

## Ball screw rolling

In linear motion ball screws represent one of the most important geometries. Besides low friction in ball screw assembly, high linear speeds and high loads considering the small size, the position accuracy under pre-load condition is the key point for usage.

### General purpose

Ball screws, or ball screw spindles are used to transform a rotational into a linear movement. Compared to other spindles and lead screws the low friction, good and noise behavior as well as a minimum of back lash are biggest advantages.

These points support the trend that ball screws are getting more and more used in linear motion, automation making, robotics and in automotive industry.

Ball screws are categorized by precisions. There are two main types: Ct transport type ball screws and Cp position type ball screws. Both have in common that lead accuracy is connected to a certain measuring length (standard = 300mm). For a higher precision of the deviation the nominal lead has to be minimized. Transport ball screw quality is considered quality class 7 and higher. Positioning ball screws have a quality class 1, 3 or 5.

Tab. 1: Tolerance classes acc. to DIN ISO 3408

Usable area $l_u$ [mm]		Tolerance for lead accuracy $e_p$ [μm]					
		Tolerance classes					
>	≤	0	1	3	5	7	10
0	315	4	6	12	23	52	210

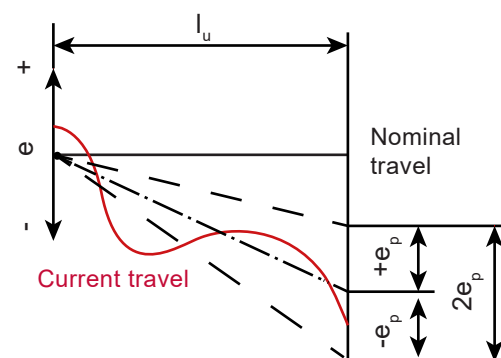
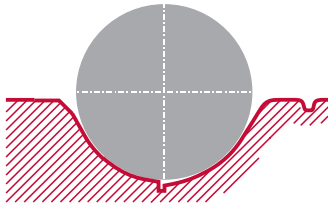


Fig. 1: Definition of lead accuracy acc. to DIN ISO 3408

$l_u$  Usable area  
 $e_p$  Dimensions of the target travel  
 (half difference between max. and min. value of the allowed travel  $2e_p$ )

State of the art are rolled ball screws with a quality class of 7... 10. Only modern CNC controlled Rolling machines give the opportunity to produce ball screws in quality class 5 and with most homogenous material class 3.



Ground ball screw	Rolled ball screw
<ul style="list-style-type: none"> <li>• continuous tip diameter shape</li> <li>• shoulder chamfer for transition</li> <li>• groove in ball screw root</li> <li>• induction deep hardening</li> </ul>	<ul style="list-style-type: none"> <li>• tip groove between pitches</li> <li>• shoulder radius for transition</li> <li>• natural gothic profile</li> <li>• close to contour hardening</li> </ul>

Fig. 2: Comparison ground / rolled Ball screw

## Process

The biggest impact on quality of ball screws is to start the thrufeed process with a radial infeed in combination with lead corrected thrufeed dies (TDU – Dies). By Radial start the straightness and symmetric contact of Dies on workpiece surface is ensured. Meanwhile the controlled friction avoids slip-stick effect.

The TDU dies already have a certain lead angle in their profile as well as the target profile shape. The design is chosen by an process engineer to have the best number of part revolutions (forming steps in calibration area) in relation to the width of the dies. With these specialized process the perfect ball screw can be made..



Fig. 3: Ball screw before and after rolling

Additionally a stable “Diameter of balls” is requested by all customers. This stability is achieved with modern NC-controlled machines. They got servo axes that control feed micron wise. With modern machine and software solutions even hardness caused deviation can be compensated.



Fig. 4: Profile Rolling machine 2-PR 30 HP

## Heat treatment distortion

Ball screws are getting induction hardened after rolling. This hardening process causes microstructural transformation. The very hard martensite structure in the surface guarantees high wear resistance. Side effect is that dimensions are changing predictably in case of homogenous material.

Exemplarily a ball screw spindle diameter of  $D=30\text{mm}$  is changing by approx.  $+30\mu\text{m}$  while lead of 5mm is changing by  $-10\mu\text{m}$  due to heat treatment of material surface. This heat treatment distortion needs already be considered by the rolling process. But meanwhile the quality demands on profile geometri (contact angle, radii) are so high, that the profile in TDU Rolling Dies has already to be anticipated for the modified lead.

Soft condition rolling is done wrong, to get a perfect product after hardening – without hard-fine machining.

This know-how and experience qualifies the maker to produce ball screw in high quality. Even no grinding is considered after heat treatment. Only a polishing process is applied to clean surface from heat treatment remnants and to bring back the shiny excellent roughness rolled surface.

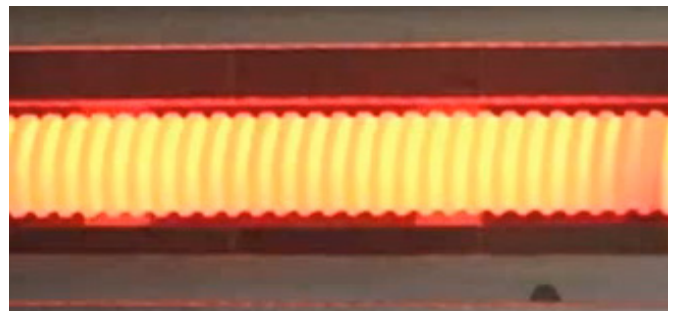


Fig. 5: Heat treatment of rolled ball screw

## Summary

Ball screws can be rolled process-stable with a quality C5, with first class material also up to C3 quality. High precision rolling dies in combination with a smart rolling process with a mechanically and thermally resistant machine ensure an economic manufacturing process of these essential components of linear motion.

With pleasure we support you technically and organizational with your ball screw project. Starting with selection of right material and material supplier we also optimize design of ball screw profile and produce rolling dies that bring perfect balance between low lead-in/lead-out areas and a big calibration area. Of course we take care and develop the rolling process but also introduce well-known heat treatment specialists and can recommend suitable polishing and finishing processes.

The whole range of activities is covered by state of the art measuring technique: most modern ZEISS CMM with own ball screw measuring software enables us and our customers to prove their product quality.



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