Modelling of failure in sheet forming using cohesive elements

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1 Introduction

Shell elements are the most efficient method for large scale simulations of sheet metal forming or deformation of sheet products. These elements have a limited description of the kinematics. This is normally a good approximation of the real deformation, but it cannot describe the failure behaviour of sheets, like necking and shear bands accurately. However, often such local details are not of interest and only the correct moment of failure and the amount of energy absorption is important.

2 Methods

Nonlocal damage models are able to produce mesh size independent results for damage softening materials. However the application of nonlocal damage models to shell elements is not straightforward. The size of shells elements is normally larger than the sheet thickness. Therefore it is not possible to use the same length scale in simulations with shells as used in simulations with solid elements. Furthermore even without damage the necking in simulations with shell elements is mesh size dependent. The neck has a width of one element, because the thickness of two neighbouring elements is not coupled.

To overcome these problems in modelling failure in large scale simulations with shell elements, these shells elements will be combined with cohesive elements (Cirak, F 2005). The traction separation law (TSL) of the cohesive elements will be taken such that failure will take place in the cohesive element and the correct amount of energy is absorbed.

The TSL is based on the combination of experiments and detailed studies using nonlocal damage models. The global response of the model with cohesive elements should be equal to the response of the detailed simulations.

3 Results

The proposed method is demonstrated on tensile and Nakazima tests (uni- and bi-axial loading) on thick ship plate steel. Simulations with solid shells and cohesive elements are compared with simulations with solid elements and a nonlocal damage model (Mediavilla, J 2006) and with experimental data. The used TSL is independent of the stress state, although it is known that ductile failure and necking depend on the stress state (triaxiality ratio). The results of the different simulations will be shown and discussed.
4 Conclusions

The simulations show that failure can be modelled with the combination of shell and cohesive elements. To improve the results quantitatively the TSL should be able to discriminate between different stress states.

REFERENCES
