11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20 - 25, 2014, Barcelona, Spain

COMPETITION BETWEEN ASB AND VOID GROWTH ASSISTED SHEAR FAILURE MECHANISMS: UNIFIED MODELLING AND APPLICATIONS

Patrice Longère[1]* and André Dragon[2]

[1] Université de Toulouse, Institut Supérieur de l'Aéronautique et de l'Espace (ISAE), Institut Clément Ader (ICA, EA 814), 10 avenue Edouard Belin, BP 54032, 31055 Toulouse cedex 4, France, patrice.longere@isae.fr, http://www.institut-clement-ader.org

[2] CNRS-Institut Pprime (UPR 3346), ISAE / Ecole Nationale Supérieure de Mécanique et d'Aérotechnique - Université de Poitiers, 1 avenue Clément Ader, BP 40109, 86961 Futuroscope - Chasseneuil du Poitou, France, andre.dragon@ensma.fr, http://www.pprime.fr/

Key Words: *Shear, Ductile Fracture, Adiabatic Shear Banding, Constitutive Modelling.*

Numerous are the engineering problems, including metal forming processes as well as accidental overloads, involving crack initiation and propagation under low stress triaxiality. Yet, whereas the metal fracture under tension dominated loading is quite well understood – resulting mostly from void germination, growth and coalescence –, there remain gaps to fill in the comprehension and description of metal failure under shear dominated loading.

Starting from experimental observations, the present work aims at reproducing via a unified model the consequences of two deterioration mechanisms occurring under low and high strain rate shear loadings, respectively, namely void growth induced damage and adiabatic shear banding.

The material considered in the present work is a high strength Ti-6Al-4V titanium alloy.

In order to study the underlying mechanisms at the origin of shear failure in the material at stake, we have carried out experiments involving shear-pressure combined loading at low and high strain rates. To observe the current and ultimate deterioration states, some tests were interrupted before fracture and other ones were conducted until ultimate failure.

At low strain rate, involving quasi isothermal conditions, the material failure has been seen to result from void growth and further dimple formation, in spite of the pressure applied. Applying the back mean stress concept to a Gurson type material, see [1], Longère and Dragon, see [2], manage to reproduce the inelastic dilatancy which accompanies the void growth observed experimentally during low strain rate shear-pressure combined loading.

At high strain rate, involving quasi adiabatic conditions, the material failure has been found to result from the adiabatic shear banding (ASB) localisation mechanism, as expected for this class of alloys. Longère and Dragon, see e.g. [3], developed an embedded band based approach able to reproduce the effects, in terms of supplementary kinematics and material degradation, induced by the formation of ASB within a representative volume element.

The purpose of the present contribution is to present a way of incorporating both the aforementioned back mean stress concept and embedded band based approach within a unified constitutive framework in view of reproducing the material deterioration under void growth or/and adiabatic shear banding. Of course, no tractable model would result from the mere superposition of the models cited above. A reasonable compromise has indeed been searched between conceptual pertinence and complexity of the unified approach and the tractability of the formalism, a number of material parameters to be identified, etc.

REFERENCES

[1] Gurson A.L., 1977, Continuum theory of ductile rupture by void nucleation and growth: Part I – Yield criteria and flow rules for porous ductile media, J. Eng. Mat. Tech., 99, pp.2-15

[2] Longère P., Dragon A., 2013, Description of shear failure in ductile metals via back stress concept linked to damage-microporosity softening, Eng. Fract. Mech., 98, pp.92-108

[3] Longère P., Dragon A., Deprince X., 2009, Numerical study of impact penetration shearing employing finite strain viscoplasticity model incorporating adiabatic shear banding, J. Eng. Mat. Tech., ASME, 131, pp.011105.1-14