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.

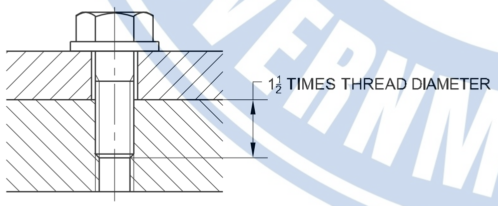
Various types of fasteners

- 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)

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)

Fig 2

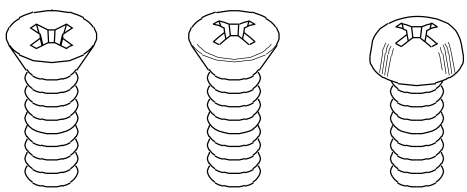
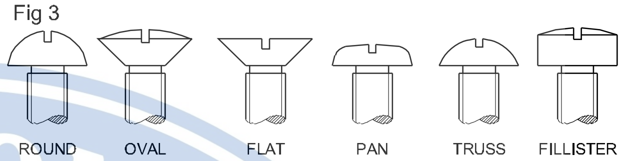


Fig 3



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.

Fig 4

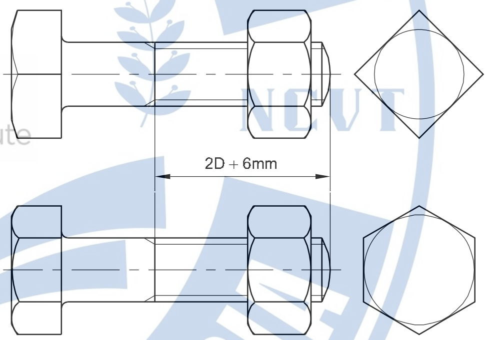
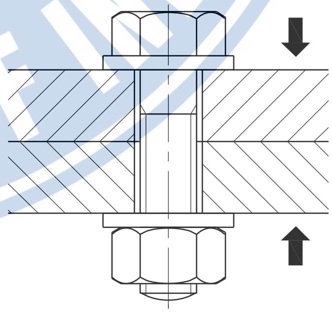


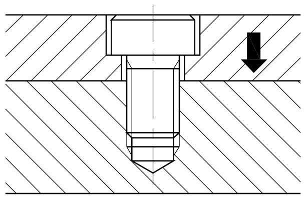
Fig 5



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.

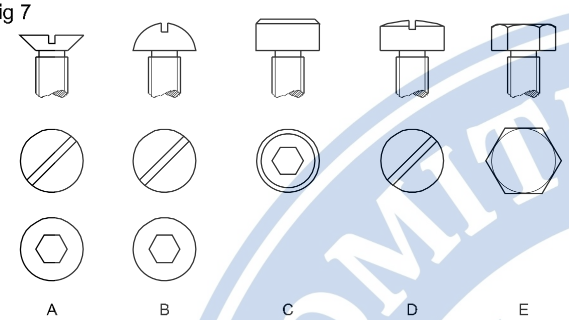
A clamping action is developed by tightening the cap screws. (Fig 6)

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).

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)

Fig 8

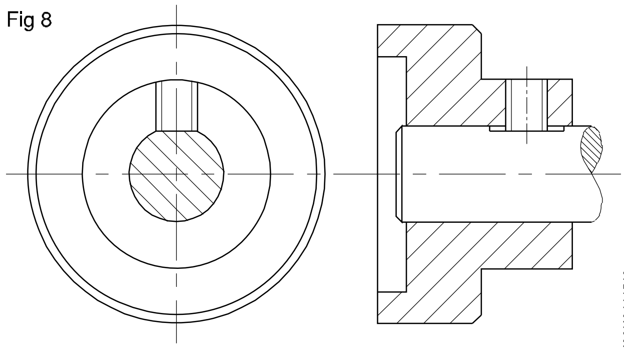
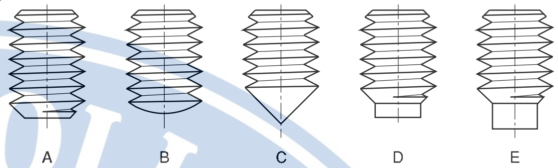


Fig 9



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.

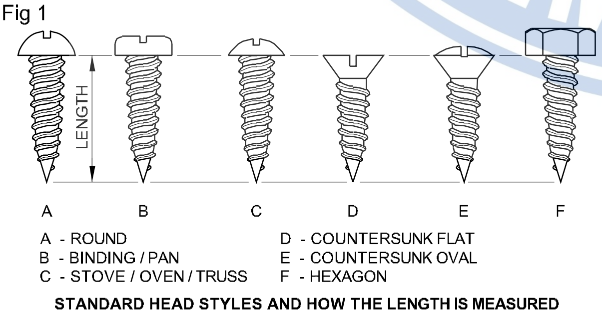
E The full dog point set screw is suitable for use as a key that slides in a key way.

Types of screws

Objective: At the end of this lesson you shall be able to
- **state the various types of fastening screws and their uses**

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)

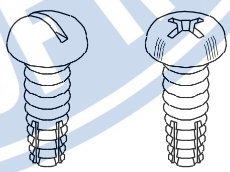
Fig 1



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

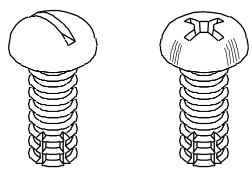
Type F: Cuts a standard machine thread used in castings and forgings. (Fig 2)

Fig 2



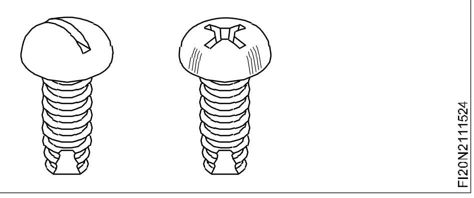
Type BF: This screw is recommended for die castings and plastics. (Fig 3)

Fig 3



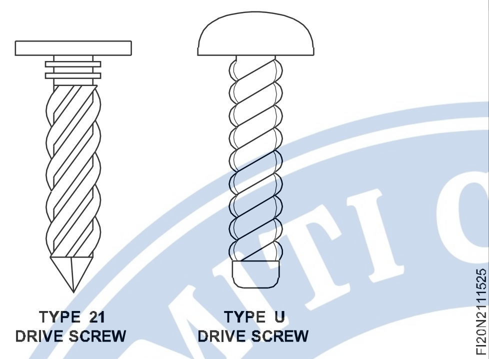
Type L: Widely used with plastics. (Fig 4)

Fig 4



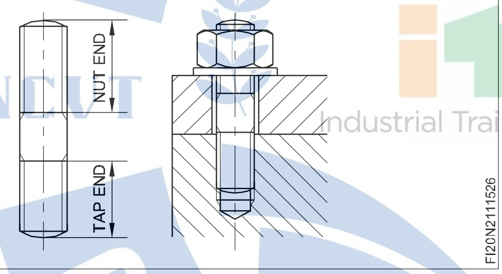
Driver screws: Driver screws are simply hammered into a drilled hole or punched hole of the proper size. They make a permanent joints. (Fig 5)

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)

Fig 6



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 x 100 = 500 N/mm^2 (MPa)

Yield stress ratio

8 x 10 = 80%

Yield stress

80% of 500 = 400 N/mm^2 (MPa)

The designation consists of two figures:

- The first figure indicates 1/100 of the nominal tensile strength in N/mm^2 and
- The second figure indicates 1/10 of the ratio, expressed as a percentage, between nominal yield stress and nominal tensil strength.

The multiplication of these two figures will give 1/10 of the nominal yield stress in N/mm^2.

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 sulpher, phosphorus and lead content:

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

- Alloy steel shall contain one or more of chromium, nickel, molybedenum 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 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 the observed while using screw driver.**

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

Hand-held screwdrivers are of the following types.

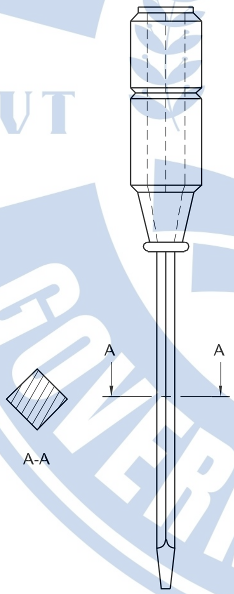
Standard screwdriver (Light duty) (Fig 1)

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

Fig 1

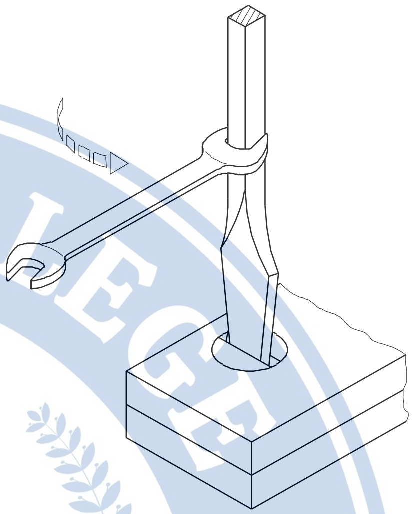
Standard screwdriver (Heavy duty) (Fig 2)

Fig 2



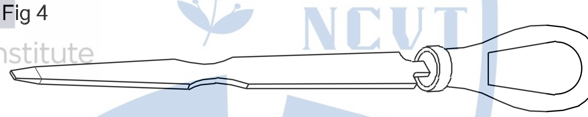
It has a square blade. The shank is also of square section for applying extra twisting force with the end of a spanner. (Fig 3)

Fig 3



Heavy duty screwdriver (London pattern) (Fig 4)

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.

Fig 5

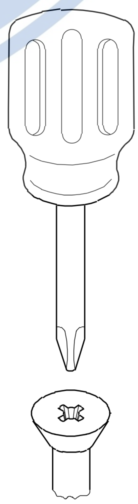


Fig 6

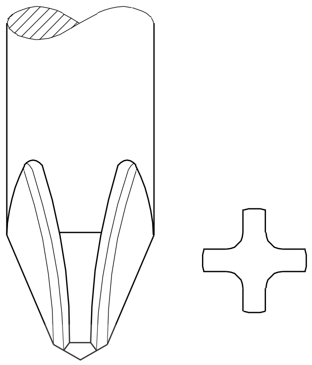


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Fig 7

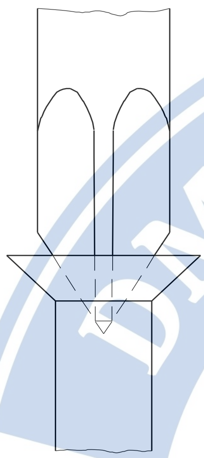

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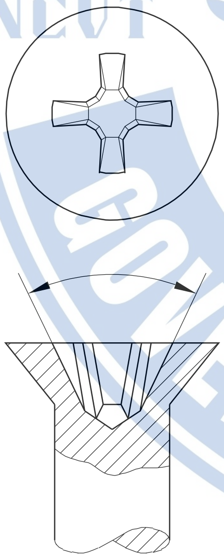
Fig 8



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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)

Fig 9

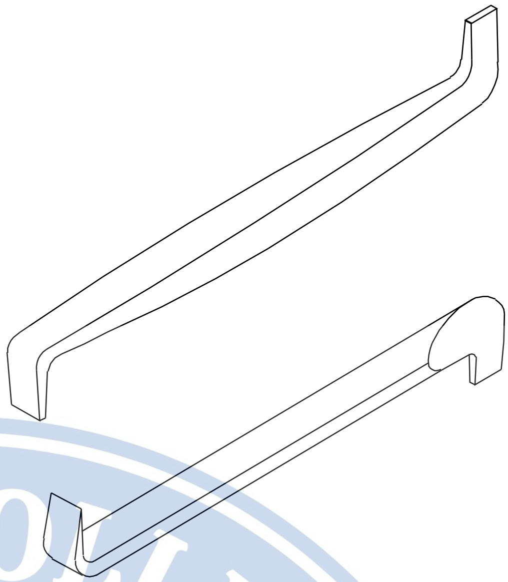

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Fig 10

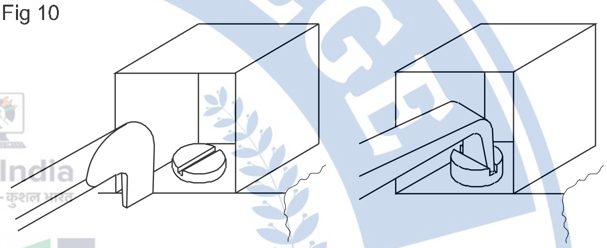

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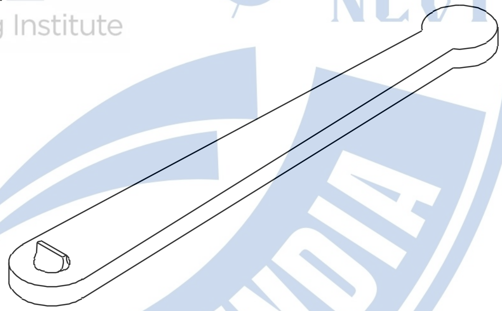
Fig 11



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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)

Fig 12

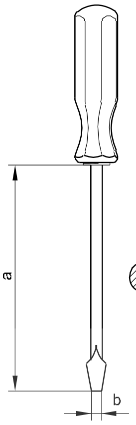


Fig 13

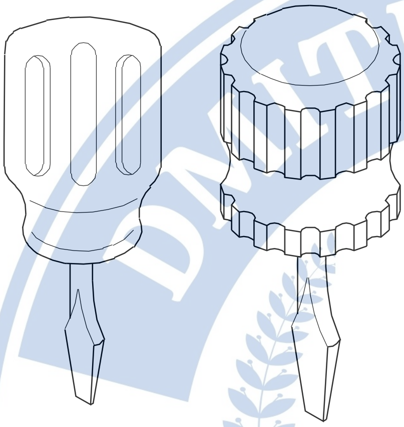
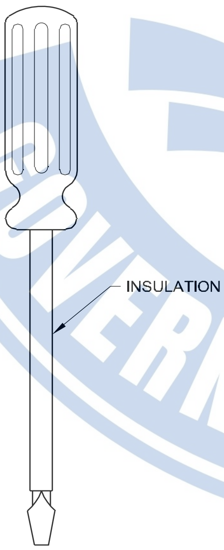


Fig 14



Precautions

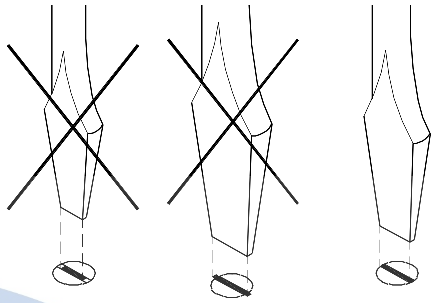
Use screwdrivers with tips correctly fitting into the screw slot. (Fig 15)

Make sure your hand and the handle are dry.

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

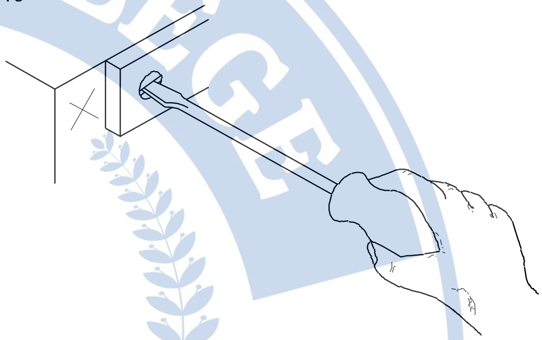
While using a Philips screwdriver apply more downward pressure.

Fig 15



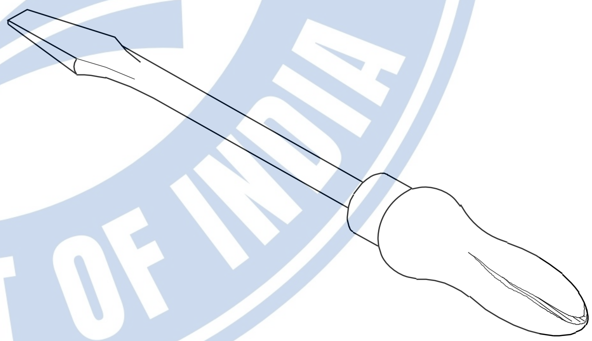
Keep your hand away to avoid injury due to slipping of screwdriver. (Fig 16)

Fig 16



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

Fig 17



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

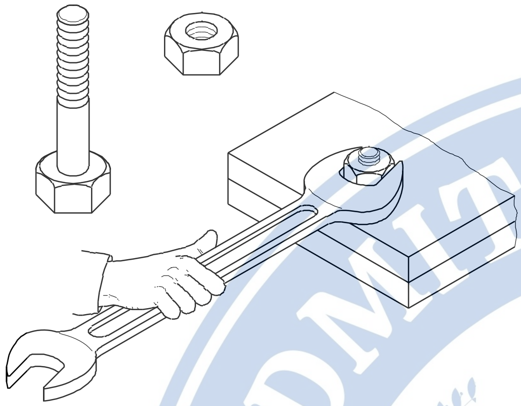
While using screwdrivers on small jobs, place the jobs on the bench or hold them in a vice.

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.

Fig 1



Types of spanners

- Open end spanners
- Ring spanners

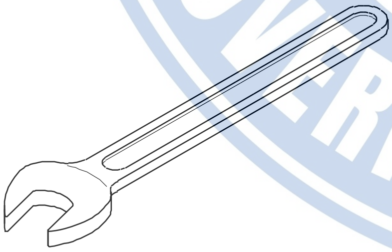
Open end spanners

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)

Fig 2



Double-ended spanners

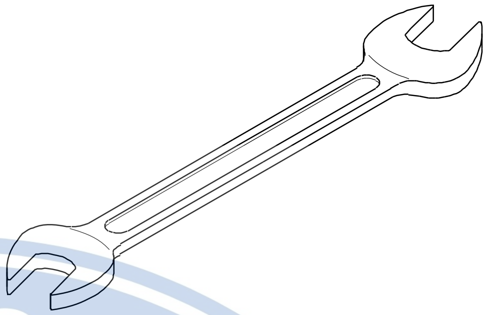
Double-ended spanners are standard spanners having two different size openings. Some spanners are made of chrome vanadium steel.

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.

Fig 3



Ring spanners (Figs 4,5 & 6)

Fig 4

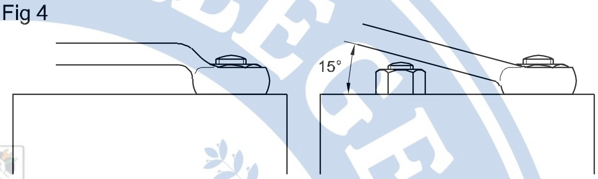


Fig 5

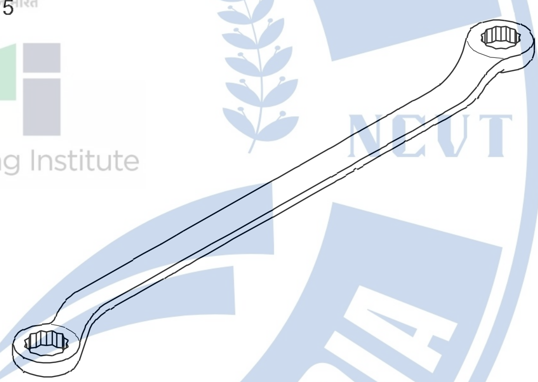
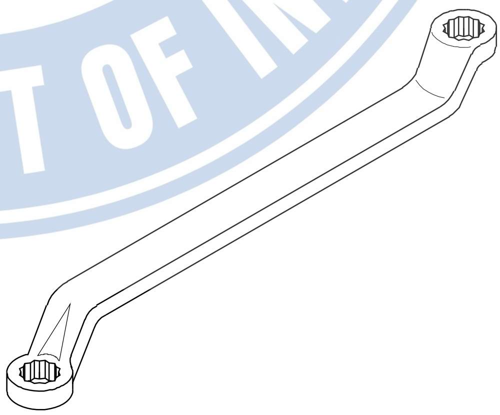


Fig 6



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)

Fig 7

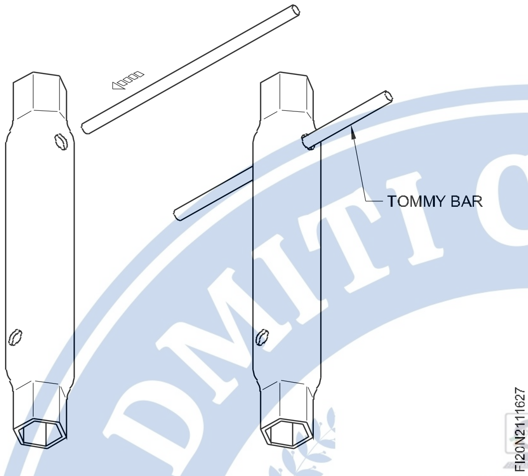
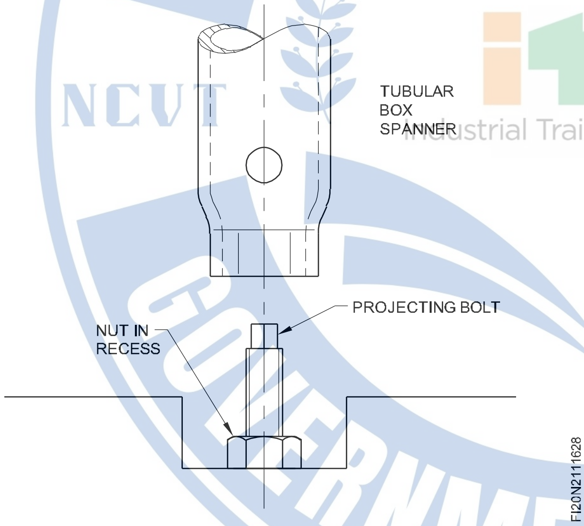
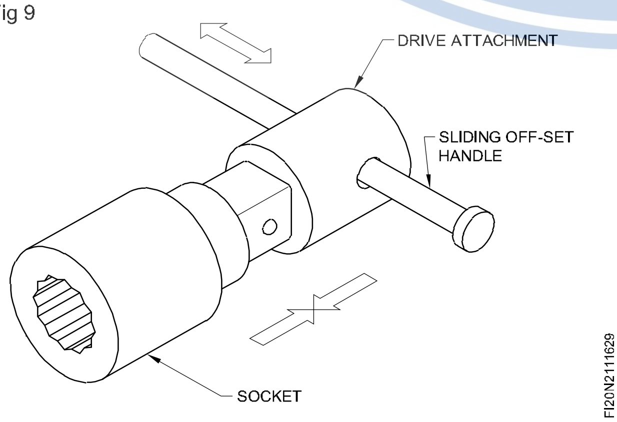


Fig 8



- Socket spanners (Fig 9)

Fig 9



- Adjustable spanners (Figs 10 &11)

Fig 10

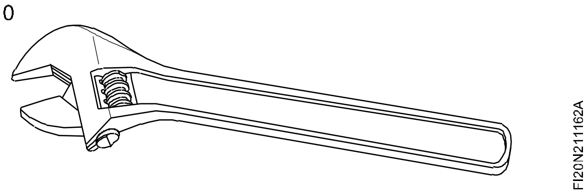
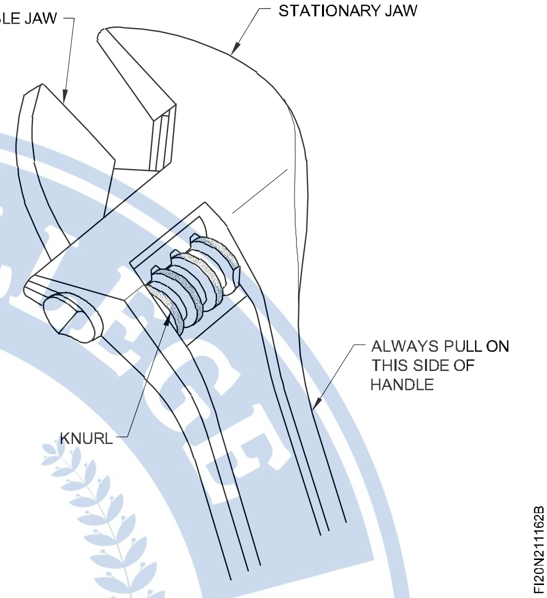


Fig 11



- Hook spanners (C-spanner) (Figs 12 & 13)

Fig 12

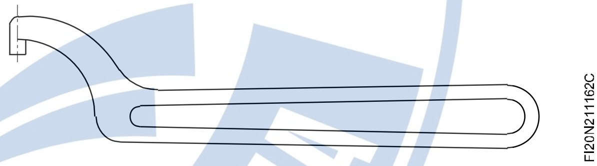
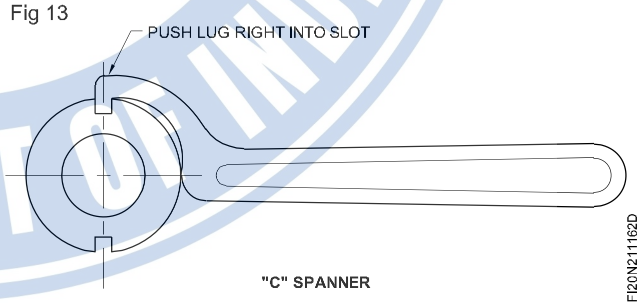


Fig 13



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.**

What does power tools mean?

Power tool is a device that is activated by a power source apart from manual labor. There are various types of power tools, e.g., electric screwdriver, hammer drills, and fast screw guns. The tools are used construction and several do it your self jobs such as productions, assembly, packaging, and maintenance. They are available in multiple sizes and shapes and are simple to operate.

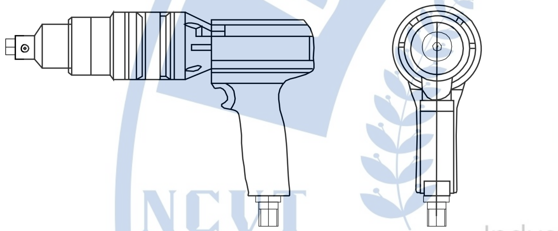
Power wrench (Fig 1)

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

Fig 1



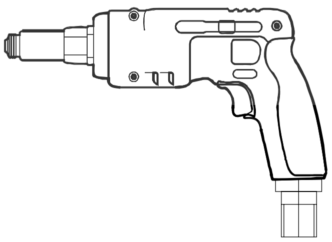
Air ratchet wrench

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 (Fig 2)

Fig 2



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 rebeatability and accuracy.

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

Air requirements

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

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

Torque wrenches

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

Torque

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

Torque wrench

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

Fastener tightening

- Always use a torque wrench to tighten fasteners, and use a slow, smooth, even pull on the wrench.
- When reading a bar type torque wrench, look straight down at the scale.
  - Viewing from an angle can give a false reading.
- Only pull on the handle of the torque wrench.

- do not allow the beam of the wrench to touch any thing.
- Tighten bolts and nuts incrementally
- Typically,this should be to one-half specified torque, to three-fourth torque, to full torque, and then to full torque a second time.

Maximum Tightening Torque

Screw Size	Maximum Torque
M4	270 Nm
M5	5.40 Nm
M6	9.50 Nm
M8	22.0 NM
M10	44.0 NM

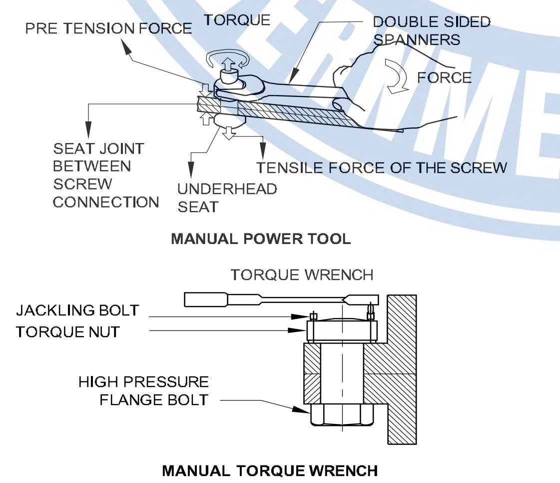
Power Screwdriver

A power screwdriver will merely give us a screw driving capability at a quick and efficient manner. They are designed to work at a slower rate than typical power drills. They however have more torque drills, giving us the ability for more power, such as drilling screws into materials without having to do any predrilling. Solid models will give us torque limiters and allow you to set the maximum 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 they are less weight drills and only take one hand to use.

Explanation on the creation of a clamping force (Fig 3)

Fig 3



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

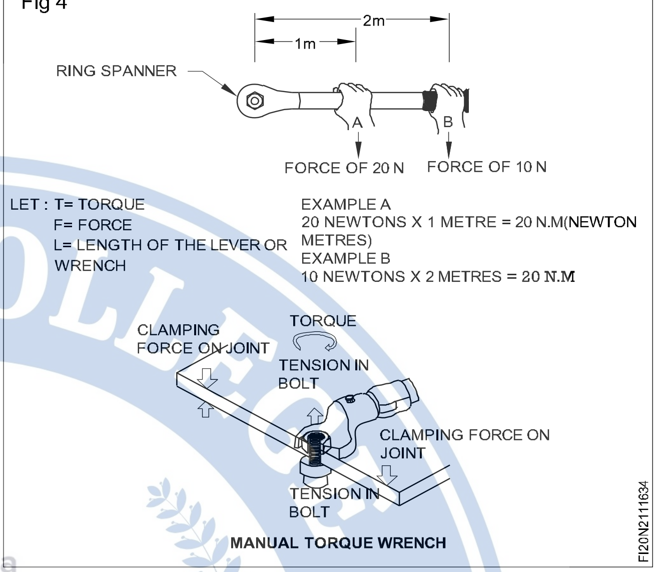
If the clamping force is too low, the fasteners can work loose due to vibrations or movement between the component parts

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 (Fig 4)

Fig 4



Torque is the result of multiplying the valve 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.

(Fig 5 to 10)

Fig 5

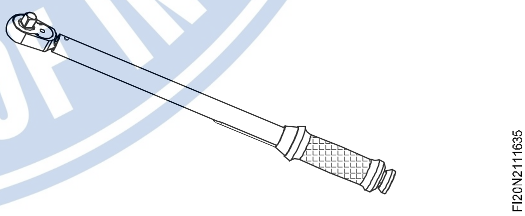


Fig 6

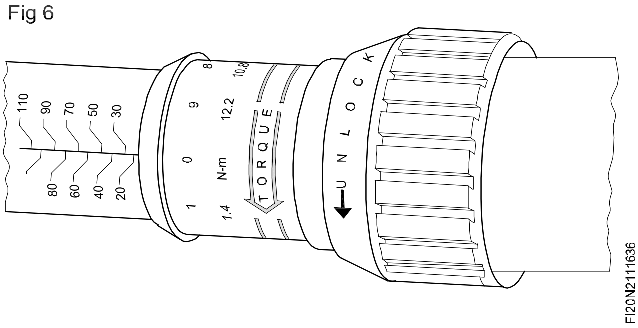


Fig 7

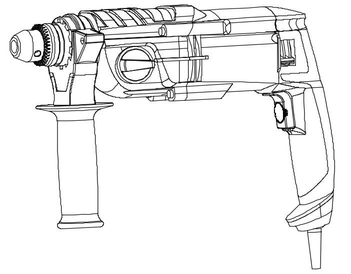


Fig 8

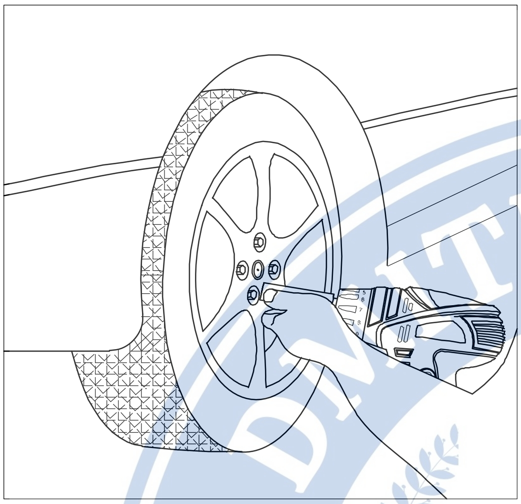


Fig 9

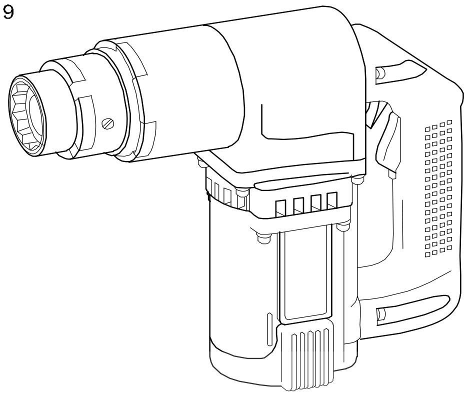
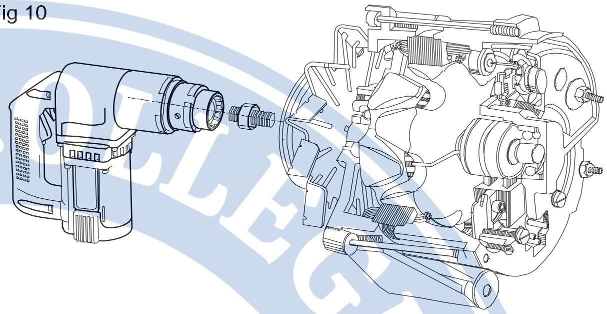


Fig 10



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 - Nuts - Types

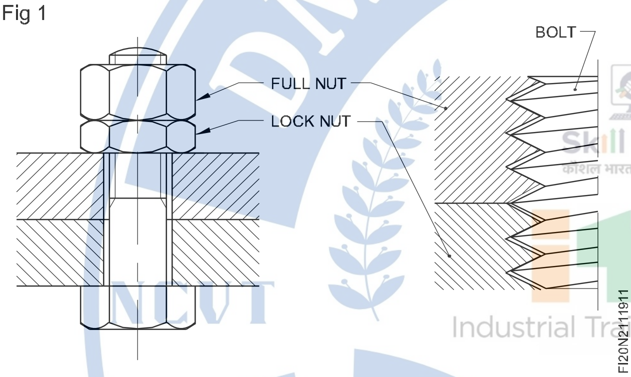
Objectives : At the end of this lesson you shall be able to
- **state the different types of locking devices**
- **state the uses of locking devices.**

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

Lock-nut

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

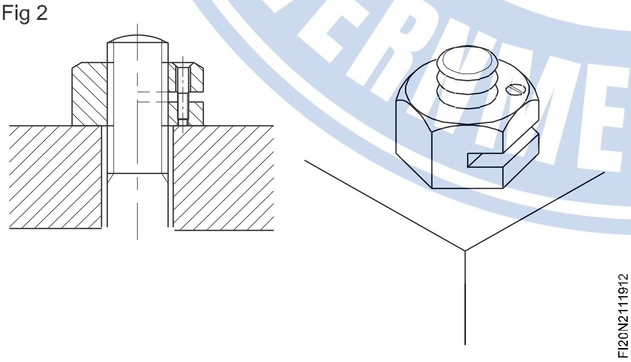
Fig 1



Sawn nut (Wiles nut)

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

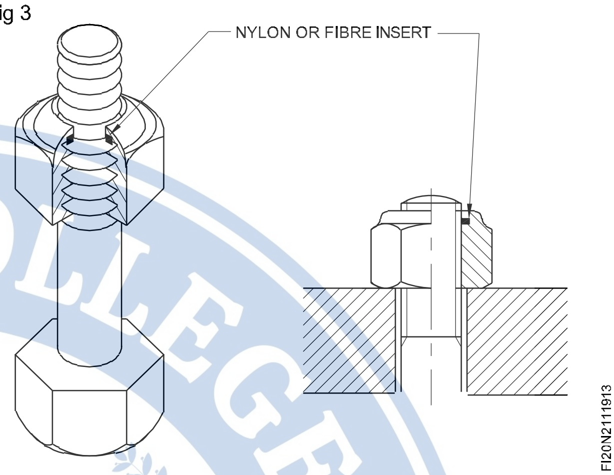
Fig 2



Self-locking nut (Simmonds nut)

This is a special nut with a nylon or fibre ring insert placed in the upper part of the nut. The internal diameter of the ring is smaller than the core diameter of the bolt thread. The nut while tightening cuts its own thread on the nylon insert. This provides a positive grip and prevents the nut from loosening due to vibration. (Fig 3)

Fig 3

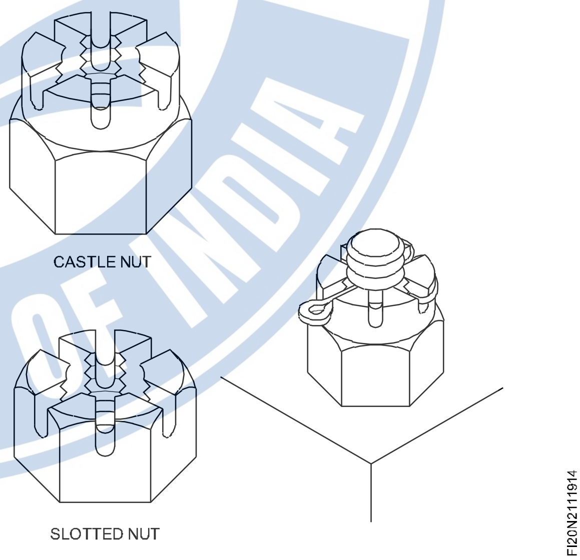


Slotted and castle nuts

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

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

Fig 4



Slotted and castle nut with split pin

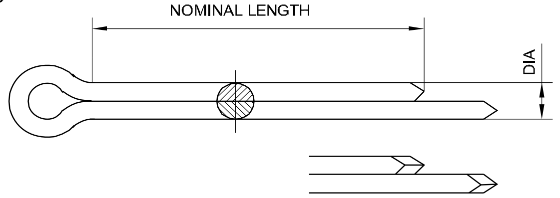
The position of the nut can be locked using a split pin.

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.

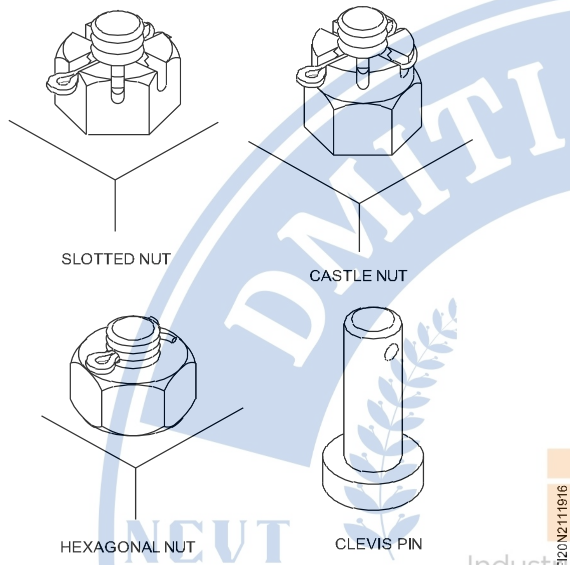
The nominal length is the distance from the underside of the eye to the end of the short leg. (Fig 5)

Fig 5



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

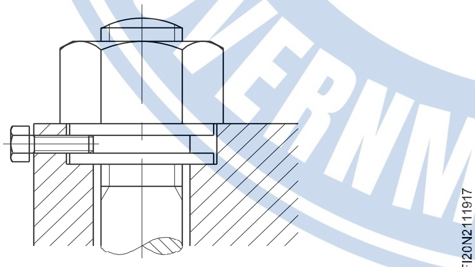
Fig 6



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)

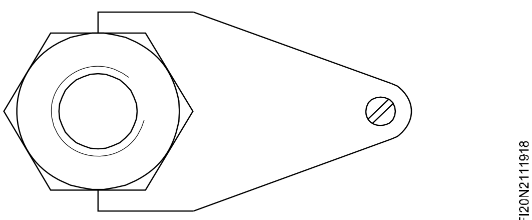
Fig 7



Locking plate

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

Fig 8

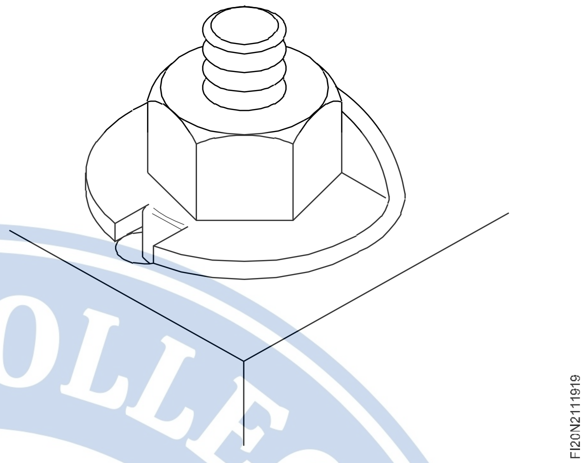


Lock-washers with lug

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

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

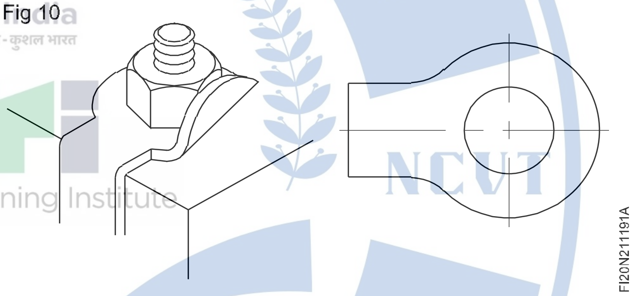
Fig 9



Tab washers (Fig 10)

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

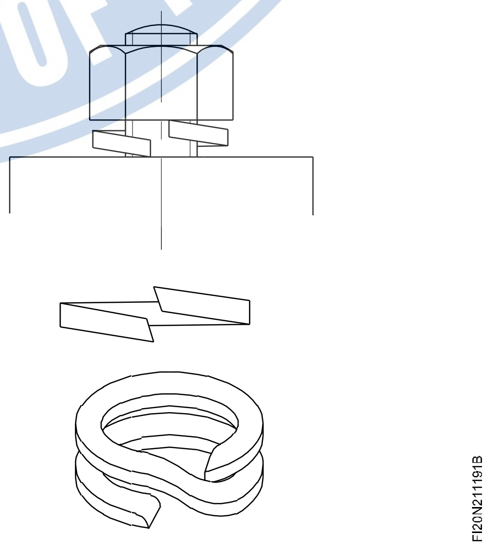
Fig 10



Spring washers (Fig 11)

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

Fig 11



Various types of keys

Objectives : At the end of this lesson you shall be able to
- **list the types of keys**
- **state the specification of keys**
- **state the standard taper of key**
- **state the uses of key pullers.**

Key

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

Purpose

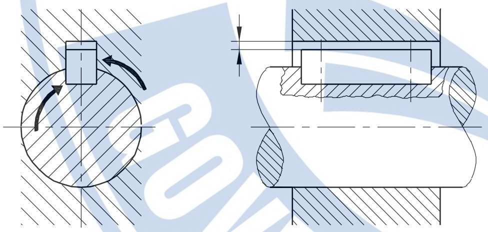
A key is an insert which is housed in the keyway to fit together a hub or a pulley to transmit torque. A keyway is provided on the shaft and also on the hub or on a pulley to connect together the conjugate parts by inserting the key in between. The key can be withdrawn at will to disengage the mating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

Common types

Parallel key or feather key (Fig 1)

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

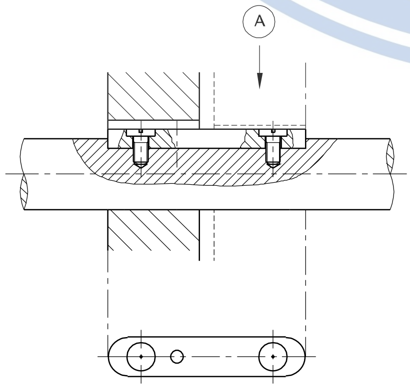
Fig 1



FUNCTIONING OF A FEATHER-KEYED JOINT

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

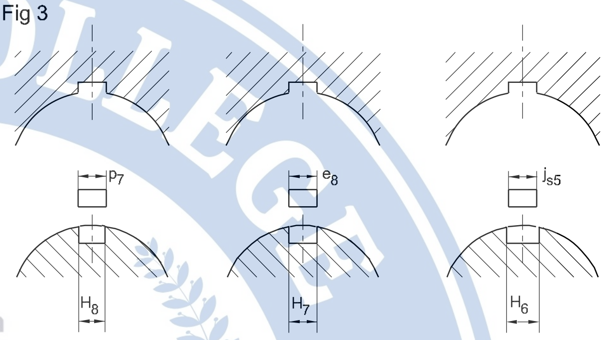
Fig 2



HUB IS MOVABLE

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

Fig 3



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.

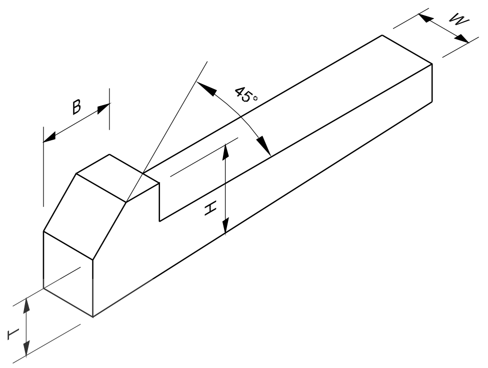
Taper is 1 in 100 on the top face only.

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 with drawn easily and used for transmitting more torque. It is not good for high speed applications.

Approximate proportion of jib-headed key (Fig 4)

Fig 4



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$H = 1.75T$

$B = 1.5\,T$

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

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

Angle of chamfer $= 45°$

Example

Diameter shaft = 46 mm

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

= 13.5 rounded off to 14 mm.

Thickness(T) = $\frac{2}{3}$ x13.5 = 9 mm

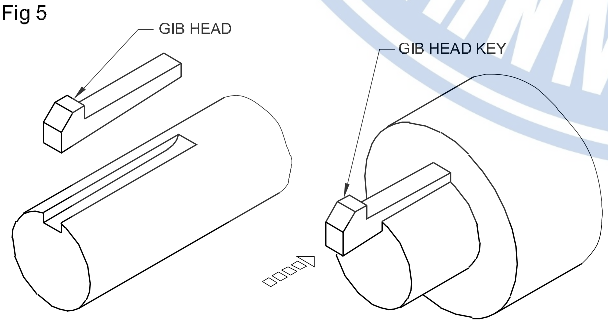
H = 1.75 x 9 = 15.75

say 16 mm

B = 1.5x9 = 13.5 mm.

Woodruff key (Fig 5)

Fig 5



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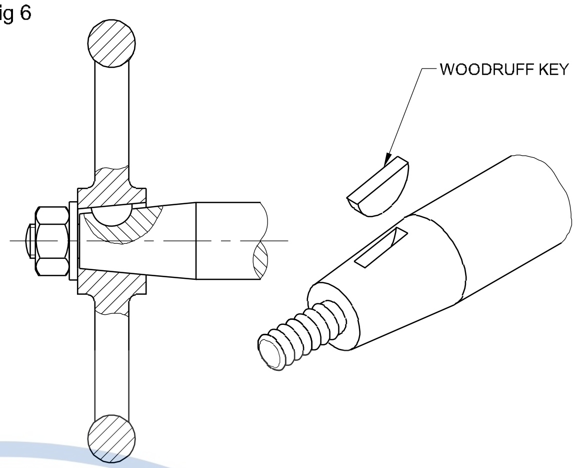
It is a semicircular key used for transmitting light torque. It fits on to the shaft on which matching recesses are cut. The top portion of the key projects out and fits in the keyway cut on the hub. (Fig 6)

Fig 6



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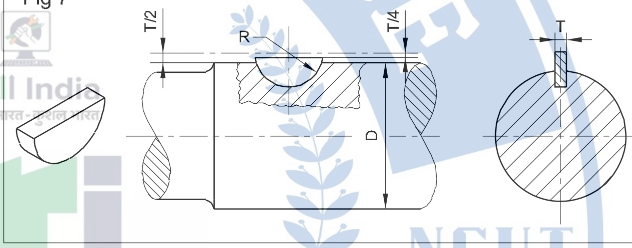
This key is particularly useful on tapered fittings or shafts. Its key way is milled to the profile of the key on the shaft which tends to weaken the shaft. This type of key positions itself in the keyway to accommodate the hub to have an easy assembly.

Approximate proportion of woodruff key (Fig 7)

Fig 7



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

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

Example

For shaft ø 30.

R = 30/3 = 10 mm

T = 30/6 = 5 mm

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

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

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

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

Fig 8

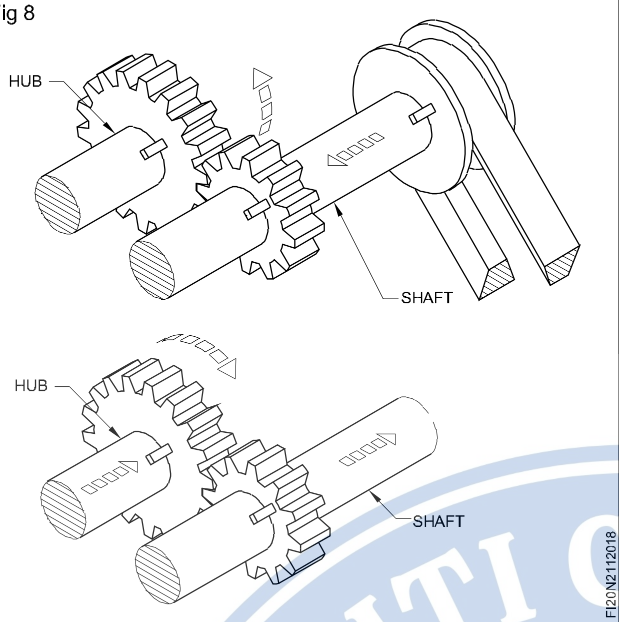
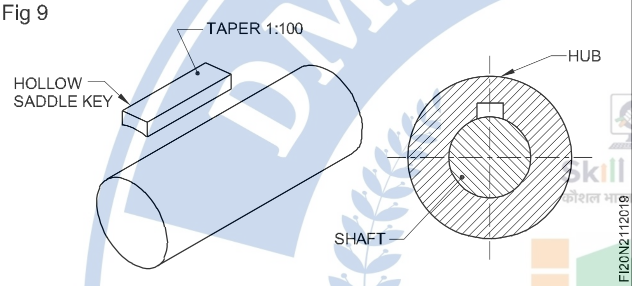


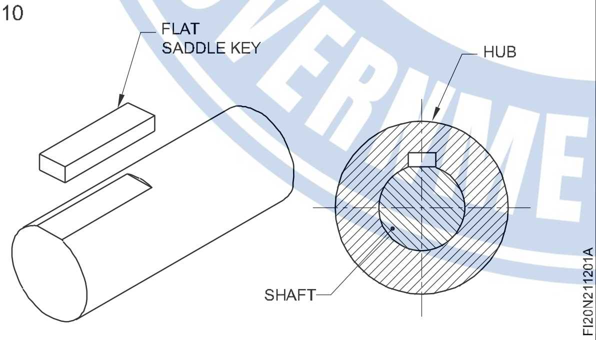
Fig 9



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

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

Fig 10



Approximate proportion

If D is the diameter of the shaft,

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

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

Example

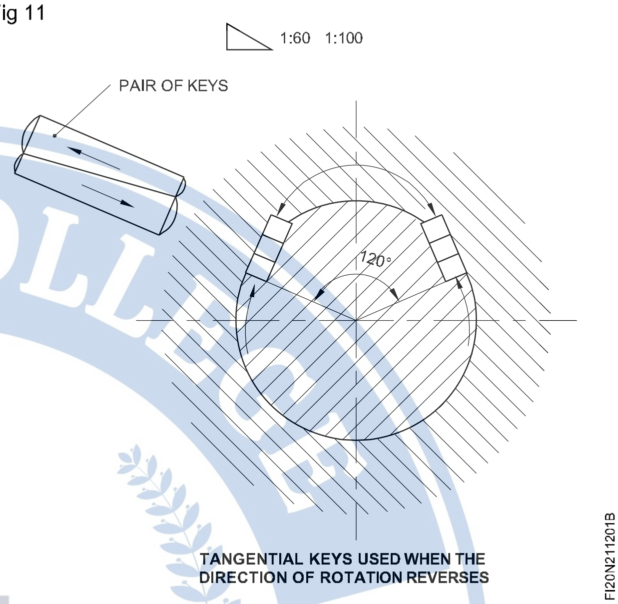
diameter shaft = 24 mm

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

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

Tangential key (Fig 11)

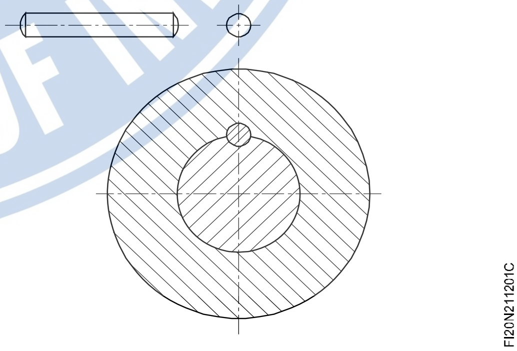
Fig 11



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)

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

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

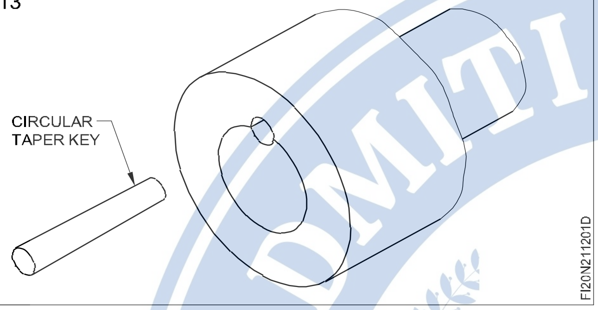
Example

Dia. of shaft = 30 mm

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

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

Fig 13



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

Fig 14

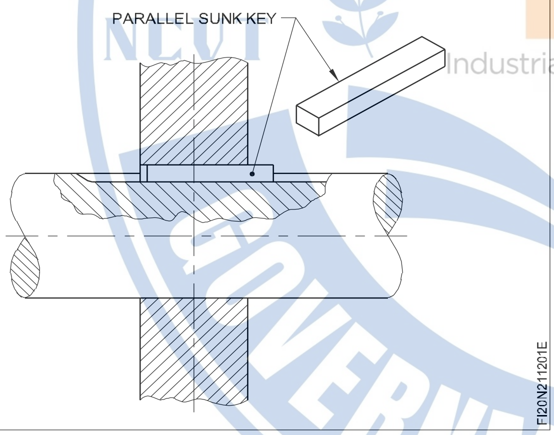
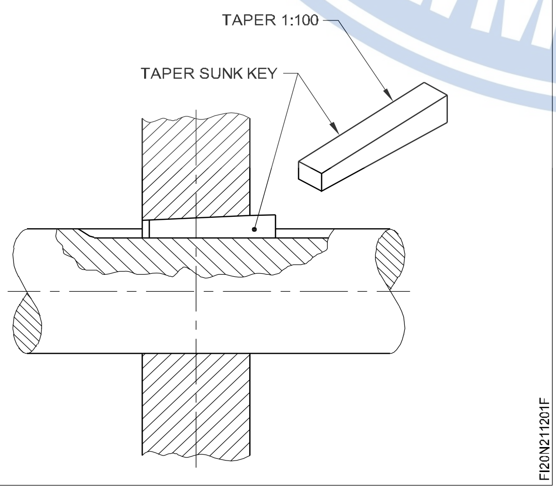
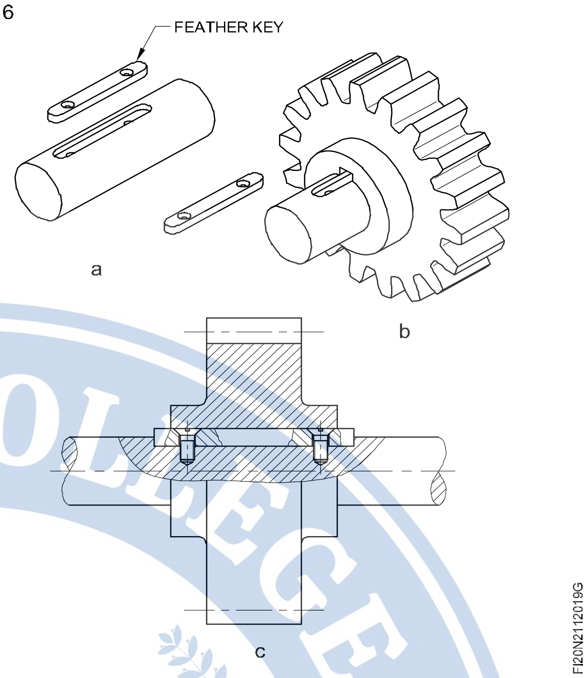


Fig 15



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

Fig 16

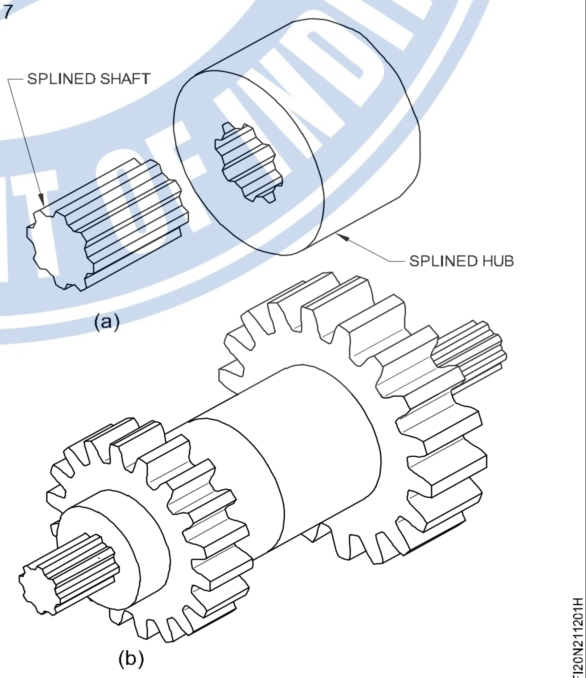


Splines: Splines are ridges (or) teeth on a drive shaft that mesh with grooves in a mating piece and transfer torque to it, maintaining the angular correspondence between them.

An alternative to spline is a key way and key

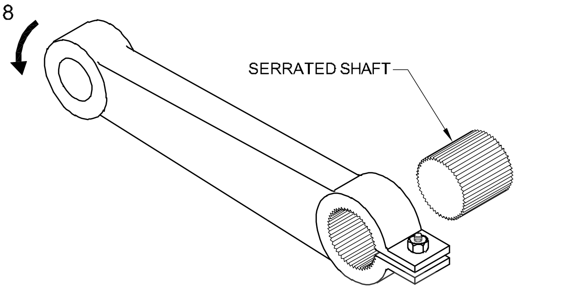
Splined shaft and serrated shaft: Splined shafts along with splined hubs are used particularly in the motor industry. The splined hub can also slide along the shaft, wherever necessary (Figs 17a and b) used while fixing change gears in a lathe and heavy duty drilling machine.

Fig 17



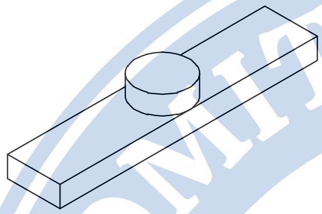
In certain assemblies, serrated shafts are also used for transmission. (Fig 18)

Fig 18



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

Fig 19



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

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

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

Key puller

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

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

Advantages

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

Easy-to-use

1 Turn wheel (A) to move the jaws (1) up or down so that they are aligned with housing (2)

2 Turn wheel (B) to fit the size of the key allowing ± 1 mm space.

3 Turn wheel (B) hand tight to secure the key with the jaws.

4 Then turn wheel (A) to extract the key perpendicularly.

5 Turn wheel (A) to move the jaws down, turn wheel (B) to open the jaws and free

Fig 20

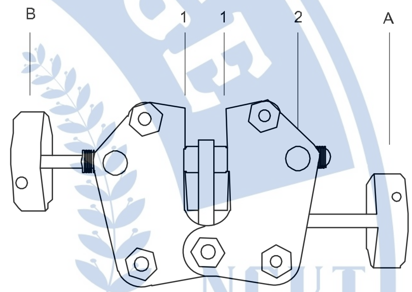


Table 1

Dimensions for keys

(IS 2048 - 1983)

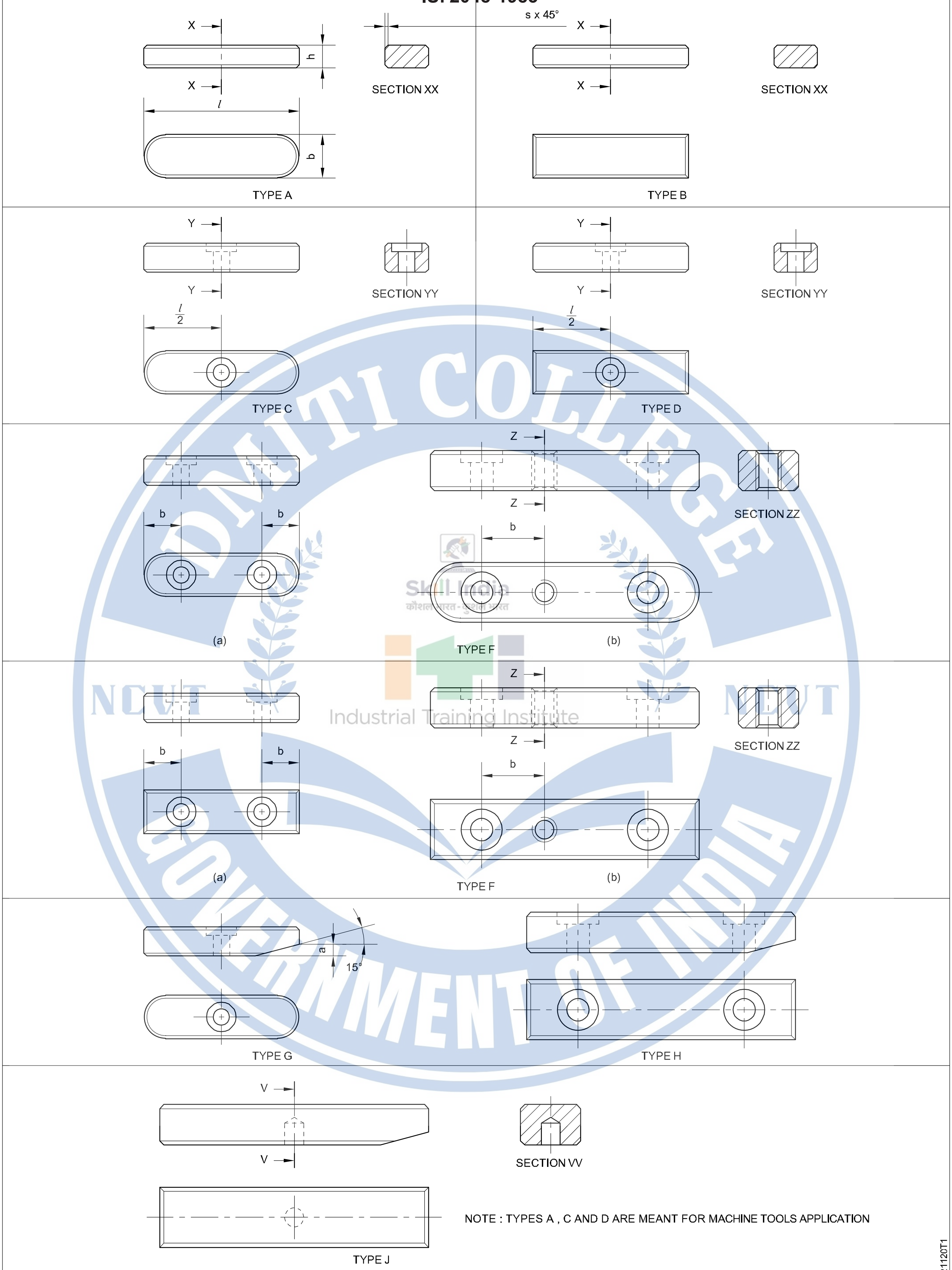
All dimensions in millimetres

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		4		0.16	0.25	8	45	10	45
	0		0						
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
	0								
10	– 0.036	8		0.40	0.60	22	110	25	110
	0								
12		8	– 0.090	0.40	0.60	28	140	32	140
14		9		0.40	0.60	36	160	40	160
	0								
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.

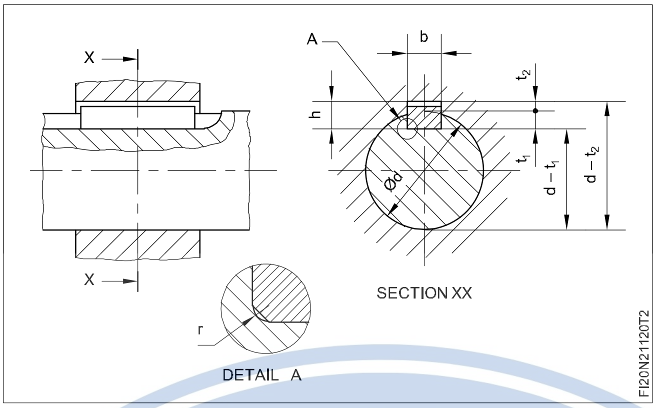
IS: 2048-1983



SUNK AND FEATHER KEYS

Table 2

Dimensions for keyways

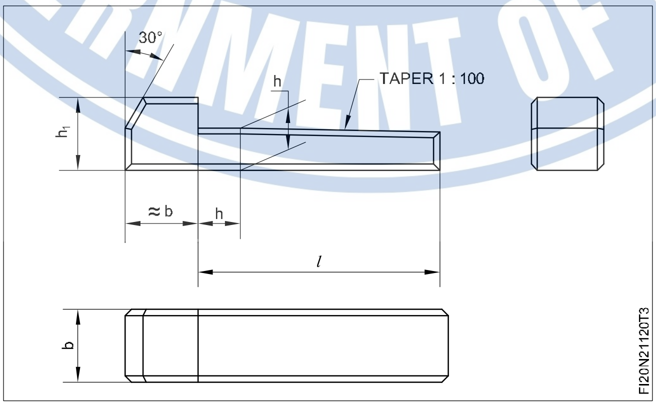


Range of shaft dia d		Key	Keyway										Range of shaft dia d		Keyway for Machine Tools Application			
		b x h	b	Tol on b					t1	Tol	t2 on t1	Tol on t2						
				Running fit		Light drive fit		Force fit										
Above	Upto			Shaft H9	Hub D10	Shaft N9	Hub Js9	Shaft & Hub P9					Above	Upto	t1	Tol on t2	t2	Tol on t2
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

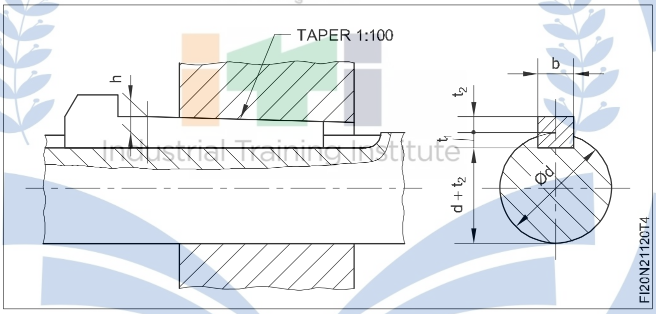


b	Tol on b h9	h	Tol on h*	s		Range of Key length, l		h1
				Min	Max	Min	Max	
4		4		0.16	0.25	14	45	7
5	0 – 0.030	5	0 – 0.030	0.25	0.40	14	56	8
6		6		0.25	0.40	16	70	10
8	0 – 0.036	7	0 – 0.090	0.25	0.40	20	90	11
10		8		0.40	0.60	25	110	12
12		8		0.40	0.60	32	140	12
14	0 – 0.043	9		0.40	0.60	40	160	14
16		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	Keyway							
		b x h	b	Tol on b D10	t1	Tol on t1	t2	Tol on t2	r	
Above	Upto								Min	Max
22	30	8 x 7	8	+ 0.098 + 0.040	4.0		2.4		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		2.4		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	0 + 0.2	3.4	0 + 0.2	0.25	0.40

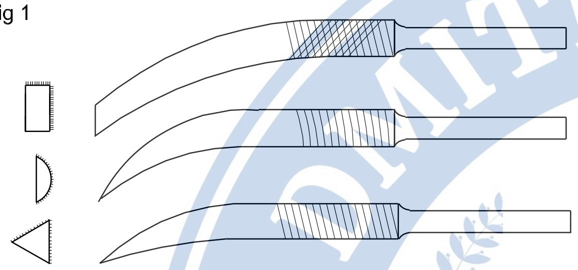
Special Files

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.

Fig 1



FI20N2112111

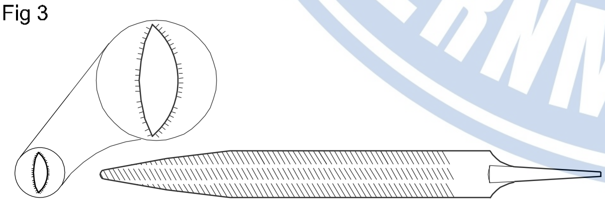
Barrette file (Fig 2): This file has a flat, triangular face with teeth on the wide face only. It is used for finishing sharp corners.

Fig 2

FI20N2112112

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

Fig 3

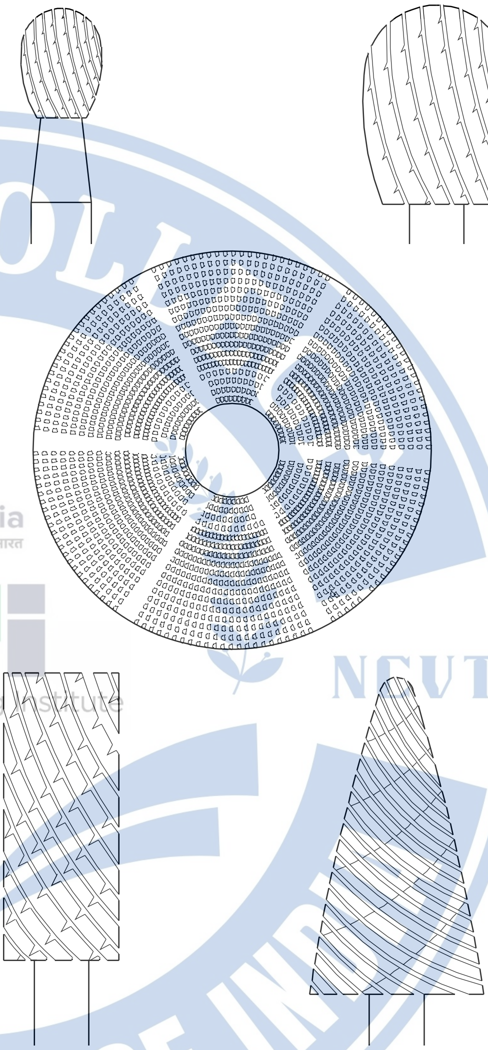


FI20N2112113

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.

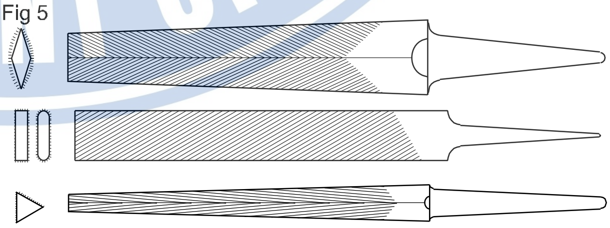
Mill saw files (Fig 5): Mill saw files are usually flat and have square or rounded edges. These are used for sharpening teeth of wood-working saws, and are available in single cut.

Fig 4



FI20N2112114

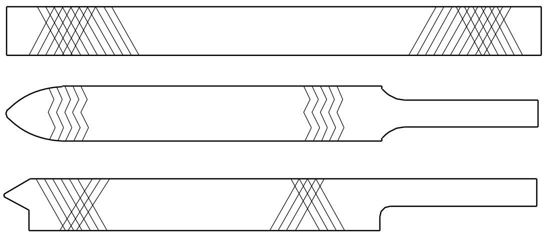
Fig 5



FI20N2112115

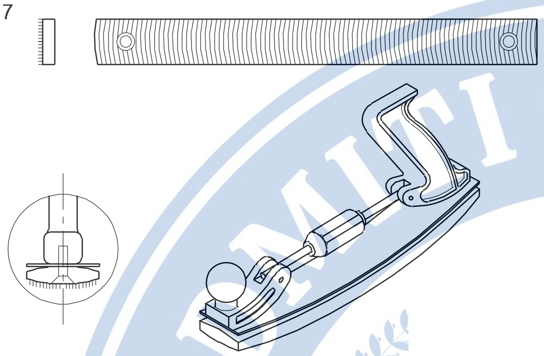
Machine files for hand filing machine (Fig 6): Machine files are of double cut, having holes or projections to fix to the holder of the filing machine. The length and shape will vary according to the machine capacity. These files are suitable for filing the inner and outer surfaces, and are ideal for diesinking and other tool-room work.

Fig 6



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.

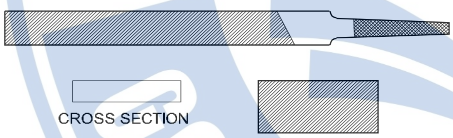
Fig 7



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 form the middle both ways and that is especially suitable for narrow work.

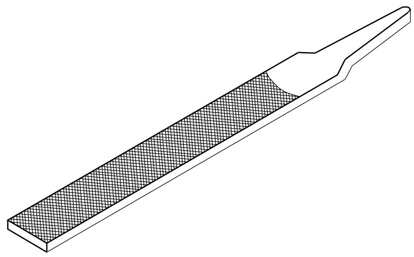
Fig 8



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.

Fig 9



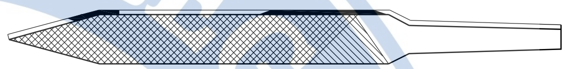
DREAD NAUGHT FILE

A similar tool is the rasp. This is an older form, with simpler teeth. As they have larger clearance between 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)

Fig 10



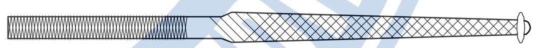
WARDING FILE

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 ward notches 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.

Fig 11



SWISS PATTERN FILE

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

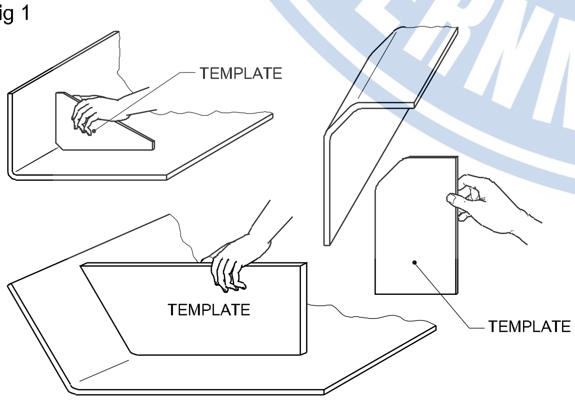
5 Drilling requirement

6 Cutting instructions

7 Assembly reference mark.

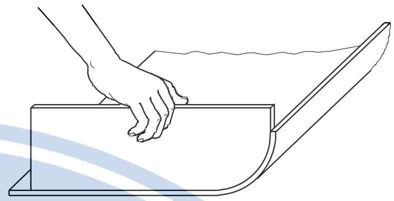
Templates as a means of checking is shown in Fig 1 to 6

Fig 1



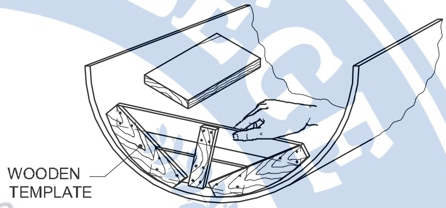
CHECKING ANGLES WITH A TEMPLATE

Fig 2



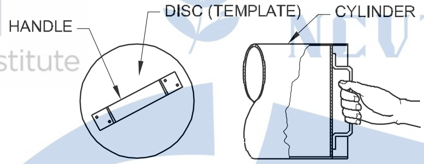
CHECKING THE CONTOUR OF A RADIUSED CORNER

Fig 3



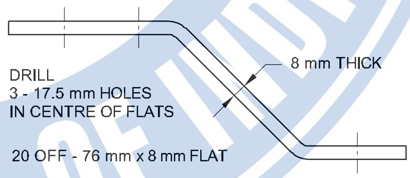
CHECKING THE CONTOUR OF A ROLLED PLATE

Fig 4



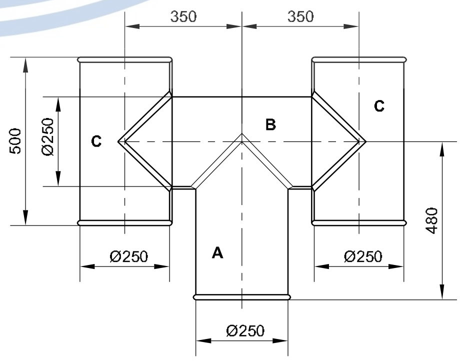
TEMPLATE USED FOR CHECKING CONTOUR OF CYLINDRICAL WORK SUCH AS DUCTWORK.

Fig 5



THE USE OF TEMPLATES AS A MEANS OF CHECKING

Fig 6



CHIMNEY SMOKE COWL

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 7

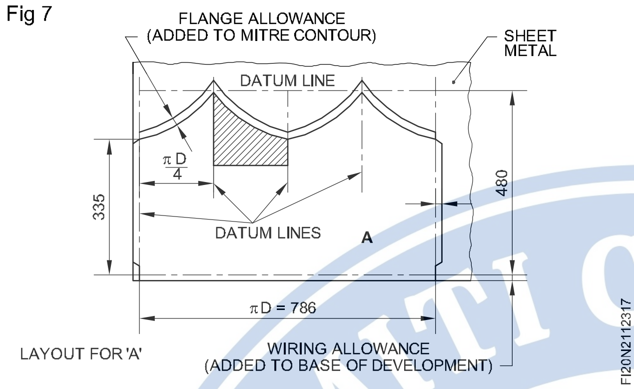
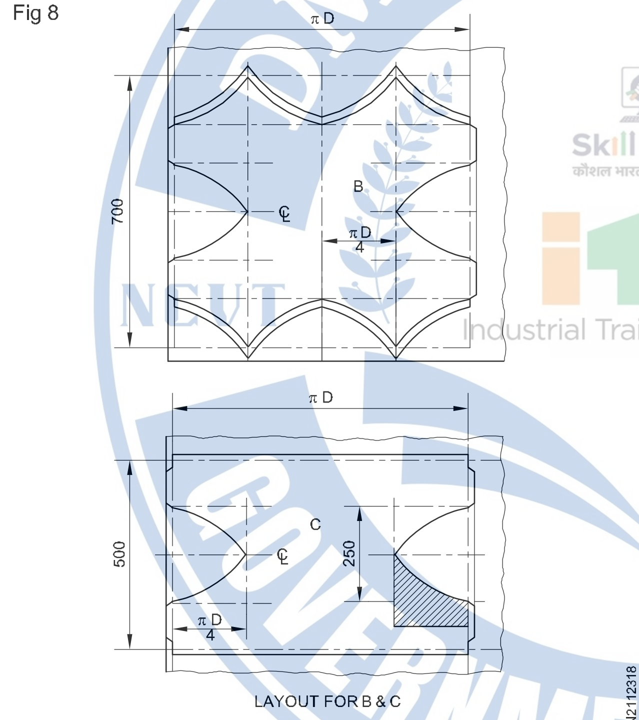


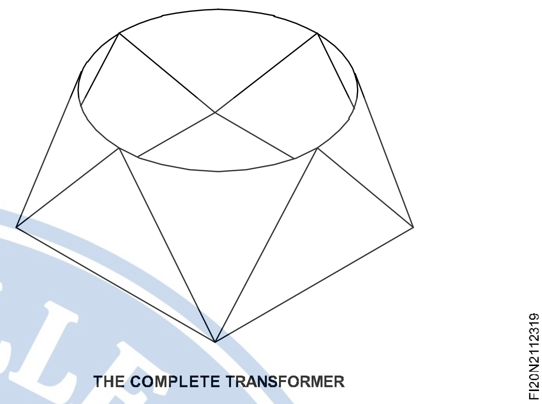
Fig 8



AN EXAMPLE OF THE USE OF TEMPLATES

Fig 9 shows a square to round transformer is an isometric view of the sheet metal trans forming 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.

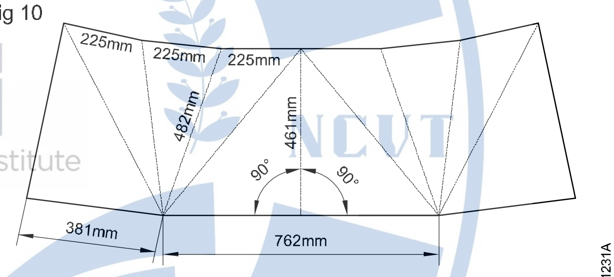
Fig 9



THE COMPLETE TRANSFORMER

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.

Fig 10



PATTERN OR HALF-TEMPLATE WITHOUT JOINT ALLOWANCES

SQUARE TO ROUND TRANSFORMER

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

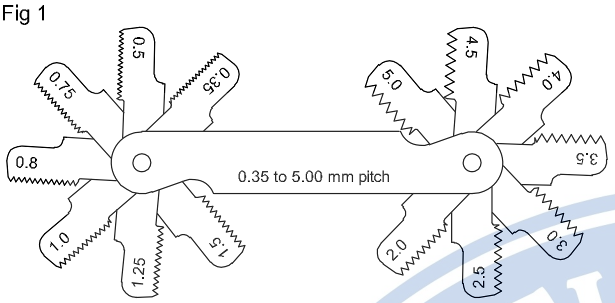
Pitch gauges are available with a number of blades assembled as a set. Each blade is meant for checking a particular standard thread pitch. The blades are made of thin spring steel sheets, and are hardened.

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)

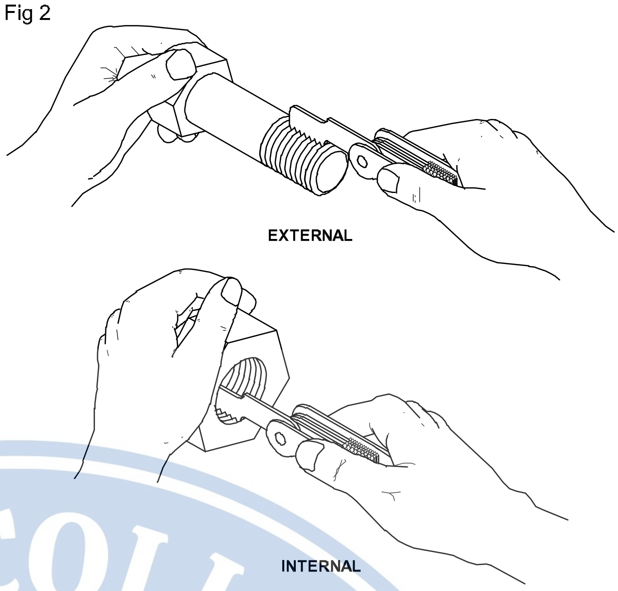
For obtaining accurate results while using the screw pitch gauge, the full length of the blade should be placed on the threads. (Fig 2)

Fig 1



SCREW PITCH GAUGE

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.**

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 is normally provided on a drawing. The gauges used to check the radius formed on the edges of diameters are fillet and the gauges used to check the fillets are called fillets gauges.

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

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

Fig 1

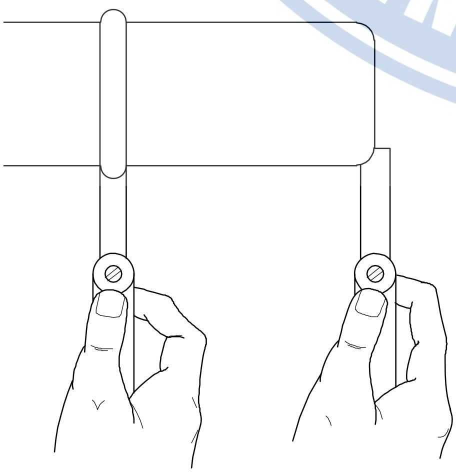
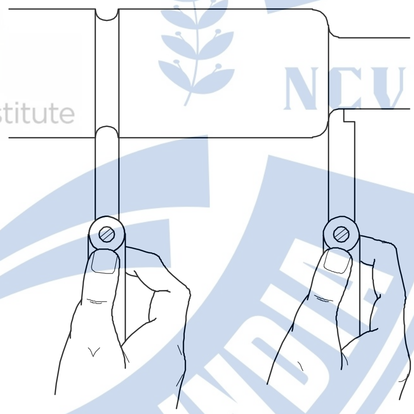
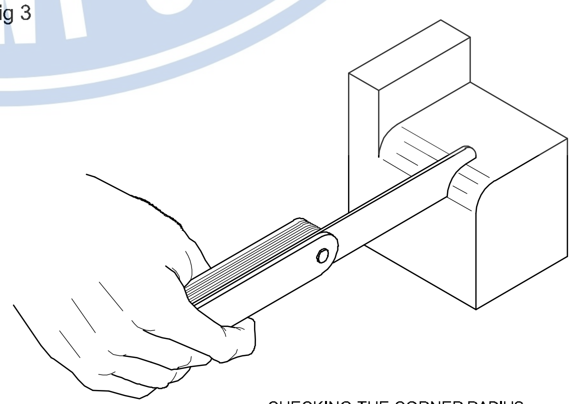


Fig 2



– Checking the corner radius of a part being filed to shape. (Fig 3)

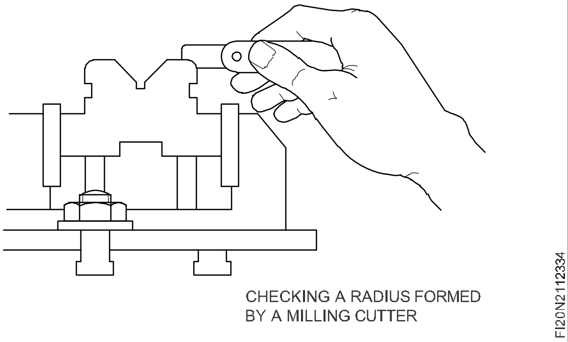
Fig 3



CHECKING THE CORNER RADIUS OF A PART BEING FILED TO SHAPE

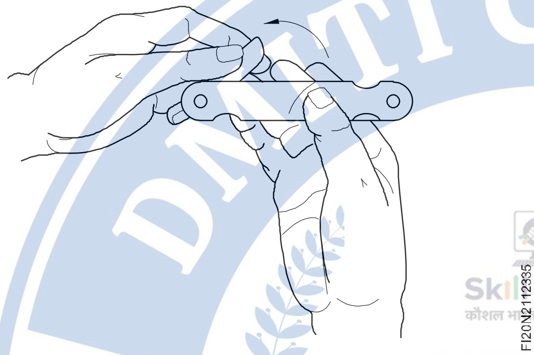
– Checking a radius formed by a milling cutter. (Fig 4)

Fig 4



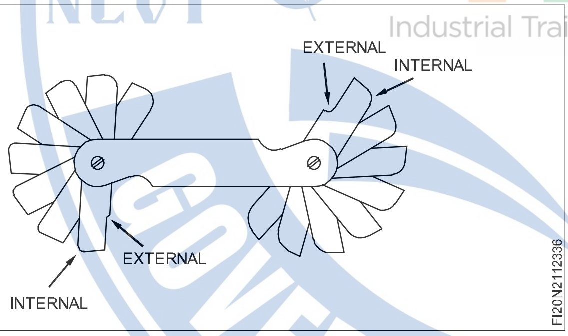
The radius and fillet gauges are available in sets of several blades which fold into a holder when not in use. (Fig 5)

Fig 5



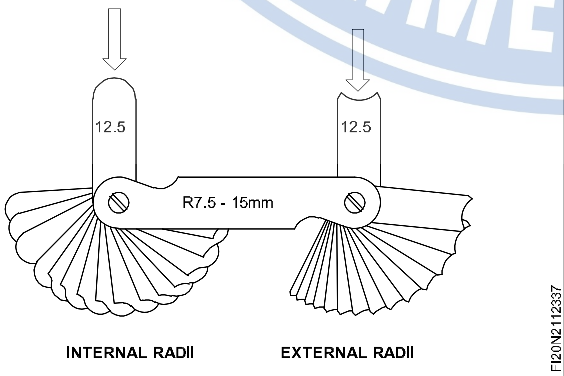
Some sets have provisions to check the radius and fillet on each blade. (Fig 6)

Fig 6



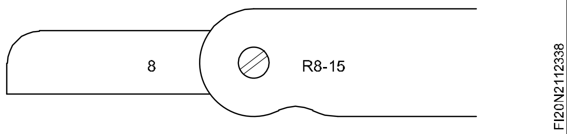
And some sets have separate sets of blades to check the radius and fillet. (Fig 7)

Fig 7



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

Fig 8



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

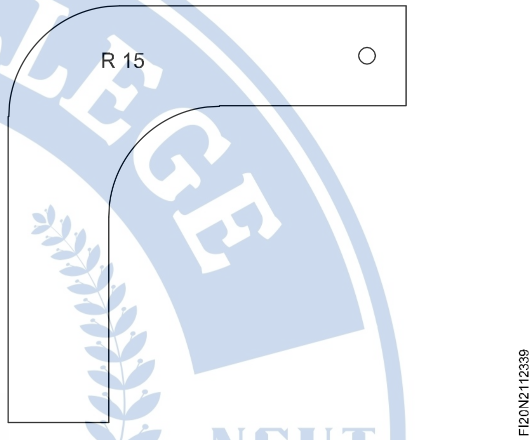
1 to 7 mm in steps of 0.5 mm

7.5 to 15 mm in steps of 0.5 mm

15.5 to 25 mm in steps 0.5 mm.

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

Fig 9



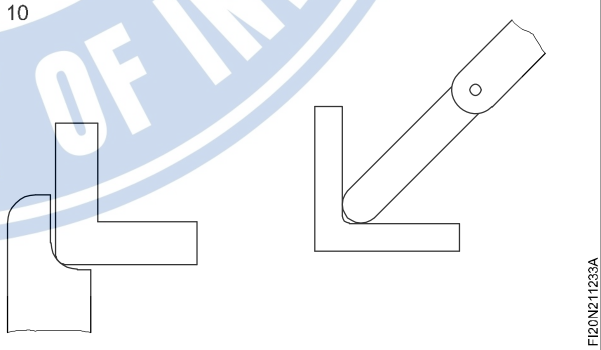
Before using the radius gauge, check that it is clean and undamaged.

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.

Fig 10



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 11

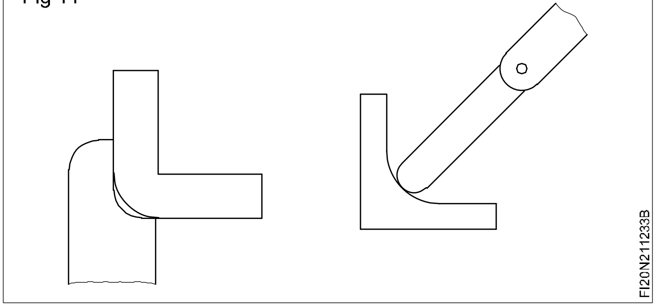
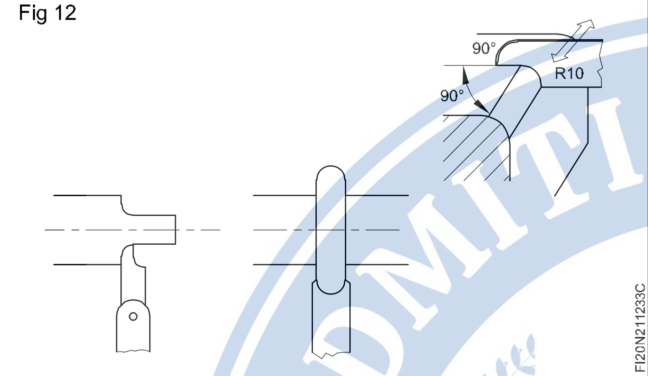


Fig 12 shows the workpiece having the same radius as that of the gauge that is being used for checking.

Fig 12

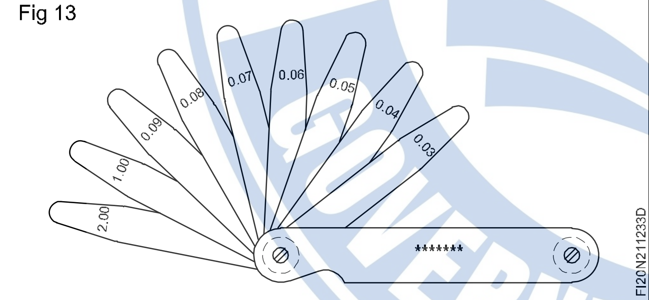


Feeler gauge and uses

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)

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.

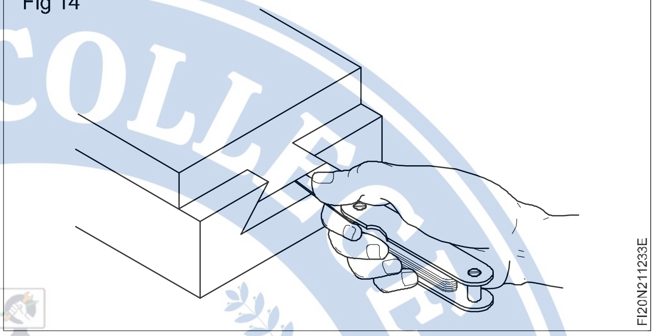
The sizes of the feeler gauges in a set are carefully chosen in order that a maximum number of dimensions can be formed by building up from a minimum number of leaves.

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:

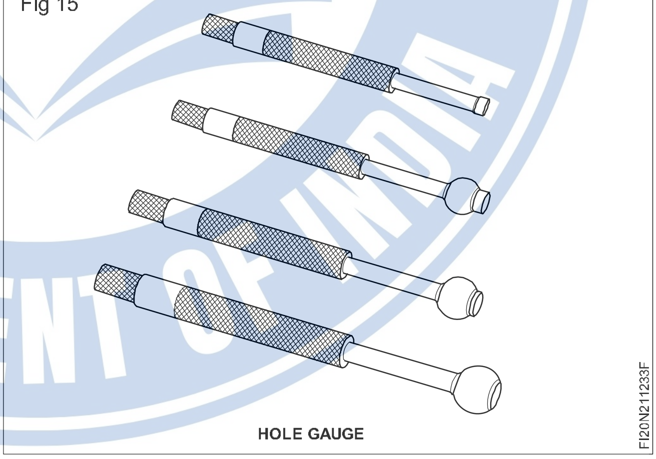
– To check the gap between the mating parts
– To check and set the spark plug gaps
– To set the clearance between the fixture (setting block) and the cutter/tool for machining the jobs
– To check and measure the bearing clearance, and for many other purposes where a specified clearance must be maintained.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

Fig 14



Hole gauge: Hole gages is used to determine the diameter of a hole. While their function is similar to bore gages, they are less precise, much simpler tools that require measurement of a transferred dimension. This gauge is made up of hardened steel, it consisting of precision machined split half ball on each gage for high-accuracy, two-point contact measuremtns throughout the entire column of small bores. (Fig 15)

Fig 15



Care and Maintenance of Gauges

- Before using a gauge, check the gauge for any rust, flaw, burr etc. If rust, flaw or burr is found, remove it.
- Do not hit the gauge by strong force
- Inspect a gauge periodically in consideration of wear, frequency in use and other factors
- Do not use gauges for any other purpose than Inspection.

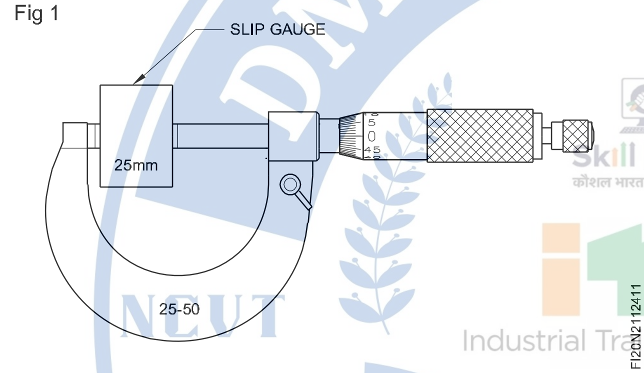
Slip Gauges

Objectives : At the end of this lesson you shall be able to
- **define the features of slip gauges**
- **state the different grades of slip gauges**
- **state the number of slips in standard**
- **state the precautions and application of slip gauges.**

Slip gauges

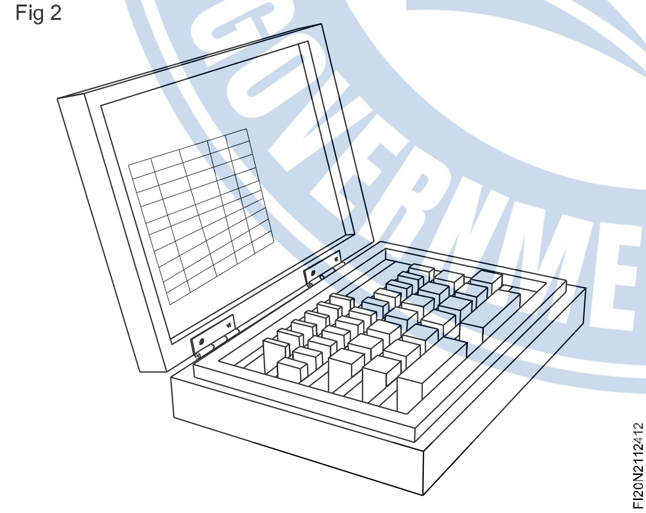
Slip gauges are gauge blocks used as standards for precision length measurement. (Fig 1) These are made in sets and consist of a number of hardened blocks, made of high grade steel with low thermal expansion. They are hardened throughout, and heat treated further for stabilization. The two opposite measuring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

Fig 1



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

Fig 2



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

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

Some sets of slip gauges also contain protector slips of some standard thickness made from higher wear-

Fig 3

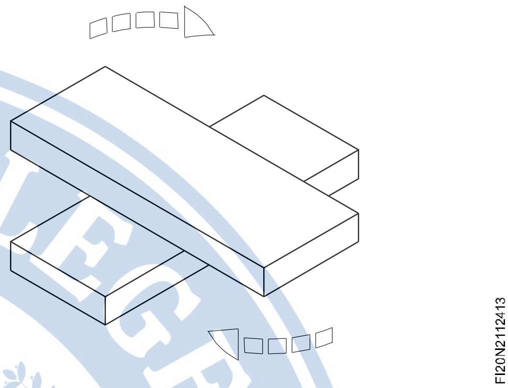
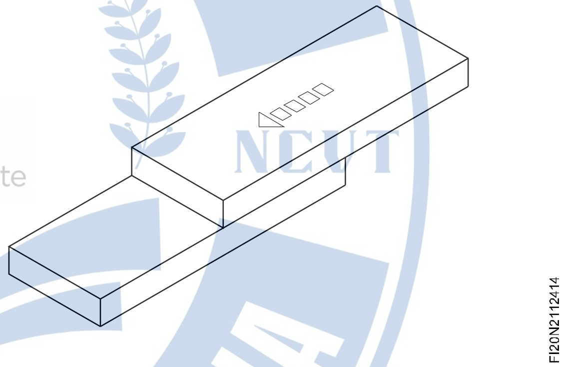


Fig 4



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.

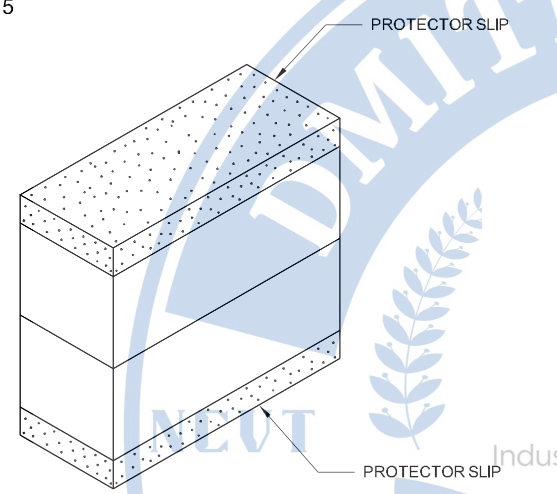
Care and maintenance points to be remembered while using slip gauges.

- 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)

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
1st series 1.001 to 1.009	0.001	9
2nd series 1.01 to 1.49	0.01	49
3rd series 0.5 to 24.5	0.5	49
4th series 25.0 to 100.0	25.00	4
Total pieces		112

Set of 103 pieces (M103)

Range (mm)	Steps (mm)	No.of pieces
1st series 1.005	-	1
2nd series 1.01 to 1.49	0.01	49
3rd series 0.5 to 24.5	0.5	49
4th series 25 to 100	25.00	4
Total pieces		103

Set of 46 pieces (M46)

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

Selection and determination of slip gauges for different sizes

Objective: At the end of this lesson you shall be able to
- **determine slip gauges for different sizes.**

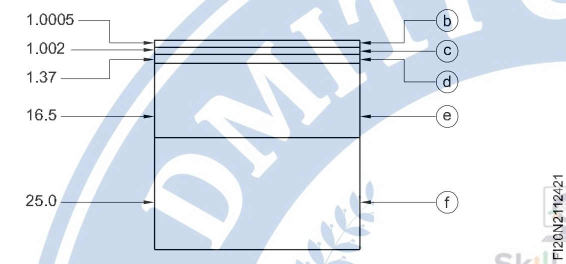
For determining a particular size, in most cases a number of slip gauges are to be selected and stacked one over the other by wringing the slip gauges.

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

Example (Without using protector slips)

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

Fig 1



Set of 112 pieces (M112)

Range (mm)	Steps (mm)	No.of pieces
1.0005	--	1
1.001 to 1.009	0.001	9
1.01 to 1.49	0.01	49
0.5 to 24.5	0.5	49
25.00 to 100.0	25.00	4
Total pieces		112

TABLE 1

Procedure	Slip pack	Calculation
a First write the required dimension		44.8725
b Select the slip gauge having the 4th decimal place	1.0005 subtract	1.0005
		43.872
c Select 1st series slip that has the same last figure	1.002 subtract	1.002
		42.870
d Select the 2nd series slip that has the same last figure and that will leave 0.0 or 0.5 as the last figure	1.37 subtract	1.37
		41.5
e Select a 3rd series slip that will leave the nearest 4th series slip	16.5 subtract	16.5
	(41.5 - 25 = 16.5)	25.00
f Select a slip that eliminates the final figure Add	25.0 subtract	25.00
	44.8725	00.00

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.**

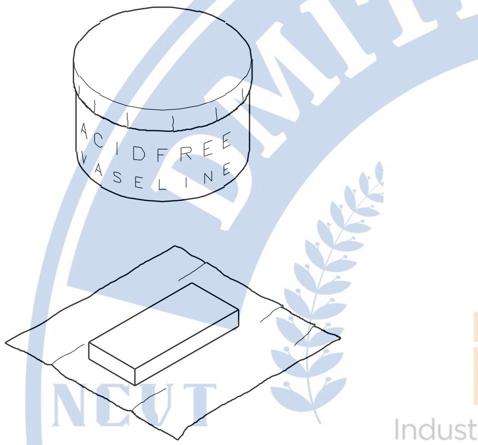
Precision measuring instruments play an important role in maintaining the quality of the products. Measuring instruments are also very expensive. It is important that the instruments are well looked after and maintained by the person who uses it.

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)

Fig 1



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

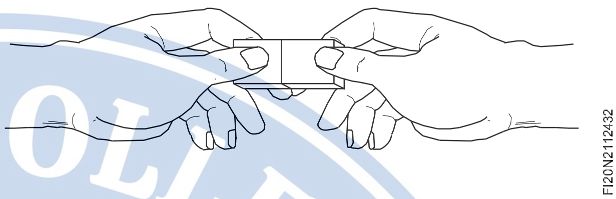
Use chamois leather for giving a light coating of vaseline.

> **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.

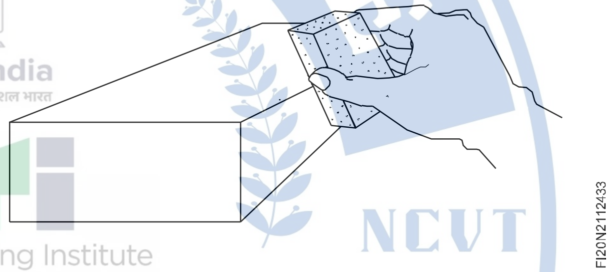
Metal or other particles between the measuring faces of slip gauges will make it impossible for them to adhere to each other.(Fig 2)

Fig 2



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

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 it to mix up with other tools.**

Application of slip gauges

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)

Fig 1

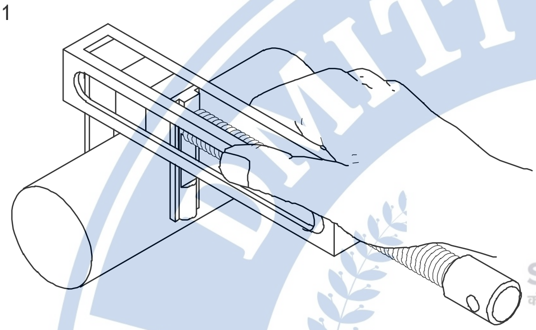


Fig 2

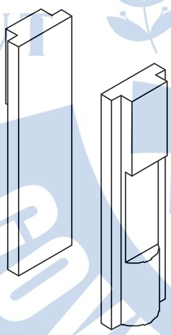
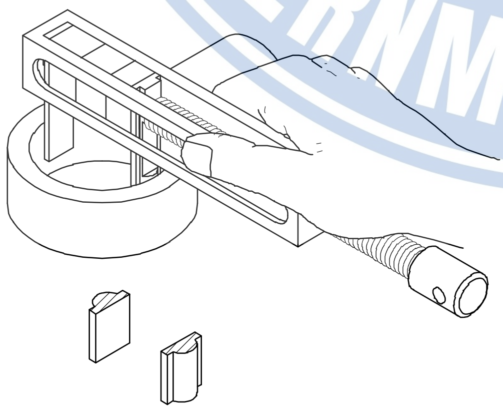
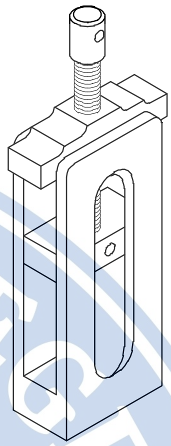


Fig 3



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)

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.

Fig 5

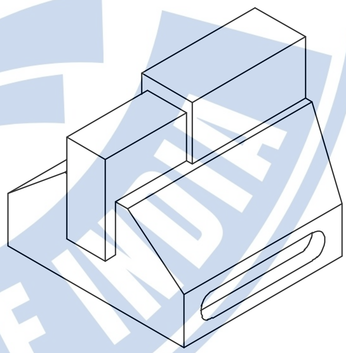


Fig 6

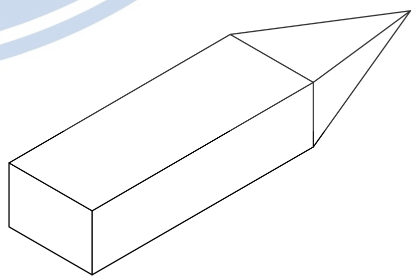
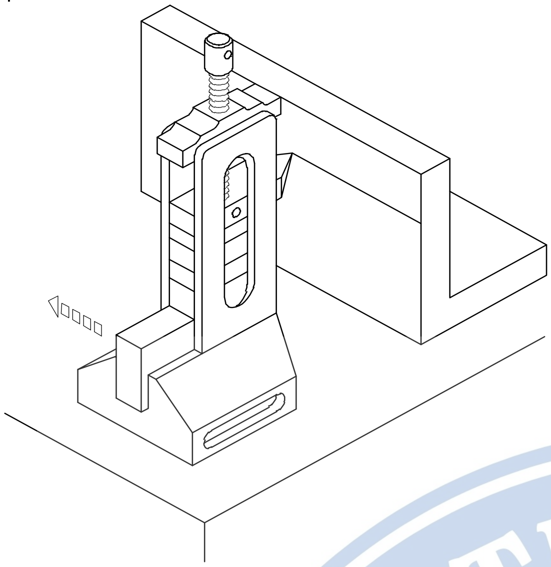


Fig 7



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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)

Fig 8

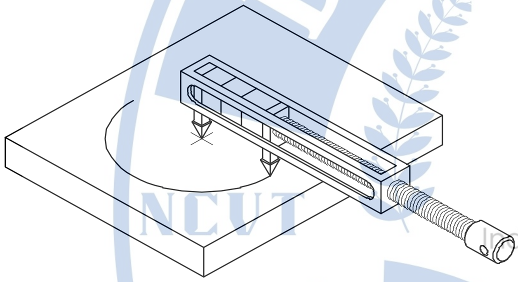

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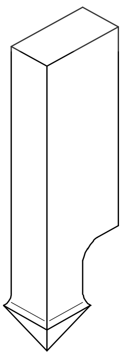
Fig 9

FI20N2112519

Fig 10



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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.

Fig 11

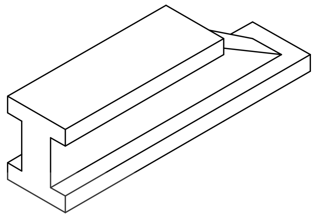

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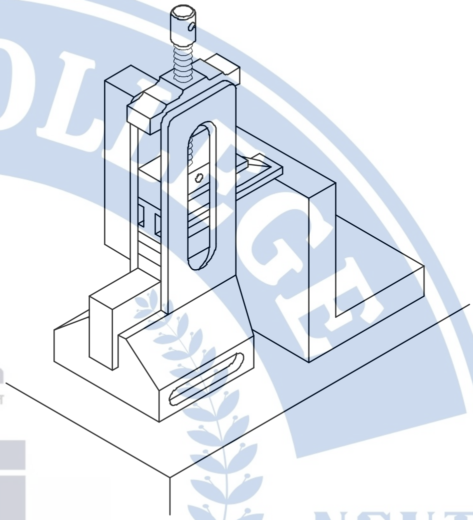
Fig 12



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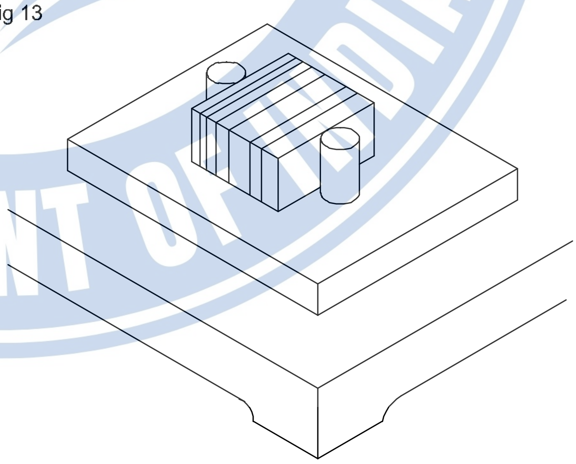
Checking centre distance of holes

With the help of precision cylindrical pins, the centre distance between holes can be accurately measured. (Fig13)

Fig 13



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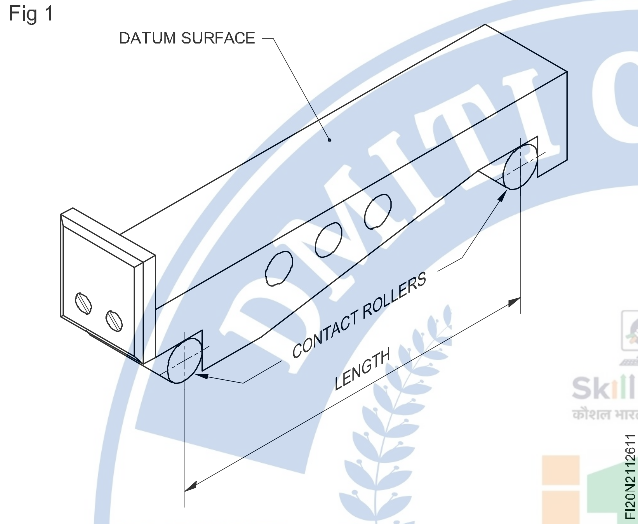
Sine bar principle application and specification

Objectives : At the end of this lesson you shall be able to
- **state the principle of a sine bar**
- **specify the sizes of sine bar**
- **state the features of sine bars**
- **state the different uses of sine bar using slip gauges.**

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

Fig 1

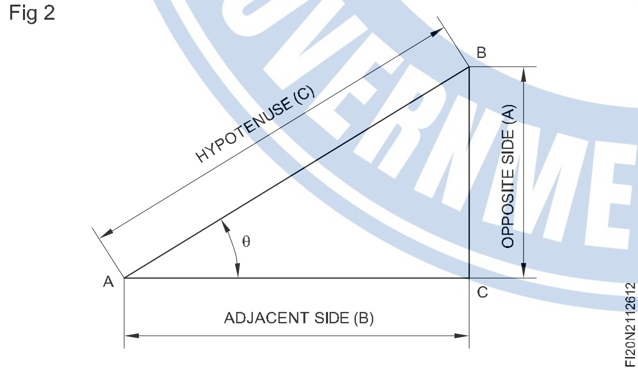


The principle of a sine bar

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

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

Fig 2

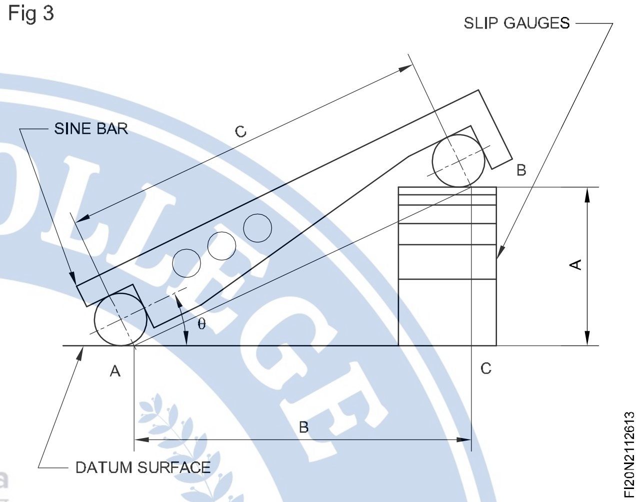


It may be noted that for setting the sine bar to different angles, slip gauges are used.

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

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

Fig 3



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

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

Features

This is a rectangular bar made of stabilized chromium steel.

The surfaces are accurately finished by grinding and lapping.

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

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

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

Uses

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

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

Fig 4

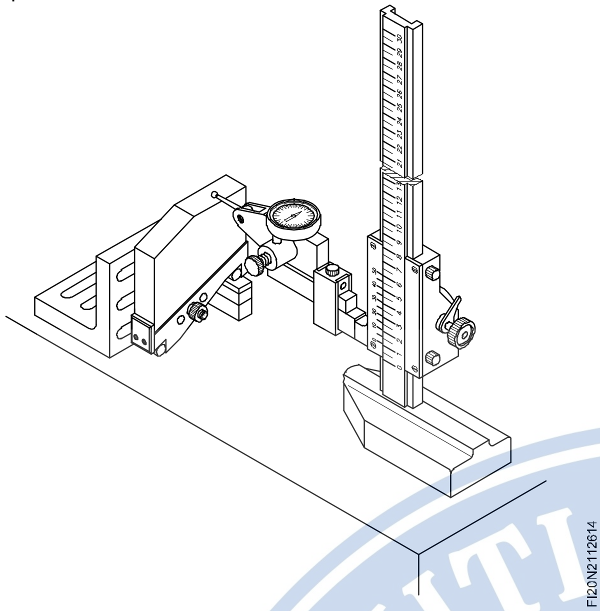


Fig 6

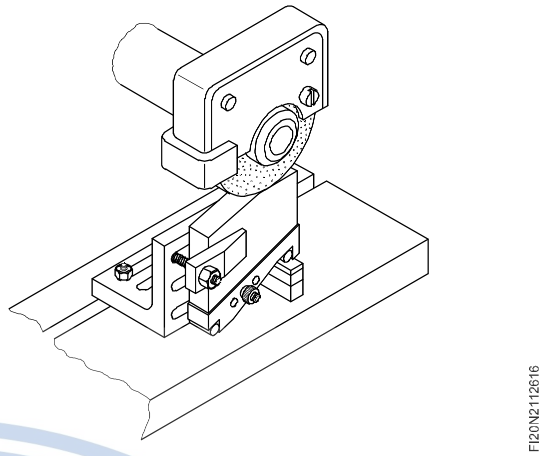
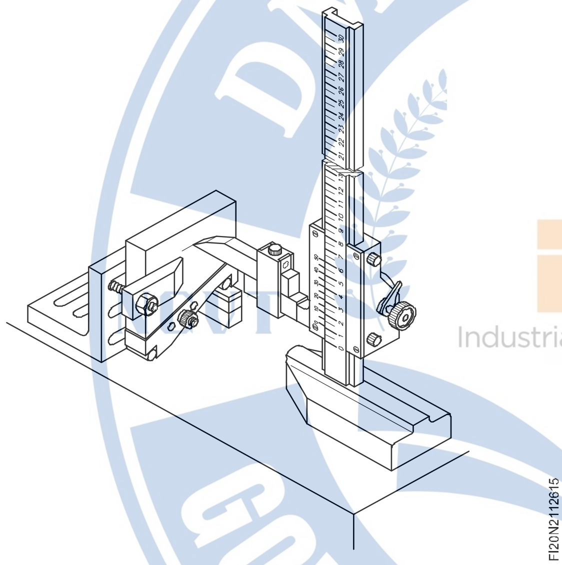


Fig 5



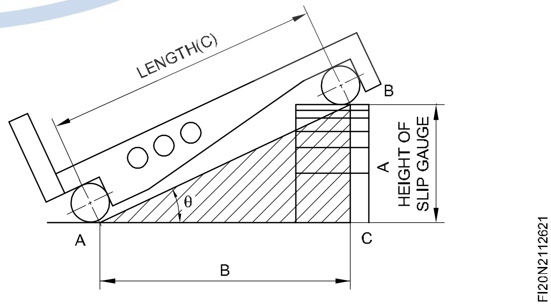
Determining taper using sine bar and slip gauges

Objectives: At the end of this lesson you shall be able to
- **determine correctness of a known angle**
- **calculate the height of slip gauges to a known angle.**

Sine bars provide a simple means of checking angles to a high degree of accuracy of not less than one minute upto 45^0.

The use of a sine bar is based on trigonometric function. The sine bar forms the hypotenuse of the triangle and the slip gauges the opposite side. (Fig 1)

Fig 1



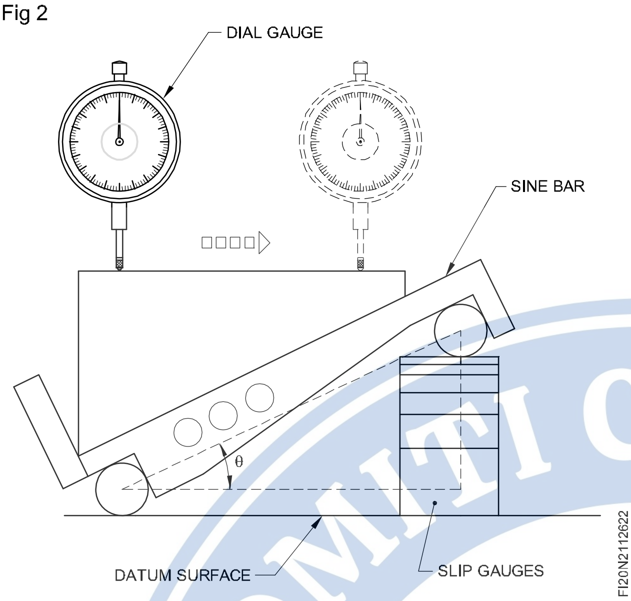
Checking the correctness of a known angle

For this purpose first choose the correct slip gauge combination for the angle to be checked.

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

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

Fig 2

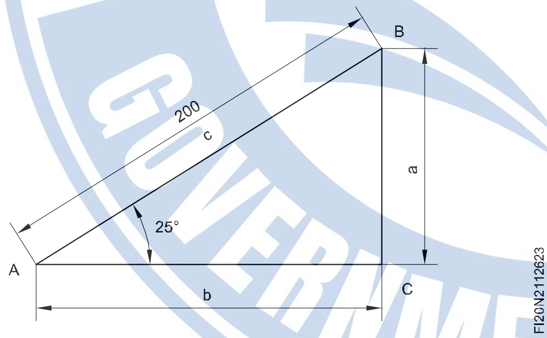


Move the dial to the other end of the component (second position). If there is any difference then the angle is incorrect. The height of the slip gauge pack can be adjusted until the dial test indicator reads zero on both ends. The actual angle can then be calculated and the deviation, if any, will be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

Method of calculating the slip gauge height

Example (Fig 3)

Fig 3



Exercise 1

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

$\theta = 25^0$ $\quad \text{Sine } \theta = \frac{a}{c}$

$a = C \text{ Sine } \theta$

$= 200 \times 0.4226$

$a = 84.52$ mm

The height of the slip gauge required is 84.52 mm.

The value of sine θ can be obtained from mathematical tables. (Natural trigonometrical functions)

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

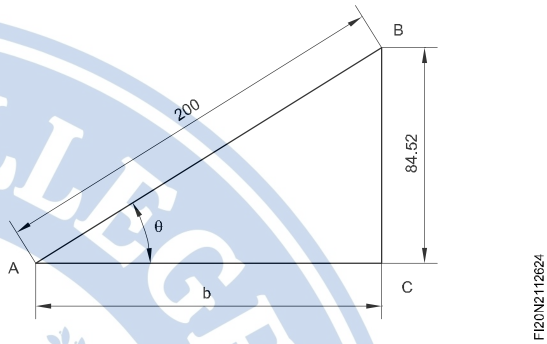
Calculating the angle for tapered components

Exercise 2

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

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

Fig 4



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

$= \frac{84.52}{200}$

$\text{sine } \theta = 0.4226$

The angle whose sine value is 0.4226 is 25^0. Hence the angle of tapered component is 25^0.

Classroom Assignment

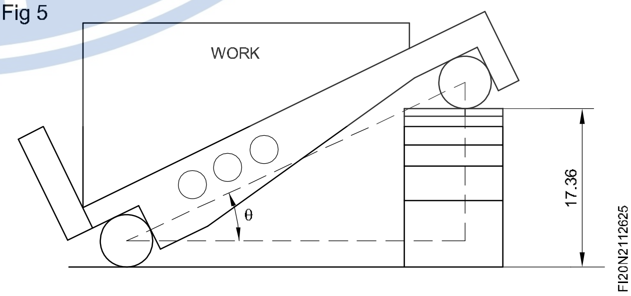
1 What will be the angle of the workpiece if the slip gauge pack height is 17.36 mm and the size of the sine bar used is 100 mm? (Fig 5)

Answer ______________________

2 Calculate the height of the slip gauge pack to raise a 100 mm sine bar to an angle of 3^0 35'.

Answer ______________________

Fig 5



Procedure to check adherence to specification and quality standards

Objectives : At the end of this lesson you shall be able to
- **state procedure to check adherence to specification**
- **state quality standards.**

Procedure to check adherence to Specification:

During the term, supplier shall manufacture all products supplied to purchaser in accordance with the specifications provided by purchaser, supplier's standard operating procedures, quality requirements and industry standards.

Why it is important to follow the manufacturer's specifications in operating machine, the reason is manufacturer instructions provide us with technical information that can help form a risk assessment, that will then allow us to develop suitable controls and wear protective equipment to protect us againt the hazards associated to a machine (or) equipment.

Quality Standards

Quality standards are defined as documents that provide requirements, specifications, guidelines, or characteristics that can be used consistently to ensure that materials, products, processes, and services are fit for their purpose.

Standards provide organizations with the shared vision, understanding, procedures, and vocabulary needed to meet the expectations of their stakeholders. Because standards present precise descriptions and terminology, they offer an objective and authoritative basis for organizations and consumers around the world to communicate and conduct business.

Principles of Quality Standards

Organizations turn to standards for guidelines, definitions, and procedures that help them achieve objectives such as:

- Satisfying their customers' quality requirements
- Ensuring their products and services are safe
- Complying with regulations
- Meeting environmental objectives
- Protecting products against climatic or other adverse conditions
- Ensuring that internal processes are defined and controlled

Use of quality standards is voluntary, but may be expected by certain groups of stakeholders Additionally, some organizations or government agencies may require suppliers and partners to use a specific standard as a condition of doing business.

Quality Standards

Topic:	**Standard:**
Quality Management	ISO 9000
	ISO 9001
Auditing	ISO 19011
Environmental Management	ISO 14000
	ISO 14001
Risk Management	ISO 31011
Social Responsibility	ISO 26000
Sampling by Attributes	Z1.4
Sampling by Variables	Z1.9
Food Safety	ISO 22000

For the global economy: Businesses and organizations complying to quality standards helps products, services, and personnel cross borders and also ensures that products manufactured in one country can be sold and used in another.

For consumers: Many quality management standards provide safeguards for users of products and services, but standardization can also make consumers' lives simpler. A product or service based on an international standard will be compatible with more products or services worldwide, which increases the number of choices available across the globe.

Lapping

Objectives: At the end of this lesson you shall be able to
- **state the purpose of lapping**
- **state the features of a flat lapping plate**
- **state the use of charging a flat lapping plate**
- **state the method of charging a cast iron plate**
- **distinguish between wet lapping and dry lapping.**

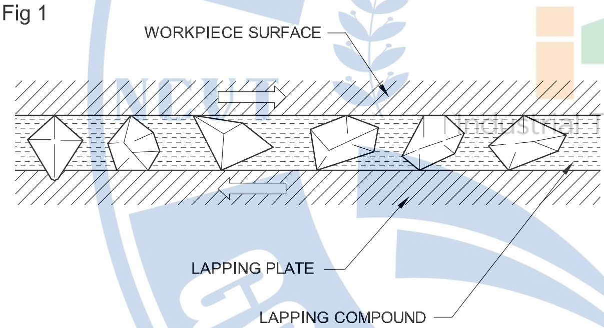
Lapping is a precision finishing operation carried out using fine abrasive materials.

Purpose: This process:

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

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

Fig 1



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

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

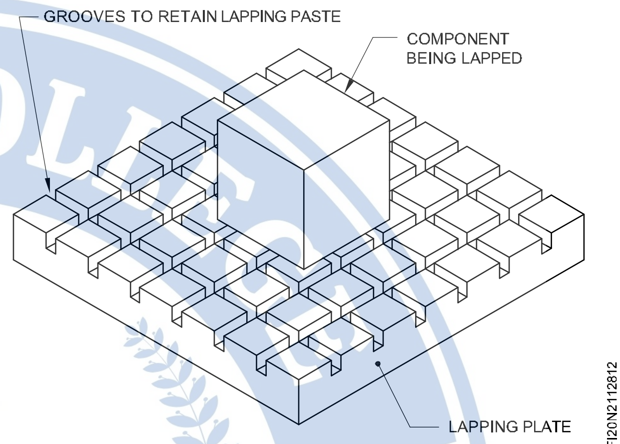
Hand lapping of flat surfaces: Flat surfaces are hand-lapped using lapping plate made out of close grained cast iron. (Fig 2) The surface of the plate should be in a true plane for accurate results in lapping.

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.

Fig 2



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, bentomite 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.

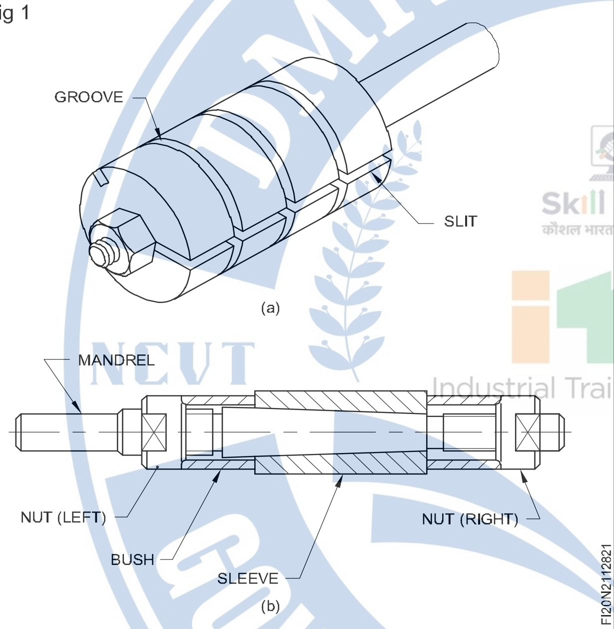
Lapping internal cylindrical surfaces

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)

Fig 1



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

Fig 2

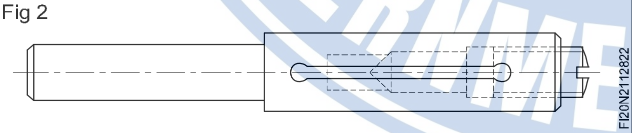
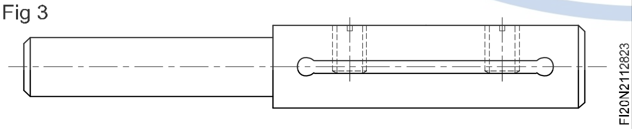
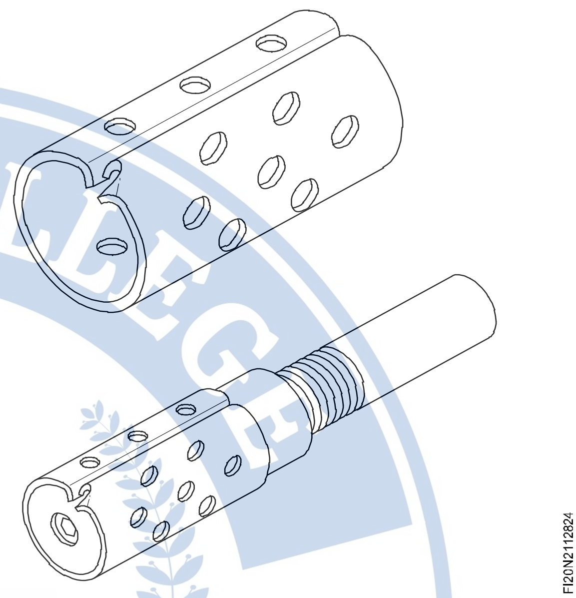


Fig 3



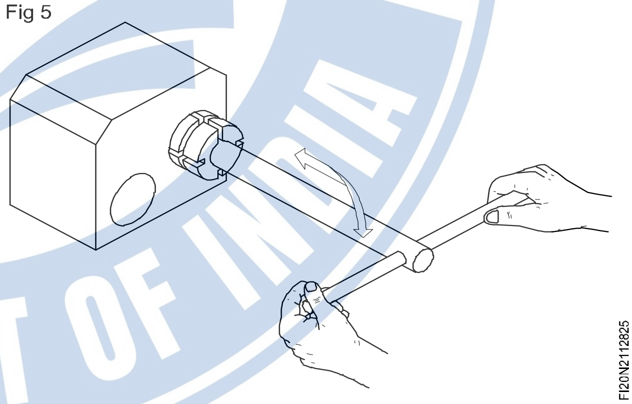
Grooves cut on the surfaces of the lap help in retaining the abrasive compound (Fig 1a) and the slits cut provide for ex-pansion. Commercially available laps are sometimes provided with holes which can hold the lapping compound. (Fig 4). Holes can be lapped manually or by using special lapping machines. 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.

Fig 4



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

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)

Fig 6

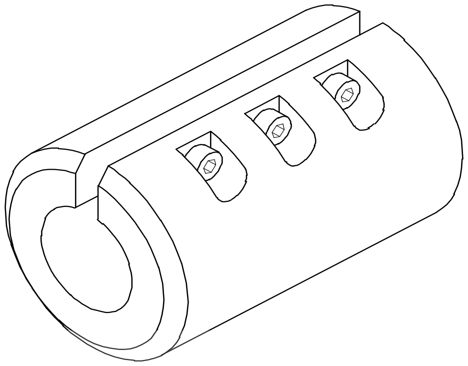


Fig 7

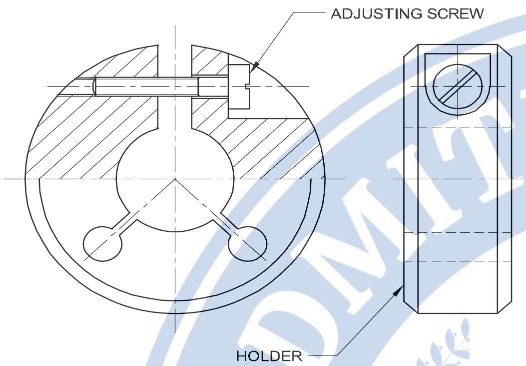
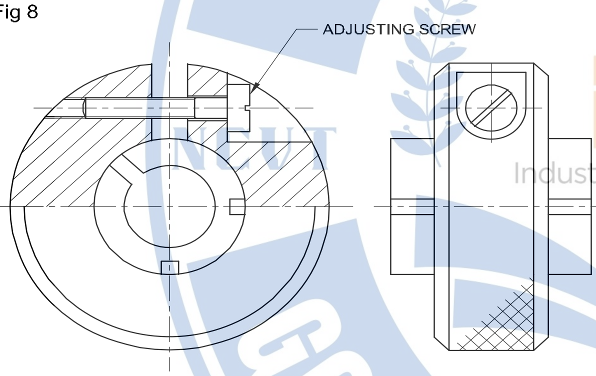


Fig 8



External threads can also be lapped using ring laps. (Fig 9) This usually consists of interchangeable threaded bushes cor-responding 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)

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.

Fig 9

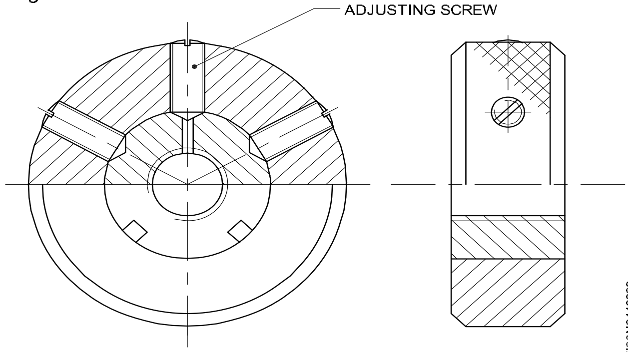


Fig 10

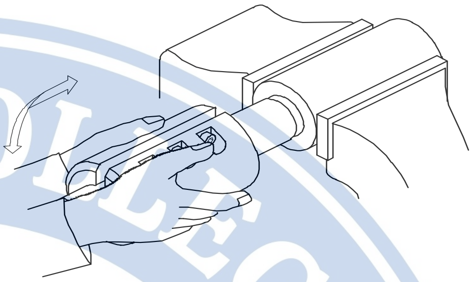


Fig 11

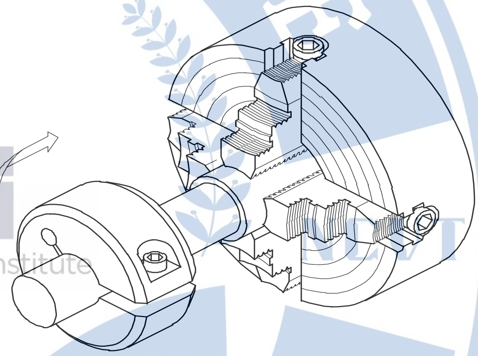
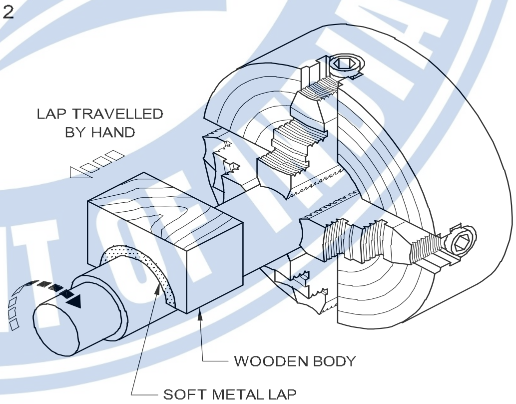


Fig 12



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.

Surface finish importance

Objectives : At the end of this lesson you shall be able to
- **state the meaning of surface texture**
- **distinguish between roughness and waviness**
- **state the need for different quality surface textures**
- **state the meaning of 'Ra' valve**
- **interpret 'Ra' and roughness grade number in drawings.**

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

Fig 1

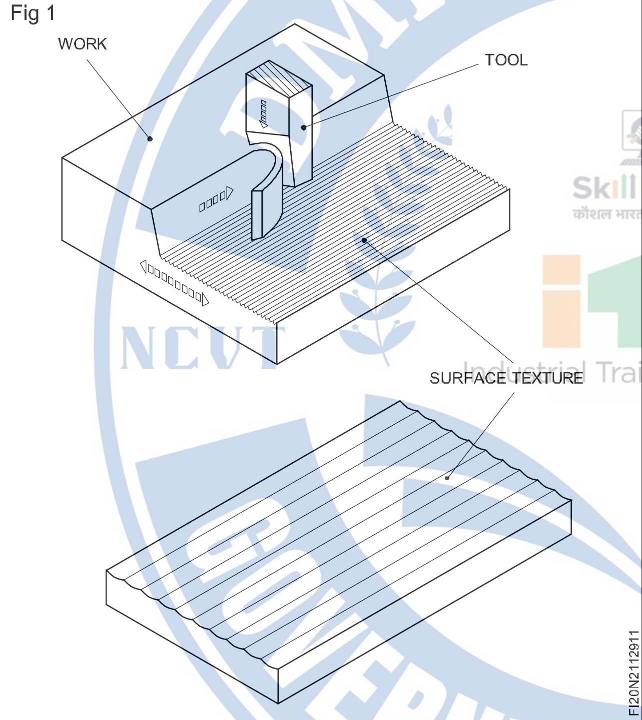
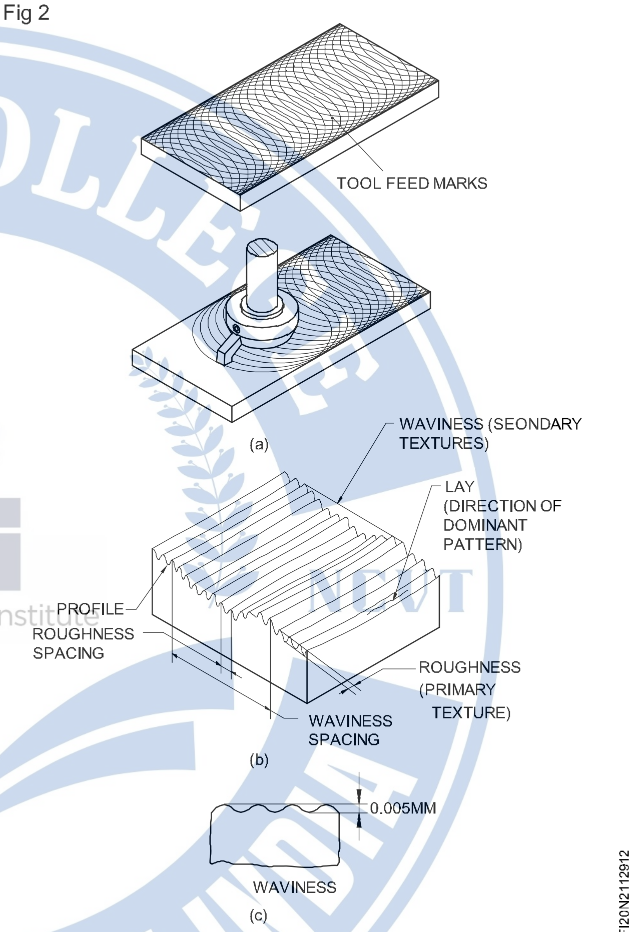


Fig 2



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.

Fig 3

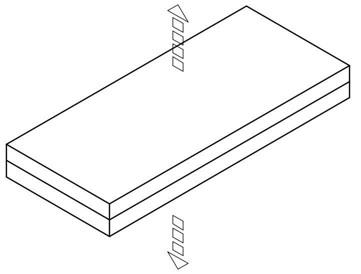


Fig 4

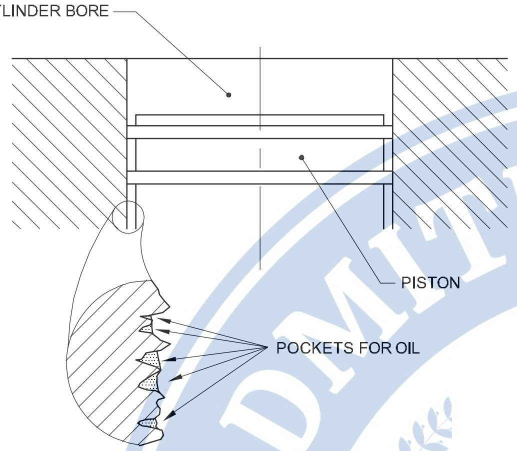
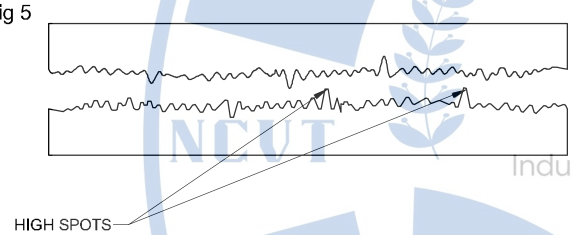


Fig 5



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

The surface texture quality can be expressed and assessed numerically.

'Ra' Values (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.

Fig 6

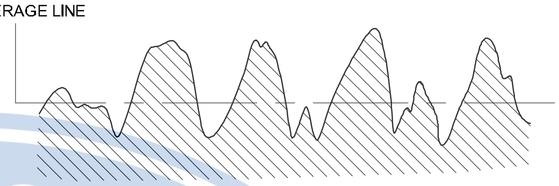
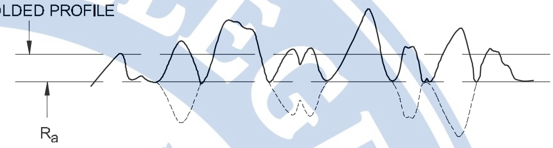


Fig 7



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

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

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

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

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

Surface texture measuring instruments

Objective: At the end of this lesson you shall be able to
- **distinguish the features of mechanical and electronic surface indicators**
- **name the parts of a mechanical surface indicator**
- **identify the features of electronic surface indicators (taly-surf)**
- **state the functions of the different features of electronic surface indicators.**

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

The instruments used for measuring the surface texture can be of a mechanical type or with electronic sensing device.

Mechanical surface indicator

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

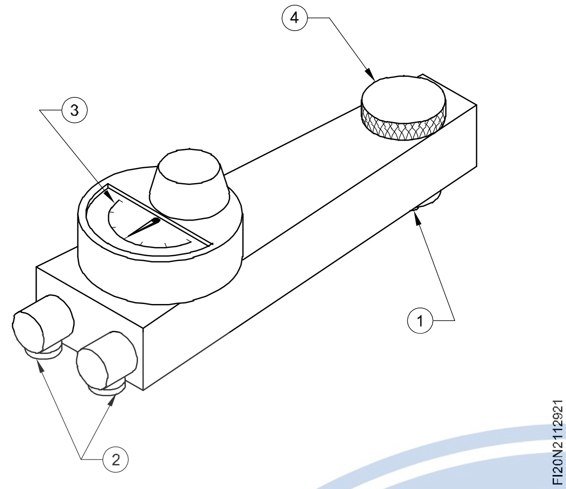
1 Measuring stylus

2 Skids

3 Indicator scale

4 Adjustment screw

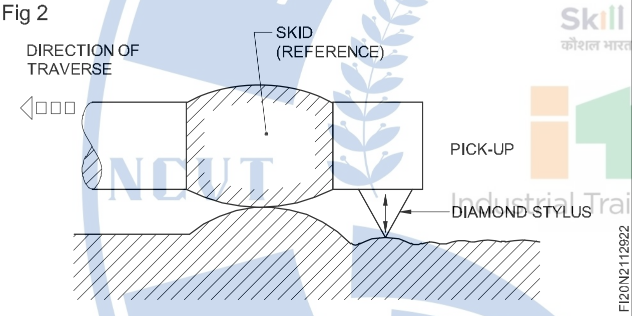
Fig 1



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

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

Fig 2



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

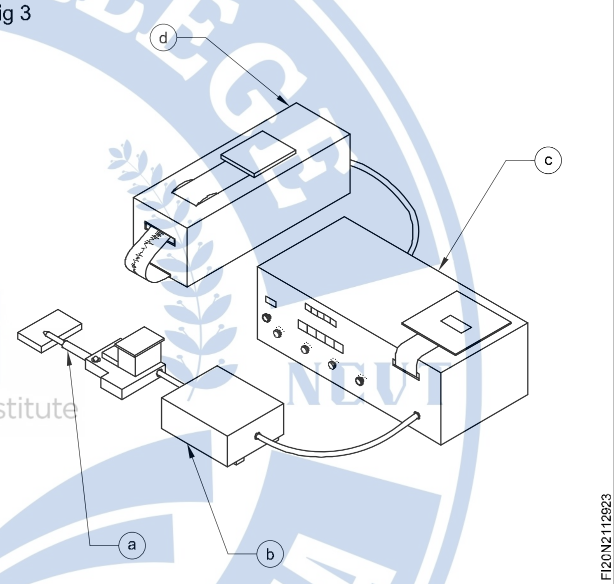
There are different types of electronic surface measuring devices; one type of such an instrument used in workshops is the taly-surf.

Taly-surf (Electronic surface indicator)

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

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).

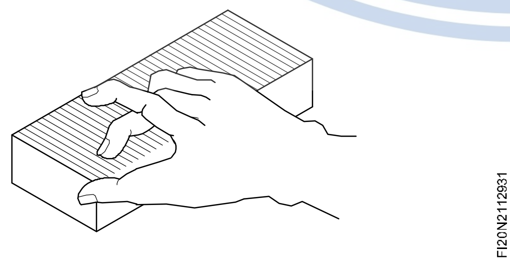
Fig 3



Surface quality

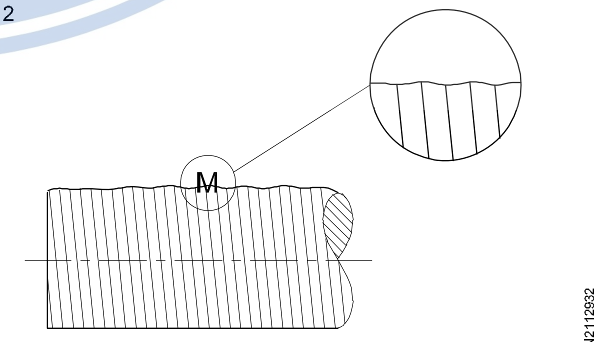
Various components are manufactured by different machining processes. The surfaces of the components differ in their appearance as well as `feel' when we move our hand over the surface. (Fig 1)

Fig 1



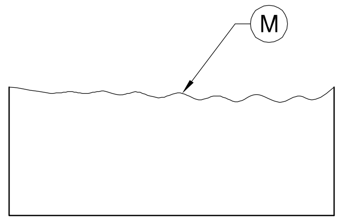
The surface will have ups and downs. These ups and downs are due to the tool marks. The pattern of these tool marks depends on the machining processes. The irregular patterns of tool marks depend on the feed, speed, tool angles, depth of cut etc. So all the machined surfaces are rough due to the inherent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

Fig 2



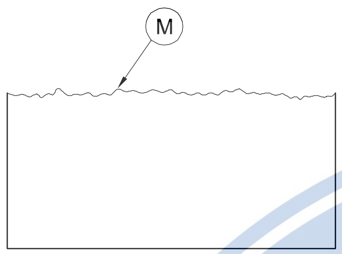
TOOL MARKS IN TURNING

Fig 3



TOOL MARKS IN MILLING

Fig 4



TOOL MARKS IN SHAPING. PLANING, SLOTTING

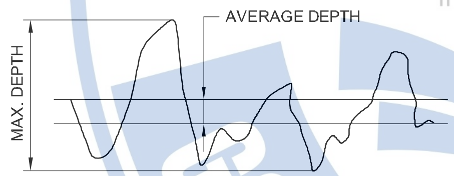
In other words, the selection process and setting of machining parameters are dictated by the type of surfaces quality demanded in the drawing of the part.

Surface roughness measurement

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

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

Fig 5



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.

Fig 6

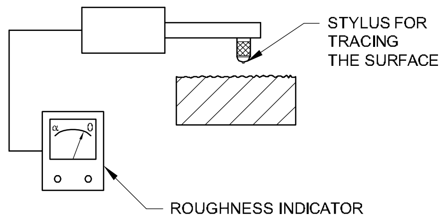
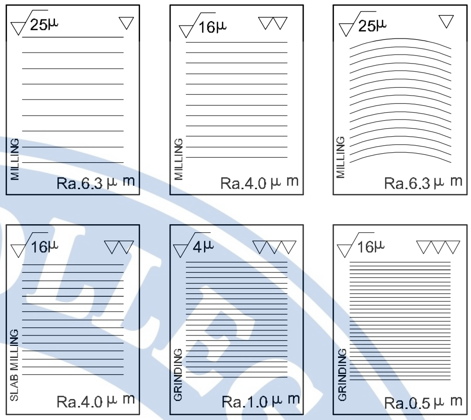


Fig 7



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

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

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

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

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

TABLE 1

Surface roughness expected from manufacturing processes IS : 3073 - 1967

Manufacturing process — 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

Manufacturing process		
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.

Fig 1

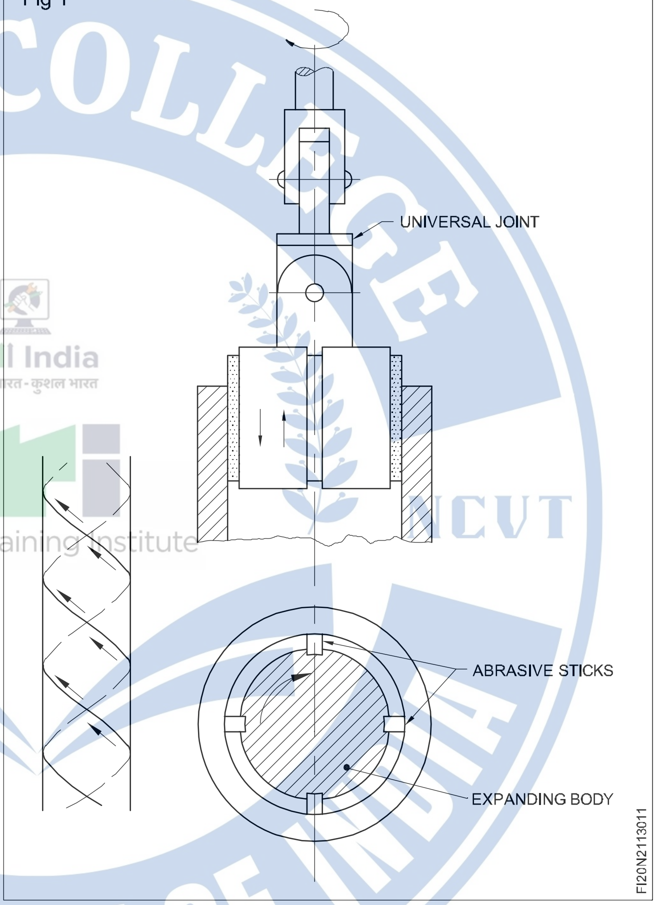
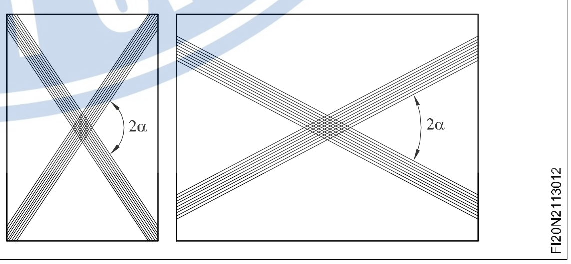


Fig 2



Jobs can be quickly changed from one type to another.

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

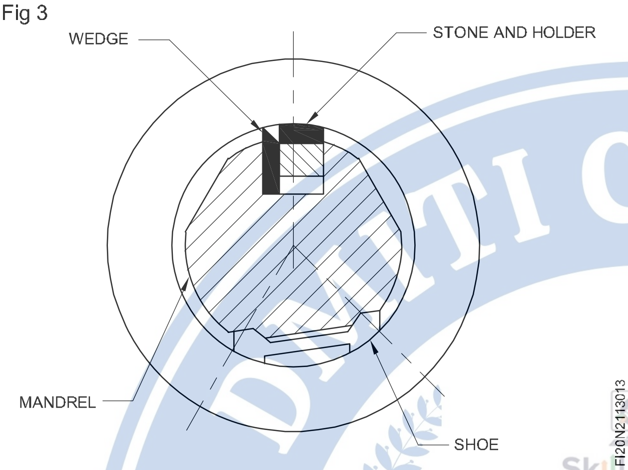
Power stroking is used for honing all types of workpieces. Power stroking may prove to be economical particularly in the case of small parts.

Note

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

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

Fig 3



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

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

Honing stones

Honing stones consist of particles of aluminium oxide, silicon carbide or diamond bonded together with vitrified clay, cork, carbon or metal. The honing stones have a porous structure and this helps for chip clearance.

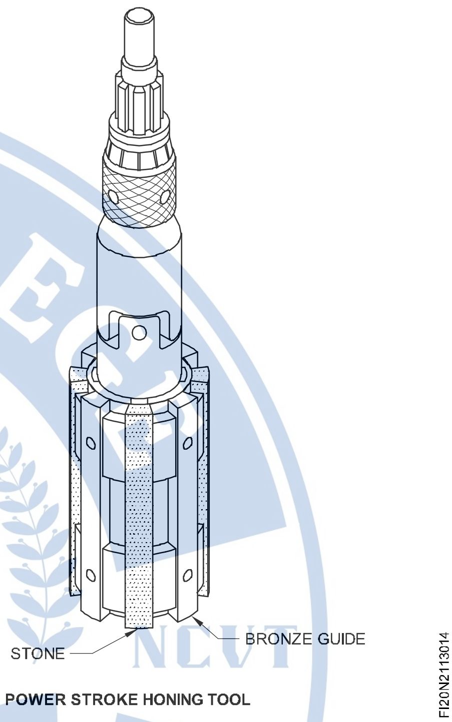
The grit size of abrasives used ranges from 36 to 600 but the most commonly used sizes are 120 to 320.

Uses of different abrasives

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

Power stroke honing tool shown in Fig 4.

Fig 4



POWER STROKE HONING TOOL

Cutting fluids

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

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 patterened 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.

Fig 1

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.

Fig 2

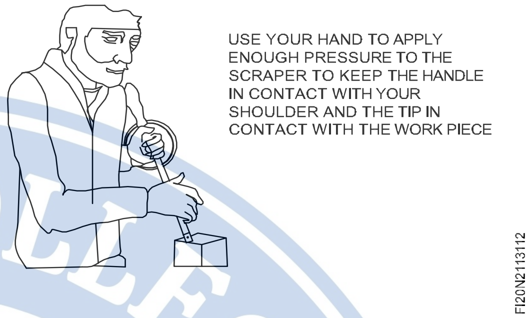
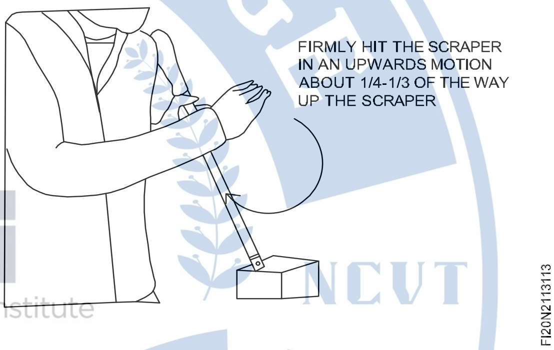


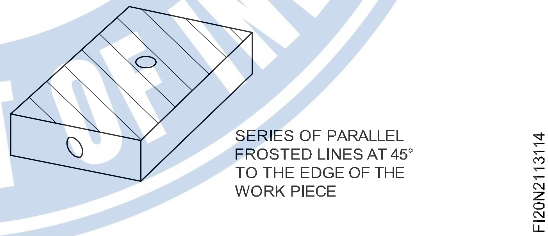
Fig 3



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.

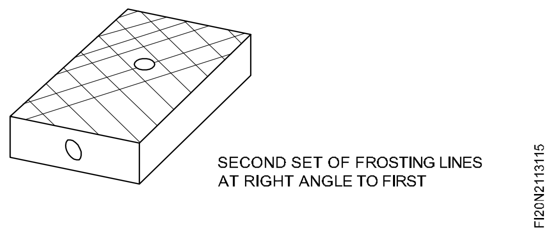
Fig 4



Step 5 - Repeat at right angles

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

Fig 5



Heat treatment of plain carbon steels

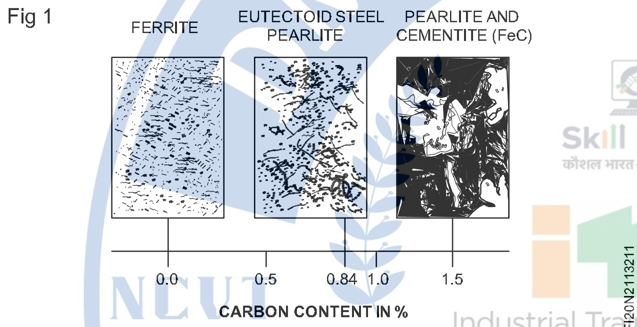
Objectives: At the end of this lesson you shall be able to
- **state the purpose of heat treatment of steel**
- **state the types of structure, constituets and properties of plain carbon steels.**

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)

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

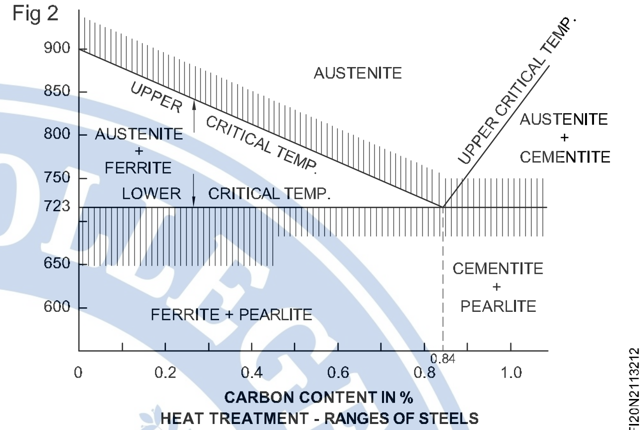
More than 0.84% carbon steel or hypereutectoid steel is pearlite and cementite.

Hypoeutectoid steel

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

Structure of steel when heated (Fig 2)

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.

Annealing: To relieve strain and stress.
To eliminate strain/hardness.
To improve machinability.
To soften the steel.

Normalising: To refine the grain structure of the steel.

Heating 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

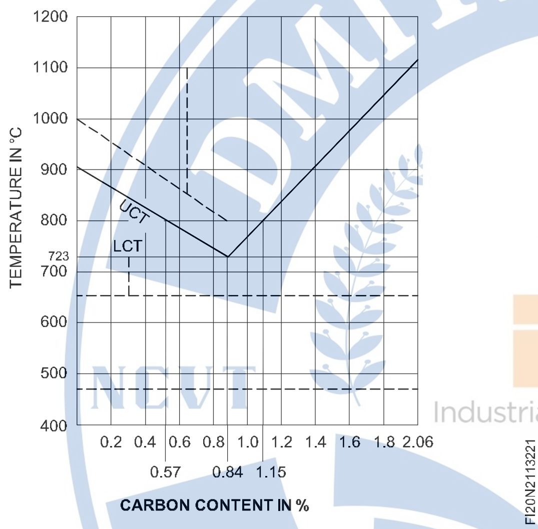
Lower critical temperature

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)

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 condi-tions 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

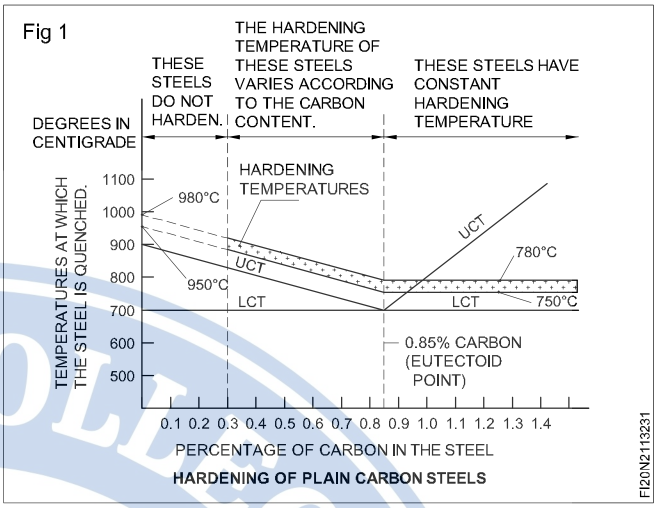
To develop high hardness and wear resistance properties.

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

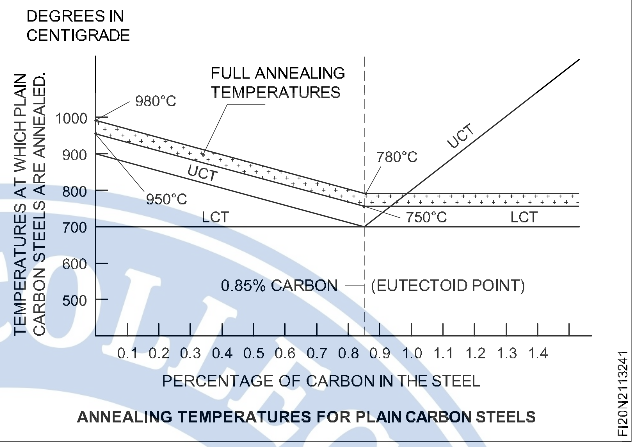
- To soften the steel.
- To improve the machinability.
- To increase the ductility.
- To relieve the internal stresses.
- To refine the grain size and to prepare the steel for subsequent heat treatment process.

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.

Fig 1



ANNEALING TEMPERATURES FOR PLAIN 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.

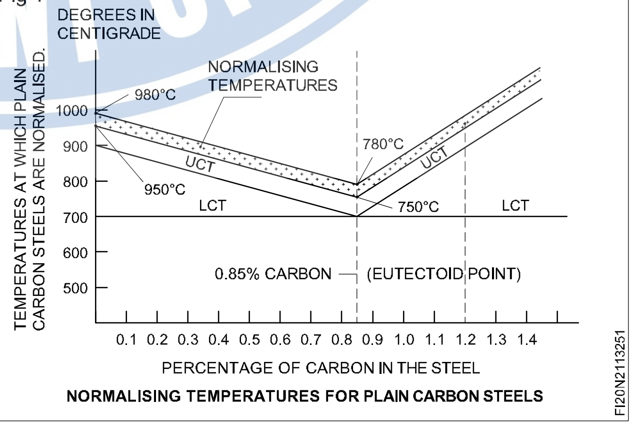
Process

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

Precautions

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

Fig 1



NORMALISING TEMPERATURES FOR PLAIN CARBON STEELS

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 surface condition and longer life. This combination of properties can be obtained in a single piece by surface hardening. (Fig 1)

Types of surface hardening

- Case hardening
- Nitriding
- Flame hardening
- Induction hardening

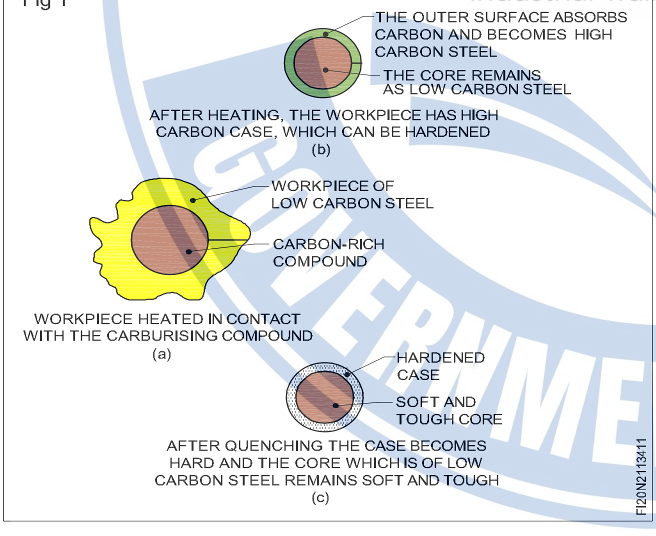
Case hardening

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)

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.

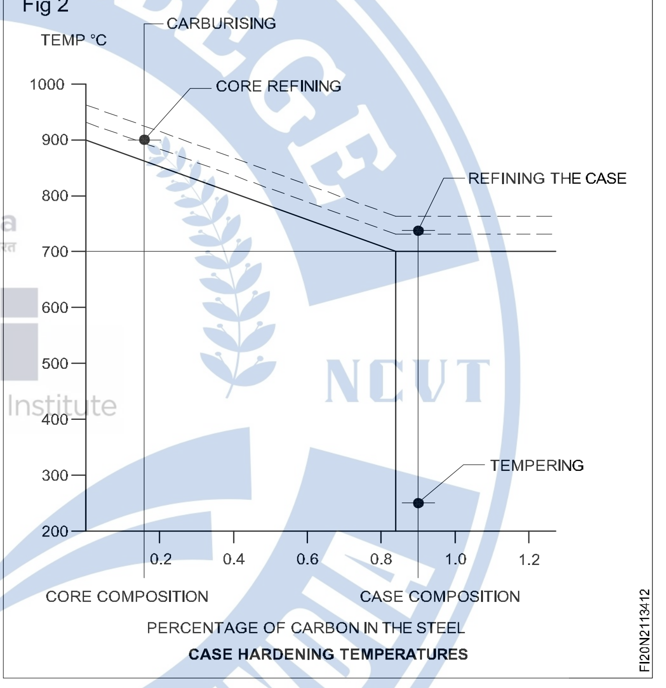
2 Heat treatment in which the core is refined and the surface hardened.

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)

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 acn enter the box to cause decarburisation.

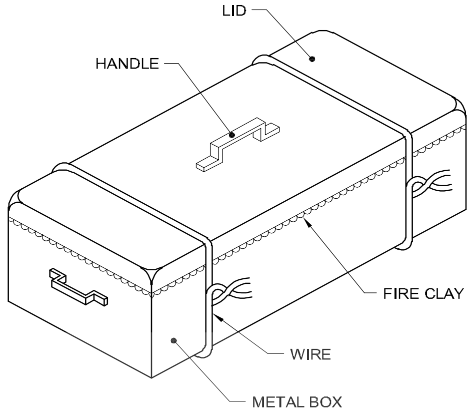
The carburising medium can be wood, bone, leather or charcoal, but an energiser, such as barium carbonate, is added to speed up the process.(Fig 4)

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.

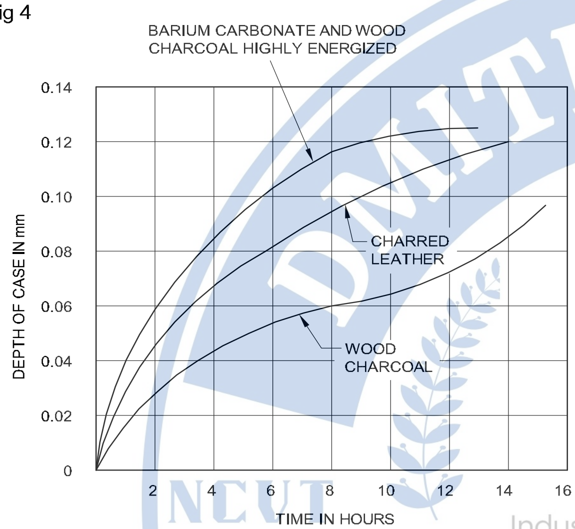
Salt-bath carburising is very rapid, but is not always suitable because it produces an abrupt change in the carbon content from the surface to the core. This produces a tendency for the case to flake.

Fig 3



PACK CARBURISING

Fig 4



RELATIVE RATE OF CARBURISATION WITH DIFFERENT SOLID CARBURISERS AT 698.8°C

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.

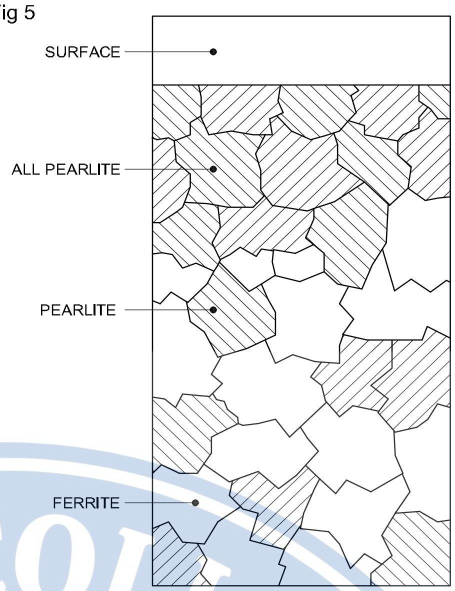
Fig 5 illustrates the appearance of the structure across its section produced by carburising.

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.

Fig 5



THE MICROSTRUCTURE OF CARBURISED STEEL

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.

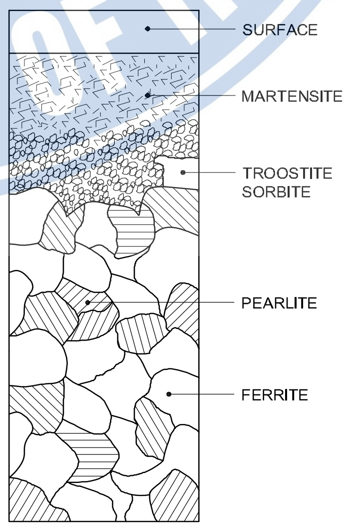
Tempering

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.

Fig 6



THE MICROSTRUCTURE OF CASEHARDENED STEEL

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, fight due to wedge action. This ensure tightness of joint in operation and prevent loosening 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:

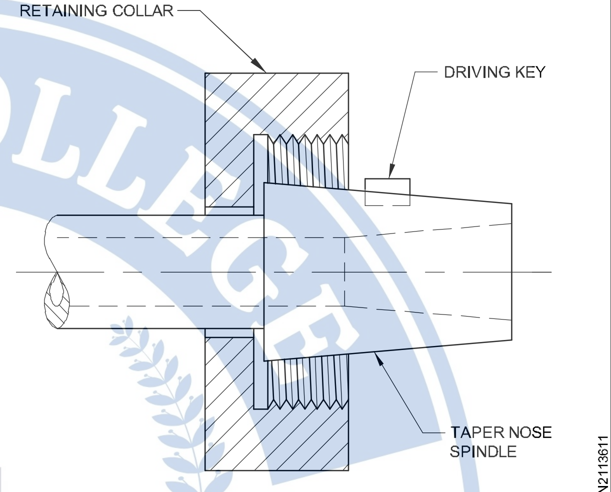
- the steepness of the tapers
- the method adopted for measuring.

Specification of tapers

While specifying taper in drawings it should indicate the:

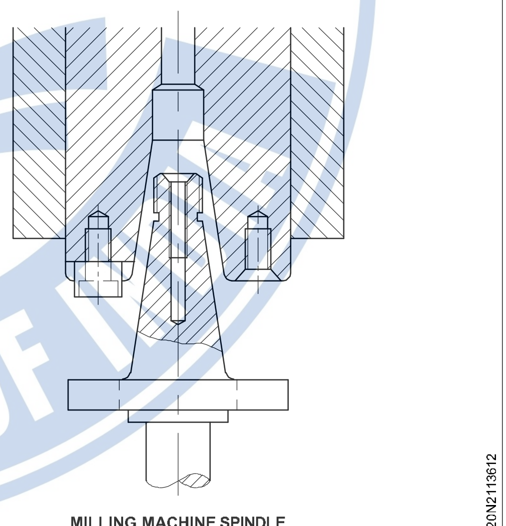
- angle of the taper
- size of the component. (Figs 6,7, 8 & 9)

Fig 1



LATHE-TAPER NOSE SPINDLE

Fig 2



MILLING MACHINE SPINDLE

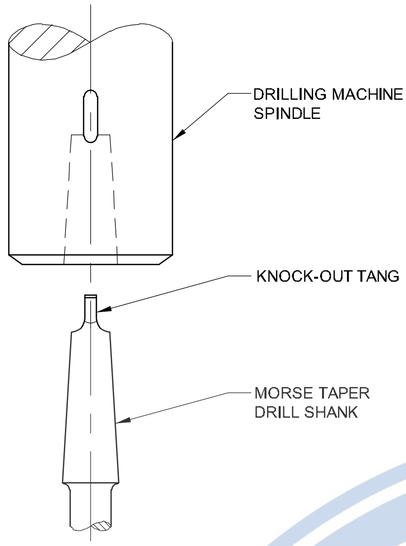
Standard tapers

Tapers for tool-holding

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

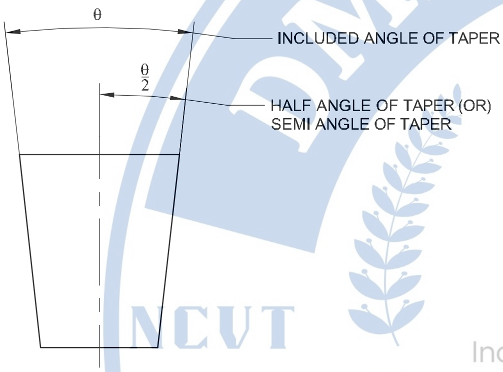
- Self-holding tapers
- Self-releasing tapers

Fig 3



DRILLING MACHINE SPINDLE AND DRILL WITH TAPER SHANK

Fig 4

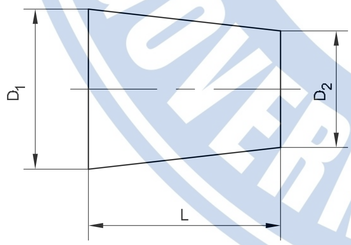


60 SECONDS (") = 1 MINUTE (')

60 MINUTES (') = 1 DEGREE OF ARC (°)

AN ANGLE EXPRESSED IN DEGREES OF ARC

Fig 5



EXAMPLE: IS SELF RELEASE TAPER

(MILLING MACHINE SPINDLE NOSE) IS GIVEN AS: $\frac{7}{24}$

i.e.

$D_1 - D_2 = 7$

$L = 24$

NOTE: L IS MEASURED PARALLEL TO THE AXIS

$$\text{TAPER} = \frac{D_1 - D_2}{L}$$

AN ANGLE EXPRESSED AS A GRADIENT

Fig 6

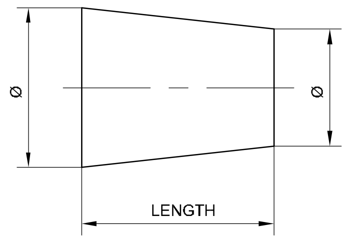


Fig 7

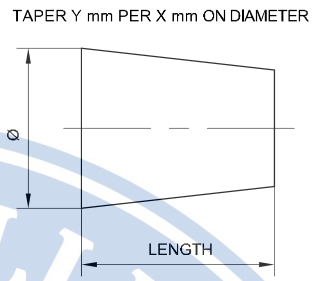


Fig 8

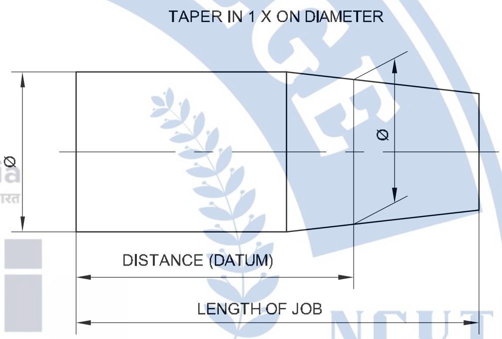
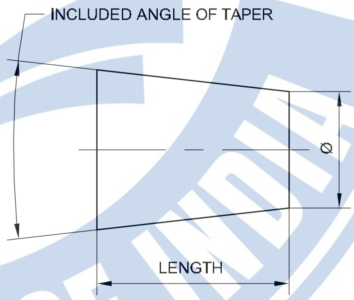


Fig 9



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)

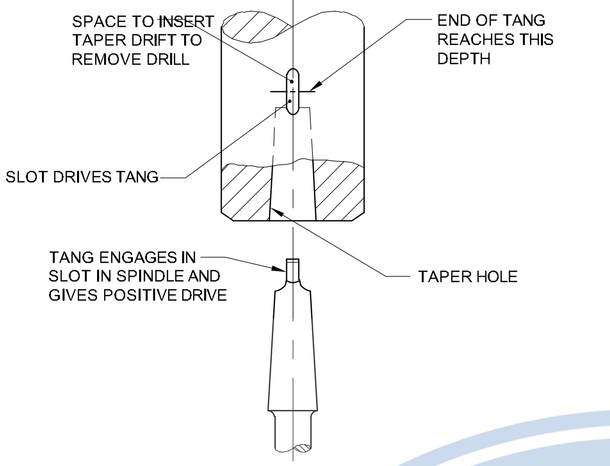
The standard tapers used for this are:

- the metric taper
- the Morse taper.

Metric taper

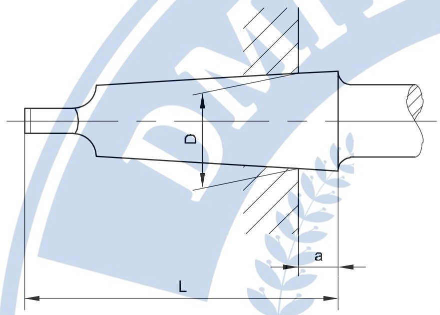
The taper on diameter is 1:20. The commonly used shank sizes in metric tapers are metric 4, 6, 80, 100, 120, 160 and 200.

Fig 10



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

Fig 11



Morse taper

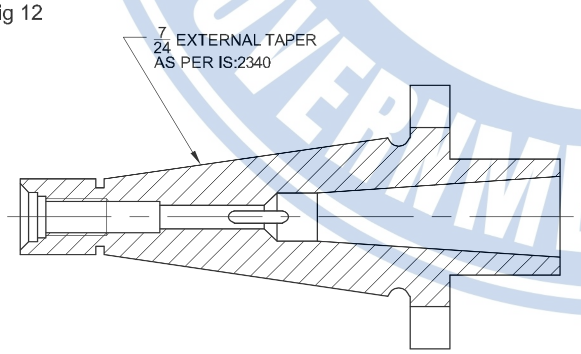
The commonly used taper shank sizes are:

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 tape (Fig 12)

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

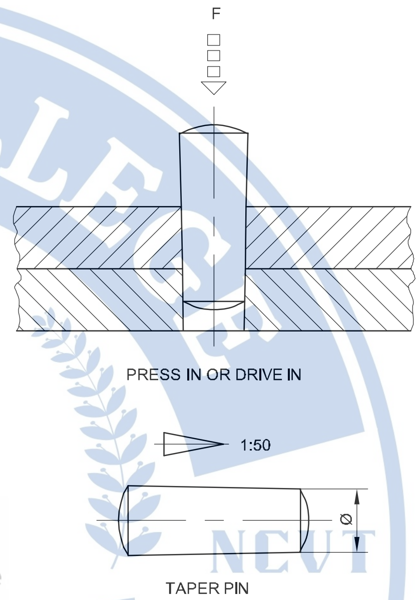
A variety of tapers are used in engineering assembly work. The most common ones are:

- pin taper
- key and keyway taper.

Pin taper

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

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)

Fig 14

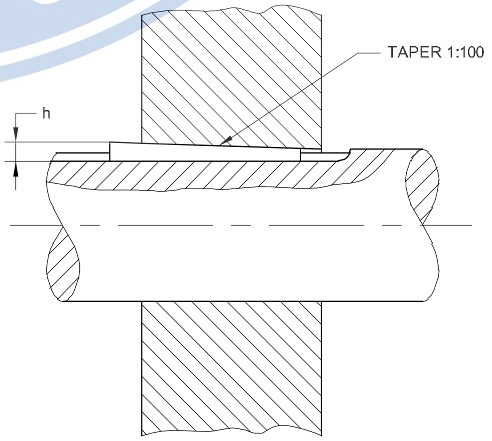
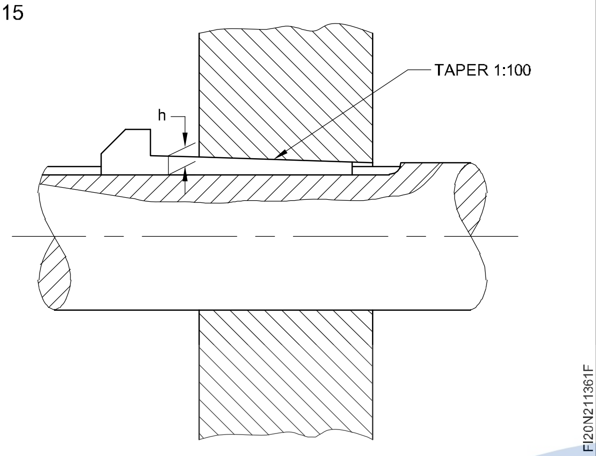


Fig 15



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 coller 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 crrosion**
- **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.

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.

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 oof molten zinc, and electrolytic galvanising where the zinc is deposited electolytically on the sheet metal base.

Cladding

In this process a cmposite a 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

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.

General procedure of electroplating

1 Cleaning with organic solvents and/or aqueous alkali.
2 Where the surface is covered by oxides as a result of corrosion, it is cleaned by immersion in acid; again electrochemical enhancement is possible by making the surface anodic.
3 Rinsing with water.
4 Electroplating.
5 Rinsing and drying.
6 Quality control prior to packing and despatch.

Process of Electroplating

Electroplating is carried out in an electrolytic cell. The article to be electroplated is first cleaned with organic solvents to remove oils, grease etc and then treated with dilute HCl and H_2SO_4 to remove oxide scales etc. The cleaned article is then made cathode of the electrolytic cell and is hung on racks placed on cathode bar.

The anode is either coating material or an electrode of inert material like graphite. The electrolyte, which is a soluble salt solution of coating metal is taken in the cell. The anode and cathode are dipped in the electrolytic solution and a direct current of electricity is passed. Plating bath is heated with steam and when cooling is required, it is cooled with water in pipes or coils placed inside the cell or tank outside it. For heating the bath, the immersion electric heaters have also been used. Under the influence of electric current, coating ions migrate to the electrode and get deposited there. Thus a thin coating of the metal is produced on the cathode.

In order to produce brighter and smooth deposits, low temperature, high current density and low metal ion concentration etc are the favourable conditions.

In order to produce brighter and smooth deposits, low temperature, high current density and low metal ion concentration etc. are the favourable conditions.

Chromium Plating

The chrome plating process is a method of applying a thin layer of chromium onto a substrate (metal (or) alloy) through an electroplating procedure.

In simple terms, electroplating is achieved by passing an electric current between two electrodes which are immersed in an electrolyte bath comprising of chromic acid. one of the electrodes will be the substrate which is to be plated. During the flow of electricity between the two electrodes, chromium atoms are deposited in a layer on the electrode to be plated.

Silver Plating

Silver plating involves submerging the Substrate into a bath of silver ions. After passing an electric current through the solution the ions deposit on to the parts surface.

Silver plating is common to numerous industries, including Bearings automative, medical, electronics and telecommunications sectors.

Nickel Plating

Nickel Electro plating is a process of applying a nickel coating onto a metal surface by means of electrolytic deposition. In order for parts to be plated, they must be clean and free of dirt, corrosion and defects so the plating can be applied. In order to prepare a product, it must be cleaned and protected before the plating process. To prepare a part, a combination of cleaning, masking, heat treating, pickling and etching are commonly used.

Galvanizing

Galvanizing is the process of applying a protective zinc coating to iron or steel to prevent rusting. The most common method is hot dip galvanizing in which steel sections are submerged in a bath of molten zinc.