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Experimental and Numerical Investigations of the Damage and Ductile Fracture Mechanisms in TRIP Steel Sheets

by

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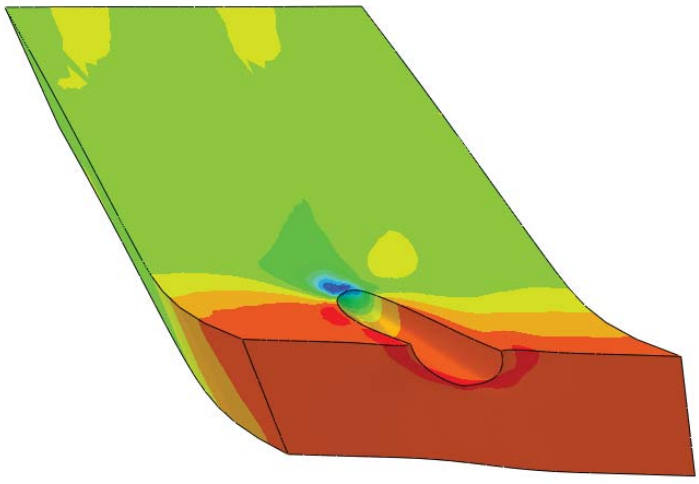

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Experimental and Numerical Investigations of the Damage and Ductile Fracture Mechanisms in TRIP Steel Sheets

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Abstract

The evolution of damage and the mechanisms responsible for ductile fracture are identified in a TRIP steel sheet material. Experiments are performed on flat notched tensile specimens with different notch radii and on disk specimens submitted to out-of-plane hemispherical punching, thereby covering stress states from uniaxial to equi-biaxial tension. For each specimen geometry, experiments have been interrupted prior to fracture at different stages of deformation: onset of through-thickness necking and 95%, 98% and 99% of the displacement at which fracture initiates. Micrographs of samples extracted from the deformed specimens permit to evaluate the material damage for increasing amounts of accumulated plastic strain, and to identify the fracture mechanisms. It is shown that the critical mechanism responsible for ultimate failure is the localization of the plastic deformation in a shear band which initiates from the boundaries of an isolated void. Very high strains are reached inside the shear band which lead to the nucleation of secondary voids ("void sheet" mechanism) and eventually result in the slant fracture of the sheet material. The orientation of the fracture surface is controlled by the shear band direction.

A micromechanical analysis based on three-dimensional void cell calculations is carried out to model the observed damage and fracture mechanisms. A void-containing RVE is submitted to loading histories measured in the experiments through hybrid experimental-numerical analysis. In particular, the increase of triaxiality occurring after the onset of localized necking and prior to fracture is taken into account. Simulation results show a good agreement with experiments and permit to model qualitatively the dependence of the material ductility to the first and third stress invariants, i.e. the stress triaxiality and Lode parameter.

***Keywords**:* Fracture mechanism, shear localization, void-containing RVE computation