11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20 - 25, 2014, Barcelona, Spain

Transient Thermo-mechanical Analysis of Dislocation Dynamics

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Key Words: *Dislocation Dynamics, Thermo-mechanical, Transient, and Plasticity*

Dislocation dynamics (DD), where dislocations and dislocation reactions are explicitly modelled, is an effective tool to study plasticity in metals at the micro-scale,. The loading rate in DD simulations is very high, leading to large strain rates. Experimentally in is known that plastic deformation at high strain rates leads to localized increases in temperature due to the high rate of heat generation through plastic work. This increase in temperature impacts the mobility of dislocations and the hardening behaviour of the material. Green's function based DD strategies are quasi-static and neglected thermal effects and so omit important physical processes. We present an XFEM/GFEM transient thermo-mechanical DD model capable of capturing the transient rise in temperature in a plastically deforming metal at high strain rates. The current model builds on a previous XFEM DD models for multi-physics problems [1-3].

In this presentation we will a) present the coupled governing equations for a thermo-mechanical DD model; b) explain the development of discrete equations based on an XFEM approximations of the dislocations; and c) demonstrate the effectiveness of this new DD methodology through several examples.

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