

## Advances in Constitutive and Failure Models for Sheet Forming Simulation

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Non-Associated Flow Rule (Non-AFR) can be used as a convenient way to account for anisotropic material response in metal deformation processes, making it possible for example, to eliminate the problem of the anomalous yielding in equibiaxial tension that is mistakenly attributed to limitations of the quadratic yield function, but may instead be attributed to the Associated Flow Rule (AFR). Seeing as in Non-AFR based models two separate functions can be adopted for yield and plastic potential, there is no constraint to which models are used to describe each of them. In this work, the flexible combination of two different yield criteria as yield function and plastic potential under Non-AFR is proposed and evaluated. FE simulations were carried so as to verify the accuracy of the material directionalities predicted using these constitutive material models. The stability conditions for non-associated flow connected with the prediction of yield point elongation are also reviewed. Anisotropic distortion hardening is further incorporated under non-associated flow. It has been found that anisotropic hardening makes the noticeable improvements for both earing and spring-back predictions. This presentation is followed by a discussion of the topic of the forming limit & necking, the evidence in favor of stress analysis, and the motivation for the development of a new type of forming limit diagram based on the polar effective plastic strain (PEPS) diagram. In order to connect necking to fracture in metals, the stress-based necking limit is combined with a stress-based fracture criterion in the principal stress, which provides an efficient method for the analysis of necking and fracture limits. The concept for the PEPS diagram is further developed to cover the path-independent PEPS fracture which is compatible with the stress-based fracture approach. Thus this fracture criterion can be utilized to describe the post-necking behavior and to cover nonlinear strain-path. Fracture modeling in the stress space including mean stress contribution is also conducted and compared with M-C criterion. Strain-path effect on fracture criteria and the role of a damage parameter have been also discussed.

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