8th. World Congress on Computational Mechanics (WCCM8)
5th European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS 2008)
June 30 –July 5, 2008
Venice, Italy

MICROMECHANICALLY MOTIVATED MACROSCOPIC MODELING OF INDUCED FLOW ANISOTROPY IN SHEET METALS

*** Yuliana Stepanova[1], Vladislav Levkovitch[2] and Bob Svendsen[3]**

[1,3] Technical University of Dortmund
Deparment of Mechanical Engineering
Chair of Mechanics, Leonhard-Euler-Str. 5
44227 Dortmund, Germany
www.mech.mb.uni-dortmund.de
[1]y.stepanova@mech.mb.uni-dortmund.de
[3]bob.svendsen@mech.mb.uni-dortmund.de

[2] Beck Arndt Engineering PTY LTD
Reprasentanz Berlin, Roennebergstr. 15
12161 Berlin, Germany
www.beckarndt.com.au
vlevkovitch@beckarndt.com.au

Key Words: *Sheet metal forming, Distortional hardening, Induced flow anisotropy.*

ABSTRACT

Sheet metal forming simulations and predicting springback using FEM play an important role for the industry, in particular for the automotive production. But in this area there are a number of problems that should be investigated and then solved.

Springback which is caused by the release of stored energy in the material during unloading is a common phenomenon in sheet forming. But since sheet forming processes usually involve non-proportional loading or strain path changes, the simulation of such processes requires taking a number of effects into consideration. The accurate prediction of springback is significant for the simulation and analysis of sheet metal forming processes. The process of sheet metal forming involves large strains and severe strain-path changes. In many metals large strains cause the development of dislocation structures leading to strong flow anisotropy. This induced anisotropic behavior manifests itself in the case of strain-path changes through a stress-strain response depending on the type of strain-path change.

In this work, we present a macroscopic model based on micromechanical considerations. The advantage of this model is that besides the shift of the yield surface center and its proportional expansion, the macroscopic form of the model also considers changes in the yield surface shape. Consequently, it is able to describe the evolving anisotropic behavior due to complex, non-proportional loading histories better. To this end, the micromechanically-based material model for combined and distortional hardening is applied to the simulation of cup deep drawing following the ring-splitting including springback.

In this work we compare the experimental results with simulation results based on the standard combined hardening model and the distortional hardening model (Levkovitch et al, 2007). The results show that in the simulation with the distortional hardening model the sheet shape is closer to the experiment than the combined model. Also pay special attention to the influence of the initial flow anisotropy on deep drawing simulation, because an adequate modeling of this induced anisotropy is crucial for the accurate prediction of residual stresses and the amount of springback.

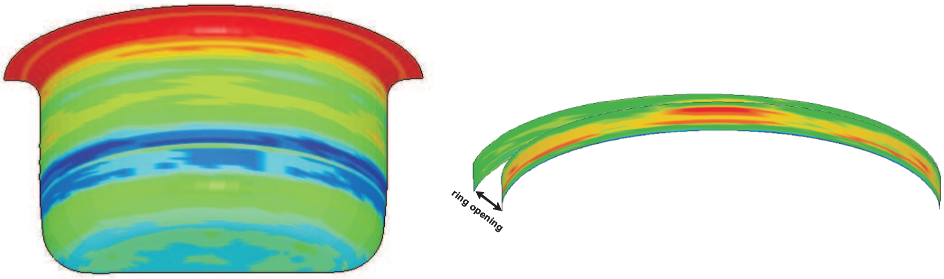

Figure 1: Distribution of the von-Mises stress in drawn cup (left) and open ring after springback (rigth)

The sheet forming example used in the current investigation involves cylindrical deep-drawing followed by ring-splitting. In this test, a cylindrical deep drawn cup is sliced into one ring which is then split in the vertical direction. Due to high residual stresses resulting from the deep drawing process, significant springback in the form of ring opening takes place (Fig.1).

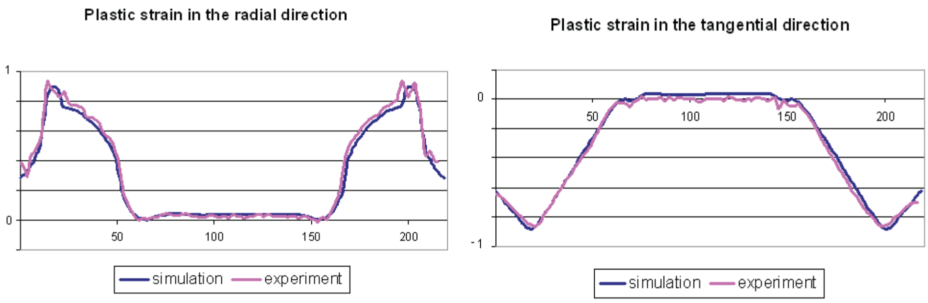

Figure 2: Comparison of experimental and numerical results of the plastic strain distribution in the radial (left) and tangential (right) direction after deep drawing.

The convergence study such as influence of mesh quality, number of elements and integration points was carried out as well as the comparison of the experimental and simulation results (Fig.2).

REFERENCES

[1] V. Levkovitch, B. Svendsen, J. Wang, “Micromechanically motivated macroscopic modeling of induced flow anisotropy and its application to sheet forming processes with complex strain-path changes”, Proceedings of NUMIFORM 2007

[2] J. Wang, V. Levkovitch, F. Reusch, B. Svendsen, J. Huẽtink and M. van Riel, “On the modeling of hardening in metals during non-proportional loading”, International Journal of Plasticity, In Press.

[3] Thomas B. Stoughton,“A general forming limit criterion for sheet metal forming”, International Journal of Mechanical Sciences, Vol. **42**, Issue 1, 1-27, 2000

[4] K. Yoshida, T. Kuwabara, M. Kuroda, “Path-dependence of the forming limit stresses in a sheet metal”, International Journal of Plasticity, Vol. **23**, Issue 3, 361-384, 2007