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An Overview of rolling contact bearing

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Abstract

This article presents an overview of rolling contact bearing. The brief introduction of construction of rolling contact bearing, classification & characteristics of rolling bearings also mentioned in this paper. The differentiate between ball bearing & roller bearing, some useful deterministic equations addressing load versus life.

Keywords: Ball bearing; rolling bearing; load life relationship;Lubrication

1. Introduction

The purpose of a bearing is to support a load while permitting relative motion between two elements of a machine. The most common type of bearing supports a rotating shaft, resisting purely radial loads, axial load or a combination of radial and axial (thrust) loads. Rolling contact bearings are also called "antifriction bearings" (due to its low friction characteristics between ball and inner & outer rings) or "rolling bearings" (due to consist of rolling element, which is inserted in retainer or cage or situated between the inner race & outer race). In a rolling bearing the starting friction is about twice the running friction, but still it is negligible in comparison with the starting friction of a sleeve bearing. It's used widely in instruments and machines in order to: support the shafts & minimize the friction and power loss associated with relative motion.

2. Rolling bearing Construction

It consist of four parts: an inner ring (fits on the axle or shaft), an outer ring (fits on the housing) the rolling elements which is classify in to two types: ball (nature of contact is point contact)& rollers (nature of contact is line contact). Rollers also classified as four types: cylindrical, needle, tapered & spherical. If pure radial load act then use cylindrical & needle roller, if pure axial load act: use cylindrical roller, ball bearing, four point angular contact ball bearing & for combined load: taper roller, spherical roller & angular contact ball bearing. The cage or separator: The important function of separating the elements at regular.
interval so that rubbing contact will not occur, hold them in place within inner & outer

raceway, and allow them to rotate.

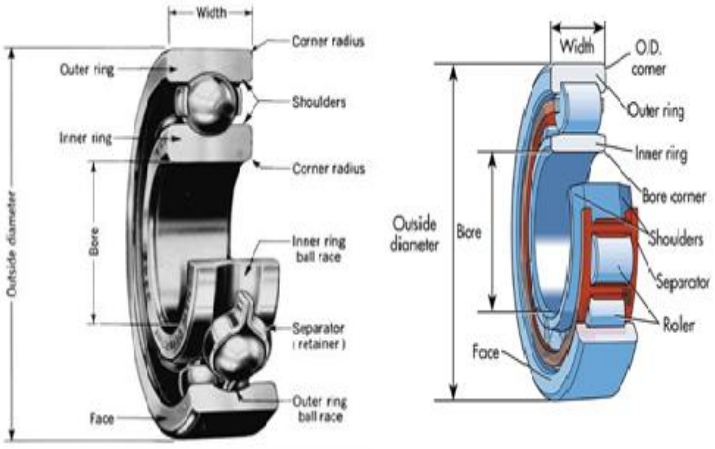


Fig. 1 Ball bearing & roller bearing [4]

These bearings are extensively used due to its relatively lower price, being almost maintenance free and for its operational ease. However, friction increases at high speeds for rolling contact bearings and it may be noisy while running.

3 Classification of rolling bearings

Depending upon the type of the rolling element used, The Rolling contact bearings divided in to two categories: ball bearing & roller bearing. Ball bearing is classified according to their bearing ring configuration: deep groove & angular contact ball bearing. Ball bearings further divided into three categories, i.e. radial contact, angular contact, and thrust. Radial-contact ball bearings are designed to support radial loads. Angular contact bearing designed to support combination of radial and axial loads. Thrust bearings designed to support axial loads. Roller bearing is classified according to shape of roller: cylindrical, needle, tapered, & spherical, further classified according to the direction in which the load is applied; radial bearing & thrust bearing [1].

3.1Deep Groove Bearing:

3.1.1 **Single row deep groove ball bearing**

The raceway grooves on both the inner and outer rings slightly larger radius than that of the balls. In addition to radial loads, axial loads can be imposed in either direction. Because of their low torque, they are highly suitable for applications where high speeds and low power loss are required.

3.1.2 Double row deep groove ball bearing*:* Adding a second row of balls increases the radial load-carrying capacity of the deep-groove type of bearing compared with the single-row design because more balls share the load.

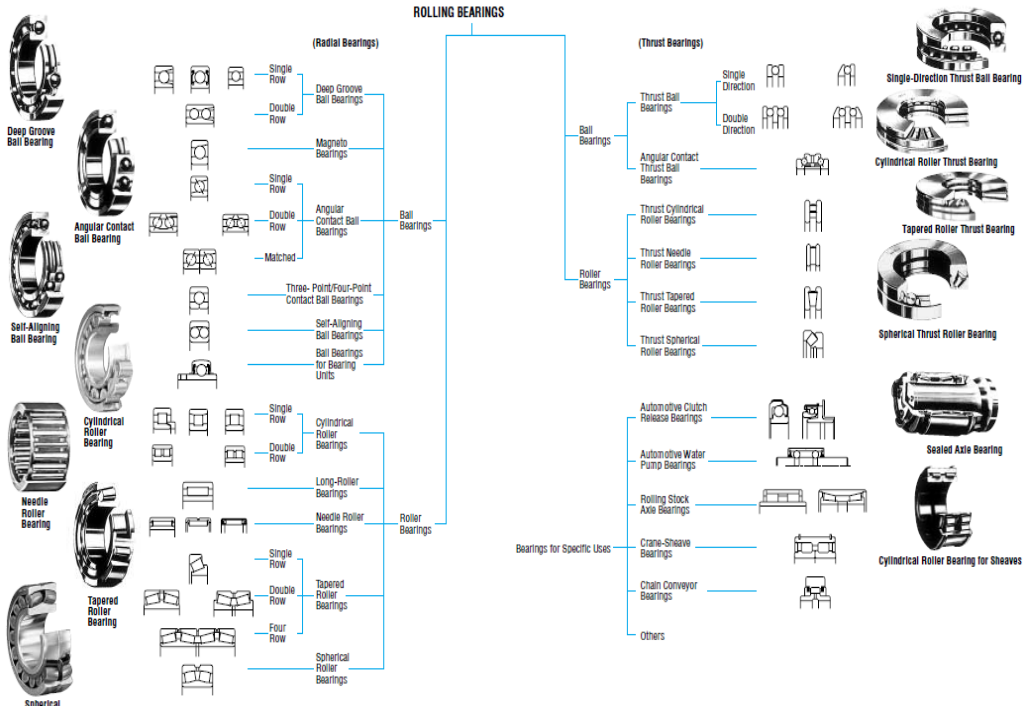


Fig. 2 Classification of rolling bearing [2]

3.1.3 Magneto Bearings: The inner groove of magneto bearings is a little shallower than that of deep groove bearings. Since the outer ring has a shoulder on only one side, the outer ring may be removed. This is often advantageous for mounting. In general, two such bearings are used in duplex pairs. Magneto bearings are small bearings with a bore diameter of 4 to 20 mm and are mainly used for small magnetos, gyroscopes, instruments, etc. Pressed brass cages are generally used.

3.1.4 Angular contact ball bearing: These types are capable of taking radial loads and also axial loads in one direction. Four contact angles of 15°, 25°, 30°, and 40° are available. The larger the contact angle, the higher the axial load capacity. For high speed operation, however, the smaller contact angles are preferred. Usually, two bearings are used in duplex pairs, and the clearance between them must be adjusted properly. Pressed-steel cages are commonly used, however, for high precision bearings with a contact angle less than 30°, polyamide resin cages are often used.

3.1.5 Double-row angular contact ball bearings: These are basically two single-row angular contact ball bearings mounted back-to-back except that they have only one inner ring and one outer ring, each having raceways. They can take axial loads in either direction.

3.1.6 Duplex Bearings: combination of two radial bearings is called a duplex pair. Possible combinations include face-to-face, which have the outer ring faces together (type DF), back-to-back (type DB), or both front faces in the same direction (type DT). DF and DB duplex bearings are capable of taking radial loads and axial loads in either direction. Type DT is used when there is a strong axial load in one direction and it is necessary to impose the load equally on each bearing.

3.1.7 Four-Point Contact Ball Bearings: The inner and outer rings of four-point contact ball bearings are separable because the inner ring is split in a radial plane. They can take axial loads from either direction. The balls have a contact angle of 35° with each ring. Just one

bearing of this type can replace a combination of face-to-face or back-to-back angular contact bearings. Machined brass cages are generally used.

3.1.8 Self-Aligning Ball Bearings: The inner ring of this type of bearing has two raceways and the outer ring has a single spherical raceway with its center of curvature coincident with the bearing axis. Therefore, the axis of the inner ring, balls, and cage can deflect to some extent around the bearing center. Consequently, minor angular misalignment of the shaft and housing caused by machining or mounting error is automatically corrected. This type of bearing often has a tapered bore for mounting using an adapter sleeve.

3.1.9 Cylindrical Roller Bearings: Replacing the spherical balls with cylindrical rollers with corresponding changes in the design of the races give a greater radial load capacity and are suitable for high speeds. There are different types designated NU, NJ, NUP, N, NF for single-row bearings, and NNU, NN for double-row bearings depending on the design or absence of side ribs. The outer and inner rings of all types are separable. Thrust load capacity is poor because any thrust load would be applied to the side of the rollers, causing rubbing, not true rolling motion. Double-row cylindrical roller bearings have high radial rigidity and are used primarily for precision machine tools. Pressed steel or machined brass cages are generally used, but sometimes molded polyamide cages are also used.

3.1.10 Needle Roller Bearings: Needle bearings are very useful where radial space is limited. They have a high load capacity when separators are used, but may be obtained without separators. They are furnished both with and without races. This makes it easier to design them into many types of equipment and components such as pumps, universal joints, precision instruments, and household appliances.

3.1.11 Tapered Roller Bearing: Tapered roller bearings combine the advantages of ball and straight roller bearings, since they can take either radial or thrust loads or any combination of the two, and in addition, they have the high load-carrying capacity of straight roller bearings. It is notably used in car wheels, train sparkplugs etc. However, the drawback is that it is difficult to manufacture and is therefore more expensive.

3.1.12 Spherical Roller Bearing: The spherical roller bearing is one form of self aligning bearing, so called because there is actual relative rotation of the outer race relative to the rollers and the inner race when angular misalignments occur. Spherical roller bearings can take, not only heavy radial loads, but also some axial loads in either direction. They have excellent radial load-carrying capacity and are suitable for use where there are heavy or impact loads. Pressed steel and machined brass cages are used.

3.1.13 Single-Direction Thrust Ball Bearings: It is mostly used for unidirectional axial load. Single-direction thrust ball bearings are composed of washer-like bearing rings with raceway grooves. The ring attached to the shaft is called the shaft washer (or inner ring) while that attached to the housing is called the housing washer (or outer ring).

3.1.14 Double-Direction Thrust Ball Bearings: In double-direction thrust ball bearings, there are three rings with the middle one (center ring) being fixed to the shaft. There are also thrust ball bearings with an aligning seat washer beneath the housing washer in order to compensate for shaft misalignment or mounting error. Pressed steel cages are usually used in the smaller bearings and machined cages in the larger

3.1.15 Spherical Thrust Roller Bearings: The spherical-roller thrust bearing is useful where heavy loads and misalignment occur. The spherical elements have the advantage of increasing their contact area as the load is increased. Pressed steel cages or machined brass cages are usually used.

4. Differentiate between ball bearing & roller bearing:

Table 1. Comparison Between Ball Bearing & Roller Bearing

Sr. No.	Comparison parameter	Ball Bearing	Roller bearing
1	Rolling Element	Spherical balls are used	Cylindrical roller, taper roller, or Spherical roller
2	Nature of contact	Point Contact	Line contact
3	Load carrying capacity	Low	High
4	Radial Dimensions	More	Less
5	Axial Dimensions	Less	More
6	Expensive	Less	More

5. Characteristics of rolling bearings

Table 2. Characteristics of rolling bearing

Bearing Type	Radial Capacity	Thrust Capacity	Limiting Speed	Radial Stiffness	Axial Stiffness
Deep-groove ball	Moderate	Moderate – both directions	High	Moderate	Low
Maximum-capacity ball	Moderate (plus)	Moderate – one direction	High	Moderate (plus)	Low (plus)
Angular contact ball	Moderate	Moderate (plus) – one direction	High (minus)	Moderate	Moderate
Cylindrical roller	High	None	Moderate (plus)	High	None
Spherical roller	High	Moderate – both directions	Moderate	High (minus)	Moderate
Needle roller	Moderate to high	None	Moderate to very high	Moderate to high	None
Single-row tapered	High (minus)	Moderate (plus) – one direction	Moderate	High (minus)	Moderate
Double-row tapered	High	Moderate – both direction	Moderate	High	Moderate
Four-row tapered	High (plus)	High – both direction	Moderate (minus)	High (plus)	High
Ball thrust	None	High – one direction	Moderate (minus)	None	High
Roller thrust	None	High (plus) – one direction	Low	None	High (plus)
Tapered roller thrust	Locational only	High (plus) – one direction	Low	None	High (plus)

Source: Collins JA, *Mechanical Design of Machine Elements and Machines*

6. Bearing Assembly

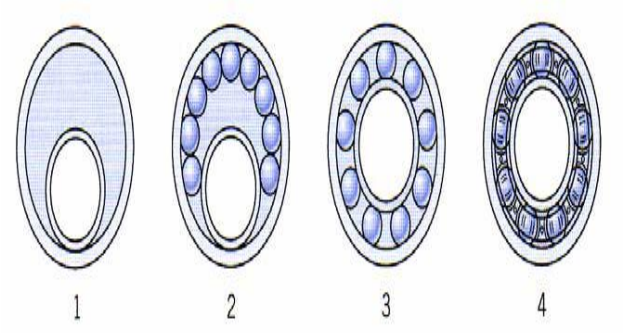


Fig.3 Assembly of rolling bearing [2]

Step 1: Move the inner race to one side of the out race
Step 2: Locate the largest gap between the two races and insert the balls in the groove
Step 3: Distribute the balls evenly, thereby centering the inner race with respect to the outer race
Step 4: Place the separator (retainer) [7]

7. Advantages and disadvantages of rolling contact bearing over sliding contact bearing:

7.1 The following are some advantages of rolling contact bearing as follows:

(i) Low starting and running friction except at very high speeds.
(ii) Ability to withstand and momentary shock loads
(iii) Accuracy of shaft alignment
(iv) Low cost of maintenance
(v) Small overall dimensions
(vi) Reliability of service.
(vii) Easy to mount and erect.
(viii) Cleanliness

7.2 The following are some disadvantages of rolling contact bearing as follows:

(i) More noisy at very high speeds
(ii) Low resistance to shock loading
(iii) More initial cost
(iv) Design of bearing housing complicated.

7.3 Application of rolling contact bearing:

The rolling contact bearing are used in large number of applications, few of them are:
(i) Industrial & automotive gear boxes
(ii) Electric motors
(iii) Machine tool spindles
(iv) Small size centrifugal pumps
(v) Automobile front & rear axle [8]

8. Designation of rolling contact bearing:

The rolling contact bearing is commonly designated by 3, 4 or 5 digit figure, which is combination of numbers or number and letters. The significance of these digits is as follows:
First number is indicates bearing types, it may be single digits or alphanumeric combination.

Table 3. Bear Numbers

Bearing Number	Type of Bearing
6	Deep groove ball bearing
2	Self aligning bearing
3	Double row angular contact ball bearing
30,31,32	Taper roller bearing
NU2	Cylindrical roller bearing

The Second number, which is single digit, indicates the bearing series. It is indicative of load carrying capacity of bearing If the number is "0", "2", "3", "4", it is an extra light, light, medium and heavy series respectively
The Third number shows bore, which are normally two digits. As the number increase, the number of rolling elements and the outside diameters of the bearing increases. If the number is "00", "01" "02", "03", "04 and onwards" the bore is 10 mm, 12mm, 15mm, 17mm, and 5 times the number respectively. & if the number is single digit, it directly gives the bore in mm.

9. Bearing life:

9.1 Static Load Capacity (C0):

The static capacity is ordinarily defined as the maximum allowable static load that does not impair the running characteristics of the bearing to make it unusable. The bearing is not rotating when the measurement is made.

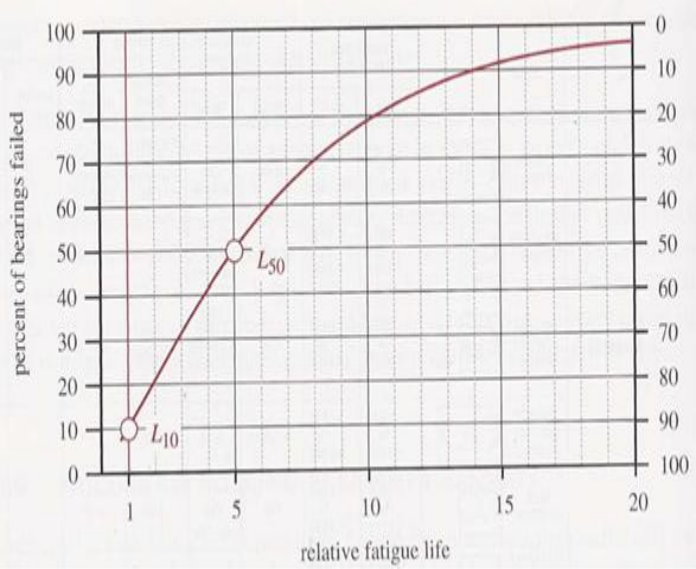
9.2 Bearing Load life:

The life of a ball bearing is the life in hours at some known speed, or the number of revolutions, that the bearing will attain before the first evidence of fatigue appears on any of the moving part.

9.2.1 Rating life (L_{10})

Rating life is defined as the life of a group of apparently identical ball or roller bearings, in number of revolutions or hours, rotating at a given speed, so that 90% of the bearings will complete or exceed before any indication of failure occur or Rating life (L_{10})is the life at which 10 percent of bearing have failed and 90% of them are still good. The terms minimum life, L_{10} life, and B_{10} life are also used as synonyms for rating life.

9.2.2 Median Life (L_{50}) is the life at which 50% of the bearings failed and 50% are still good. It is generally not more than 5 time the rate life L_{10}.



9.2.3 Bearing load life: If two groups of identical bearings are tested under loads P_1 and P_2 for respective lives of L_1 and L_2, then,

$L_1/L_2=(P_2/P_1)^a$ (i)

Where,

L : life in millions of revolution or life in hours

a : constant which is 3 for ball bearings and 10/3 for roller bearings

9.2.4 Basic load rating

It is that load which a group of apparently identical bearings can withstand for a rating life of one million revolutions, if say, L_1 is taken as one million then the corresponding load is

$C= P(L)^{1/a}$ (ii)

Where, C is the basic or dynamic load rating

9.2.5 Equivalent radial load

The load rating of a bearing is given for radial loads only. Therefore, if a bearing is subjected to both axial and radial load, then an equivalent radial load is estimated as,

$P_e=XVP_r+YP_a$ (iii)

Where,

P_e : Equivalent radial load

P_r : Given radial load

P_a : Given axial load

V : Rotation factor (1.0, inner race rotating; 1.2, outer race rotating)

X : A radial factor

Y : An axial factor

The values of X and Y are found from the chart whose typical format and few representative values are given below. The factor, C_o is obtained from the bearing catalogue.

P_a/C_o	**e**	$P_a/P_r \leq e$ X Y	$P_a/P_r \geq e$ X Y
0.021	0.21	1.0 0.0	0.56 2.15
0.110	0.30	1.0 0.0	0.56 1.45
0.560	0.44	1.0 0.0	0.56 1.00

10. Selection procedure of bearing:

Depending on the shaft diameter and magnitude of radial and axial load a suitable type of bearing is to be chosen from the manufacturer's catalogue, either a ball bearing or a roller bearing. The equivalent radial load is to be determined from equation (iii). If it is a tapered bearing then manufacturer's catalogue is to be consulted for the equation given for equivalent radial load. The value of dynamic load rating C is calculated for the given bearing life and equivalent radial load. From the known value of C, a suitable bearing of size that conforms to the shaft is to be chosen. However, some augmentation in the shaft size may be required after a proper bearing is chosen [9]

11. Lubrication:[5]

lubrication play an important role in rolling contact bearing because when bearing is in motion , friction begin because the ball or roller rotate inside the cage or between the outer race & inner race. It may be the reason of failure of bearing. The purposes of an antifriction-bearing lubricant may be summarized as follows:

1 To provide a film of lubricant between the sliding and rolling surfaces
2 To help distribute and dissipate heat
3 To prevent corrosion of the bearing surfaces
4 To protect the parts from the entrance of foreign matter.

Either oil or grease may be employed as a lubricant. The following rules may help in deciding between them.

- **Uses of Grease**

1. The temperature is not over 200°F.
2. The speed is low.
3. Unusual protection is required from the entrance of foreign matter.
4. Simple bearing enclosures are desired.
5. Operation for long periods without attention is desired.

- **Use Oil when**

1. Speeds are high.
2. Temperatures are high.
3. Oil tight seals are readily employed.
4. Bearing type is not suitable for grease lubrication.
5. The bearing is lubricated from a central supply which is also used for other machine parts.

12. Conclusion:

Bearings are one of the important machine elements extensively used due to its relatively lower price, being almost maintenance free and for its operational ease. When a bearing is in operation, contact stresses occur on the inner ring, rolling elements and outer ring.

If the bearing is clean, lubricated, sealed against dust and operates at reasonable temperature, then metal fatigue will be the only cause of failure.

The assembled bearing consists of two separate parts:

1. The cone assembly (cone, rollers and cage).
2. The cup

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