Improved numerical fracture strain prediction of ductile plates for failure in nominal plane strain tension

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ABSTRACT

Accurate fracture strain predictions of metal plates are of particular interest to engineers in the automotive industry in relation to the structural integrity of the car frame. However, existing shell element based models that have been calibrated to a specific plate material cannot match the fracture strains measured from both a V-bend test and a plane strain tension test[1] even though both tests nominally are considered as failure in plane strain tension. The discrepancy is tied to the difference in the through-thickness variation of stresses found in the two tests. This has raised a concern for the accuracy in the existing simulation tools, and the present study aims to address the issue by supplying further insight into the mechanisms at play during failure in plane strain tension. Attention is focused on the through-thickness variation in the stress and strain fields. Both types of tests are analyzed in detail by using the micro-mechanics based Gurson material model to predict the damage evolution and fracture strain. All analyses are conducted in Abaqus/Explicit and consider for each test a 2D plane strain cross-section. For the V-bend test friction between support rollers, punch, and coupon is included as part of the analysis. The detailed micro-mechanics based simulations reveal great similarities between the two tests when considering the triaxiality levels before the onset of localization. However, the post-localization deformation, stress, and damage evolution are very different when comparing V-bend testing to plane strain tension testing. For example, through-thickness thinning clearly develops during a plane strain tension test but is absent in the V-bend test. The present study makes it possible to identify the differences between the two nominally plane strain tension states and, through this, it is the aim to improve the existing shell element simulation tools for plate analysis.

REFERENCES

[1] Woelke, P. B., Londono, J. G., Knoerr, L. O., Dykeman, J., and Malcolm, S. Fundamental Differences between Fracture Behavior of Thin Sheets under Plane Strain Bending and Tension. *Iop Conference Series: Materials Science and Engineering* (2018) **418**, doi: 10.1088/1757-899X/418/1/012078