Identification and Integration of Directional Distortional Hardening Model in Case of Monotonic Proportional Loading

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ABSTRACT

Distortion of yield surfaces due to plastic deformation of metals has been experimentally demonstrated by several authors [1,2]. A distorted yield surface exhibits higher curvature in the direction of loading, while it becomes flattened in the opposite direction. Such a behavior is referred to as the directional distortional hardening (DDH) [3,4].

A thermodynamically consistent DDH model extending the von Mises yield criterion was introduced in [4]. The model uses a fourth-order tensor-valued internal variable to capture yield surface distortion. Consequently, simplified versions of the model were published by same authors [5]. The simplest form defines the yield condition as

$$\frac{3}{2}\left(1 - c\boldsymbol{\alpha}\colon\frac{\boldsymbol{s}-\boldsymbol{\alpha}}{\|\boldsymbol{s}-\boldsymbol{\alpha}\|}\right)(\boldsymbol{s}-\boldsymbol{\alpha})\colon(\boldsymbol{s}-\boldsymbol{\alpha}) - k^2 = 0, \tag{1}$$

where $\boldsymbol{s}$ is the deviatoric stress tensor, $\boldsymbol{\alpha}$ is the back-stress tensor, k is the isotropic hardening parameter, and c is the distortional parameter.

In order to use model in connection with return mapping algorithms, conditions for maintaining convexity of the yield surface (1) must be met as shown in [6]. These conditions are represented by restrictions on model's internal parameters and complement a set of restrictions for thermodynamic consistency.

The model can be completely integrated in analytical way. This treatment results in an analytical relation for stress-strain curve and may be used for analysis of the model and verification of numerical implementation. Moreover, a new option for identification of model's was developed by this integration.

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