

TECHNOLOGICAL INNOVATIONS IN THE PRODUCTION OF VEHICLE DOOR PANEL FRAME AS A TYPICAL STAMPED-AND-WELDED COMPONENT

¹Monika HYRCZA-MICHALSKA, ²Guido PICCARI

¹*Silesian University of Technology, Faculty of Materials Engineering and Digitalisation of Industry, Materials Innovation Laboratory, 8 Krasińskiego Street, PL40-019 Katowice, Poland, EU, monika.hyrcza-michalska@polsl.pl*

²*IPB Polska Ltd. 5B Chemików Street, PL32-600 Oświęcim, Poland, EU, guido.piccari@ipb-polska.pl*

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Abstract

Based on the prior experience of IPB Polska Ltd. in Oświęcim, Poland, design specifications were formulated for the introduction of technological innovations in the production of vehicle door recess trim as a typical stamped-and-welded component. The goal of these innovations was to produce the component as a single-piece, hot-stamped part made from laser-welded blanks (TWB) instead of the typical multi-piece cold-stamped and welded construction. These activities were planned to reduce the product's weight, increase the structural strength of this component, and reduce the total number of manufacturing operations required to produce the finished component. A research and development project was secured to build a pilot installation for hot-forming and to verify the planned solution. This article presents the design phase of the innovative product and pilot production line, as well as the results of the practical verification of the designed solution under production conditions.

Keywords: Hot forming, laser-welded blanks, door ring sub-assembly, pilot production line

1. INTRODUCTION

The manufacture of modern vehicle structures requires the use of advanced high-strength steels, replacing the higher-strength steels previously used, and in the form of multi-component assemblies to ensure adequate structural strength [1]. Thanks to developments in joining techniques in the field of laser welding, it has become possible to use optimised, custom-designed laser-welded blanks [2, 3]. This reduces the weight of the final component and reduces stamping waste. Until now, the use of laser-welded blanks has been limited to cold stamping. To increase the effective utilisation of the potential of this type of blank and high-strength steels such as 22MnB5 (PHS-Press Hardened Steels), advanced hot forming methods are used, such as: hot-forming, hot stamping, super plastic forming, SPF, and hot gas forming and High Pressure Warm Forming (FLEXFORM™).

IPB Polska Ltd. has launched an R&D project aimed at product and process innovation in the manufacture of stamped vehicle components with high structural strength. The door ring was selected for testing as a representative sub-assembly, a pressed-and-welded component with complex geometry, which will be manufactured as a single hot-stamped blank from laser-welded steel blanks. Door ring sub-assembly before project implementation was made in several pressed operation on transfer presses line or made of many elements. Hence the aim of the research became product innovation involving a reduction in the number of component parts required to manufacture the sub-assembly, assembly operations and product's weight (manufacturing a lighter sub-assembly). The process innovation, on the other hand, was aimed at: to boost production capacity and competitiveness in the automotive subcontracting market; optimise the tools for production on triple-action presses using hot-forming technology; incorporating sustainable development

objectives into more advanced and efficient products and technologies, and reducing waste and energy consumption by streamlining production processes.

2. METHODOLOGY

Leveraging best industry practices for the use of laser-welded assemblies showed on **Figure 1** and own experience [5] innovations at IBP Polska Ltd. have been introduced into the manufacturing process for one of the basic types of stampings – door ring. Physical and numerical modelling were used to design the manufacturing process for this stamping.

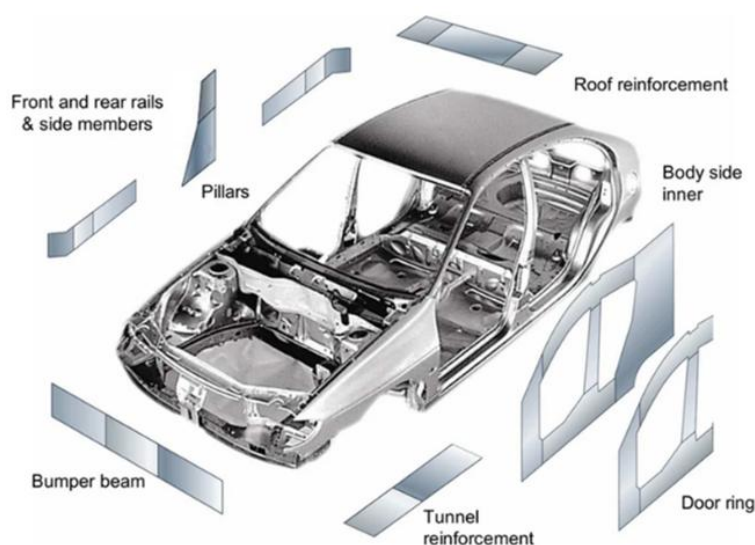


Figure 1 Good Manufacturing Practices: Tailor Welded Blanks in car body production [4]

Based on the most effective and state-of-the-art solutions used in the automotive industry [6-10], using tailor welded blanks (TWBs) instead of homogeneous feedstocks was design. The final geometry of the feedstocks is showed in **Figure 2** and it was taken from the results of numerical simulations carried out in Autoform software. The same software was use to desing advanced tools. Based on simulation results in the form of the final product's geometry, a set of prototype tools for multi-stage stamping on a triple-action press was manufactured. The design of tools for manufacturing door- ring draw piece was made possible by mastering modern methods of rapid tool prototyping. In addition, the design of the stamping press and tools incorporated proprietary, patent-pending design solutions for the cooling system.

The door ring drawpiece was designed using the recommended advanced high-strength steels from the press-hardened steel (PHS) group, specifically grades 22MnB5 and Ductibor 500P (CR600T-LA-DS). In order to achieve the required strength and correct geometry in a single complex-shaped drawpiece, it is necessary to use hot forming – hot stamping – to work the high-strength blank.

The Quick Plastic Forming (QPF) method was selected as the most effective manufacturing method for complex stamped components production. QPF is an advanced industrial hot blow forming method developed by General Motors. It is used for the rapid, mass production of complex body panels from sheets of aluminium or magnesium alloys. It represents a further development and acceleration of traditional superplastic forming (SPF). In this solution, in addition to modifications to classical hot forming to accelerate the forming process to superplastic conditions, non-homogeneous tailor-welded blanks (TWB) welded to high-strength steel sheets are applied. Such a complex solution ensures the production of a single-piece door ring sub-assembly in place of a multi-piece welded structure. Using hot forming – QPF type as a manufacturing technology – 1 tool , reduced numbers of operation.

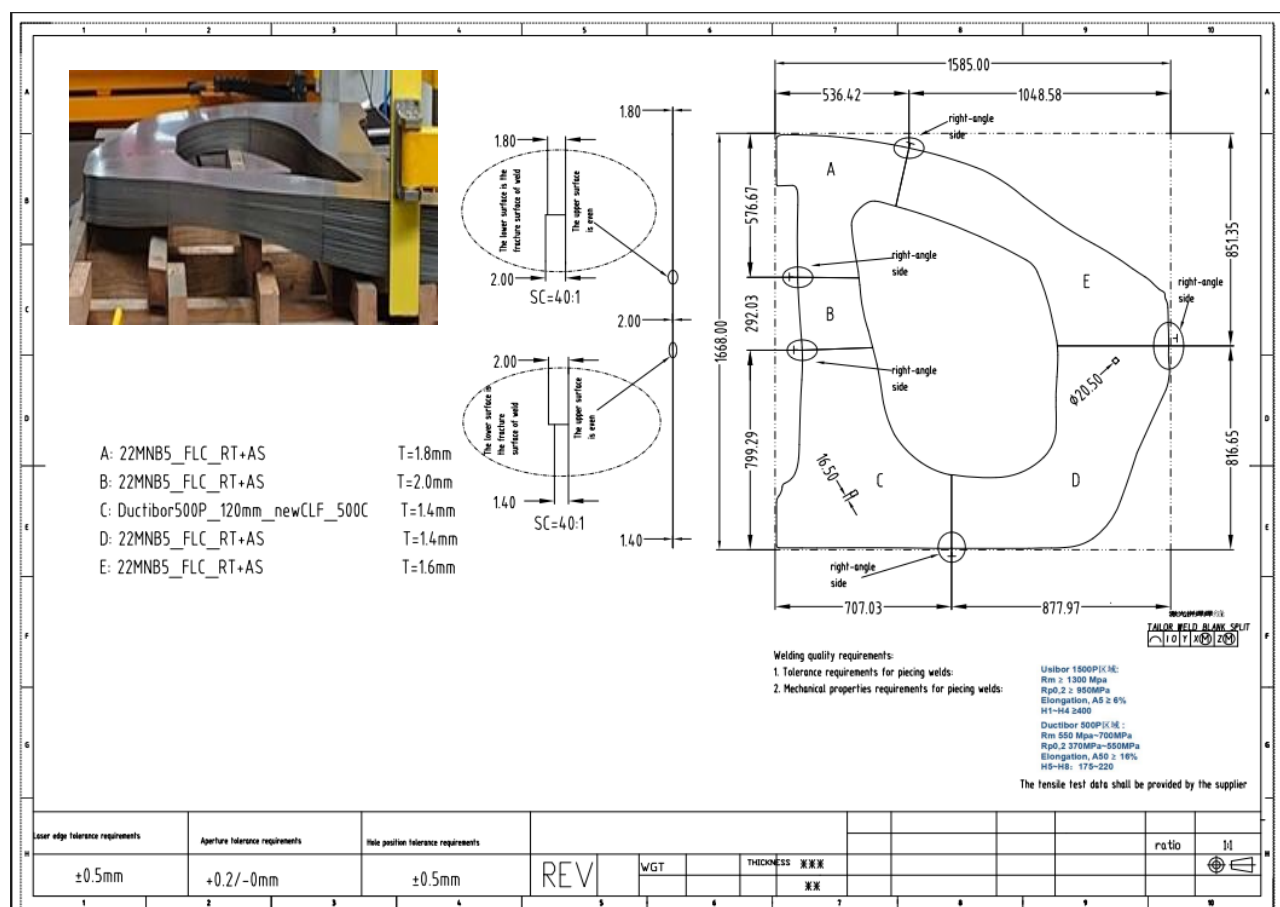


Figure 2 IPB's project of Tailor Welded Blanks door ring production based on [5, 6]

QPF method is based on hot stamping and both technologies of manufacturing were tested in experiments at IPB Polska Ltd. This paper presents the results of the applied research carried out as part of a development project conducted at that company between 2018 and 2023.

3. RESULTS

3.1 Result 1: Pilot installation for hot forming door ring

The use of hot stamping in the production of door recess edging required the development of a new, flexible production cell. At the heart of the system is a Mossini hydraulic press with a nominal pressure of 2,000 tonnes (Figure 3a). The press has been fitted with high-performance cooling systems, specifically designed for QPF processes. The second key component of the cell is the Schwartz furnace (Figure 3b) for heating TWB batches. Its design comprises several heating shelves, each enclosed by a separate door to minimise heat loss when removing individual batches. The transport system is supplemented by two robots fitted with gripper arms, enabling the transport of hot batches and stamped parts, as well as transport and storage tables. The robots and arms are protected by layers of heat-resistant fabric. The final stage in the processing of the door recess is the final trimming at the laser cutting station. The production cell constructed in this way constitutes a pilot plant, and its layout is shown in Figure 4. For pressing were used innovative tools showed in Figure 5.

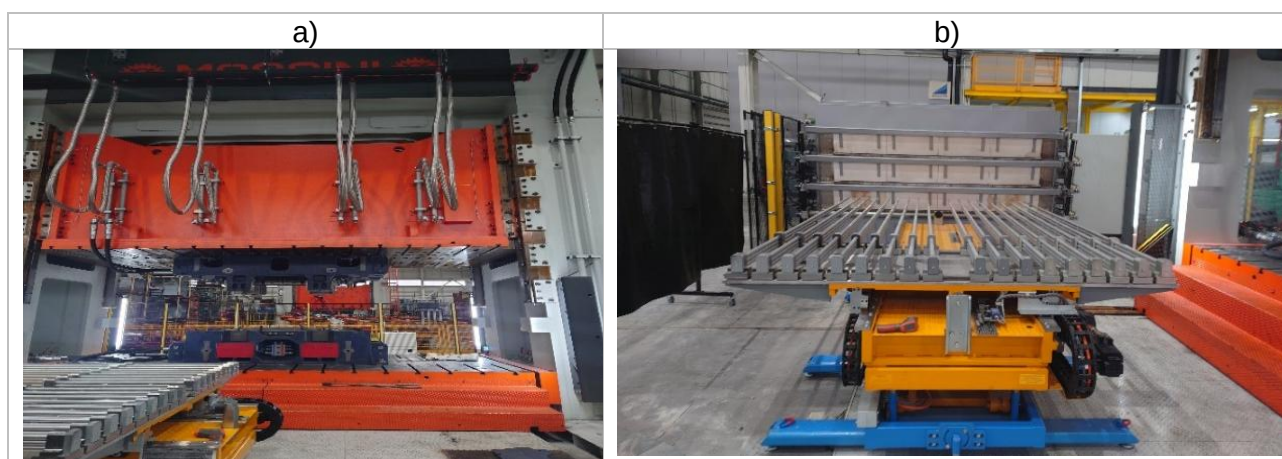


Figure 3 Photographs of basic elements of pilot manufacturing line at IPB Polska Ltd.: a) Mossini 2000T hydraulic Press, b) Schwartz furnace and centring table

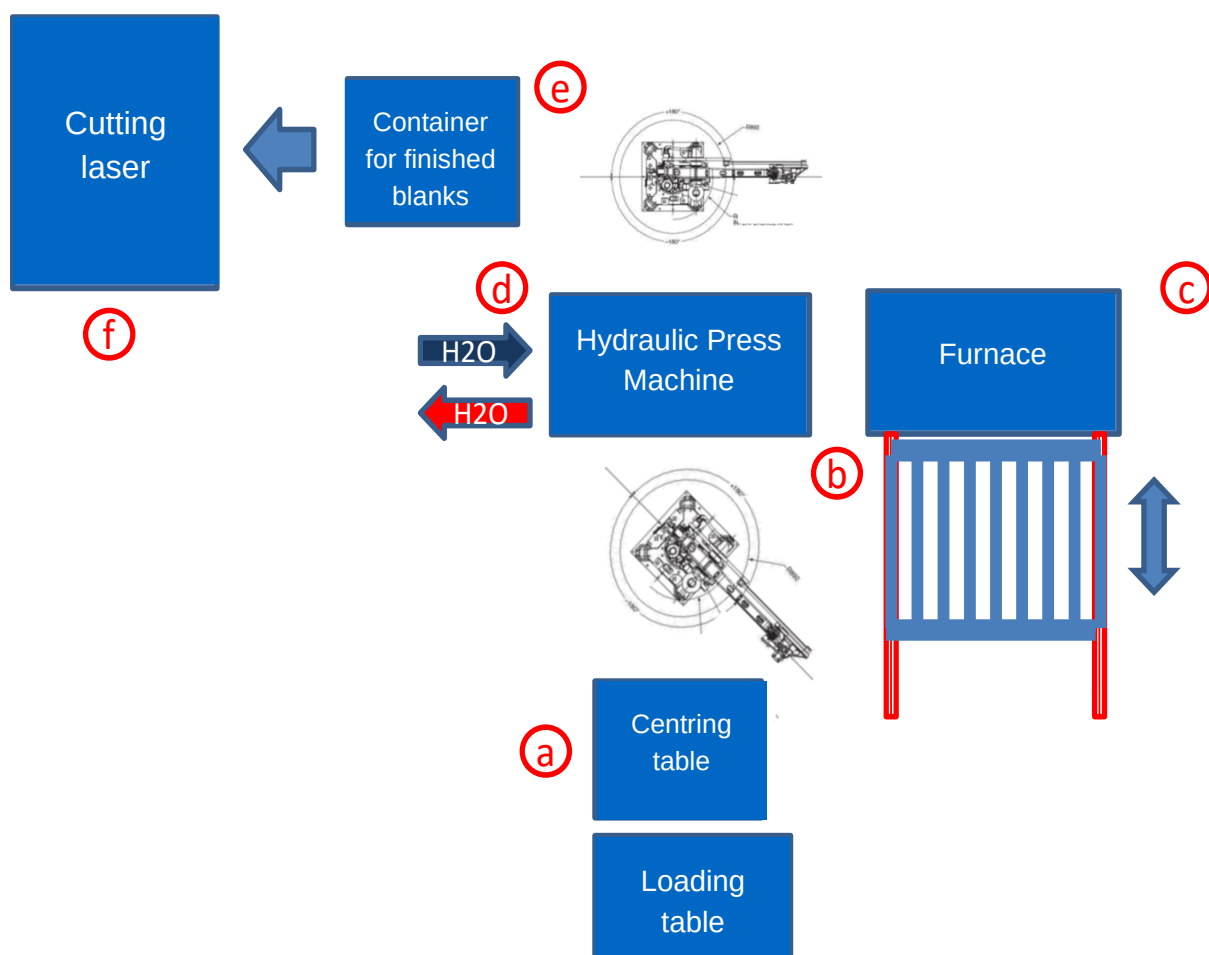


Figure 4 The pilot plant layout, showing the press, furnace and manipulators, where: a – tables (loading and centring), b – press (Mossini 2000T), c – furnace with feeder, d – cooling system for the press and tools, e – collection container for stamped parts, f – laser cutting station for finishing stamped parts after QPF (Quick Plastic Forming) stamping, M1/2 – manipulators

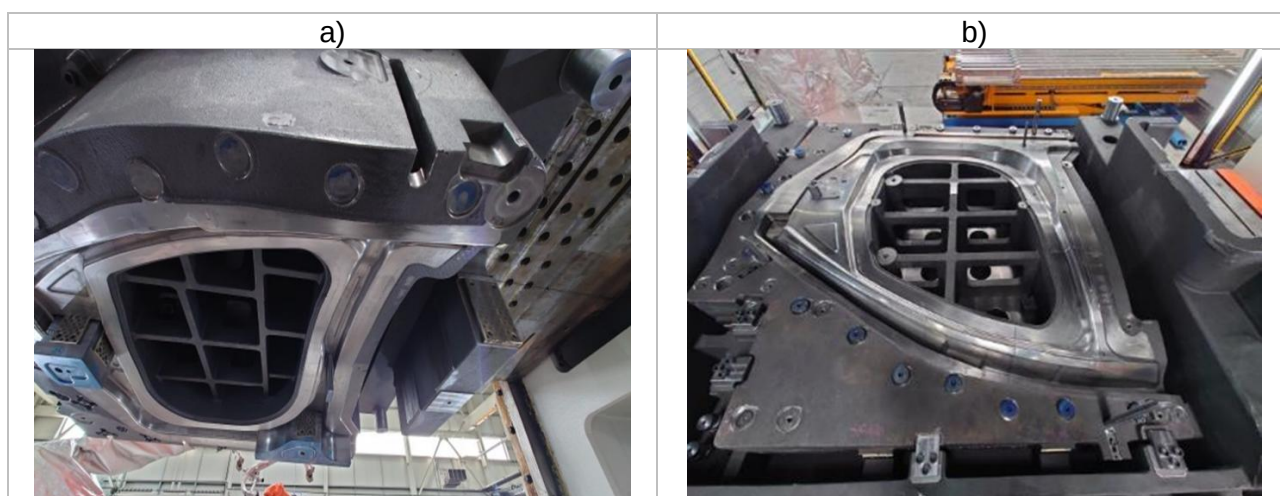


Figure 5 Innovative, a prototype tool for the production of a single-piece pressed element : a) upper, b) lower

3.2 Result 2: Innovative product - door ring

The production of the door ring using a ready-made die, employing IPB's proprietary hot-forming technology – QPF technology – was carried out during the final stage of the project. Process parameters such as: the heating time for batches, the transport time from the furnace to the press, the pressing time and the pressing forces in specific areas of the die, as well as the cooling time within the die, are trade secrets. These were determined on the basis of simulation calculations and operational trials carried out during line testing on a trial batch of over 100 pressed parts. The finished pressed component for the door ring is shown in **Figure 6a**. Each pressed component was subjected to a visual inspection and dimensional measurements using an optical scanner (**Figure 6b**). The measurement results were compared with the product's design geometry. An example summary of the measurement results for a compliant (OK) stamped part is shown in **Figure 7**. Geometric measurements of products manufactured on the pilot line using proprietary tools indicate that the door recess sub-assembly can be effectively processed as a single-piece component using the proposed solution, which was to be demonstrated in the project.



Figure 6 Photography of door ring sub-assembly after hot forming: a) drawpiece made on pilot line b) geometry inspection by using an optical scanner

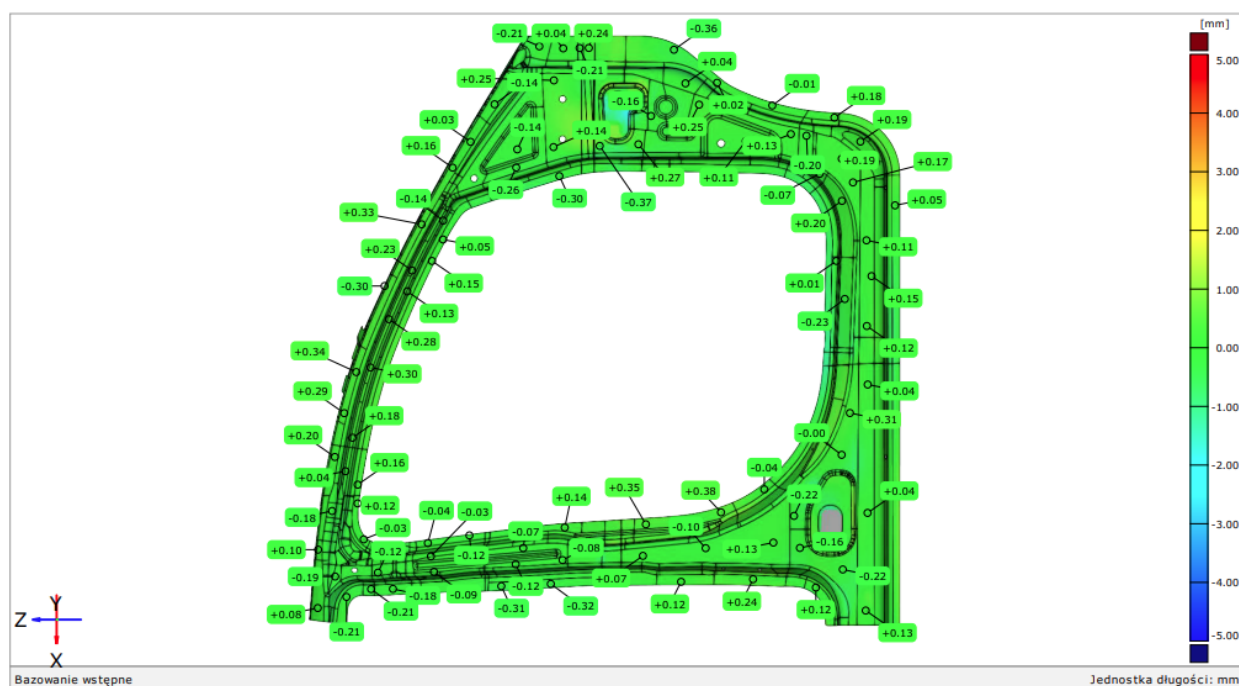


Figure 7 An example summary of the measurement results for a compliant (OK) stamped part

4. CONCLUSION

IPB Polska Ltd. has developed a pilot production line for manufacturing door recess trim drawpieces, enabling the efficient production of complex-shaped hot-stamped products from TWB-type blanks. It has thus successfully completed a research and development project. The end result of the project is a significantly improved manufacturing process for the inner edge of vehicle doors – door ring. By using laser-welded blanks (TWB), it is possible to stamp a single complex semi-finished product created by welding flat components of varying geometries together rather than joining individual stamped parts by overlapping them to form a vehicle door interior assembly. This has resulted in a less complex, more economical manufacturing process.

The finished product is unique on an international scale. The increased strength of the door interior trim blank is ensured by the use of 22MnB5 steel and its hot-forming. Furthermore, the product made from TWB blanks is 6 kg lighter than one pressed from homogeneous, unwelded blanks, as a standard blank weighs 63 kg and a TWB blank 57 kg; in mass production, this translates to a reduction in material consumption of approximately 10%.

Cost savings and more sustainable and responsible manufacturing are in line with the concept of a sustainable economy, and the project has a positive impact on the implementation of the principle of sustainable development due to the project's results.

The ability and expertise to manufacture stamped products using technically advanced methods and with complex geometries give the company a competitive edge in securing more substantial manufacturing contracts.

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REFERENCES

- [1] Reducing Complexity & Cost through Parts Consolidation. A front body structure study using advanced high-strength steels [online]. 2026. [viewed: 2026-05-27]. Available from:
<https://www.worldautosteel.org/resources/technical-publication/parts-consolidation/>
- [2] HILDITCH T.B., de SOUZA T., HODGSON P.D., 2 - Properties and automotive applications of advanced high-strength steels (AHSS). *Welding and Joining of Advanced High Strength Steels (AHSS)*, 9-28 (2015)
<https://doi.org/10.1016/B978-0-85709-436-0.00002-3>
- [3] KUZIAK R., KAWALLA R., WAENGLER S., Advanced high strength steels for automotive industry. *Arch. Civ. Mech. Eng.* **8** (2), 103-117 (2008) [https://doi.org/10.1016/S1644-9665\(12\)60197-6](https://doi.org/10.1016/S1644-9665(12)60197-6)
- [4] MÚNERA, D.D., PIC, A., ABOU-KHALIL, D., et al.: Innovative press hardened steel based laser welded blanks solutions for weight savings and crash safety improvements. *SAE Int. J. Mater. Manuf.* **1**(1), 472–479 (2009)
- [5] HYRCZA-MICHALSKA M., ROJEK J., FRUITOS O.: Numerical simulation of car body elements pressing applying tailor welded blanks - practical verification of results. *Arch. Civ. Mech. Eng.* **10** (4), 31-44 (2010)
- [6] MERKLEIN M., LECHLER J.: Investigation of the thermo-mechanical properties of hot stamping steels. *J. Mater. Process. Technol.* **177**, 452–455. (2006) <https://doi.org/10.1016/j.jmatprotec.2006.03.233>
- [7] FAN DONG W., KIM HAN S., DE COOMAN BRUNO C.: A review of the physical metallurgy related to the hot press forming of advanced high strength steel. *Steel Research Int.* **80** (3), 241-248 (2009)
<https://doi.org/10.2374/SRI08SP131>
- [8] KARBASIAN H., TEKKAYA A.E.: A review on hot stamping. *J. Mater. Process. Technol.* **210** (15), 2103–2118 (2010)
- [9] NEUGEBAUER R., SCHIECK F., POLSTER S., MOSEL A., RAUTENSTRAUCH A., SCHÖNHERR J., PIERSCHEL N.: Press hardening – An innovative and challenging technology. *Arch. Civ. Mech. Eng.* **12** (2), 113–118 (2012) <https://doi.org/10.1016/j.acme.2012.04.013>
- [10] WRÓBEL I.: FEM simulation of hot forming stamping processes, *MECHANIK Scientific Technical Monthly Magazine* **7**, 606-608 (2017) <https://doi.org/10.17814/mechanik.2017.7.87>