Module 14

Brief overview of bearings

Lesson 2

Rolling contact bearings

Instructional Objectives:

At the end of this lesson, the students should be able to understand:

- About rolling contact bearings
- Ball bearing and roller bearing
- Basics definitions of design parameters of rolling contact bearings
- Selection method for rolling contact bearings

14.2.1 Rolling contact bearing

Rolling contact bearings are also called anti-friction bearing due to its low friction characteristics. These bearings are used for radial load, thrust load and combination of thrust and radial load. 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. These bearings are of two types,

Ball bearing and *Roller bearing*

14.2.2 Ball bearing

A typical ball bearing is shown the Fig.14.2.1. The figure shown on the right side, with nomenclature, is the schematic representation of the actual bearing.

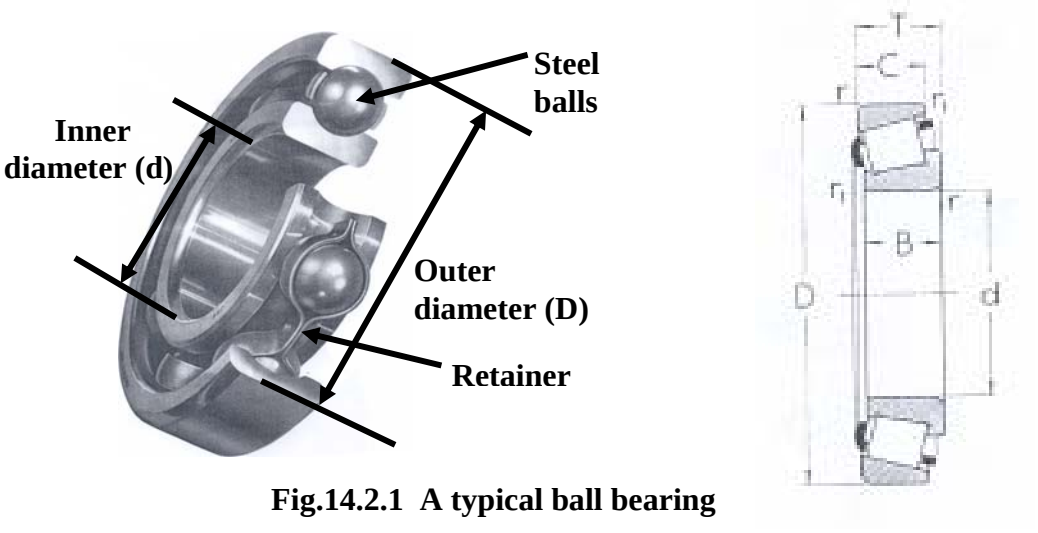

Fig.14.2.1 A typical ball bearing

The bearing shown in the figure is called Single row deep groove ball bearing. It is used to carry radial load but it can also take up considerable amount of axial load. The retainer keeps the steel balls in position and the groove below the steel balls is the inner ring and over it is the outer ring. The outer ring, called outer race, is normally placed inside a bearing housing which is fixed, while the inner race holds the rotating shaft. Therefore, a seat of diameter d and width B is provided on the shaft to press fit the bearing. The arrangement for housing a bearing is shown through a schematic diagram, Fig.14.2.2.

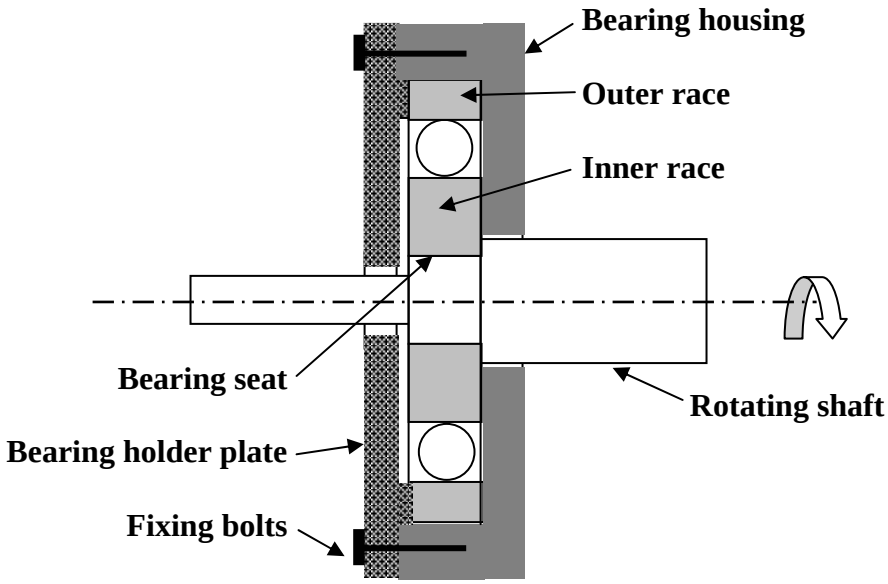

Fig. 14.2.2 A typical arrangement for housing a bearing

Single row Angular Contact Ball Bearing

The figure Fig.14.2.3 is a Single row Angular Contact Ball Bearing. It is mostly used for radial loads and heavy axial loads.

Fig. 14.2.3

Double Row Angular Contact Bearing

Double Row Angular Contact Bearing, shown in Fig.14.2.4, has two rows of balls. Axial displacement of the shaft can be kept very small even for axial loads of varying magnitude.

Fig. 14.2.4

Single thrust ball bearing

This Fig.14.2.5 shows a Single thrust ball bearing. It is mostly used for unidirectional axial load.

Fig. 14.2.5

Taper Roller Bearing

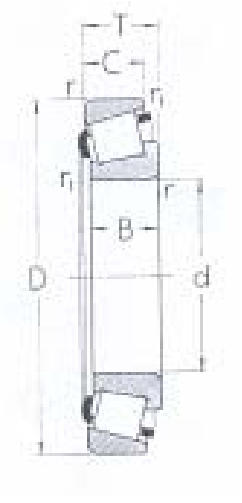

Fig. 14.2.6

A taper roller bearing and its nomenclature are shown in Fig.14.2.6 above. It is generally used for simultaneous heavy radial load and heavy axial load. Roller

Fig. 14.2.3

bearings has more contact area than a ball bearing, therefore, they are generally used for heavier loads than the ball bearings.

Spherical Roller Bearing

A spherical roller bearing, shown in the Fig.14.2.7, has self aligning property. It is mainly used for heavy axial loads. However, considerable amount of loads in either direction can also be applied.

Fig. 14.2.7

Cylindrical Roller Bearing

For heavy radial load and high speed use, cylindrical roller bearings, shown in the Fig.14.2.8, are used. Within certain limit, relative axial displacement of the shaft and the bearing housing is permitted for this type of bearings.

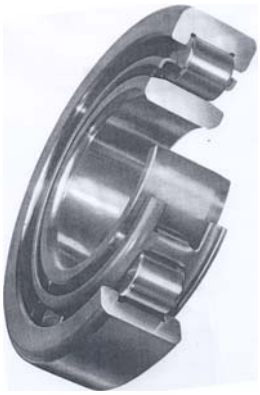

Fig. 14.2.8

14.2.3 Rolling contact bearing selection

Some of the important terminologies which are required for selection of rolling contact bearing are given below.

Rating life:

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.

Suppose we consider 100 apparently identical bearings. All the 100 bearings are put onto a shaft rotating at a given speed while it is also acted upon by a load. After some time, one after another, failure of bearings will be observed. When in this process, the tenth bearing fails, then the number of revolutions or hours

lapsed is recorded. These figures recorded give the rating life of the bearings or simply L_{10} life (10 % failure). Similarly, L_{50} means, 50 % of the bearings are operational. It is known as median life. Fig.14.2.3 defines the life of rolling contact bearings.

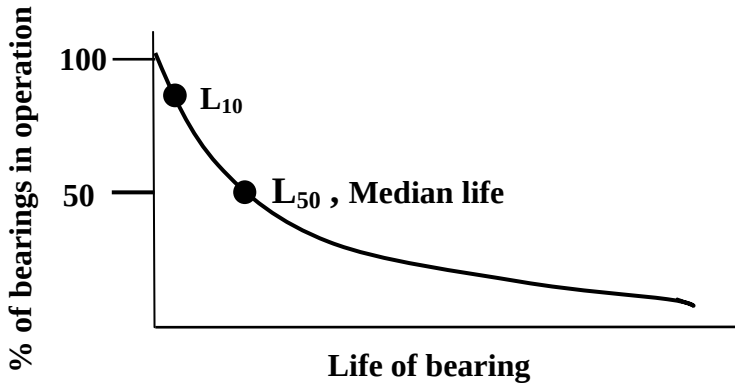

Fig. 14.2.9 Definition of life of rolling contact bearing

Bearing load

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,

$$\frac{L_1}{L_2} = \left(\frac{P_2}{P_1} \right)^a \qquad (14.2.1)$$

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

Basic load rating

It is that load which a group of apparently identical bearings can withstand for a rating life of one million revolutions.

Hence, in (15.3.66), if say, L_1 is taken as one million then the corresponding load is,

$$C = P(L)^{\frac{1}{a}} \qquad (14.2.2)$$

Where, C is the basic or dynamic load rating

Therefore, for a given load and a given life the value of C represents the load carrying capacity of the bearing for one million revolutions. This value of C, for the purpose of bearing selection, should be lower than that given in the manufacturer's catalogue. Normally the basic or the dynamic load rating as prescribed in the manufacturer's catalogue is a conservative value, therefore the chances of failure of bearing is very less.

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,

$$P_e = VP_r \quad \text{or}$$

$$P_e = XVP_r + YP_a \qquad (14.2.3)$$

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.

$\frac{P_a}{C_o}$	**e**	$\frac{P_a}{P_r} \le e$	$\frac{P_a}{P_r} \ge e$
		X Y	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

The factor, C_o is the bearing obtained from catalogue.

14.2.4 The selection procedure

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 (14.2.3). 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.

Sample problem

A simply supported shaft, diameter 50mm, on bearing supports carries a load of 10kN at its center. The axial load on the bearings is 3kN. The shaft speed is 1440 rpm. Select a bearing for 1000 hours of operation.

Solution

The radial load P_r = 5 kN and axial load P_r = 3 kN. Hence, a single row deep groove ball bearing may be chosen as radial load is predominant. This choice has wide scope, considering need, cost, future changes etc.

Millions of revolution for the bearing, $L_{10} = \frac{60 \times 1440 \times 1000}{10^6} = 86.4$

For the selection of bearing, a manufacturer's catalogue has been consulted.

The equivalent radial load on the bearing is given by,

$$P_e = XVP_r + YP_a$$

Here, V=1.0 (assuming inner race rotating)

From the catalogue, C_o = 19.6 kN for 50mm inner diameter.

$$\therefore \frac{P_a}{C_O} = \frac{3.0}{19.6} = 0.153,$$

Therefore, value of e from the table (sample table is given in the text above) and by linear interpolation = 0.327.

Here, $\frac{P_a}{P_r} = \frac{3}{5} = 0.6 > e$. Hence, X and Y values are taken from fourth column of the sample table. Here, X= 0.56 and Y= 1.356

Therefore, $P_e = XVP_r + YP_a = \ 0.56 \times 1.0 \times 5.0 + 1.356 \times 3.0 = 6.867\ \text{kN}$

$$\therefore \text{ basic load rating, } C = P\,(L)^{\frac{1}{3}} = 6.867 \times (86.4)^{\frac{1}{3}} = 30.36\ \text{kN}$$

Now, the table for single row deep groove ball bearing of series- 02 shows that for a 50mm inner diameter, the value of C = 35.1 kN. Therefore, this bearing may be selected safely for the given requirement without augmenting the shaft size. A possible bearing could be SKF 6210.

Questions and answers

Q1. What is rating life of a rolling contact bearing?

A1. 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.

Q2. What is basic load rating of a rolling contact bearing?

A2. It is that load which a group of apparently identical bearings can withstand for a rating life of one million revolutions.

$$C = P(L)^{\frac{1}{a}}$$

Where, **C** is the basic load rating and P and L are bearing operating load and life respectively and **a** is a constant which is 3 for ball bearings and 10/3 for roller bearings.

Q3. Why determination of equivalent radial load is necessary?

A3. The load rating of a bearing is given for radial loads only. Therefore, if a bearing is subjected to both axial and radial loads, then equivalent radial load estimation is required.

References

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