A nonlinear inelasticity model exhibiting dilatational and distortional inelasticity with a smooth elastic-inelastic transition

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ABSTRACT

Standard rate-independent elastic-plastic theory uses a yield function to distinguish between elastic response and plastic response. In particular, the consistency condition, which requires the yield function to remain zero during loading, causes an abrupt transition between elastic and plastic response with a kink in the stress-strain curve. Lubliner et al. (1993) developed a small deformation rate-independent theory with a yield function and a smooth elastic-inelastic transition. Panoskaltsis et al. (2008) generalized the model in (Lubliner et al., 1993) but the function h used in this generalization limited attention to sharp elastic-inelastic transitions. Einav (2012) generalized previous hypo-plastic and hyper-plastic models, which produce rate-independent smooth stress-strain curves with no elastic range and for which the inelastic deformation rate depends linearly on the total strain rate. More recently, Hollenstein et al. (2013) have developed a large deformation model, which has a smooth elastic-inelastic transition and unifies the notions of rate-independent models with a finite elastic range (e.g. Lubliner et al.; Panoskaltsis et al., 2008), rate independent models with no elastic range (e.g. Einav; 2012) and rate-dependent viscoplastic overstress-type models (Perzyna,1963). Jabareen (2015) developed a numerical integration algorithm, which needs iterations but allows for generalized functional forms and remains strongly objective.

In the present study, a nonlinear thermomechanical model is developed, which exhibits dilatational and distortional inelasticity with a smooth elastic-inelastic transition. The material is considered to be a composite of a thermoelastic component and a dissipative component, with energies and stresses of the composite being separated additively into the energies and stresses of the components. The model unifies rate-independent and rate-dependent responses without the need for special loading and unloading conditions. Inelasticity of the dissipative component includes a rate of inelastic distortional deformation and a new model for the rate of inelastic dilatational deformation.

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