A New Eulerian Approach to Crystal Plasticity

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Abstract: Looking at severe plastic deformationexperiments, it seems that crystalline materials at yield behave as a special kind of anisotropic, highly viscous fluids flowing through an adjustable crystal lattice space. High viscosity provides a possibility to describe the flow as a quasi-static process, where inertial and other body forces can be neglected. The flow through the lattice space is restricted to preferred crystallographic planes and directions causing anisotropy. In the deformation process the lattice is strained and rotated.

We present derivation of a model that is based on the rate form of the decomposition rule: the velocity gradient consists of the lattice velocity gradient and the sum of the velocity gradients corresponding to the slip rates of individual slip systems. We employ the Gibbs potential to obtain rate of stress–strain response.

The proposed crystal plasticity model allowing for large deformations is treated as the flow-adjusted boundary value problem. We provide local in time existence result for considered model. As a test example we analyze a plastic flow of an single crystal compressed in a channel die. We propose finite element scheme for a numerical solution in the Arbitrary Lagrangian Eulerian (ALE) configuration.

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