Prof. Dr.-Ing. Jörg Schröder
Institut für Mechanik
Fak. Ingenieurwissenschaften
Abt. Bauwissenschaften

UNIVERSITÄT DUISBURG ESSEN

Prof. Dr. Axel Klawonn
Lehrstuhl für
Numerische Mathematik
FB Mathematik

Essen, 17.04.08

Seminar Mechanik und Numerische Mathematik

Herr Prof. Dr.-Ing. Rolf Mahnken
Universität Paderborn
Lehrstuhl für Technische Mechanik

„Simulation of a Hybrid-Forming Process considering Thermal Shock Loading and Phase Transformation“

Metal forming processes are important technologies for production of engineering structures. Besides existing processes a new hybrid-forming process has been developed by Steinhoff et al. [1], in particular to improve functionality. In order to optimize the resulting material properties it becomes necessary to simulate the entire forming process by taking in account different physical effects such as cyclic changes in the forming tools material behaviour or phase transformations in the work piece. In this work we concentrate on both, the forming tool and the work piece.

Inhomogeneous cyclic thermo-mechanical stresses and strains lead to higher risks of failure of the forming tool. The first part of our work is the verification of a material model for the material X37CrMoV5-1 and the validation of finite element calculations for a tool-like specimen under complex thermal loadings in order to predict the material behaviour in further applications. To this end thermal shock experiments of tool-like specimens are performed. Optical measuring systems are used for three-dimensional digitalisation of specimens to get a sufficient amount of data. Results of experimental optical measurings and results of finite element calculations are compared. Additionally, damage analysis using the eddy current method is performed to characterize the surface state of the cyclically thermal shocked specimens. This damage analysis provides data for lifetime prediction models under thermal shock conditions.

The second part of our work is the verification of a macroscopic material model for a low-alloy steel, which considers transformation induced plasticity for the phase change from austenite to martensite as well as viscoplastic effects [2]. Further, an effective integration scheme is provided, which is implemented into a commercial finite element program. Parameter identification based upon an extensive amount of experimental data for a low-alloy steel [3] by taking into account the effects of uniaxial compressive and tensile stress on the kinetics of phase transformation at different temperatures is presented. Finally, the austenite to martensite phase transformation in a shaft subjected to thermal loading is investigated in a finite element simulation.

References:
[1] Steinhoff, K.; Weidig, U.; Scholtes, B.; Zinn, W.: Innovative Flexible Metal Forming Processes based on Hybrid Thermo-Mechanical Interaction, Steel Research Int. 76, 154-159 (2005)
[2] Schneidt, A.; Mahnken, R.: Macromodelling of Transformation Induced Plasticity combined with Viscoplasticity for Low-Alloy Steels, Steel Research Int. 79, 110-123 (2008)
[3] Ahrens, U.: Beanspruchungsabhängiges Umwandlungsverhalten und Umwandlungsplastizität niedrig legierter Stähle mit unterschiedlich hohen Kohlenstoffgehalten, Dissertation, University of Paderborn (2003)

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gez. Prof. Dr. A. Klawonn **gez. Prof. Dr.-Ing. J. Schröder**

Telefon: + 49 201 183 23 39, Fax: + 49 201 183 24 26, E-Mail: axel.klawonn@uni-due.de
Telefon: + 49 201 183 26 82, Fax: + 49 201 183 26 80, E-Mail: j.schroeder@uni-due.de