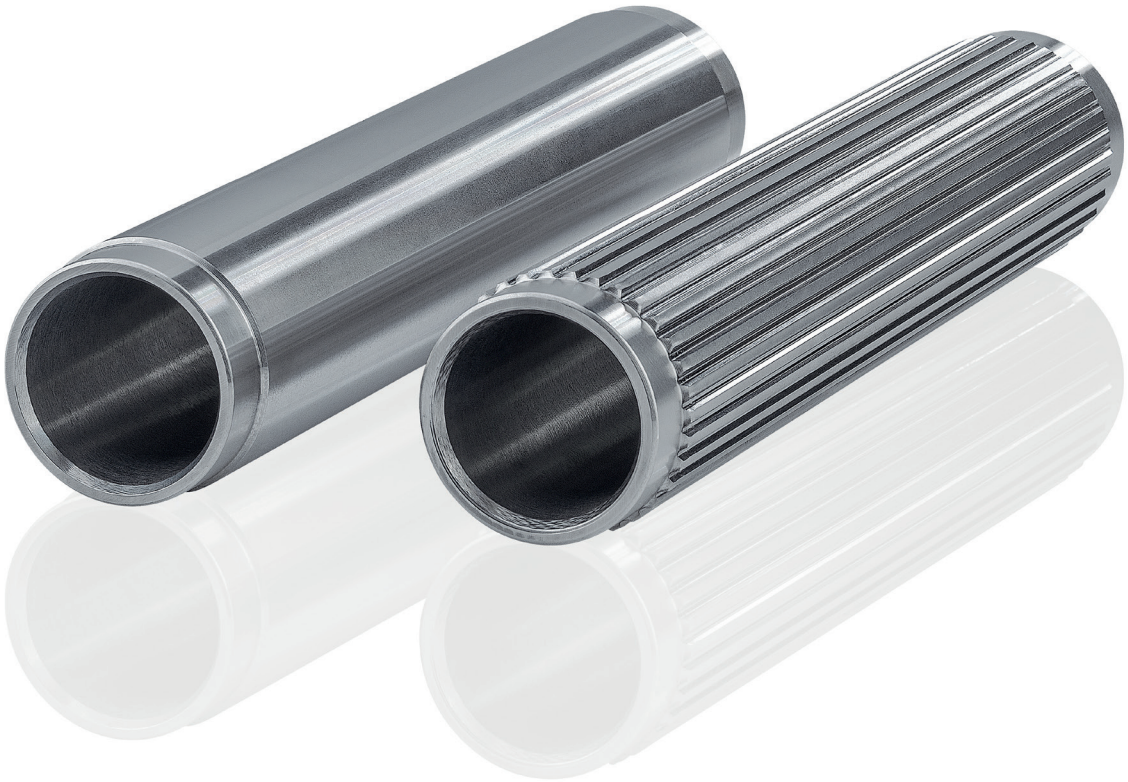

Fig. 1: Hollow Rotor Shaft (left: before right: after rolling)

eMobility - Rotor shaft

Involute splines on hollow shafts thanks to Thruforce Rolling now applicable also on rotor shafts of electro motors for electric vehicles.

Challenges of electromobility

Inverter-controlled synchronous and asynchronous motors currently determine the development in electromobility. For these assemblies, either permanent magnets, copper windings for excitations or squirrel-cages are used. Besides several advantages and disadvantages these designs provide special physical challenges: components with relatively high mass are mounted in a high speed rotation system and have to transfer the system power to rotor shaft without any backlash. In addition to mechanical load and tensions in material a widening caused by high rotations speeds is occurring in this system and could lead to different overlapping conditions between shaft and rotor package.

For transition of power several designs can be considered, one of them is the shaft-hub-connection with external spline on shaft and internal spline on hub (Rotor). In the past this mechanical connection with an involute spline was mainly applied in transmission production in automotive industry but also can transfer the complete torque of the electro motor to the axes of a car. At the same time, these gears are well-calculated and industrially cheap to produce.

The hollow Rotor shaft

For weight reduction and cheap production especially one trend can be seen in the market: “The assembled rotor shaft”. The shaft consists of rotor and two flange parts made as single parts and later welded together. The flange parts already have bearing seats and secondary connection elements for the output gear of the reduction gear. A very good runout of all components to each other is essential.

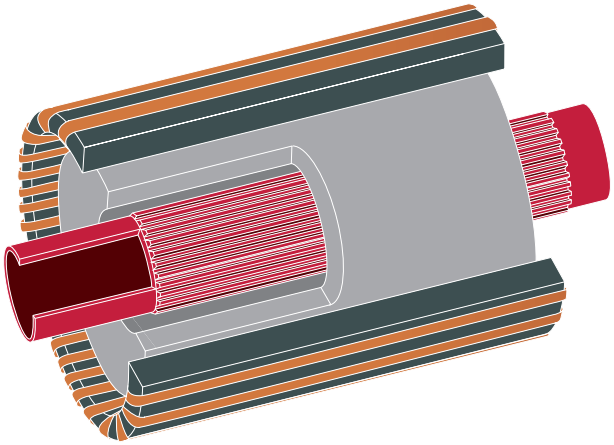

Fig.2: Hollow Rotor shaft section

The assembled Rotor shaft also includes a tube part that later gets an involute spline on circumference. This part only has a small wall thickness left that is designed to transfer the torque but to keep the mass as small as possible. Production wise it is now a challenge to apply an involute spline on this thin-walled part, preferably by cold forming.

Thruforce rolling

Right here the process of spline rolling with thruforce rolling can be applied. A normal spline is rolled with Rolling Dies at once on whole length. While applying continuous feed and rotation of rolling dies an involute spline is formed precisely. Considering this process for a hollow part rapidly leads to the thoughts that tensions in material are getting too high and tube gets deformed. As results this could lead to widening of base material or bad runout as well as high total pitch error.

Due to this reasons a modified process has been developed initially for hollow shafts of double clutch transmissions. This process is predestined for rolling of splines on rotor shafts.

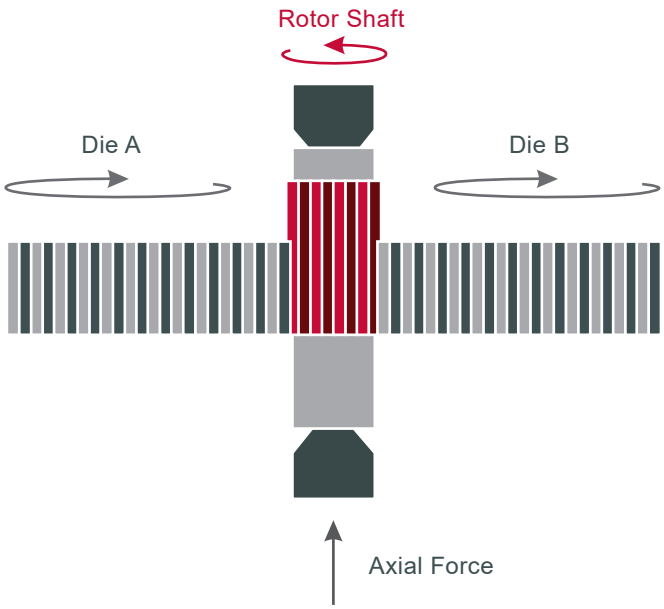

Fig. 3: Hollow Rotor shaft in thruforce

A workpiece is clamped between centers and positioned in work area by the NC controlled center rolling device. There two specially shaped Rolling Dies, which run completely synchronous to each other, are positioned at the start of the long hollow spline. Feed is already applied and while continuously rolling off, the workpiece is pushed through into axial direction. This movement in connection with geometry of rolling dies cause a material flow of material in circumference of rotor shaft leading to radial forming of spline. Main attraction is the flexibility of this process.
Only by controlling different process parameters like rotation speed and feed speed the size of forming area and therefor force and resulting tensions can be controlled. These tensions are adjusted so precisely that spline is formed but base material of tube is not influence negatively. Continuously the spline is rolled on full length of workpiece.

Even a geometric pre-adjustment of spline parameters due to following heat treatment process can be applied stable.

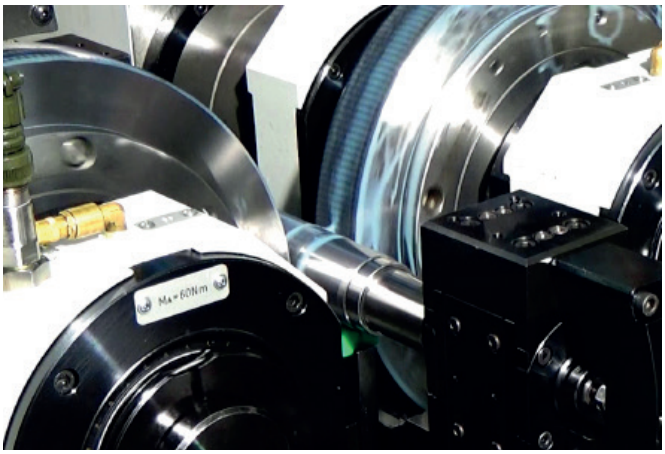

Fig. 4: Process Thruforce Rolling

Bonus:
It is state of the art in engineering that this process is set-up so precisely that support of formed area, e.g. by a mandrel in bore, is not needed. An expensive adjustment of hole tolerance is not needed. Costs are going down.

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