Increasing performance of Hot Stamping systems

Christian Palm\textsuperscript{a,*}, Robert Vollmer\textsuperscript{b}, Jens Aspacher\textsuperscript{a}, Mohammad Gharbi\textsuperscript{b}

\textsuperscript{a}Schuler Pressen GmbH, Louis-Schuler-Str. 1, D-68753 Waghaeusel, Germany
\textsuperscript{b}Schuler Pressen GmbH, Bahnhofstr. 41, D-73033 Goeppingen, Germany

Abstract

The hot stamping market will be growing in the next years, but also the requirements of the OEMs and the competition between the suppliers are rising. To be successful in the hot stamping market part manufacturers need equipment with high performance, flexibility and a highly reliable process.

In conventional hot stamping presses an uncontrolled process is used for forming and quenching. Deviations of the blank thickness, tool wear, polishing of classical tools is impairing the quenching condition and therefore the part quality over the time. This paper presents a method how to improve the production rates over the whole life cycle of a hot forming part. By using a hydraulic cushion in the press table, the performance of the hot stamping process is increased dramatically. The cushion force leads to a controlled process with improved heat transfer rates and a constant and reliable cooling time. Also the part quality is rising because of the reliable process.

In the future, the importance of hot stamping systems with a fast, reliable and stable process and an optimized interchange between hot stamping equipment and quality assurance will increase and become the most important competition advantage for part manufacturers.

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* Corresponding author. Tel.: +49-7254-988-346. E-mail address: Christian.Palm@schulergroup.com
1. Introduction

Hot stamping also called press hardening is the hot forming of steels with subsequent hardening in the forming die. The technology has become the most cost-effective solution to produce lightweight parts in car body structures and is applied by almost all manufacturers of automotive parts worldwide. Current car bodies have a content of hot stamped part nearly up to 40% in mass of BIW [1]. The current market share of hot stamped parts is estimated at some 300 million parts per year manufactured on approximately 400 production lines operated by the OEMs and automotive suppliers. Continuous growth in figures up to an annual volume of 600 million parts is being anticipated in the next years, which corresponds to some 150-200 additional production lines not including any replacements of existing lines.

The widespread use of the hot stamping process and the platform strategy of the OEMs has resulted in an increase of the production volumes, more difficult parts and greater variety regarding batch sizes. This calls for a maximum flexibility in the configuration of batches and a reduction of the die change and tryout times by the manufacturers. In addition, more flexibility in the selection of the manufacturing process to handle different materials of different quality, coating or other different requirement is desirable. As the market is rapidly growing, also competition is becoming more aggressive. This in turn compels suppliers to further professionalize their processes in order to enhance efficiency and profitability without compromising on quality [2].

Suppliers of hot stamping lines of the current third generation of presses are required to provide full system expertise in all aspects of the manufacturing process i.e. the development of parts, the technology of dies, presses and systems, the assistance in commissioning, maintenance and training [3]. Other future challenges and fields of activity are the optimization of the entire manufacturing process and the integration of upstream and downstream processes (laser blanking, laser trimming etc.).

2. State of the art in Hot Stamping

In conventional direct hot stamping process an austenitic blank with a temperature of approximately 930 °C is transferred from the furnace into a press die within a few seconds. The typical temperature at the beginning of the forming process is between 650 and 850 °C, depending on transfer time and press speed. After forming the part is cooled down under high contact pressure in the die at a minimum cooling rate of 28 K/s [4]. This guarantees a fully martensitic structure with optimum strength of the material which is well described in literature [5,6]. Much higher cooling rates of more than 100 K/s can be and are achieved in reality [7] which is essential for higher rates of production. It is shown that the cooling performance of a hot stamping part is correlating with the overall thermal resistance between the sheet metal and the cooling ducts. The thermal resistance is mainly dependent of following different factors:

- Geometrical factors (Thickness of sheet metal, Distance from die surface to cooling duct, Density and distance between cooling ducts)
- Interfacial Properties (Contact pressure, Temperature difference, Roughness, Flow properties of cooling medium)
- Physical material properties (Thermal conductivity of sheet and die material, Heat capacity)

There is a technical limitation to optimize geometrical and physical properties, whereas further potential of improvement of the interfacial properties is available. Weiss et al show [8] that the heat transfer coefficient (HTC) between blank and die has a share of about 40% regarding the total thermal resistance a significant adjusting screw to shorten the quenching time. The HTC is effected by the temperature difference and the contact pressure of the two contacting bodies which is pointed out in several publications [9-11]. The increase of the HTC with increasing contact pressure like shown in figure 1 can be explained with surface smoothing and the resulting higher surface contact areas.
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