Modelling the coupling between plastic activity and allotropic transformation in iron

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ABSTRACT

Mechanical and structural properties of iron alloys are greatly influenced by their microstructure and local defects population. As massive interplay between these two aspects occur during austenite-ferrite transformation, its understanding is crucial in designing material functionality. In this work, a model, written under the small strain assumption, is built by incorporating transformation-related components into a power functional whose stationarity conditions are equivalent to the thermo mechanical crystal plasticity problem [1]. Evolution of internal variables, including plastic slip increments and fraction of the material locally transformed, are computed through the minimization of the functional. Dislocation glide is regarded as the driving mechanism for mechanical response. Henceforth, dislocation densities are introduced in hardening laws for plasticity. Behavior of the BCC phase is modelled by a statistical formulation inspired from [2] whereas a storing and annihilation law is considered for the FCC phase. A spherical contribution encompasses transformation strain. Besides, a latent heat term is added to account for the thermal effect of the transformation.

In parallel, experiments are conducted with a home-made device on plastically deformed iron samples Joule heated up to the α-γ transformation temperature. To reproduce experimental results, simulations are carried out using Zorglib finite element software. Geometry and grain orientations are extracted from experimental data. Typical grain size is around one millimeter. Samples are loaded mechanically in tension then are subjected to a volume heat source. Conduction is introduced in the volume and radiation conditions are set at free surfaces. Emissivity coefficient is adjusted to fit experimental thermal response. Grains exhibit strong heterogeneities in strain accommodation. An attempt is made to identify how certain nucleation sites are favored by previous plastic activity and what are the preferred schemes for slip systems activity inheritance while passing the transformation.

REFERENCES

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