SELECTION OF A SCREW DRIVE

The selection of a ballscrew drive or leadscrew drive is governed by the following:

AXIAL FORCE: The actual force acting on the spindle, generally comprising components which are constant with respect to time (eg. an applied load) and components which vary with respect to time (impact loads, acceleration forces etc).

The axial force is limited by the following:

- The permissible axial force for the spindle bearings.
- The required service life.
- The critical buckling force of the spindle, which is subject to compressive loads.
- The permissible axial force for the nut, in the case of leadscrew drives.

General principle: Motion drives, particularly those operating at high speed, usually require ballscrews, while leadscrews are advantageous for low speeds and for clamping motions; Used with axial sliding bearings they are suited to systems with extremely high static load capacities where there is limited impact (e.g. presses, locking devices, vices etc.).

FEED SPEED: The product of spindle speed and pitch.

The spindle speed is limited by the following:

- The critical speed of the screw drive.
- The load dependent maximum speed in the case of leadscrew drives.
- The efficiency and the facilities for heat dissipation, in the case of high duty cycles.

General principle: Medium feed speeds with a low duty cycle can be handled with multi-start leadscrew drives. Higher speeds and duty cycles require single start or multi-start ballscrew drives.

ACCELERATION: Dependent not only on the spindle pitch but also on the mass moments of inertia and external forces of the overall system and the characteristic data of the motor and control card.

ACCURACY: The accuracy which a screw drive can achieve (positioning spread) is dependent on the spindle pitch deviation *and also on:*
The backlash between nuts and spindle. This can be eliminated with a ballscrew drive by means of preloading, possible, only to a limited degree, with leadscrew drives.
Frictional conditions with leadscrew drives, *the high coefficient of static friction*, leads to the “stick slip” effect. With ballscrew drives the coefficient of friction is virtually constant in the relevant speed range.

General principle: High accuracy positioning usually requires ballscrew drives.

SELF LOCKING: Leadscrew drives with a Helix angle of <2.5° can be considered self locking. Other screw drives may over-haul depending on operating conditions, and may require suitable design measures incorporating (brake motors with 3-phase drives and suitable control cards with DC drives).

DUTY CYCLE: Limited by the temperature rise and the provisions for the dissipation of heat. Large leadscrew drives in particular convert approx. 65% of the power applied into heat, due to their poor efficiency.

General principle: Medium duty cycles can be handled with multi-start leadscrew drives. Above this, ballscrew drives are required.

GENERAL OPERATING CONDITIONS: Ballscrew drives are sensitive to dirt, impact loads and rough handling. Leadscrew drives are more robust, particularly when used with metal nuts.

SERVICE LIFE: The service life of ballscrew drives can be calculated in the same way as with a roller bearing.
With leadscrew drives the service life is dependent mainly on the lubrication between nut and spindle and thus cannot be calculated in general terms.

General principle: Ballscrew drives will generally be selected when high load capacity and service life are required; it is, however, possible to achieve comparable service life with carefully dimensioned leadscrew drives.

PRICE: Ballscrew drives are more expensive than leadscrew drives and require more elaborate measures for protection against dirt. However, due to their greater efficiency, ballscrew drives can be operated with smaller, more cost effective, drive units.

DESIGN CONSIDERATION BALLSCREWS

PRELOAD (BACKLASH ELIMINATION): Backlash;
Single nut ballscrews are designed with specific axial and radial clearances in order to ensure that the balls achieve a 45° contact angle. This axial clearance plus the elastic deflection of the balls and ball tracks provides a total deflection known as ‘backlash’. *The following considers the factors which influence backlash and its elimination:*

Balltracks;
Semi Circular Forms (Fig 1, see page 25): Close conformity ball tracks are used where high load carrying capacity is required.

Gothic Arch Form (Fig 2, see page 25): Has the advantage over the semi circular form with regard to maintaining the contact angle, minimising radial-play, and axial backlash.

Backlash Elimination: Backlash may be minimised by the use of Gothic Arch Form and the accurate selection of ball size.

Preloading: Ballscrews applied to CNC machine tools require the elimination of backlash and the minimisation of elastic deflection in order to achieve high system rigidity and repeatability of positioning.

Preloading with a single nut: This can be achieved in two ways; by using a Gothic Arch Form and the selection of ball size or by off-setting the pitch of one circuit within the ball nut. This method is often referred to as ‘internal preload’
(see Fig 3 & Fig 4, see page 25).

Preloading using two ball nuts: Preload using two nuts is obtained by loading two nuts together (compressive) or forcing them apart (tensile).

Compressive preload (Fig 6, below): This is achieved by bolting two nuts together through the flanges with a spacer between them the size of which is adjusted to give the required preload.

Tensile preload (Fig 5, below): This is the most common method of preloading and is usually achieved by rotating one nut in relationship to the other; the preload is adjusted/fixed using a ground and keyed spacer between the nuts.

Preload considerations: The preload applied to a ballscrew must be carefully considered as heavy preloads (giving high system rigidity) reduce life and increase the power requirements. Optimum preload is generally set at one third of the average work load; some variations from this may be required for specific applications.

BACK DRIVING: Due to the inherent high efficiency of ballscrews back-driving under load can occur. Where this is unacceptable it may be prevented by incorporating a suitable device in the drive system. In cases where it is intended to produce a rotation from an axial thrust it is recommended that the lead of the ballscrew be at least one third of the shaft diameter.

BALLSCREW INSTALLATION AND MAINTENANCE

INSTALLATION: JENA-TEC Ballscrew drives are precision components; their installation requires specialist knowledge and suitable measuring facilities. Alignment errors can generally not be felt when the screw drive is rotated by hand due to the low friction of ballscrew assemblies.

PROTECTION: Covers: JENA-TEC Ballscrew drives must be protected from dust, chips and corrosive surroundings even if equipped with wipers. Protective measures include:
Bellows: Suitable only for vertical installation without additional guides.
Spiral cover springs.
Telescopic tubes or sleeves: These take up a lot of axial space.

LUBRICATION:

Oil-mist lubrication: Central lubrication by oil mist is the best method.

Oil lubrication: the oil supply should not exceed the volume lost by the wipers; otherwise use recirculating oil lubrication. Oil types: viscosity 3 up to 13°E or 25 to 100 cSt at 40°C

Grease lubrication: Add grease as appropriate to the volume lost via the wipers (under normal operating conditions it is sufficient to add grease every 200 to 300 hours).
Note: Excessive grease will cause friction and thus temperature rise.
A slight escape of grease from the lips of seals is the sign that sufficient grease is present.

OPERATING TEMPERATURES: The permissible operating temperature for JENA-TEC ballscrew drives is between -30 and +80° C, up to 110°C is permissible for brief periods. A precondition for this is correct lubrication.
Note: The torque may increase by a factor of up to 5 at temperatures below -20°C.

TRAVEL STOPS: To prevent damage to the ballscrew due to overtravelling it is advised that limit switches or mechanical stops are fitted to the machine structure. Generally it is recommended that overtravelling stops are not fitted to the ballscrew shaft.

BACKDRIVING: To prevent back driving under load when the drive is released systems need to incorporate safety devices i.e. brakes or clamps.

BALLTRACKS

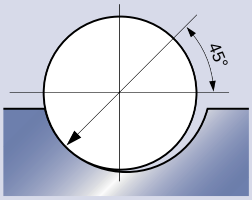

FIG 1 – Semi Circular Form

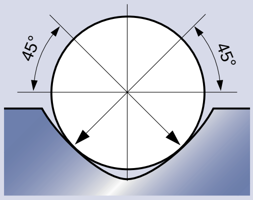

FIG 2 – Gothic Arch Form

PRELOAD METHOD

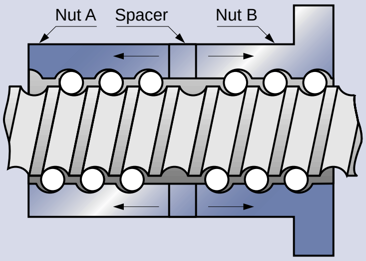

FIG 5 – Tensile Preload

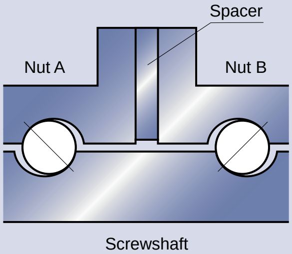

FIG 6 – Compressive Period

PRELOAD WITH SINGLE NUT

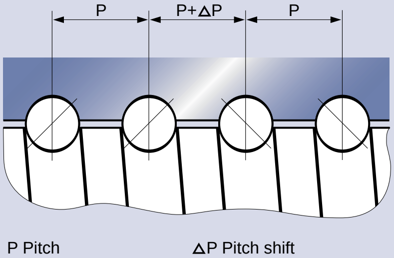

FIG 3 – Off-Set Pitch

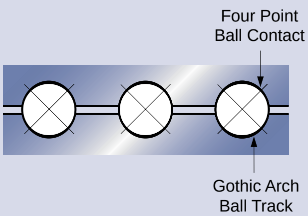

FIG 4 – Gothic Arch Form