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Ductile fracture criteria study for deep drawing process

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Introduction

The present study shows deep drawing process simulation using the finite element method (FEM). The 3D axisymmetric model performed sheet metal forming operations to reduce the computation time. The ductile fracture criteria were conducted to investigate forming limits during the sheet metal forming simulation.

Workpiece Material and Simulation Design

The annealed 5182 aluminum alloy was used during the deep drawing process simulation. The blank thickness was chosen as 0.96 mm for each simulation model, and 1 mesh size was generated. The die, holder, and punch were generated as a 3D discrete rigid body. The deformable shell element was used for the blank. Ductile fracture material criteria was defined for the workpiece. The 1/4 quarter 3D model was used for the analysis, and Abaqus/Explicit procedure was conducted for the simulation.

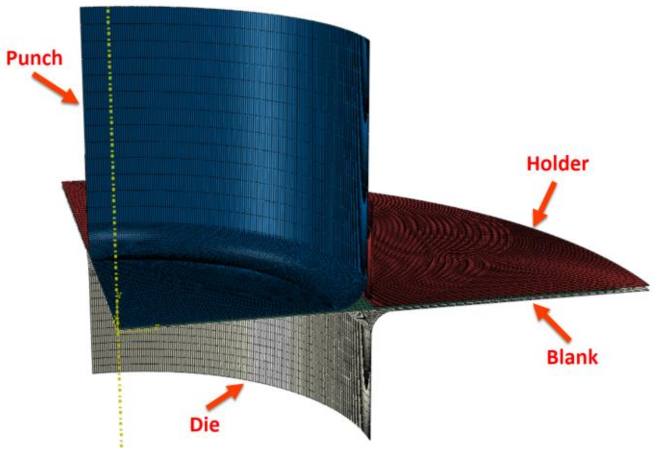
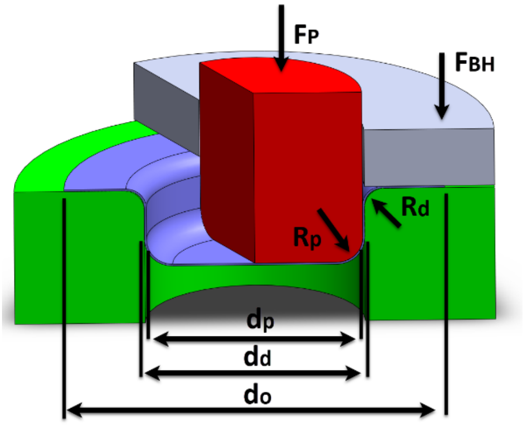


Fig. 1. 3D quarter axisymmetric deep drawing process model



Initial diameter of blank	d_o = 216 mm
Punch diameter	d_p = 108 mm
Holder diameter	d_h = 110 mm
Die diameter	d_d = 110 mm
Drawing ratio	β = 2
Punch Radius	r_p = 7 mm
Die radius	r_d = 5 mm
Initial blank thickness	t_0 = 0.96 mm

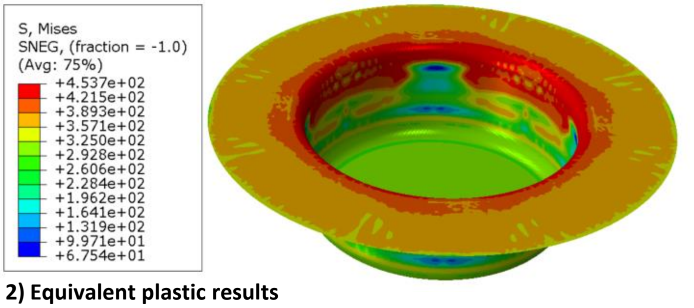
$$\beta = \frac{d_o}{d_p}$$

3D-axisymmetric deep drawing simulation part details

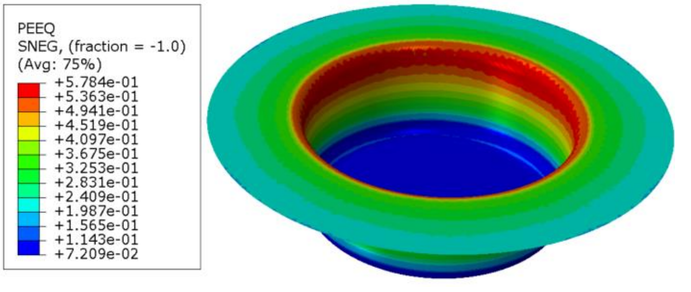
Blank	3D Shell element
Punch	3D discrete rigid
Holder	3D discrete rigid
Die	3D discrete rigid

Finite Element Results

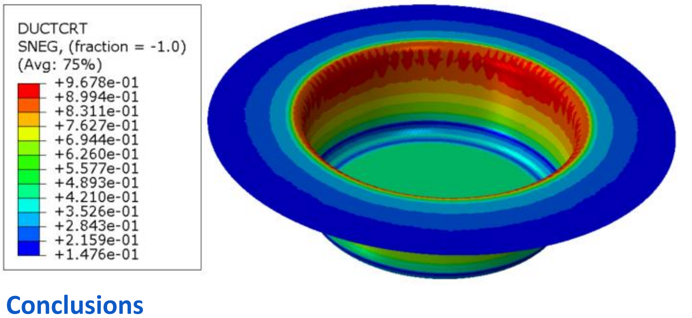
1) Stress results



2) Equivalent plastic results



3) Damage initiation results for ductile workpiece



Conclusions

The following conclusions were drawn from this study:

1. The maximum stress is around 453 MPa, accumulated on the workpiece's die radius area.
2. Relying on the stress results, the ductile criterion is a model for predicting the onset of damage due to high stress in the die radius zone.
3. The results show that the equivalent plastic strain has a significant role in predicting the ductile damage limits of the workpiece.

References

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