Basic Static Load Rating of Rolling Contact Bearings

The load carried by a non-rotating bearing is called a static load. The basic static load rating is defined as the static radial load (in case of radial ball or roller bearings) or axial load (in case of thrust ball or roller bearings) which corresponds to a total permanent deformation of the ball (or roller) and race, at the most heavily stressed contact, equal to 0.0001 times the ball (or roller) diameter.

In single row angular contact ball bearings, the basic static load relates to the radial component of the load, which causes a purely radial displacement of the bearing rings in relation to each other.

Static Equivalent Load for Rolling Contact Bearings

The static equivalent load may be defined as the static radial load (in case of radial ball or roller bearings) or axial load (in case of thrust ball or roller bearings) which, if applied, would cause the same total permanent deformation at the most heavily stressed ball (or roller) and race contact as that which occurs under the actual conditions of loading.

The static equivalent radial load (*W0R) for radial or roller bearings under combined radial and* axial or thrust loads is given by the greater magnitude of those obtained by the following two equations, *i.e.*

1. $W_{0R} = X_0 . W_R + Y_0 . W_A$; and 2. $W_{0R} = W_R$

where W_R = Radial load,

W_A = Axial or thrust load,

X_0 = Radial load factor, and

Y_0 = Axial or thrust load factor.

Life of a Bearing

The ***life of an individual ball (or roller) bearing may be defined as the number of revolutions (or*** hours at some given constant speed) which the bearing runs before the first evidence of fatigue develops in the material of one of the rings or any of the rolling elements.

The ***rating life of a group of apparently identical ball or roller bearings is defined as the number*** of revolutions (or hours at some given constant speed) that 90 per cent of a group of bearings will complete or exceed before the first evidence of fatigue develops (*i.e. only 10 per cent of a group of* bearings fail due to fatigue).

The term ***minimum life is also used to denote the rating life. It has been found that the life*** which 50 per cent of a group of bearings will complete or exceed is approximately 5 times the life which 90 per cent of the bearings will complete or exceed. In other words, we may say that the average life of a bearing is 5 times the rating life (or minimum life). It may be noted that the longest life of a single bearing is seldom longer than the 4 times the average life and the maximum life of a single bearing is about 30 to 50 times the minimum life.

Basic Dynamic Load Rating of Rolling Contact Bearings

The basic dynamic load rating is defined as the constant stationary radial load (in case of radial ball or roller bearings) or constant axial load (in case of thrust ball or roller bearings) which a group of apparently identical bearings with stationary outer ring can endure for a rating life of one million revolutions (which is equivalent to 500 hours of operation at 33.3 r.p.m.) with only 10 per cent failure.

Dynamic Equivalent Load for Rolling Contact Bearings

The dynamic equivalent load may be defined as the constant stationary radial load (in case of radial ball or roller bearings) or axial load (in case of thrust ball or roller bearings) which, if applied to a bearing with rotating inner ring and stationary outer ring, would give the same life as that which the bearing will attain under the actual conditions of load and rotation.

The dynamic equivalent radial load (W) for radial and angular contact bearings, except the filling slot types, under combined constant radial load (W_R) and constant axial or thrust load (W_A) is given by

$$W = X \, . \, V. \, W_R + Y \, . \, W_A$$

where V = *A rotation factor,*

= 1, for all types of bearings when the inner race is rotating,

= 1, for self-aligning bearings when inner race is stationary,

= 1.2, for all types of bearings except self-aligning, when inner race is stationary.

Dynamic Load Rating for Rolling Contact Bearings under Variable Loads

The approximate rating (or service) life of ball or roller bearings is based on the fundamental equation,

$$L = \left(\frac{C}{W}\right)^k \times 10^6 \text{ revolutions}$$

or

$$C = W\left(\frac{L}{10^6}\right)^{1/k}$$

where L = Rating life,

C = Basic dynamic load rating,

W = Equivalent dynamic load, and

k = 3, for ball bearings,

= 10/3, for roller bearings.

The relationship between the life in revolutions (L) and the life in working hours (L_H) is given by

$$L = 60\, N \,.\, L_H \text{ revolutions}$$

where N is the speed in r.p.m.

Now consider a rolling contact bearing subjected to variable loads. Let W_1, W_2, W_3 etc., be the loads on the bearing for successive n_1, n_2, n_3 etc., number of revolutions respectively.

If the bearing is operated exclusively at the constant load W_1, then its life is given by

$$L_1 = \left(\frac{C}{W_1}\right)^k \times 10^6 \text{ revolutions}$$

$\therefore$ Fraction of life consumed with load W_1 acting for n_1 number of revolutions is

$$\frac{n_1}{L_1} = n_1 \left(\frac{W_1}{C}\right)^k \times \frac{1}{10^6}$$

Similarly, fraction of life consumed with load W_2 acting for n_2 number of revolutions is

$$\frac{n_2}{L_2} = n_2 \left(\frac{W_2}{C}\right)^k \times \frac{1}{10^6}$$

and fraction of life consumed with load W_3 acting for n_3 number of revolutions is

$$\frac{n_3}{L_3} = n_3 \left(\frac{W_3}{C}\right)^k \times \frac{1}{10^6}$$

But $\quad \dfrac{n_1}{L_1} + \dfrac{n_2}{L_2} + \dfrac{n_3}{L_3} + \ldots = 1$

or $\quad n_1 \left(\dfrac{W_1}{C}\right)^k \times \dfrac{1}{10^6} + n_2 \left(\dfrac{W_2}{C}\right)^k \times \dfrac{1}{10^6} + n_3 \left(\dfrac{W_3}{C}\right)^k \times \dfrac{1}{10^6} + \ldots\ldots = 1$

$$\therefore n_1 (W_1)^k + n_2 (W_2)^k + n_3 (W_3)^k + \ldots\ldots = C^k \times 10^6 \qquad \ldots(i)$$

If an equivalent constant load (W) is acting for n number of revolutions, then

$$n = \left(\frac{C}{W}\right)^k \times 10^6$$

$$\therefore \qquad n\,(W)^k = C^k \times 10^6 \qquad \text{...}(ii)$$

where $n = n_1 + n_2 + n_3 + \,.....$

From equations (*i*) and (*ii*), we have

$$n_1\,(W_1)^k + n_2\,(W_2)^k + n_3\,(W_3)^k + \,..... = n\,(W)^k$$

$$\therefore \qquad W = \left[\frac{n_1\,(W_1)^k + n_2\,(W_2)^k + n_3\,(W_3)^k + \,....}{n}\right]^{1/k}$$

Substituting $n = n_1 + n_2 + n_3 + \,.......$, and $k = 3$ for ball bearings, we have

$$W = \left[\frac{n_1\,(W_1)^3 + n_2\,(W_2)^3 + n_3\,(W_3)^3 + \,....}{n_1 + n_2 + n_3 + \,....}\right]^{1/3}$$

Note : The above expression may also be written as

$$W = \left[\frac{L_1\,(W_1)^3 + L_2\,(W_2)^3 + L_3\,(W_3)^3 + \,...}{L_1 + L_2 + L_3 + \,....}\right]^{1/3}$$