4.6. Critical Speed of the Spline Shaft

When a Ball Spline shaft is used to transmit power while rotating, as the rotation speed of the shaft increases, the rotation cycle nears the natural frequency of the spline shaft. It may cause resonance and eventually result in inability to move. Therefore, the maximum shaft speed must be limited to a level that does not cause resonance. If the shaft's rotation cycle exceeds or nears the resonance point during operation, it is necessary to reconsider the spline shaft diameter. The critical roration speed of the spline shaft is obtained using the equation (6) below, in which the value is multiplied by a safety factor of 0.8.

●Critical Rotation Speed

$$N_c = \frac{60\lambda^2}{2\pi \cdot \ell_b^{\,2}} \cdot \sqrt{\frac{E \times 10^3 \cdot I}{\gamma \cdot A}} \times 0.8 \quad \cdots(6)$$

N_c : Critical speed (min^{-1})

ℓ_b : Center distance (mm)

E : Young's modulus ($2.06 \times 10^5 N/mm^2$)

I : Minimum geometrical moment of inertia of the shaft (mm^4)

$$I = \frac{\pi}{64} d^4 \quad d : \text{Minor diameter (mm)}$$

(See tables 3 and 4 on page B-18)

γ : Density(specific gravity) ($7.85 \times 10^{-6} kg/mm^3$)

$$A = \frac{\pi}{4} d^2 \quad d : \text{Minor diameter (mm)}$$

(See tables 3 and 4 on page B-18)

A : Spline shaft sectional area (mm^2)

λ : Factor according to the mounting method

① Fastened—free λ=1.875

② Supported—supported λ=3.142

③ Fastened—supported λ=3.927

④ Fastened—fastened λ=4.73