On the analysis of targeted cooling processes and resulting residual stresses

# Sonja Hellebrand¹\*, Lisa Scheunemann², Dominik Brands¹ and Jörg Schröder¹

1 Institute of Mechanics, Faculty of Engineering, University Duisburg-Essen,

Universitätsstraße 15, 45141 Essen, Germany

[sonja.hellebrand@uni-due.de](mailto:sonja.hellebrand@uni-due.de), [dominik.brands@uni-due.de](mailto:dominik.brands@uni-due.de), [j.schroeder@uni-due.de](mailto:j.schroeder@uni-due.de)

[www.uni-due.de/mechanika/index\_englisch.php](http://www.uni-due.de/mechanika/index_englisch.php)

2 Department of Mechanical and Process Engineering, Technical University Kaiserslautern,

Gottlieb-Daimler-Straße 47, 67663 Kaiserslautern, Germany

[scheunem@rhrk.uni-kl.de](mailto:scheunem@rhrk.uni-kl.de)

Key Words: *residual stresses, austenite-to-martensite phase transformation, cooling process, FE simulations*

Current research focuses on the induction of targeted residual stresses during the manufacturing process of a component in order to improve its properties in a desired manner. Instead of minimizing residual stresses after forming for instance by heat treatment, the idea is to define stress states which are favourable regarding e.g. service life or wear resistance. Therefore, hot bulk forming processes are investigated which allow the utilization of several interactions, for example of mechanical, thermal and metallurgical kind. During forming and cooling of a component, residual stresses arise especially due to the phase transformation from an initially austenitic state. Fast cooling in water or with a spray results in a diffusionless phase transformation to martensite, cf. [1].

There are different numerical approaches to take into account this microscopic phenomena, e.g. one can resolve the microscale in terms of multi-scale Finite Element simulations, see [2]. However, in order to reduce numerical costs, phenomenological single-scale approaches are favourable, see [3]. Thus, in this contribution a phenomenological approach to investigate the cooling of a cylindrical specimen with eccentric hole is presented. Therefore, a thermo-elasto-plastic material model in the linearized framework is implemented into the Finite Element Analysis Programm FEAP, see [4]. Numerical results are shown and discussed in comparison to experimental data.

**REFERENCES**

1. S. Uebing, D. Brands, L. Scheunemann and J. Schröder, Residual stresses in hot bulk formed parts – two-scale approach for austenite-to-martensite phase transformation, *Arch. of. Appl. Mech*., 2021.
2. J. Schröder, *Plasticity and Beyond – Microstructures, Crystal Plasticity and Phase Transitions,* CISM LectureNotes 550, Eds. J. Schröder, K. Hackl, chapter A numerical two-scale homogenization scheme: the FE2-method, 1-64, (2014).
3. S. Uebing, D. Brands, L. Scheunemann, C. Kock, H. Wester, B.-A. Behrens and J. Schröder, Residual Stresses in Hot Bulk Formed Parts – A Phenomenological Approach for the Austenite-to-Martensite Phase Transformation, *13th ICTP*, 2021.
4. R.L. Taylor, FEAP - A finite element analysis program, Version 8.2, 2011.