Fraunhofer IWS Dresden

FRAUNHOFER-INSTITUT FÜR WERKSTOFF- UND STRAHLTECHNIK IWS

DEEP ROLLING OF 3D FREEFORM SURFACES

Increase of component lifetime by local alteration of surface skin characteristics

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Task

Lifetime and safety improvements of components under fatigue load become increasingly important in mechanical and system engineering. Mechanical compacting of the surface region provides an excellent solution to meet this challenge. The method significantly improves fatigue and strain corrosion resistance. However, it is often very difficult to integrate this process into modern machine tools.

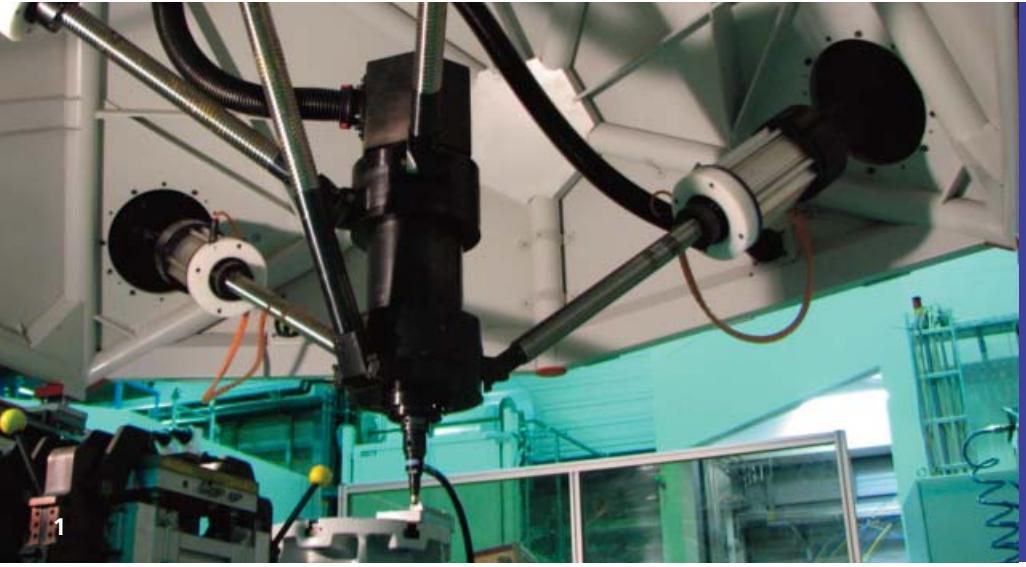
Here the deep rolling procedure is a very promising approach. This technique carries, apart from machining parts of rotational symmetry in turning machines, a hitherto nearly unused potential with respect to the treatment of freeform surfaces in 3D machines.

Solution

Fraunhofer IWS engineers worked in cooperation with the company Metrom and the Network Initiative Mechanical Engineering on the force controlled deep rolling of components in 3D milling machines. The project was funded by the Saxony State Department of Economics, Labor and Traffic.

The advantages are

- outstanding surface quality
- relatively large depth effect
- force control adjusts the affected material depth
- machining and surface treatment can be done in one setup
- precise localized treatment is possible
- can be integrated into modern machines
- moderate investment costs.



Strategy

Parts under cyclic bending are prone to critical crack formation on the part surface. The following strategies are proven measures to increase the parts` lifetime and security:

- reducing the surface roughness: This reduces the notches and makes crack formation more difficult
- introducing localized compressive stress: This reduces the tensile stress necessary for crack formation

3D Motion Machine

The tests were performed on a 3D capable milling center using parallel kinematics, a so-called Pentapod. Jointly with the producer, the IWS scientists modified the system in such a way that it enables a fast internal measurement and control of the pressure force of the working spindle. This is an important advantage for deep rolling processes.

Even in the cases of complex shapes and varying tolerances and deformations, a constant pressure force and surface quality can be guaranteed.

Results

The suggested machine and control system was able to realize the integrated deep rolling process. Parts of uniform surface quality were reproducibly manufactured. The surface roughness was reduced by up to 78 %. Depending on the material it is possible to increase the hardness. Some of the tested materials were hardened up to 10 %. Fatigue tests revealed that sharp contour transitions should be avoided, because they may favor crack initiation during cyclical loading.

Application Areas

Components with challenging geometries:

Energy production

- shafts, blade root mounting and blade root of modern gas and steam turbines
- compressors, pump wheels

Automotive manufacturing

- car suspension components; e.g. wishbones and trailing arms formed from sheet metal or cast aluminum material

Machine building and plant engineering

- load bearing points and bearing surfaces in transmission and motor casings

Aerospace

- deep rolling of laser beam welded structural elements to compensate weld seam undermatching

Titel photo
Locally rolled sample
1 3D machine tool (Pentapod)
2 Hydraulic roll tool in test configuration

Characteristics of the Machine Tool

Manufacturer:	Metrom GmbH, Chemnitz, Germany
System:	fully 3D capable 5 axis parallel kinematics
Control loop:	force control
Frequency:	max. 500 Hz
Force range:	1.0 to 12.0 kN

Funded by:

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