# 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, see Figure 1. Using intermediate annealing steps large deformations and a good surface quality can be accomplished.

*Figure 1 : Leading edge of the tail of an airplane*

## Objective

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. This can be accomplished by finite element simulations of this stretch-forming process. It will be necessary to use a material model that incorporates the temperature and strain-rate dependency of the material.

## Material model

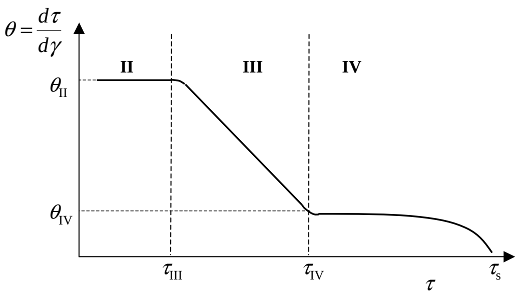
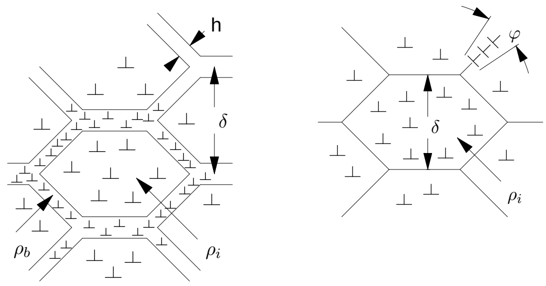



*Figure 2 : Strain hardening versus flow stress*

The flow curve at relatively low temperatures can be divided into four stages, see Figure 2. Stage I does not occur in this case. Stage II is characterised by a linear strain hardening rate, which is only weakly sensitive to temperature and strain rate. Stage III begins when the flow curve deviates from linearity. This stress is strongly strain rate and temperature dependent. In stage IV there is a linear strain hardening rate again [1].

The Alflow model [2] describes the strain hardening using these stages and three microstructural parameters, see Figure 3.




*a Small deformation* *b Large deformations*

*Figure 3 : Schematic of the dislocation cell structure*

At small strains (stage II) the stored dislocations are arranged in a cell structure characterised by a subgrain size $\delta$, cell walls of thickness $h$, and wall dislocation density $\rho_b$, and a dislocation density within the cells $\rho_i$. Stage III begins when the dislocation density inside the cells becomes saturated. In this stage the misorientation increases rapidly and the cell/subgrain size decreases. At large strains (stage IV) the subgrain walls have collapsed into subboundaries of a well-defined misorientation $\varphi$.

## Future work

The material parameters for the Alflow model will need to be determined. When the model proves to be sufficient it will be implemented in the finite element code DIEKA.

## References

1. U.F. Kocks and H. Mecking, Progress in Materials Science (2003) Vol. 48, 171-273.
2. E. Nes, Progress in Material Science (1998) Vol. 74, 129-193.