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Investigation of workpieceside parameters and application of innovative surface engineering technology for improving the tribological performance within hot stamping

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Hot stamping has been established as a key technology for manufacturing safety-relevant car body components with high strength-to-weight ratio. Due to high forming temperatures, lubricants cannot be used during the process. Consequently, high friction and severe wear effects occur at the blank-die interface, which negatively impact the workpiece quality and tool lifetime. Therefore, methods for reducing the tribological load have to be found. Within the scope of this paper, workpieceside parameters as well as an innovative tool modification technology were investigated to improve the friction and wear behavior during hot stamping.

Keywords: Hot stamping, Tool modification, Process parameters, Laser implantation, Layer formation

1. Introduction

Since 2000 political pressure and social demand to reduce fuel usage and CO_2 emissions of modern automotive vehicles have been constantly increasing. To this end the European Union has committed to decrease the greenhouse gas emissions until the year 2030 by at least 40 % compared to 1990 [1]. One approach for achieving this goal lies in hot stamping, which allows for the manufacturing of lightweight body in white components. The hot stamping process is based on the austenitization of steel sheets above 900 °C, which are subsequently formed and quenched in water-cooled dies [2]. Since hot stamped parts are formed at high temperatures, no suitable lubricants have yet been found. As a result, increased friction and severe wear effects occur in the process, which negatively impact tool lifetime and overall part quality. To improve the tribological behavior, both workpiece as well as tool side measures have been investigated.

2. Methods

A new surface engineering technology named laser implantation has been applied, in order to improve the tribological performance of hot stamping tools. The implantation technique is based on manufacturing highly wear-resistant, separated, and elevated microfeatures by embedding hard ceramic particles into the hot stamping tool surface via pulsed laser radiation. It is assumed that the laser-generated spots significantly reduce the contact area between tool and workpiece, which in turn influences the tribological interactions during the forming operation. To further improve the tribological performance, workpiece side measures have to be investigated. A significant factor contributing to friction and wear behavior is the coating layer of the sheet metal. The furnace temperature and holding time influence the layer formation and surface roughness of the workpiece and therefore the tribological interactions at the blank-die interface during the process. To verify the effectiveness of each approach, strip drawing tests were carried out under hot stamping conditions. The setup of the test rig is shown in Fig. 1.

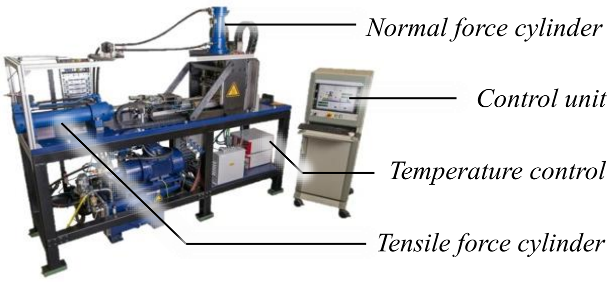

Figure 1: Strip drawing test rig for analyzing the tool modification and workpieceside parameters.

3. Discussion

The laser implantation process enabled the generation of highly wear resistant surface features on the tool surface. In this regard, the geometrical shape and mechanical properties of the spots could be precisely adjusted by varying the laser parameters as well as the composition of embedded ceramic particle. Compared to conventional tooling systems, the modified surfaces revealed a significantly higher wear resistance as well as reduced friction forces due to the limited contact area and the high fraction of finely dispersed ceramic particles, which abate the formation of adhesive wear. Moreover the tribological investigation of the workpiece side parameters revealed, that the layer formation had a significant impact on the occurring friction and wear mechanisms. Based on these investigations, a process window to further improve the tribological conditions could be determined. In future research work, both investigated workpiece and tool side measures will be transferred to an industry-related tooling geometry, to verify the effectiveness of both approaches.

4. References

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