8.9 Temperature dependence of radial load rating

If the rolling bearing unit is operated at high temperatures above 120℃, the bearing material's degree of hardness is reduced and thus the radial load rating is also reduced. In turn, the rated life is also reduced at high temperature operations. The temperature dependence of the radial load rating is shown in equation 8.12

$Ct = ft \cdot C$ ··················(8.12)

Here, Ct : Dynamic radial load rating at fixed operating temperature (Kg)

ft : Temperature factro (reducing factor for radial load rating)

C : Dynamic load rating (Kg)

<TABLE 8.3> Temperature factor(ft)

Bearing temperature(℃)	125	150	175	200	225	250
Temperature factor(ft)	0.95	0.90	0.85	0.75	0.65	0.6

9. Bearing load calculation

A load on a bearing is commonly produced by the weight of the supporting structure, weight of the shaft itself, power transmission of gear or belt, and loads generated by the operation of the machine. Some loads can be theoretically calculated while others are very difficult to calculate.

In addition, machine operation is usually accompanied by vibration and shocks. These affects make accurate calculation of the applied load very difficult. Therefore, in order to determine the bearing load more accurately, many calculation factors determined from experience are multiplied to the calculated loads.

9.1 Load factor

The real load on a bearing is usually greater than the calculated value because of vibrations and shocks.

Therefore, the real applied load is determined by multiplying the calculated load with load factors.

Bearing load = Load factor(fw) × calculated load ·· (9.1)

<TABLE 9.1> Load factor

Load condition	fw	Application example
Smooth operation with no shocks	1.0~1.2	Electrical machines, compressed air machines
Operation with small shocks	1.2~2.0	Power transmission, metallic machines, building machines, moving machines
Operation with frequent vibrations and shocks	2.0~3.0	Construction machines, rolling machines, agricultural machinery

9.2 Belt or chain drive load during rotation

The following method is used when belt or chain is used to transmit power. Added moment M is

$$M = 97400\frac{H}{n}\ (Kg - cm) \cdots\cdots\cdots\cdots(9.2)$$

Effective transmission power P is

$$P = \frac{M}{r}\ (Kg) \cdots\cdots\cdots\cdots(9.3)$$

Her H : transmission horse power (KW)

n : rotation speed (rpm)

r : effective radius of pully or sproket wheel

<TABLE 9.2> Belt factor, fb

Belty type	fb
V belt	2.0 ~ 2.5
Plane belt(with tension plley)	2.5 ~ 3.0
Plane belt	4.0 ~ 5.0
Silk belt	3.5 ~ 4.5
Chain	1.25 ~ 1.5

Remark : Take the larger numbers for fb and fc for slow speed poeration and for operation with short axis to axis distance.

9.3 Gear rotation load

The calculation method for gear load is different for different styles of gear. The following method applies for the simplest style spur gear.

The gear moment M is,

$$M = 97400\frac{M}{n}\ (Kg-cm) \cdots\cdots(9.4)$$

In figure 9.1, tangential force P_1 is,

$$P_1 = \frac{M}{r}\ (Kg) \cdots\cdots\cdots\cdots(9.5)$$

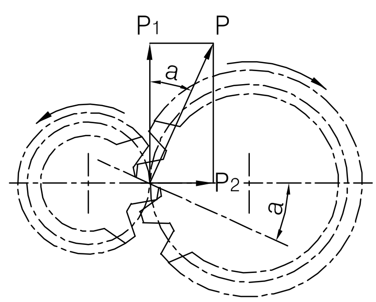
Perpendicular force P_2 is

$$P_2 = P_1 \cdot \tan\alpha \cdots\cdots\cdots\cdots(9.6)$$

Therefore, theoretical total force P applied to the bearing is calculated by

$$P = \sqrt{P_1^2 + P_2^2} = \frac{P_1}{\cos\alpha} \cdots\cdots\cdots\cdots(9.7)$$

The actual applied load on the bearing must be calculated by multiplying the gear factor, fg, listed in Table 9.3. The gear factor is based on the teeth angle and the overall quality of the gear.



[FIGURE 9.1]

<TABLE 9.3> Gear factor, fg

Gear type	fg
Precision gear (both pitch and dimension error are less than 0.02mm)	1.05 ~ 1.1
Regular gear (both pitch and dimension error are from 0.02 to 0.1mm)	1.1 ~ 1.13

Actual bearing load P is calculated by multiplying the theoretically calculated load Po, with the applicable rotation factor (fb, fc, fg) and load factor fw.

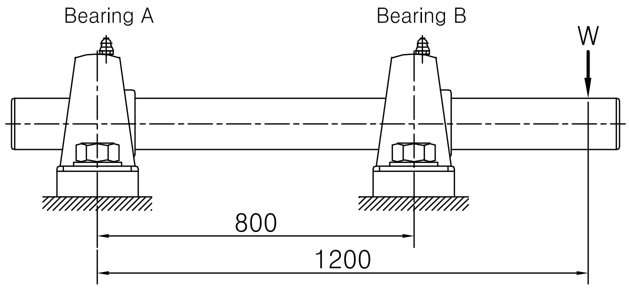
For example, for belt rotation $p = fb \cdot fw \cdot P0$ ·····(9.8)

for chain rotation $p = fc \cdot fw \cdot P0$ ·····(9.9)

for gear rotation $p = fg \cdot fw \cdot P0$ ·····(9.10)

10. Ball bearing unit selection calculation examples

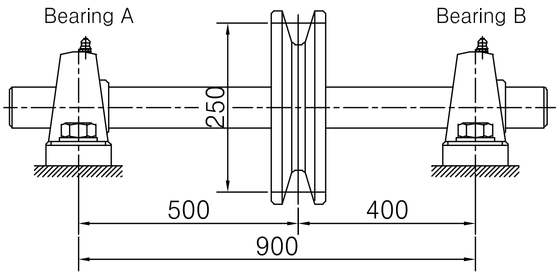
(Example 1) As shown in the drawing, radial load w = 500 Kg is applied to the shaft. What is the applied load on bearing A and B ?



Solution) $W_A = \frac{1200 - 800}{800} \times 500 = 250(Kg)$

$W_B = \frac{1200}{800} \times 500 = 750(Kg)$

(Example 2) As shown in the drawing, the shaft is rotated by a V-belt with transmission power H = 7.5 KW, shaft speed n = 500 rpm, and pulley pitch diameter d = 250mm. what is the applied load on bearing A and B ?



Solution) Rotating moment

$$M = 97400 \times \frac{H}{n}$$

$$= 97400 \times \frac{7.5}{500} = 1461(Kg-cm)$$

Effective transmission power P for the V-belt is,

$$P = \frac{M}{r} = \frac{1461}{25/2} = 116.8(Kg)$$

Now, the belt factor fb for the above belt is listed in Tabel 9.2 is 2.5 and the load factor fw listed in Table 9.1 is 1.2. Then, the real applied force, P, on the bearing is.

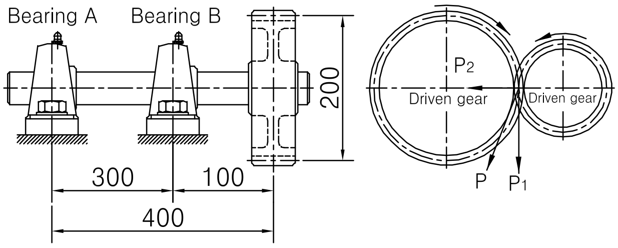
$$P = 2.5 \times 1.2 \times 116.8 = 350.4(Kg)$$

Therefore, applied force on bearing A and B are

$$WA = \frac{400}{900} \times 350.4 = 155.7\ (Kg)$$

$$WB = \frac{500}{900} \times 350.4 = 194.7\ (Kg)$$

(Example 3) As shown in the drawing, the shaft is rotated by a spur gear with trasmission power H = 5.5KW, shaft speed n = 500 rpm, pitch diameter d = 200 mm and teeth pressure angle $\alpha = 14°30'$. What is the applied load on bearing A and B ?



Solution) Rotating moment M on the gear is

$$M = 97400 \times \frac{H}{n}$$

$$= 97400 \times \frac{5.5}{500} = 1071.4(Kg-cm)$$

Tangential force P_1 is

$$P_1 = \frac{M}{r} = \frac{1071.4}{10} = 107.1(Kg)$$

Perpendicular force P_2 is

$$P_2 = P_1 \tan\alpha = 107.1 \times \tan 14°30' = 27.7(Kg)$$

Therefore, total applied force P on the gear is

$$P = \sqrt{P_1^2 + P_2^2} = \sqrt{107.1^2 + 27.7^2} = 110.6(Kg)$$

Assuming that the gear factor fg = 1.2 and the load factor fw = 1.2, the real applied force W on the shaft is

$$W = 1.2 \times 1.3 \times 110.6 = 172.5(Kg)$$

Therefore, the applied force on bearing A and B are

$$WA = \frac{100}{300} \times 172.5 = 57.5\ (Kg)$$

$$WA = \frac{400}{300} \times 172.5 = 230\ (Kg)$$