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A convex fourth order yield function for orthotropic metal plasticity. (English)

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Summary: *M. Gotoh* [Int. J. Mech. Sci. 19, 505–512 (1977; Zbl 0373.73038)] proposed the first fourth order polynomial yield function under plane stress states that could simultaneously represent both yield stress and r-value directional properties of orthotropic sheet metals. The parameter identification procedure of this model can result in unbalanced overall errors in the anisotropy description, and the convexity of this yield function is not guaranteed. In this regard, a direct method is proposed to uniquely determine the nine model parameters using four yield stress and three r-value measurements. Out of them, only three expressions are new, and the rest remain identical to the published version of Gotoh. However, it is necessary to check the convexity restrictions on the obtained model parameters. Therefore, model parameters of two dissimilar materials that violate these restrictions are accurately identified from the literature. And, an effective procedure to reestablish the yield function convexity using new bounds on equi-biaxial stress is suggested. In the second part, an inverse method for the identification of the yield function parameters is proposed. In this approach, seven nonlinear expressions are solved together to determine the nine parameters of the convex guaranteed Gotoh's yield function. The advantages and disadvantages of two methods are discussed in detail by comparing with the existing ones in recent literature. It is shown that both these methods are successful in representing the anisotropic behavior of both aluminum and steel experimental data's available in the literature. In addition, a new 3D extension of the Gotoh's yield function is suggested by introducing four additional parameters to capture the influence of out of plane shear stresses. When all the parameters are set to a unit value, the yield function exactly coincides with the 3D von-Mises yield function. Further, the direct approach is extended to account for distortional hardening behavior of fcc and bcc materials.

MSC:

74C05 Small-strain, rate-independent theories of plasticity (including rigid-plastic and elasto-plastic materials)

74E10 Anisotropy in solid mechanics

Keywords:

sheet metal forming; rate-independent elastoplasticity; associated flow rule; orthotropic yield function; yield stress; Lankford coefficient

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