Gauges

Objectives : At the end of this lesson you shall be able to
- **state the features of Go and No - Go gauges**
- **list the types of gauges used in production**
- **explain about the selective and non - selective asembly**
- **state the hole basis and shaft basis system.**

Features of Go and No- Go gauges

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

Go and No - Go principle

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

Essential Features

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

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

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

The dimension of these gauges are usually stamped on them.

Types of gagues used in production

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

Gauges and types of gauges

Objective: At the end of this lesson you shall be able to
- **define gauges their necessity and types.**

Gauge

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

Advantages of gauging

Faster checking of the product is within the specified limits.

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

Gauges are economical when compared to measuring instruments.

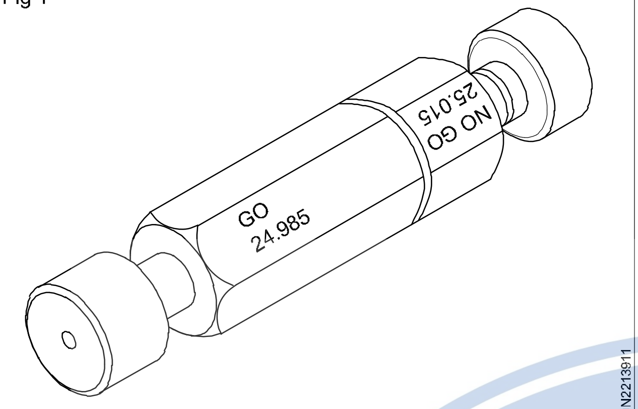
Instrument used for gauging

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

Types of cylindrical plug gauges

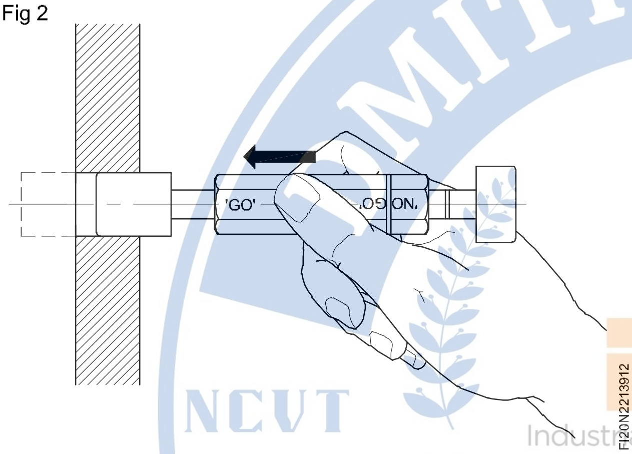
Double-ended plug gauge (Fig 1 and 2)

Fig 1



DOUBLE ENDED PLUG GAUGE

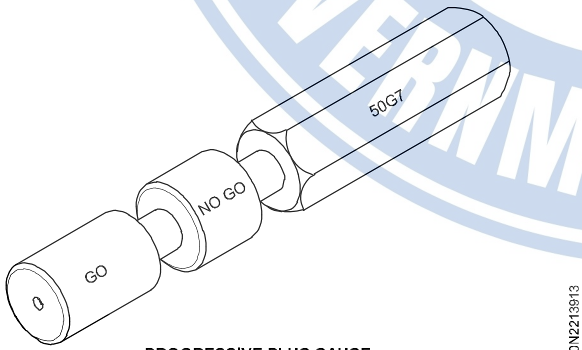
Fig 2



Progressive plug gauge (Fig 3)

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

Fig 3

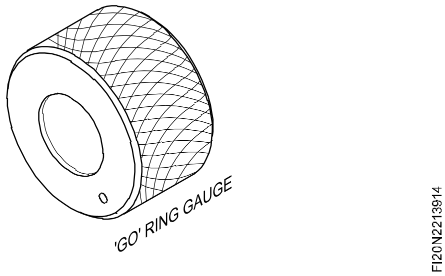


PROGRESSIVE PLUG GAUGE

Plain ring gauge (Fig 4)

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

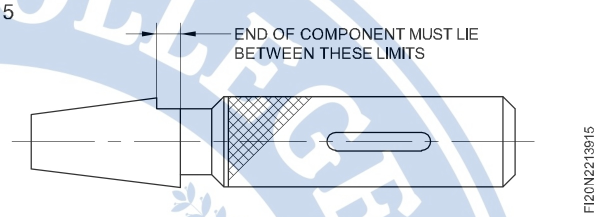
Fig 4



Taper plug gauges (Fig 5)

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

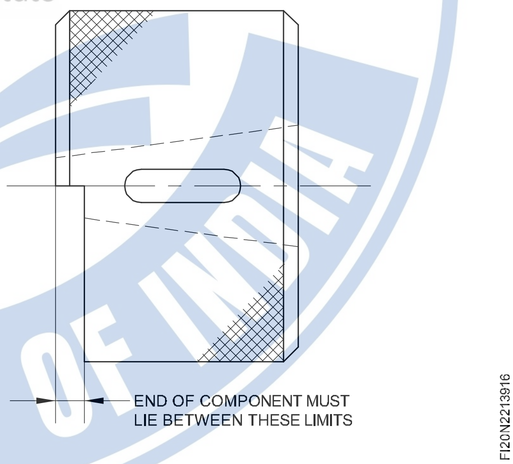
Fig 5



Taper ring gauges (Fig 6)

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

Fig 6



Thread plug gauges (Figs 7 and 8)

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

Thread ring gauges (Fig 9)

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

Fig 7

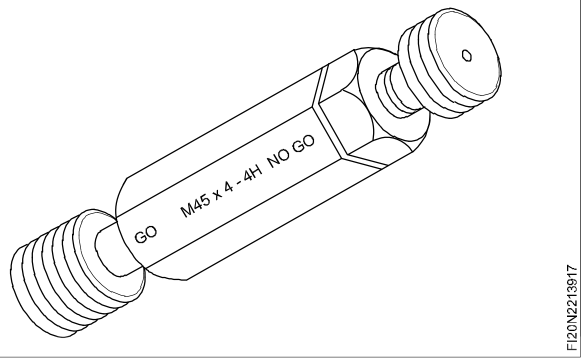


Fig 8

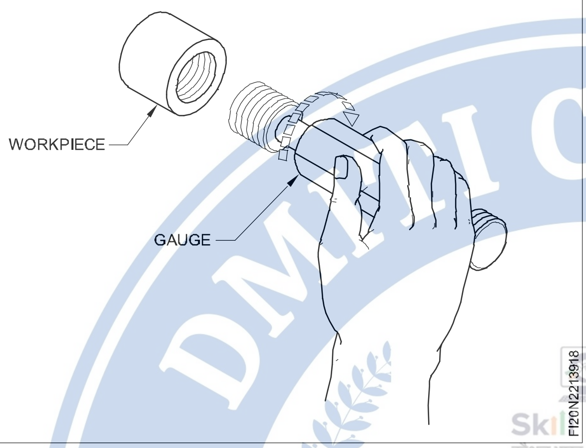
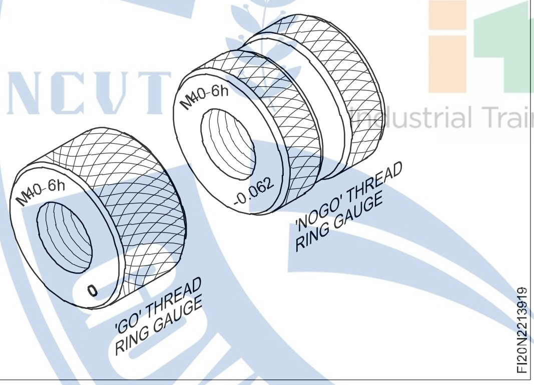


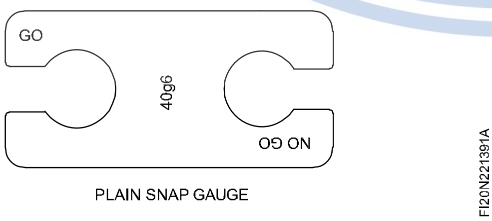
Fig 9



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

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

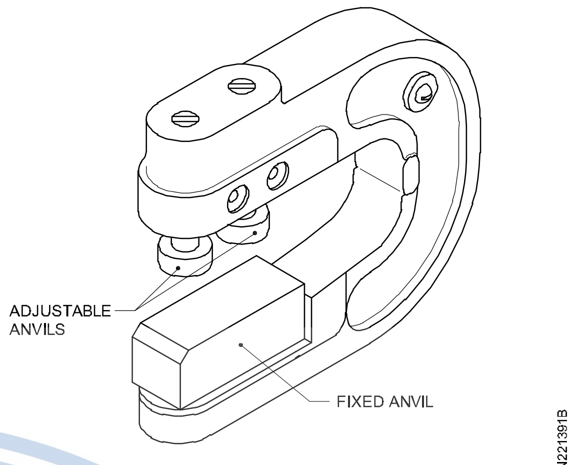
Fig 10



PLAIN SNAP GAUGE

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

Fig 11



ADJUSTABLE SNAP GAUGE

Fig 12

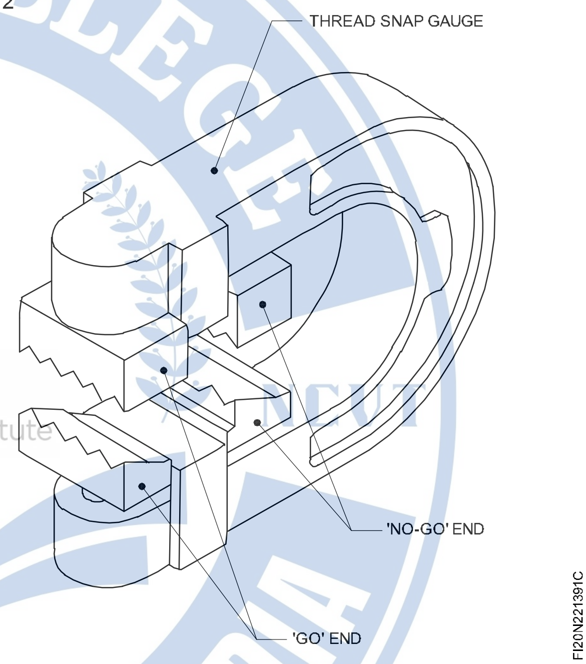
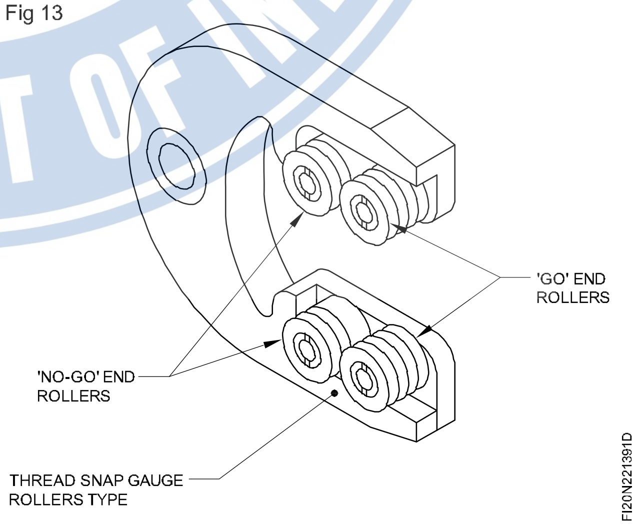


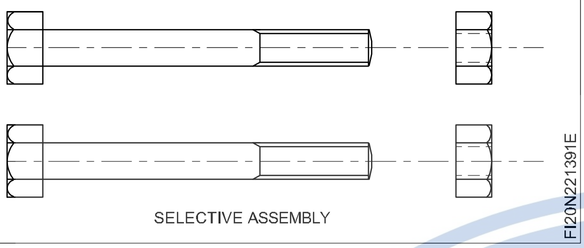
Fig 13



Selective assembly

The figure illustrate difference between a selective assembly and a non - selective assembly. It will be seen in (Fig 14) that each nut fits only one bolt. Such an assembly is slow and costly,and maintanance is difficult because spares must be individually manufactured.

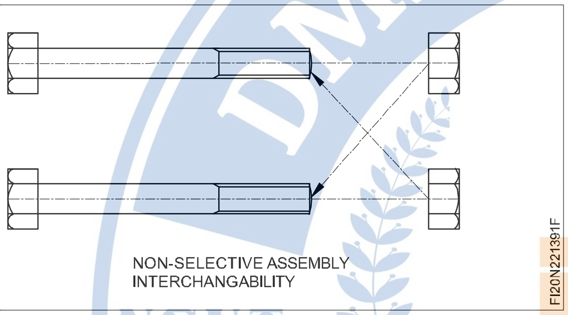
Fig 14



Non - selective assembly

Any nut fits bolts of the same size and thread type. Such an assembly is rapid, and costs are reduced. Maintenance is simpler because spares are easily available. (Fig 15)

Fig 15



Non - selective assembly provides interchangeability between the components.

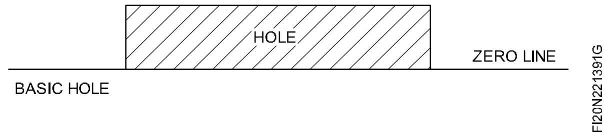
In modern engineering production, i.e. mass production, there is no room for selective assembly. However, under some special circumferences, selective assembly is still justified.

Hole basis system

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

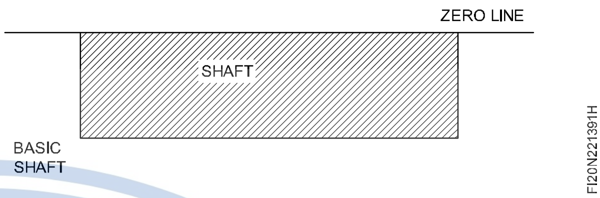
The fundamental deviation symbol 'H' is chosen for the holes, when the hole basis system is followed. This is because the lower deviation of the hole 'H' is zero. It is known as 'basic hole' (Fig 16).

Fig 16



Shaft basis system (Fig 17)

Fig 17

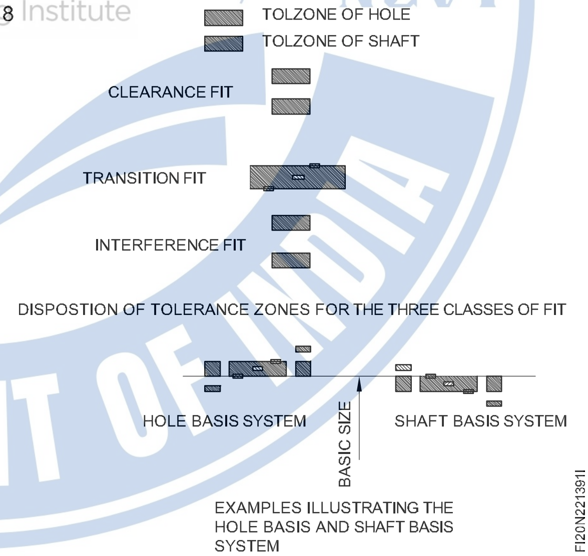


In a standard system of limits and fits, where the size of the shaft is kept constant and the variations are given to the hole for obtaining different class of fits, then it is known as shaft basis. The fundamental deviation symbol ' h' is chosen for the shaft when the shaft basis is follwed. This is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

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

The three classes of fits, both under hole basis and shaft basis, are illustrated in figure 18.

Fig 18



Bearings

Objectives : At the end of this lesson you shall be able to
- **state the purpose of bearings**
- **state the characteristics of plain bearings**
- **describe journal bearing & thrust bearing**
- **describe ball bearing and its types**

What are bearings?

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

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

The need for bearings

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

A bearing material should have the following properties.

It should:

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

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

Uses

Bearings are used to:

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

Bearings are generally grouped as:

- plain bearings
- anti-friction bearings.

Fig 1

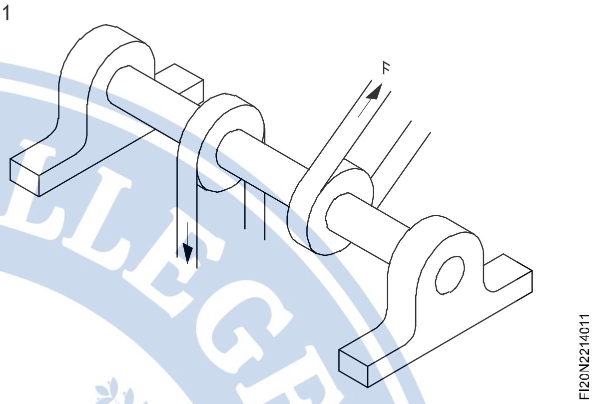
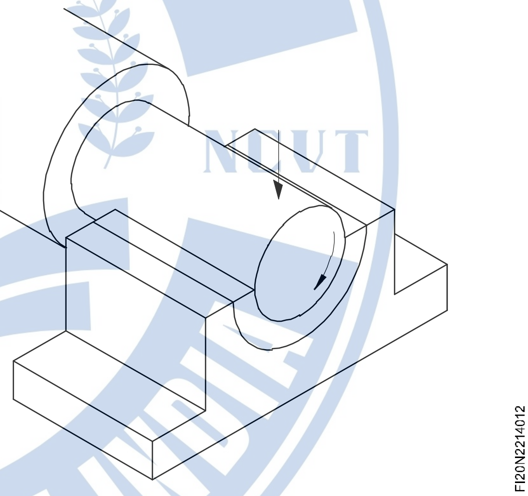


Fig 2



Plain bearings

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

Radial or journal bearing

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

Thrust bearing

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

Characteristics of plain bearings

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

Fig 3

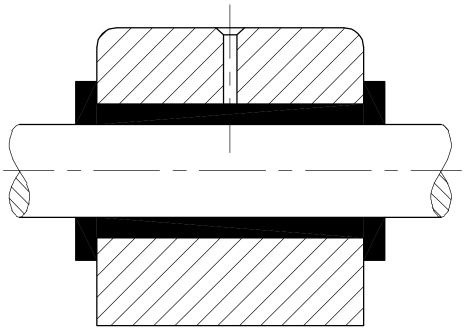


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Fig 4

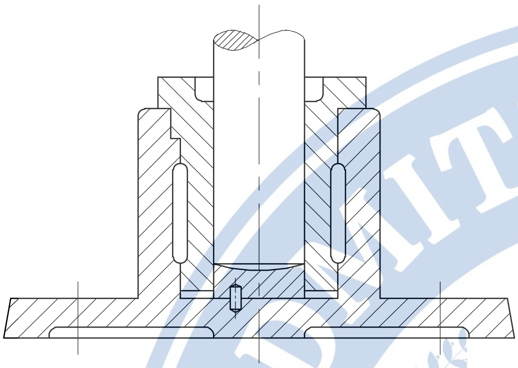

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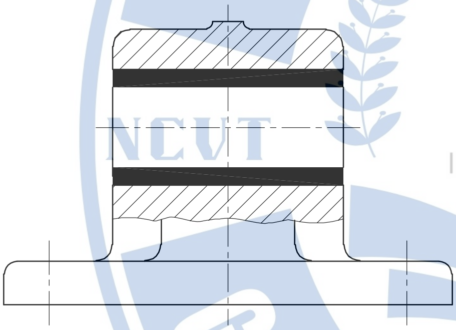
Fig 5



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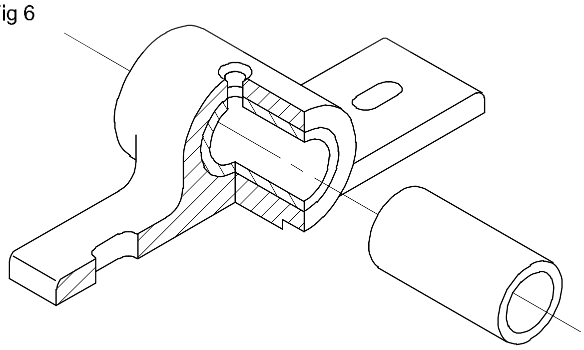
Plain bearings are kept in position without allowing them to rotate along with the shaft. For this purpose they are press fitted in the housing or provided with a key or screws. (Fig 5)

Types of plain bearings

Solid bearings (Fig 6)

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

Fig 6



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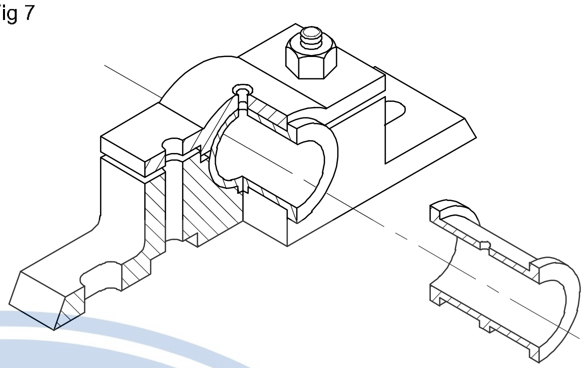
Split bearings (Fig 7)

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

Fig 7



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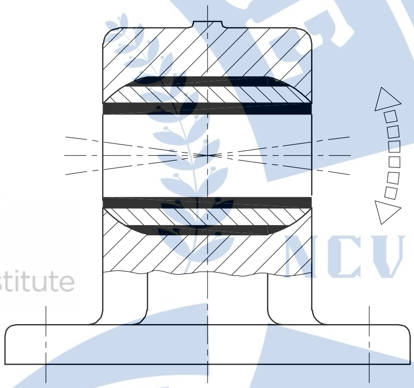
Self-aligning bush bearings (Fig 8)

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

Fig 8



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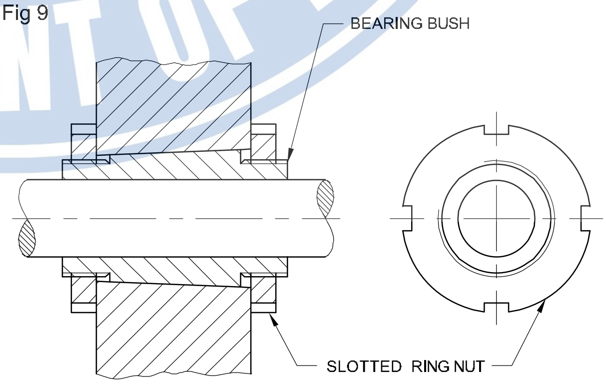
Adjustable slide bearing (Fig 9)

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

Fig 9



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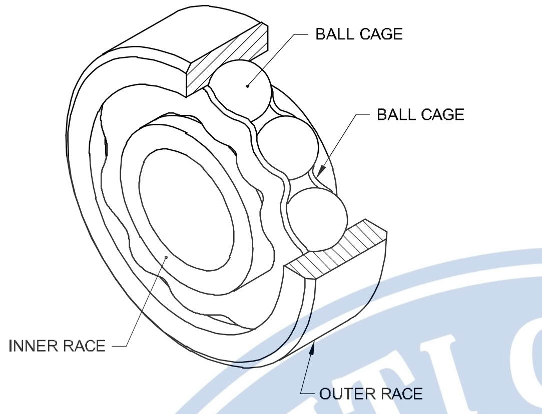
Anti-friction bearing

General features of anti-friction bearings

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

Fig 10



Rolling elements

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

Races

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

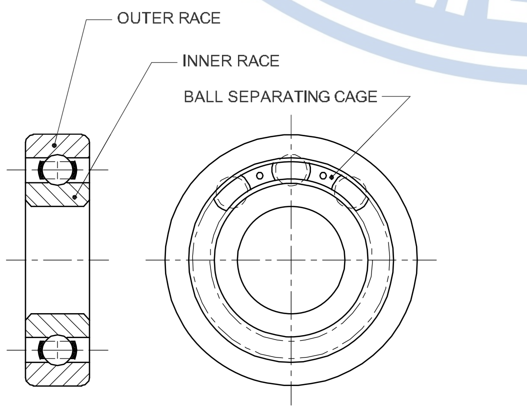
Cage

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

Ball-bearings

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

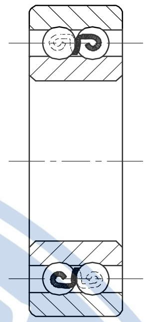
Fig 11



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

Self-aligning ball-bearings (Fig 12)

Fig 12



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

Ball bearing types

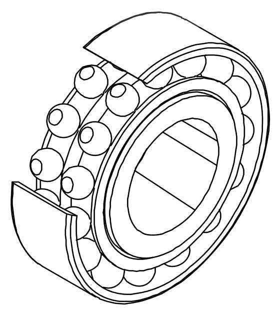
The three most commonly used types of ball bearings are the radial bearing, the angular contact bearing, and the double row ball bearing. The radial ball bearing is designed to accommodate primarily radial loads but the deep groove type will support bidirectional thrust loads up to 35% of the radial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

Single row ball bearing

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

Double row ball bearing (Fig 13)

Fig 13



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

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

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

Advantages of double row ball bearings

1 Double row ball bearings support heavy radial loads. thrust loads from either direction, or combined radial and thrust loads. They are normally used in positions where radial loads exceed the capacity of a single row bearing with a comparable bore and OD.

2 Double row bearings are designed with the bore and outside diameter the same as single row bearing but are narrower than two single row bearing.

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

Double row angular contact ball bearings

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

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

- 5200 series - Lights load,higher speed, more/smaller balls per bore diameter

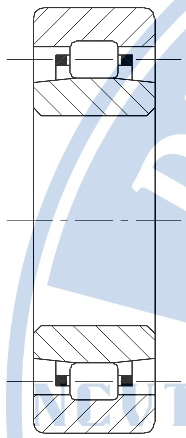
- 5300 series - Heavier load, slower speed, fever/larger balls per bore diameter.

Roller & needle bearings

Objectives : At the end of this lesson you shall be able to
- **describe roller & needle bearing**
- **state types of roller bearing**
- **state the method of fitting bearings.**

Roller bearings (Fig 1)

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

Fig 1

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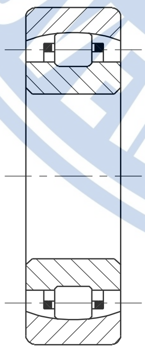
Self aligning roller bearings (Fig 2)

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

Fig 2

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Needle bearings

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

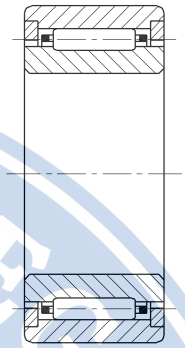
Fig 3

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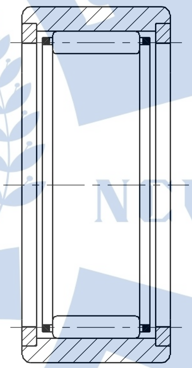
Fig 4

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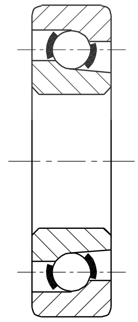
In this design the needles are in contact with the shaft journal.

Angular contact ball-bearing

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

Fig 5

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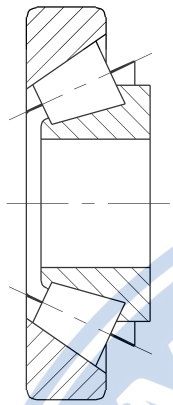
Tapered roller bearings (Fig 6)

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

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

Fig 6



Thrust ball-bearing

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

Fig 7

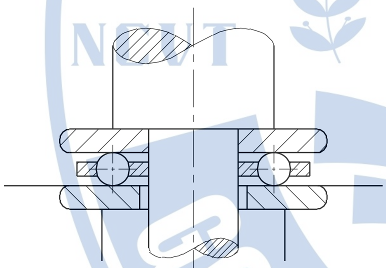
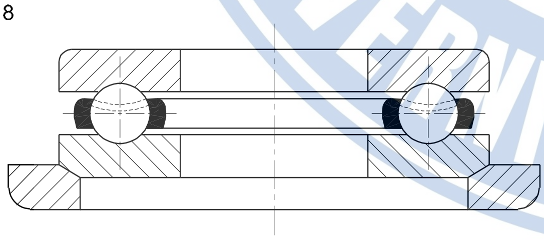


Fig 8



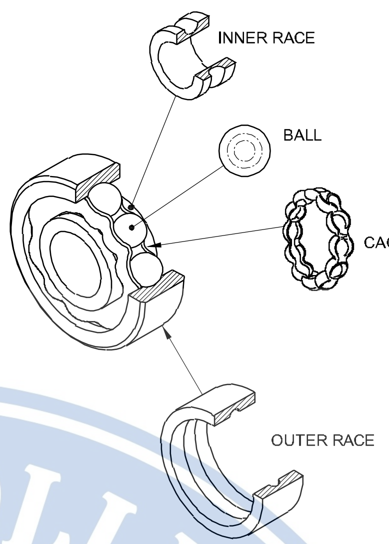
Bearings are the supporting members of a rotating shaft. They provide safe and reliable service when properly applied and maintained.

Rolling contact

Rolling contact bearing is also known as anti-frictional bearing. In this bearing, contacting elements have rolling friction which is much lesser than sliding friction. Bell bearings have point contacting while roller bearings have the contact.

Rolling elements (Fig 9)

Fig 9



COMPONENTS OF BALL BEARING

A rolling element bearing consists of four basic parts.

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

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

Materials

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

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

Importance of proper fit

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

In general applications, when the journal (spindle) is rotaing, the inner face will have an interference fit with the journal and the outer race will have a close push fit. In the case of a stationary spindle, when the outer race is the rotating member, the interference fit will be withh the outer race, and the hub and close push fit with the inner race and spindle. The degree of tightness and looseness depends upon the load, speed, temperature and the type of the bearing.

Bearing mounting

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

Fig 10

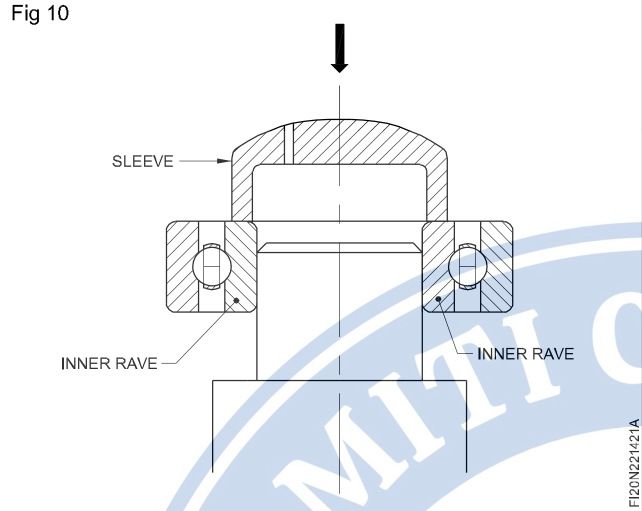
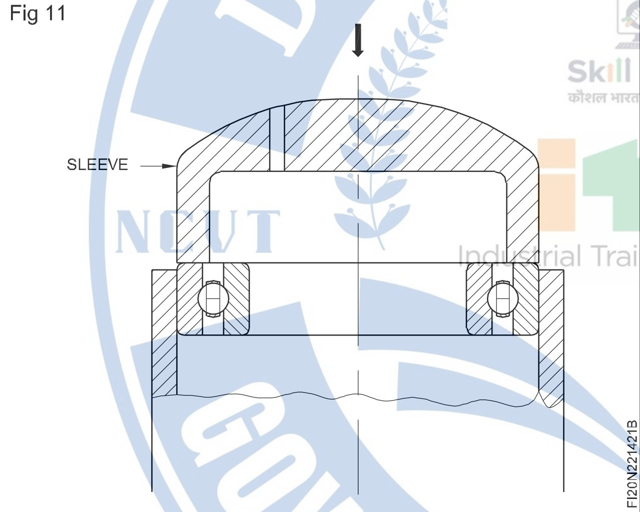


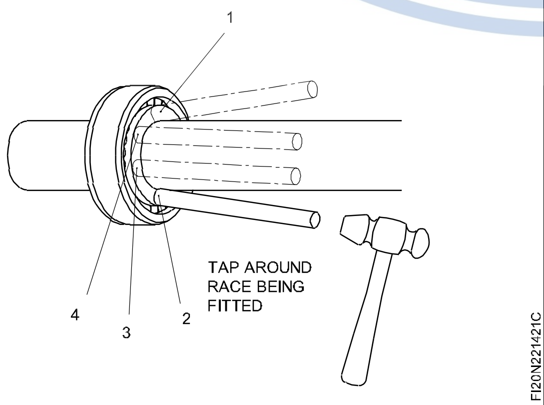
Fig 11



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

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

Fig 12

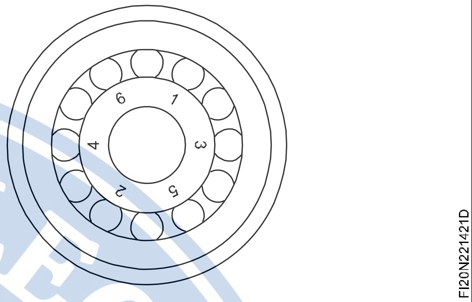


The mounting sleeve should have its faces parallel and flat.

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

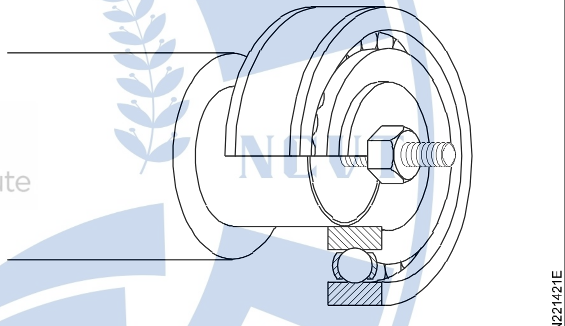
When a suitable bearing puller is not available, as soft metal drift may be used to drive the bearing into position. While striking the bearing onthe inner race, it should be struck progressively on the opposite point of the race as shown in Fig 13.

Fig 13



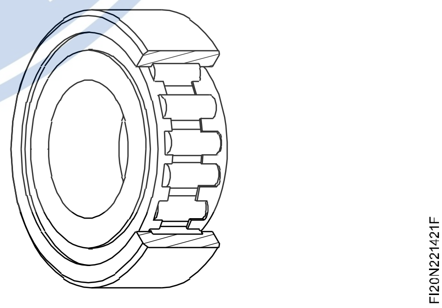
If a shaft is having internal threads at the centre (Fig 14) or external threads, they can be utilised for mounting the bearings.

Fig 14



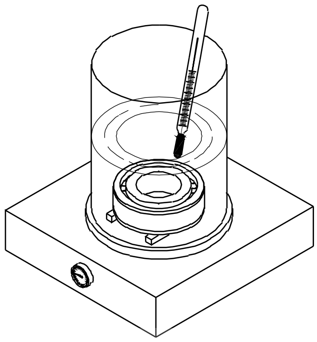
Separable parts of cylindrical roller bearing are more independently. Mount the inner ring first and the outer race with the roller and cage assembly after bit of oiling or greasing. (Fig 15)

Fig 15



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

Fig 16



OIL HEATING OF BEARING

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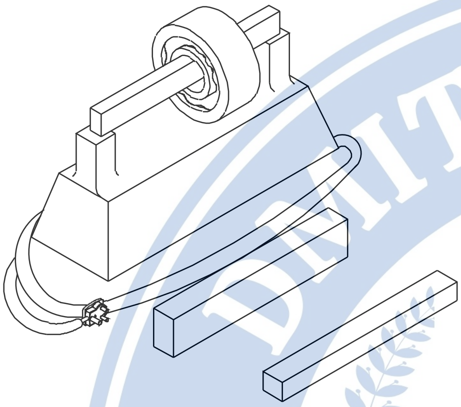
Fig 17



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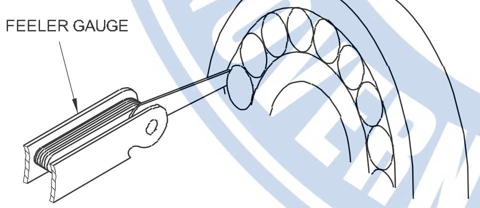
In no case should the rolling contact bearing be heated more than 140°C.

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

Fig 18



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The inner ring of bearings with the tapered bore is always mounted with an interference fit, usually on a taper adopter sleeve or a withdrawal sleeve. When the bearing driven up the original radial, the internal clearance is reduced. The reduction in clearance required can be referred to in the table provided by the bearing manufacturer. The clearance is measured as shown in Fig 18.

Bearing dismounting

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

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

Fig 19

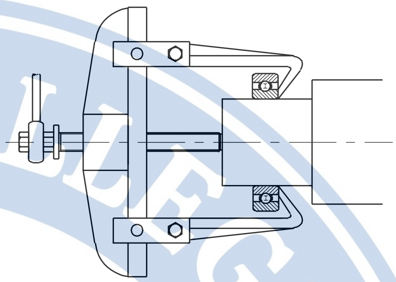

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Fig 20

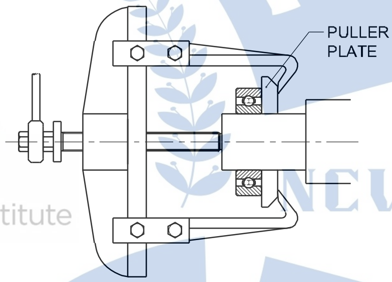

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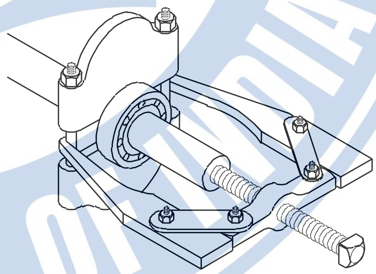
Fig 21



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

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

Fig 22

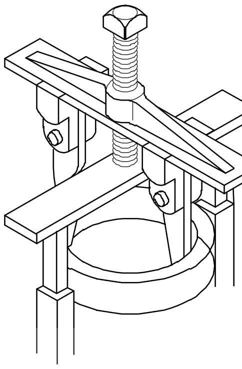
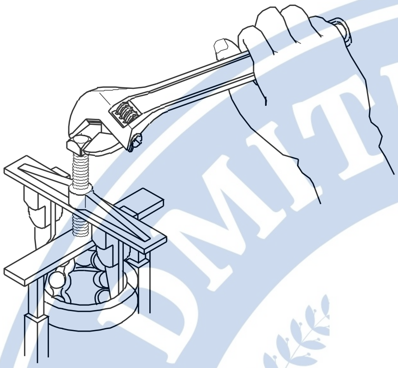


Fig 23



Care and maintenance

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

Bearing materials

Objectives: At the end of this lesson you shall be able to
- **state the properties of plain bearing materials**
- **name the different materials commonly used for making plain bearings**
- **state the characteristics of different bearing materials.**

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

In general the bearing materials should have the following properties.

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

Bearing materials (Plain bearings)

White metal

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

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

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

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

Cadmium based alloy

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

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

Copper lead alloys

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

Lead bronze and tin bronze

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

These bearings find application for intermediate load and speed requirements.

Aluminium alloys

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

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

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

Cast iron

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

Sintered alloys

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

Plastics

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

- Good resistance to corrosion.
- Silent operation.

- Ability to be moulded in different shapes easily
- Elimination of the need for lubrication.

The most commonly used types of plastic materials are

- laminated phenolics
- nylon
- teflon.

Laminated phenolics

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

Nylon

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

Teflon

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

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

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

Purposes of using lubricants

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

Prevention of rust and corrosion

Objectives : At the end of this lesson you shall be able to
- **state the importance of keeping the work free from rust and corrosion**
- **state the need for prevention of corrosion**
- **name the different methods of metallic coatings used for preventing crrosion**
- **state the different cementation processes**
- **state the application of different metallic protective coatings**
- **state the treatments to provide pleasing finish.**

The importance of keeping the work free from rust and corrosion

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

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

Protective treatment of metal surface

The type of protective treatment used depends upon:

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

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

Commonly used metallic corrosion-resisting coatings

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

Galvanizing

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

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

Electroplating

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

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

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

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

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

Cladding

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

Fig 1

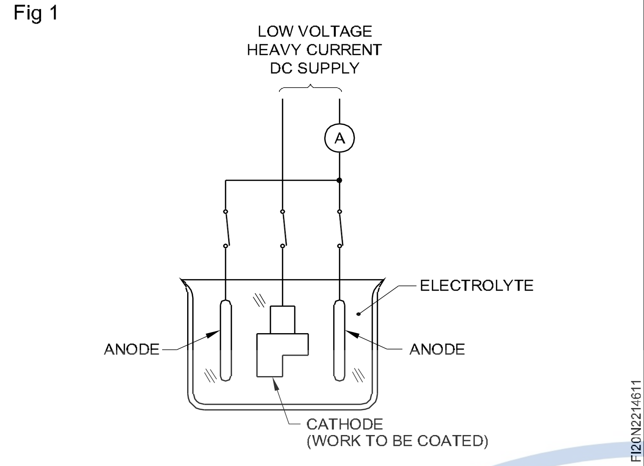
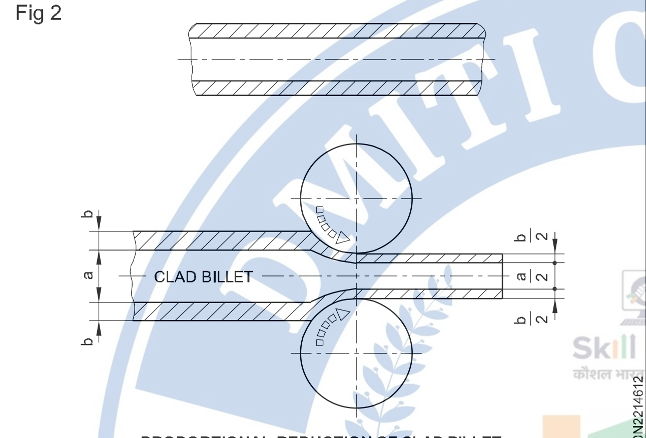


Fig 2



PROPORTIONAL REDUCTION OF CLAD BILLET

Metal spraying

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

Cementation

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

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

Sherardising

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

Calorising

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

Chromising

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

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

Zinc

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

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

Aluminium

Aluminium and its alloys have a great affinity for oxygen. Aluminium surfaces quickly develop a thin, transparent film of aluminium oxide or 'Alumina' which prevents further oxidation and retains bright appearance. However exterior use of aluminium results in the thickening of the oxide film. This film becomes grey in colour and protects the parent metal from further attack. The oxide film on aluminium and its alloys can be artificially thickened by a process called anodising.

Lead

Lead is one of the most corrosion-resistant of all metals. A large quantity of lead is used as sheathing material for underground telephones and power cables. The WHITE OXIDE film resulting from exposure to the atmosphere prevents further attack.

Stainless steel

It has high structural strength as well as resistance to corrosion. Stainless steels are not confined to applications requiring resistance to atmosphere corrosion. They are used extensively for chemical plant and food processing equipment where they combine corrosion resistance at elevated temperatures.

Nickel

Nickel is used extensively for 'NICKEL PLATING' as it has high resistance to chemical attack. When alloyed with copper in the proportion of 2:1 (Nickel two third) 'MONEY METAL' is produced which is extremely resistant to corrosion, particularly to sea water and acid.

Chromium

One of its most important uses is for electroplating metallic surfaces. It is highly resistant to the influence of corrosion and it retains its high polish and colour for a long period.