5. Turbines

Numerous components of gas turbines, (stationery or in aircraft), steam and water turbines are subject to high mechanical, thermal and chemical loads which lead to life shortage by fatigue. The most exposed components are blades, blade disks and shafts. Housings and flange connections, also run under critical conditions.

5.1 Turbine shafts

Shafts for power plant turbines with diameters up to approximately 1200 mm and lengths up to approximately 16 m are provided with numerous grooves with radial depth until 400 mm and widths from 90 mm up. These grooves cause a considerable notch effect under the operational conditions (torsion and bending vibrations). The fillet radii are made as large as possible by 20 to 80 mm, in order to minimize the notch effect. However, these measures were not enough to achieve the desired operational safety. For this reason, deep rolling was imposed to increase durability.

Past experience existed with heavy deep rolling tools having roller diameters of 120 and 90 mm. Therefore, use of this roller size was mandatory. The task was to execute the deep rolling process in one setting with the prior cutting process.

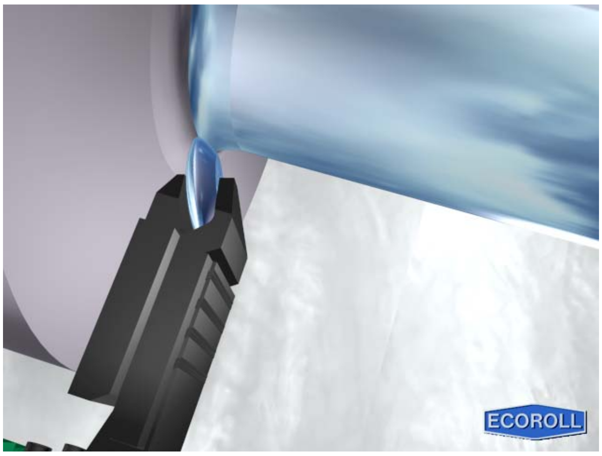

Fig. 5-1: FAK 120; deep rolling turbine shaft

The tools should be easy to install and simply to operate. A pressure supply for hydraulic cylinders should be avoided. The deep rolling operation should include the basic groove diameter, the flanks and the transition radiuses.

A mechanical system with low friction leaf springs was designed. The machine infeed is used to preload the springs and to generate the rolling force. ECOROLL offers these tools to FAK 90 and FAK 120.

The rolling force can be measured by two different means:

- inductive stroke sensor with analogous or digital display and line recorders for real-time documentation
- mechanical dial gages

The rolling force is determined with help of a standardized load - deflection characteristic curve.

Fig.5-1 shows the deep rolling tool FAK 120 in use. Typical parameters are:

Circumferential speed	50 - 150 m/min	
Feed rate	0,5 - 1 mm/rev.	
Rolling force	10 - 30 kN (2250 to 6750 lbf)	maximum capacity: 35 kN (8000 lbf)

Because of the size of the components, endurance tests were not executed. No the total about the increase of the faitigue strength are available therefore. The residual compressive stress characteristic served as judgment criterion for the selection of the optimal machining parameters.

5.2 Turbine disks

Turbine disks of steam turbines partially become exposed to hot steam contaminated with critical chemicals. Especially chloride however also other materials cause stress corrosion cracking but only under the influence of tension stresses. So, elimination of these stresses avoids stress corrosion cracking.

These disks run under a high tangential and radial tension stresses evoked through the centrifugal. These operation conditions can lead to the sudden destruction of the material, by stress corrosion cracking. Research results show that residual compressive stresses in the top layer avoid the stress corrosion by the absence of tensional stresses.

Fig. 5-2: turbine wheel

The disks (Fig. 5-2), show a contour existing of a flat cone with subsequent transition radiuses, that lead in to the cylindrical hub diameter inside and to the outer collar at the opposite side.

This contour deep rolled with the hydrostatic tool HG13-9E270° (Fig. 5-3), in four sections. The division of the sections is determined by the maximum alteration of the contact angle from + / - 35° between tool and workpiece surface.

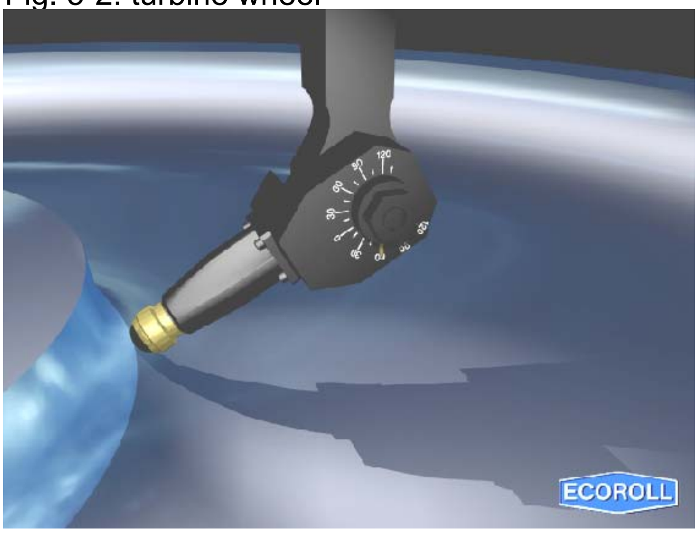

Fig. 5-3: deep rolling turbine wheel with HG13

After finishing of one section, the process is interrupted, the tool dug out and set manually on the new angular position for the next section. The adjustment is possible in steps of 15°. A delayed pressure built-up on the beginning of each treatment zone as well as the delayed pressure relief avoids any inhomogeneity of the residual compressive stresses. Through a connection with the CNC-control with the hydraulic unit can be switched on and off program-controlled over M-functions.

The criterion for the optimization of the treatment parameters was the attainable compressive stress characteristic. The following parameters where chosen: