TAILORED TEMPERING

ISMR SAYS:

"Tailored tempering of high-strength and ultra-high strength steels is the key to success"

Following a one-year test phase, AutoForm-ThermoSolver has been in productive use at Daimler since 2012

Photo courtesy of Daimler AG

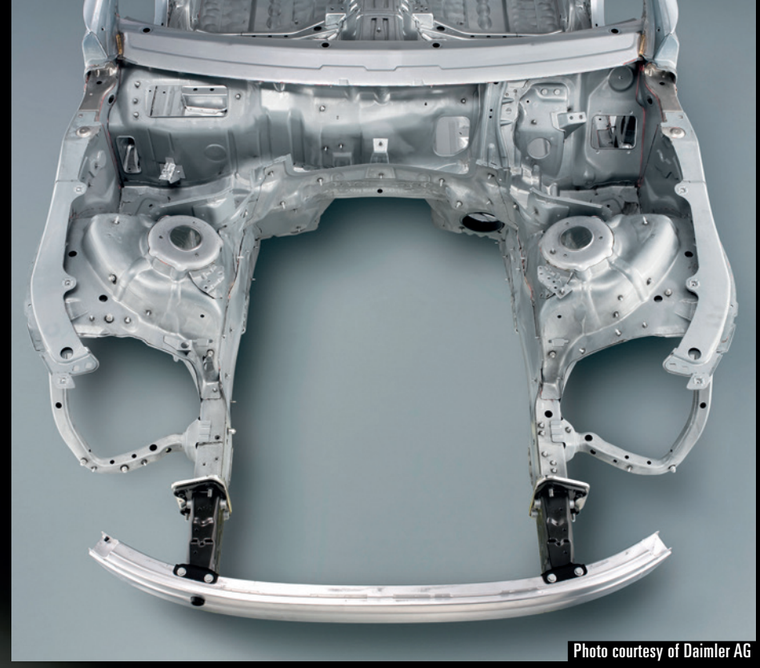


Photo courtesy of Daimler AG

Lightweight construction plays an important role in the automotive industry, particularly in the reduction of fuel consumption and CO_2 emissions. A considerable contribution to this end must therefore also be made by the body-in-white. This can be achieved by using suitable materials and processing them intelligently.

Tailored tempering of high-strength and ultra-high strength steels is the key to success – but also creates many challenges.

Simulation-based design

Daimler solves these challenges by using computer simulation with software from AutoForm Engineering. Determining what the particular forming tool should look like and how the process of tailored tempering should be carried out in detail are demanding tasks. They require a comprehensive understanding of material behaviour, heat flow and the kinetics of phase transformation. In-depth insight into the structural transformation of material is necessary for the analysis and subsequent control of the tailored tempering process.

"It is precisely the complexity of this process that makes simulation-based process design on the computer so helpful. The simulation software, however, must be able to realistically represent the hot forming and quenching processes as well as reliably predict the final part properties and thereby deliver the tooling expertise for this special type of hot forming," AutoForm Engineering told ISMR.

Setting this challenging task as its objective, AutoForm Engineering GmbH succeeded in developing AutoForm-ThermoSolver software which includes a thermo-mechanical model. A temperature history can be delivered by this software for any material point in the sheet metal. As a result, insight into the material behaviour during hot forming and, in particular, quenching is provided.

"All the relevant phenomena and their interaction must be modelled to make a prediction with a reasonable amount of accuracy. On the thermal side, this concerns the heat flow between sheet, tool and environment, where radiation as well as convection must also be taken into consideration. In terms of mechanics, the plastic deformation of the sheet metal must be considered and, from a metallurgical point of view, phase transformation has to be taken into account due to cooling," explained AutoForm Engineering.

After various experiments and tests, AutoForm verified the thermo-mechanical-metallurgical model and identified other decisive parameters.

A testing tool

In co-operation with Daimler AG, an experimental testing tool was developed with systematic tests carried out at the Institute for Manufacturing Technology at the University of Erlangen-Nürnberg. AutoForm contributed with a pilot version of AutoForm-ThermoSolver. This collaboration resulted in the development of fundamental expert knowledge concerning the process window and the resulting material properties which are dependent upon the relevant process parameters.

> "intensive examination of the tailored tempering process also provides important insights for conventional press hardening."

Daimler built a tool for a B-pillar to apply the latest results in the production of a real part and to check the quality of the simulation results. A small batch of B-pillars was then produced at the Sindelfingen plant and mechanical properties were closely and extensively examined. Samples from various areas on the part were tested in tensile tests and results were discussed among the experts at Daimler and AutoForm.

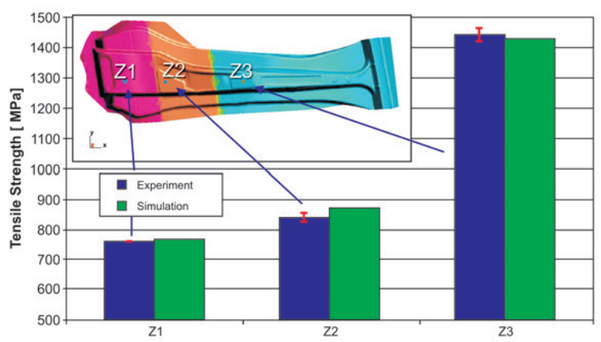
> "In co-operation with Daimler AG, an experimental testing tool was developed"

"All physical influences that are decisive for the accuracy of the results had to be incorporated into the simulation model. Secondary influences were filtered out, which had a resulting positive influence on the speed of calculation," added AutoForm Engineering.

During the course of testing, the collaborating partners decided that latent heat must be taken into account during the cooling process. The final part properties could then be calculated by AutoForm-ThermoSolver with accuracy.

"Results such as tensile strength, tensile stretch, thickness and stress distribution, as well as hardness and martensite distribution, can be clearly illustrated through graphics. The additional calculation time for the tailored tempering process compared to conventional forming was a mere five per cent, on average. This rather modest increase is, in any case, more than justified by the improved understanding of the process," AutoForm Engineering explained.

Tensile strength testing



Editor's Note

AutoForm offers software solutions for die-making and sheet metal forming industries along the entire process chain. With 250 employees dedicated to this field, AutoForm is a leading provider of software for product manufacturability, tool and material cost calculation, die face design and virtual process optimisation. All of the Top 20 automotive OEMs and most of their suppliers have selected AutoForm as their software of choice. See **www.autoform.com**

Successful collaboration

The objectives set for the collaboration between Daimler and AutoForm were therefore achieved. Following a one-year test phase, AutoForm-ThermoSolver has been in productive use at Daimler since 2012.

Even complex process strategies can be calculated with AutoForm-ThermoSolver. Thermo-mechanical influences on material behaviour during part production can now be better taken into consideration. Additional data on the metallurgical calculation model increases the validity and information content of the simulation.

"Last but not least, intensive examination of the tailored tempering process also provides important insights for conventional press hardening. The need for further development on the calculation of thermal distortion was also identified. As a result, intensive work has been carried out over the past few months. The next step in this collaboration is to verify the practical suitability of the latest development and then release it as a future product version of AutoForm-ThermoSolver," the software manufacturer concluded. ■

Refining the process

AutoForm-ThermoSolver enables automotive manufacturers and suppliers to develop and define the processes involved in the hot forming of parts (reinforced sides, A-/B-pillars, front and rear bumper supports and other parts). The software simulates direct and indirect press hardening and supports the tailored tempering process. The development of stamped parts with locally pre-defined strength properties is therefore possible. The simulation takes into consideration the real strength distribution in hot formed parts which improves accuracy in crash simulations.

AutoForm-ThermoSolver graphically illustrates final part properties such as thickness distribution and stress distribution as well as hardness and martensite distribution. This offers engineers insight into the structural transformation of the material.