Numerical investigation of void growth with respect to lattice orientation in bcc single crystal structure

E.E. Asik*, E.S. Perdahcioglu and A.H. van den Boogaard

University of Twente, Faculty of Engineering Technology, Nonlinear Solid Mechanics,
P.O. Box 217,7500 AE, Enschede, The Netherlands
e-mail: e.e.asik@utwente.nl, web page: http://www.utwente.nl/et/

ABSTRACT

Failure of ductile metals has widely been observed to occur by nucleation, growth and coalescence of voids [1]. Plastic anisotropy has a key importance on the growth and strain distribution leading to coalescence of the voids in addition to the stress state [2,3]. In this study, growth of pre-existing voids in bcc single crystals were investigated by using rate independent crystal plasticity framework. Deformation of bcc crystal structure was modeled by using two different approaches, namely, with 24 potential slip systems of {110}<111> and {112}<111> types and with non-Schmid effects on {110}<111> slip system and the resultant deformation was compared with respect to each other [4,5]. Finite element simulations were conducted based on 2D plane strain calculations of a unit cell with one cylindrical void. Fully periodic boundary conditions were employed during the deformation of the unit cell under uniaxial and biaxial loading conditions. Unit cell with one hole was used to investigate the effect of lattice orientation on the growth and shape change of the voids. It was observed that the lattice orientation had an immense effect on the distribution of strain within the unit cell. Furthermore, various hole sizes were used to model the effect of inter-void spacing in order to investigate strain distribution between voids, which may lead to coalescence and failure.

REFERENCES

[1] V. Tvergaard, "Material failure by void growth to coalescence." *Advances in applied Mechanics*, **27**, 83-151 (1989).

[2] J.R. Rice, and D.M. Tracey. "On the ductile enlargement of voids in triaxial stress fields∗." *Journal of the Mechanics and Physics of Solids*, **17**, 201-217, (1969).

[3] S. K. Yerra, C. Tekog, F. Scheyvaerts, L. Delannay, P. Van Houtte, and T. Pardoen. "Void growth and coalescence in single crystals." *International Journal of Solids and Structures*, **47**, 1016-1029, (2010).

[4] C. Miehe, and J. Schröder. "A comparative study of stress update algorithms for rate-independent and rate-dependent crystal plasticity." *International Journal for Numerical Methods in Engineering*, **50**, 273-298, (2001).

[5] D. Cereceda, M. Diehl, F. Roters, D. Raabe, J.M. Perlado, and J. Marian. "Unraveling the temperature dependence of the yield strength in single-crystal tungsten using atomistically-informed crystal plasticity calculations." *International Journal of Plasticity*, **78**, 242-265, (2016).