Impact & Crashworthiness Laboratory

Report No. 228

Effect of Non-linear Loading Paths on Sheet Metal Fracture: Large Strain In-plane Compression Followed by Uniaxial Tension

(Master Thesis)

by

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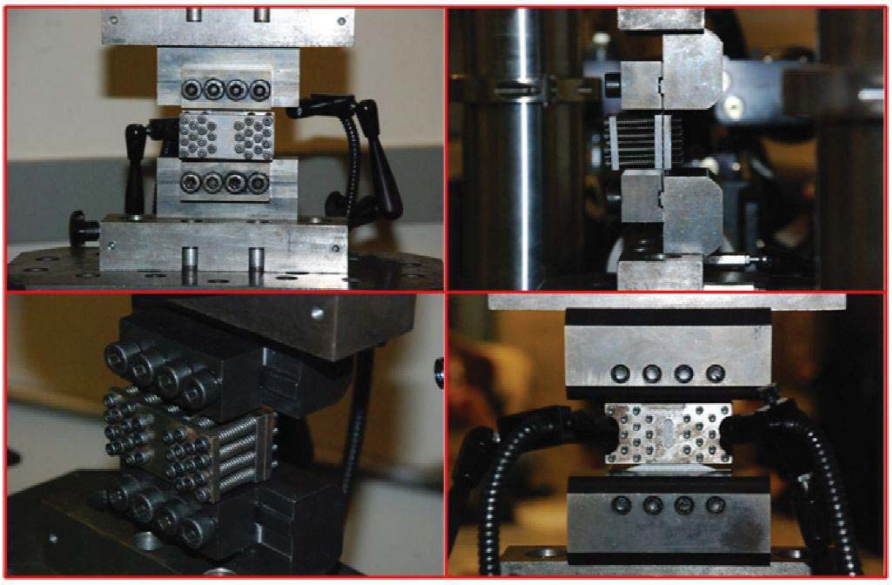

February 2012

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Abstract

Advanced high strength steel sheets are rapidly entering the transport industry, as their high strength to weight ratio helps improving fuel and costs efficiency. The early ductile fracture of these materials limits their formability and crashworthiness. A phenomenological criterion to predict ductile fracture has been developed based on a law of damage accumulation weighted by the stress state. The calibration of such a model requires accurate measurements of the history of stress and strain state up to the onset of fracture. The phenomenon of localized necking occurs prior to ductile fracture in most types of loading of sheet metal. In order to measure the local state of stress and strain, a hybrid experimental and numerical method is tested. The Finite Element model can accurately predict the load displacement relation using a quadratic Hill 48 yield surface and an associated flow rule. The evolution of the local stresses and strains in the material are found to be non linear after necking. Results of such a method to calibrate the fracture criterion provide a validation of the model in a large range of loadings, including uniaxial, biaxial and shear.

The effect of a reverse loading is then explored by developing an innovative experimental procedure to adapt the hybrid method for in plane compression followed by uniaxial tension of sheet metal. An Anti Buckling Device (ABD) and special grips are developed to delay buckling of the sheet. The hybrid method requires an accurate constitutive model of the material in the case of reverse loading for the Finite Element model. A modified Yoshida hardening called IH + LK + LNK combining isotropic hardening, linear and non linear kinematic hardening provides good prediction of the load displacement relation. An analysis of the history of local stresses and strains up to the onset of fracture suggests that limited damage is accumulated during the compression phase, validating the phenomenological model.

***Keywords**:* Reverse Loading, Ductile Fracture, In Plane Compression, Kinematic Hardening..