Modeling of austenitic TRIP-steels at small scales – mean-field homogenization and simulation of oligo-crystals

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ABSTRACT

High-alloyed, initially fully-austenitic TRIP-steels show a variety of different inelastic deformation mechanisms, including dislocation glide, twinning and stacking-fault formation as well as martensitic phase transformation. The activation of a particular deformation mechanism depends on the stacking-fault energy of the steel and/or indirectly on the applied temperature through the temperature dependence of the former.

This contribution aims for a two-scale material model that captures the different deformation mechanisms and their interactions by employing an extended version of the mean-field homogenization approach [1, 2]. This concept is suitable for finite deformations and accounts for the inelastic deformation gradient associated with the corresponding inelastic deformation mechanism, e.g. the Bain-strain for phase transformation.

Within the mean-field approach, the constitutive behavior of the corresponding phases is described by a finite deformation, rate-independent single crystal plasticity model incorporating both the elastic and plastic anisotropy of the crystal. The driving forces for the different inelastic deformation mechanisms are properly identified from thermodynamical considerations and associated evolution equations are derived from the corresponding multi-surface criteria, e.g. for twinning and phase transformation. Model predictions for proportional and non-proportional loading histories at the material point level will be presented and thoroughly discussed.

Furthermore, the rate-independent single crystal plasticity model is employed in the simulations of the deformation behavior of oligo-crystalline tensile specimens. Model predictions are compared to experimental results obtained from small-scale testing.

REFERENCES

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