9. Allowable speed

9.1 Constant speed rotation

As the rotational speed of the bearing increases, the temperature of the bearing also rises due to heat generation inside the bearing due to friction. This may result in damage to the bearing, such as seizure, and the bearing will be unable to continue stable operation. Therefore, the maximum speed at which it is possible for the bearing to continuously operate without the generation of excessive heat beyond specified limits is called the **allowable speed** (min^{-1}). The allowable speed of a bearing depends on the type of bearing, bearing dimensions, type of cage, load, lubrication conditions, and cooling conditions.

The bearing dimensional table gives approximate allowable rotational speeds for grease and oil lubrication.

- The bearing must have the proper internal clearance prescribed in the **NTN** Engineering standard design specifications and must be properly installed.
- A quality lubricant must be used. The lubricant must be replenished and changed when necessary.
- The bearing must be operated at normal operating temperature under ordinary load conditions ($P \leq 0.08C_r$, $F_a / F_r \leq 0.3$).

If the load is below the minimum necessary load (refer to the section "8. Bearing internal clearance and preload 8.4"), rolling elements may not turn smoothly. If so, please contact **NTN** Engineering for more information.

Allowable speed for deep groove ball bearings with contact seal (LLU type) or low-torque seal (LLH type) is determined according to the circumferential speed of the seal. For bearings to be used under heavier than normal load conditions, the allowable speed values listed in the bearing tables must be multiplied by an adjustment factor. The adjustment factors f_L and f_C are given in **Fig. 9.1** and **Fig. 9.2**.

Also, **when radial bearings are mounted on vertical shafts**, retention of lubricant and cage guidance are less favorable when compared to horizontal shaft mounting. Therefore, the allowable speed should be reduced to **approximately 80 % of the listed speed**. For speeds other than those mentioned above, and for which data is incomplete, please consult **NTN** Engineering.

If rotational speed is to exceed allowable rotational speed given in the dimensions table, it will require special considerations, such as using a bearing for which cage specifications, internal clearance and precision have been thoroughly checked. It may require adopting forced circulation, jet oil or mist oil lubrication as the lubrication method.

Under such high speed operating conditions, when special care is taken, the standard allowable speeds given in the bearing tables can be adjusted upward. The maximum speed adjustment values, f_B, by which the bearing table speeds can be multiplied, are shown in **Table 9.1**. However, for any application requiring speeds in excess of the standard allowable speed, please consult **NTN** Engineering.

Bearings with solid grease (refer to the section 11.4) have their original allowable rotational speed provision. For details, see the special catalog "**Bearings with solid grease (CAT. No. 3022/E)**".

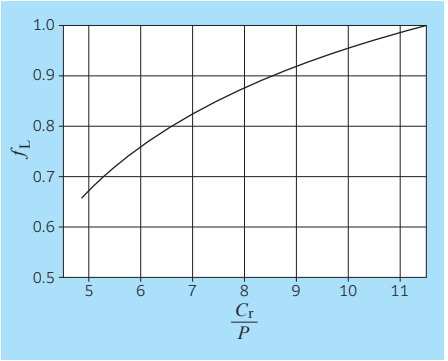

Fig. 9.1 Value of adjustment factor f_L depends on bearing load

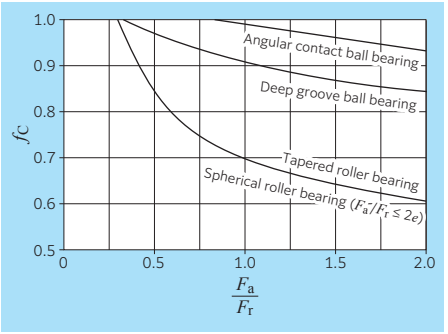

Fig. 9.2 Value of adjustment factor f_C depends on combined load

Table 9.1 Adjustment factor, f_B, for allowable number of revolutions

Bearing type	Adjustment factor f_B
Deep groove ball bearing	3.0
Angular contact ball bearing	2.0
Cylindrical roller bearing	2.5
Tapered roller bearing	2.0

9.2 Low-speed rotation and rapid acceleration/deceleration

When the bearing rotational speed is particularly low [the product of the rotational speed n (min^{-1}) and the rolling element pitch diameter D_{pw} (mm) is $D_{pw} \cdot n < 10\,000$], an elastohydrodynamic lubrication oil film may not be formed at the contact surface between the rolling element and the raceway surface.

Under such conditions, lubricant containing an extreme-pressure additive (EP additive) should be used.

When rapid acceleration/deceleration is included in the operating conditions, the cage may break.

Please contact **NTN** Engineering because the allowable rotational speed needs to be examined individually.

9.3 Oscillating applications

In small oscillating movement, the rotation direction changes before the bearing makes one rotation.

The moment when the rotation method forwards and reverses, the rotational speed becomes zero. At this time, a lubrication oil film in the fluid mechanics may not be formed or maintained.

Under such conditions, lubricant containing an extreme-pressure additive (EP additive) should be used.

Suitable preload may be applied to reduce the sliding of rolling elements.

When the oscillation angle is extremely small, an oil film is unlikely to be formed on the contact surface between the raceway surface and the rolling element, and fretting (refer to page A-173) may occur.

Please contact **NTN** Engineering because the allowable rotational speed needs to be examined individually.

9.4 Heat rating rotational speed

The heat rating rotational speed is an index standardized in JIS B 1550:2010 (ISO 15312:2003) that uses bearing operating temperature as reference.

This standard refers to the rotational speed of the inner ring of the bearing when the heat generation amount due to the bearing internal friction becomes equivalent to the heat radiation amount of the shaft and housing for mounting the bearing in the case where the bearing is operated at the reference condition below.

Reference conditions are shown below.

(1) Reference temperature
Reference temperature of static outer ring (housing raceway washer): 70 °C
Reference ambient temperature around bearing: 20 °C

(2) Reference load
Radial bearing ($0° \leq \alpha \leq 45°$):
Pure radial load of $0.05 \times C_{0r}$
Thrust roller bearing ($45° \leq \alpha \leq 90°$):
Pure axial load of $0.02 \times C_{0a}$

(3) Lubricant
The lubricant must be mineral oil that is free of an extreme-pressure additive and have viscosity ν below the following values at 70 °C.
Radial bearing:
ν = 12 mm^2/s (equivalent to ISO VG32)
Thrust roller bearing:
ν = 24 mm^2/s (equivalent to ISO VG68)

(4) Lubrication method
In oil bath lubrication, the oil level is the center of the rolling element that is at the lowermost position.

Refer to JIS B 1550:2010 (ISO 15312:2003) for further details.