Features of the Ball Screw

Driving Torque One Third that of a Sliding Screw

In a ball screw, balls roll between the screw shaft and the nut to achieve high efficiency. The required driving torque is only one third of the conventional sliding screw. (See Fig. 1 and Fig. 2.) As a result, it is capable of not only converting rotational motion to straight motion, but also converting straight motion to rotational motion.

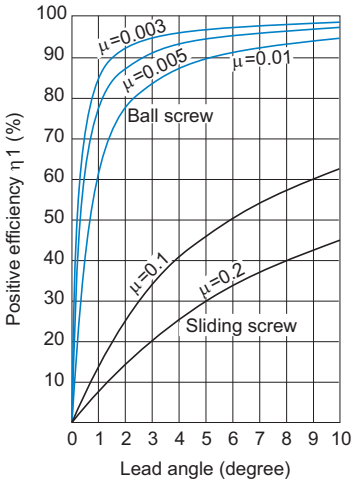


Fig. 1: Positive Efficiency (Rotational to Linear)

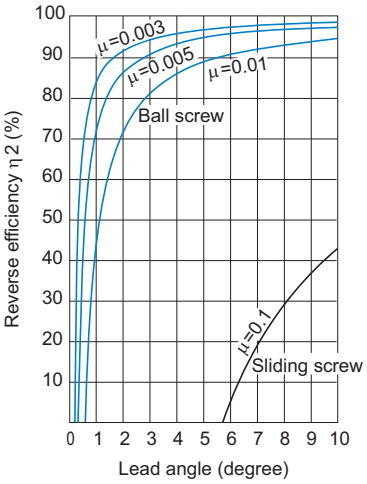


Fig. 2: Reverse Efficiency (Linear to Rotational)

Calculating the Lead Angle

$$\tan\beta = \frac{Ph}{\pi \cdot d_P}$$

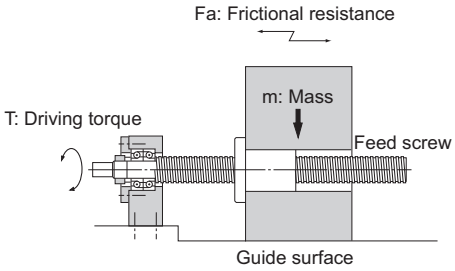
β	: Lead angle	(°)
d_P	: Ball center-to-center diameter	(mm)
Ph	: Feed screw lead	(mm)

Relationship between Thrust and Torque

The torque or thrust generated when thrust or torque is applied is obtained from equations (1) to (3).

● Driving Torque Required to Gain Thrust

$$T = \frac{Fa \cdot Ph}{2\pi \cdot \eta 1} \quad \cdots\cdots\cdots(1)$$



T : Driving torque (N·mm)
Fa : Frictional resistance on the guide surface (N)
Fa = μ×mg
μ : Frictional coefficient of the guide surface
g : Gravitational acceleration (9.8 m/s²)
m: Mass of the transferred object (kg)
Ph : Feed screw lead (mm)
η1 : Positive efficiency of feed screw
(see Fig. 1 on B15-6)

● Thrust Generated When Torque is Applied

$$Fa = \frac{2\pi \cdot \eta 1 \cdot T}{Ph} \quad \cdots\cdots\cdots(2)$$

Fa : Thrust generated (N)
T : Driving torque (N·mm)
Ph : Feed screw lead (mm)
η1 : Positive efficiency of feed screw
(see Fig. 1 on B15-6)

● Torque Generated When Thrust is Applied

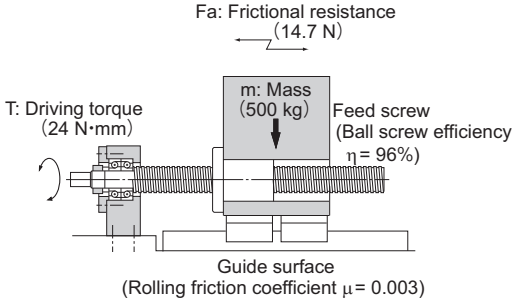
$$T = \frac{Ph \cdot \eta 2 \cdot Fa}{2\pi} \quad \cdots\cdots\cdots(3)$$

T : Torque generated (N·m)
Fa : Thrust generated (N)
Ph : Feed screw lead (mm)
η2 : Reverse efficiency of feed screw
(see Fig. 2 on B15-6)

Examples of Calculating Driving Torque

When moving an object with a mass of 500 kg using a screw with an effective diameter of 33 mm and a lead length of 10 mm (lead angle: 5°30'), the required torque is obtained as follows.

Rolling guide (μ = 0.003)
Ball screw (from μ = 0.003, η = 0.96)



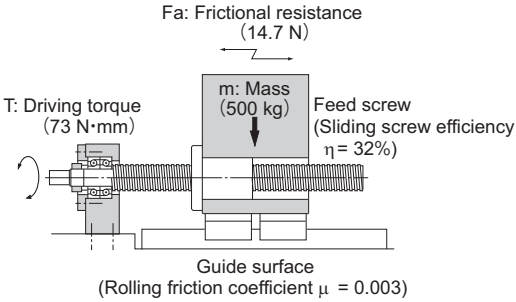
Frictional resistance on the guide surface

$Fa = 0.003 \times 500 \times 9.8 = 14.7\ N$

Driving torque

$$T = \frac{14.7 \times 10}{2\pi \times 0.96} = 24\ N \cdot mm$$

Rolling guide (μ = 0.003)
Sliding screw (from μ = 0.2, η = 0.32)



Frictional resistance on the guide surface

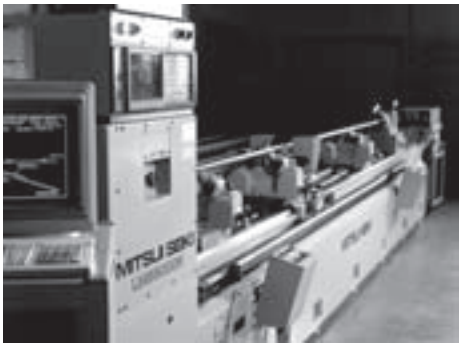
$Fa = 0.003 \times 500 \times 9.8 = 14.7\ N$

Driving torque

$$T = \frac{14.7 \times 10}{2\pi \times 0.32} = 73\ N \cdot mm$$

Ensuring High Accuracy

Ball screws are ground with the highest level of equipment at a factory with strict temperature controls. Their accuracy is assured under a thorough quality control system that covers assembly to inspection.



Automatic lead-measuring machine using a laser

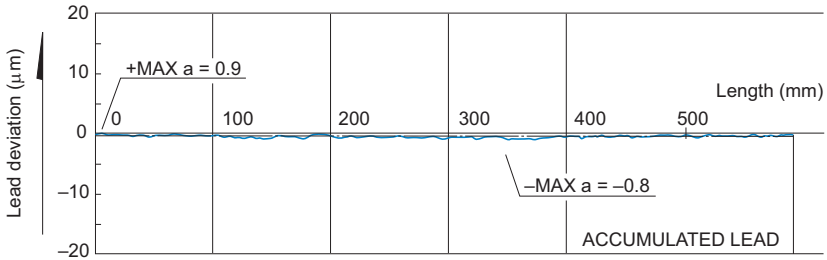


Fig. 3: Lead Accuracy Measurement

Conditions
Model No.: BIF3205-10RRG0+903LC2

Table 1: Lead Accuracy Measurement Unit: mm

Item	Standard value	Actual measurement
Directional target point	0	—
Representative travel distance error	±0.011	–0.0012
Fluctuation	0.008	0.0017

Capable of Micro Feeding

A ball screw requires a minimal starting torque due to its rolling motion, and does not cause a slip, which is inevitable with a sliding motion. Therefore, it is capable of accurate micro feeding.
Fig. 4 shows the travel distance of the ball screw in one-pulse, 0.1-μm feeding. (An LM Guide is used for the guide surface.)

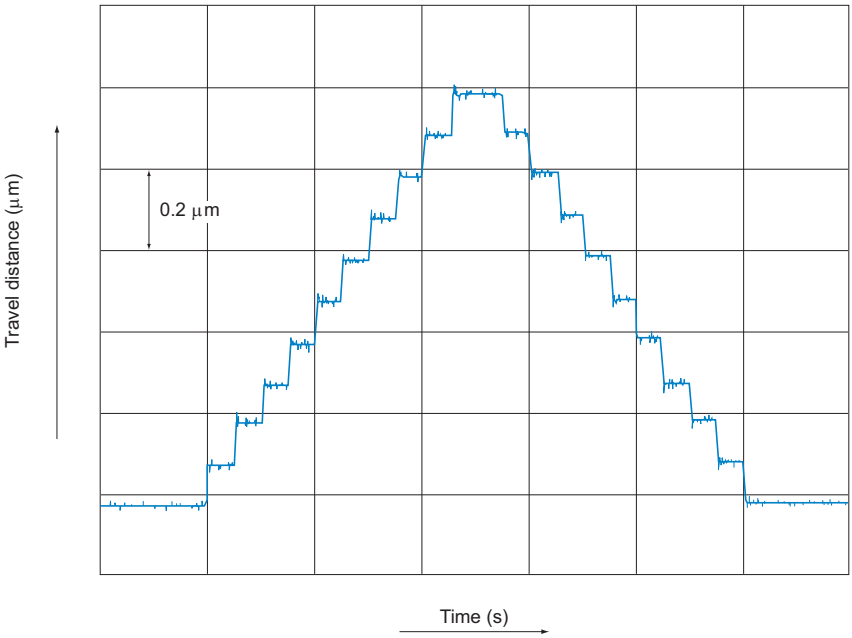


Fig. 4: Data on Travel in 0.1 μm Feeding

High Rigidity without Backlash

Since a ball screw is capable of receiving a preload, it can be preloaded with an axial clearance below zero, allowing it to achieve high rigidity. In Fig. 5, when an axial load is applied in the positive (+) direction, the table is displaced in the same (+) direction. When an axial load is provided in the reverse (-) direction, the table is displaced in the same (-) direction. Fig. 6 shows the relationship between the axial load and the axial displacement. As indicated in Fig. 6, as the direction of the axial load changes, the axial clearance occurs as a displacement. Additionally, when the ball screw has a preload applied, it gains a higher rigidity and a smaller axial displacement than a zero clearance in the axial direction.

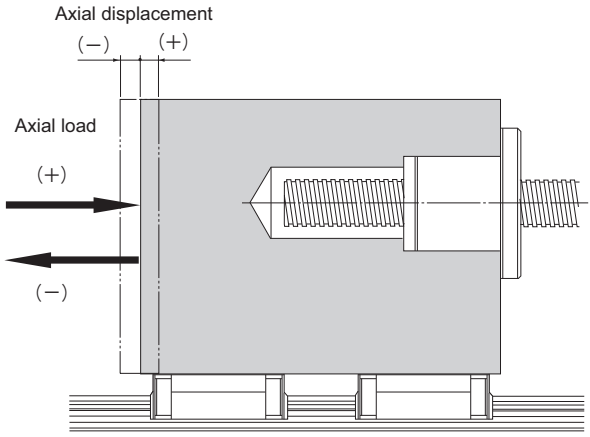


Fig. 5

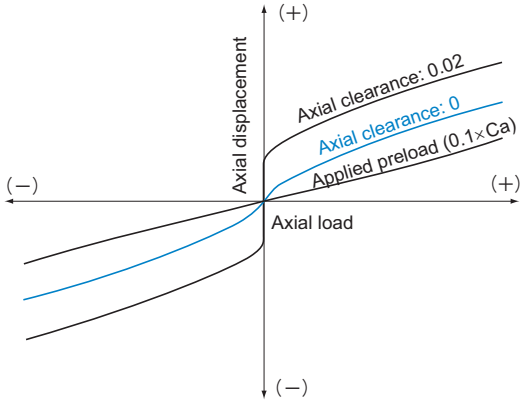


Fig. 6: Axial Displacement in Relation to Axial Load

Capable of Fast Feed

Since the ball screw is highly efficient and generates little heat, it is capable of a fast feed.

High Speed Example

Fig. 7 shows a speed diagram for a large lead rolled ball screw operating at 2 m/s.

Conditions

Item	Description
Sample	Large Lead Rolled Ball Screw WTF3060 (Shaft diameter: 30 mm; lead: 60 mm)
Maximum speed	2 m/s (Ball screw rotational speed: 2,000 min^{-1})
Guide surface	LM Guide Model SR25W

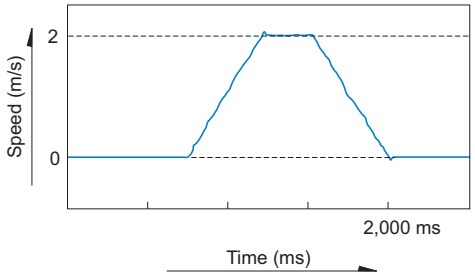


Fig. 7: Velocity Diagram