Application of the Green Tensor in the Modeling of the Dissolution-Precipitation Creep

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ABSTRACT

The dissolution-precipitation creep is a deformation process in polycrystalline and granular materials which occurs under moderate pressure and high temperature. During this process, material particles dissolve from a part of the crystal boundary and move to another boundary part of the same crystal or to the boundary of another crystal. Although occurring at the level of crystals, this material transport often causes macroscopic motions and deformations.

In this presentation, a mechanical model with a variational structure is proposed for the simulation of the described process. Here, the material time derivative of the elastic energy and the dissipation form the Lagrangian whose minimum determines the state of the deformation in each time step. The elastic energy corresponds to the linear elastic material while the dissipation is adapted to the described process. It depends on two types of velocities: the velocity of the material transport and the velocity of the boundary motion [1]. These velocities are coupled through the condition for the balance of mass.

The evaluation of deformations requires a two-step procedure. The minimization of the Lagrangian with respect to the internal variables yields evolution equations in the integral form which are valid on the boundaries of crystals. This part of the boundary value problem is solved by using the FEM. The minimization with respect to displacements yields the equilibrium equation in the local form for whose solution the method of the Green function is applied [2]. Moreover, as the material with a periodic microstructure is assumed, an application of the Fourier transformation becomes possible [3]. The main advantage of the new-proposed model in comparison with the model presented in [1] is that because of the application of the fundamental solution, the equilibrium and evolution equations are solved only on the boundary of the crystals. The presentation closes with numerical examples concerned with the behavior of a single crystal and a polycrystal when a pressure load has been applied over the long period of time.

REFERENCES

[1] S. Klinge, K. Hackl and J. Renner, “A mechanical model for dissolution-precipitation creep based on the minimum principle of the dissipation potential”, Proc. Roy. Soc. A. (accepted for publication)

[2] M. Koslowski, A. Cuitaño, and M. Ortiz, “A phase-field theory of dislocation dynamics, strain hardening and hysteresis in ductile single crystals”, J. Mech. Phys. Solid, 50, 2597-2635, (2002).

[3] A. Garroni and S. Müller, “Γ-Limit of a phase-field model of dislocations”, *SIAM J. Math. Anal.*, **36(6)**, 1943-1964 (2005).