6th European Conference on Computational Mechanics (ECCM 6)
7th European Conference on Computational Fluid Dynamics (ECFD 7)
11-15 June 2018, Glasgow, UK

Ductile failure under cyclic loadings: modeling and simulation

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Keywords: *Ductile failure, Isotropic hardening, Kinematic hardening, Cyclic loadings*

This contribution is devoted to the modeling and simulation of ductile failure under cyclic loadings. Under such conditions, a reduction of ductility is observed, due to an effect of gradual increase of the mean porosity (volume fraction of voids) during each cycle, known as the ratcheting of the porosity. This effect of ratcheting, which is not predicted by Gurson's model [1], is fundamentally tied to two features of the material behaviour, namely strain hardening and elasticity [2].

First, we develop a Gurson-type, micromechanically-based model accounting for both isotropic and kinematic hardening. The derivation is based on a sequential limit-analysis of a hollow sphere made of a rigid-hardenable material [3]. The heterogeneity of the hardening is accounted for by discretizing the cell into a finite number of spherical phases in which the quantities characterizing hardening are considered as homogeneous.

The model is compared to finite element simulations. First, overall yield loci are investigated for both isotropic and kinematic pre-hardening. Then, evolution problems under conditions of fixed triaxiality are studied. Various hardening laws are considered (isotropic, kinematic and mixed), leading to a ratcheting of the porosity as well as a "belly-shaped" evolution of the porosity, which are in general well reproduced by the model. The effect of elasticity, evidenced by the numerical simulations, is finally discussed.

REFERENCES

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

[2] R. Lacroix, J.B. Leblond and G. Perrin, Numerical study and theoretical modelling of void growth in porous ductile materials subjected to cyclic loadings, *European Journal of Mechanics - A/Solids*, Vol. **55**, pp. 100–109, 2016.

[3] L. Morin, J.C. Michel and J.B. Leblond, A Gurson-type layer model for ductile porous solids with isotropic and kinematic hardening, *International Journal of Solids and Structures*, Vol. **119**, pp. 167–178, 2017.