Prediction of ductile fracture in metal blanking

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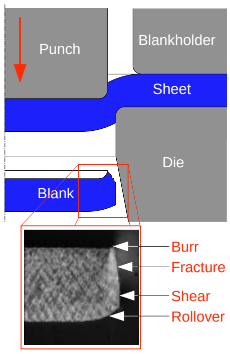
A.M. Goijaerts, L.E. Govaert and F.P.T. Baaijens

Eindhoven University of Technology,
Faculty of Mechanical Engineering,
Section Materials Technology,
P.O. Box 513, NL 5600 MB Eindhoven

Introduction

In critical applications the development of a blanking process becomes trial-and-error due to the empirical blanking knowledge. A FEM-model, validated up to fracture, is present but a proper ductile fracture model is missing.



Objective Develop a ductile fracture model valid for the metal blanking process.

Modelling ductile fracture

Experimental An axi-symmetrical set-up is built with five different clearances. The material used is a Cr-steel that yields Von-Mises-like with isotropic hardening. For every clearance the punch-displacement at fracture (a+b+c, roll-over + shear zone + burr) is shown with the standard deviations in figure 2. This trend is mainly influenced by the triaxiality ($\frac{\sigma_h}{\sigma}$, hydrostatic stress over Von Mises stress) and is similar to results from literature.

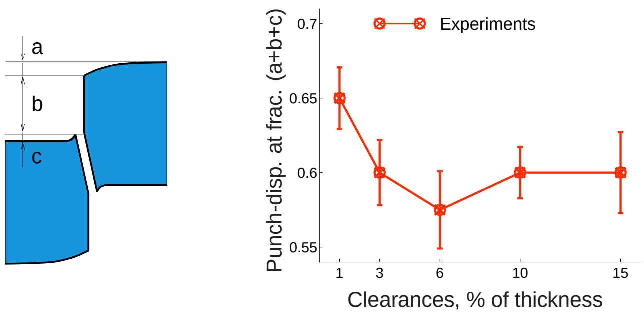


Figure 2: Experimental results

Numerical A validated FEM-model, to simulate the five different experiments, is present [1] and thus the *deformation- and stress-history* of the process can be calculated to evaluate criteria of the form: $\int_{\varepsilon_p} (\sigma, \varepsilon) d\varepsilon_p = C$, where fracture initiates if the integral reaches the critical C.

In the left side of figure 3, examples of particle-trajectories are shown starting at the circle in the undeformed situation and initiating fracture at the cross. The history-variables, shown on the right side, are representative for the history of material points, that will eventually initiate fracture, in two extreme geometries.

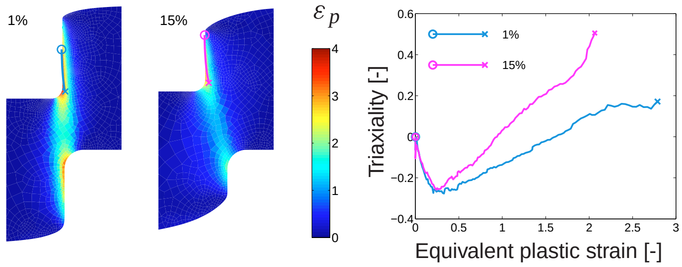


Figure 3: Numerical simulation of the blanking history

Results

None of the existing criteria can satisfactorily predict ductile fracture in blanking. But, if the effect of triaxiality is changed, two existing models can be adapted so they can predict ductile fracture initiation in blanking over the wide range of clearances (The C is determined in the 15% clearance experiment and ductile fracture initiation is predicted for the others):

Oyane et.al. adapted $\int_{\varepsilon_p} < 1 + 3\frac{\sigma_h}{\sigma} > d\varepsilon_p = C$

Rice & Tracey adapted $\int_{\varepsilon_p} e^{\frac{5}{2}\frac{\sigma_h}{\sigma}} d\varepsilon_p = C$

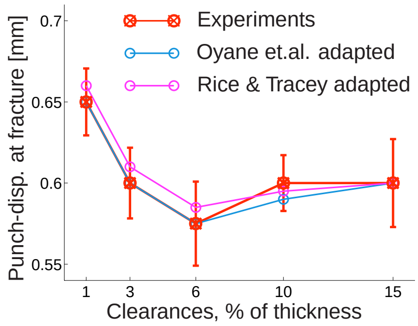


Figure 4: Two adapted models that predict ductile fracture

Conclusion

It is shown that ductile fracture initiation can be predicted in the blanking process over a wide range of clearances by two modified ductile fracture models that can be characterised (determining C) in a single blanking experiment. Further research has to investigate whether these ductile fracture criteria are applicable in other deformation processes.

Reference:

[1] Stegeman YW, Goijaerts AM, Brokken D, Brekelmans WAM, Govaert LE and Baaijens FPT (1998) An experimental and numerical study of a planar blanking process. Accepted for publishing in *Journal of Materials Processing Technology*