Numerical Modeling of Spring Back in Bending of Stainless Steel Sheets at Temperatures up to 350 °C

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Introduction

Spring back is a phenomenon that occurs in industrial manufacturing processes, particularly in sheet metal forming, where a material returns to its original shape after being bent or formed, leading to unwanted deformations or dimensional inaccuracies in the final product. Finite element simulation is used extensively for stress analysis of the materials forming processes and in the calculations of the structures under mechanical or thermal loads. In this graduation project, spring back phenomena has been studied on a sheet metal bending of stainless steel and simulated by using Abaqus software. For sheet metal bending simulation, various scenarios are considered, including (i) different temperatures (25 ~350°C), (ii) different sheet thicknesses (0.5~6 mm) and (iii) different bending angles (90~135°). The program needs to be provided with the material data and other conditions. . In addition, the elastic material parameter as a function of temperature will be used as listed in the literature.. A comparison will be carried out between different scenarios obtained from the finite element model.

Studied Materials

Table 1. Typical chemical composition of the testing material

Elements (wt. %)	Si	Fe	Cu	Mn	Ni	Cr	P	Co	V	Al	C	Mo	Nb
Stainless Steel AISI 304	0.45	69.7	0.19	0.80	9.50	18.9	0.04	0.15	0.09	0.01	0.07	0.7	0.04

Tensile Test

Figure 1. Tensile Testing Machine Type Instron, Model: 3367, maximum load 30 kN.

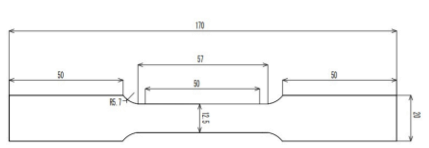

Figure 2. Shape and dimensions of tensile test specimens in mm,standard ASTM E8M-09, type12.5 mm.

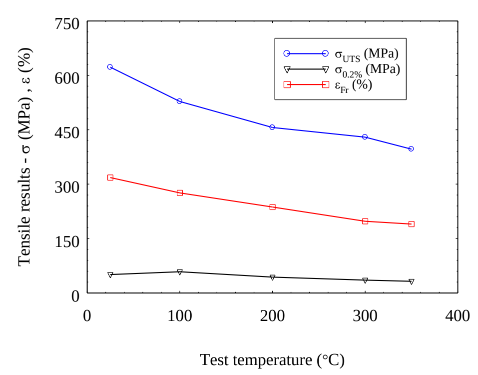

Figure 5. Tensile test parameters as a function of the relative test temperature. Ultimate tensile stress σ_{UTS}, yield stress σ_Y, and fracture strain ε_{Fr}

$\sigma_t = \sigma(1+\varepsilon)$ $\varepsilon_t = \ln(1+\varepsilon)$

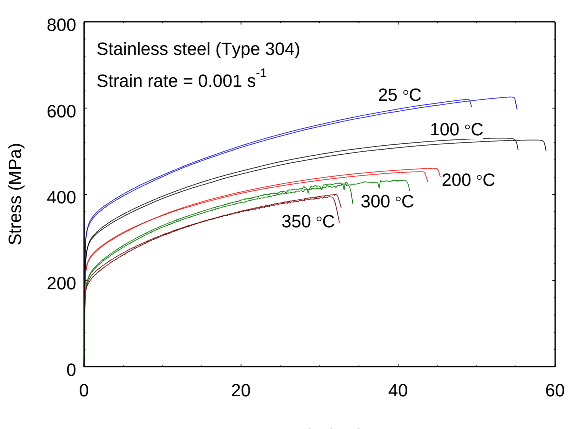

Figure 3. Engineering stress-strain curves at different temperatures (25-350°C) for the austenitic stainless steel.

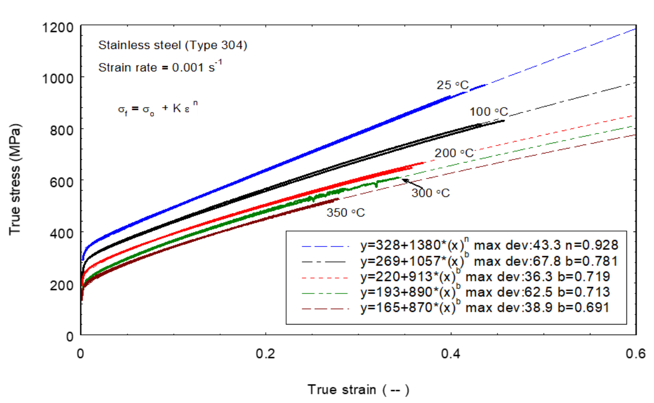

Figure 4. Description of stress-strain curves at different temperatures (25-350°C) for the austenitic stainless steel.

Abaqus model

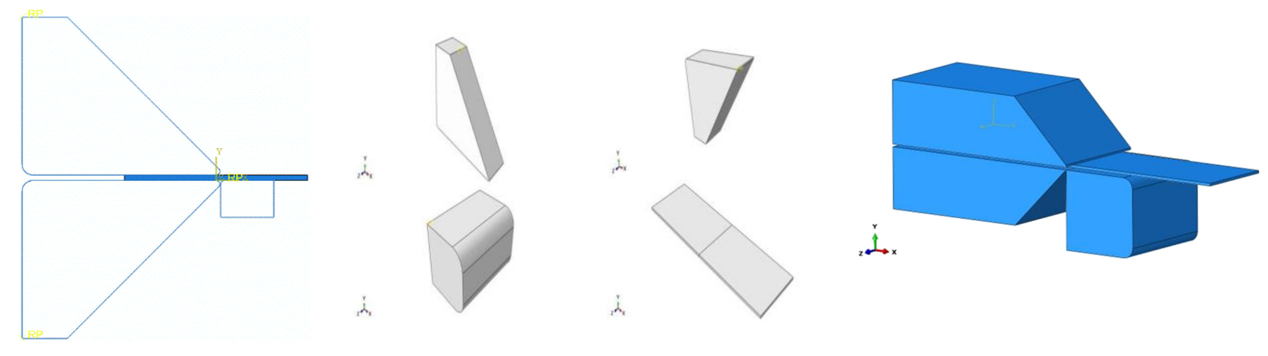

Figure 6. FE model in 3-D and 2-D

Finite Element Results

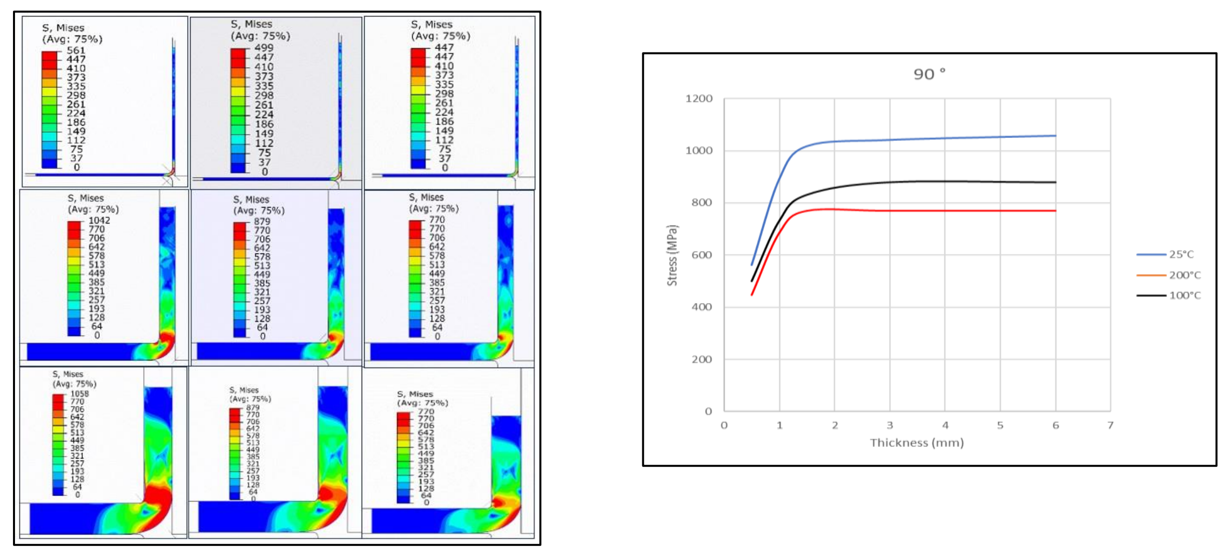

Figure 7. Stress distribution result of 90° bending angle

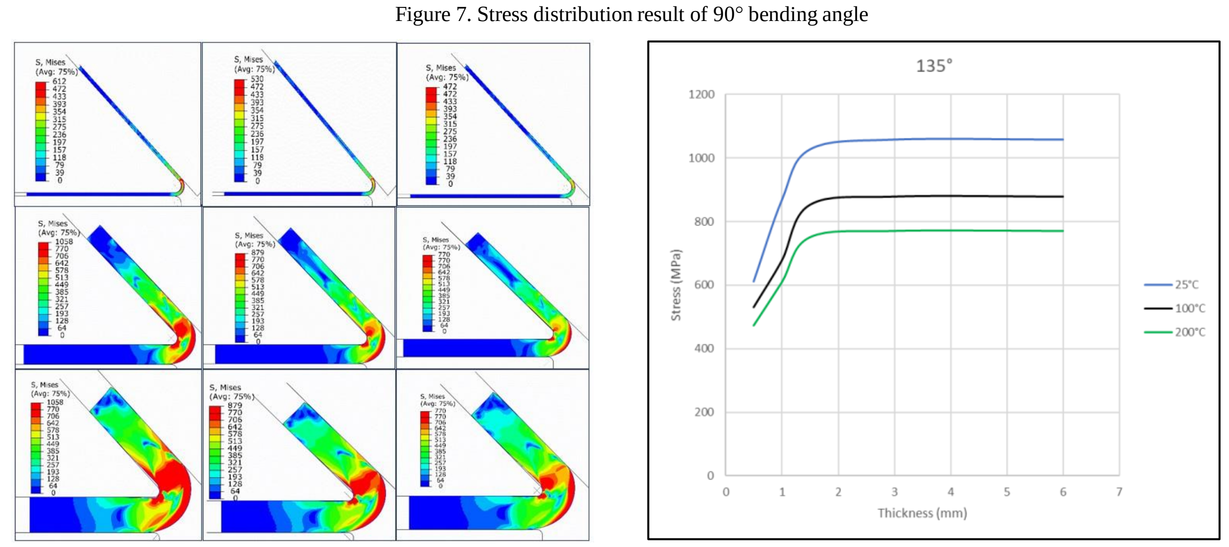

Figure 8. Stress distribution result of 135° bending angle

Before and after spring back phenomenon

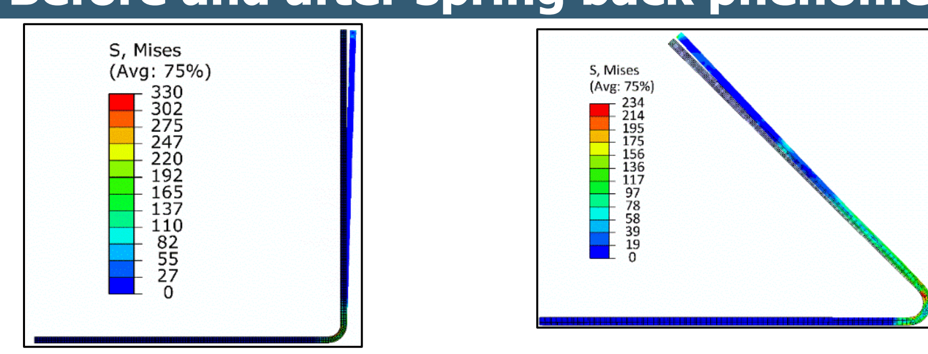

Figure 9. Sheet metal before and after spring back phenomenon at 90° and 135°bending angle

Curves results for spring back angle

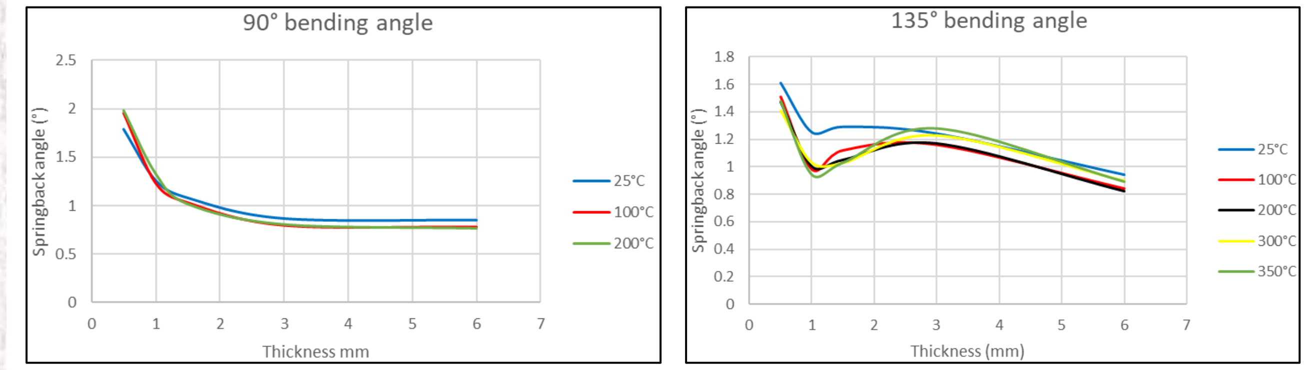

Figure 10. Variation of spring back angle at different thicknesses and temperatures at 90° and 135° bending angle

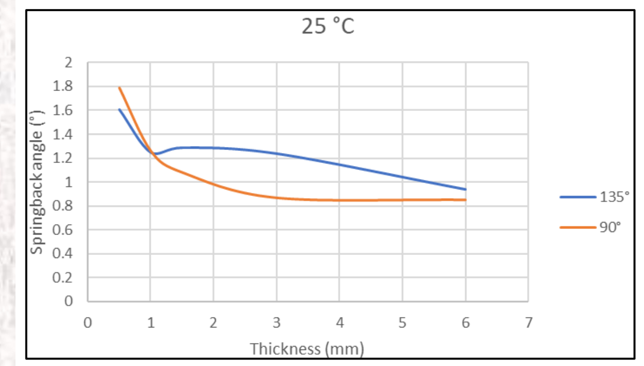

Figure 11. Variation of spring back angle at different thicknesses for 25 °C

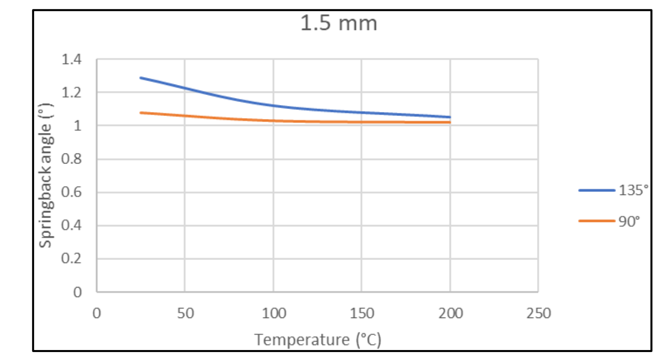

Figure 12. Variation of spring back angle at different temperatures for 1.5 mm

Curves results for force-stroke angle

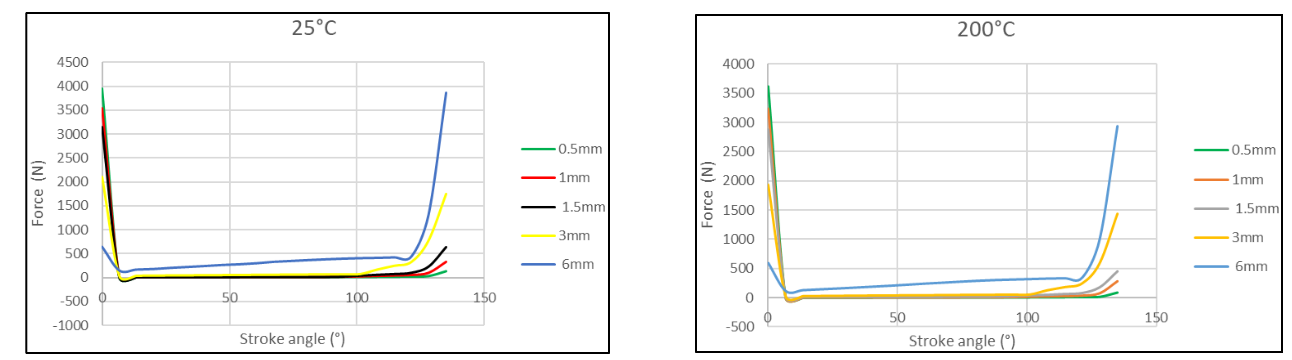

Figure 13. Force verses stroke angle at different thicknesses for 25 °C and 200 °C at 135° bending angle

Conclusions

Based on modelling of tensile test of stainless steel sheet and the finite element simulation of spring back on bending of stainless-steel sheets, the following points can be concluded:

- At a given temperature, increases of sheet thickness results in decreases of spring back angle. Because thinner sheet thickness have lower resistance to deformation and more prone to elastic recovery.
- At lower temperatures material more rigid,so when the load is released sheet undergoes greater elastic recovery, results larger spring back angle.
- When bending angle increases spring back angle increase, because of the greater deformation and higher levels of residual stress.
- Elastic modulus represent material stiffness, or the ability to resist deformation under load in elastic range. Higher elastic modulus results in lower spring back angle.

References

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