Selection of Ball Screws 2

Under No load

$$T_P = K\frac{P_L L}{2\pi}\ (N\cdot cm) \quad \cdots (5)$$

$$K = 0.05(\tan\beta)^{-\frac{1}{2}}$$

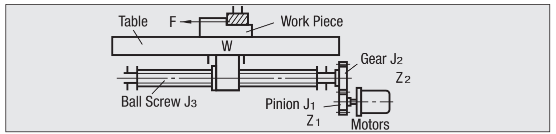
Where:

- P_L : Preload (N)
- L : :Ball Screw Lead(cm)
- K : Coefficient of Internal Friction
- ß : Lead Angle $\beta \approx \tan^{-1}\left(\frac{L}{\pi D}\right)$
- D : Thread Outer Diameter

Selecting the Driving Motors

When selecting a driving motor, it is necessary to satisfy the following conditions:

1.Ensure a marginal force sufficient to counter the load torque exerted on the motor's output thread.
2.Enable starting, stopping at prescribed pulse speeds, sufficiently powered to counter the moment of inertia exerted on the motor's output thread.
3.Obtain the prescribed acceleration and deceleration constants, sufficient to counter the moment of inertia exerted on the motor's output thread.



•Constant Speed Torque Exerted on the Motor Output Thread

This is the amount of torque required to drive the output thread against the applied external load, at a constant speed.

$$T_1 = \left(\frac{PL}{2\pi\eta} + T_P\frac{(3P_L - P)}{3P_L}\right)\frac{Z_1}{Z_2}\ (N\cdot cm) \quad \cdots (6)$$

Where: $P \leq 3P_L$

- T_1: Driving Torque at Constant Speed(N·cm)
- P : External Axial Load(N)
  $P = F + \mu Mg$
- F : Thrust Reaction Produced in Cutting Force(N)
- M : Masses of Table and Work Piece(Kg)
- μ : Coefficient of Friction on Sliding Surfaces
- g : Gravitational Acceleration(9.8m/s²)
- L : Ball Screw Lead(cm)
- η : Mechanical Efficiency of Ball Screw or Gear
- T_P: Friction Torque Caused by Preloading(N·cm)Referto Formula (5)
- P_L: Preload(N)
- Z_1: Number of Pinion's Teeth
- Z_2: No. of Gear's Teeth

•Acceleration Torque Exerted on the Motor Output Thread

This is the amount of torque required to drive the output shaft against the external load during acceleration.

$$T_2 = J_M\omega = J_M\frac{2\pi N}{60t}\times 10^{-3}(N\cdot cm) \quad \cdots (7)$$

$$J_M = J_1 + J_4 + \left(\frac{Z_1}{Z_2}\right)^2\left\{(J_2+J_3)+(J_5+J_6)\right\}(kg\cdot cm^2) \quad \cdots (8)$$

Where:

- T_2 : Driving Torque in Acceleration(N·cm)
- ω : Motor Thread Angular Acceleration(rad/s²)
- N : Motor Thread Revolutions(min⁻¹)
- t : Acceleration(s)
- J_M : Moment of Inertia Exerted on the Motor(kg·cm²)
- J_1 : :Moment of Inertia Exerted on Pinion(kg·cm²)
- J_2 : Moment of Inertia Exerted on Gear(kg·cm²)
- J_3 : Moment of Inertia Exerted on Ball Screw(kg·cm²)
- J_4 : Moment of Inertia Exerted on Motor's Rotor(kg·cm²)
- J_5 : Moment of inertia of moving body
- J_6 : Moment of inertia of coupling
- M : Masses of Table and Work Piece(kg)
- L : Ball Screw Lead(cm)

Moment of inertia exerted on cylinders as screws and cylinders such as Gears (Calculation of $J_1 \sim J_4, J_6$)

$$J = \frac{\pi\gamma}{32}D^4\ell(kg\cdot cm^2) \quad \cdots (9)$$

Where:

- D : Cylinder Outer Diameter(cm)
- ℓ : Cylinder Length(cm)
- γ : Material Specific Gravity
  $\gamma = 7.8\times 10^{-3}(kg/cm^3)$
  $J_5 = M\left(\frac{L}{2\pi}\right)^2(kg\cdot cm^2)$

•Total Torque Exerted on the Motor Output Thread

Overall torque can be obtained by adding results from formulas (6) and (7).

$$T_M = T_1 + T_2 = \left(\frac{PL}{2\pi\eta} + T_P\frac{(3P_L - P)}{3P_L}\right)\frac{Z_1}{Z_2} + J_M\frac{2\pi N}{60t}\times 10^{-3}\ (N\cdot cm) \quad \cdots (10)$$

Where:

- T_M : Total Torque Exerted on the Motor Output Thread(N·cm)
- T_1 : Driving Torque at Constant Speed(N·cm)
- T_2 : Driving Torque at In Acceleration(N·cm)

Once you have temporarily found the type of motor you need, check

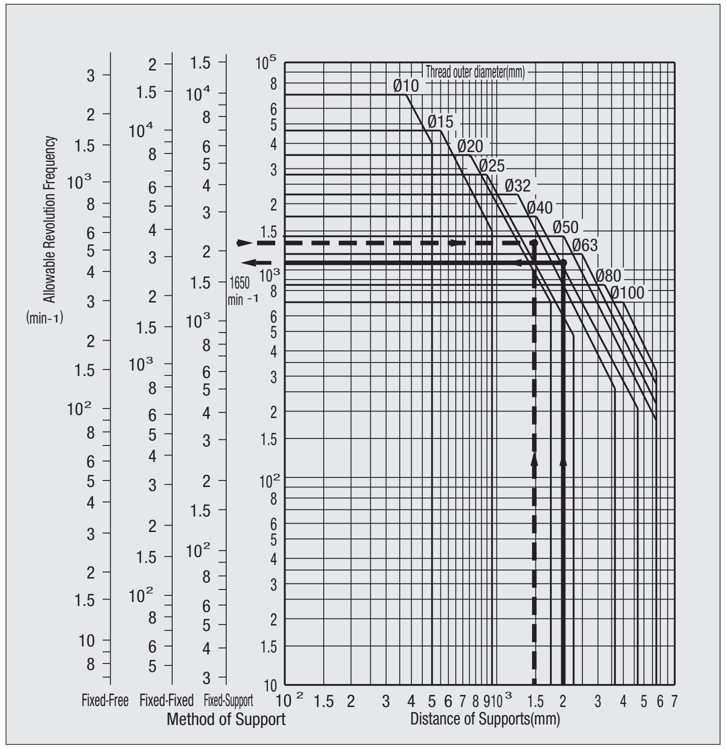
1. effective torque,
2. acceleration constant and
3. motor overload properties and heat tolerance during repeated starting, stopping.

It is necessary to ensure a sufficient margin for these parameters.

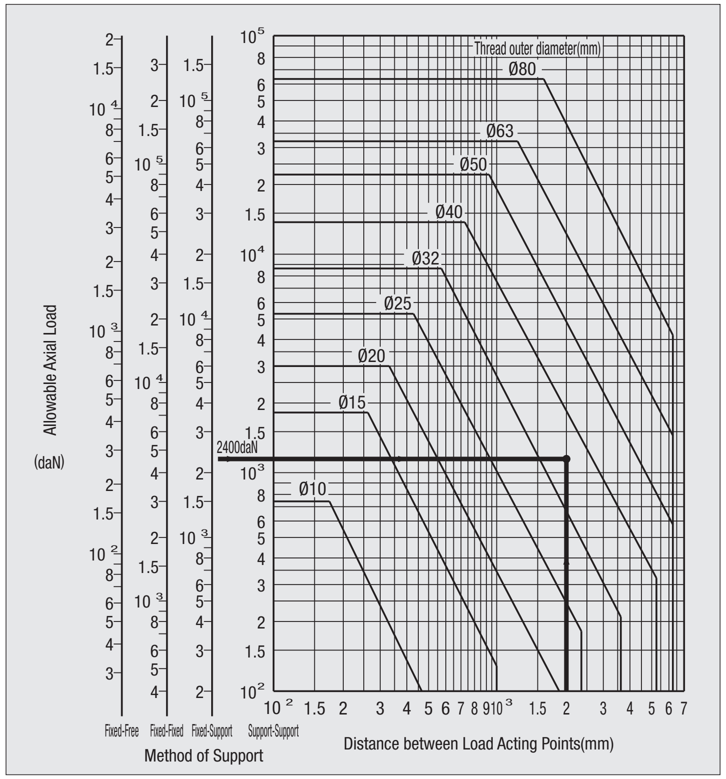
(Reference)

1daN=10N≈1.02kgf

Allowable Revolutions Curve



Allowable Axial Load Curve



Ex.1. How to Obtain the Allowable Revolution Frequency

Calculation of allowable revolution frequency when ball screws with a thread outer diameter of 40mm are fixed and supported with a distance of 2000mm.

1. Find the intersection between a distance of 2,000mm between supports and a thread outer diameter of 40mm.
2. Read the allowable revolution frequency for the intersection on the fixed-support graduation.
   The maximum allowable revolution frequency is 1650 min⁻¹.

Ex.2. How to Obtain the Thread Diameter

Calculation of shaft diameter when maximum revolution of 2000min⁻¹ is fixed and supported with a distance of 1500mm.

1. Find the intersection between a distance of 1500mm of supports and the allowable revolution frequency of 2000 min⁻¹(from the fixed-support scale).
2. Read the thread diameter as 32mm of the diagonal line to the intersection on the outside. The Maximum Revolutions is 2000 min⁻¹. is satisfied thread diameter.

Ex.3. How to Obtain the Thread Diameter

This example assumes a distance of 2000mm between load acting points, the fixed-support method of support and the max. axial load of 2400daN.

1. Find the intersection between a distance of 2000mm between load acting points and the axial load of 2400daN(from the fixed-support graduation).
2. Read the shaft diameter of the diagonal line nearest to the intersection on the outside. The shaft diameter can be a min. 40mm.

min⁻¹=r/min=rpm
1daN=10N≈1.02kgf