11 Bearing life

11.1 Life

Even in regular condition, because of contact stress, material will flake from the rolling surface of inner or outer rings or rolling elements by fatigue. Fatigue flaking is the main phenomenon of bearing failures therefore , generally , the life of bearing refers to its fatigue life .Fatigue life expressed in terms of revolution which one bearing ring or washer continues to operate before another bearing ring (or washer) or rolling element appears fatigue flaking.

In some particular cases, bearing is likely to flake because of precision reduction caused by abrasion, or exceed the noise scope required by machine, here, life refers to accuracy life or noise life .

Furthermore, bearing may fail because of burn, abrasion , crack , seizure and rust, Rustiness etc. but these should be considered as failures. Fatigue life is different from failures. Improper choice, mounting , lubricant and seals are all factors to failures. Paying attention to these factors can avoid failures.

1) Reliability

In practical situations, same bearings may have different actual life under the same condition. Fatigue life of bearing is in accordance with specified probability distribution; therefore, bearing life is expressed by failure probability, and also can be judged by reliability. It refers to the percentage which bearing can reach or exceed the theoretical life when they are applied under same condition. Reliability of a single bearing is the probability of reaching or exceeding its theoretical life.

2) Basic life and correction rating life

What we called rating Fatigue life refers to the total revolution of 90 %the same type bearings are used for operation under the same condition without rolling fatigue.

Considering the required reliability , special bearing performance and specific operation condition, what we get after correction to basic rating life is correction rating life.

11 .2 Basic load rating

Basic load rating contains basic dynamic load and static load rating. In which the load capacity of bearings under rotational conditions (n>10r/min) is called basic dynamic load while the bearing in stationary conditions or rotating slowly (n ⩽ 10r/min) called static load rating.

1) Radial basic dynamic load rating

Radial basic dynamic load rating refers to the constant radial load that a bearing can take, under which the basic rating life is one million revolutions. As to single row angular contact ball bearing , this load refers to the radial load causing pure radial movement between bearing rings.

2) Axial basic dynamic load rating

Axial basic dynamic load rating refers to central axial load of constant magnitude in a constant direction, under which the basic rating life is one million revolutions.

3) Radial static load rating

Radial static load rating refers to the radial static load (similar to the following contact stress) caused by the maximum load of rolling bearing in the center of contacting stress surface between in of rolling element and raceway, while the bearing is in stationary conditions or rotating slowly.
4600 Mp_a spherical roller bearing
4200 MP_a all other annular ball bearing
4000 MP_a all the radial roller bearing
As to single row angular contact ball bearing, its radial static load rating refers to radial load causing relative pure radial movement between bearing rings.

4) Axial specified static load rating

Axial direction specified static load refers to virtual central axis static load (similar to the following contact stress) caused by rolling bearing in the contact center of maxima rolling body and raceway groove.
4200 MP_a thrust ball bearing
4000 MP_a all the thrust roller bearing

11.3 Bearing dimension selection according to dynamic load rating

11.3.1Dynamic equivalent load rating

Basic dynamic load rating is defined under assumed running conditions .The load condition is: radial bearing only takes pure radial load, thrust bearing only takes pure axial load .In most application situations, bearing actually take both radial load and axial load. Therefore, when calculating bearing life, we must change actual load into dynamic equivalent load in accordance with load condition of dynamic load rating. Equivalent dynamic radial load refers to radial load. Axial direction equivalent dynamic load refers to constant central load. So under this load rolling bearing has the same life as under actual load.

11.3.2 Life calculations

The relationship among basic rating life, basic dynamic load rating and dynamic equivalent load rating can be described as the following formula:

$$L_{10}=\left(\frac{C}{P}\right)^{\varepsilon} \quad \text{or} \quad \frac{C}{P}=L_{10}^{\frac{1}{\varepsilon}}$$

Thereinto :
L_{10} :Basic rating life million rotations
C :Dynamic basic specified load rating N
P :Dynamic equivalent load N
ε :Life coefficient ball bearing $\varepsilon=3$
Roller bearing $\varepsilon=10/3$

If bearing ' s rotation speed is constant , its basic rating life can be expressed by hours :

$$L_{10k}=\frac{10^6}{60n}\left(\frac{C}{P}\right)^{\varepsilon} \quad \text{or} \quad L_{10k}=\frac{10^6}{60n}L_{10}$$

There into
L_{10k} : Basic rating life h
n :Rotation speed . r/min

As to bearings applied to automotive wheel hubs, its basic rating life can be expressed by miles:

$$L_{10k}=\pi D\left(\frac{C}{P}\right)^{\varepsilon} \text{ Or } L_{10k}=\pi D L_{10}$$

There into
L_{10k} :Basic rating life km
D : wheel diameter mm

If bearings make movement like a swing, the amplitude of swing around center is $\pm\ \gamma\ ^{\circ}$, then:

$$L_{10osc}=\frac{180}{2\gamma}L_{10}$$

There into :
L_{10osc} : Basic rating life
(Million times swing periods)
γ :Amplitude (degree)

When amplitude is small, no need to calculate basic rating life.

In order to simplify the calculation, we take 500 h as the standard of rating life, and speed coefficient f_n and life coefficient f_h :

$$f_n=\left[\frac{33\frac{1}{3}}{n}\right]^{\frac{1}{\varepsilon}}$$

$$f_h=\left[\frac{L_{10k}}{500}\right]^{\frac{1}{\varepsilon}}$$