Instructions

In this assignment, you are expected to model sheet metal forming with geometric nonlinearity and an elastic plastic material with isotropic hardening. The finite element solutions should be compared to experimental results of sheet metal forming carried out in Numisheet Benchmark 2002. Although the material is slightly different in the experiments, the results are still comparable. The experimental results are provided at the end of this assignment. Your task is to model the punch, sheet metal and the die using 2D plane strain elements and simulate the forming process followed by release of the punch.

Problem - Sheet metal forming

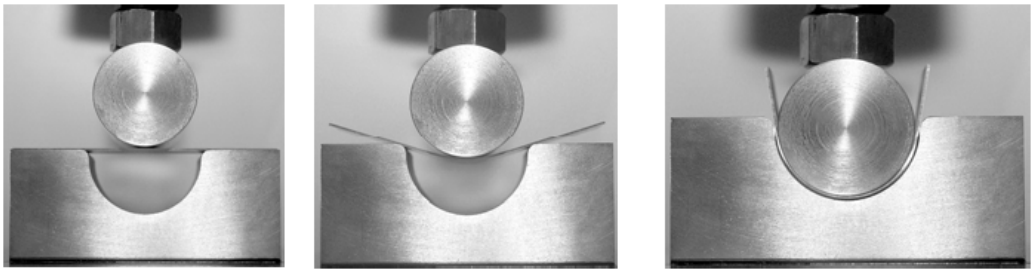

Figure 1: Free bending of an Aluminium alloy sample

An aluminium alloy sheet metal is formed using a punch as shown in figure 1. Afterwards the punch is retracted and causes spring back. The material properties and dimensions of the geometry are as given below:

Material:
E = 70.5 GPa
ν = 0.342
Initial yield stress σ_o = 194 MPa
Holloman hardening $\sigma = K\epsilon^n$
where K = 550.4 N/mm^2 and n = 0.223

Dimensions:
Punch radius = 23.5mm
Die radius R2 = 25.0mm
Die shoulder R3 = 4.0mm
Width of tools = 50.0mm
Length of sheet (initially) = 120.0mm
Thickness of sheet = 1.0mm
Width of sheet = 30.0mm
Punch stroke = 28.5mm

The figure 2 shows the model details and figure 3 shows the initial and final position of the punch.

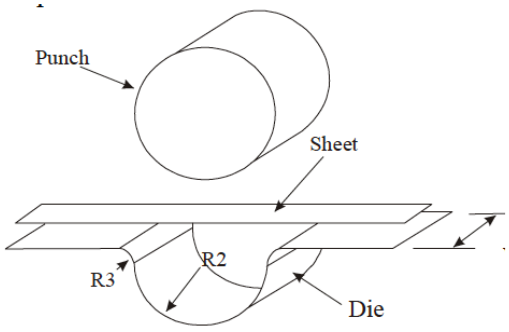

Figure 2: Representation of the model

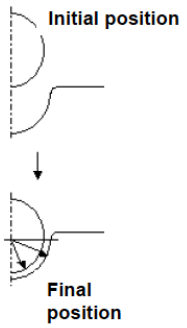

Figure 3: Initial and final position of the punch

Boundary conditions

- Fixed bottom surface
- Vertical displacement of the punch

Applied load

None

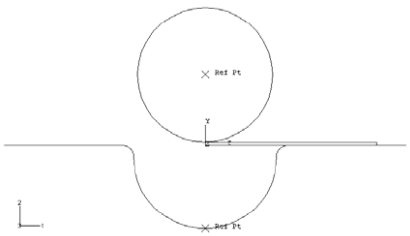

Figure 4: 2D geometry of the forming process

Assignment

- Model the punch, sheet metal and die cross-section as shown in the figure 4.
- Model the punch and die as rigid bodies.
- Sliding contact must be modelled around the circular surface. Use 2 different contact properties, one frictionless and the other with a coefficient of friction $\mu = 0.1342$.
- Find out the forming angle and the angle after realease and compare with the experimental values provided at the end of this assignment.
- Plot the punch force against the punch displacement and compare with the experimental data provided at the end of this assignment.
- Comment on the mesh refinement through the thickness and along the length of the sheet metal.
- All results must be provided for both frictionless and friction contact.

Experimental results

Forming angles	Angles after release
19.6- 21.0	53.4 - 55.8

Figure 5: Experimental results for forming and release angles

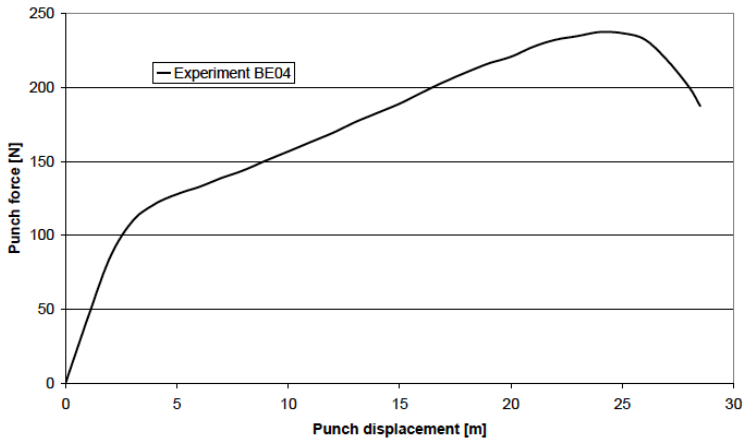

Figure 6: Experimeantal punch force against displacement curve