The 8th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2022
5 – 9 June 2022, Oslo, Norway

A COMPARISON OF AN EFFICIENT CRYSTAL PLASTICITY FINITE ELEMENT METHOD AND A SPECTRAL SOLVER

Tomáš Mánik[1*], Arash I. Aria[2], Hassan M. Asadkandi[3] and Bjørn Holmedal[4]

[1] Norwegian University of Science and Technology, Trondheim, Norway,
tomas.manik@ntnu.no, www.ntnu.no/ansatte/tomas.manik
[2] Norwegian University of Science and Technology, Trondheim, Norway,
arash.i.aria@ntnu.no, www.ntnu.no/ansatte/arash.i.aria
[3] Norwegian University of Science and Technology, Trondheim, Norway,
hassan.m.asadkandi@ntnu.no, www.ntnu.no/ansatte/hassan.m.asadkandi
[4] Norwegian University of Science and Technology, Trondheim, Norway,
bjorn.holmedal@ntnu.no, www.ntnu.no/ansatte/bjorn.holmedal

Key Words: *Crystal plasticity, Finite element method, Return mapping algorithm, Line search, Spectral method*

A recent fully implicit implementation of a rate-independent crystal plasticity finite element method (CPFEM) [1,2] enables efficient and robust calculations for any realistically large strain increments. Uniqueness of the rate-independent solution is ensured by a regularized crystal yield surface [3]. Fast convergence of the return-mapping algorithm is achieved by a well-chosen initial guess and use of line search as part of the Newton iterations. The algorithm shows excellent stability, even with a yield surface exponent as high as one million, corresponding to a strain rate sensitivity of 10^{-6}. A rate dependent version is also implemented, where the yield surface is replaced by a visco-plastic potential. As an alternative to CPFEM, DAMASK [4], a crystal plasticity simulation tool based on a spectral solver, has been reported to reduce computational costs by 1-2 orders of magnitude compared to CPFEM [5]. This was obtained using a strain rate sensitivity of 0.05. In the current work, uniaxial tension of a polycrystalline representative volume element, deformed up to large strains, is simulated by both CPFEM and DAMASK for strain rate sensitivities down to 0.001. Computational costs and both the global (average) and local model-response are compared and discussed.

REFERENCES

[1] T. Manik, H. M. Asadkandi and B. Holmedal, A robust algorithm for rate-independent crystal plasticity. *Under Review*.
[2] https://gitlab.com/ntnu-physmet/crystal-plasticity
[3] B. Holmedal, Regularized Yield Surfaces for Crystal Plasticity of Metals, *Crystals*, 10, 1076, 2020
[4] F. Roters, et al., DAMASK – The Düsseldorf Advanced Material Simulation Kit for modeling multi-physics crystal plasticity, thermal, and damage phenomena from the single crystal up to the component scale. *Comp. Mat. Sci.* 158, pp. 420-478, 2019
[5] P. Eisenlohr, et al., A spectral method solution to crystal elasto-viscoplasticity at finite strains. *Int. J. of Plast.*, Vol. 46, pp. 37-53, 2013