8th. World Congress on Computational Mechanics (WCCM8)
5th European Congress on Computational Methods in Applied Sciences and Engineeering (ECCOMAS 2008)
June 30 –July 5, 2008
Venice, Italy

Discrete transformation-dislocation model

J. Shi[1,⋆], S. Turteltaub[1] and E. Van der Giessen[2]

[1] Delft University of Technology
Faculty of Aerospace Engineering
Kluyverweg 1
2629HS Delft
The Netherlands
{J.Shi,S.R.Turteltaub}@tudelft.nl

[2] University of Groningen
Zernike Institute of Advanced Material
Nijenborgh 4
9747AG Groningen
The Netherlands
E.van.der.Giessen@rug.nl

Key Words: *discrete dislocation plasticity, martensitic transformation.*

ABSTRACT

A discrete model for analyzing the interaction between plastic flow and martensitic phase transformations is developed. The model is intended for simulating the microstructure evolution in a single crystal of austenite that transforms non-homogeneously into martensite. The plastic flow in the untransformed austenite is simulated using a plane-strain discrete dislocation model. The phase transformation is modeled via the nucleation and growth of discrete martenstic regions embedded in the austenitic single crystal. At each instant during loading, the coupled elasto-plasto-transformation problem is solved using the superposition of analytical solutions for the discrete dislocations and discrete transformation regions embedded in an infinite homogeneous medium and the numerical solution of a complementary problem used to enforce the actual boundary conditions and the heterogeneities in the medium. In order to describe the nucleation and growth of martensitic regions, a nucleation criterion and a kinetic law suitable for discrete regions are specified. The constitutive rules used in discrete dislocation simulations are supplemented with additional evolution rules to account for the phase transformation. To illustrate the basic features of the model, simulations of specimens under plane strain uniaxial extension and contraction are analyzed. The simulations indicate that plastic flow reduces the average stress at which transformation begins, but it also reduces the transformation rate when compared to benchmark simulations without plasticity. Furthermore, due to local stress fluctuations caused by dislocations, martensitic systems can be activated even though transformation would not appear to be favorable based on the average stress. Conversely, the simulations indicate that the plastic hardening behavior is influenced by the reduction of the effective austenitic grain size due to the evolution of transformation. During cyclic simulations, the coupled plasticity-transformation model predicts plastic deformations during unloading, with a significant increase in dislocation density. This information is relevant for the development of meso- and macroscopic elasto-plasto-transformation models.