Two-scale FE-FFT-based computational modeling of the local and effective material behavior of viscoplastic polycrystals at finite strains

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ABSTRACT

Recently, two-scale FE-FFT-based methods have been proposed to predict the local and overall mechanical behavior of polycrystalline [1-2] and composite materials [3] for the geometrically linear case. The purpose of this work is the extension to finite strain crystal plasticity [4], efficient and robust Fourier solvers and the prediction of accurate micromechanical fields during macroscopic deformation processes. Assuming scale separation, the macroscopic boundary value problem (BVP) is solved using finite element (FE) methods with a reduced integration formulation and hourglass stabilization yielding one integration point (e.g. Gauss point) per element and locking free element behavior. The solution of the local problem which is attached to each macroscopic Gauss point as a periodic unit cell (UC) is found employing fast Fourier transforms (FFT), fixed-point and Newton-Krylov subspace methods. The overall material behavior is determined by the mean UC response in the usual fashion. In order to ensure both, accurate micromechanical fields and feasible overall computation times, an efficient but rather simple solution strategy [2] for two-scale simulations is employed. Virtual grain structures are generated based on digitalized and edited EBSD maps. As an example, the local and effective material behavior of 42CrMo4 steel is predicted during macroscopic deformation processes (e.g. three-point bending, indentation tests).

REFERENCES

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