Chair of Metal Forming and Casting
TUM School of Engineering and Design
Technical University of Munich

Process Chain Optimisation
Casting – Heat Treatment – Machining (IDaP+)

Final Report

Motivation and Approach

The IDaP+ research project investigated the entire process chain comprising casting, heat treatment, and machining. The project was based on the hypothesis that uncertainties in downstream processing can originate in preceding process steps and that considering individual processes separately, with fixed tolerance specifications, leaves optimization potential untapped. A stress lattice and a stator housing served as test geometries. They were produced by gravity or low-pressure casting using 3D-printed sand molds, followed by T6 heat treatment and machining. After each process step, the components were measured and analyzed for geometric deviations and the development of residual stresses.

Results

To optimize the process chain, sensor and control data were linked across processes and integrated into an overall digital model. A molten metal flow sensor was also developed for the low-pressure-casting process to analyze mold filling. No residual stresses were measurable in the sand-cast aluminum components due to their slow cooling. Geometric deviations after casting, however, were attributed to volumetric shrinkage and tolerances in the sand mold. Through iterative compensation, the mean absolute deviation of the stress lattice from the target geometry was reduced from 0.5 to 0.2 mm after a single iteration. Deviations occurring after machining were also reduced by adjusting the immersion direction during heat treatment. The results demonstrate how an integrated analysis of the process steps can help identify the causes of deviations and improve the dimensional accuracy of cast components.

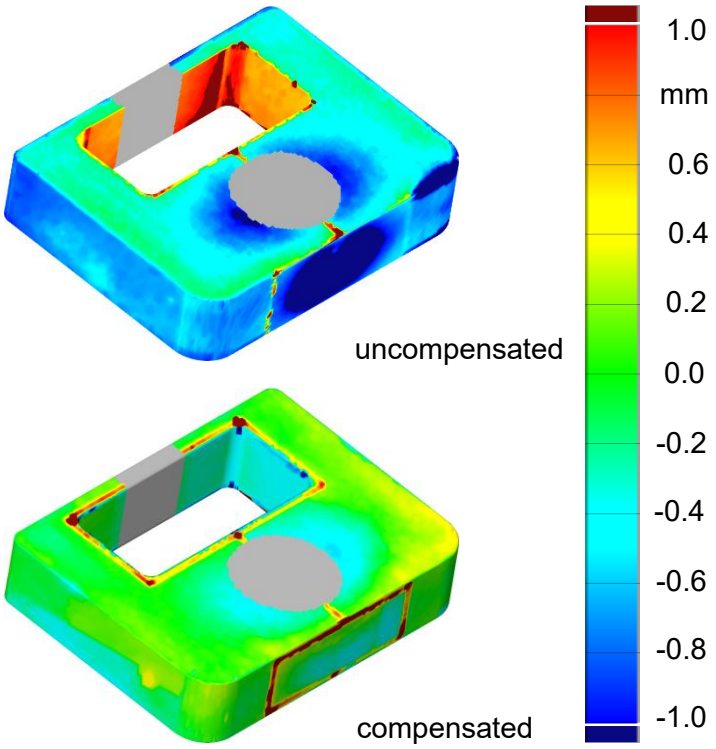

Figure 1 Deviations from the target geometry of the stress lattice after casting, before and after deviation compensation

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Partnerships

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Research done by Georg Fuchs