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Prediction of forming limit curve at fracture for sheet metal using new ductile fracture criterion

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Abstract: Application of a ductile fracture criterion (DFC) can lead to an accurate determination of the fractures in the sheets. In this study, a new uncoupled ductile fracture criterion has been developed which considers the material parameter effects on the FLCs and can simply be implemented to the finite element codes. Two different constitutive models have been employed with the new DFC in order to evaluate the results obtained for fracture prediction. Various experimental tests have been utilized to validate the new criterion and its results are also compared with other well-known uncoupled DFCs. It is observed that the new criterion predicts the ductile fracture for all aluminum, steel and stainless steel materials better than the former criteria.

Keywords: Fracture, Anisotropic material, Constitutive behavior, Energy methods, Finite elements

1. Introduction

Forming limit curves (FLC) have been extensively used to evaluate formability in the sheet metal forming industry. The first FLC was experimentally plotted using the grids of circles printed or etched before the forming. There are many theoretical FLCs developed by simply drawing the curve and avoiding the costly and time consuming experimental tests. The most well-known models are based on the localization and bifurcation theories. However, FLCs have some shortcomings which limit their effectiveness in the processes struggling with nonlinear strain paths or fracture phenomena. Chakrabarty et al. (2005) and Yoshida et al. (2007) and Nurcheshmeh et al. (2011) studied the effect of changing strain paths on the forming limit curves (FLC) and forming limit stress curves (FLSC) of sheet metals using phenomenological plasticity models. They showed that the nonlinear loading path will significantly affect the FLCs functionality.

Some researchers tried to find the relations between material parameters and FLCs to decrease the uncertainty of the FLCs. Bleck et al. (1998) studied three kinds of theoretical forming limit curves in the forming of (IF) steels. They concluded that forming limit diagram is affected by the thickness of the blank, the yield and tensile