Notes on strain gradient plasticity: Finite strain covariant modelling and global existence in the infinitesimal rate-independent case.

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Abstract

We propose a model of finite strain gradient plasticity including phenomenological Prager type linear kinematical hardening and nonlocal kinematical hardening due to dislocation interaction. Based on the multiplicative decomposition a thermodynamically admissible flow rule for F_p is described involving as plastic gradient $\operatorname{Curl} F_p$. The formulation is covariant w.r.t. superposed rigid rotations of the reference, intermediate and spatial configuration but the model is not spin-free due to the nonlocal dislocation interaction and cannot be reduced to a dependence on the plastic metric $C_p = F_p^T F_p$.

The linearization leads to a thermodynamically admissible model of infinitesimal plasticity involving only the Curl of the non-symmetric plastic distortion p. Linearized spatial and material covariance under constant infinitesimal rotations is satisfied.

Uniqueness of strong solutions of the infinitesimal model is obtained if two non-classical boundary conditions on the plastic distortion p are introduced: $\dot{p}.\tau = 0$ on the microscopically hard boundary $\Gamma_D \subset \partial\Omega$ and $[\operatorname{Curl} p].\tau = 0$ on the microscopically free boundary $\partial\Omega \setminus \Gamma_D$, where τ are the tangential vectors at the boundary $\partial\Omega$. Moreover, we show that a weak reformulation of the infinitesimal model allows for a global in-time solution of the corresponding rate-independent initial boundary value problem. The method of choice are a formulation as a quasivariational inequality with symmetric and coercive bilinear form. Use is made of new Hilbert-space suitable for dislocation density dependent plasticity.

Key words: gradient plasticity, thermodynamics with internal variables, material and spatial covariance, isotropy, plastic spin, rate-independence

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