6th European Conference on Computational Mechanics (ECCM 6)
7th European Conference on Computational Fluid Dynamics (ECFD 7)
11-15 June 2018, Glasgow, UK

Stabilised Multi-Slip Strain-Gradient Crystal Plasticity

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Keywords: *Stain-gradient plasticity, Stabilised FEM, Convection-diffusion equations.*

Advanced plasticity models for crystalline materials based on dislocations transport are formulated in terms of dislocations densities in order to make them computationally affordable.

Such aggregated descriptions lead to sets of coupled non-linear partial differential equations of diffusion-convection type. When convection dominates over other transport mechanisms, the most traditional numerical methods fail when applied to approximate their solution. Therefore, dedicated stabilisation techniques must be developed in order to obtain physically meaningful and numerically well behaved approximations [1].

The objective of this communication is to present such a stabilisation technique based on coefficient perturbations and to apply it to a system of dislocation transport equations [2].

The effectiveness of the stabilisation technique is demonstrated through the treatment of 2D crystal plasticity problems involving multiple slip systems coupled with mechanical quasi-static equilibrium [3]. The underlying stabilised dislocation transport model considered is generic, covering most cases of the physical assumptions presented in the literature.

The flexibility and versatility of the proposed stabilisation technique is demonstrated by its ability to easily handle the boundary conditions of the problem at hand, and the non-linearity of the dislocation transport equations. It is also shown that it successfully renders strictly positive numerical approximations which are smooth and free of any spurious oscillations.

REFERENCES

[1] Dogge M.M.W., Peerlings R.H.J., and Geers M.G.D. Extended modelling of dislocation transport-formulation and finite element implementation, *Advanced Modeling and Simulation in Engineering Science*, 2015; **2:29**.

[2] Hernández H., Massart T.J., Peerlings R.H.J., and Geers M.G.D. Towards an unconditionally stable numerical scheme for continuum dislocation transport. *Modelling and Simulation in Materials Science and Engineering* 2015; **23**, No. **8**.

[3] Yefimov S. and van der Giessen E. Multiple slip in a strain-gradient plasticity model motivated by a statistical-mechanics description of dislocations, *International Journal of Solids and Structures*, 2005; **45**, 3375-3394.