The Performance and Prediction Ability of Advanced Approach to Ductile Fracture

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ABSTRACT

The present paper deals with the modelling of ductile fracture which is the result of severe plastic deformation [1]. It can be result of a crash or accident [2] or introduced intentionally [3]. There is a need of increasing the safety in many fields of industrial sector or transportation. One option of studying the limit states is the computational modelling [4], besides experimenting [5]. The aluminium alloy 2024-T351 is widely used for studies of ductile fracture [6]. The material was supplied as a cold-rolled plate for this study and examined within a broad range of stress states. First of all, the flow curve was determined using the standard tensile test of smooth cylindrical bar [7]. Then, the tensile tests of variously notched cylindrical bars were conducted to show the pressure dependence. The tensile and torsion tests of notched tube were added in order to document the dependency on the deviatoric stress state. Finally, the compression test of smooth cylinder was executed. Then, deviatoric stress state dependent plasticity and the original ductile fracture hyperbolic criterion were calibrated. The damage accumulation nonlinearity was examined through loading–unloading experiments. The double damage curve approach from fatigue was revisited and calibrated using the semi-cyclic testing [8]. Finally, the softening effect was studied aiming to couple the damage with plasticity [9]. The performance and prediction ability was verified after the model was completely calibrated and implemented into the Abaqus finite element software. Three different cases of tension were chosen for this comparative purpose. The tension of notched cylindrical and tubular specimens and flat specimen. The ductile fracture criterion coupled with plasticity should provide the slant fracture in the conditions of plane strain due to localization [10]. Nevertheless, it is shown that the proposed approach has still some drawbacks in prediction of the crack propagation.

REFERENCES

[1] M. Dunand and D. Mohr, “On the predictive capabilities of the shear modified Gurson and the modified Mohr–Coulomb fracture models over a wide range of stress triaxialities and Lode angles”, *J. Mech. Phys. Solids*, **59**, 1374–1394 (2011).

[2] R. Törnqvist, *Design of crashworthy ship structures*, PhD Thesis, Technical University of Denmark (2003).

[3] K. Komori, “Simulation of crack arrest in blanking using the node separation method”, *Int. J. Mech. Sci.*, **68**, 150–159 (2013).

[4] P. Kubík, F. Šebek and J. Petruška, “Ductile fracture criteria in prediction of slant fracture”, In *ECCOMAS Congress 2016*, 6699–6710 (2016).

[5] K. Pack, M. Luo and T. Wierzbicki, “Sandia fracture challenge: Blind prediction and full calibration to enhance fracture predictability”, *Int. J. Fract.*, **186**, 155–175 (2014).

[6] J. Papasidero, V. Doquet and D. Mohr, “Ductile fracture of aluminum 2024-T351 under proportional and non-proportional multi-axial loading: Bao–Wierzbicki results revisited”, *Int. J. Solids Struct.*, **69–70**, 459–474 (2015).

[7] MS. Joun, J.G. Eom and M.Ch. Lee, “A new method for acquiring true stress–strain curves over a large range of strains using a tensile test and finite element method”, *Mech. Mater.*, **40**, 586–593 (2008).

[8] D.J. Celentano and J.-L. Chaboche, “Experimental and numerical characterization of damage evolution in steels”, *Int. J. Plast.*, **23**, 1739–1762 (2007).

[9] A.M. Beese, M. Luo, Y. Li, Y. Bai and T. Wierzbicki, “Partially coupled anisotropic fracture model for aluminum sheets”, *Eng. Fract. Mech.*, **77**, 1128–1152 (2010).

[10] F. Šebek, P. Kubík, and J. Petruška, “Localization problem of coupled ductile failure models compared to uncoupled ones”, In *Engineering Mechanics 2014*, 632–635 (2014).