FORMING LIMIT DIAGRAMS FOR PERFECT AND IMPERFECT SHEETS USING PLASTIC MODELS WITH TWO POROSITIES

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Abstract

Localised necking in biaxially stretched sheets is investigated using a rate independent porous plastic constitutive relation with two porosity parameters; one associated with the

void volume fraction and the other associated with the weakening effect of void shape

changes in shear dominated stress states.

Imperfection localisation analysis is performed, where band imperfection triggers the onset

of localised necking as defined by a loss of ellipticity of the governing equations in the

band. This band imperfection is taken to be either an increase in initial void volume fraction

or an increase in the volume fraction of void nucleating particles.

Proportional straining plane stress calculations are carried out for ratios of imposed in-plane

principal strain rates ranging from –1 (shear) to 1 (equal biaxial tension). The predicted

forming limit curves are compared with predictions for a localised necking bifurcation of an

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elastic-plastic solid.

In the bifurcation analysis, four regimes are observed in the forming limit diagram: (i) a

shear softening dominated regime; (ii) a plastic properties dominated regime; (iii) a porosity

induced localisation regime $0 \leq \rho \leq 0.4$; and (iv) a porosity induced failure regime (loss of

load carrying capacity).

In the imperfection localisation analysis, for negative values of the imposed strain ratio,

except for near pure shear where the second porosity reduces the critical strains, the

predicted critical localisation strains and the predicted critical localisation band orientations

differ little from the corresponding critical values predicted by the bifurcation analysis. For

biaxial tensile states the critical localisation strains are sensitive to the nature and magnitude

of the imperfection. Besides, when void nucleation occurs over a very narrow range of strain or stress, void nucleation and the onset of localised necking can coincide.