$$F_{ae}+\frac{0.6}{Y_{II}}F_{rII}=2\,000+\frac{0.6}{1.6}\times 3\,931$$

$$=3\,474\text{N},\ \{354\text{kgf}\}$$

$$\frac{0.6}{Y_I}F_{rI}=\frac{0.6}{0.73}\times 1\,569=1\,290\text{N},\ \{132\text{kgf}\}$$

Therefore, with this bearing arrangement, the axial load $F_{ae}+\frac{0.6}{Y_{II}}F_{rII}$ is applied on bearing Ⅰ but not on bearing Ⅱ.

For bearing Ⅰ

$F_{rI}=1\,569\text{N},\ \{160\text{kgf}\}$

$F_{aI}=3\,474\text{N},\ \{354\text{kgf}\}$

since $F_{aI}/F_{rI}=2.2>e=0.83$

the dynamic equivalent load $P_I=XF_{rI}+Y_IF_{aI}$

$$=0.4\times 1\,569+0.73\times 3\,474$$

$$=3\,164\text{N},\ \{323\text{kgf}\}$$

The fatigue life factor $f_h=f_n\frac{C_r}{P_I}$

$$=\frac{0.42\times 38\,000}{3\,164}=5.04$$

and the rating fatigue life $L_h=500\times 5.04^{\frac{10}{3}}=109\,750\text{h}$

For bearing Ⅱ

since $F_{rII}=3\,931\text{N},\ \{401\text{kgf}\},\ F_{aII}=0$

the dynamic equivalent load

$P_{II}=F_{rII}=3\,931\text{N},\ \{401\text{kgf}\}$

the fatigue life factor

$$f_h=f_n\frac{C_r}{P_{II}}=\frac{0.42\times 43\,000}{3\,931}=4.59$$

and the rating fatigue life $L_h=500\times 4.59^{\frac{10}{3}}=80\,400\text{h}$ are obtained.

Remarks For face-to-face arrangements (DF type), please contact NSK.

**(Example 6)**
Select a bearing for a speed reducer under the following conditions:
Operating conditions
Radial load $F_r=245\,000\text{N},\ \{25\,000\text{kgf}\}$
Axial load $F_a=49\,000\text{N},\ \{5\,000\text{kgf}\}$
Speed $n=500\text{min}^{-1}$
Size limitation
Shaft diameter: 300mm
Bore of housing: Less than 500mm

In this application, heavy loads, shocks, and shaft deflection are expected; therefore, spherical roller bearings are appropriate.
The following spherical roller bearings satisfy the above size limitation (refer to Page B196)

| $d$ | $D$ | $B$ | Bearing No. | Basic dynamic load rating $C_r$ (N) | {kgf} | Constant $e$ | Factor $Y_3$ |
|---|---|---|---|---|---|---|---|
| 300 | 420 | 90 | **23960 CAE4** | 1 230 000 | 125 000 | 0.19 | 3.5 |
| | 460 | 118 | **23060 CAE4** | 1 920 000 | 196 000 | 0.24 | 2.8 |
| | 460 | 160 | **24060 CAE4** | 2 310 000 | 235 000 | 0.32 | 2.1 |
| | 500 | 160 | **23160 CAE4** | 2 670 000 | 273 000 | 0.31 | 2.2 |
| | 500 | 200 | **24160 CAE4** | 3 100 000 | 315 000 | 0.38 | 1.8 |

since $F_a/F_r=0.20<e$
the dynamic equivalent load $P$ is

$$P=F_r+Y_3F_a$$

Judging from the fatigue life factor $f_h$ in Table 5.1 and examples of applications (refer to Page A25), a value of $f_h$, between 3 and 5 seems appropriate.

$$f_h=f_n\frac{C_r}{P}=\frac{0.444\,C_r}{F_r+Y_3F_a}=3\text{ to }5$$

Assuming that $Y_3=2.1$, then the necessary basic load rating $C_r$ can be obtained

$$C_r=\frac{(F_r+Y_3F_a)\times(3\text{ to }5)}{0.444}$$

$$=\frac{(245\,000+2.1\times 49\,000)\times(3\text{ to }5)}{0.444}$$

$$=2\,350\,000\text{ to }3\,900\,000\text{ N},$$
$\{240\,000\text{ to }400\,000\text{ kgf}\}$

The bearings which satisfy this range are **23160CAE4**, and **24160CAE4**.





# 6. LIMITING SPEED

The speed of rolling bearings is subject to certain limits. When bearings are operating, the higher the speed, the higher the bearing temperature due to friction. The limiting speed is the empirically obtained value for the maximum speed at which bearings can be continuously operated without failing from seizure or generation of excessive heat. Consequently, the limiting speed of bearings varies depending on such factors as bearing type and size, cage form and material, load, lubricating method, and heat dissipating method including the design of the bearing's surroundings.
The limiting speeds for bearings lubricated by grease and oil are listed in the bearing tables. The limiting speeds in the tables are applicable to bearings of standard design and subjected to normal loads, i. e. $C/P\geqq 12$ and $F_a/F_r\leqq 0.2$ approximately. The limiting speeds for oil lubrication listed in the bearing tables are for conventional oil bath lubrication.
Some types of lubricants are not suitable for high speed, even though they may be markedly superior in other respects. When speeds are more than 70 percent of the listed limiting speed, it is necessary to select an oil or grease which has good high speed characteristics.

(Refer to)
Table 12.2 Grease Properties (Pages A110 and 111)
Table 12.5 Example of Selection of Lubricant for Bearing Operating Conditions (Page A113)
Table 15.8 Brands and Properties of Lubricating Grease (Pages A138 to A141)

## 6.1 Correction of Limiting Speed

When the bearing load $P$ exceeds 8 % of the basic load rating $C$, or when the axial load $F_a$ exceeds 20 % of the radial load $F_r$, the limiting speed must be corrected by multiplying the limiting speed found in the bearing tables by the correction factor shown in Figs. 6.1 and 6.2.
When the required speed exceeds the limiting speed of the desired bearing; then the accuracy grade, internal clearance, cage type and material, lubrication, etc., must be carefully studied in order to select a bearing capable of the required speed. In such a case, forced-circulation oil lubrication, jet lubrication, oil mist lubrication, or oil-air lubrication must be used.
If all these conditions are considered. The maximum permissible speed may be corrected by multiplying the limiting speed found in the bearing tables by the correction factor shown in Table 6.1. It is recommended that NSK be consulted regarding high speed applications.

## 6.2 Limiting Speed for Rubber Contact Seals for Ball Bearings

The maximum permissible speed for contact rubber sealed bearings (DDU type) is determined mainly by the sliding surface speed of the inner circumference of the seal. Values for the limiting speed are listed in the bearing tables.

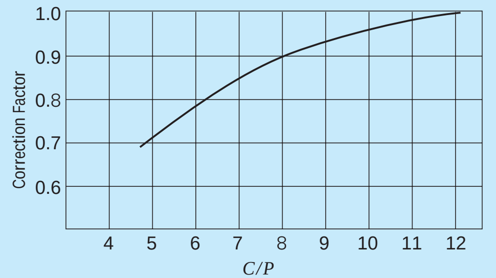


**Fig. 6.1 Limiting Speed Correction Factor Variation with Load Ratio**

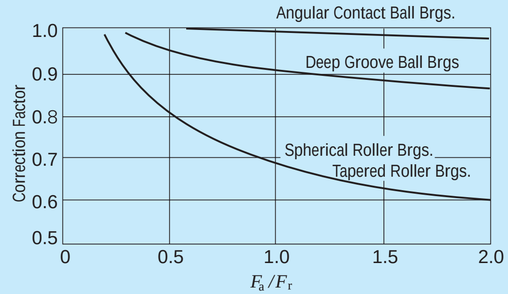


**Fig. 6.2 Limiting Speed Correction Factor for Combined Radial and Axial Loads**

**Table 6.1 Limiting Speed Correction Factor for High-Speed Applications**

| Bearing Types | Correction Factor |
|---|---|
| Cylindrical Roller Brgs.(single row) | 2 |
| Needle Roller Brgs.(except broad width) | 2 |
| Tapered Roller Brgs. | 2 |
| Spherical Roller Brgs. | 1.5 |
| Deep Grooove Ball Brgs. | 2.5 |
| Angular Contact Ball Brgs.(except matched bearings) | 1.5 |