Calculation example

Obtain maximum allowable load to the ball groove section under conditions in Fig. Ⅱ-2•2

* Use conditions

Nut model: DFT4010-5

From the dimension table C_{0a} = 137000 (N)

f_s=2 (normal operation, no vibration impact)

* Calculation

By Formula Ⅱ-6:

$P_0 = C_{0a}/f_s$ = 137000/2 = 68500 (N)

* Result

Maximum allowable load of the ball groove section

P_0 = 68500 N

B-Ⅱ-3 Permissible Rotational Speed

Permissible rotational speed is determined by the following two factors:

- Critical speed which is the resonance vibration of the shaft.
- d・n value which is involved in damaging the ball recirculation components.

B-Ⅱ-3.1 Critical Speed of the Screw Shaft

Calculate the critical speed which is the matching value of the ball screw rotational speed and the natural frequency of the screw shaft. The permissible rotational speed is up to the 80% range of the critical speed. Refer to Page B459 "Supporting conditions of screw shaft and ball nut" and use the formula below to calculate critical speed. Fig. Ⅱ-3•1 shows permissible rotational speeds to critical speed for each screw shaft diameter.

(Use the formula below if screw shaft nominal diameter exceeds 125 mm.)

Formula to calculate permissible rotational speed to the critical speed

$$n_c = \alpha \times \frac{60\lambda^2}{2\pi L^2}\sqrt{\frac{E \cdot I \cdot g}{\gamma \cdot A}} = f\frac{d_r}{L^2} \times 10^7 \ (\text{min}^{-1}) \cdots\cdots (\text{Ⅱ-7})$$

In this formula:

α: Safely factor (α = 0.8)

E: Elastic modulus (E = 2.06 x 10^5 MPa)

I: Moment of inertia of area of screw shaft

$$I = \frac{\pi}{64} d_r^4 \quad (\text{mm}^4) \cdots\cdots (\text{Ⅱ-3})$$

d_r: Screw shaft root diameter (mm) [See the dimension table.]

g: Acceleration of gravity (= 9.8 × 10^3mm/s^2)

γ: Specific weight (γ = 7.65 x 10^{-5}N/mm^3)

A: Cross section area of the screw shaft root diameter (mm^2)

$$A = \frac{\pi}{4} d_r^2 \quad (\text{mm}^2) \cdots\cdots (\text{Ⅱ-5})$$

L: Unsupported length (mm) [See Fig. Ⅱ-4•1, 2 'Supporting conditions of screw shaft and ball nut' on Page B513]

f、λ: Factors determined by the supporting condition

Supporting condition	f	λ
Fixed - Simple support	15.1	3.927
Fixed - Fixed support	21.9	4.730
Fixed support - Free	3.4	1.875
Simple - Simple support	9.7	π

Calculate the resonance of the screw shaft whether you use shaft rotation or nut rotation. Critical speed varies by the nut traveling position. Please consult NSK for detailed calculation.

If using a ball acrew exceeding the critical speed, it is necessary to increase the natural frequency by using an intermediate support, etc. If using with nut rotation, it is possible to operate exceeding critical speed by installing a vibration energy absorbing system (optional, vibration control damper: patented by NSK) to the screw shaft. (Refer to "Nut rotatable ball screws" in Page B469.)

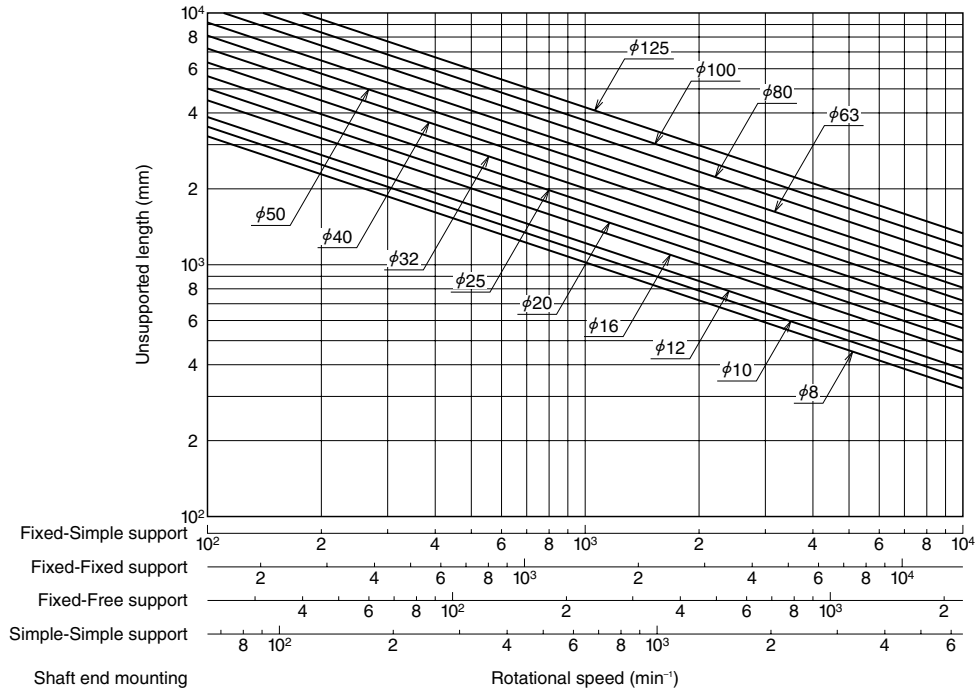

Fig. Ⅱ-3•1 Permissible rotational speeds vs. critical speeds

Calculation example

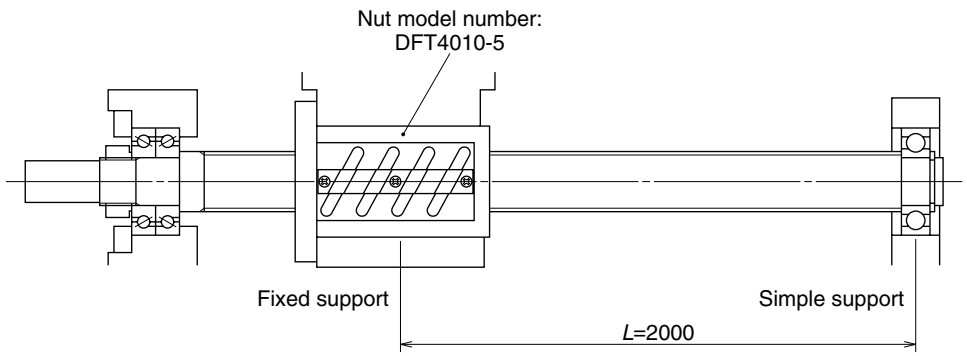

Fig. Ⅱ-3•2 Calculation example of ball screw permissible rotational speed

Calculate the permissible rotational speed to the critical speed under conditions in Fig. Ⅱ-3•2.

* Use conditions

Nut model: DFT4010-5

From Fig. Ⅱ-3•2 - Supporting condition is Fixed - Simple support $\rightarrow \lambda = 3.927$、$f = 15.1$

(Same as the supporting condition (ii) in Fig. Ⅱ-4•1 'Supporting conditions of screw shaft and ball nut.')

Unsupported length L = 2000 mm

From the dimension table: Screw shaft root diameter

d_r = 34.4 mm

* Calculation

By Formula Ⅱ-7

$$n_c = f\frac{d_r}{L^2} \times 10^7 = 15.1 \times \frac{34.4}{2000^2} \times 10^7 = 1298.6(\text{min}^{-1})$$

* Result

Permissible rotational speed to critical speed

n_c = 1290 min^{-1} or under

B-Ⅱ-3.2 d • n Value

Permissible rotational speed is also limited by d・n value (d : shaft dia mm; n: rotational speed per minute min^{-1}). d・n value indicates peripheral speed (revolution speed of balls).

Table Ⅱ-3•1

For positioning type (C5 grade or higher),	Standard specification	d・n ≦ 70000	
For transporting type (Ct7 grade)	High-speed specification	d・n ≦ 100000	※1
For transportation type (Ct10 Grade)		d・n ≦ 50000	

Special measure is taken for high-speed specification products. Operating exceeding the limitation is possible under certain conditions. Please consult NSK.

* Please consult NSK if the maximum rotational speed exceeds 3000 min^{-1}, even both the critical speed of the screw shaft rotation and the d・n value are in ranges of the allowable limit.

※1

- Refer to HMC Series for the ball screw for high speed machine tools.
- Refer to BSS Series for the high speed and low noise ball screws.