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# Instability based ductile fracture prediction in AA 7075-T651 using acoustic emission data

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## Abstract

Cracks initiate in ductile materials through the process of void nucleation, growth, and coalescence. Micromechanical models, such as the Gurson-Tvergaard-Needleman (GTN) model, are widely used to predict ductile fracture. The failure criterion in the GTN model is based on the attainment of a critical volume fraction of voids, which often fails to capture the loading path dependence of ductile fracture. A more recent approach by Keralavarma et al. (2020) uses a stress-state dependent crack initiation criterion based on Rice's plastic instability theory, combined with a void coalescence criterion. The failure criterion depends on the material's plastic constitutive law and void nucleation parameters. The criterion can be incorporated into both uncoupled and coupled damage plasticity approaches, offering robust prediction of fracture initiation. Accurate calibration of model parameters is critical for reliable predictions. This study integrates the stress-state dependent fracture criterion into an uncoupled damage-plasticity framework using rate-independent J2 plasticity theory. The approach requires the parameters related to strain hardening and void nucleation to be calibrated from experimental data. The parameters in the hardening law are calibrated in the usual way using uniaxial tensile tests. Here, we proposed a novel methodology to calibrate void nucleation parameters in the strain controlled void nucleation law of Chu and Needleman (1980) using acoustic emission (AE) data. These parameters were first calibrated using the AE amplitude data from a dogbone specimen, and validated against the AE data obtained from notched tensile specimens with varying notch radii. The mean and standard deviation of the nucleation strain are calibrated using AE data, and the maximum volume fraction of nucleating voids ( $f_N$ ) is determined through a parametric study. Predictions using the calibrated model are validated against experimental data for a range of specimen geometries, including notched bars, compact tension (CT) specimens, and four-point bend specimens. The model accurately predicts ductility of notched bars and CT specimens with an  $a/W$  ratio of 0.46. The study demonstrates the model's accuracy and potential as a reliable alternative to phenomenological ductile fracture models.

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