Numerical thermo-elasto-plastic analysis of residual stresses on different scales during cooling of hot forming parts

S. Uebing*, L. Scheunemann, D. Brands, J. Schröder

* Institut für Mechanik, Abteilung Bauwissenschaften
Universität Duisburg-Essen
Universitätsstr. 15, 45141 Essen, Germany
e-mail: sonja.uebing@uni-due.de, web page: http://www.uni-due.de

ABSTRACT

In actual research, more and more attention is paid to the understanding of residual stress states as well as the application of targeted residual stresses to expand liftime or stiffness among other things. In course of that, the numerical simulation and analysis of the forming process of components, which goes along with the evolution of residual stresses, plays an important role. Temperature dependent forming processes, such as hot bulk forming, offer the opportunity to adjust material parameters, e.g. deformation state, temperature profile or cooling media, independently. Hence, the upsetting test of a cylinder with an eccentric hole at high temperatures on different scales is examined. In this contribution, we focus on the mircoscopic and mesoscopic level. This multiscale view enables a detailed description of phenoma on the microscale such as the lattice shearing from face-centered cubic austenite unit cells to body-centered tetragonal martensite cells and is directly related to the typical classification of residual stresses following [1].

A combination of a Multi-Phase-Field model, see [2], and a twoscale Finite Element method, see [3] is utilized for numerical analysis. A first microscopic simulation considers the lattice change, such that the results can be homogenized and applied on the mesoscale. Based on this result, a polycrystal consisting of a certain number of austenitic grains is built and the phase transformation from austenite to martensite is described with respect to the mesoscale. Afterwards, a twoscale Finite Element simulation is applied to introduce plastic effects and compute resulting residual stress states. In this contribution, the work flow will be explained and some first results will be discussed.

REFERENCES

[1] E. Macherauch, H. Wohlfahrt and U. Wolfstied, *Härterei-Technische Mitteilungen – Zeitschrift für Werkstoffe, Wärmbehandlung, Fertigung*, **28**(3), 201-211, (1973).

[2] I. Steinbach, *Phase-field models in materials science*, Modelling and Simulation in Materials Science and Engineering, **17**(7):073001, (2009).

[3] J. Schröder, *Plasticity and Beyond – Microstructures, Crystal Plasticity and Phase Transitions*, CISM Lecture Notes 550, Eds. J. Schröder, K. Hackl, chapter A numerical two-scale homogenization scheme: the FE2-method, 1-64, (2014).