

Burnishing of CEPS Worms

Worm gears provide perfect characteristics for support of steering force in automotive. For high lifetime and low noise emission of this gear a burnishing operation is essential.

Worm Gears

Worm gears are assemblies of drive systems to convert high rotation speeds of an electric motor into high torque and low rotation speeds on output gear. Due to this dynamic performance the worm gear requires a high grade of surface quality. The request for average roughness is R_z less than $1 \mu\text{m}$. This high demand on surface quality is resulting from the need of wearfree operation and low noise emission.

Cold Rolling

The cold forming manufacturing processes Thread and Profile Rolling, as well as Spline Rolling increase their share in modern production also in areas that so far have been reserved to machining processes. While only being strong in the past in processes with moderate quality demands these processes spread nowadays in high quality fields of linear motion – like high quality ball screws. Advantages compared to machining process are obvious: While consuming less energy the material waste is dramatically reduced. These characteristics and the restraint to reduce consumption of resources as well as high energy prices will push forming operations more and more in the future with one single focus: To produce economically.



Fig. 1: Profile Rolling Machine PR 15 HP

CEPS–Column-Type Electric Powered Steering

Cars with low weight only need limited Steering Force. Especially these cars with their low needed steering torque are predestinated to be equipped with a worm gear for support of drivers steering motion. The worm gear assembly and its torque actively join the drivers steering operation at steering column after detecting the motion and activating and controlling an electric motor. This torque is added to the steering torque of driver directly at the column.

The main components of this gear: worm and worm wheel can be made of steel with hardened, ground worm or as latest development with a steel, not hardened, worm with plastic worm wheel as counterpart. Especially last mentioned pair has special demands on the used components.

1. The Worm gear assembly is located at steering column and therefore very close to cockpit. Any noise has to be avoided.
2. The less resistant part is made out of plastics. To avoid a fast wear, any scratch or geometrical defect on surface of worm flank has to be eliminated. Even smallest feed marks of machining processes would lead to damages of this part very fast.



Fig. 2: Steering worms

Process chain

Normally worms are made by two different processes. Either the fast whirling process is used with its higher tooling cost or the slower milling process with shape milling cutters.

Instead of expensive soft fine machining process like grinding or subsequent lapping or superfinishing a cold rolling process is used. This economic process in combination with modern NC-Technique achieves highest quality tolerances and smoothing of surface as well as corrections in profile. In general material in flank is formed and moved so even the profile shape of worm is corrected.

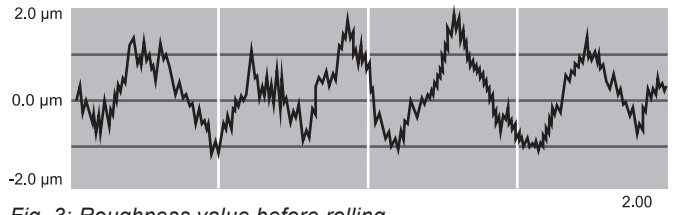


Fig. 3: Roughness value before rolling

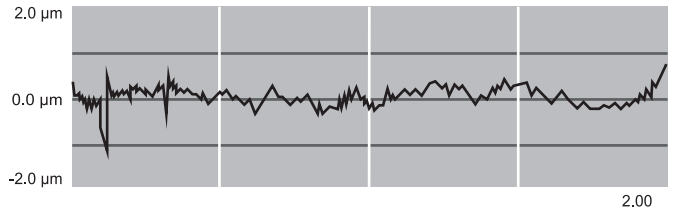


Fig. 4: Roughness value after rolling

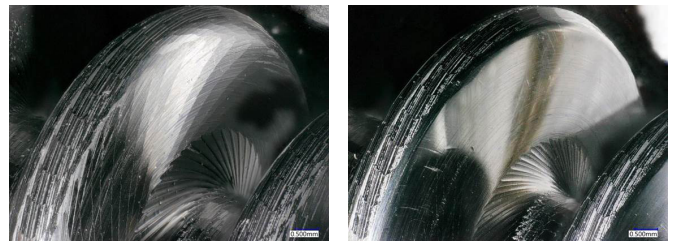


Fig. 5: Flank of worm before and after rolling

Improvement of Fa (profile shape error), Fb (Lead error) and Roughness can be achieved, in special cases by factor 8. Additionally profile modifications like crownings or tip reliefs can be corrected. A part-to-part time of 12s leads to high efficiency.

The pre-machined burnished steering worm is ready for installation and can run during the whole lifetime cycle of the assembly while production cost compared to conventionally made worms are reduced dramatically.



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