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FORMING LIMITS BY NECKING AND FRACTURE IN SHEET METAL FORMING

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Workability in sheet metal forming has been commonly defined by the Forming Limit Curve (FLC), which defines the onset of localized necking. However, not only the onset of localized necking is known to suffer from ambiguity in its experimental determination but also there are materials and processes that are capable of experiencing fracture without previous necking.

Nowadays the vision is to start driving research and development to the characterization of the onset of failure by fracture (also known as the Fracture Forming Limit, FFL) and to the utilization of alternative representations to the well-known principal strain space such as the space of the effective strain at fracture vs. stress triaxiality.

This paper aims at assessing the numerical and experimental formability limits by localized necking and fracture in the space of the effective strain at fracture vs. stress triaxiality. The experimental tests were carried out on AA1050-H111 aluminium sheets with 1 mm of thickness, under different loading conditions that cover strain paths from uniaxial to biaxial stretching by means of tensile, hemispherical dome, bulge and Nakazima tests. The numerical simulations were performed with the finite element computer program LS-DYNA using shell elements and a material model considering normal anisotropy and coupled ductile damage.

The overall agreement of numerical simulations with experiments is good for all test cases and reveal that the onset of localization by necking should be defined as a region rather than a single line (FLC). The ambiguity in defining the FLC and the correlation between critical ductile damage and failure by fracture justifies the preference in using the FFL. In fact, results confirm for sheet metal forming the applicability of a stress triaxiality based ductile damage criterion to predict failure by fracture in crack opening mode I (by tension).