TECHNICAL INSIGHT

NSK

PRODUCT AND APPLICATION ENGINEERING INFORMATION

A PUBLICATION OF NSK AMERICAS

BEARING LIFE

Calculating the basic fatigue life expectancy of rolling bearings

Bearing life is essentially the length of time a bearing can be expected to perform as required in predefined operating conditions. It is based primarily on the probable number of rotations a bearing can complete before it starts showing signs of fatigue, such as spalling or cracking due to stress.

WHAT DETERMINES A BEARING'S SERVICE LIFE?

In addition to natural wear and tear, bearings can fail (prematurely) due to other factors such as extreme temperatures, lack of lubrication, or damage to the seals or cage. Bearing damage of this kind is often the result of choosing the wrong bearing, inaccuracies in the design of the surrounding components, improper installation or poor maintenance.

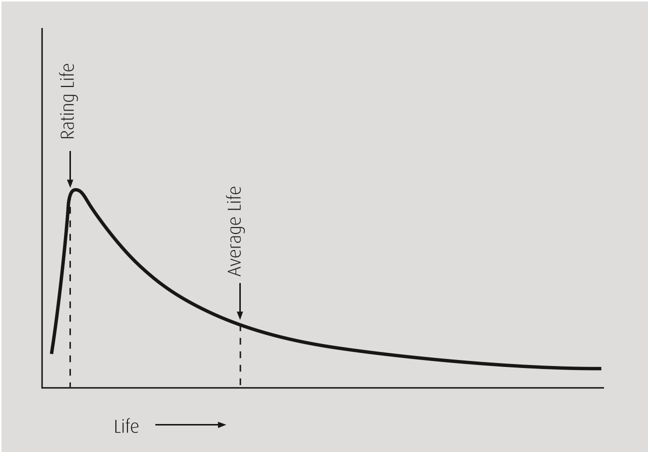
1. Basic fatigue life rating L_{10}

A bearing's basic fatigue life rating is calculated using the number of rotations which 90% of all bearings in a specific group achieve or exceed in a calculated time without failure (probability of failure: 10%).

A standardized formula – also known as the catalog method (ISO 281:2007) – is the conventional means of calculating a bearing's life. The parameters are bearing load, rotational speed, dynamic load rating and bearing type. The result is the bearing fatigue life L_{10} or L_{10h}.

- The **Dynamic load rating (basic load rating)** is defined as the constant load applied on bearings with stationary outer rings that the inner rings can endure for a rating life of one million

Typical signs of fatigue: small flakes of the bearing material become detached (flaking/spalling).



Failure Probability and Bearing Life

revolutions (10^6 rev). The basic load rating of radial bearings is defined as a central radial load of constant direction and magnitude, while the basic load rating of thrust bearings is defined as an axial load of constant magnitude in the same direction as the central axis. The load ratings are listed under C_r for radial bearings and C_a for thrust bearings in the dimension tables.

› The **dynamic equivalent load P** is defined as a mathematical radial load for radial bearings or axial load for axial bearings of a constant magnitude and direction which has the same effect on bearing life as the forces actually acting on the component. In the case of combined or constant loads, the value of P is calculated using the following formula:
$P = X \cdot F_r + Y \cdot F_a$
Apart from Thrust Spherical Roller Bearing:
$P = F_a + 1{,}2 \cdot F_r$, where $F_r / F_a \leq 0.55$

L_{10}/L_{10h}: basic life rating [10^6 rotations/h]

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

C Dynamic load rating [N]
P Dynamic equivalent bearing load [N]
p Exponent (3 for ball bearings, 10/3 for roller bearings) [–]
n Rotational speed [rpm]

Adjusting bearings to the operating temperature

If standard bearings are used at high operating temperatures, the bearing steel loses hardness. The nominal load rating should therefore be adjusted for higher temperatures with the aid of this equation:

C_t: Basic Load Rating

$$C_t = f_t \cdot C$$

C_t Basic load rating after temperature correction (N)
f_t Temperature factor
C Basic load rating before temperature adjustment (N)

Temperature Factor f_t					
Bearing temperature °C	125	150	175	200	250
Temperature factor f_t	1.00	1.00	0.95	0.90	0.75

2. Modified bearing life

Although nominal bearing life is sufficient as a criterion, it is desirable for many applications to calculate service life more precisely, taking lubrication and contamination into account.

It has also been established that the grades of steel and quality of manufacturing now available make it possible for bearings to last longer than the nominal life L_{10} suggests if conditions are favorable and the contact load does not exceed a certain level. However, unfavorable operating conditions may shorten the service life. To take this into account, the factors a_1, a_2 and a_3 have been defined, resulting in the modified bearing life L_{na}.

L_{nm}/L_{nmh} Modified bearing life / [10^6 rotations/h]

$$L_{na} = a_1 \cdot a_2 \cdot a_3 \cdot L_{10} \qquad L_{nah} = a_1 \cdot a_2 \cdot a_3 \cdot L_{10h}$$

a_1 Life adjustment factor for reliability
a_2 Life adjustment factor for special bearing properties
a_3 Life adjustment factor for operating conditions

Reliability Factor a_1						
Reliability (%)	90	95	96	97	98	99
a_1	1.00	0.62	0.53	0.44	0.33	0.21

PREDICTING THE SERVICE LIFE OF NSK PRODUCTS USING THE ABLE FORECASTER

The ABLE Forecaster (Advanced Bearing Life Equation) software developed by NSK provides more precise information about the bearing life of NSK products because evaluations of application scenarios and trials are incorporated into the calculations.