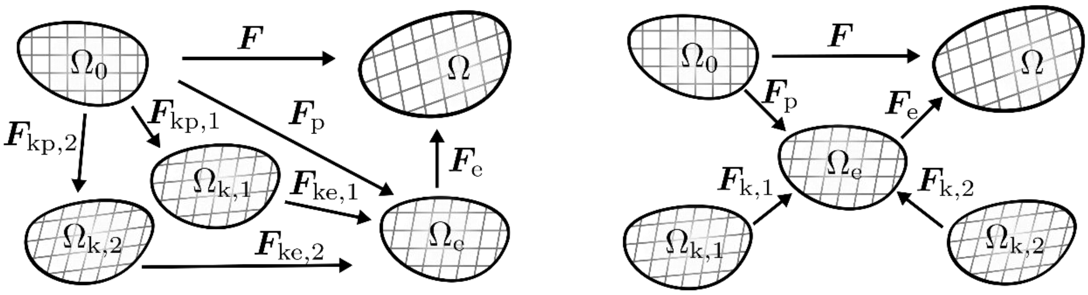
Evaluation of two hyper elastoplastic frameworks for kinematic hardening

Knut Andreas Meyer*, Magnus Ekh

Division of Material and Computational Mechanics,
Chalmers University of Technology
Gothenburg, Sweden
E-mail: knut.andreas.meyer@chalmers.se

For many materials, kinematic hardening has proven necessary when developing realistic constitutive models. In this contribution, two frameworks for modeling kinematic hardening for finite strains, using the multiplicative split of the deformation gradient, have been evaluated. The first was introduced by Lion (2000), in which the model was derived from rheological models. This framework has been used to model sheet metal forming by Reese and coworkers. The second framework, was introduced by Wallin et al. (2003) and has been used to model the Swift effect and large shear strains in railway applications.

The frameworks can be distinguished by how the kinematic configuration Ω_{k} is introduced. In Lion (2000) a multiplicative split of the plastic deformation gradient $\boldsymbol{F}_{\mathbf{p}} = \boldsymbol{F}_{\mathbf{ke}}\boldsymbol{F}_{\mathbf{kp}}$ (Figure 1a) is employed. Wallin et al. (2003) introduce a separate kinematic configuration coupled to the intermediate (elastic) configuration Ω_{e} via the kinematic deformation gradient $\boldsymbol{F}_{\mathbf{k}}$ (Figure 1b).



(a) Lion (2000) (b) Wallin et al. (2003)

Figure 1: The spatial configurations introduced in each framework for two backstresses

To evaluate the frameworks, their abilities to model large biaxial strains have been compared. Standard numerical examples, such as uniaxial tension and simple shear are considered first. Thereafter, the models have been compared with experiments on a fully pearlitic steel: Solid cylindrical specimens were twisted in steps of 90° until failure, while subjected to an axial stress. For the case of -500 MPa nominal axial stress, failure occurred at the shear deformation gradient component $F_{\phi z} = 1.75$. A modified kinematic evolution law based on Burlet and Cailletaud (1986) was found necessary to accurately model the biaxial material response seen in the experiments.

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