Asociación Argentina de Mecánica Computacional

Resúmenes de Mecánica Computacional Vol I, pp. 231-231
C.I. Pairetti, M.A. Pucheta, M.A. Storti, C.M. Venier (Eds.)
A. Albanesi (Issue eds.)
Rosario, November 5-8, 2024

HOMOGENIZED DESCRIPTIONS FOR THE ELASTOPLASTIC RESPONSE OF POLYCRYSTALLINE SOLIDS WITH COMPLEX HARDENING LAWS: APPLICATION TO NEUTRON-IRRADIATED BAINITIC STEELS

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Keywords: steels, irradiation, crystal plasticity, polycrystal, Fast Fourier Transform based method

Abstract. Homogenized descriptions are provided for polycrystalline solids deforming in accordance with certain crystal plasticity laws recently proposed for neutron-irradiated bainitic steels. These laws express intragranular plastic slip rates in terms of resolved shear stresses and key microstructural features, such as densities of forest dislocations and of solute clusters, for a wide range of deformation rates, temperatures, and radiation doses. The elastic domain is delimited by thresholds on the resolved stresses that depend on dislocation densities in an intricate manner, and the plastic hardening is described by evolution laws of the Mecking-Kocks type for the dislocation densities with plastic slip. However, thresholds also depend nonlinearly on the resolved stresses themselves. Full-field homogenized descriptions are generated with a Fast Fourier Transform algorithm implemented in the computer code CraFT, while mean-field homogenized descriptions are generated by means of a linear-comparison scheme based on a generalized-secant linearization of the crystal plasticity laws. Multiple ways of accounting for plastic hardening in the mean-field descriptions are explored. Sample results are reported in the form of uniaxial traction curves and concomitant dislocation density evolutions under different scenarios. Overall, the generalized-secant linearization is found to provide an appropriate compromise between precision and mathematical complexity to generate homogenized descriptions for the elastoplastic response of polycrystalline media governed by complex crystal plasticity laws.

ISSN: 3072-7723 DOI: 10.70567/rmc.v41i22.234