Slip System Activity in Rate-Independent Crystal Plasticity

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ABSTRACT

One crucial issue in crystal plasticity is the non-uniqueness of the set of active slip systems. This is due to ambiguities in the transformation from local slips on individual slip systems to the global deformation of the whole crystal. Hence, the same global deformation can be achieved by different superpositions of slips on individual slip systems. To avoid this problem, crystal plasticity models are often regularized by the introduction of a viscoplastic potential. However, regularization additionally introduces a certain amount of artificial rate dependency. If the simulated material is expected to behave rate independently the governing parameters have to be tuned to resemble this behaviour leading to several numerical difficulties. In such a case it may be better to treat the system by alternative methods avoiding viscoplastic regularization entirely. One possibility is Maximum Dissipation Crystal Plasticity, a method that has already been proposed by the authors in [1]. Maximum Dissipation Crystal Plasticity is able to come up with a unique set of active slip systems by selection according to the rate of dissipation, i.e., an energy minimization method. The method has been derived in a finite deformation framework and has been implemented into the commercial finite element package ABAQUS as a user material subroutine, working on an integration point level. This ensures maximum usability for arbitrary finite element crystal plasticity problems. It has been shown that maximum dissipation crystal plasticity obtains different results as compared to viscoplastically regularized approaches, e.g., as used in [2], depending on the nature of the hardening matrix. Especially when cross-hardening contributions become important, such that cross-hardening is stronger than self-hardening, the differences are quite considerable. The importance of cross hardening for real materials has been documented in [3]. Further investigation naturally leads to a systematic study of the different results for Maximum Dissipation Crystal Plasticity and the regularized model. In the present contribution this systematic study, where the different entries of the hardening matrix are varied, will be presented and further conclusions will be discussed. Additionally, calculations of a realistic polycrystal will be discussed for both viscoplastically regularized and Maximum Dissipation Crystal Plasticity.

REFERENCES

[1] Markus Orthaber, Thomas Antretter and Hans-Peter Gänser, "On the selection of active slip systems in rate independent crystal plasticity", Key Eng. Mat., **554-557**, 1147-1156 (2013).

[2] C. Gérard, F. N`Guyen, N. Osipov, G. Cailletaud, M. Bornert and D. Caldemaison, "Comparison of experimental results and finite element simulation of strain localization scheme under cyclic loading", Comp. Mat. Sci., **46**, 755-760 (2009).

[3] B. Devincre, L. Kubin and T. Hoc, "Collinear superjogs and the low-stress response of fcc crystals", *Script. Mat.*, **57 (10)**, 905-908 (2007).