On the use of strain localization theory in calibration of fracture models: an application to high strength steels

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ABSTRACT

This study investigates the possibility of calibrating an uncoupled plasticity and fracture model for high strength steels based solely on a single tensile test, and still obtain results in acceptable agreement with experimental observations for moderate and high stress triaxiality. By combining the experimental results from the tensile test with unit cell simulations and localization analyses using metal and porous plasticity models, the aim is to reduce the need for extensive experimental testing in the calibration procedure.

Adopting J2 plasticity, the material parameters in the hardening rule were calibrated to data from the tensile test. Finite element simulation of the test was carried out using the calibrated plasticity model. The deformation history from the elements across the diameter of the specimens was extracted, and used in strain localization analyses, see Morin et al. [1]. The imperfection band approach proposed by Rice [2] was applied in these analyses using the Gurson model [3] inside and J2 plasticity outside the band. Unit cell simulations were carried out to calibrate the q-parameters introduced by Tvergaard [4] into the Gurson model, and thus to ensure an accurate description of the void growth phase. The parameters governing damage evolution in the Gurson model were calibrated such that failure was predicted by the strain localization analyses at the same macroscopic strain as in the uniaxial tensile test. Strain localization analyses were then carried out for a wide range of stress triaxialities and used to calibrate the fracture model.

The uncoupled plasticity and fracture models were calibrated this way for three high-strength steels and used in finite element simulations of tensile tests on notched specimens giving a wide range of stress triaxiality. The predicted failure strain was compared with experimental results. The proposed calibration method exhibited promising results and satisfactory agreement was obtained for all steels investigated.

REFERENCES