Chair of Metal Forming and Casting (*utg*)
Department of Mechanical Engineering
Technical University of Munich

Compensation of deviations in bulk-forming

Development of a numerical compensation strategy for deterministic geometrical deviations

Motivation

In bulk-forming, deviations from the desired component geometry often occur. A precise design of the tools is crucial in order to achieve the approximation of the *actual* geometry to the *target* geometry of the part. The compensation of deterministic dimensional deviations currently consists of a very time-consuming iterative process, in which the CAD geometry of the tool is adapted in order to modify the FE mesh. To make this process more efficient, it is necessary to perform a stress-based compensation on a reference point-based replacement model of the part.

Approach

First, it is necessary to be able to derive the replacement model from the *target* geometry. For this purpose, the most important points univocally representing the *target* geometry are identified by the user and selected as reference points. The deviations of the *actual* geometry from the *target* geometry are hence measured only at such reference points.

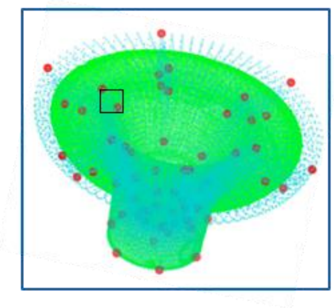

Fig. 1: Comparison *target-actual* geometry and reference points.

Once the replacement model has been decided, the compensation can be carried out. The innovative approach used in the project is a stress-based methodology that can reproduce the adapted tool geometry relying only on the part *target* geometry. In a first linear-elastic finite element analysis, the *target* geometry is deformed to the measured *actual* geometry. This is achieved by applying displacement boundary conditions to the nodes, which are derived from the values of the deviations at the reference points. In this deformed configuration, which now corresponds to the measured *actual* geometry, the stress state is recorded. In a subsequent again linear-elastic FE calculation, this stress state is then applied to the original *target* geometry. As a result of the stress relaxation, a new configuration is obtained, which represents the adjusted *target* geometry. Assuming that the tool geometry corresponds to the *target* geometry during forming, the adapted tool geometry can then be obtained, leading to significantly less deviating final parts.

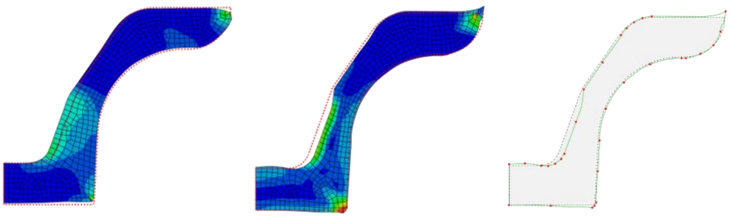

Fig. 2: First and second FE analysis and resulting tool geometry contours.

Conclusion

An innovative compensation methodology based on residual stresses is developed to minimize dimensional deviations in bulk-forming. A crucial step in the compensation strategy is the description of the geometry through a reference point based replacement model and the conversion from the CAD to the FEM world.

Fig. 3: Adapted tool geometry

Scandola Lorenzo, M.Sc.
Walther-Meissner-Str. 4
85748 Garching

Tel. +49 89 289 13 804
Fax +49 89 289 13 738
lorenzo.scandola@utg.de
www.utg.mw.tum.de

Gefördert durch:
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Partner:
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