A MULTISCALE APPROACH FOR MODELING THERMOPLASTIC MATERIAL BEHAVIOUR OF DUAL-PHASE STEELS

P. Wriggers[1] and S. Zeller[1] & S. Loehnert[1]

1. Leibniz University Hannover, wriggers@ikm.uni-hannover.de

Focus Material: Metals

Focus of the Presentation: *Physics-based multi-scale model development;*

Abstract

In this work focus is placed placed on the development of material models for dual phase steels subjected to thermomechanical loading at finite strains. Especially the behaviour of the ferritic matrix of dual-phase steels will be investigated. Since the driving mechanisms for the plastic deformation in the ferritic phase are the formation, movement and pile-up of dislocations on preferred planes in preferred directions, many crystal plasticity models for the purely mechanical single crystal behaviour motivated by these mechanisms were proposed in the past. In this work these ideas are extended to thermomechanical material behaviour and a thermomechanical crystal plasticity model is developed for the single crystal behaviour. Attention is paid to the description of the evolution of the microstructure and its dependence on the history of deformation and on the history of temperature of the processes under consideration. Elementary processes of multiplication and annihilation of dislocations are analysed in terms of temperature and deformation rate dependence. Thermal activation is used to describe these dependences and evolution equations are postulated for the state variables describing the current dislocation structure and by this the influence of the deformation and temperature history on current material behaviour. These evolution equations and their temperature and rate dependence are crucial for the formulation of the model. Estimations of the critical resolved shear stress necessary to move dislocations through the crystal resulting from the interaction of dislocations on different slip systems and the resistance of the atomic lattice and the energy associated with a line element of a dislocation allow to formulate a thermoplastic constitutive material model for the single crystal behaviour of the ferritic phase. The developed material model will be used to simulate the material behaviour of the polycrystalline microstructure under different loading conditions.

The developed ideas and the resulting model are transferred to the macroscopic behaviour of sheet metal wrought material consisting of dual-phase steels. Within this homogenization process focus is placed on the consistency between experimental observations on a macroscopic length scale, the belonging constitutive thermoplastic material model on a macroscopic length scale and the developed material model for the single crystal behaviour. Possible forms and dependences on temperature and state variables for the macroscopic thermomechanical material model are deduced. Especially a thermodynamically consistent form for the energy stored in the material is presented