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MULTI-TIME SCALING INDUCED CRYSTAL PLASTICITY FE MODELS FOR PREDICTING FATIGUE IN POLYCRYSTALLINE ALLOYS

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The recent years have seen a paradigm shift towards the use of material microstructure based detailed mechanistic models for predicting fatigue crack nucleation and propagation. These approaches seek accurate description of material behavior through crystal plasticity based finite element models. This talk will present the development of a microstructure based modeling of dwell fatigue crack initiation in polycrystalline alloy Ti alloys. The model implements crystal plasticity theory with explicit grain structures and the mechanical response of polycrystalline aggregates are deduced from the behavior of constituent crystal grains. Finite element calculations show that depending on the loading conditions, significant gradients of stresses or strains can evolve, even within a single slip system. These calculations provide a platform for the implementation of physics based crack nucleation and propagation criterion that accounts for the effects of microstructural inhomogeneity. Systematic development of a crystal plasticity based fatigue crack nucleation model for titanium alloys under dwell loading is conducted in this study.

A major bottleneck with 3D crystal plasticity finite element (CPFE) simulations for fatigue life prediction is the accommodation of large number of cycles to failure, often observed in experiments. In single time-scale CPFE solutions using conventional time integration algorithms, each cycle is resolved into a large number of time steps. A high time step resolution is required for each cycle throughout the loading process, often leading to prohibitively large computational requirements. The presentation will discuss a wavelet transformation based multi-time scaling (WATMUS) algorithm for accelerated crystal plasticity finite element simulations. The WATMUS algorithm does not require any scale-separation and naturally transforms the coarse time scale response into a monotonic cycle scale without the requirement of sub-cycle resolution. The method significantly enhances the computational efficiency in comparison with conventional single time scale integration methods. Adaptivity conditions are developed to improve accuracy and efficiency.

REFERENCES

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