Effect of kinematic hardening on the polycrystalline plasticity of FCC materials, under cyclic deformation

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A crystal plasticity finite element method (CPFEM) has been implemented to investigate the effect of kinematic hardening on the cyclic stress-strain response of face-centered cubic (FCC) materials. We have employed a rate-dependent crystal plasticity constitutive model that incorporates latent hardening due to slip interaction in the 12 slip systems of the FCC crystal [1]. Kinematic hardening due to scalar back-stresses has been defined, assuming pure self-hardening, which restricts the initiation of slip, by modifying the resolved shear stress, at individual slip systems [2]. The back-stresses have been defined using a hardening-dynamic recovery law, by Armstrong-Frederick (AF), and a Ohno-Wang (OW) type evolution law, introduced by McDowell. Cyclic loading simulations were performed in a representative volume element (RVE) consisting of 1000 grains with random orientation. The size of our RVE is 10 units with an element size of 1 unit. Preliminary results from the CPFEM model, using a single cycle of strain with an amplitude of 1.8 %, predicts the stress-strain hysteresis loop reported in [2]. Analysis of the stress-strain response for multiple strain cycles, and sensitivity of our CPFEM model predictions to the hardening and dynamic recovery coefficients in the AF and OW type laws, is currently underway. Additionally, validation of our model predictions with the stress-strain response and hardening behavior of FCC materials under cyclic loading experiments, would be performed. A predictive micromechanical CPFEM model would be instrumental in understanding the gradual degradation of mechanical strength in FCC materials due to accumulated inelastic deformation under fatigue loading conditions.

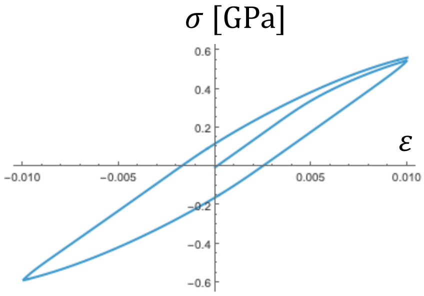

Figure 1. Cyclic stress-stress response for one strain cycle, using the AF type hardening-dynamic recovery law.

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