Textured Punches

Tribological optimization of cutting punches through micro texturing by machine hammer peening

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Department	Tribology
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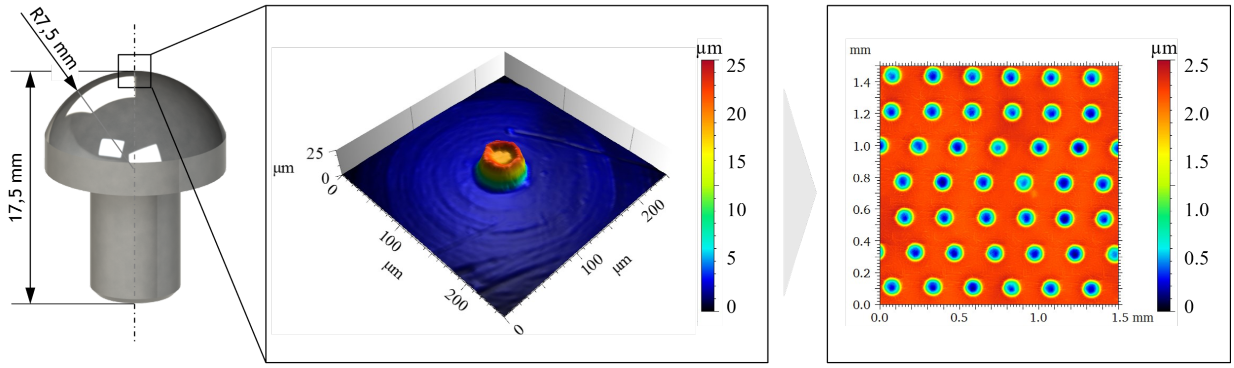


[1] Peening head, micro tip and resulting topography

Abstract

The tool life of punches in shear cutting or related processes is strongly influenced by the surface properties of the tools used. By using special hammer peening heads, the surface of metallic materials can be specifically structured through machine hammer peening. The micro-indentations created in this way act as both a lubricant and wear particle reservoir. This makes it possible to increase the effective tool life.

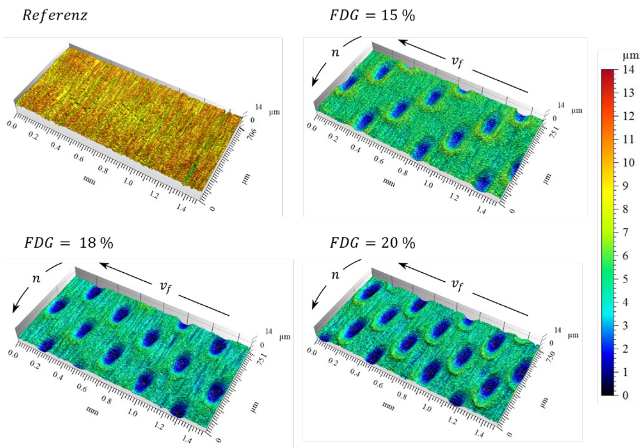
Project description

By tribologically optimizing tool surfaces with the help of machine-generated microstructures, downtimes can be minimized while maintaining high product quality. Especially with high contact normal stresses due to hydrostatic and hydrodynamic effects, friction value reductions of up to 30% can be achieved. In addition, unavoidable wear particles, which contribute significantly to tool failure in the long term, are absorbed by the microstructures. This effectively delays the onset of wear. In addition to structuring, texturing by machine hammer peening simultaneously includes the effects of smoothing, the generation of residual compressive stresses close to the surface, and the increase in hardness. This means that the entire product life cycle can be made more efficient and effective with just one processing step. However, due to the high tool hardness, manipulation through microstructuring of the tool surface is not yet feasible in terms of process technology and the local tribological stress has only been insufficiently researched.

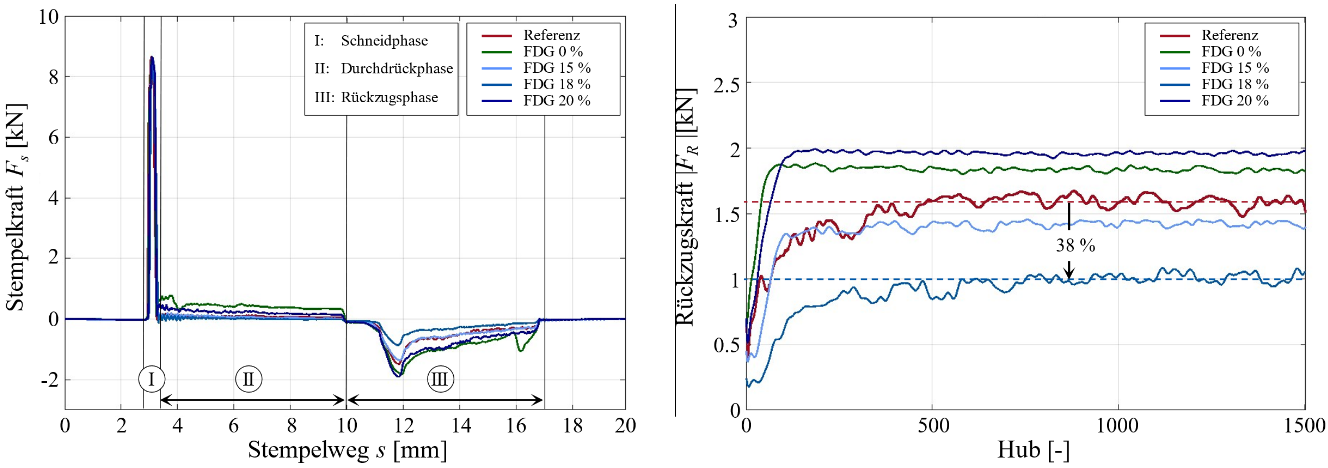
Results

Texturing of blanking punches

A texturing center with kinematics comparable to a lathe is used to apply the structure to rotationally symmetrical cutting punches. The MHP system is guided along the surface contour of the rotation axis via a feed axis with a defined ratio of speed and distance. An additional axis of rotation ensures that the entire surface of the punch shell is machined. This results in a spiral-shaped processing trajectory. Defined structuring distances can be set by controlling the impact frequency, feed speed (v_f) and rotational speed (n). This enables the texturing of different densities to the lateral surface. The ratio of the area of the applied cavities to the initial tool surface is referred to as the degree of surface coverage α and is decisive for the influence achieved on the tribological properties. Based on previous tribometer studies, industrial blanking punches with a diameter of 6 mm were structured with an α of 15, 18 and 20 %. The initial surface of the industrial reference and the textures achieved are shown in Figure [2].



[2] Textured punch surfaces



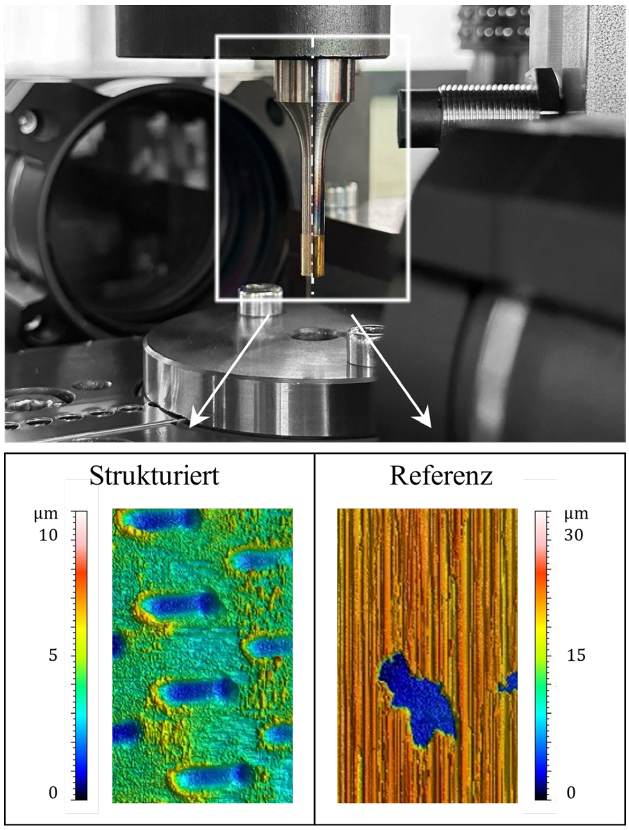
[3] Blanking forces of the textured punches

Process Performance

The functionality of the textures created on the blanking punches were tested on a Bruderer BSTA 810-145 high-speed press. The blanking tool used represents a single-stage conventional shear cutting operation with a stripper. The punching force F_S is monitored in the tool by a Kistler force sensor. This is based on the piezoelectric effect and is integrated directly above the punch holder. The clearance considered in this test series is 150 μm. To generate pronounced push-through and withdraw phases, the immersion depth of the punch in the die was set to 7.4 mm and the oiling was limited to the prelube of the test material. The stroke rate was 300 1/min. With the described parameter set, 1,500 strokes were performed for each of the cutting punches presented. Figure [3] shows the average punch force curves of the test series.

Influence on service life

In addition, an additional wear-provoking condition was created by increasing the immersion depth and stroke rate. This leads to higher relative speeds in the process and longer contact between the punch and the sheet metal. As a result, the load on the punch increases significantly and rapid wear development is provoked. With this adapted parameter set, an industrial reference punch is compared with a cutting punch with an α of 17 % in a supplementary analysis. Under these adapted conditions, severe wear sets in on the reference punch after 8000 strokes. This is followed by a comparison with the structured counterpart. This shows no failure-critical wear after 13,000 strokes. Figure [4] shows a picture of the blanking punches at the end of the test series. Galling in the form of a golden coating in the immersion area of the lateral surface is clearly visible. These initially occur gradually during the process, but gradually lead to a reduction in the effective clearance. The acting contact normal stress increases in the push-through and pull-back phases, and the resulting increase in frictional force leads to the dissipation of heat. This further increases the tendency to adhesion onto the punch. The effects amplify each other until the process is no longer controllable and the tool ultimately fails. This is demonstrated by the tarnish on the punch shank and the microscope images of the 30 μm thick adhesion layer in the immersion area.



[4] Surface of the worn punches

Summary

The feasibility and effectiveness of micro texturing on the lateral surface of shear cutting punches by mechanical surface hammering was demonstrated. In order to optimize the tribological properties, it is necessary to adjust the degree of surface coverage specifically to the tribological system under consideration. The tool, lubricant system, sheet material and the prevailing process parameters must be taken into account. With targeted dimensioning, it is possible to reduce friction and increase the service life of the cutting punch. Additional tests and analytical considerations are planned in order to derive generalized guidelines for micro texturing by machine hammer

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peening for other tribological systems and sheet metal working processes. With constructive accessibility of the tool through an MHP system, the technology offers the potential to make a wide range of processes more efficient and more resource-friendly. Deterministic surface structuring is therefore a key technology for increasing sustainability in sheet metal forming.

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