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NUMERICAL SIMULATION TO CHARACTERIZE FRACTURE LIMIT IN SHEET METAL FORMING

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ABSTRACT

With advances in sheet metal forming sectors there are instances (Embury and Duncan 1981)(Silva et al. 2008) where the use of conventional forming limit curve (FLC) is not accurate. For this reason recently researchers (Atkins 1996; Isik et al. 2014) have started using modified forming limit diagram (FLD) which rely on fracture limits rather than necking limit as in the case of FLC. This study involves numerically simulating and replicating these fracture limits for Copper as material. Load-displacement graph is used to validate the accuracy of the simulation when compared to experimental values. The study so far shows good prediction of fracture and possibility to plot the FLD with fracture limits using these simulations. These simulations give very good insight to the stain path followed by the specimen before its fracture.

Keywords: numerical simulation, shear specimen, fracture limit, copper.

INTRODUCTION

The graph between the major strains and the minor strains in principal stain space is called as forming limit diagram (FLD). Forming limit curve (FLC) represents the failure limit of sheet metal on the onset of necking. This FLC was developed by (Goodwin 1968) and (Keller 1968). Until recent times FLC served the purpose but (Embury and Duncan 1981) showed that in some instances fracture preceded necking and the FLC rendered of no use in those instances. Later with development of incremental forming it was observed that sheet metal can be formed far beyond FLC and still does not ‘fail’ (Silva et al. 2008). For this reason Fracture forming limit line (FFL) was introduced by (Atkins 1996).

In order to plot the forming limits based on fracture limits, several researches (Martins et al. 2014) (Isik et al. 2015)(Soeiro et al. 2015) have been proposed solutions. In these works the FFL is plotted using special specimen on the universal tensile machine. The aim of this study is to replicate these in simulation for Copper.

RESULTS AND CONCLUSIONS

Specimen are designed as per the specification provided in (Isik et al. 2014). But in the before-mentioned work Al alloy was used. For this work experimental data for Copper is used. The FEM 3D modelling conditions are kept as close to actual tests as possible. The constitutive model selected was Von mises Plasticity model with isotropic hardening and the normalized Cockroft-Latham damage criterion was used as the fracture condition. The obtained numerical simulation is validated using load-displacement curve. As can be seen for double notch tensile test (DNTT) in figure 1, the simulation fairly matches with the actual experimental readings with error deviation below 7%.

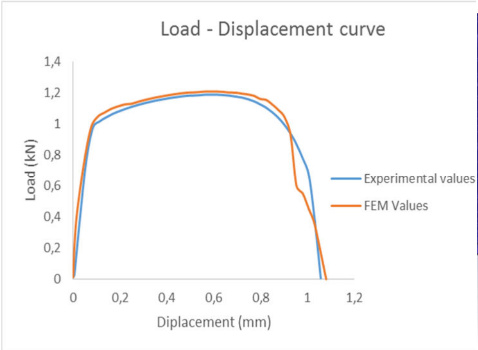

Fig. 1 - Load - displacement curve

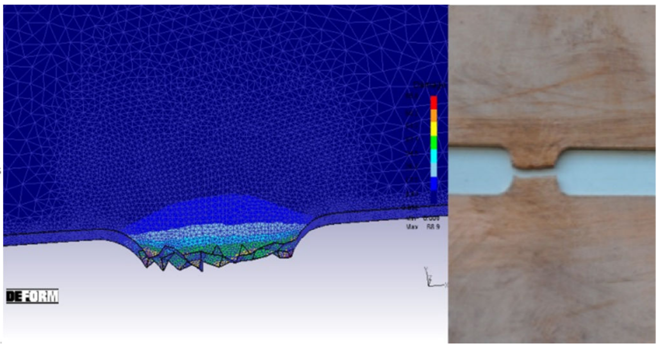

Fig. 2 - Fracture in FEM and in experiment for DNTT

This study shows simulation as well as experimental values of Copper - FFL. The numerical results are verified with experimental load-displacement curve. The formability analysis can be carried out in triaxiality plane with current results. The strain path for each specimen can be traced using simulations. These strain paths give insight to failure mechanism.

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