Driving machines (engines or prime movers)

This group includes all machines whose purpose is to drive other machines. Examples include:

electric motors
steam turbines
diesel engines
petrol engines
air motors

The common characteristic of these machines is that they convert an energy input of varying kinds into a mechanical output in the form of a rotating drive shaft.

Transmission machines

These are machines whose purpose is to transmit mechanical energy from a driving to a driven machine. Examples include:

gearboxes
differentials
variable speed drives

The mechanical energy transmitted often undergoes a speed transformation and these machines often incorporate some means of drive disengagement such as a clutch.

Driven machines

These machines cannot operate independently and need to be coupled to a driving machine. Examples include:

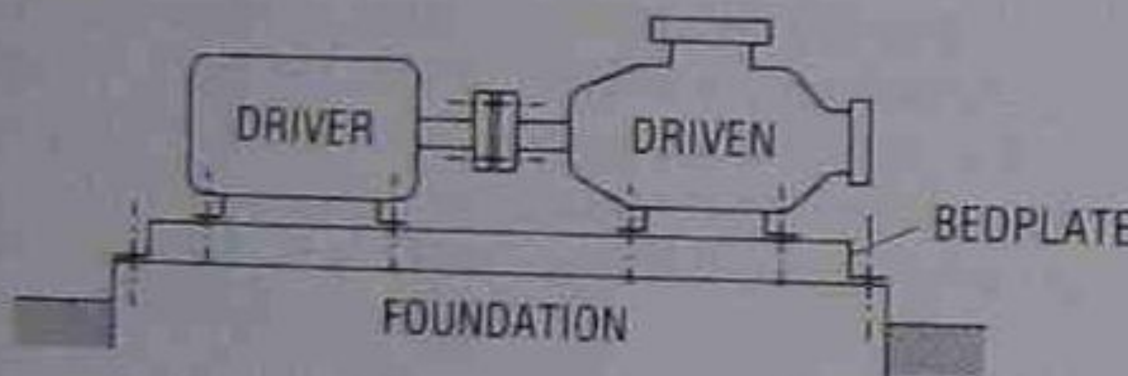
pumps
compressors
fans
generators
blenders
machine tools

Although each machine is different in some way, and each engineering situation gives rise to special requirements, there are a number of conditions that are critical to the operation of all rotating machines. In Chapter 1, seven criteria were identified that can be used to determine the operating condition of a machine. They were:

Performance
Downtime
Service life
Efficiency
Safety
Environmental impact
Maintenance cost

If a machine is to perform 'satisfactorily' according to these criteria, then the following conditions must be satisfied.

Rotating machines are frequently required to operate in 'sets' e.g. driver-driven, and therefore require a common bedplate on which the separate units can be mounted. This common bedplate provides a rigid, level structure which enables the machines to be maintained in alignment during operation. Independent machines that are sufficiently rigid and are not required to align with other equipment may be mounted directly onto a foundation.



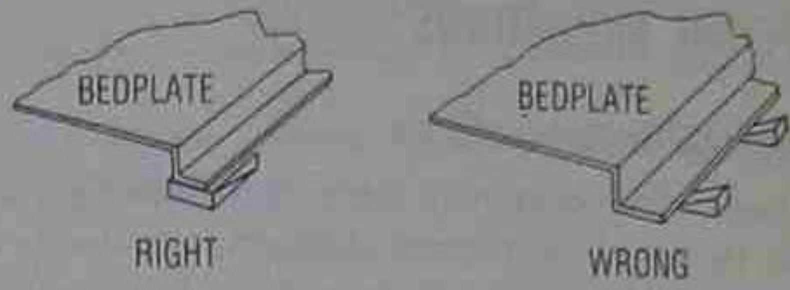


Fig. 3-3 Using wedge-shaped shims.

Fig. 3-4 A dial indicator set up across a coupling.

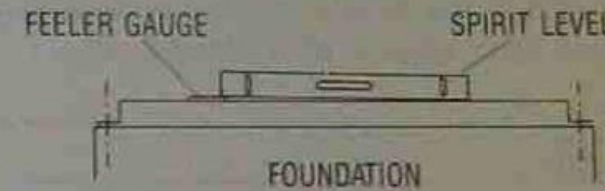
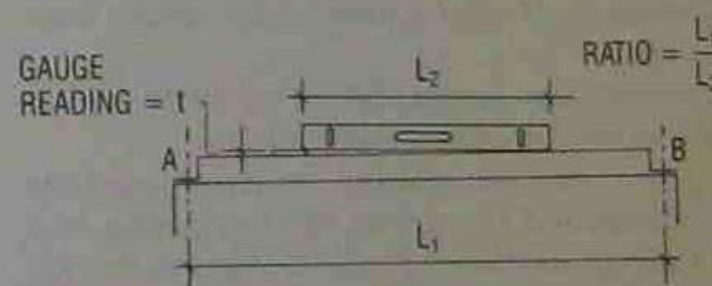


Fig. 3-5 Using a feeler gauge to determine adjustments.

(ii) Determine the ratio of the length of the bedplate to the length of the spirit level as shown in Fig. 3-6.



SPECIAL MOUNTINGS

Adjustable mountings

In cases where machinery items are free-standing or may be subject to frequent changeover or change of position, anchor bolts may be replaced by adjustable mountings that provide a quick and easy means of levelling.

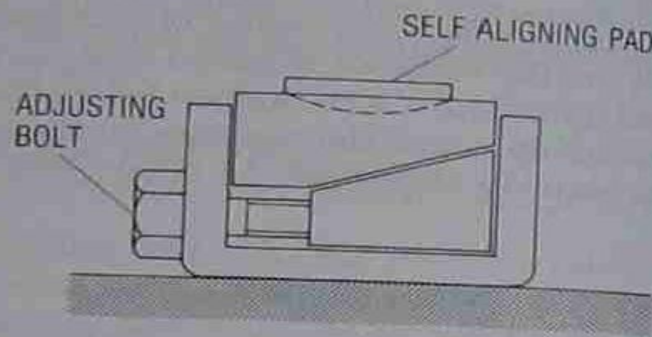


Fig. 3-8 A typical example of an adjustable mounting.

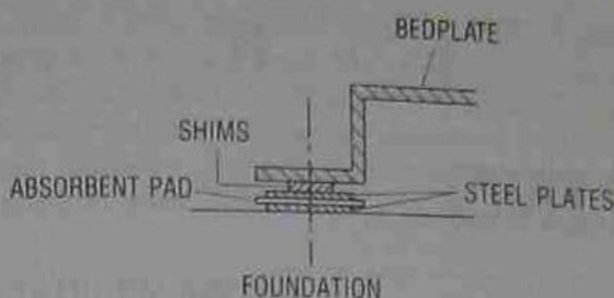


Fig. 3-9 Inserting absorbent material between bedplate and foundation

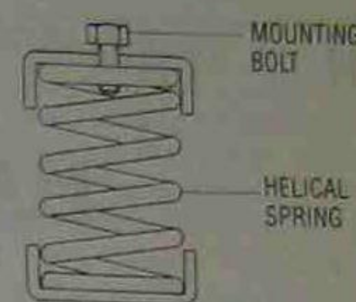


Fig. 3-10 A simple spring mounting.

PRINCIPLES OF BALANCING

If the centre of gravity of a rotating machine element does not coincide with its centre of rotation, then the machine is said to be unbalanced. When the machine is stationary, the off-centre mass causes the machine element to settle in a fixed position. (Fig. 4-1)

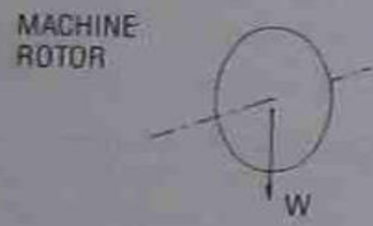


Fig. 4-1 Stationary machine with an off-centre mass.

As the machine element rotates, a centrifugal force associated with the off-centre mass develops and imposes a fluctuating load on the shaft support bearings as shown in Fig. 4-2.

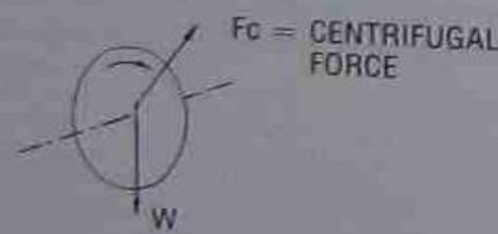


Fig. 4-2 Rotating machine with an off-centre mass.

STATIC BALANCING

The simplest and easiest method of balancing is one that uses static conditions to determine the relative position of the centre of gravity and centre of rotation. This method is relatively straightforward but it is strictly limited to machine elements with only one plane of correction, such as circular saw blades and other 'thin' rotors.

The procedure involves setting up the rotor so that it can rotate freely and settle in its equilibrium position. This usually requires the rotor to be removed from the machine and balanced on knife edges as shown in Fig. 4-3.

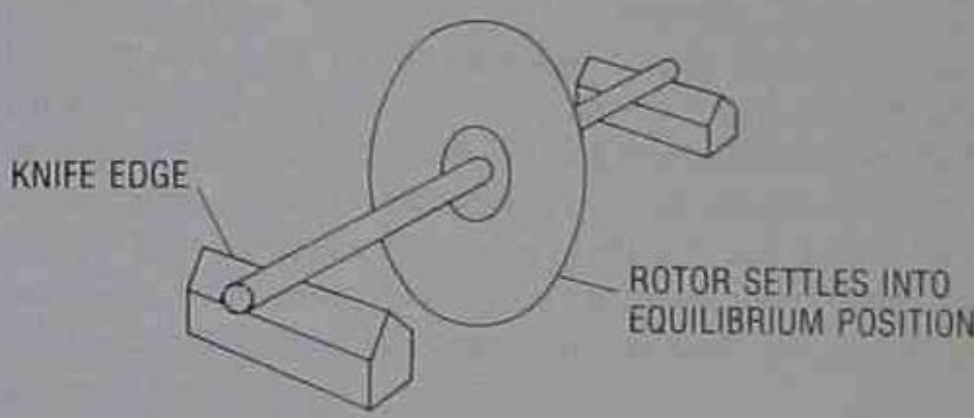


Fig. 4-3 Preparing the rotor for static balancing.

DYNAMIC BALANCING

Where a rotor has more than one plane of correction, i.e., anything other than a 'thin' rotor, balancing must be carried out dynamically. It is normal practice for the machine rotor to be removed and temporarily installed on a special balancing machine. The machine is then run up to a suitable speed and the out-of-balance forces measured.

The principle of dynamic balancing is based on the measurement of the rotating couples that are set up as a result of the out-of-balance forces. Because most rotating machine elements have their mass distributed over some axial distance, the problem of determining the correct position for mass compensation becomes more complicated. Fig. 4-4 shows the twisting effect on the support bearings of the centrifugal force associated with the off-centre mass distribution.

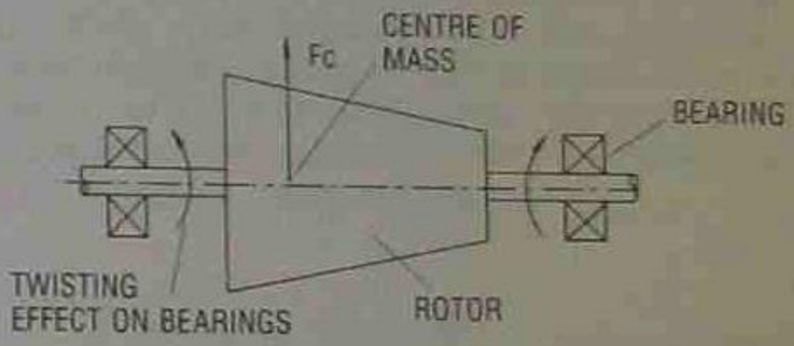


Fig. 4-4 Twisting effect associated with off-centre mass distribution in a machine rotor.

Whenever the surfaces of two bodies are in contact, the force of friction will resist relative motion between them. The operation of almost all industrial equipment relies on the relative motion of separate machine elements and lubrication is necessary to overcome the effects of the friction forces. To lubricate means 'to make smooth and slippery', and thus the application of a lubricant helps to reduce the effect of friction. Friction causes energy to be wasted in the form of heat and causes the rubbing surfaces to wear. The introduction of a lubricant separates the surfaces in contact and thus reduces the effects of friction although friction can never be entirely eliminated.

The basic purposes of lubrication are to:

reduce friction
reduce wear
dampen shock
cool moving elements
prevent corrosion
seal out dirt

LUBRICANT SELECTION

The selection of a lubricant is determined by the following factors:

Load The load on the bearing will determine the pressure that the lubricant will have to work agai

Speed As operating speeds increase the lubrica surfaces will tend to wear faster.

Temperature The operating temperature affect the properties of the lubricant.

Environment The lubricant may be required cope with the presence of water or corro materials.

Lubricant selection should normally be left those who are expert in the field. However, general rule it is worth remembering that for pl journal bearings:

- For light loads and high speeds – use a lubricant low viscosity; and
- For high loads and low speeds – use a lubricant high viscosity.

METHODS OF APPLICATION

The golden rule of lubrication is said to be: 'Good lubrication depends on the right lubricant being available in the right quantity at the right time.' For this to be achieved the technician must be aware of a number of basic principles governing the application of lubricants.

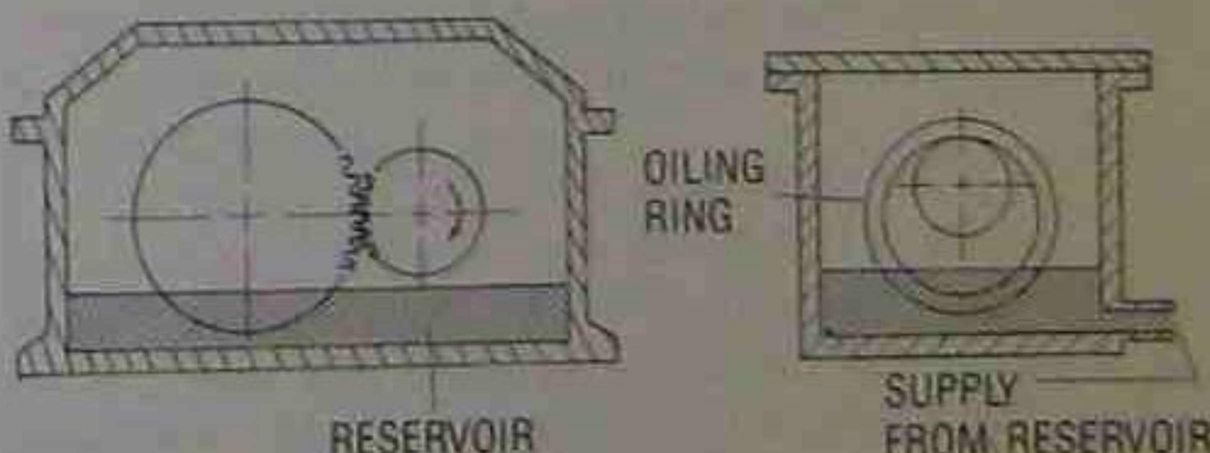
- Cleanliness is vital. Lubricating equipment must be kept free of dirt and other contaminants.
- Lubricants are not necessarily interchangeable and as a general rule should not be mixed. Before changing lubricant the equipment should be cleaned out.
- An excess of lubricant, especially grease, will cause excessive heat to build up and eventual breakdown of the lubricant.
- Lubricant filters or strainers should always be changed at the recommended time.

- The selection of lubricant for a particular application should be left to qualified personnel if possible.
- Inadequate lubrication can often be identified by the operating condition of a bearing, especially its temperature. As a general rule, if a bearing is too hot to hold a hand on it, then lubrication may be inadequate and should be investigated.
- Lubricants are potentially hazardous materials and should be stored with regard to safety and effect on the environment.

There are four basic methods by which lubricants can be applied and these are selected according to design criteria and the particular demands of the equipment.

Splash lubrication

Splash lubrication relies on the components requiring lubrication being partially immersed in an oil sump so that they pick up oil as they rotate. The oil picked up in the process may also be deposited on the shaft bearings and other components. A variation on this method is the ring-type oiler which uses a steel or brass ring which rotates with the shaft and picks up oil which it deposits on the upper surface of the shaft. Examples of these methods are shown in Fig. 5-10.



CHARACTERISTICS AND PROPERTIES

There are four basic types of lubricant:

liquid
semi-solid or plastic
solid
gaseous

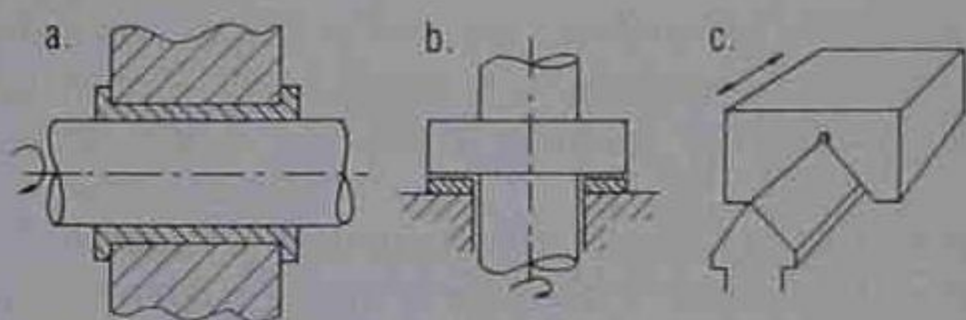
and they can be classified according to their source:

animal
vegetable
mineral

Most lubricants are mineral based and are obtained from petroleum by refining processes and further purification and blending. Petroleum and petroleum products belong to the group of chemicals known as 'hydrocarbons' because they are compounds of the elements hydrogen and carbon in varying combinations.

A bearing is a device which supports a rotating shaft or spindle or guides one component which slides over another. In addition to its supporting function, a bearing is designed to allow relative movement between two separate components to occur with the least possible frictional resistance. Almost all industrial mechanisms contain elements which require relative movement between contacting surfaces and therefore include some sort of bearing.

In principle, bearings fit into two main categories: **Plain bearings** in which the surface of one component slides over the surface of another and where the surfaces in contact are specially prepared in order to minimise friction and wear.



Rolling element bearings in which a series of rolling elements, i.e. either balls or rollers of various shapes, are interposed between the two surfaces in order to facilitate movement of one with respect to the other. Rolling element bearings are sometimes referred to as anti-friction bearings because the relatively small contact area of the rolling elements helps to reduce, though not eliminate, the resistance to relative motion.

Bearings can also be classified according to the type of function they perform:

Journal bearings which support a rotating shaft or spindle and confine radial motion as in Figs. 6-1a and 6-2a.

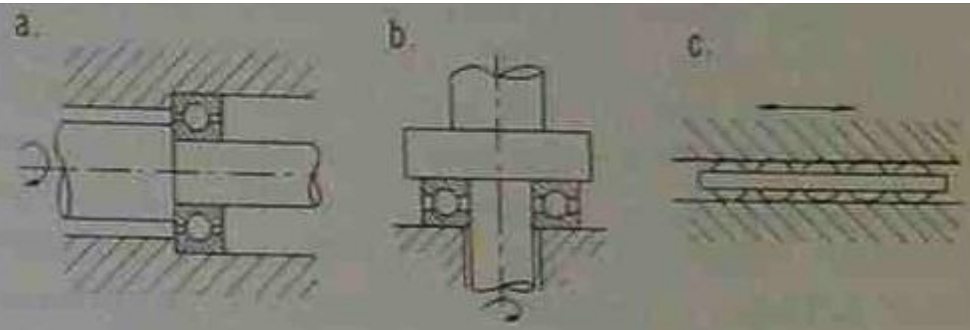


Fig. 6-2 Examples of rolling element bearings.

Thrust bearings which prevent axial motion of a shaft as in Figs. 6-1b and 6-2b.

Linear bearings which guide or support relative motion between components in a straight line as in Figs. 6-1c and 6-2c.

The function a bearing performs is largely determined by the type of load that it has to carry. The type of load also determines the particular type of bearing selected. Loads can be one of three kinds:

Radial
Axial
Combination

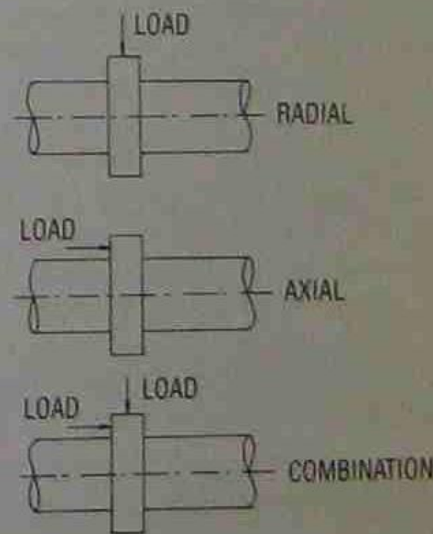


Fig. 6-3 Bearing loads.

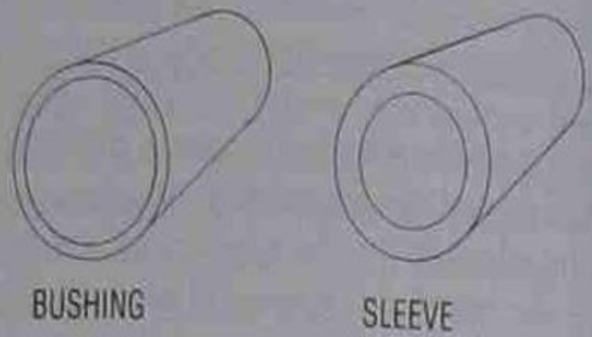


Fig. 6-4 Types of solid journal bearings.

Thrust bearings

A plain thrust bearing supports the end thrust of a shaft and restrains axial movement. The bearing surface itself consists of a stationary surface in the form of a pad against which the rotating element bears.

The most common form of plain thrust bearing is the thrust collar arrangement with the bearing face machined with radial grooves as shown in Fig. 6-7.

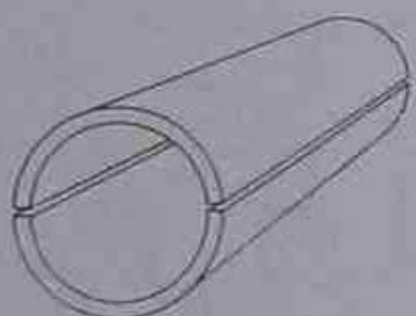


Fig. 6-5 Split journal bearing.

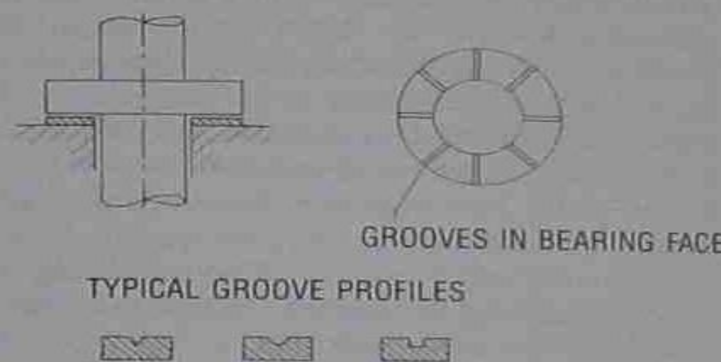


Fig. 6-7 Plain thrust bearing.

Linear bearings

Linear bearings, which are often called ways or guides, support either linear or curvilinear motion and are often associated with reciprocating mechanisms.

There are various forms that linear bearings can take, some of which are shown in Fig. 6-10.

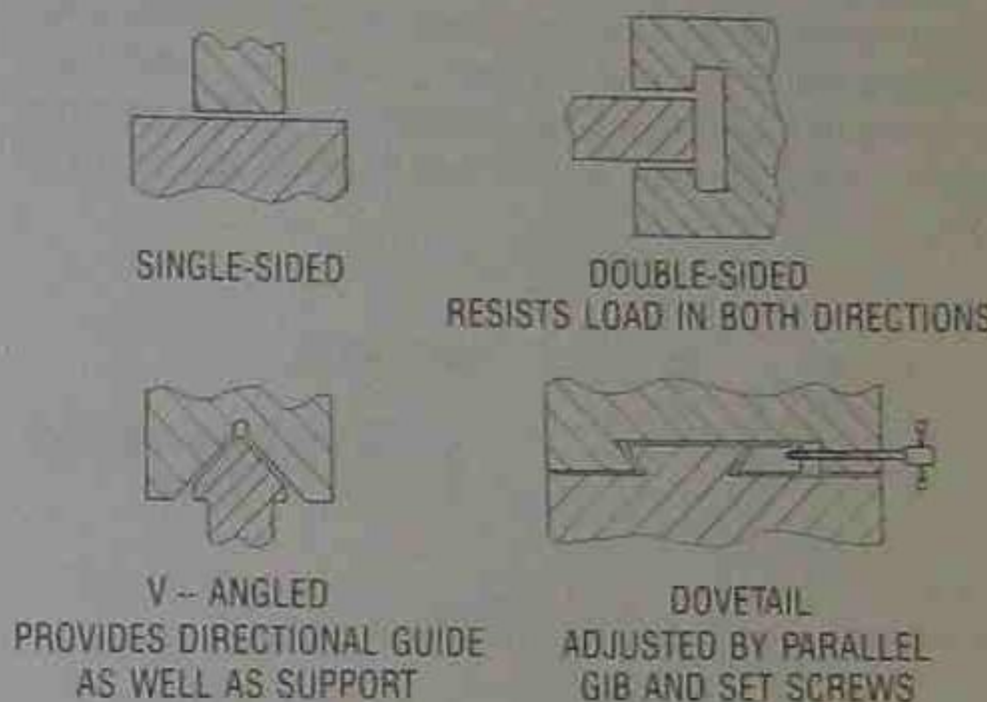


Fig. 6-10 Typical plain linear bearings.

Copper-lead alloys

These provide strength and fatigue resistance up to four times that of whitemetals. Conformability and embeddability are lower however, and are sometimes improved by overlaying a thin layer of whitemetal in a tri-metal construction as shown in Fig. 6-11.

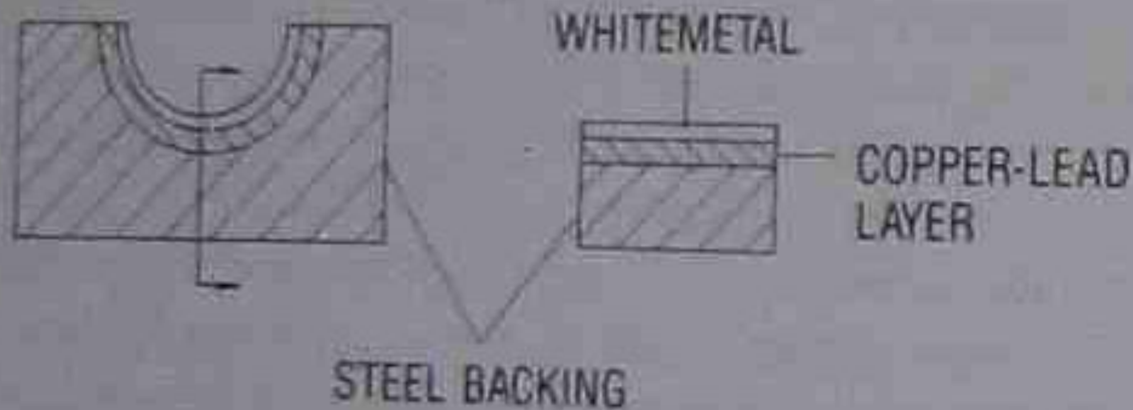


Fig. 6-11 Overlaying a copper-lead alloy with whitemetal.

6.2 ROLLING ELEMENT BEARINGS

PRINCIPLES OF OPERATION

Rolling element bearings, or anti-friction bearings as they are often called, differ from plain bearings in that they incorporate rolling elements, either balls or rollers, which are held between two raceways as shown in Fig. 6-31. A soft metal cage or retainer separates the rolling elements and ensures that they are evenly spaced, but does not carry any load. As a result of the relatively small area of contact between the rolling elements and the races, the frictional resistance to relative motion is comparatively low.

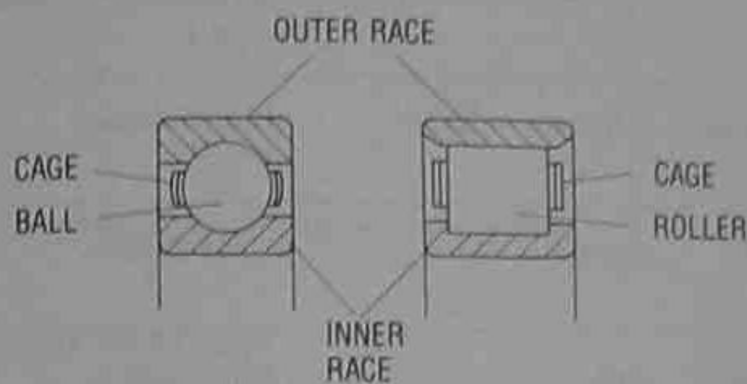


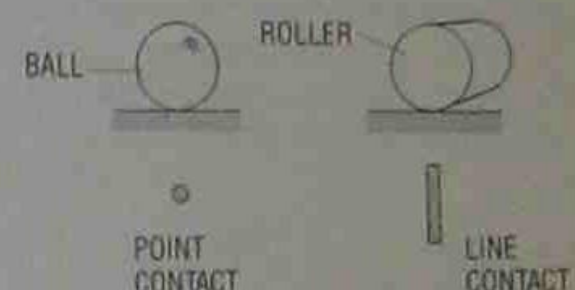
Fig. 6-31 Typical ball and roller bearings.

Because the relative motion between the moving

Ball bearings
can operate at higher speeds without overheating,
are less expensive for lighter loads,
have lower frictional resistance at light loads,
are available in a wider range of sizes.

Roller bearings
can carry heavier loads,
are less expensive for heavier loads and larger sizes,
are superior under shock or impact loading,
provide greater rigidity.

The important physical difference between balls and rollers that gives rise to this difference in performance is the variation in the area of contact between the rolling elements and the raceway. The ball has a small area of contact which resembles point contact depending on how much deformation of the ball and raceway occurs. The roller, by comparison, has a greater area of contact which resembles line contact. The difference is shown in Fig. 6-32.



Linear bearings

The construction of slider or linear motion bearings is slightly different from that of journal and thrust bearings.

Ladder bearings

These consist of two hardened steel plates that are separated by a series of balls or rollers held in a cage as shown in Fig. 6-35. They may be used either vertically or horizontally.

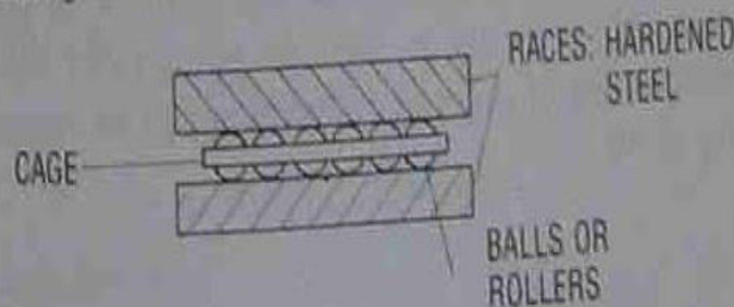


Fig. 6-35 Ladder bearing.

Recirculating ball and roller bearings

In these units the rolling elements are only in contact with the way or slide for a specific distance, then they leave the load area, drop into a return channel and return to the opposite end of the assembly to be fed back into the loaded area. The roller version can carry greater load than the ball but tends to have a shorter life.

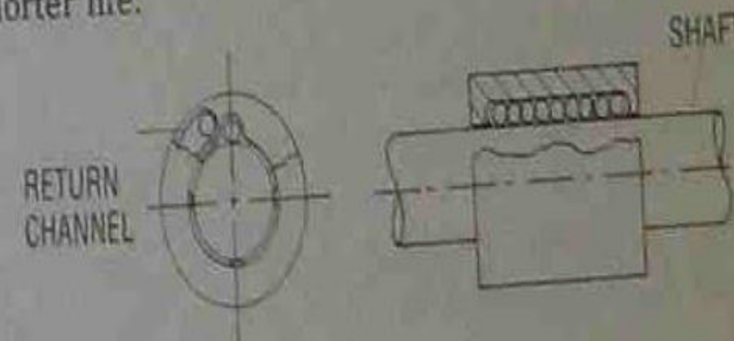


Fig. 6-36 Recirculating ball bearing.

Recirculating roller-chain bearings

An endless chain assembly of rollers is mounted on a solid bearing race attached to a carriage. The rollers are often shaped to fit a ground shaft or way. As the carriage or slide moves, the bearing races roll on the concave rollers which are in contact with the shaft.

Fretting

Fretting corrosion or false brinelling is most likely t occur when a rolling element bearing is dry a stationary. It is due to slight, almost impercepti motion between the contacting surfaces of the rolli elements and raceways. Such motion may b transmitted to the bearing from an external source may come from the machine itself. Fretting produc a characteristic red-brown dust at the interface.

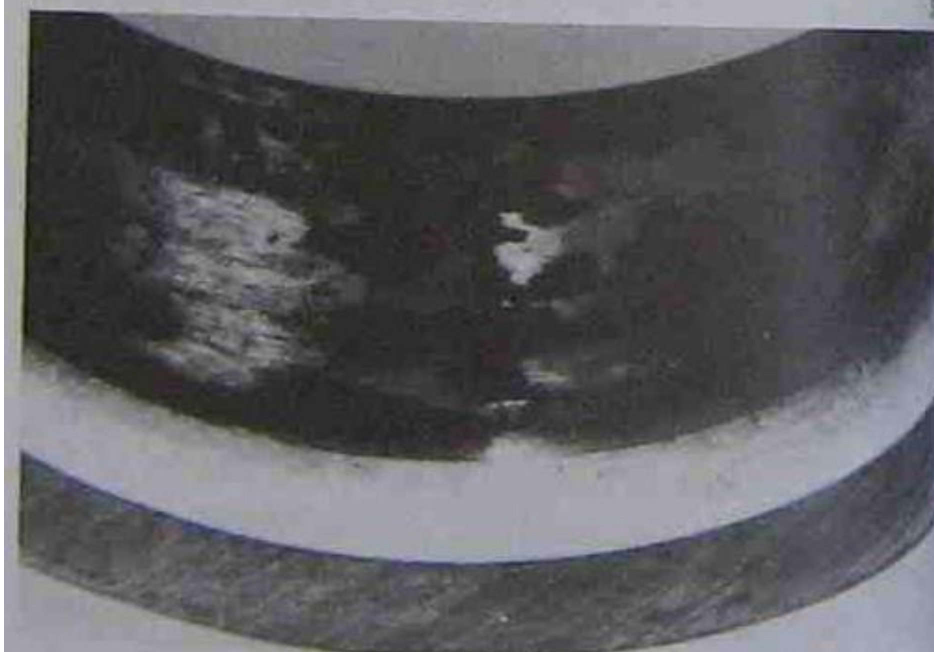


Fig. 6-75 A typical example of fretting.

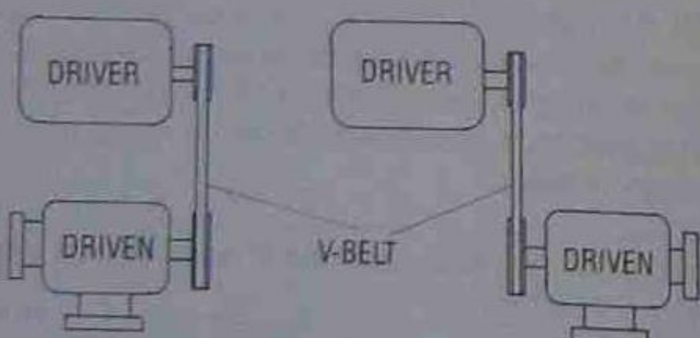
As was discussed in Chapter 2, most rotating machines operate in sets which include a driver and driven machine at least and often include a transmission machine such as a gear box as well.

7-1 V-belt drives

Although various other types of belt drives are also used, V-belts are the most common. However, many of the maintenance considerations that apply to V-belts are also relevant to other types of belt drive such as flat belts and timing belts.

PRINCIPLES OF OPERATION

V-belts are normally used to transfer power between two shafts whose axes are parallel and some distance apart.



There are various ways in which the output sha[...] one machine can be linked to the input shaf[...] another so that transmission of power can take pla[...]

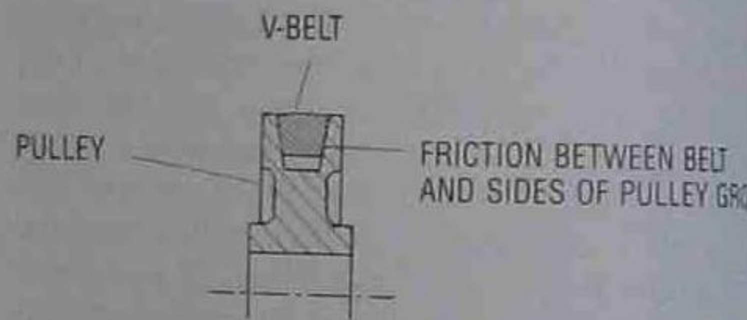


Fig. 7-2 V-belt in pulley.

In order to be able to transmit power, the belt m[...] be under tension so that it is forced down into t[...] groove. The belt is squeezed and friction develo[...] between the sides of the belt and the sides of t[...] groove. The depth of the groove is always grea[...]

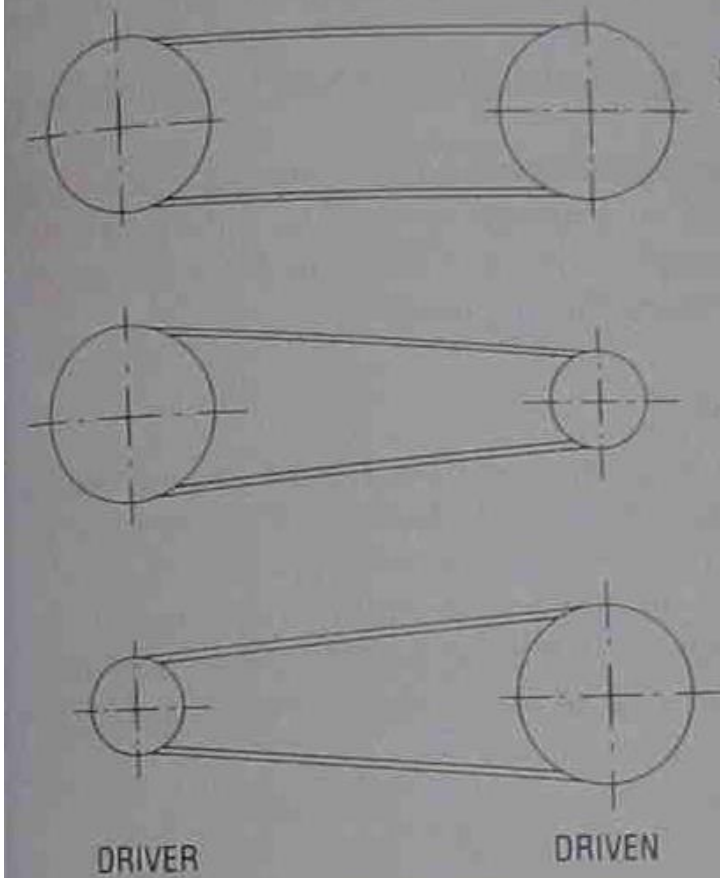


Fig. 7-4 Alternative arrangements for V-belt drives.

The speed ratio between the two pulleys of a belt drive can be calculated from a simple formula.

$$\text{driven speed (RPM)} = \frac{\text{driver pulley diameter (mm)}}{\text{driven pulley diameter (mm)}} \times \text{driver speed (RPM)}$$

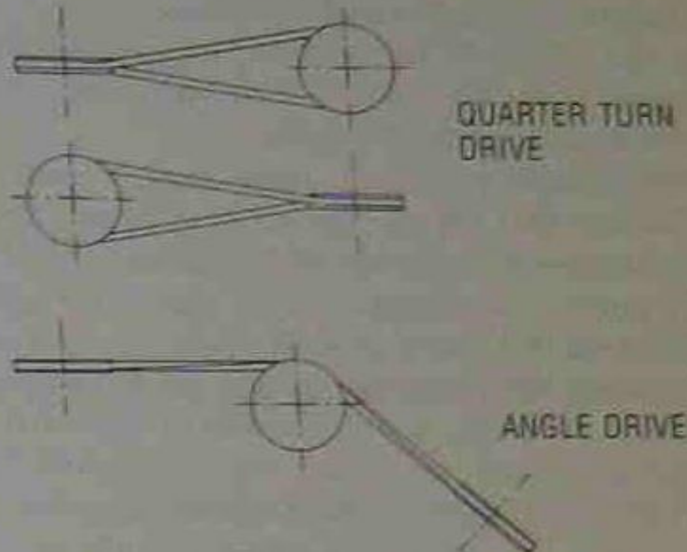
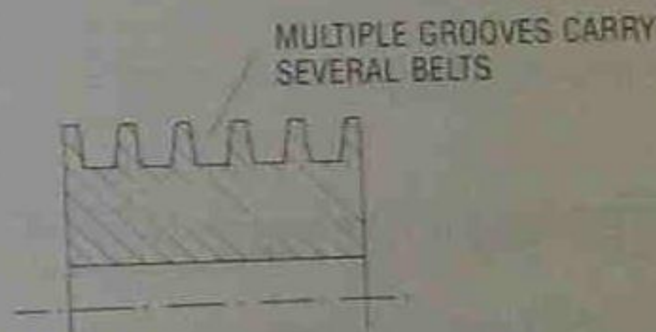


Fig. 7-5 V-belts can be used for quarter turn and angle drives.

Multiple V-belt

In order to increase the capacity of the drive an arrangement which uses several belts mounted on multi-grooved pulleys is often used.



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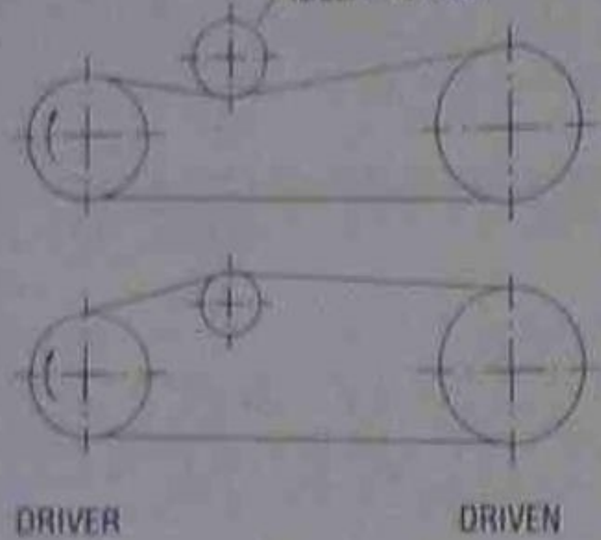
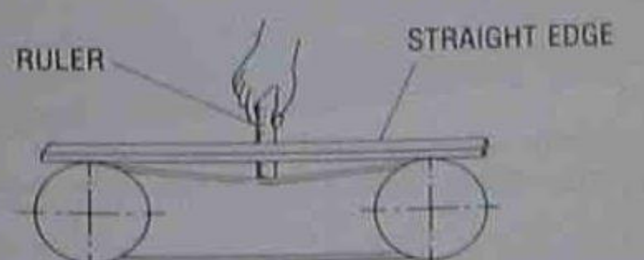


finally accepted.

Belt tension adjustment

It is important that V-belts run with the amount of tension recommended by the manufacturer. If tension is insufficient then the belt will slip and overheating and wear will result. If the belt is too tight it will also cause overheating as well as damage to bearings.

There are a number of ways in which belt tension can be checked. The most common is to depress the belt and measure the deflection using a ruler and straight edge as shown in Fig. 7-13.



Alignment

The correct alignment of the shafts and pulleys vital to the operation of a V-belt drive. Misalignme of pulleys can occur in several ways.

The first step in aligning the pulleys is to check th the two shafts are level and parallel. This should done by using a spirit level on the exposed shaft

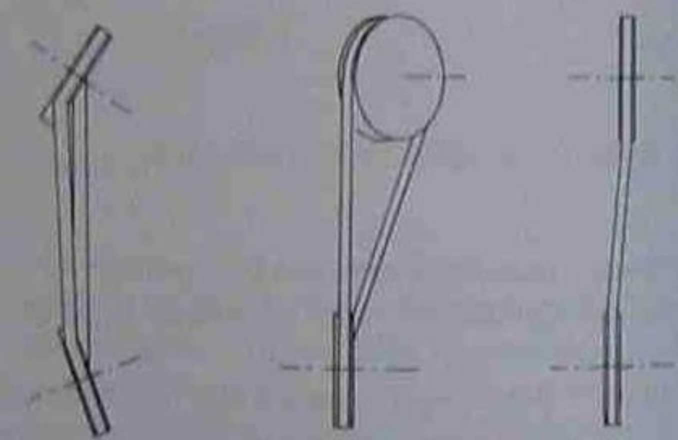
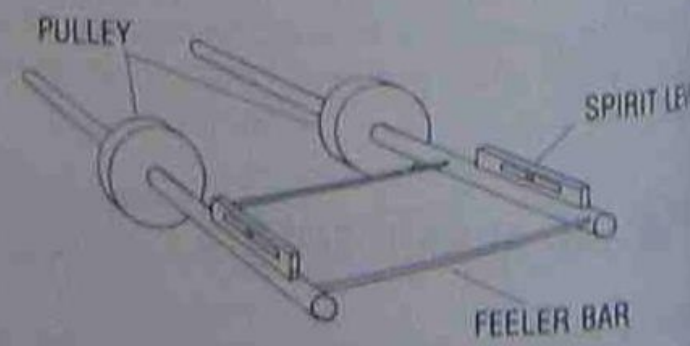


Fig. 7-10 Misalignment of pulleys.



7.2 CHAIN DRIVES

Chains and sprockets provide a positive form of drive which does not slip and they can therefore be used where synchronisation of motion is important. There are various types of chains available, the most common being the roller chain dealt with here. Many of the maintenance practices described also apply to other types of chains such as silent chain, rollerless chain, etc.

PRINCIPLES OF OPERATION

Chains and sprockets fulfil the same basic function as belts and pulleys in transferring power between two parallel shafts. Instead of relying on friction, a chain drive is a positive drive in which the links of the chain engage with specially formed teeth on the sprocket.

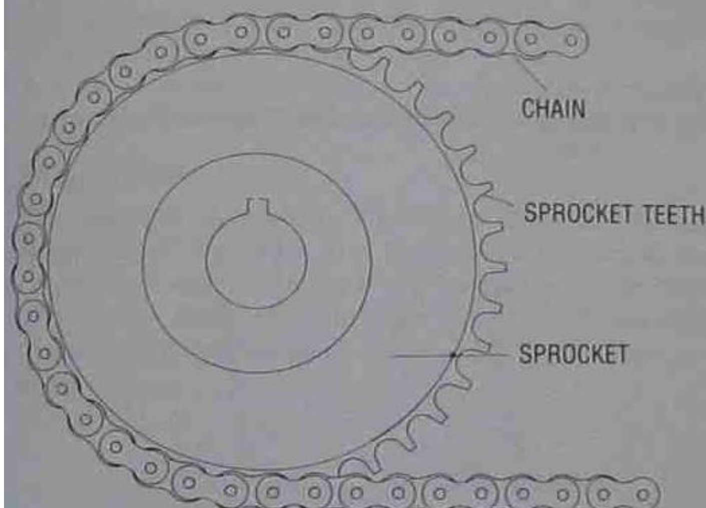


Fig. 7-24 Chain and sprocket.

Standard roller chain is made up of alternate roller links and pin links.

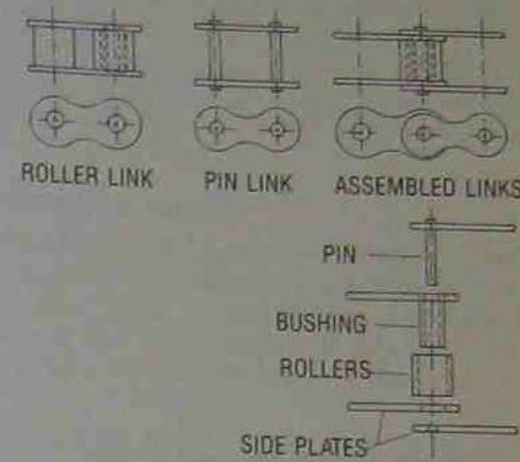


Fig. 7-25 Standard roller chain.

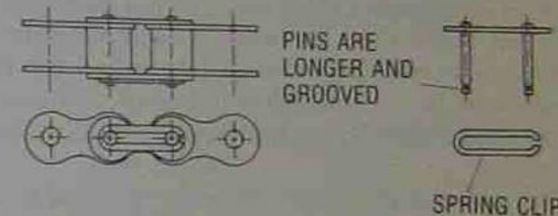
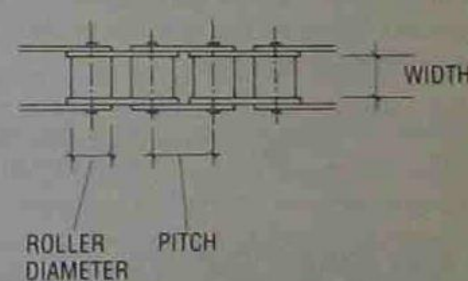


Fig. 7-26 Special joining link.



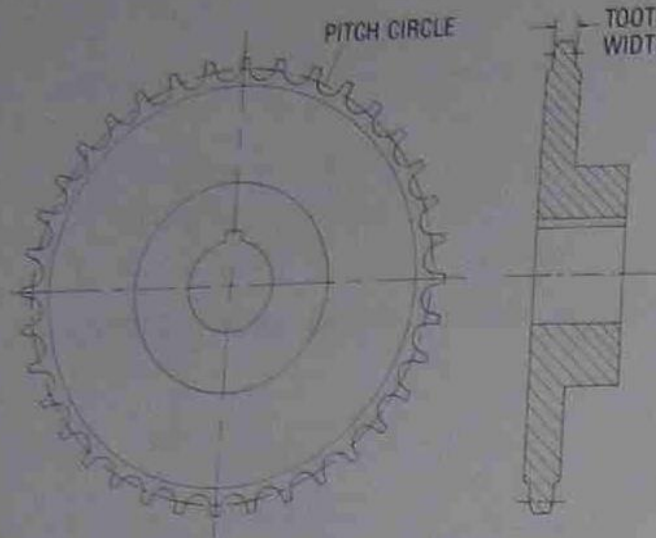


Fig. 7-28 Chain drive sprockets are usually manufactured with an integral hub.

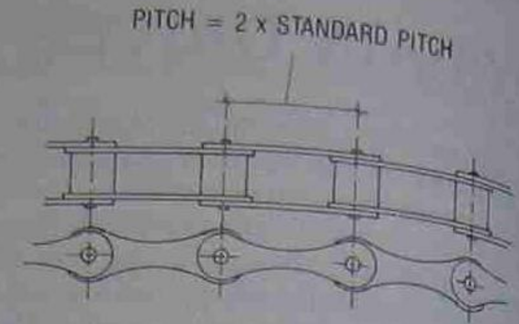


Fig. 7-29 Double pitch chain.

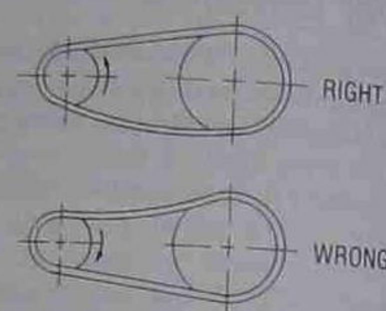
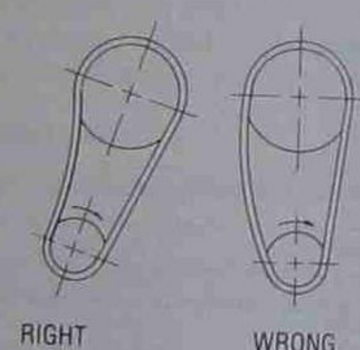


Fig. 7-30 In a horizontal drive, slack should accumulate on the strand.



It is normal practice to design chain drives in such a way that the number of chain pitches and the number of sprocket teeth ensure that the same link does not contact the same tooth each revolution. If there are an even number of pitches on the chain there must be an uneven number of teeth on the sprocket and vice versa. This helps to reduce uneven wear.

Chain drives are more sensitive to misalignment than belt drives and must be properly tensioned. They are generally suitable for speeds up to 1350 metres per minute (4500 feet per minute).

The speed of the driven sprocket in relation to the speed of the driver can be determined by using a simple formula based on the number of teeth on the driver and driven sprockets:

$$\underset{\text{(RPM)}}{\text{speed of driven}} = \underset{\text{(RPM)}}{\text{speed of driver}} \times \frac{\text{no. of teeth on driver}}{\text{no. of teeth on driven}}$$

7.3 GEAR DRIVES

Gear drives are used to transmit power from one machine to another where changes of speed, torque, direction of rotation or shaft orientation are required. They may consist of one or more sets of gears depending on the requirements. In most cases the gears are mounted on shafts supported by an enclosed casing which also contains a lubricant.

Most gear drives in use are speed reducers. They reduce the speed of shaft rotation between driver and driven machines and, at the same time, produce a corresponding increase in torque. The recent increased use of high speed machinery, such as centrifugal compressors, has also generated a need for speed increasers.

PRINCIPLES OF OPERATION

A gear is a form of wheel with teeth machined around the outer edge which allow it to engage with another similar wheel or rack.

The most important features of a gear are the tooth profile or cross-sectional shape, and the number of teeth. In modern gears the tooth profile is based on an involute curve which is the shape produced when a line is traced by a point on a cord which is 'unwound' from a cylinder as shown in Fig. 7-44.

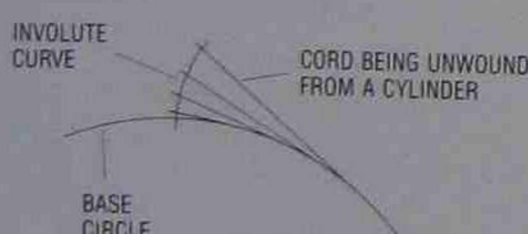


Fig. 7-44 Generating the involute form.

by friction and so teeth are cut into the outer edges of the discs to provide a means of positive engageme as shown in Fig. 7-45.

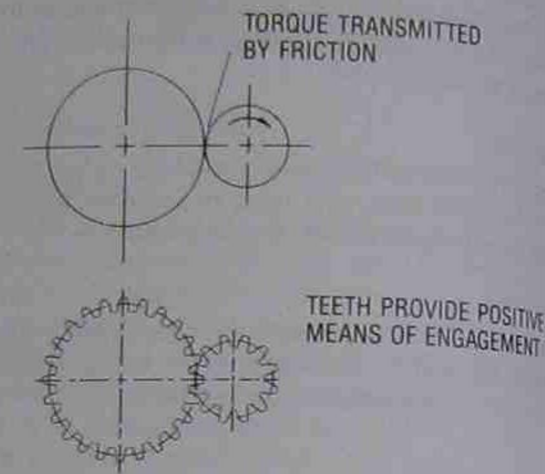
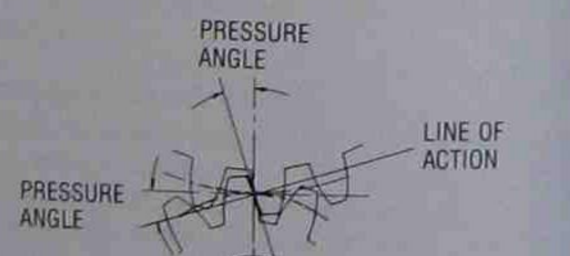


Fig. 7-45 Teeth provide a means of positive engagement.

The imaginary circles on which the gears are c are called the pitch circles, and the pitch circ diameter is the major dimension on which ge geometry is based. The other important dimension the pressure angle. This is the angle between tangent to the pitch circle and the line of contact two mating teeth as shown in Fig. 7-46.



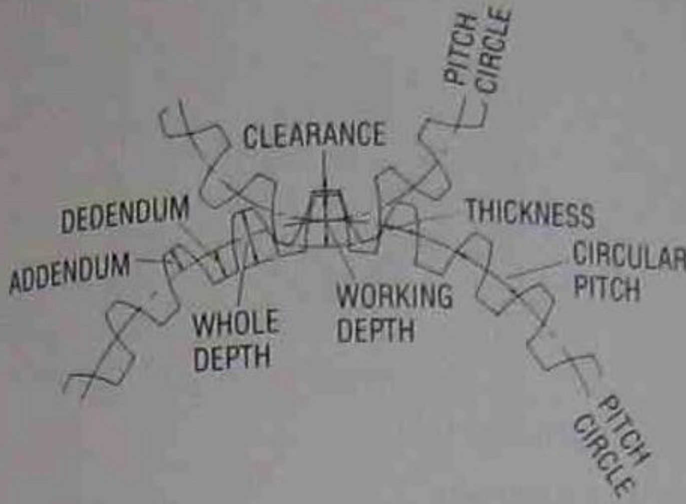


Fig. 7-47 Terms used in circular gear geometry.

In practice, gears are cut to provide running clearance between mating teeth. This is known as backlash.

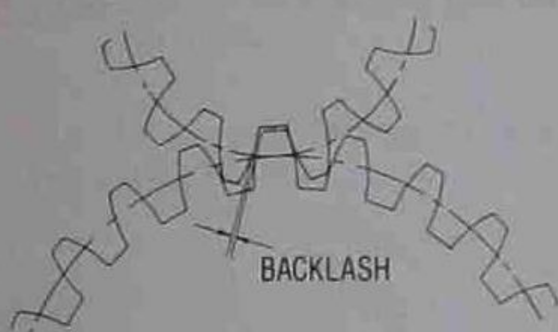


Fig. 7-48 Gears are cut to provide backlash.

TYPES AND ARRANGEMENTS

The following types of gears are in common use.

Spur gears

The spur gear is the simplest type of gear and has teeth cut parallel to the axis. Spur gears may be used as external or internal gears or as a rack and pinion.

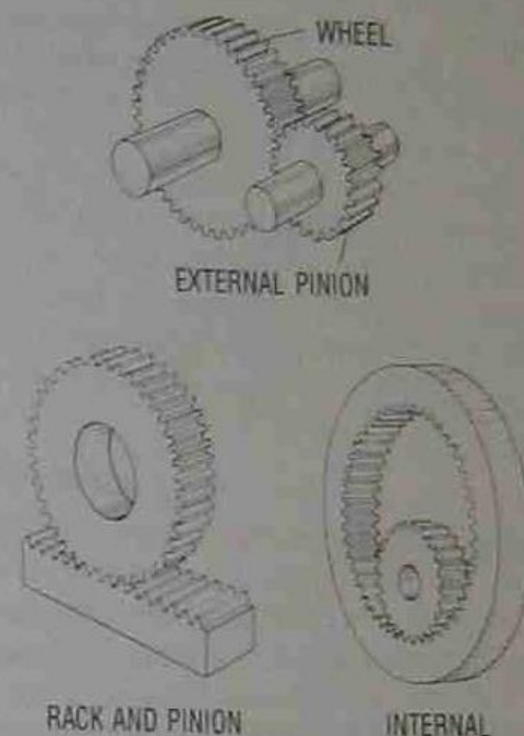


Fig. 7-49 Spur gears.

7.4 SHAFT COUPLINGS

Couplings are the devices used to connect two shafts with a common axis of rotation so that one can drive the other. Unlike the other transmission elements discussed in this chapter, couplings do not change the characteristics of the motion they transmit. Speed, torque and direction of rotation all remain the same from driver to driven.

PRINCIPLES OF OPERATION

There are two major categories of shaft coupling. When two shafts are truly aligned the coupling may be **rigid** or **solid**, in which case one shaft merely becomes a direct extension of the other. If some misalignment of the shafts is likely, the coupling must contain a mechanism able to absorb that misalignment and still transmit motion smoothly from one shaft to another. Couplings which accomplish this are known as **flexible** couplings and they operate according to two basic principles.

The simplest types of flexible coupling employ a flexible element to absorb the misalignment. Elastomeric materials such as rubber are normally used for the flexible element although metal elements are also common. This type of coupling requires no lubrication and is generally referred to as **material-flexing**.

The second group may be described as **mechanical-flexing** and involves mechanical components that slide or otherwise move relative to each other to provide the necessary flexibility. This type of coupling requires lubrication to minimise wear.

Rigid

The two most common rigid couplings are the flanged and sleeved types shown in Fig. 7-69.

Rigid couplings cannot normally be used where shafts need to be aligned on installation, as in the case of independent driver and driven units, but are used for line shafting where some means of disconnection is required.

Material-flexing

The most common types of material-flexing couplings are:

Jaw couplings

These utilise a flexible element which fits between two sets of metal jaws.

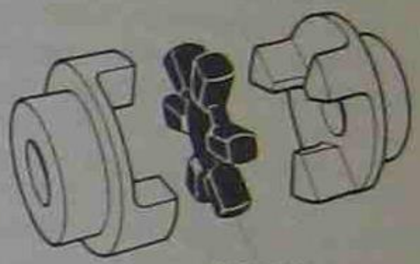


Fig. 7-70 Jaw coupling.

Pin couplings

TYPES

There are various commonly-used couplings which meet the needs of the majority of industrial applications.

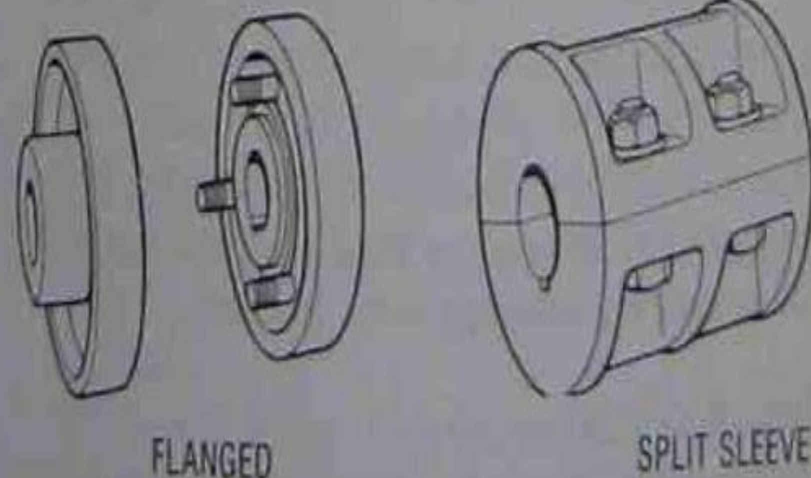


Fig. 7-69 Two common types of rigid coupling. Renold

Two metal flanges are connected by steel studs upon which flexible buffers, usually made of rubber, are mounted. They are sometimes referred to as crown pin or cone ring couplings and a typical example is shown in Fig. 7-71.

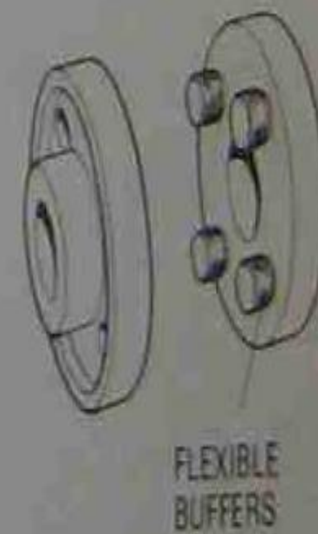


Fig. 7-71 Typical example of a pin coupling.

7.5 CLUTCHES

Clutches are devices that enable two shafts or rotating elements to be connected or disconnected while at rest or in relative motion. They must be capable of transmitting the maximum torque requirement of the drive system, and of disengaging completely and allowing one shaft to rotate independently of the other. Some clutches allow transmission of motion in one direction only.

The best known application of a clutch is in the transmission system of a motor vehicle. There are many other industrial applications in which clutches are critical machine elements, and they play a particularly important role in the operation of automatically controlled machinery.

PRINCIPLES OF OPERATION

There are two aspects to clutch operation: torque transmission and clutch actuation.

Torque transmission

There are three principle ways in which torque and motion are transmitted from one shaft to another: positive engagement, friction and wedging action.

Positive engagement

The simplest and most basic arrangement is one which relies on positive engagement by means of teeth on coupling halves such as the one shown in Fig. 7-80. Engagement is achieved by allowing one of the clutch halves to slide axially along the shaft. This mechanism has the advantage of being unable to slip but is very limited in its ability to allow engagement on the run, although this can be achieved at low speeds with certain tooth designs.

bringing two contacting surfaces together and relying on the friction between them to transmit the torque. Often a special plate covered with materials with a high coefficient of friction is interposed between the surfaces to increase the efficiency of the clutch.

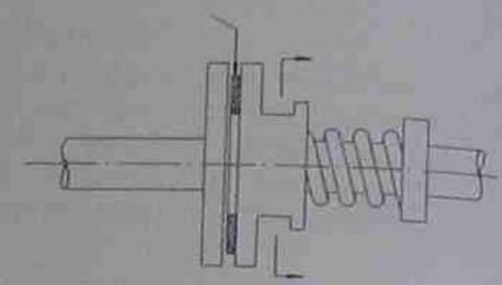


Fig. 7-81 Engagement by friction.

The torque carrying capacity of a friction clutch is directly related to the area of contact between the friction surfaces.

Wedging action

The principle employed in freewheeling and over-running clutches, where motion is required to be transmitted in one direction only, is one that relies on the wedging action of a roller or specially designed element trapped between two races. Rotation of the drive shaft in one direction causes the rollers to wedge and transmit torque to the other shaft, as shown in Fig. 7-82. If the drive shaft rotates in the opposite direction, the driven shaft can either remain stationary or freewheel.

stationary or freewheel.

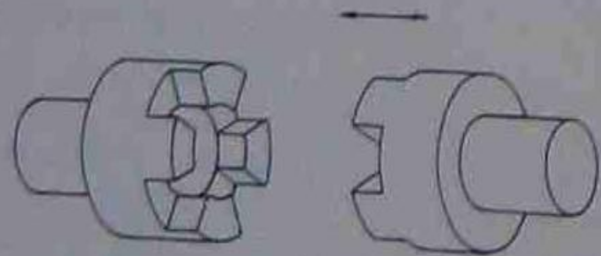


Fig. 7-80 Engagement by teeth

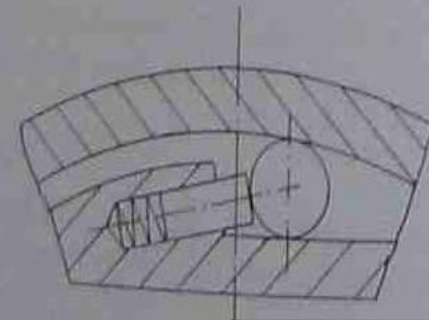


Fig. 7-82 Engagement by rollers

Friction

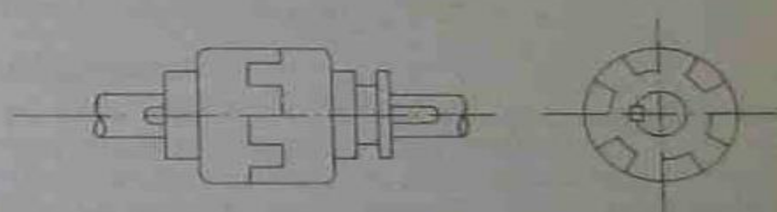
Many types of clutch rely on friction to transmit torque. This is the principle used in most motor vehicle clutches. A typical arrangement involves

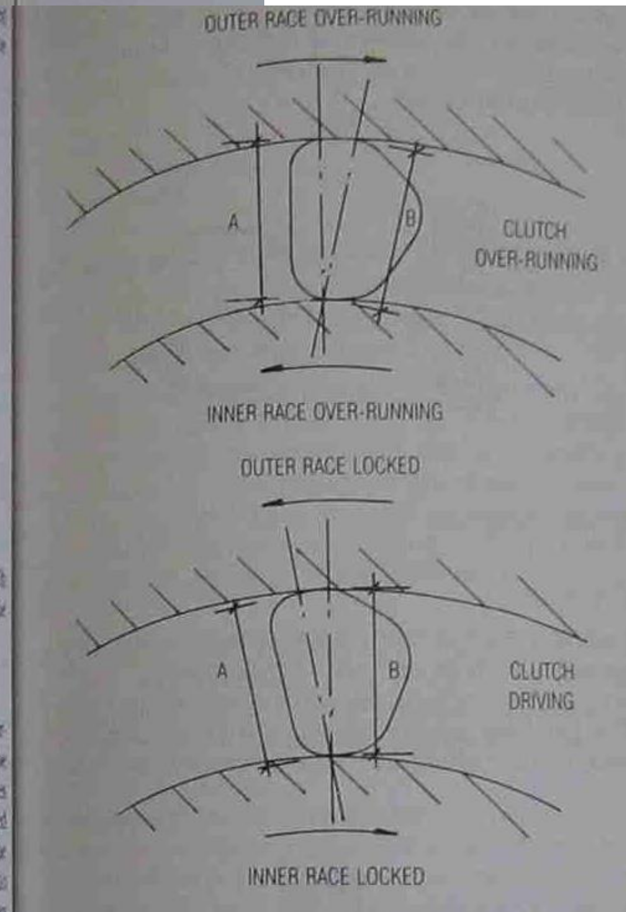
Power transmission

The following types of clutches are the ones most commonly used for power transmission.

Dog-tooth

The dog-tooth clutch is a positive displacement type that is very simple in design. One half is operated by a lever and slides on a key or splines. It can be operated only when stationary or moving at very low speeds.





METHODS OF ALIGNMENT

The straight edge and feeler gauge method

The simplest and easiest method, but also the least accurate, is to use a straight edge across the coupling halves to test for parallel run-out and feeler gauges or a taper gauge between the coupling halves to test for angular run-out as shown in Fig. 8-6.

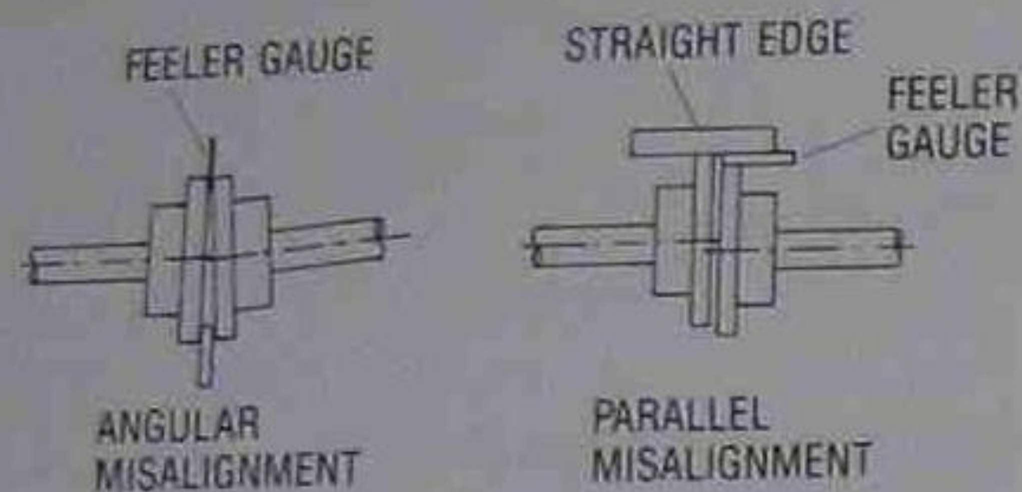
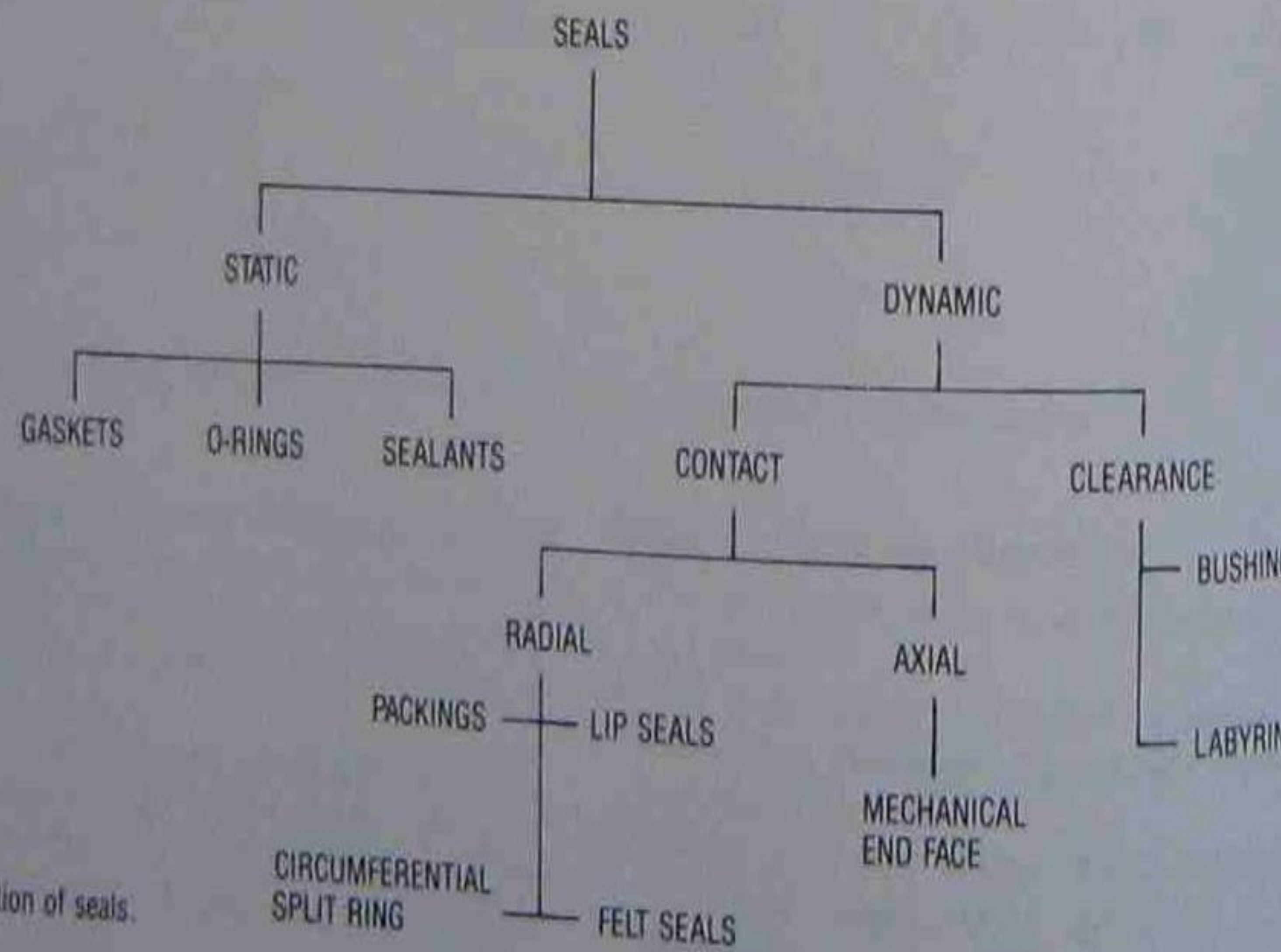


Fig. 8-6 Using a straight edge and feeler gauge.



-1 Classification of seals.

A gasket requires an externally applied compressive force to maintain sealing contact. This force is normally provided by a set of flange bolts but various types of clamps or clips may also be used. The compressive force applied to the gasket material between the flange faces must be capable of:

- Accommodating surface variations in the flange faces and in the gasket material itself;
- Overcoming the hydrostatic end-force caused by the internal pressure trying to push the flanges apart;
- Leaving sufficient residual stress to contain the pressure and prevent it from extruding the gasket through the clearance space.

Fig. 9-2 shows the relationship between the forces acting on a gasket.

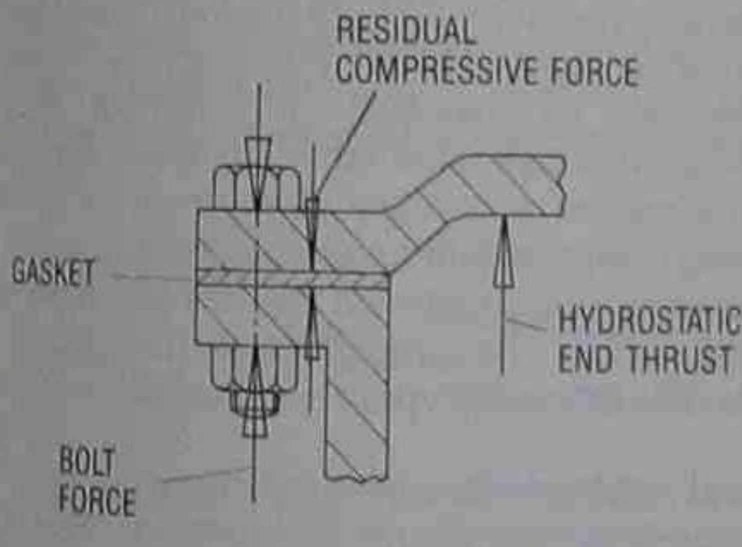
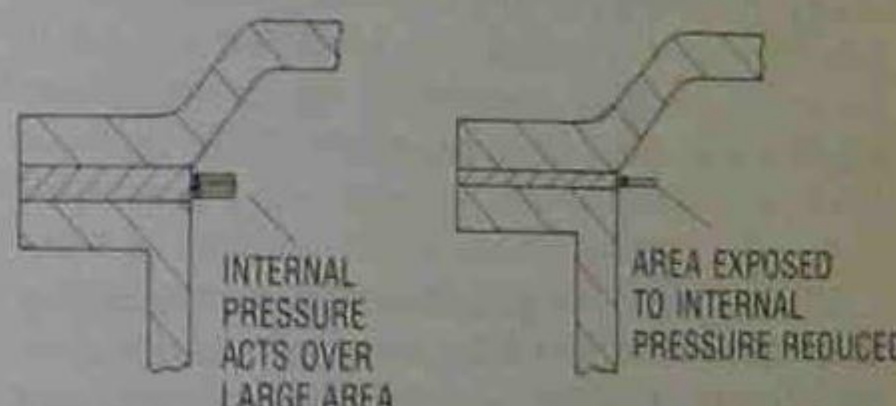


Fig. 9-2 Relationship between the forces acting on a gasket.

... However, the ability of a gasket to accommodate surface imperfections will depend on the nature and thickness of the material in relation to the surface finish of the flanges and the internal pressure. A soft gasket material, which may provide a good seal against a comparatively rough surface, may extrude at the working pressure required. It may be necessary to improve the surface finish of the flanges so that a thinner, harder gasket material, capable of containing the working pressure, can be used.

Generally speaking, thinner gasket materials are more suitable for containing higher internal pressures when used between suitable machined flanges because the area exposed to the internal pressure is reduced, and thus the force tending to extrude the gasket is also reduced. See Fig. 9-3.



9.2 O-RINGS

The elastomeric O-ring is one of the most versatile forms of static sealing arrangement and can also be used as a dynamic seal. The O-ring itself is normally contained within a groove machined into one of the flange faces. The elasticity of the material allows a good seal to be achieved with relatively low contact force.

SEALING PRINCIPLES

A key factor in the performance of an O-ring is the elastomeric properties of the material. An elastomeric material is one which can be repeatedly stretched to twice its normal length and still return to size on release. An O-ring with such properties, once compressed, produces an automatic tightening force and can also adjust to any deformation in the housing as long as the initial compression is maintained. An O-ring will cease to be effective when the material loses its elastomeric properties or when the initial compression of the gasket is lost.

Fig. 9-12 A typical arrangement of a static sealing O-ring.

sealing pressure rises in direct response to the increase in internal pressure. However, the total sealing pressure is always higher than the internal pressure by an amount equal to the initial compression of the O-ring:

sealing pressure = internal pressure + initial compression

The maximum internal pressure that can be tolerated by an O-ring will depend on the characteristics of the material and its resistance to extrusion. If the internal pressure is too great then there may be a tendency for the O-ring to extrude into the clearance gap between the flanges as shown in Fig. 9-14.

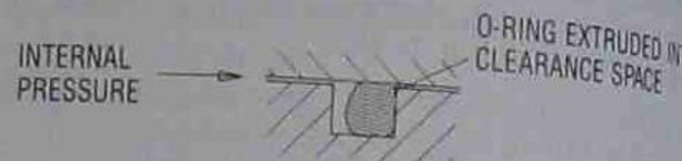


Fig. 9-14 O-ring extrusion.

This is most likely to occur with a static seal if pressure pulsations are sufficient to force the flanges apart. The tendency for an O-ring to extrude can be overcome by the use of a wedge shaped anti-extrusion ring, as shown in Fig. 9-15.

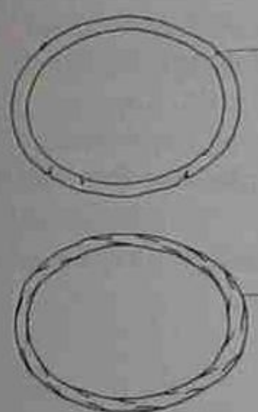
FAILURE PATTERNS

The condition of an O-ring after disassembly may provide evidence of the cause of failure.

A ring that has been extruded will show the effects of nibbling along the i.d. as shown in Fig. 9-16.

Fig 9-16 Evidence of extrusion.

Damage caused to O-rings during assembly will usually be evident as nicks or cuts or possibly as twisting.



9. 9-17 Evidence of damage during assembly.

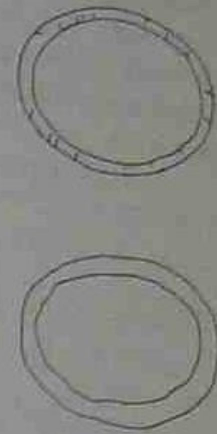
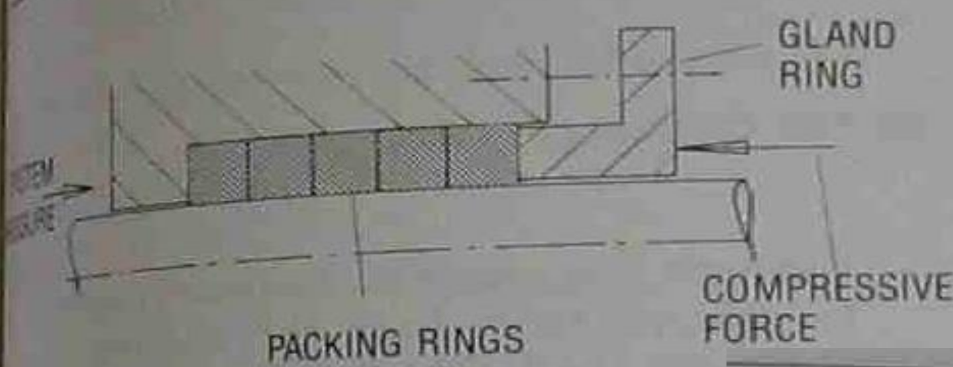


Fig. 9-18 O-ring deterioration.

EALING PRINCIPLES



9-53 The operating principles of a packed gland.

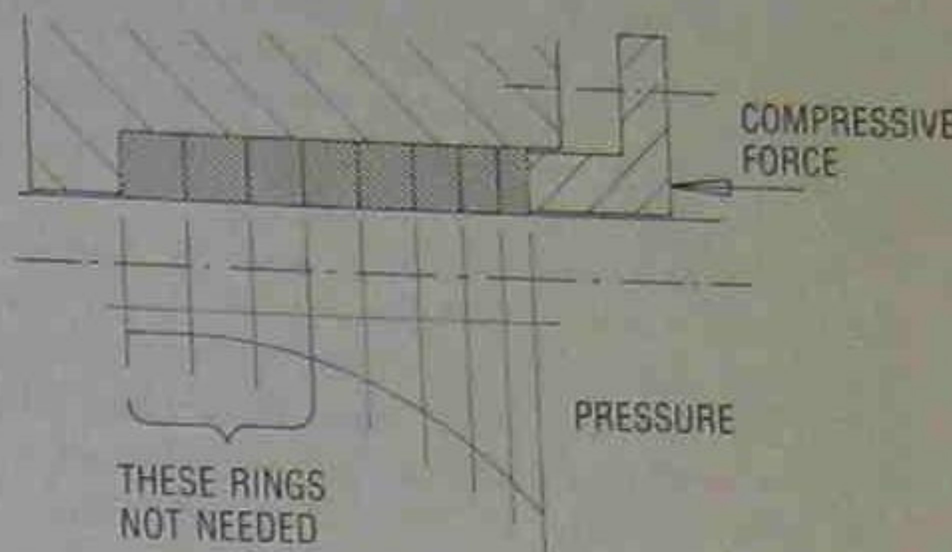


Fig. 9-54 If there are too many rings, the innermost do little work.

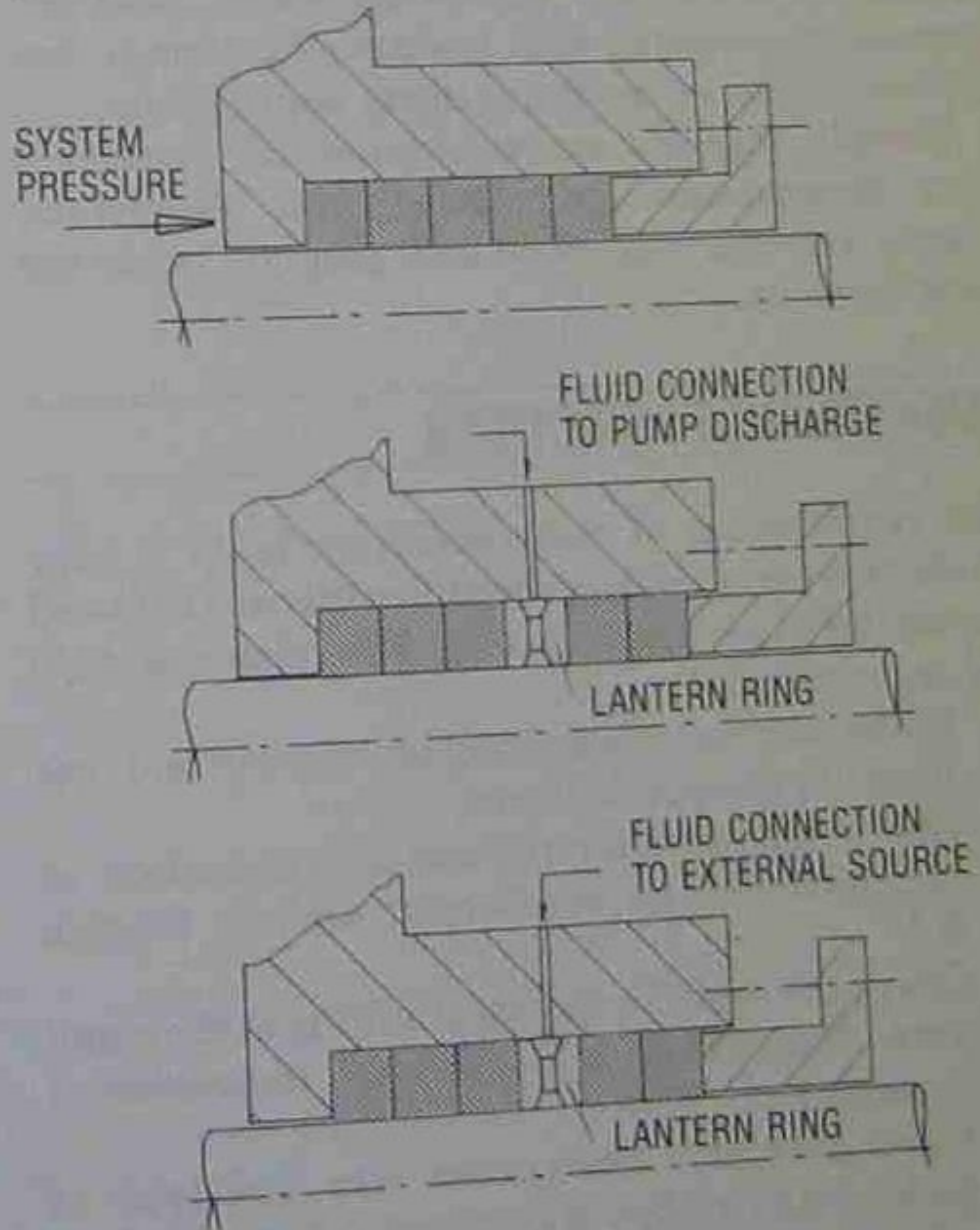


Fig. 9-55 Alternative methods of lubricating a packed gland.

METHODS

All the methods described below are designed to monitor the condition of on-line machinery and all can be considered as improved, mechanised versions of inspection by personnel. Before the development of these techniques, condition monitoring was carried out by the operator of a machine who observed the running condition using the senses of sight, hearing, touch and smell. This meant that the operator would **look** for obvious signs of defects, **listen** for unusual sounds, **touch** to check overheating and **smell** to detect burning or overheating. This method of inspection can work quite effectively when the operator is experienced and in constant attendance on the machine. In modern industry however, the majority of machines run unattended and although inspection by personnel is still an important element in the monitoring process, mechanised techniques are essential if constant surveillance is to be achieved.

Temperature monitoring

This is one of the simplest methods available and involves the use of thermocouples or resistance thermometers to measure bearing temperature. The sensing element should be located within 1.5 mm (0.05") of the bearing surface and good thermal contact is vital.

Spectrographic oil analysis

Samples of lubricating oil can be analysed using a spectrometer and the proportions of metal elements present can be determined. The oil samples used must be representative of the total contents of the system and should be taken under normal operating conditions. The major source of metals found in lubricating oil is wear debris, and a knowledge of the component materials can indicate the origin of the metals detected.

Troubleshooting can be described as a logical system of investigation designed to yield the correct cause of breakdown in the shortest possible time and with the least likelihood of error. The term, **breakdown** is used to indicate any machine condition that is considered to be less than satisfactory according to these factors:

performance
downtime
service life
efficiency
safety
environmental impact
cost

The following protective equipment should be worn when necessary:

Head protection

- Safety helmet

Eye protection

- Safety glasses or goggles

Ear protection

- Ear muffs or plugs

Hand protection

- Strong gloves

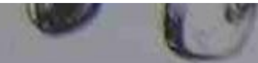
Body protection

- Overalls

All protective clothing and safety devices used should conform to the relevant standards.

Housekeeping

Good housekeeping means keeping the workplace clean, ordered and tidy so that unnecessary hazards



Hand protection
- Strong gloves

Respiratory protection
- Respirator or mask

Foot protection
- Safety shoes or boots

All protective clothing and safety devices used should conform to the relevant standards.

Housekeeping

Good housekeeping means keeping the workplace clean, ordered and tidy so that unnecessary hazards are eliminated. It is an important part of working safely and good engineering practice, and involves the following:

- Keeping work areas and benches clean and tidy and free from discarded material.
- Keeping floor areas clean and free from spills of oils or other liquids.
- Returning tools and equipment to their proper places of storage.
- Returning unused materials to the appropriate storage area.
- Disposing of waste and refuse in appropriate receptacles.
- Keeping aisles, accessways and exits clear and free from obstructions.
- Ensuring that all signs and notices can be seen and easily read.
- Ensuring that all necessary safety equipment is kept in good condition and is available for use when required.

Use of hand tools

Good maintenance technicians *never* blame their tools! Tools must be kept in good condition at all times and the right tool for the job must be used