Process simulation of press hardening - Heat transfer in sliding contacts - PROCSIM3

Project within Sustainable Production Technology

Greger Bergman and Mats Oldenburg

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FFI

Content

FFI in short

FFI is a partnership between the Swedish government and automotive industry for joint funding of research, innovation and development concentrating on Climate & Environment and Safety. FFI has R&D activities worth approx. €100 million per year, of which half is governmental funding. The background to the investment is that development within road transportation and Swedish automotive industry has big impact for growth. FFI will contribute to the following main goals: Reducing the environmental impact of transport, reducing the number killed and injured in traffic and Strengthening international competitiveness. Currently there are five collaboration programs: **Vehicle Development, Transport Efficiency, Vehicle and Traffic Safety, Energy & Environment and Sustainable Production Technology.**

For more information: www.vinnova.se/ffi

1. Executive summary

Requirements for weight reduction of load carrying structures in the automotive industry requires new high-performance materials and innovative forming processes. The availability of methods for material and process modelling is an essential condition for developing new industrial processes in a short time. The development of thermo-mechanically controlled forming processes is a success criterion for introducing new high-performance materials. The key technologies include hot stamping of boron-alloyed steel.

The goal of the research project is to develop necessary knowledge about the process relationships that have the greatest impact on the outcome of simultaneous forming and quenching. These relationships should be formulated in such a way that they can be implemented in a finite element code for simulation of the complete manufacturing process.

Two parameters have been identified as key factors for the accuracy of the results in thermo-mechanical forming simulations: the heat transfer coefficient between the blank and the tool and the microstructure evolution during quenching. The goal of developing an experiment in order to study the heat transfer at sliding contacts and to create a heat transfer model based on sliding speed, pressure, surface finish and temperature has not been reached. However, the corresponding static experiments have been conducted and a pressure and temperature dependent regression model has been implemented. An improved phase transformation model which includes the effect of carbon segregation has been implemented.

2. Background

The press hardening process (or hot stamping) was invented back in the seventies in cooperation by former Norrbottens Järnverk and Luleå Tekniska Högskola. In summary, the process is based on the forming of hot blanks, in the austenitic state, to improve the formability as well as obtaining a final martensitic structure by subsequent rapid cooling in the forming tools. The technique can be summarized in the following steps, see also Figure 1.

1. Punching of blanks in uncoated boron steel, 22MnB5
2. Heating to austenitizing in a gas or electrical heated furnace

3. Handling of blanks between furnace and press
4. Forming and hardening in cooled tools
5. Internal transport to surface cleaning
6. Surface cleaning by shot blasting
7. Packing of components to customer

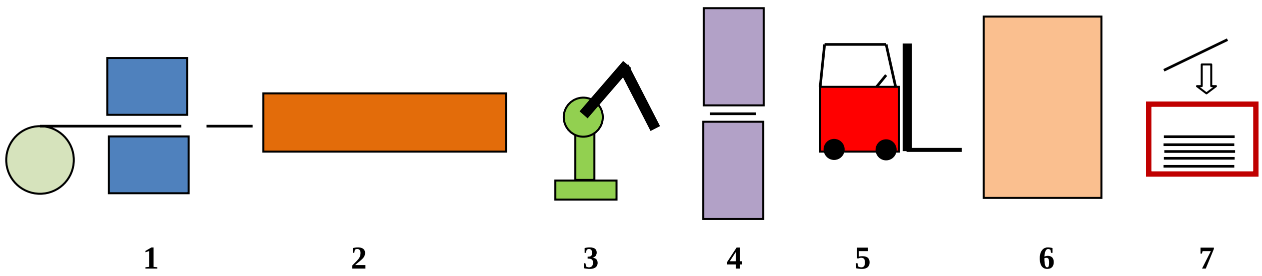

Figure 1. Illustration of a typical press hardening process.

In the press hardening process, a low alloyed steel material called 22MnB5 is commonly used due to its desirable properties and low price. The thickness range commonly used is in the interval 1 to 2 mm. Carbon content in the interval 0.2 to 0.25 wt% in combination with a low amount alloying elements provide good weldability. The steel in question has good hot forming characteristics and hardenability in combination with fine final mechanical properties. The fine hardenability is achieved by the addition of the alloying elements; manganese, chromium, silicon and boron. The majority of the components produced are for the automotive industry around the world. The usage of Ultra High Strength Steel (UHSS) components, to which the hardened boron steel belongs, is with advantage used as passive safety components due to its excellent mechanical properties. This in turn provides great weight reductions with maintained or increased passive safety. More specific examples of press hardened components are; a, b, c-pillars, side impact beams, roof bows and bumper beams, some of these are illustrated in Figure 2. Reductions of the car body weight immediately reduce the energy usage which in turn gives a decrease in CO_2 emissions. The usage of UHSS components is expected to increase dramatically the coming years, not only in passenger cars but also in heavier vehicles such as trucks and buses. In the case of trucks, great savings both for the economy as well as environment are expected due to decreased curb weight and increased loading capacity.

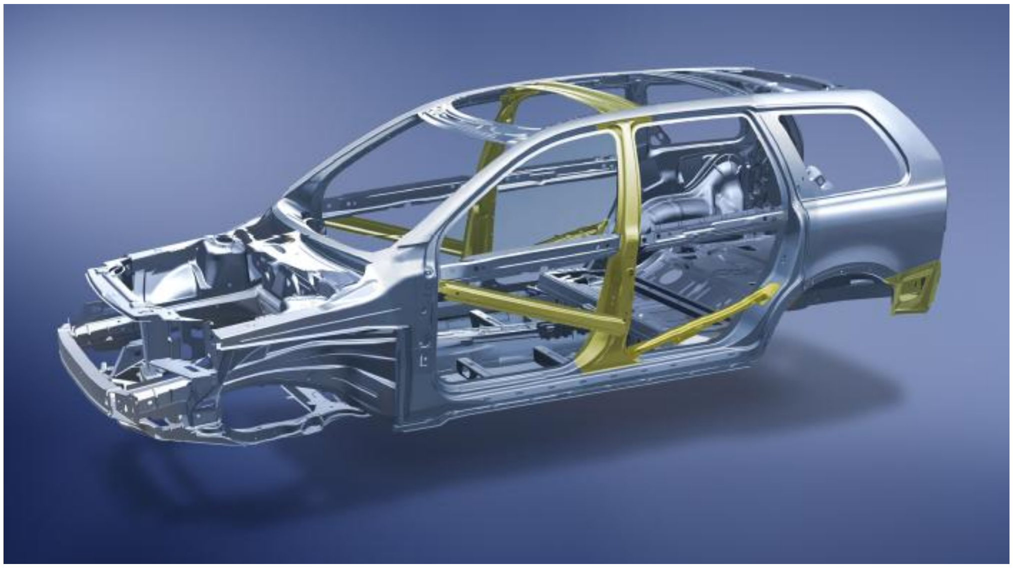

Figure 2. Illustration of some press hardened UHSS components, marked in yellow.

3. Objective

The project objective has been to develop material and process modelling in order to predict the final shape, microstructure and material properties during the development of new processes and components.

4. Project realization

The project has been realized by the cooperative work between the partners Gestamp HardTech AB and Division Mechanics of Solid Materials at Luleå University of Technology.

5. Results and deliverables

5.1 Delivery to FFI-goals

The project has increased the knowledge in the field of virtual manufacturing processing, which has made it possible to perform forming simulations with increased accuracy. This contributes significantly to reducing all losses in the production processing and significantly reduces the environmental impact of the manufacturing process.

6. Dissemination and publications

6.1 Knowledge and results dissemination

The implemented phase transformation model for hot forming analysis is now used daily by forming analysts at Gestamp's R&D- and Tech centers in Europe.

6.2 Publications

No publications have been made.

7. Conclusions and future research

Two parameters have been identified as key factors for the accuracy of the results in thermo-mechanical forming simulations: the heat transfer coefficient between the blank and the tool and the microstructure evolution during quenching. The implemented phase transformation model improves the accuracy, especially for simulation of components with tailored material properties.

Future work will include fitting parameters of a physically based heat transfer model to the experiments.

8. Participating parties and contact person

Contact person

Greger Bergman

GBergman@se.gestamp.com

Luleå tekniska universitet

Contact person

Mats Oldenburg

mats.oldenburg@ltu.se