



New Interface between Casting Process and Forming Simulation

MAGMA Gießereitechnologie GmbH and Simufact Engineering GmbH are pushing forward the integrated simulation of the entire process chain. The new interface between casting process and forming simulation enables the transfer of simulated local properties of the cast part to the subsequent simulation of the forming process.

Management Summary

- Pushing forward the simulation of the entire process chain including casting and subsequent forming operations
- **Efficient optimization of the process chain:** The simulation of the annealing and forming steps now starts with the real temperature profile as the product is handed over from the casting process.
- **Even more realistic starting conditions for forming simulation:** Simulation of the forming process now starts with a workpiece in as-cast shape. The shrinkage cavity of the ingot head is considered in the forming simulation.
- **Improved quality of the formed product:** The forming process can be laid out with the focus to close porosity and voids, which originate from casting.
- **Layout of a robust forming process:** Potential risks for the forming process, which originate from shrinkage porosities inside the workpiece are now identified in early process development stages.
- **Easier and faster setup of forming simulation model:** No need to estimate or reverse-engineer cast ingot geometries.
- **Cost savings:** Replace expensive shop-floor trials by numerical modelling.

This interface is specifically addressing companies which carry out both: casting and (open die) forming operations.

MAGMA Gießereitechnologie GmbH in Aachen, Germany and Simufact Engineering GmbH in Hamburg, Germany are pushing forward the integrated simulation of the entire process chain. The new interface between casting process and forming simulation enables the transfer of simulated local properties of the cast part to the subsequent simulation of the forming process. MAGMASOFT allows to predict various local properties as well as defects in the casting or ingot. Local properties or defects may be affected by the forming process influencing the final part quality after forming. The interfaces to transfer the necessary data are offered by both companies along with the new software releases MAGMASOFT® 5.4 and Simufact Forming 15. They enable the transfer of selected casting properties to the forming simulation for all processes and any casting material like steels, aluminum or others.

MAGMASOFT® is capable to establish robust process conditions and the best possible layout of a casting process for an optimized product quality. All aspects of the casting process are considered, including pouring, solidification, removal of the die and cooling down of the casting. The simulation delivers various criteria describing the quality of a casting part, such as shrinkage distribution, porosity, macro segregation, inclusions at the casting surface. It also allows assessing residual stresses, risk for cracks and local material properties such as tensile strength or ductility.

Although a complex casting process is modelled which involves the die and a casting system, which is considered in the forming simulation, MAGMASOFT® enables to extract the geometry of the particular part, which will be used during forming. In case of a cast ingot the exported information contains the ingot including the lost head shaped by the shrinkage cavity right after solidification.

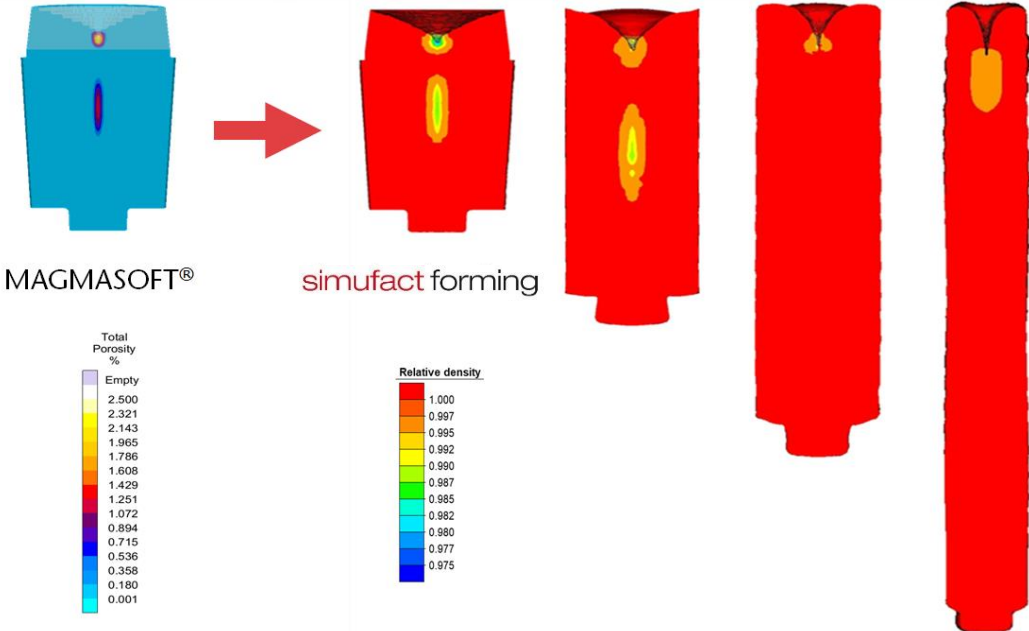
Any required geometrical information as well as the selected casting quality or property data are part of the transfer file to be imported into the Simufact Forming software. Based on the user choice, various application cases can be addressed such as:

- Removal of centerline porosity by the forging process

Cast ingots very often have porosity along the centerline. These local defects are often inevitable, even in an optimized casting process. It is of high importance to judge whether the hydrostatic pressure in the forming process is able to close the voids. Casting process simulation delivers the defect location and gives quantitative data for the local material density. This information is a valuable input to the forming simulation in order to predict the quality of the forged product.

During the forming simulation, the porosity is described by the relative density of the material, which is changed during the forming process based on a simplified adapted material law. Once the relative density reaches one, all voids are closed and the material is fully consolidated. The relative density is not reduced if the hydrostatic pressure decreases again in the process. The maximum hydrostatic pressure needed to close all voids is the only material parameter needed. It can be calibrated easily based on the simulation results. Optionally, a minimum hydrostatic pressure can be specified to include a minimum stress level needed before the voids start to close. For further details, please refer to Simufact Forming documentation and [1].

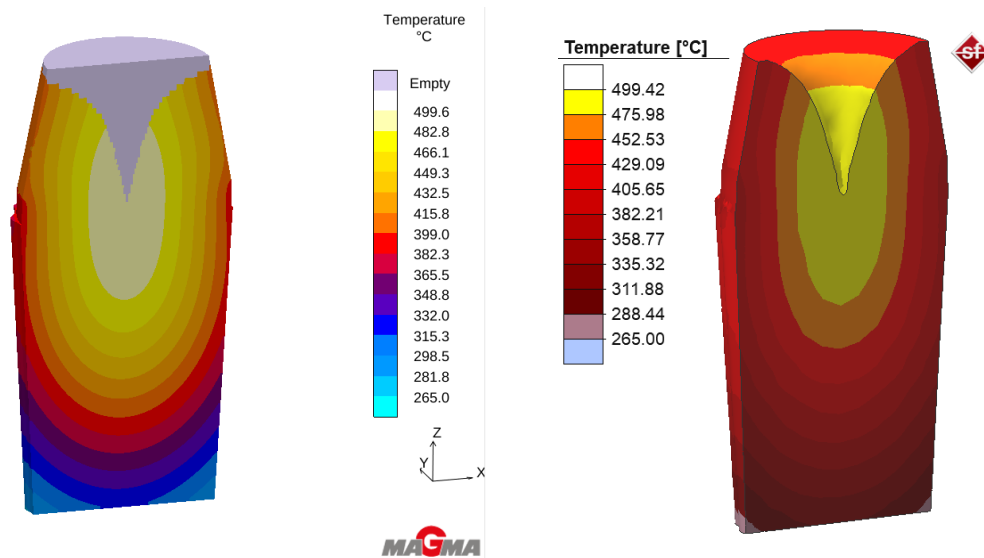
Reduction of porosity predicted by cogging simulation (geometries displayed are not to scale):



- Temperatures after casting as starting point for heat treatment and forming

In order to optimize the energy balance of the entire process chain and to reduce the production time, it might be feasible to transfer the casting in a hot state to the subsequent processes (heat treatment and forming steps). Casting process simulation delivers the temperature distribution at the specified point of time when the casting is moved for further treatment. In this way, the simulation of heat treatment and forming steps can be started based on a precise temperature distribution from the casting process.

Temperature distribution as imported from casting simulation:



Cross-sectional view of the transferred temperature distribution

Ongoing developments together with early adopter customers of the common interface will provide the possibility to transfer additional result values to the forming simulation to further increase the benefits:

- Flow of alloy inhomogeneity during forming

Steel castings may show significant macro segregation, i.e. local inhomogeneity of alloying elements due to convective currents during the casting process. MAGMASOFT® casting process simulation provides information about the distribution of each element in the casting. In the forming process different areas with different local element concentration may be relocated due to the material flow assessed during forming simulation. Therefore, the distribution of elements in the cast part can be an important input to the forming simulation in order to gain information about the local material properties of the final product.

- Inclusions at the casting surface and their effect on the forming process

The presence of non-metallic inclusions may harm the surrounding metal matrix, for example regarding ductility. Therefore, they can locally influence the product quality during the forming process. Casting process simulation delivers information about the probability, the potential location and the extent of re-oxidation inclusions in the casting and at the casting surface. This information is an important input to forming simulation in order to judge how to process a specific casting.

[1] Quality prediction through combined simulation of ingot casting and forging, I. Hahn, M. Schneider, H. Schafstall, C. Barth, Proceedings of the 2nd International Conference on Ingot Casting Rolling & Forging - ICRF2014, 7th-9th May 2014, Milan, Italy.