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NUMERICAL IMPLEMENTATION OF A SIMPLE MODEL FOR DIRECTIONAL DISTORTIONAL HARDENING IN METAL PLASTICITY

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As seen in numerous experiments, yield surfaces change their shape and location during plastic straining. Several models of directional distortional hardening to capture such behavior have been proposed recently. Their application lies in sheet metal forming processes, in combined ratchetting, or in any application containing sequenced non-proportional plastic straining.

The presented work outlines and tests the finite element implementation of the simplest form of directional distortional hardening models proposed in [2] by Feigenbaum and Dafalias – a model derived from a more complex one in [1], which involves a fixed scalar distortional parameter. Here, the directional distortion is dictated by the scalar contraction of the backstress tensor $\boldsymbol{\alpha}$ and the unit radial tensor $\mathbf{n}_\mathrm{r}$. Therefore, possible shapes of predicted subsequent yield surfaces are limited to certain size, position and elongation of the shape with orientation always facing from the origin, as demonstrated in Figure 1. The evolution equations are based on the Armstrong-Frederick evanescent memory type hardening rule. The associative flow rule is adopted. Properties of the model are thoroughly studied in connection to convexity condition derived in [3] and later to numerical stability.

The explicit integration scheme with subincrementation, the tangent stiffness-radial corrector method, is employed. Size limitations of integration increments are discussed in a series of iso-error maps. The implementation is verified by a comparison of numerical results with analytical solutions pertinent to proportional load cases. Complex non-proportional loading paths are verified by a very fine numerical computation. Finally, the template of this implementation is presented.

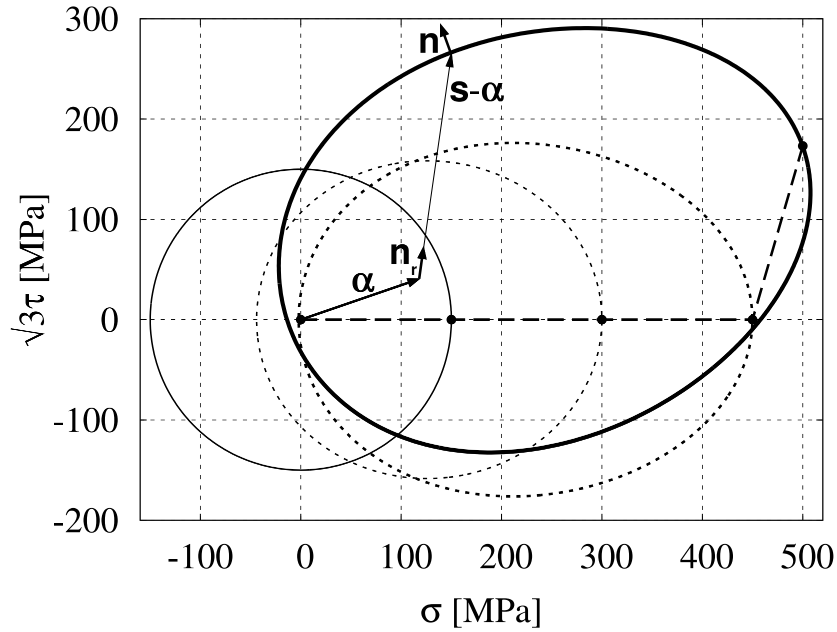

Figure 1: Yield surface evolution – simple tension and tension-shear combined

This work studies phenomena in numerical implementation related to the yield surface shape distortion, therefore, it will help with other models to come.

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