

SCALE BRIDGING CREEP: ON THE USAGE OF PHASE-FIELD TO MODEL THE CARBIDE GROWTH IN 30CrMoNiV5-11 ALLOY DURING HEAT TREATMENT

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ABSTRACT

The creep lifetime of critical industrial components is strongly influenced by the evolution of alloy microstructural features under (complex) thermomechanical loading^[1]. Accurately predicting the creep life in steel alloys benefits from modeling their complex microstructure evolution. The present work showcases a phase-field framework for modeling the particle kinetics, mainly the carbide growth, of a steel alloy widely used for turbine shaft application, 30CrMoNiV5-11. The long-term objective is to provide a physically-informed digital microstructure to a mean-field creep model, which serves as a bridge to a macroscopic finite element model.

A multicomponent and multiphase phase-field formulation based on the Kim-Kim-Suzuki^[2] (KKS) approach and Moelans et al.'s work^[3] is employed to capture the phase evolution under prescribed stress and temperature conditions, representative of the local thermomechanical loading. The considered alloy has a complex and heterogeneous microstructure; only the key microstructural features (dominant carbides and alloying elements) are considered to simplify the modeling. The governing equations are solved using a fully-implicit GPU-accelerated spectral method.

Experimental data (standard creep tests, EBSD, SEM, TEM, XRD) and Thermo-Calc simulations from the European project AID4Greenest^[4] are leveraged to describe the thermodynamic input of the model and to validate the predicted carbide growth. In addition, systematic comparisons of the particle kinetics quantitative descriptors, i.e. the number density and mean radii, are carried out using the Thermo-Calc PRISMA tool. The resulting digital microstructures provide a consistent basis for subsequent scale transition toward multi-scale creep modeling.

REFERENCES

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- [4] AID4GREENEST (<https://aid4greenest.eu/>)