Plasticity of crystalline solids treated as material flow through adjustable crystal lattice

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Considering severe plastic deformation experiments as a motivation, plastic behaviour of crystalline solids is treated as a highly viscous material flow through an adjustable crystal lattice space [3].

We present thermodynamic derivation of the model of rate dependent crystal plasticity including evolution of Cauchy stress. Unlike the standard approach [4], [1] we follow [5] which is not purely phenomenological. Moreover we extend our approach to rate independent model by implicit constitutive relation between slip rate and resolved shear stress.

Inspired by numerical methods of fluid dynamics FEM Eulerian representation is formulated and applied in a solution of a flow adjustment boundary value problem of equal channel angular extrusion. We compare our results to [2] considering compressible case.

This is joint work with Jan Kratochvíl, Josef Málek, Martin Kružík and Jaroslav Hron.

References

[1] *R. J. Asaro, A. Needleman*: Overview no. 42 Texture development and strain hardening in rate dependent polycrystals. Acta Metallurgica *33* (1985), 923–953.

[2] *O. Cazacu, I. R. Ionescu*: Dynamic crystal plasticity: An eulerian approach. J. Mech. Phys. Solids *58* (2010), 844–859.

[3] *J. Kratochvíl, M. Kružík, R. Sedláček*: A model of ultrafine microstructure evolution in materials deformed by high-pressure torsion. Acta Materialia *57* (2009), 739–748.

[4] *D. Peirce, R. J. Asaro, A. Needleman*: Material rate dependence and localized deformation in crystalline solids. Acta Metallurgica *31* (1983), 1951–1976.

[5] *K. R. Rajagopal, A. R. Srinivasa*: A Gibbs-potential-based formulation for obtaining the response functions for a class of viscoelastic materials. Proc. R. Soc. Lond., Ser. A, Math. Phys. Eng. Sci. *467* (2011), 39–58.