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.**

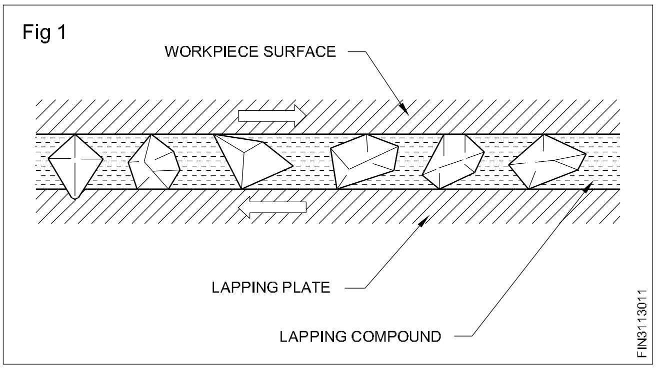
Lapping is a precision finishing operation carried out using fine abrasive materials.

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



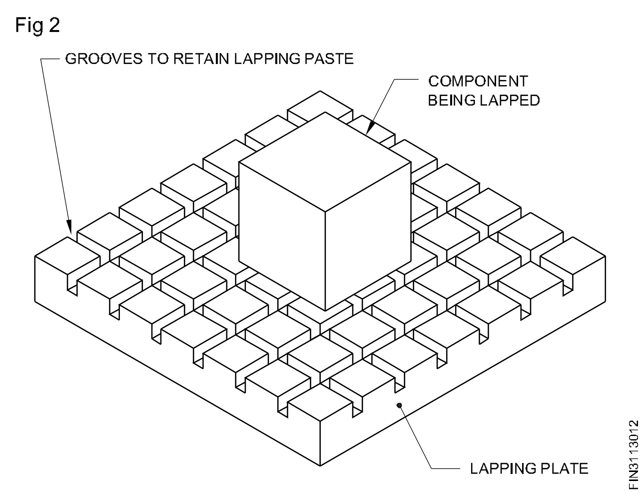
The lapping compound consists of fine abrasive particles suspended in a 'vehicle' such as oil, paraffin, grease etc.

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.

Fig 2



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

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

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

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

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

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

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

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

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

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

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

Lap materials and lapping compounds

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

- **name the different types of lap materials**
- **state the qualities of different lap materials**
- **name the different types of abrasive materials used for lapping**
- **distinguish between the application of different lapping abrasives**
- **state the function of lapping vehicles**
- **name the different lapping vehicles**
- **name the solvents used in lapping.**

The material used for making laps should be softer than the workpiece being lapped. This helps to charge the abrasives on the lap. If the lap is harder than the workpiece, the workpiece will get charged with the abrasives and cut the lap instead of the workpiece being lapped.

Laps are usually made of:

- close grained iron
- copper
- brass or lead

The best material used for making lap is cast iron, but this cannot be used for all applications.

When there is excessive lapping allowance, copper and brass laps are preferred as they can be charged more easily and cut more rapidly than cast iron.

Lead is an inexpensive form of lap commonly used for holes. Lead is cast to the required size on steel arbor. These laps can be expanded when they are worn out. Charging the lap is much quicker.

Lapping abrasives: Abrasives of different types are used for lapping.

The commonly used abrasives are:

- Silicon Carbide
- Aluminium Oxide
- Boron Carbide and
- Diamond

Silicon carbide: This is an extremely hard abrasive. Its grit is sharp and brittle. While lapping, the sharp cutting edges continuously break down exposing new cutting edges. Due to this reason this is considered as very ideal for lapping hardened steel and cast iron, particularly where heavy stock removal is required.

Aluminium oxide: Aluminium oxide is sharp and tougher than silicon carbide. Aluminium oxide is used in un-fused and fused forms. Un-fused alumina (aluminium oxide) removes stock effectively and is capable of obtaining high quality finish.

Fused alumina is used for lapping soft steels and non-ferrous metals.

Boron carbide: This is an expensive abrasive material which is next to diamond in hardness. It has excellent cutting properties. Because of the high cost, it is used only in specialised application like dies and gauges.

Diamond: This being the hardest of all materials, it is used for lapping tungsten carbide. Rotary diamond laps are also prepared for accurately finishing very small holes which cannot be ground.

Lapping vehicles: In the preparation of lapping compounds the abrasive particles are suspended in vehicles. This helps to prevent concentration of abrasives on the lapping surfaces and regulates the cutting action and lubricates the surfaces.

The commonly used vehicles are:

- water soluble cutting oils
- vegetable oil

- machine oils
- petroleum jelly or grease
- vehicles with oil or grease base used for lapping ferrous metals.

Metals like copper and its alloys and other non-ferrous metals are lapped using soluble oil, 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.

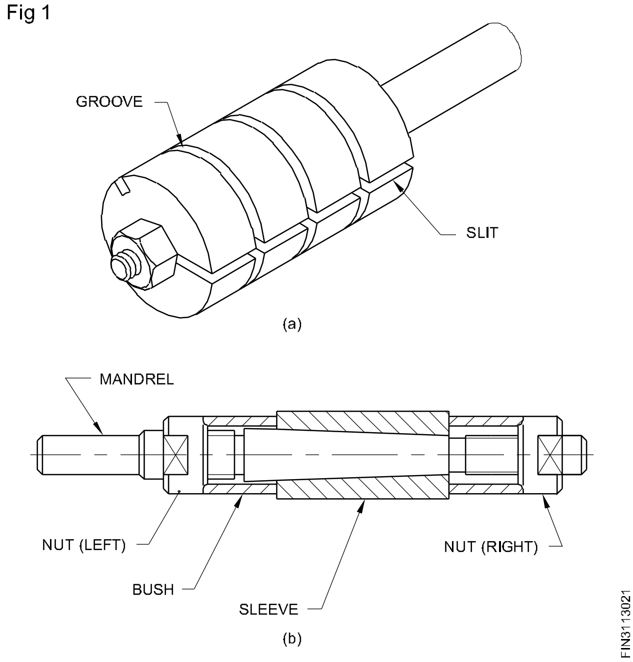
Lapping internal cylindrical surfaces

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

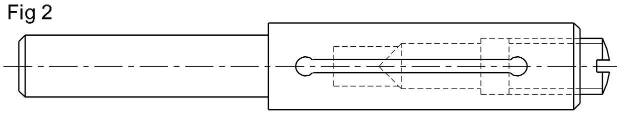
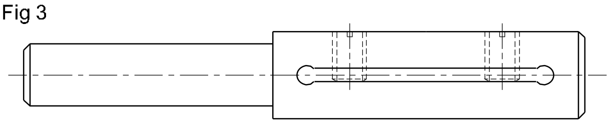
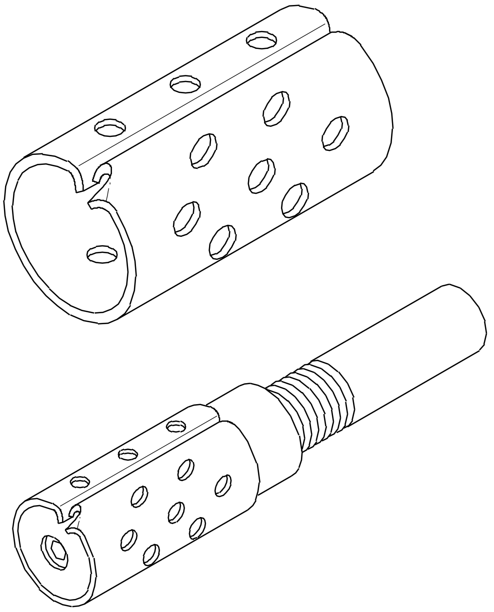


Fig 3



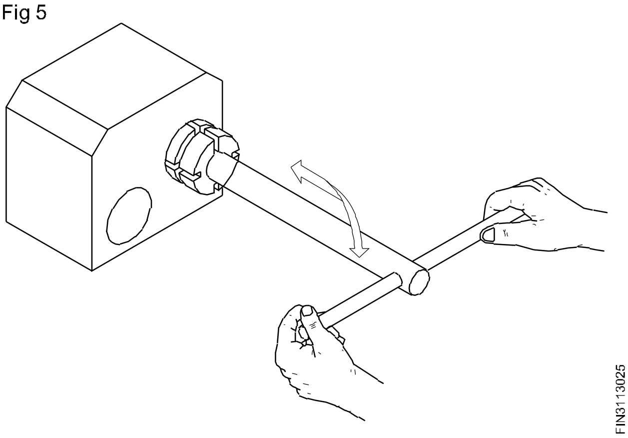
Grooves cut on the surfaces of the lap help in retaining the abrasive compound (Fig 1a) and the slits cut provide for ex-pansion. Commercially available laps are sometimes provided with holes which can hold the lapping compound. (Fig 4). Holes can be lapped manually or by using special lapping machines.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



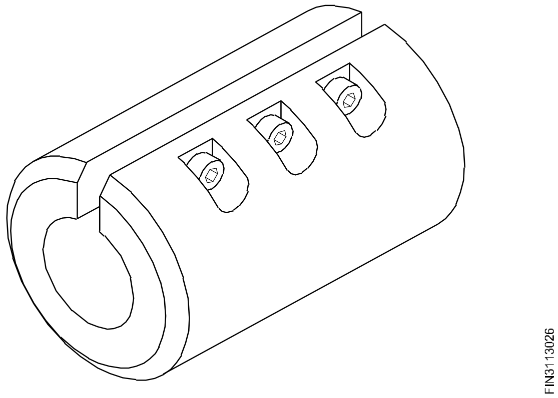
While lapping, the lap should be pushed forward in the bore giving a clockwise movement at the same time.

Lapping external cylindrical surfaces

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

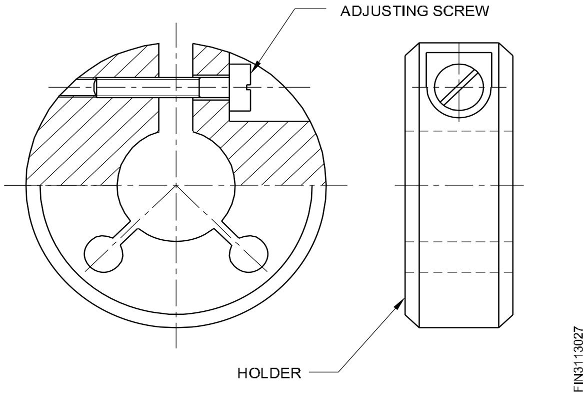
The simplest form is a split bush with clamping screws, which permits some adjustment of sizes. (Fig 6)

Fig 6



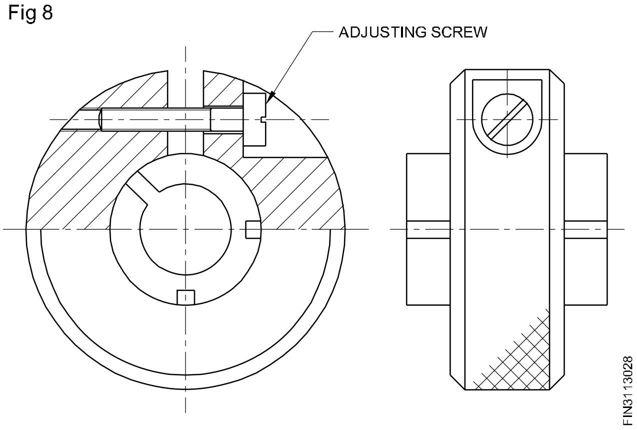
The adjustable ring lap will have slots cut on it which permit the feeding of the lapping compound and adjustment of sizes. (Fig 7)

Fig 7



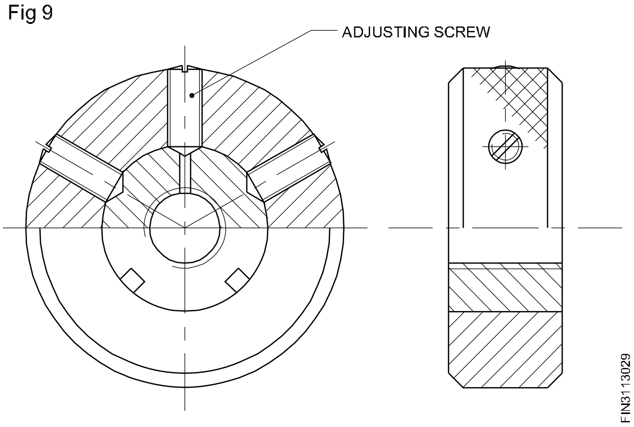
Another type of ring lap with interchangeable bushes is also available. In a single holder different sizes of bushes can be used. (Fig 8)

Fig 8



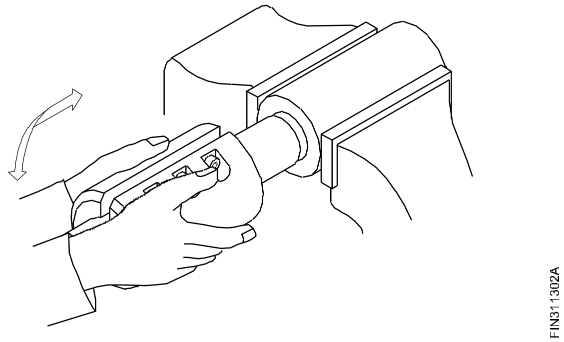
External threads can also be lapped using ring laps. (Fig 9) This usually consists of interchangeable threaded bushes cor-responding to the external thread to be lapped. A slight adjustment of sizes is also possible. Ring laps are usually made of closely grained cast iron.

Fig 9



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)

Fig 10



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

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

Fig 11

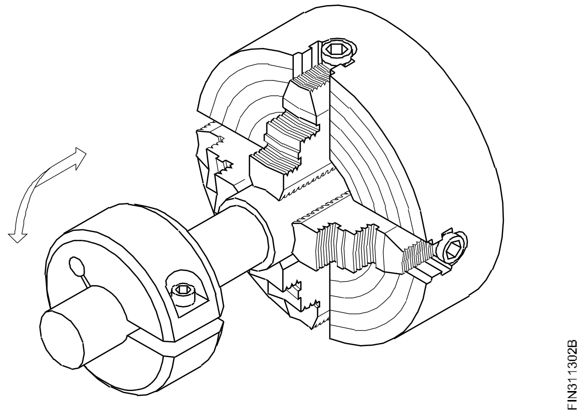
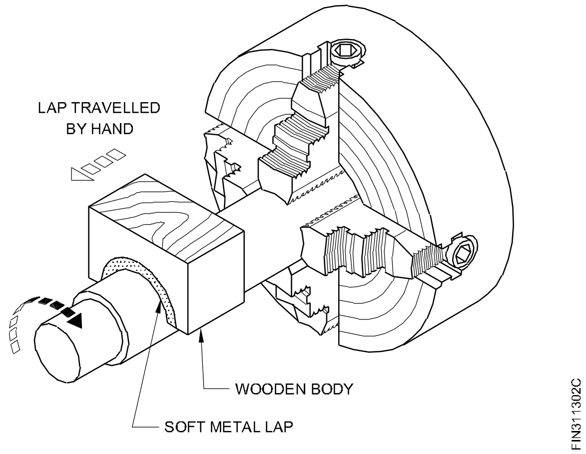


Fig 12



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.

The external cylindrical laps can be charged by presssing 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

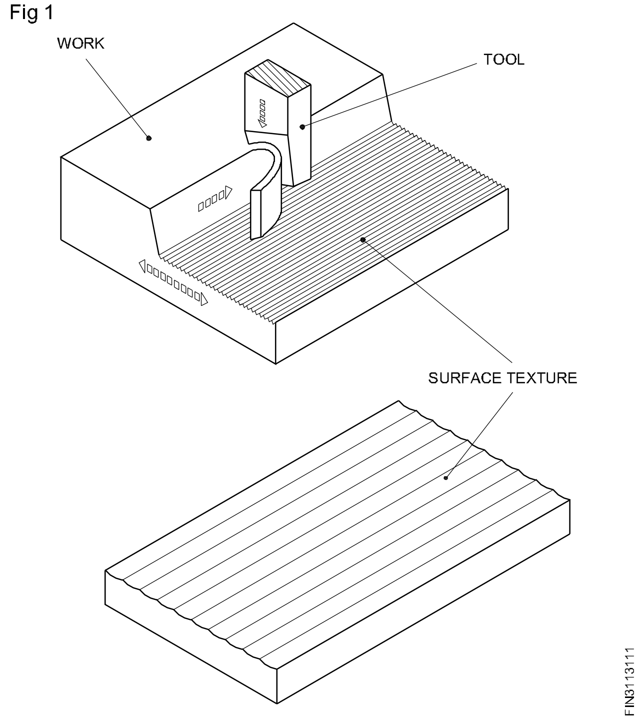
- Do not dwell in the same place while lapping.
- Keep the lap moist always.
- Do not add fresh abrasive during lapping; recharge if necessary.
- Do not apply excessive pressure while lapping.

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



The components of surface texture

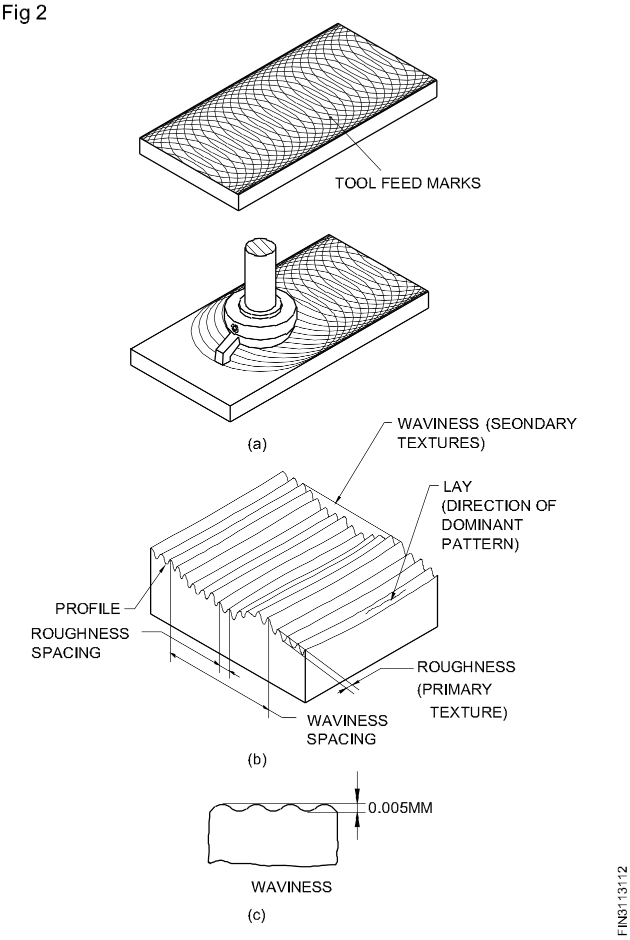
Roughness (Primary texture)

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

Waviness (Fig 2b & 2c)

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

Fig 2



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

Examples

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

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

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

Fig 3

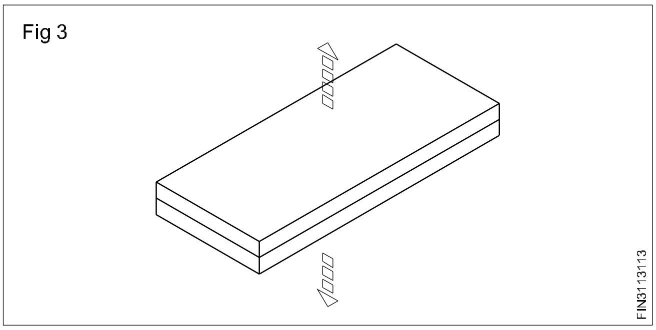
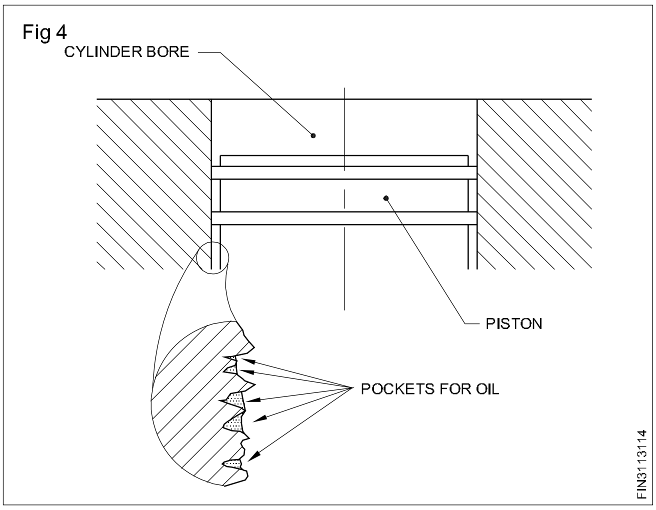
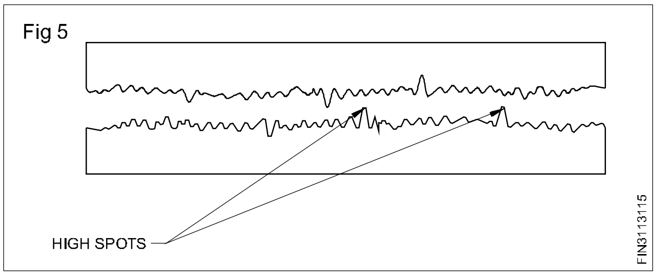


Fig 4



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

Fig 5



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

The surface texture quality can be expressed and assessed numerically.

'Ra' Values (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

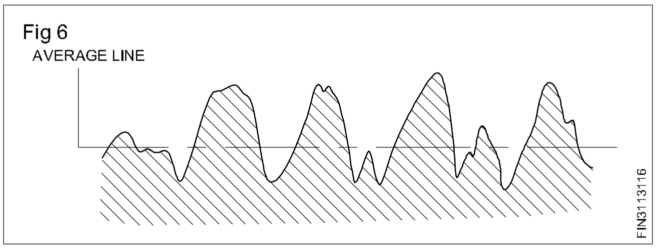
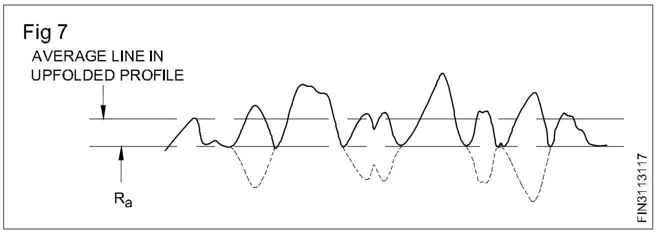


Fig 7



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 (0.000001) or (m), this also can be indicated in the corresponding roughness grade number, ranging from N_1 to N_{12}.

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

Surface texture measuring instruments

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

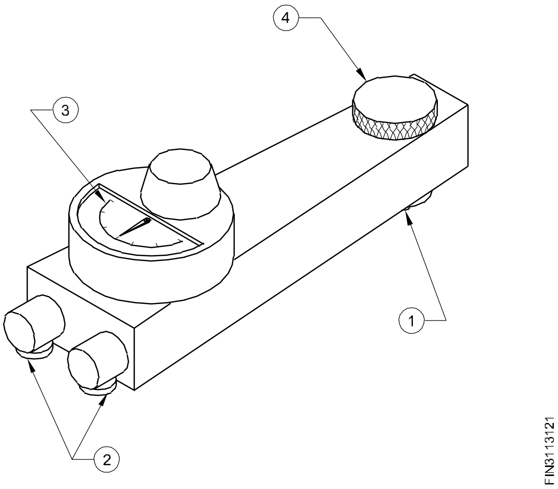
The use of surface finish standards which we have seen earlier is only a method of comparing and determining the quality of surface. The result of such measurement very much depends on the sense of touch and cannot be used when a higher degree of accuracy is needed.

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

Mechanical surface indicator

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

Fig 1



1 Measuring stylus

2 Skids

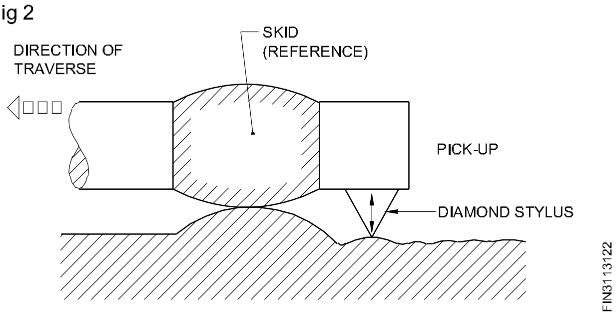
3 Indicator scale

4 Adjustment screw

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

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

Fig 2



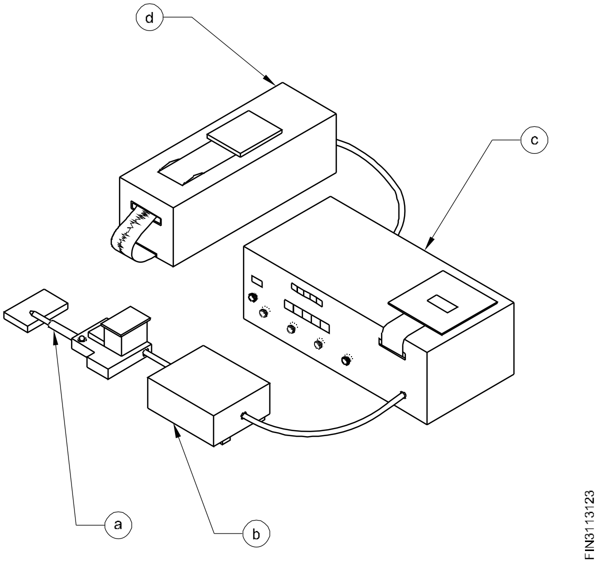
When using a mechanical surface indicator, measurement must be read as it is moved over the surface, and then a profile curve is drawn manually to compute the mean value.

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

Taly-surf (Electronic surface indicator)

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

Fig 3

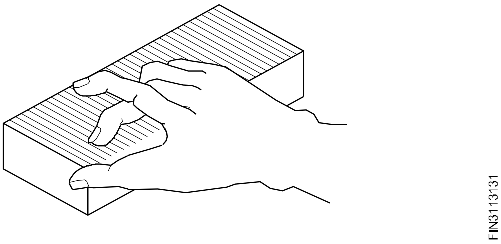


The measuring head of this unit consists of a stylus (a) and a motor race (b) which controls the movement of the instrument head across the surface. The movement of the stylus is converted to electrical signals. These signals are amplified in the surface analyser/amplifier (c) which calculates the surface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

Surface quality

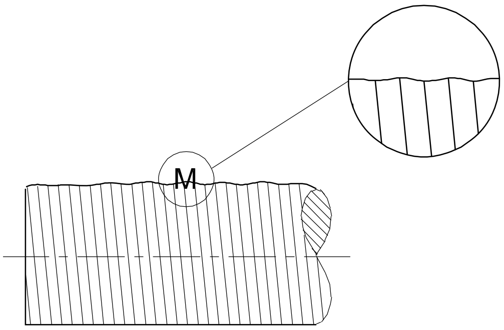
Various components are manufactured by different machining processes. The surfaces of the components differ in their appearance as well as `feel' when we move our hand over the surface. (Fig 1)

Fig 1



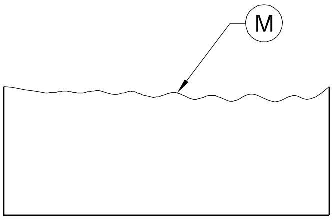
The surface will have ups and downs. These ups and downs are due to the tool marks. The pattern of these tool marks depends on the machining processes. The irregular patterns of tool marks depend on the feed, speed, tool angles, depth of cut etc. So all the machined surfaces are rough due to the inherent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

Fig 2



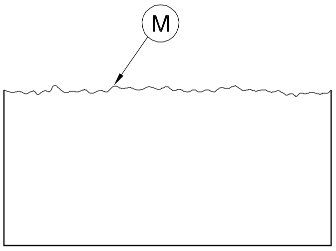
TOOL MARKS IN TURNING

Fig 3



TOOL MARKS IN MILLING

Fig 4



TOOL MARKS IN SHAPING. PLANING, SLOTTING

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

Surface roughness measurement

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

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

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

Fig 5

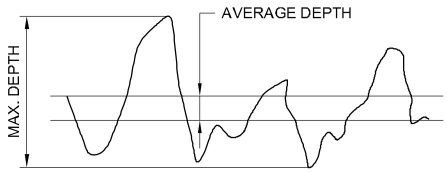
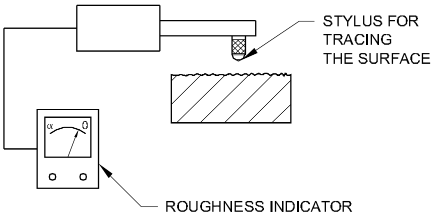


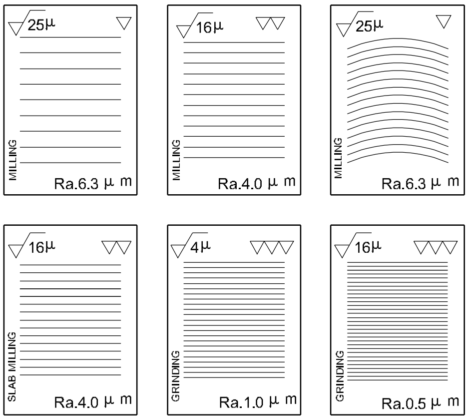
Fig 6



Surface finish standard

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

Fig 7



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

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

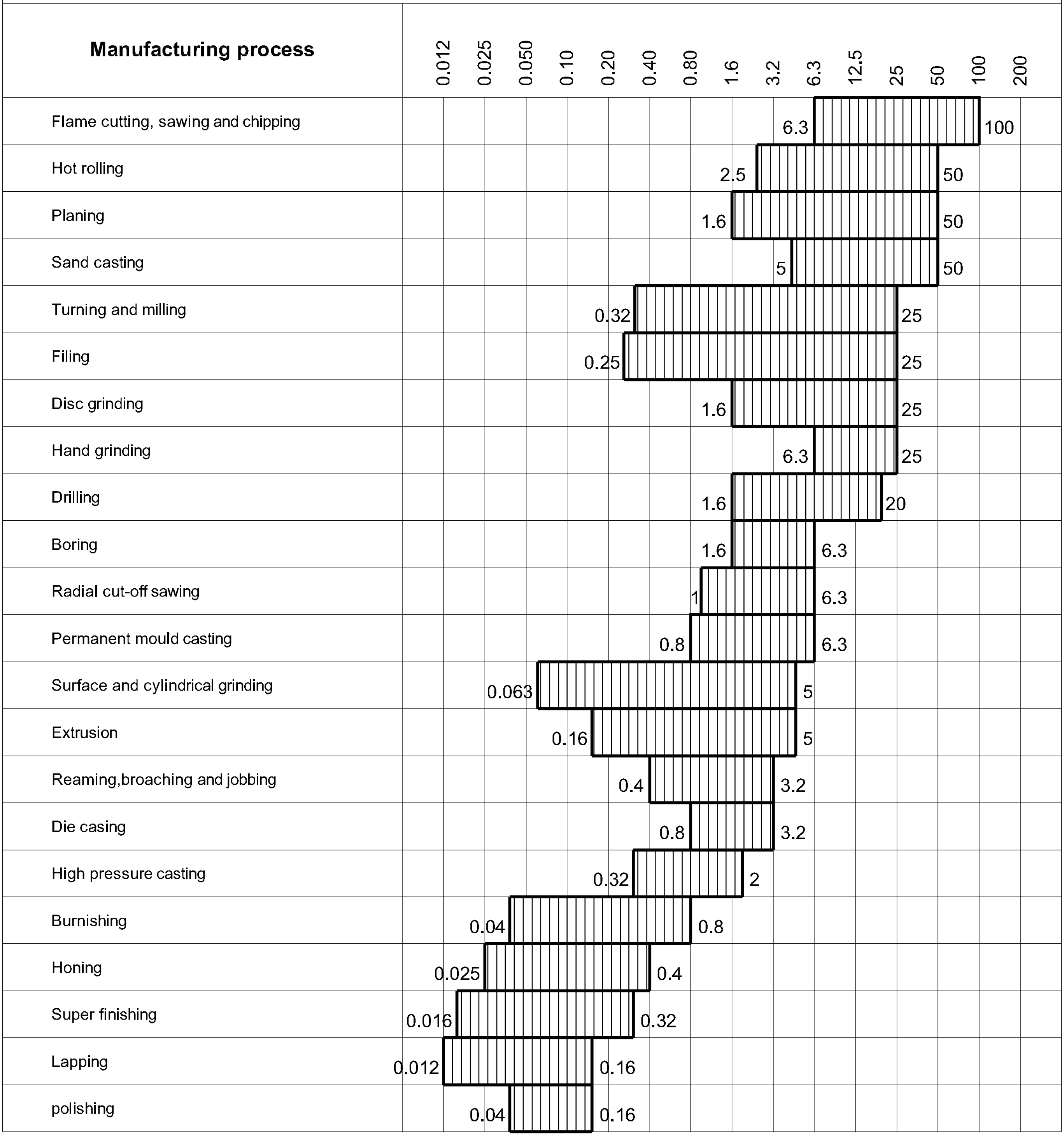
If the degree of accuracy of checking is high, then the application of a sensitive instrument is inevitable.

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

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

TABLE 1

Surface roughness expected from manufacturing processes IS : 3073 - 1967



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