Formability Limit Prediction of TRIP780 Steel Sheet Using a Lode Angle Dependent Gurson-Based Model with Thomason Coalescence Criterion and Bifurcation Analysis

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Abstract. For biaxial stretching strain paths, which are typically encountered in sheet metal forming, the stress triaxiality is low, i.e. 0.33 to 0.67. At this level of triaxiality, voids change their shape from spherical to general spheroidal shape. In the literature, unit cell study shows the dependency of void shape on the lode parameter, especially at low stress triaxiality. Many authors also pointed out the influence of lode parameter on ductile failure. In the current study, a lode parameter dependent Gurson-based model (which is an enhanced extension from the original Gurson (1977) model) is combined with the Rice (1976) localization criterion for the prediction of formability limits of TRIP780 steel sheet. Moreover, Thomason's (1985) coalescence criterion is considered for the prediction of critical porosity. For the anisotropic plastic behavior of the dense material, the quadratic Hill (1948) yield surface is used. Porosity evolution due to shear mechanism, as a monotonic decreasing function of lode parameter is analyzed. In addition, the effect of lode parameter on the prediction of forming limit diagram (FLD) is investigated. It is observed that the accelerated evolution of porosity, due to the consideration of lode parameter, induces lower ductility limits for the modified Gurson-based model, as compared to the original Gurson model. The results also demonstrate that the use of the Thomason coalescence criterion for the determination of critical porosity plays an important role on the prediction of FLDs, as compared to fixed critical porosity used with the conventional Tvergaard and Needleman (1984) coalescence criterion. On the whole, the FLD predicted with the developed numerical tool is in accordance with the experimental FLD.

REFERENCES

A. L. Gurson, (1977). Continuum theory of ductile rupture by void nucleation and growth: Part I—Yield criteria and flow rules for porous ductile media. *Journal of Engineering Materials and Technology*, 99(1), 2–15.

R. Hill, (1948). A theory of the yielding and plastic flow of anisotropic metals. *Proc. R. Soc. Lond. A*, 193(1033), 281–297.

J. R. Rice, (1976). The localization of plastic deformation. In: Koiter (Ed.), *Theoretical and Applied Mechanics*, 207–227.

P. F. Thomason, (1985). A three-dimensional model for ductile fracture by the growth and coalescence of microvoids. *Acta Metallurgica*, 33(6), 1087–1095.

V. Tvergaard, A. Needleman, (1984). Analysis of the cup-cone fracture in a round tensile bar. *Acta Metallurgica*, 32(1), 157–169.