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Shear Localization in Polycrystalline Metal at High-Strain Rates with Dynamic Recrystallization: Crystal Plasticity Modeling and Texture Effect

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ABSTRACT

Shear localization is an important failure mode, or even the dominant mode in metals at high-strain rates. However, it is a great challenge to accurately predict the occurrence and evolution of shear localization in metals at the high-strain rate deformation. Here, a dislocation-based crystal plasticity constitutive model with a crucial mechanism of shear instability, namely dynamic recrystallization, was developed. The evolution equations of dislocation density and grain size in the process of dynamic recrystallization were proposed and incorporated into the new constitutive model. The threshold of the stored energy in crystals was used as the criterion for the occurrence of dynamic recrystallization. Dynamic compression of a nanograin Cu-Al alloy was performed using the crystal plasticity finite element method based on the new constitutive model, and good agreement of the numerical prediction with the existing experimental data validates the new constitutive model. The results show dynamic recrystallization can be a more dominant mechanism for the occurrence of shear instability than thermal softening. In addition, dynamic tension and shear of the Cu-Al alloys with five typical textures were also simulated, showing that both loading mode and texture can significantly affect the formation of shear localization. This work is helpful for us to understand the role of microstructural evolution in the formation of shear localization at high-strain rates and to design the microstructure for artificially controlling or preventing the formation of shear localization.

KEYWORDS

Dynamic recrystallization; shear localization; high-strain rate; crystal plasticity

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