Analysis of the Stress-state-dependent Damage and Failure Behavior of Ductile Metals under Biaxial Loading Conditions

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ABSTRACT

The presentation deals with experimental and numerical analysis of ductile metals based on biaxial experiments and corresponding numerical simulations to characterize the stress-state-dependent damage and failure behavior. Investigations ([1], [2], [3]) have shown that damage mechanisms, including growth and coalescence of voids as well as micro-shear-cracks, depend on the stress state. In this context, a thermodynamically consistent anisotropic continuum damage and failure model for ductile metals [4] with a kinematic definition of damage tensors is used. Considering fictitious undamaged configurations, the model contains a stress-state-dependent yield condition and a stress-state-dependent non-associated flow rule to characterize the plastic behavior. Modeling of damage behavior is related to damaged configurations and is described by a stress-state-dependent damage criterion and a damage rule.

A series of biaxial experiments with different proportional tension-compression loadings and corresponding numerical simulations have been performed to analyze stress states and damage behavior. The geometry of the specimen [5] is characterized by different notches in order to obtain localized strains and to investigate the damage and failure behavior. Therefore, critical regions of the specimens were recorded during the experiments with a digital image correlation technique to evaluate strain fields. In addition, force-displacement diagrams were created to compare the global behavior between experiments and numerical simulations. Furthermore, scanning electron microscopy images were made to detect relations between damage mechanisms and occurring stress states.

REFERENCES

[1] Y. Bao and T. Wierzbicki. On fracture locus in the equivalent strain and stress triaxiality space. *International Journal of Mechanical Sciences*, 46, 81–91, 2005.

[2] M. Brünig, O. Chyra, D. Albrecht, L. Driemeier and M. Alves. A ductile damage criterion at various stress triaxialities. *International Journal of Plasticity*, 24, 1731–1755, 2008.

[3] X. Gao, G. Zhang, C. Roe. A study on the effect of stress state on ductile fracture. *International Journal of Damage Mechanics*,19 ,75–94, 2010.

[4] M. Brünig. An anisotropic ductile damage model based on reversible thermodynamics. *International Journal of Plasticity*, 19, 1679–1713, 2003.

[5] S. Gerke, P. Adulyasak, M. Brünig. New biaxially loaded specimens for the analysis of damage and fracture in sheet metals. *International Journal of Solids and Structures*, 110-111, 209–218, 2017.