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A thermodynamically consistent constitutive model for diffusion-assisted plasticity in Ni-based superalloys

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Abstract

An elasto-viscoplastic thermodynamically consistent constitutive model for diffusion-assisted phase transformations is presented here. The model accounts for the different deformation mechanisms, their time dependence, the crystal rotations produced by microtwin propagation and the chemistry-plasticity coupling occurring at high temperature. It is applied to the study of the chemically assisted microtwinning observed in Ni-based superalloys in the temperature range of 600-800°C. The model parameters are calibrated against multi-directional mechanical data from tensile creep tests of single crystal superalloy MD2. The constitutive model is implemented into a crystal plasticity finite element code to study the activation of the different deformation mechanisms within single crystal and polycrystalline aggregates. A relation between the rotations of the crystal and the creep life of the different crystal orientations is established. The results reveal the critical role of the strong anisotropy of microtwin formation on the asymmetric behavior of the alloy and its relevant role on the mechanical performance.

Keywords: creep, crystal plasticity, Ni-based superalloys, phase-transformation

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