will cause the wheel to wobble and the cut will not run square to the pipe. This may result in a:

- chipped wheel (Fig 9)
- worn out pin. (Fig 10)



During pipe cutting, small flakes of metal break away and clog up the links and cutting wheels. Clean the links and wheels using a wire brush and soak the cutter in paraffin or kerosene to wash out the small particles of dirt and flakes.

After cleaning, apply a light oil on all moving parts, links and wheels for easy cutting operation and to prevent rust forming on the tool.

Store the cutter and protect the wheels from possible damage when not in use.

Plumbing tools - Pipe wrench and chain pipe wrench

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

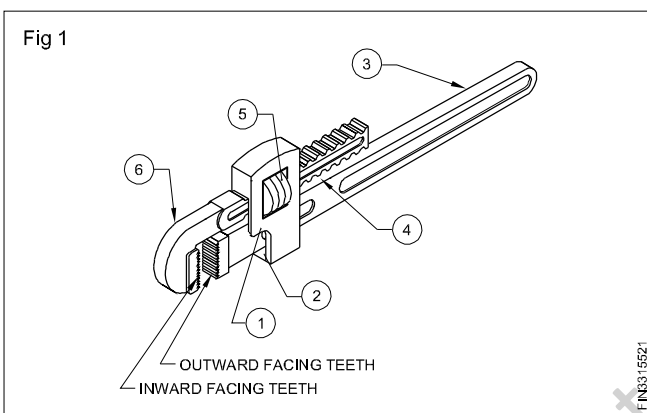
- name the elements of a pipe wrench and chain pipe wrench
- state the uses of pipe and chain pipe wrenches
- state the care and maintenance of pipe wrenches.

Pipe wrenches

These are adjustable pipe wrenches with different shapes. They are used for:

- holding and gripping pipes
- assembling and dismantling of pipes and fittings.

The Stillson pipe wrench (Fig 1) is designed as a heavy duty tool to withstand rough handling and heavy work. The jaws give an immediate and positive grip.



It may be used for all pipes with 15 mm to 50 mm diameters. Pipe wrenches are selected according to the pipe size.

Parts (Fig 1)

The Stillson pipe wrench consists of the following parts.

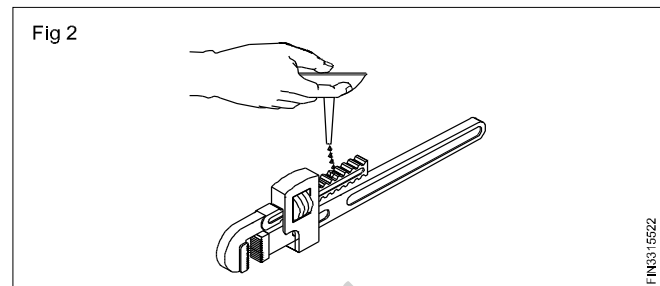
- 1 Pivot
- 2 Spring
- 3 Handle or lever
- 4 Spring
- 5 Adjusting nut
- 6 Moveable jaw

While using this pipe wrench, the jaws must be placed over the workpiece to their full depth and tightened by means of the adjusting nut.

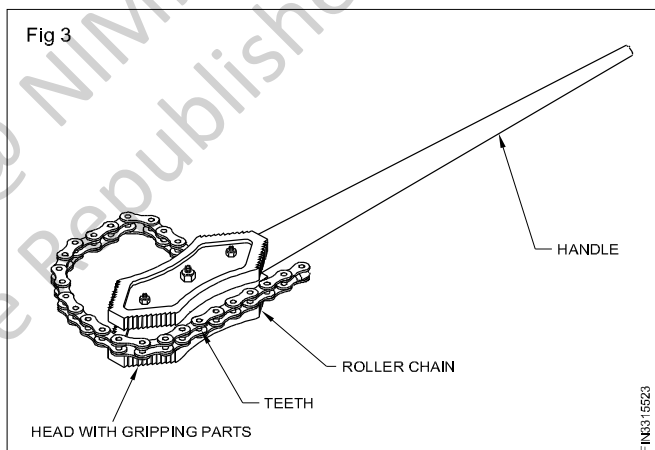
Care and maintenance

The ability of the pipe wrench to grip the pipe is directly related to the condition of the teeth.

- Cleaning the teeth and sharpening them with a triangular file can restore some wrenches to useful condition.
- Oil should be applied to the adjustment nut periodically to prevent rusting. (Fig 2)



Chain pipe wrench (Fig 3)



Chain pipe wrenches are used for pipes with diameters of 50 mm to 150 mm. They may be used for gripping cylindrical or irregular objects.

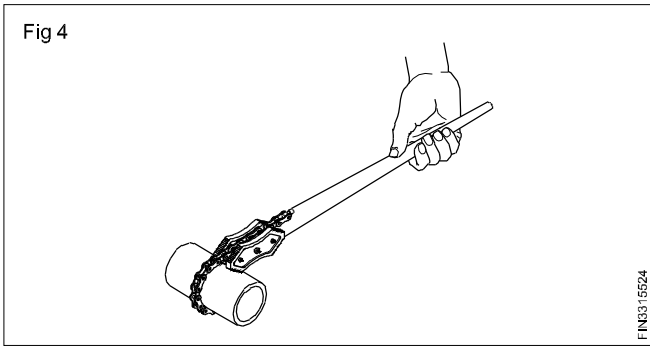
Application of chain pipe wrench

To use a chain pipe wrench, the head is placed on the pipe and the chain pulled round the circumference of the pipe. The chain is then engaged with the large teeth in the centre of the head.

The movement of the lever in the direction indicated by the arrow in the figure causes the serrated edges of the head to wedge firmly against the pipe giving a firm grip. (Fig 4)

The chain pipe wrench is a heavy gripping tool and should not be used for pipes with less than 50 mm diameter.

Apply oil or grease on the cutting edges when not in use.



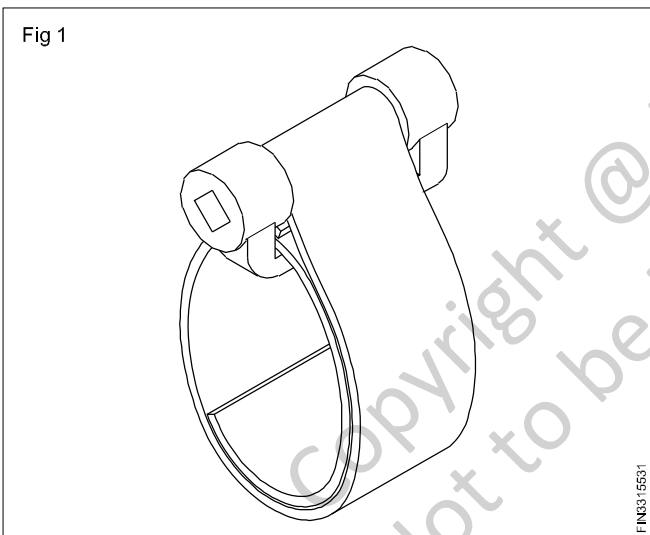
Pipe wrenches

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

- state the different types of pipe wrenches - strap wrench and foot print wrench
- state the uses of each type of wrench.

Strap wrench (Fig 1)

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.



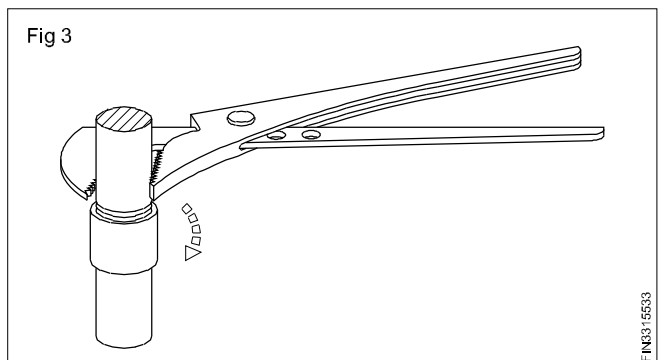
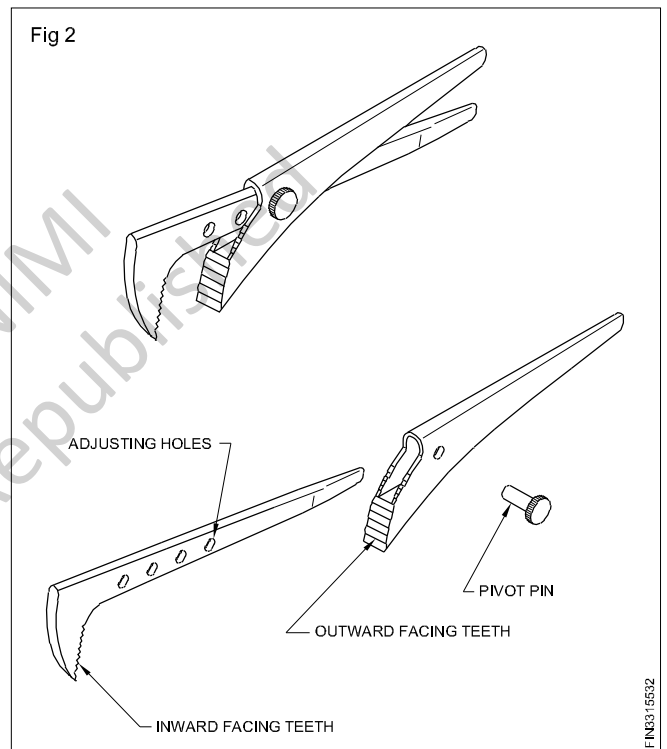
Footprint wrench (Fig 2)

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 3)

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



Pipe bending machines

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

- identify the three most common pipe benders
- differentiate their constructional features
- name the parts of bending machines
- state the uses of bending machines.

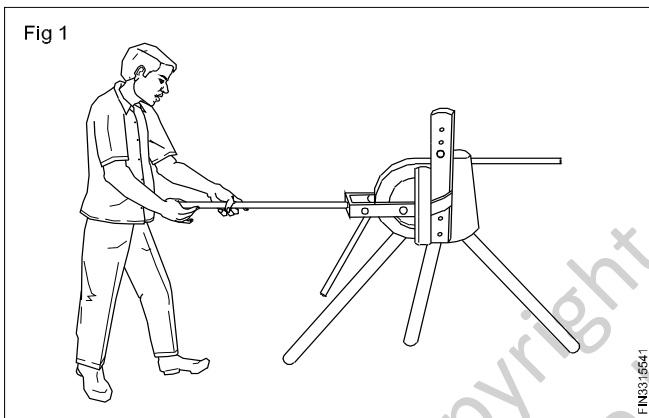
There are some situations in plumbing jobs, where it is preferable to bend a pipe rather than use a pipe fitting.

The most common pipe benders are listed here.

Portable hand operated pipe bender (Fig 1)

The portable hand-operated pipe bender consists of the following parts

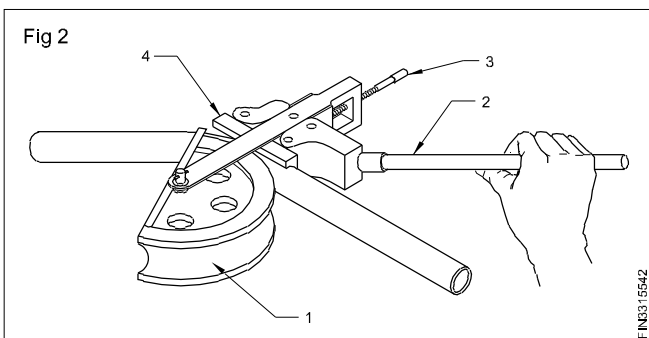
- 1 Tripod stand
- 2 Pipe stop lever
- 3 Handle or lever
- 4 Inside former



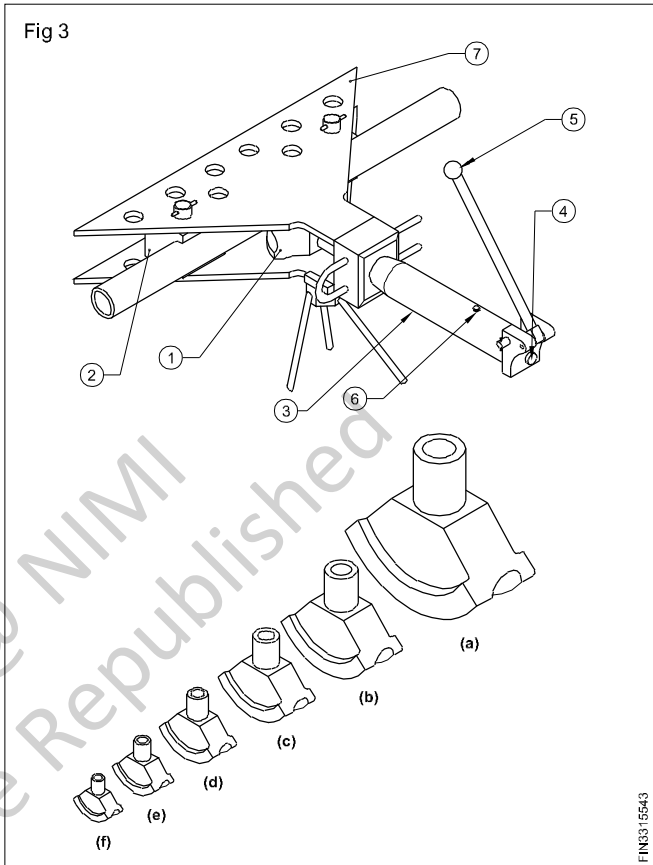
Bench type hand operated pipe bender (Fig 2)

This consists of the following parts. It is used for bending galvanized iron and steel pipes.

- 1 Inner former
- 2 Lever or handle
- 3 Adjusting screw with lock nut
- 4 Pipe guide



Hydraulic bending machine (Fig 3)



This machine can be used for bending G.I and M.S.pipes without sand filling to any direction.

It consists of the following the parts.

- 1 Inner former
- 2 Back former
- 3 Hydraulic ram
- 4 Pressure release valve
- 5 Operating lever
- 6 Bleed screw
- 7 Base plate

Inner formers are interchangeable and are able to bend pipes up to 75 mm diameters. (Figs 3a, b, c, d, e & f)

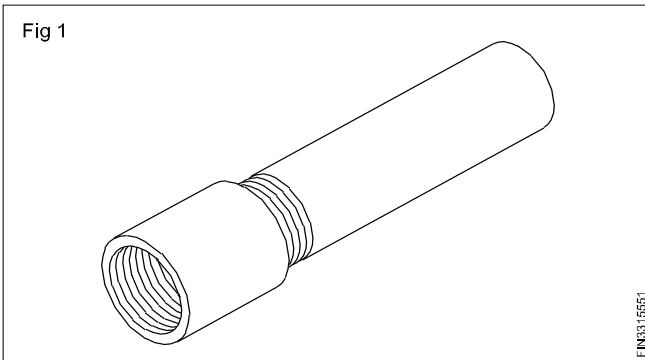
Pipes, dies, die stocks and taps

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

- identify die sets, die stocks and pipe taps
- name the parts of a die stock
- state the method of checking pipe threads.

Pipe dies

Most of the G.I. pipes that plumbers install are threaded at both ends. The pipes are available in lengths of 6 metres and it will be necessary to cut the pipe to the required length and thread it. (Fig 1)

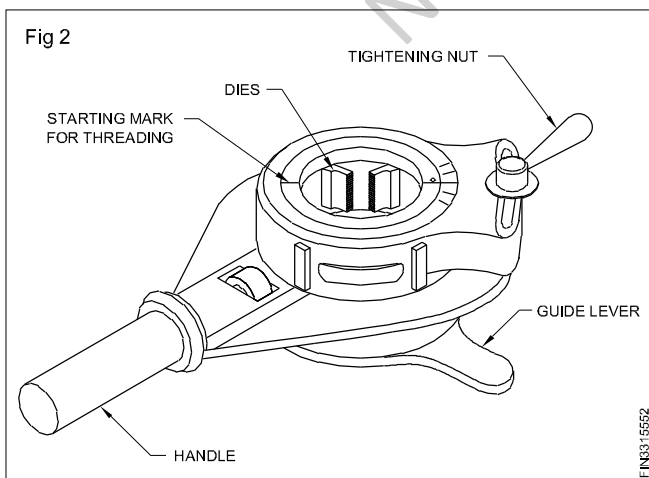


The threads on G.I. pipes and fittings for water supply systems are the standard pipe threads. External pipe threads are cut by pipe dies available in sizes from 1/4" to 4".

The dies must be sharp so that they will cut metal rather than push it around. Dies which push the metal around instead of cutting freely cause threads to break.

Die stocks

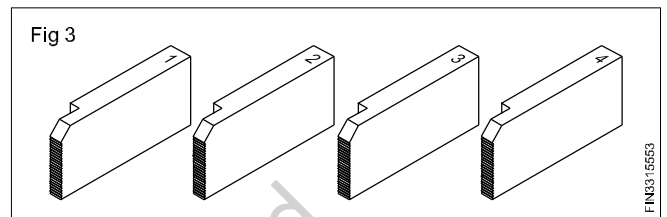
Die stocks are required to turn the dies. The ratchet type die stock is preferred because it permits the operator to use his body weight to rotate the die while standing to one side of the pipe. (Fig 2) Die stocks are adjustable.



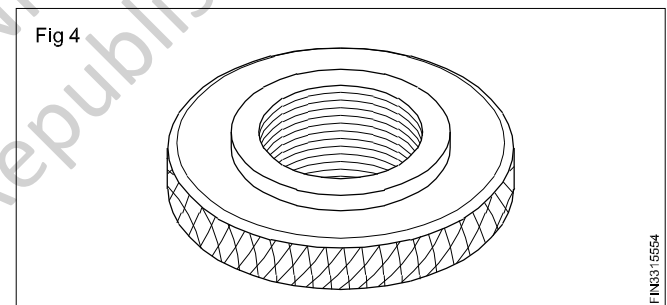
Die sets

Each die is clearly marked with its type of thread and range of pipe for which it is suitable. Each die has an identification number, that is 1 to 4. Die sets are available in various sizes.

These dies must always be used and stored as a set. (Fig 3)



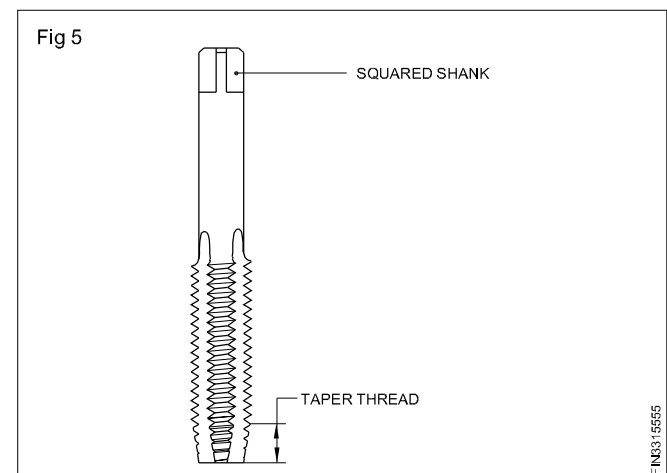
Pipe threads are usually cut with threading dies and can be checked by using the pipe ring gauge. (Fig 4)



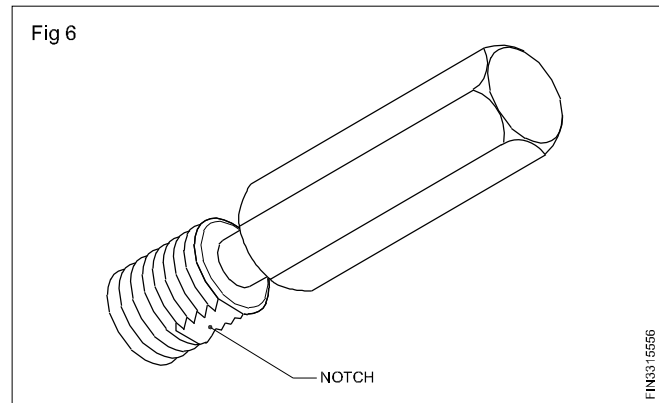
Pipe taps

Internal pipe threads are usually cut with standard taper pipe taps. (Fig 5)

In gauging internal pipe threads, the pipe plug thread gauge



In gauging internal pipe threads, the pipe plug thread gauge should be screwed tight by hand into the pipe until the notch on the gauge is flush with the face. When the thread is chamfered the notch should be flushed with the bottom of the chamfer. (Fig 6)



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Standard pipe fitting

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

- identify the standard pipe fitting
- dismantling the pipe fitting
- assemble the pipe fitting
- explain the rain water harvesting.

Standard pipe fitting: 'Pipe fittings' are those fittings that may be attached to pipes in order to:

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

Long radius elbows have a radius equal to $1\frac{1}{2}$ times the bore of the pipe.

Short radius elbows have a radius equal to the bore of the pipe.

The 45° elbows allow pipe deviation of 45° .

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

Dismantling: The term dismantling implies carefully separating the parts without damage and removing. This may consist of dismantling one or more parts as specified or according to the usage.

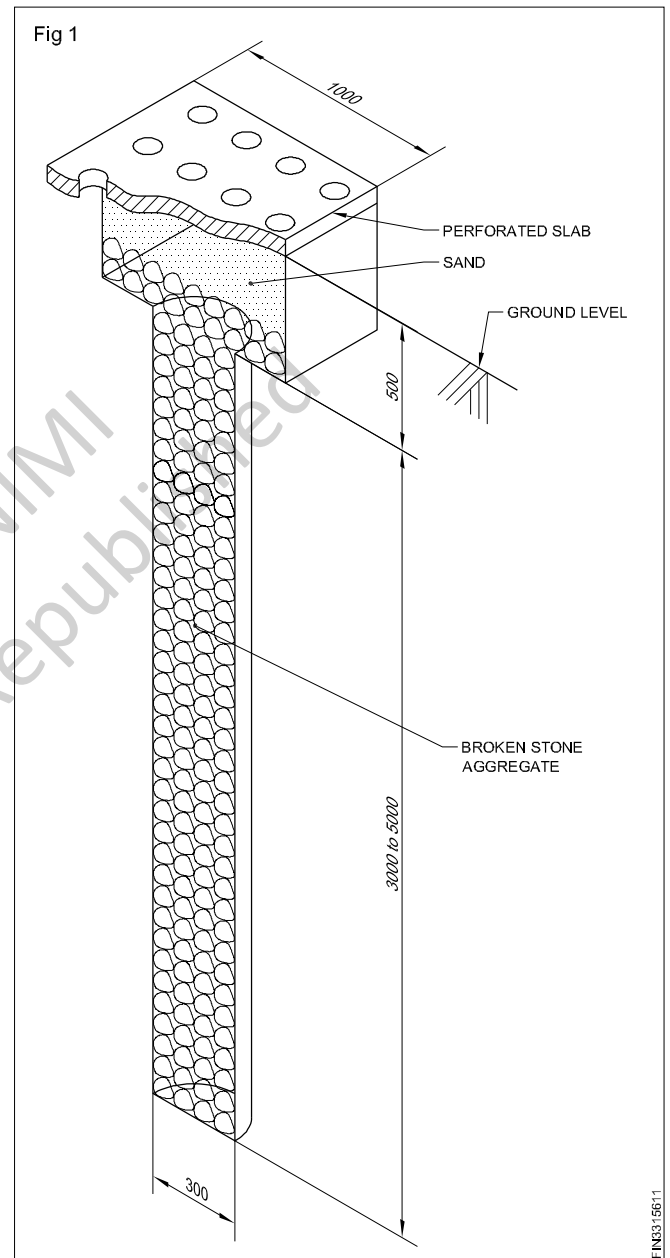
Rain water harvesting: Collection of rain water when it rains for use during non monsoon months is called rain water harvesting. When rainfall occurs in heavy during a short spell if it is not collected, it floods the area or run off to sea. It is quite possible to put all the water into soil below with little effort and less expenditure so that rain water is not lost but goes to recharge ground water table. (Fig 1)

Benefits of harvesting

- Ground water table raises.
- Reduce the salinity.
- Avoid flooding.

Method of rainwater harvesting

- Percolators/ soakpit
- Percolation trenches
- Service well cum recharge well method



Maximum plot area to be kept as unpaved so that the rain water can percolate to ground.

The rain water from season 1st rain should normally not to be used for percolation to recharge structures. For such water, suitable arrangement for bypass in pipe system should be introduced.

A suitable provision should be made if possible to allow rain water to percolate to ground water after passing it through settlement tank because such rain water contain silt which is deposited on sand bed reduces the percolation rate.

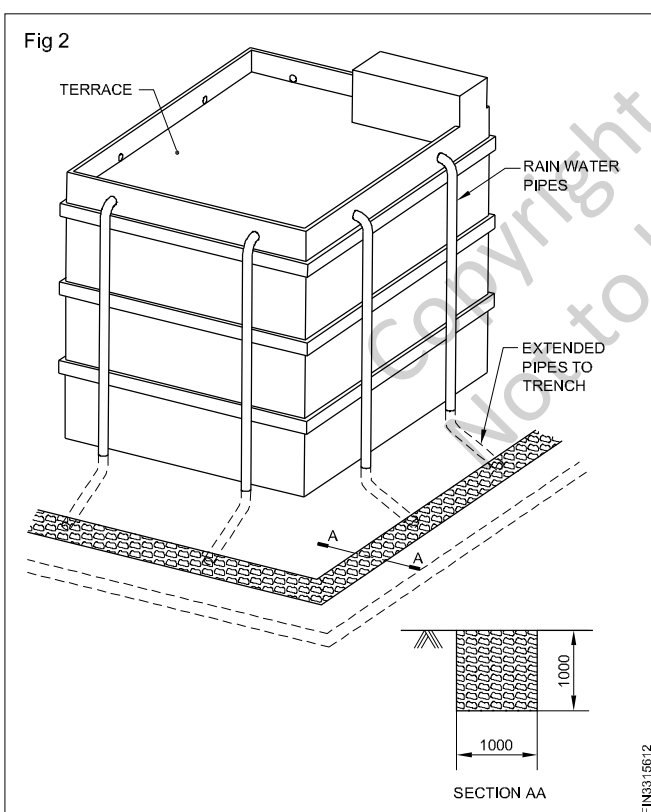
The recharge structure should be made on a plot at the places of lower levels/ elevations so that rain water may flow towards it under normal gravitation flow.

On a vast and sloppy land patch, the contour bunds preferably of mud with height varying from 15cm to 30cm should be made to store run off temporarily over the katcha land area, thus allowing more time for percolation of water to the ground water and arresting the flow of run off to the drains/ sewers.

For recharge of run off from roads suitable arrangements in the foot path by introducing some katcha area should be made.

In large residential and office complexes the drive ways, pucca path and areas should had some katcha area which may facilitate rain water to percolate to ground water. (Fig 2)

Ideal conditions for rain water harvesting and artificial recharge to ground water. Artificial recharge techniques



are adopted where:

- Adequate space for surface storage is not available specially in urban areas.
- Water level is deep enough (more than 8m) and adequate sub- surface storage is available.
- Permeable strata is available at shallow/ moderate depth upto 10 to 15mtr.
- Where adequate quality of surfac water is available for recharge to ground water.
- Ground water quaility is bad and our aim is to improve it.
- Where there is possibility of intrusion of saline water especially in coastal area.
- Where the evaporation rate is very high from surface water bodies.

The decision whether to store or recharge rain water depends on the rain fall pattern of a particular region.

- If the rainfall period between two spells of the rain is short i.e. two to four months, in such situation a small domestic size water tank for storing rain water for drinking and cooking purpose can be used.
- In other regions where total annual rainfall occurs only during 3 to 4 months of monsoon and the period between two such spells is very large i.e. 7 to 8 months, so it is feasible to use rain water than for storage which means that huge volumes of storage container are required.

Repair and maintenance of household water taps

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

- name the parts of a water tap
- state the functions of each part
- state the constructional features of a water tap
- state the common defects in water taps, their causes and remedies.

Repair and maintenance of household water taps

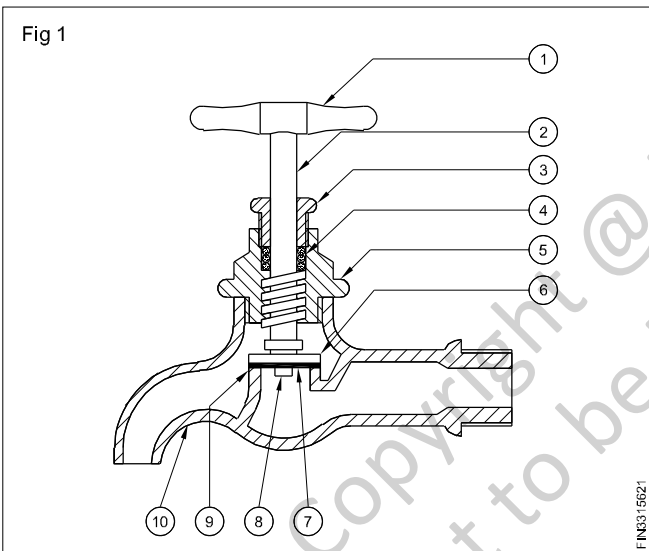
There are many old and new designs of taps in the market. It is advisable to read the manufacturer's instructions when repairing and replacing washers or packing materials.

All types of screw-down water taps have two parts which must be maintained.

The packing of the stuffing box for the spindle or shaft.

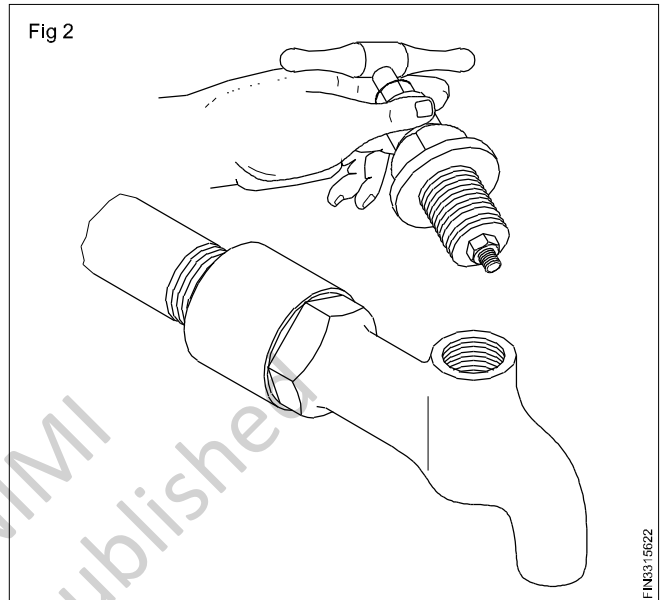
The washer (rubber, leather or fibre) on the metal disk-holder or valve disk.

Fig 1 shows the inside parts of a screw-down type water tap.

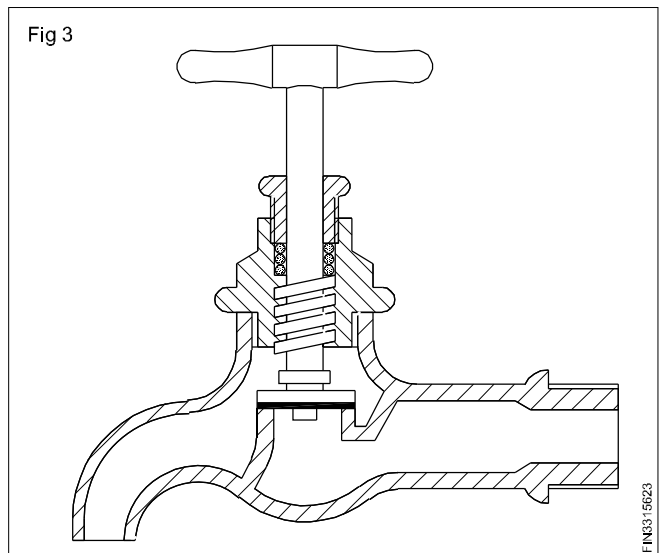


- 1 Handle
- 2 Spindle/ shaft
- 3 Gland nut
- 4 Stuffing box/ packing
- 5 Bonnet
- 6 Metal disk-holder/ valve disk
- 7 Washer (rubber/ leather/ fibre)
- 8 Retainer nut/ washer nut
- 9 Valve seat
- 10 Body of the tap.

The body of the water tap contains the seat. The bonnet which holds the working parts is screwed on to the body. (Fig 2)



When the water tap is screwed down, the washer is squeezed between the two metal faces and this makes the joint watertight. (Fig 3)



The spindle has a handle at the upper end and a threaded screw at the other end.

Resting in the bottom of the spindle is the metal disk-holder containing the rubber washer which is held in position by a nut underneath.

The stuffing box at the top of the water tap has a soft graphite grease hemp packing. As the stuffing box screw is tightened, this packing is compressed, thus making a watertight joint.

Defects in the working of screw-down water taps

Defects	Causes	Remedy
Water flowing or dripping from the tap even when firmly closed.	Worn out or defective washer. Piece of grit, rust or other foreign matter on the washer. Defective seating.	Replace washer. Remove foreign matter. Reseat tap.
Water flowing from around the spindle or stuffing box screws. screw.	Defective packing in stuffing box. Screw of stuffing box not screwed down tightly.	Replace packing with greased hemp. Tighten stuffing box
Spindle continuously slipping when turned and tap will not shut off.	Spindle thread worn out.	Replace tap.
Tap hard to turn on and off.	Stuffing box packing dry. Spindle bent.	Renew packing with greased hemp of some oil into the stuffing box. Renew tap.
Loud noise in the tap when turned on.	Valve loose on the spindle. Washer loose on valve.	Renew tap. Renew the valve of the washer.

Visual Inspection

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

- explain visual inspection and its need
- state advantages and disadvantages of visual inspection.

Testing

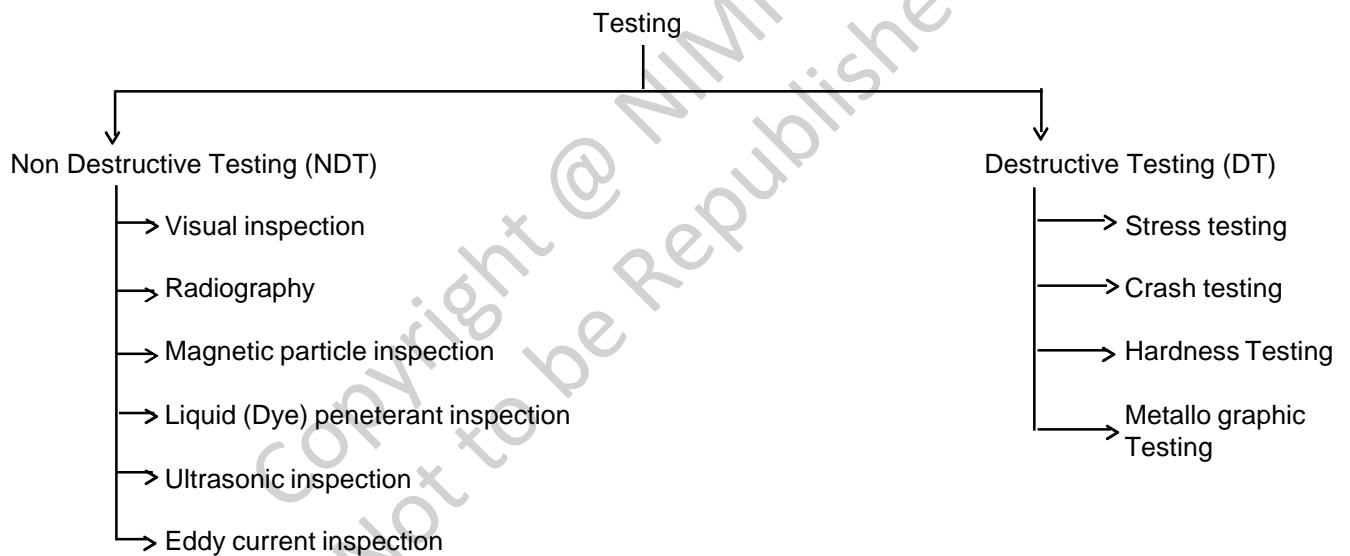
The method by which the presence, quality, genuiness of anything is determined is called testing

Testing is trial of the quality of something

in our industry or project management testing is done for mechanical properties such as

- 1 Strength
- 2 Ductility
- 3 Hardness
- 4 Elasticity
- 5 Toughness
- 6 Shape
- 7 Surface finish
- 8 Colour etc.

Testing is two types



Visual inspection

Visual inspection is a non destructive testing method used to evaluate the item, by just observation. Visual inspection is used to inspect the

- Surface condition of the item
- Alignment of mating surfaces
- Dimensions and settings as per design

Visual inspection is usually the first method employed for locating defects

Visual inspection is the outlet & most common NDT method

Mechanical and optional aids may be necessary to perform visual inspection such as

Optical AIDS	Mechanical AIDS
Magnifying glass	Vernier calliper
Microscopes	Micrometer
Fibro scopes	Depth gauges
Video cameras	Feeler gauges

Types of visual inspections

- a Direct visual testing
- b Remote visual testing
- c Translucent visual testing

Direct visual testing

It may usually made when access is sufficient to place the eye within 600mm on the surface to be examined and angle between plane of vision & surface shall not be less than 30°.

Translucent visual inspection

It is a supplement of direct visual inspection. The method uses the help of artificial lighting which is contained in illuminator that produces directional lighting. The lighting must be so that there are no surface glares or reflections from surface under examination.

Advantages of visual inspection

- 1 Does not require any special equipments other than good eyesight.
- 2 It is very inexpensive from other methods of non destructive testing
- 3 It provides immediate results.
- 4 It requires minimum training to the inspector
- 5 Visual inspection is highly portable as less accessories to inspect are needed.

Disadvantages of visual inspection

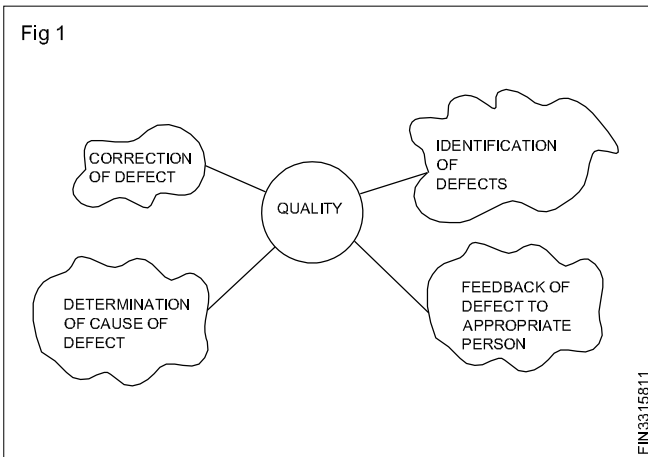
- 1 The accuracy of the visual inspection depends largely on the experience and knowledge of the inspector
- 2 Only large defects, discontinuities can be detected.
- 3 Possibility of misinterpretation of scratches as cracks.
- 4 It may be limited to detection of surface dimensional defects only.

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Quality control & inspection

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

- **define inspection, its types**
- **define quality and its characteristics**
- **explain quality control and its need**
- **define SPC (statistical process control).**



An inspection determines if the material or item is in proper quantity and quality

Inspection can be done

1. Individually
2. Lot by lot

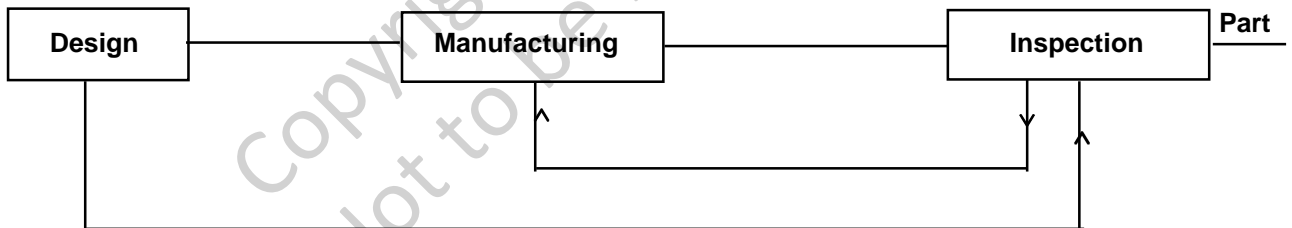
Inspection is generally divided into three categories

1. Receiving inspection
2. Inprocess inspection
3. Final inspection/ product quality control

Inspection:
Inspection can be termed as the watch dog of manufacturing process

Inspection and quality control

An inspection is most generally an organised examination or formal evaluation exercise. which may include measurement, testing, gauging, comparison of materials or items.

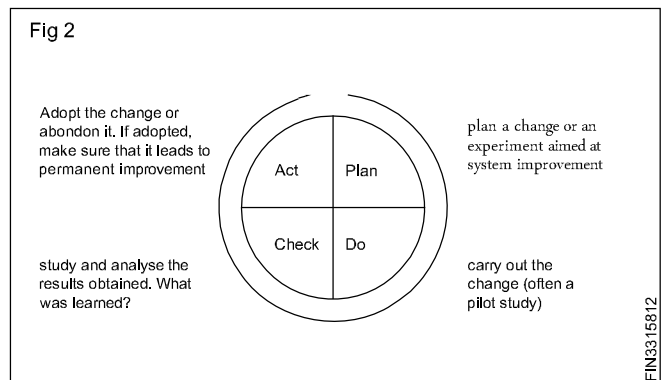


- Inspection process is mostly manual**
- The role of inspection is to verify and validate the VARIANCE DATA and it does not involve separating the good from bad.**

PDCA cycle model

PDCA cycle model is also known as DEMING CYCLE/ STEWART CYCLE, CONTROL CYCLE.

This model is implement to improve the quality and effectiveness of process with in product life cycle management and project management.



It contains of 4 steps

- Plan
- DO
- Check
- Act

Objective of inspection

- Access conformity with design specifications
- Improve product quantity and reliability

Elements of inspection process

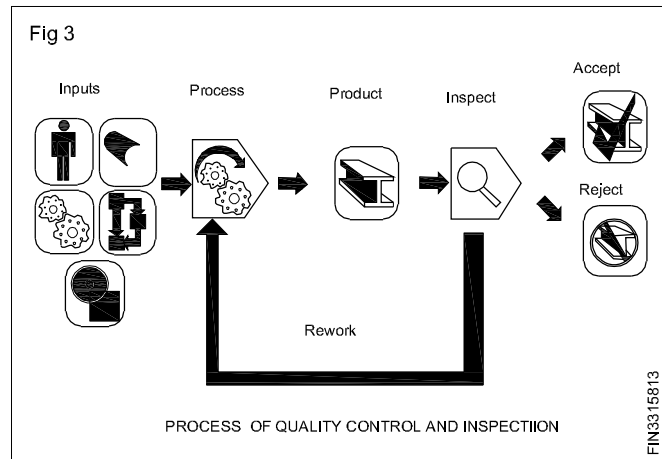
- Interpretation of quality requirements
- Sampling of the material to be inspected.
- Examination of the material from the sample to be inspected.
- Decision and action against the inspection of sample whether to pass or reject.

Quality

- Quality is in conformance to the requirements or specifications
- Quality is fitness for use

The quality of product or service is the fitness of that product or service for meeting or exceeding its intended use as required by the customer.

- Quality of a product or a service defined by one or more elements. These elements are known as quality characteristics
 - Quality characteristics can be classified into these categories
- 1 Structural characteristics (Length of part, weight of can, strength of beam, viscosity of fluid, etc)
 - 2 Sensory characteristics (taste of good food, beauty of model, smell of fragrance, etc.)
 - 3 Time oriented characteristics (warranty, reliability, maintainability etc.)
 - 4 Ethical characteristics (Honesty, courtesy, friendliness, etc).



Quality control

Quality control is a short process by which entities review the quality of all factors involved in production

ISO 9000 design quality control (QC) as:

“ A part of quality management focussed on fulfilling quality requirements”

This approach emphasises on three aspects.

- 1 Elements such as controls, job management, designed well managed process, performance and integrity. Criteria, identification of records.
- 2 Competence such as knowledge, skills, experience & qualifications
- 3 Soft elements such as personnel, integrity, confidence organizational culture, motivation, team spirit & quality relationship.

Inspection is a major component of quality control, where physical product is examined visually (or the end results of service are analyzed). Product inspectors will be provided with list of descriptions of an acceptable product defects such as cracks or surface blemishes.

**ED of quality control

Every operation is connected with the quality of the product it is important that quality requirements be satisfied and production schedules are met. The satisfaction of end user mainly depended on quality

Quality control is needed for

- 1 Encourage quality consciousness
- 2 Satisfaction of consumers
- 3 Reduction in production cost
- 4 Effective utilisation of resources
- 5 Increased good will among the consumers
- 6 Reducing inspection cost

- 7 Increase in sales
- 8 Best quality in available resources

SPC (Statistical process control)

If a product is to meet or exceed customer expectations, generally it should be produced by a process that is stable or repeatable. More precisely, the process must be capable of operating with little variability around the target or nominal dimensions of the product's quality characteristics. Statistical process control (SPC) is a powerful collection of problem-solving tools useful in achieving process stability and improving capability through the reduction of variability.

SPC is one of the greatest technological developments of the twentieth century because it is based on sound underlying principles, is easy to use, has significant impact and can be applied to any process. Its seven major tools are

- 1 Histogram or stem-and-leaf plot
- 2 Check sheet
- 3 Pareto chart

- 4 Cause-and-effect diagram
- 5 Defect concentration diagram
- 6 Scatter diagram
- 7 Control chart

Although these tools, often called "the magnificent seven," are an important part of SPC they comprise only its technical aspects. The proper deployment of SPC helps create an environment in which all individuals in an organization seek continuous improvement in quality and productivity. This environment is best developed when management becomes involved in the process. Once this environment is established. Routine application of the magnificent seven becomes part of the usual manner of doing business, and the organization is well on its way to achieving its quality improvement objectives.

Of the seven tools, the shewhart control chart is probably the most technically sophisticated. It was developed in the 1920s by Walter A. Shewhart of the Bell Telephone Laboratories. To understand the statistical concepts that form the basis of SPC we must first describe Shewhart's theory of variability.

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