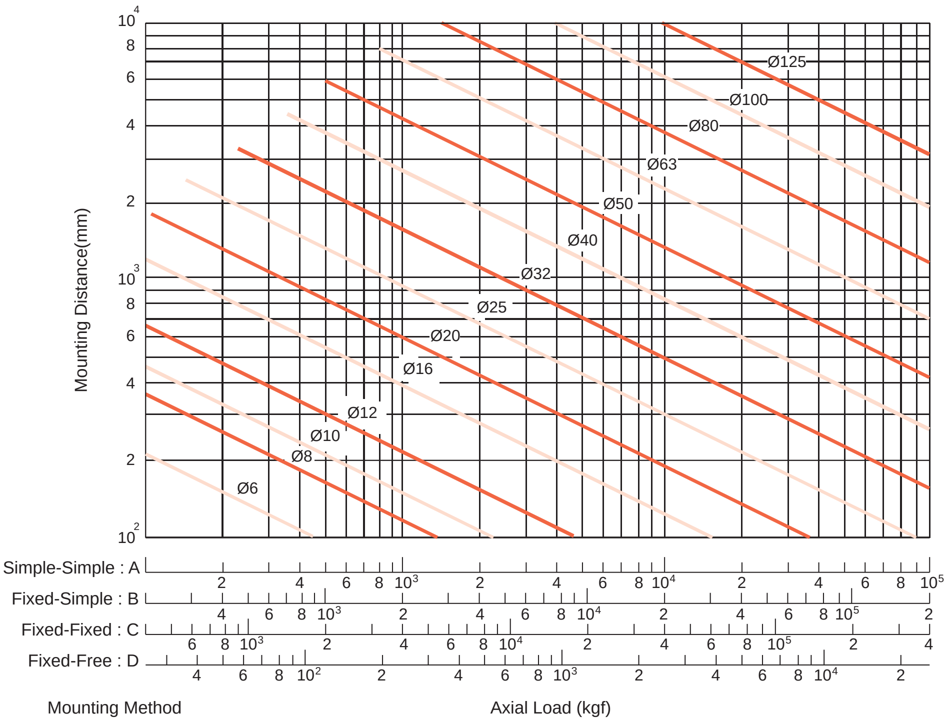

Fig 1.4.16 Buckling Load vs. Nominal Diameter and Length

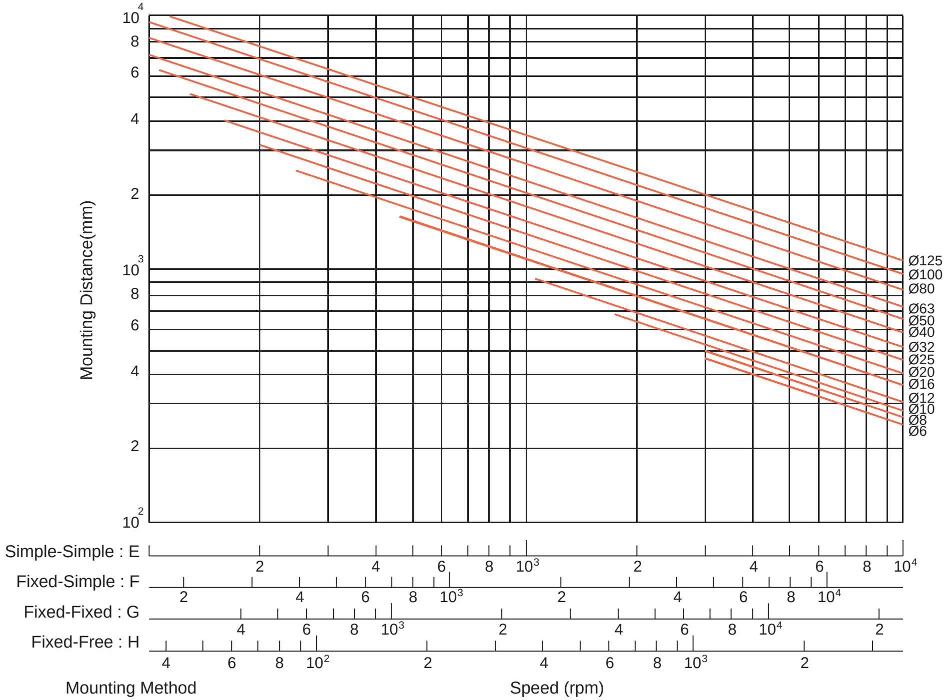

Fig 1.4.17 Buckling Load vs. Nominal Diameter and Length

■ 1-4-3 Critical Speed

(1) Dangerous speed

To prevent the screw's natural frequency attain resonance which will occur critical speed, it's necessary to look into the ball screw allowable rotation speed (Below 80% of the Critical Speed). More detail of allowable rotation speed classified though screw diameter please refer to Fig 1.4.17.

(2) dm•n value

The allowable rotation speed is regulated also by the Dm x N value (Dm : diameter of central circle of steel ball, N : Revolution speed, rpm) which expresses the peripheral speed.

Generally,

For precision

(accuracy grade C7 to C0)
Dm x N ≤ 70,000

For general industry (C10)
Dm x N ≤ 50,000

If your requirement about the product will exceed the limitation, please contact with TBIMOTION to discuss the detailed solution for the ideal product.

※When ε, the ratio of screw length and shaft diameter has exceeded 70, please contact with TBIMOTION to arrange the special arrangement for production.

$$n = \alpha \cdot \frac{60\lambda^2}{2\pi L^2}\sqrt{\frac{EIg}{\gamma A}} = f\frac{dr}{L^2} \cdot 10^7 (rpm)$$

Where

α : Safty factor (α = 0.8)

E : Verticle elastic modules ($E = 2.1 \cdot 10^4 kgf/mm^2$)

I : Minimum secondary torque of axial section plane

$I = \frac{\pi}{64} dr^4 (mm^4)$

dr : Screw shaft root diameter (mm)

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

γ : Density ($\gamma = 7.8 \cdot 10^{-6} kgf/mm^3$)

A : Screw shaft sectional area ($A = \pi dr^2/4\ mm^2$)

L : Mounting distance (mm)

f, λ : Coefficient determined from the ball screw mounting method

Floated-Floated f = 9.7 (λ =π)

Fixed-Floated f = 15.1 (λ = 3.927)

Fixed-Fixed f = 21.9 (λ = 4.730)

Fixed-Free f = 3.4 (λ = 1.875)

1-5 Driving Torque

■ 1-5-1 Driving torque Ts of the transmission shaft

$T_S = T_P + T_D + T_F$ (in fixed speed)
$T_S = T_G + T_P + T_D + T_F$ (when accelerating)
T_G : Acceleration torque (1)　T_P : Load torque (2)
T_D : Preload torque (3)　T_F : Friction torque (4)

(1) Acceleration T_G

$T_G = J\alpha$ (kgf・cm)

$\alpha = \frac{2\pi n}{60\Delta t}$ (rad/s^2)

J : Moment of inertia (kgf・cm・s^2)
α : Angular acceleration (rad/s^2)
n : Revolutions (min^{-1})
△t : Starting time (sec)

(3) Preload torque T_D

$T_D = \frac{K \cdot P_{PL} \cdot \ell}{\sqrt{\tan\alpha} \cdot 2\pi}$ (kgf・cm)

K : Internal coefficient
(0.05 is usually adopted)
P_{PL} : Preload (kgf)
ℓ : Lead (cm)
α : Lead angle

(4) Fricition torque T_F

$T_F = T_B + T_O + T_J$ (kgf・cm)

T_B : Friction torque of bracing shaft
T_O : Friction torque of free shaft
T_J : Friction torque motor shaft

(2) Lead torque T_P

$T_P = \frac{P \cdot \ell}{2\pi\eta_1}$ (kgf・cm)

$P = F + \mu Mg$

P : Axial load (kgf)
ℓ : Load (cm)
η_1 : Positive efficiency
The efficiency when rotating motion is altered to linear motion
F : Cutting force (kgf)
μ : Friction
M : Mass of moving object (kg)
g : Acceleration of gravity (9.8 m/s^2)

$T_P = \frac{P \cdot \ell \cdot \eta_2}{2\pi}$ (kgf・cm)

η_2 : Reverse efficiency
The efficiency when linear motion returns to rotating motion

The friction torque of the bracing shaft would be affected by the volume of lubrication oil. Besides, be careful with the excessive tight end seal may lead to unexpected over friction torque or temperature rise.

【For reference】Moment of inertia of load (refer to Table 1.5.1)

$J = J_{BS} + J_{CU} + J_W + J_M$

J_{BS} : Moment of inertia Ball screws shaft
J_{CU} : Moment of inertia Coupler
J_W : Moment of inertia Linear motion part
J_M : Moment of inertia Roller shaft part of motor shaft

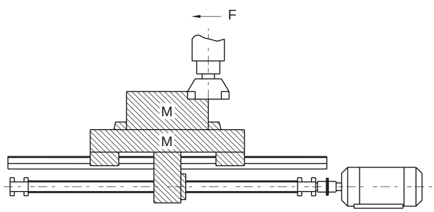

Fig 1.5.1 Moment of inertia of load

1-5 Driving Torque

Table1.5.1 Conversion formula for moment of inertia of load

Moment of inertia converted from motor shaft \ Formula	J
Cylinder load	$\frac{\pi \rho L D^4}{32}$
Linearly moving object	$\frac{M}{4}\left(\frac{V\ell}{\pi \cdot N_M}\right)^2 = \frac{M}{4}\left(\frac{P}{\pi}\right)^2$
Unit	kg . m^2
Moment of inertia during deceleration	$JM=\left(\frac{N\ell}{N_M}\right)^2 J\ell$

ρ : Density (kg/m^3)　$\rho = 7.8 \cdot 10^3$
L : Cylinder length (m)
D : Cylinder diameter(m)
M : Mass of the linear motion part (kg)
V : Velocity of the linear moving object (m/min)
N_M : Motor shaft revolutions (min^{-1})

P : The moving magnitude of the linearly moving object per rotation of the motor (m)
$N\ell$: Rotations in longitudinal moving direction (min^{-1})
$J\ell$: Moment of inertia in load direction
J_M : Moment of inertia in motor direction

■ 1-6-1 Selection of Nut

(1) Series

When making selection of series, please take demanded accuracy, intended delivery time, dimensions(the outside diameter of screw, ratio of lead/ the outside diameter of screw) preload and etc into consideration.

(2) Circulation type

Selection of circulation type : Please consider the efficiency of screw nut's mounting space. The advantage of each circulation type will be specified in figure 1.6.1.

(3) Number of loop circuits

Performance and service life should be considered when selecting number of loop circuits.

(4) Shape of flanges (FLANGE)

Please make selection based on the available space for the installation of nuts.

(5) Oil hole

Oil hoIes are provided for the precision ball screws, please use them during machine assembling and regular furnishing.