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Simulation of thermo-mechanical aluminium sheet forming

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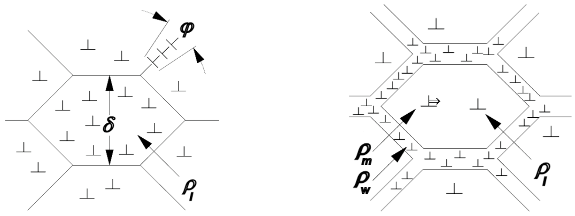
Introduction

The stretch-forming process is used to manufacture for instance the leading edge of the tail of an airplane. Using intermediate annealing steps large deformations and a good surface quality can be accomplished.

The objective of this research is to accurately model the stretch-forming process with intermediate annealing, so that the number of annealing steps and therefore the costs can be reduced. The finite element model will have to use a material model that incorporates the temperature and strain-rate dependency of the material.

Material models

In this project two material models are considered. The Alflow model [1] is a work hardening model based on three microstructural elements: the dislocation density within the cells ρ_i, the subgrain size δ and the misorientation φ.
The 3IVM model [2] uses the mobile dislocations ρ_m, the immobile dislocations in the cell interior ρ_i and the immobile dislocations in the cell walls ρ_w.

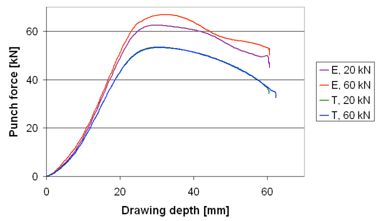


Schematic cell structure for the Alflow model (left) and the 3IVM model (right)

Using initial simulations the best model for our purposes will be chosen. Next, it will have to be expanded to incorporate the effects of precipitation, solutes, grain size and dynamic stress.

Experiments and simulations

Deep drawing experiments have been performed on AA 2024-O using two different blank holder forces, 20 kN and 60 kN, and two types of lubrication, Envilub (E) and Teflon sheet (T). The punch force – drawing depth curves show that for Teflon sheet the blank holder force has almost no influence, the friction is therefore almost zero. Initial simulations have been performed, using existing hardening models and estimates of material parameters, but the results are not yet satisfactory.



These results will be improved by using the new material model and correct parameters. The next step will be the simulation of the actual stretch forming process with intermediate annealing.

References

[1] E. Nes, Progress in Material Science (1998) 74, 129-193.
[2] F. Roters, D. Raabe and G. Gottstein, Acta Materialia (2000) 48, 4181-8189.

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