Finishing the raceways of EPS ball screw racks

In the passenger car segment, over the years, hydraulic steering systems have been replaced by electromechanically-supported EPS (Electronic Power Steering) systems. The main advantage of this type of drive is the adaptive design and the combination with numerous assistance systems. For instance, when driving at slower speeds, such as when parking, higher power assistance is enabled than at faster speeds. Other benefits of EPS systems are the low noise development, lower energy consumption, especially in straight line operation, and better environmental compatibility, as no hydraulic fluids are required. [PFEF13]

In R-EPS steering systems, the force transmission of the electric steering assistance is taken over by the ball screw nut and the ball screw rack. So both are important components of this type of steering. (see Figure 1)

Figure 1 Ball screw drive

To allow the balls to roll virtually noiselessly between the steering nut and the ball screw rack, the raceways in both workpieces must be precisely manufactured. The raceways have a 'Gothic' profile, which provides a four-point support for the balls (see Figure 2). This achieves outstanding running properties, an even load distribution and a high level of stiffness.

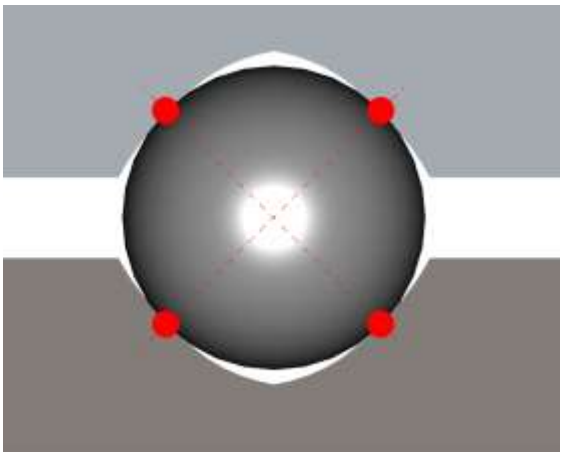

Figure 2 Gothic profile

The final surface of the ball screw rack is manufactured by a finishing or superfinishing process. This generally removes between 4 and 6µm, calculated based on the diameter. This is usually preceded by grinding, but spinning and rolling are also commonly used methods for creating the ball screw. The various manufacturers achieve very different service lives in the finishing process of between 150 and 1800 workpieces, where two honing stones are in simultaneous use (see Figure 3).

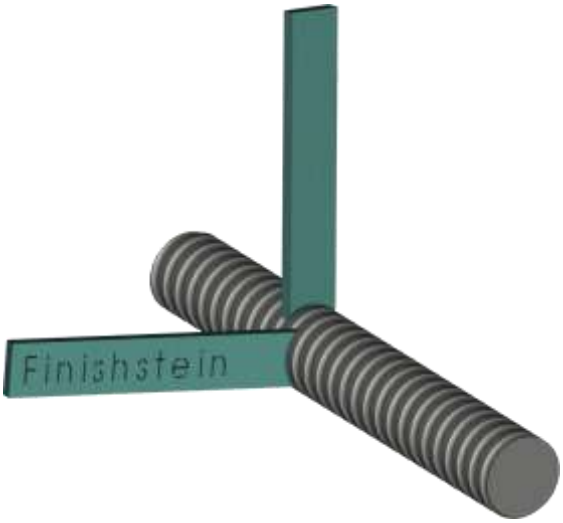

Figure 3 Intermeshed honing stones

The primary focus is on the roughness characteristics and waviness in order to ensure the optimal rolling of the balls. Process parameters such as oscillation, the number of overruns and the contact pressure have a significant influence on the surface quality. For example, an increase in the overruns achieves a better roughness, but significantly increases the cycle time and the stone wear. This is where the expertise and extensive experience of abrasives manufacturers Meister Abrasives AG and Schleifscheibenfabrik Alfons Schmeier GmbH & Co. KG come to the fore, as requirements are not just met by the parameters set on the machine, but also through optimised tool specification (see Figure 4).

Figure 4 Example specification

When designing this type of grade, the aim is to establish a good compromise between the achievable surface quality, material abrasion, self-sharpening and tool wear. [SCHI11] Impregnation with sulphur has established itself in this respect, but not every processing machine is compatible with this method and, where possible, the honing oil must regularly be cleared of residues. Untreated or higher sintered corundum grades can be the solution in this case, as they often exceed the performance of a sulphur-impregnated silicon carbide or white corundum specification and do not bring the aforementioned disadvantages (see Figure 5).

Workpiece	Ball screw rack
Material	Ck45
Machining allowance [mm]	0.006
Surface requirement	Rz 1.5 Ra 0.2 Rpk 0.4 Rk 1.0 FFT
Machine	Thielenhaus Centerstar
Specification used	410A 800/7 100 VX243 W1
Surface achieved	Rz 0.7 Ra 0.12 FFT o.k.
Benefits	✓ Very long service life ✓ No use of sulphur ✓ Lower production costs per part

Figure 5 Case study: Finishing ball screw rack with sintered corundum

On the bonding side, Ceramic has established itself for finishing ball screw racks. By controlling the bonding amount, the bonding components and the heat, the properties of the ceramically bonded honing stone can be specifically adjusted. The cutting materials used range from white corundum through to sintered corundum and silicon carbide and predominantly lie within a grit size range of 700 to 1000 Mesh; but CBN and diamond qualities are also increasingly being requested. In contrast to a conventional tool, a tool with super-abrasive grit must be profiled to the target contour with extreme precision and additionally sharpened right from the start, as it does not have the same self-forming properties [KLOC18]. Meister Abrasives takes up this special challenge and the in-house CBN and diamond grades, with grit sizes in the single-digit micrometer range are regularly used for raceway finishing (see Figure 6).

Figure 6 CBN finishing stone structure

In summary, it should be noted that finishing ball screw racks is an extremely sensitive process that can often only be sustainably improved or stabilised by optimising the tool. When combining process parameters and tool recipes, only a small window exists in which self-sharpening, material abrasion, service life and surface quality meet the objectives. In addition, the finishing stone quality must remain perpetually equivalent. Consequently, the best results are achieved in close collaboration between the producer and the tool manufacturer.

Bibliography

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