CLASSIFICATION OF BEARINGS

Bearing is the machine element which not only supports the rotating shaft but also gives us smooth rotation. Normally the shaft is known as journal. There is relative motion between the bearing and the journal. The only disadvantage of using bearing is that some of the journal power is wasted to overcome frictional resistance between their contacts. So to minimize this frictional resistance, we use lubricant which not only eliminates the frictional resistance but also separate journal and bearing by making a lubricant film.

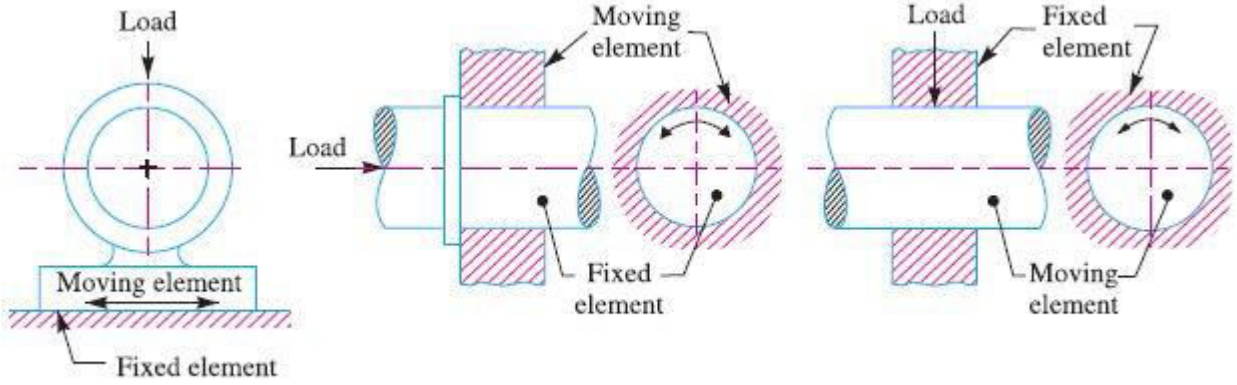
Bearings are classified – according to the load direction to be supported and according to the

- Depending upon the load
- Nature of the contact.

Depending upon load direction to be supported:

There are two types of bearings under this classification – radial bearing and thrust bearing.

In radial bearings, load is applied perpendicular to the direction of the journal motion but in thrust bearing, load is applied along the direction of the motion of journal.

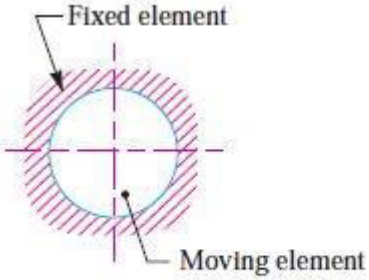


(*a*) Radial bearing. (*b*) Radial bearing. (*c*) Thrust bearing.

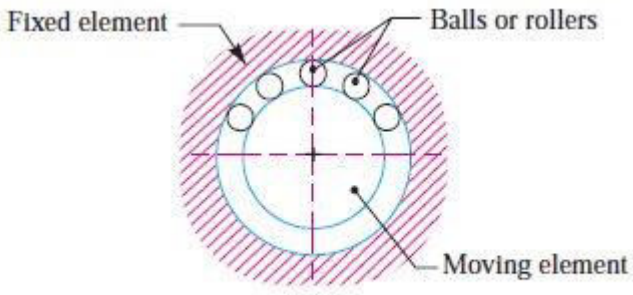
Depending upon nature of contact

There are two types under this classification – sliding contact bearing and roller contact bearing.

In sliding contact bearing, sliding action takes place between moving and fixed element, it is also called plain bearing whereas in roller contact bearing, steel balls or rollers are used between fixed and moving elements.



(*a*) Sliding contact bearing.

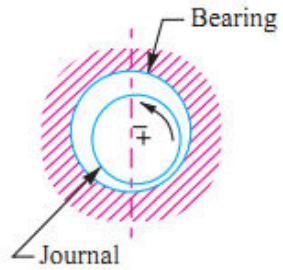


(*b*) Rolling contact bearings.

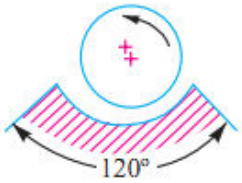
Types of sliding contact bearings

Sliding contact bearing is the type in which sliding action takes place between fixed element and moving element. There are different types of sliding contact bearings

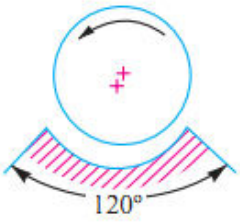
- Full journal bearing
- Partial journal bearing
- Fitted journal bearing



(*a*) Full journal bearing.



(*b*) Partial journal bearing.



(*c*) Fitted journal bearing.

When the sliding action takes place between journal and bearing along the circumference of the circle or on the arc of the circle, it is called journal or sleeve bearings. When this contact is 360° then it type is called full journal bearing. But if we have 120° contact between journal and bearing then it is called partial journal bearing.

Full journal bearing is used in industrial machines to support radial loads in any direction. On the other hand, partial journal bearing is used only to support in one radial direction and is used in rail road car axles.

Partial journal bearing has less friction due to less contact angle compare to full journal bearing. In both types, diameter of journal is less than the diameter of

bearing. So both types are also called clearance bearing. When there is no clearance between journal and bearing then it is called fitted journal bearing.

According to the thickness of lubricant layer, sliding contact bearings can be classified as following

- Thick film bearing
- Thin film bearing
- Zero film bearing
- Hydrostatic bearing

In thick film bearing, the lubricant layer is between journal and bearing and is so thick that their surfaces do not touch directly. This type of bearing is also called hydrodynamic lubricated bearing.

When the thickness of the layer decreases such that both journal and bearing have partial contact then it is called thin film bearing. If we have no lubricant between journal and bearing then it is called zero film bearing. But if we have no relative motion between journal and bearing but bearing supports steady load then it is called hydrostatic bearing.

Applications of sliding contact bearing

Sliding contact bearings are found in

- Centrifugal pump
- Steam and gas turbines
- In petrol and diesel engine as crankshaft bearing
- In concrete mixer, marine installation and in rope conveyor

Rolling contact bearings

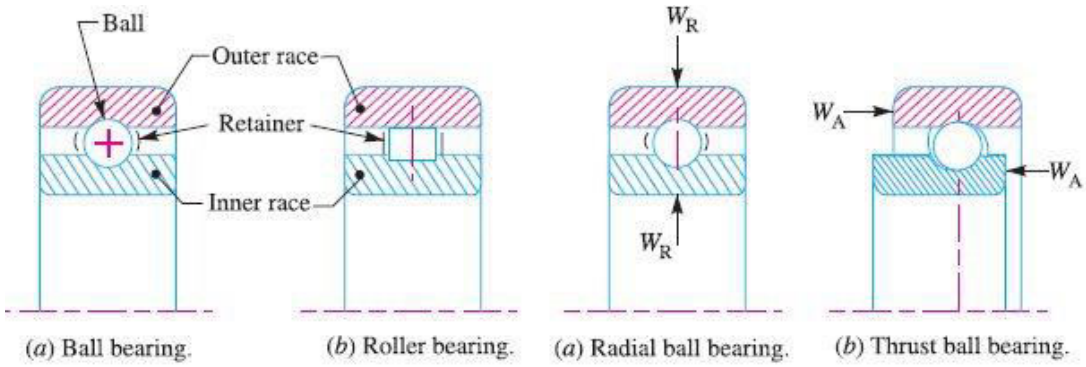
The type of bearing in which we have rolling contact instead of sliding is called rolling contact bearing. As compared to other bearings, this bearing has an advantage of low starting friction when the shaft starts rotating. Due to this reason, this bearing is also called as antifriction bearing.

Types of rolling contact bearings

There are two types of rolling contact bearings

- Ball bearings
- Roller bearings

In terms of construction, both types have inner race and outer race. Inner race is attached with the journal and outer race with the support. In between these races, we have balls in case of ball bearing and rollers in case of roller bearings. Ball bearings are used to support low loads while roller bearings are used to support heavy loads. The main reason behind high load bearing capability of roller bearing is due to the presence of line contact which is absent in ball bearings.



(*a*) Ball bearing. (*b*) Roller bearing. (*a*) Radial ball bearing. (*b*) Thrust ball bearing.

Both balls and rollers are in their place at proper distance through retainers. Retainers are actually thin strips used to support balls and rollers at their place.

If we classify rolling contact bearing according to load direction it has two types

- Radial bearings
- Thrust bearings

If the load applied on the bearing is perpendicular to the axis of the shaft, it is called radial bearing. But if the load applied on the bearing is along the axis of the shaft then it is called thrust bearing.

Like other bearings, this bearing also has some advantages and some disadvantages which are following

Advantages

- It offers us low starting as well as running friction.
- It can withstand quick shock load
- It has the capability to self align
- It has overall small dimensions
- It is easy to mount as well as to erect
- Reliability of services
- Cleanliness

Disadvantages

- It offers more resistance at high speed
- Initial cost is very high
- It has low resistance towards shock loading
- It has complicated bearing housing design

Thrust ball bearings

Ball bearing is defined as the type in which there is ball contact between races and thrust ball bearing is defined as the bearing type in which load acts along the axis of the shaft. Similarly thrust ball bearing is defined as the type of bearing in which load acts on the balls along the axis of the shaft.

This bearing has two types which are following

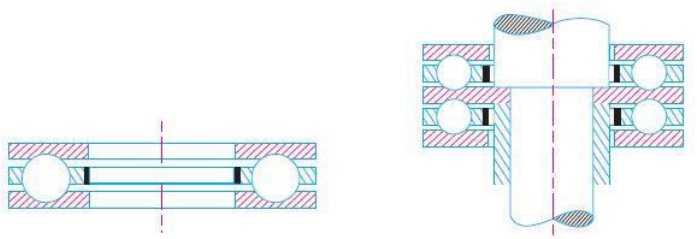
- Single direction thrust ball bearing
- Double direction thrust ball bearing

Single direction thrust ball bearing

This type has one row of balls and can rotate between shaft washer and housing washer. This bearing can mount separately and has the ability to support axial load only in one direction. We cannot use this bearing for radial load.

Double direction thrust ball bearing

Unlike single direction thrust ball bearing, this bearing has two separate ball rows. It has two housing washers and a shaft washer in which two separate ball rows rotate. This type has the advantage to use for loading in both directions.



(*a*) Single direction thrust ball bearing. (*b*) Double direction thrust ball bearing.

Washer type

Washers are flat in terms of configuration because they cannot give misalignment between shaft and housing. Flat face washers are available in two types pressed steel and steel cage.

For suitable operation, we applied minimum load to check its load bearing ability. This minimum load can be calculated as following

$F_{am} = A.(n/1000)^2$

Where in the above expression, F_{am} is the minimum load, A is the minimum load factor and n is the rotational speed.

Types of radial ball bearings

A ball bearing is a type of bearing in which we have rolling contact instead of line contact. In terms of configuration, radial ball bearings are very similar to axial ball bearings where the balls are in contact with inner race and outer race. In radial ball bearings, the load application is perpendicular to the balls. So we can defined radial ball bearing as a type of bearing in which load acts perpendicular to the balls surface.

There are different types of radial ball bearings which are following

- Single row deep groove bearing
- Filling notch bearing
- Angular contact bearing
- Double row bearing
- Self-aligning bearing

Single row deep groove bearing

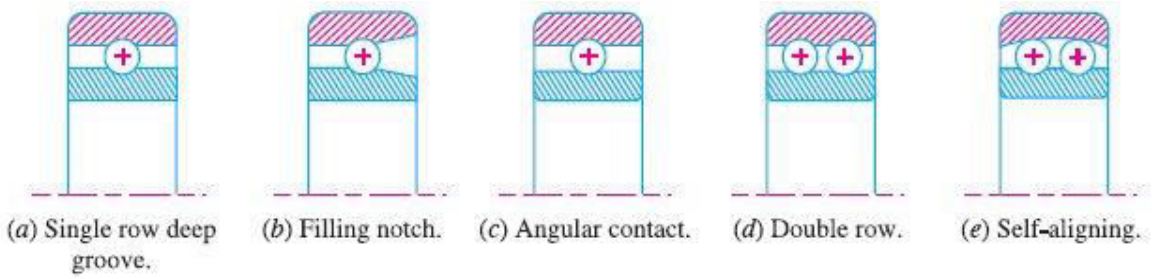
In this bearing type, races are off-set at the time of assembling so that maximum balls can insert between races. After the insertion of ball, races are centered. Retainers are used to keep the balls at their position but one thing is also important in the working of retainer and this is to make balls arrangement symmetric.

This type is used for carrying high loads and best suits at high speed. The load bearing capability of this type depends upon the number of balls we insert between races and their size.

Filling notch bearing

The above bearing races are off-set during assembly but this bearing has notches in the races. The reason to choose notches in the bearing is to put more balls in it. This bearing has more balls then single row deep groove ball bearings.

These balls are not easy to enter in the races. So we put them in the notches forcefully. This bearing has more load carrying capacity than filling notch bearing.



(*a*) Single row deep groove. (*b*) Filling notch. (*c*) Angular contact. (*d*) Double row. (*e*) Self-aligning.

Angular contact bearing

As the name defined angular, this bearing has one angular surface. Its outer race is cut away during assembly so that balls can insert in it. Like filling notch bearing, this bearing also has more balls then deep groove bearing. The main advantage of using this bearing is that no notch is present in both races.

We can use this bearing where we need to bear large axial load only in one direction as well as large radial load. To remove the problem of axial load carrying capacity in one direction, we use pair of bearings so that it can support axial load in any direction.

Double row bearing

This is a type in which angular or radial contact is made between races and balls. In terms of area, this bearing is narrower than two single row bearing. This bearing can support load slightly less than twice single row bearing.

Self-aligning bearing

This is a bearing type which can support shaft deflection upto 2-3 degrees. There are two types of self aligning bearings

- Externally self-aligning bearing

- Internally self-aligning bearing

In externally self-aligning bearing, outer diameter of outer race is ground to spherical surface and fits in the mating spherical surface of the casing. But in case of internally self-aligning bearing, the inner surface of outer race is ground to spherical surface.

Types of roller bearings

Roller bearings are the type in which we have rollers between races. These bearings have more loads bearing capability compare to the similar class ball bearing. This bearing is classified in many types which are following

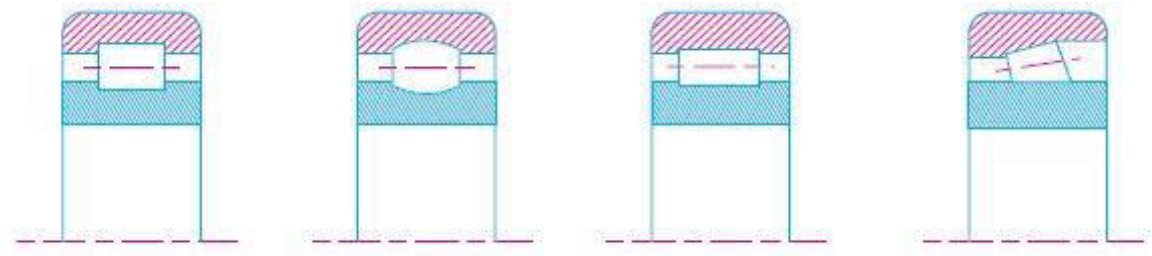
- Cylindrical roller bearings
- Spherical roller bearings
- Needle roller bearings
- Tapered roller bearings

Cylindrical roller bearings

This type of bearing has short rollers, high radial load carrying ability and moderate axial load carrying ability. These bearings best suits for high speed applications. Practically these rollers are not in complete cylindrical shape but are crowned at the end to reduce stress concentration.

The key feature of this bearing type is that it offers lowest co-efficient of friction and generate less heat. Cylindrical shape of the rollers permit inner ring to support axial movement and resist thermal expansion due to high speed application.

These bearings are used in turbine engine's main shaft, in gearbox with high radial load carrying capability and in transmission. Commonly the size of bearing is 22 mm to 300 mm but for special purposes, we can make them for size up to 600 mm.



(*a*) Cylindrical roller. (*b*) Spherical roller. (*c*) Needle roller. (*d*) Tapered roller.

Spherical roller bearings

These bearings are self aligned bearing just like a type we have in ball bearing and can support axial movement in only one direction. These bearings can do this if we grind one of its races in spherical shape. It can bear the tolerance of 1.5°.

If we use double row spherical roller bearings then it can support axial movement in any direction.

Needle roller bearings

This bearing is slim and can fill space completely. So the filling ability of the needle roller eliminates the use of retainer which was considered to be the essential part of the bearing.

We can use this bearing where we need to support large heavy loads along with oscillatory motion just like in heavy duty diesel engine.

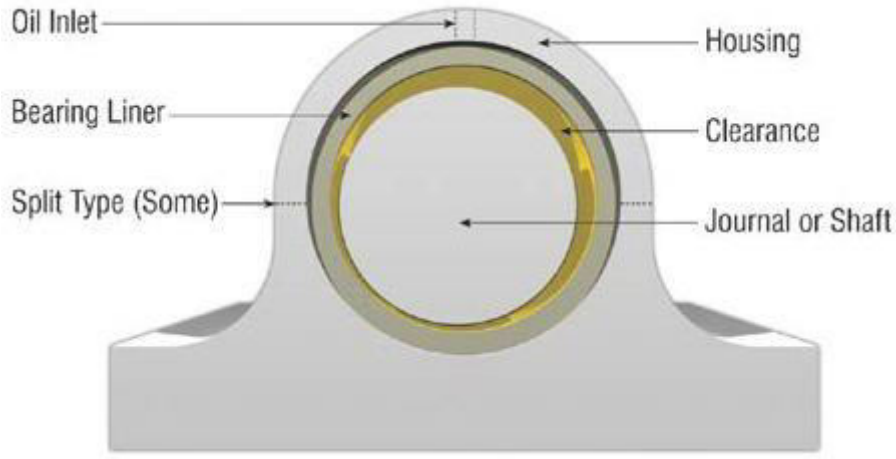
Tapered roller bearings

In this type, we use rollers but with converging cross section and their elements intersect at common point. These bearings are used to support both axial and radial loads. Practically they are available in markets with different taper angle and as single or double row bearings

Journal bearing

Journal bearing is a type of sliding contact bearing used to support radial load. Let us consider its simplest type a solid bearing in which there is a cast iron block. In this block, there is a hole in which our shaft runs. To get grip on the shaft, its lower portion is extended to make base which have two holes for fulfilling fastening purposes.

At the top, there is one more hole which is used for lubrication purpose. This bearing is used in diesel and gasoline piston engines. The purpose of using this bearing in engines is to support rapidly rotating crankshaft.



This bearing has some advantages over other bearings like the continuous supply of motor oil forming a thin oil film and stops metal to metal contact, simple is construction and easy in replacing. It only supports the radial load and fails to support high axial load because centrifugal forces forcefully moves the shaft out from the hole. So it is recommended to use this bearing for slow speed radial load applications. The life duration of this bearing is high, it has the capability to make engine quiet and give smooth running.

In spite of these advantages, this bearing has some disadvantages. It offers high magnitude of friction because its surface contact is high. Due to this reason, it consumes more energy than other rolling contact bearings and results in the more heat generation during operation.

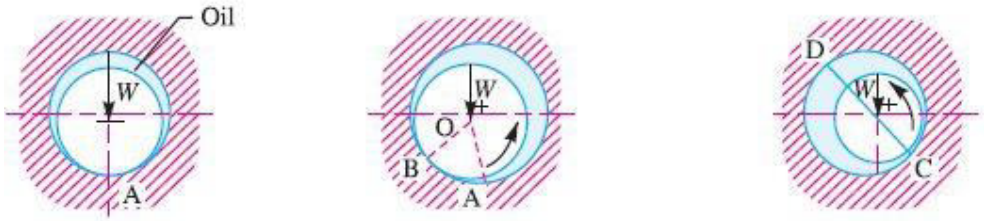
Wedge film journal bearing

Bearing is the part of machine which is used to provide smooth shaft operation. To reduce wear in the contact between shaft and bearing, lubricant is used.

Initially when the shaft is not rotating, there is constant lubricant thickness throughout the circumference of the bearing surface but as the flow started, the thickness region started varying. When the flow of viscous film is from converging section in the journal bearing, it is called wedge film journal bearing. In this bearing, load carries when there is relative motion between bearing and journal.

Consider a simple case in which both bearing and journal is at rest and a steady load is applied. Under the steady load application, it experiences a metal to metal contact at point A which is along the line of action of supported load.

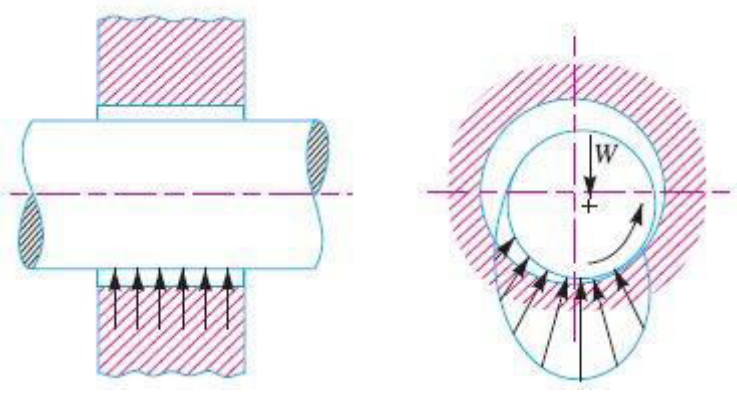
Now consider the journal to start rotating slowly in the anticlockwise direction. In this case, the point of contact will shift to point B and the angle AOB will be the angle of sliding friction. In the absence of lubricant, there will be a metal to metal dry friction. But in case of lubricant, there will be a thin lubricated film which will partially separate journal and bearing.



(a) At rest. (b) Slow speed. (c) High speed.

When we increase the journal speed further, we observe the formation of continuous fluid film and its center will move to point C. There is an important point when we consider the area from point D to C in the direction of motion, film is in converging area, form converging film and this curved converging film is known as wedge shaped film. This part has the tendency to support steady load. But if we consider the part C to D, film is diverging and it does not have the tendency to increase positive pressure used to support steady load.

In the following pressure variation in converging area is shown



In ideal case, contact angle from D to C is 180° but due to side leakage this contact angle is less than 180°.

Lubricants

Lubricants are the most important component of the industry. They are used to minimize the friction between two rubbing metals. They makes sure the smooth and prolong operation of the machine part. A good lubricant must have some properties which are following

- High boiling point
- Low freezing point
- Corrosion preventive
- High viscosity index
- High resistance to oxidation
- Stability to heat at working condition.

Wherever there is a metal contact, lubricants are used between these surfaces. During operation, when both metals rotate, they produce friction which results in the heat generation. To make sure that the machine part used for prolongs life, lubricants remove the heat abruptly.

Now looking at the other aspect of the heat generation process during machine part rotation, the lubricant must have high boiling point that it must retain its original state. Otherwise, lubricant will leak out from the casing and results in the failure of the machine parts.

The working of lubricant is intense so to make sure the safe operation, lubricant must chemically inert otherwise it will destroy the external surfaces of the machine part.

Lubricants are classified into three groups

- Liquid
- Semi liquid
- Solid

Mineral oils and synthetic oils are the ones used as liquid lubricants. Mineral oils are commonly used because they are cheap and have more stability.

Similarly we use grease as semi-liquid lubricant because they have higher viscosity than oils. Grease is used where we have low speed and high pressure because at high temperature, grease changes state.

Solid lubricants are used when both liquid and semi liquid lubricant fails to retain their oil film. The most common example of solid lubricant is graphite which can be used either alone or mixed with grease or oil.