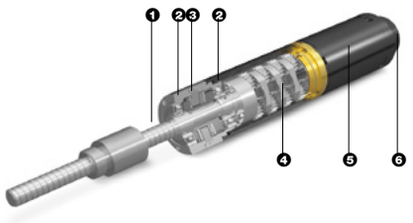
Spindle Drive Basics

Design

❶ Spindle, directly implemented in the gearhead
❷ Radial bearing
❸ Axial bearing
❹ Planetary gearhead 0–4 stages
❺ Motor
❻ Encoder



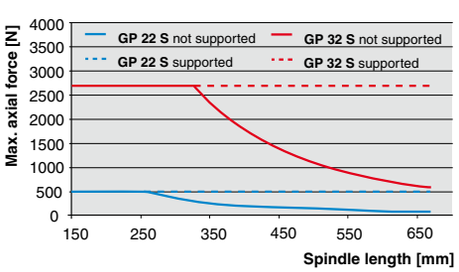
The particular type of spindle required must first be established before a spindle drive can be designed. Every type of spindle has different characteristics and a number of specific limits. These limits are taken into account in the technical data.

Ball screw:
– highly efficient
– not self-locking
– high load capacity
Metric spindle:
– self-locking
– low costs
Trapezoidal spindle:
– same as metric spindle
– higher load capacity than metric spindle

Feed force

For the calculation of the feed force acceleration and friction forces as well as gravity have to be taken into consideration. Exceeding the maximum permissible load must be avoided, as this damages the spindle. The maximum permissible feed force is displayed for standard spindles. For longer spindles, the permissible feed force can be limited by the critical compressive force of the spindle. In this case, supporting the end of the spindle may be necessary.

Limitation for ball screws



Torque

The required torque of the spindle M_a [mNm] is calculated with the feed force F_a [N] (load), the thread lead p [mm] and the efficiency of the spindle η_1.

$$M_a = \frac{F_a \cdot p}{2 \cdot \pi \cdot \eta_1}$$

In combination with the gearhead, the required motor torque M_{mot} [mNm] is:

$$M_{mot} = \frac{F_a \cdot p}{2 \cdot \pi \cdot i \cdot \eta}$$

Where i is the gearhead reduction ratio and η the efficiency of the complete spindle drive.

Technical Data

The "Technical Data" block contains generally applicable data on spindle, nut and gearhead. These are independent of the gearhead reduction ratio.

Length

The data sheets show the spindle drives with the standard lengths. Other lengths are available as an option in 5 mm steps up to a given maximum length. Please give detailed requirements for special lengths.

Max. efficiency/mass inertia

The values stated refer to the spindle alone (without gearhead). The values with gearhead are given in the "Gearhead data" main data field.

Nut

Standard spindle drives are supplied with a thread nut. Flange or cylinder nuts are also available as an option. See details with corresponding reference number on page 304.

Bearing

The output stage and the spindle are supported by preloaded axial bearings. This means that the high axial forces can be absorbed directly by the gearhead without additional support.

Speed and feed velocity

Feed velocity v [mm/s] is linked to output speed n [rpm] by the lead p [mm].

$$v = \frac{p \cdot n}{60}$$

In combination with the gearhead, the motor speed n_{mot} [rpm] is:

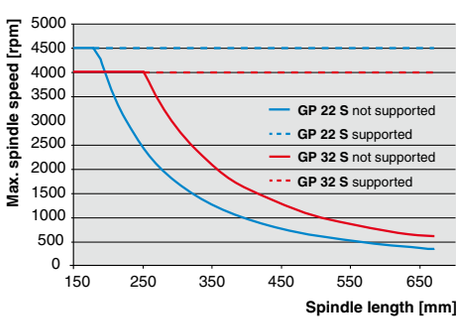
$$n_{mot} = \frac{v \cdot 60 \cdot i}{p}$$

Where i is the gearhead reduction ratio and p the spindle lead.

The spindle speed is limited by the resonance frequency of the spindle and for ball screws additionally by the ball return system.

In addition, the maximum permissible speed of the gearhead has to be considered.

Max. spindle speed at ball screws



Spindle Drive Data

Line 7 Max. efficiency
The given efficiency is a maximum value that applies when loaded with maximum feed force. Efficiency falls sharply with very small loads. The stated value refers to the complete spindle drive (gearhead and spindle).

Line 20 Max. feed velocity
Specifies the maximum permissible feed velocity.

Line 21 Max. feed force (continuous)
Is the maximum permissible feed force which may be continuously applied. Exceeding this value results in a reduced service life.

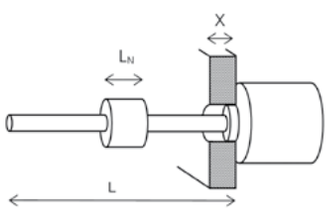
Line 22 Max. feed force (intermittent)
Is the maximum permissible feed force which may be intermittently applied. "Intermittently" is defined as follows:
– during max. 1 second
– during max. 10% of operation
Exceeding these values results in a reduced service life.

Line 23 Mechanical positioning accuracy
In this value, following factors are taken into consideration:
– backlash of the gearhead
– accuracy of the spindle
– axial play of the nut

Maximum stroke

The maximum possible stroke depends on the length of the spindle L [mm]. The length of the nut L_N [mm] and the thickness of its mounting plate X [mm] must be taken into consideration.

Stroke = L – (L_N + X + stroke reserve + opt. SPIN02)



Mounting and safety instructions

Using a ball screw with a flange nut, the mounting through a hole is only possible with the optional rectangular mounting flange.
The ball screw nut may never be removed. As the balls are preloaded remounting would be impossible.
The spindle may never block during operation, as this could damage the spindle nut or gearhead.
Service life crucially depends on the precision with which the gear is fixed to the spindle nut. Eccentricities and angle errors sometimes result in massive radial loading which must never exceed the given maximum value.
Additional information can be found in the maxon online shop at the item under downloads.