Integrating texture response into a deep drawing FEM-simulation via viscoplastic self-consistent model

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Abstract

In the aerospace and automotive industries, deep drawing processes are of major interest. The emission reduction efforts and hence the shift to alternative propulsion systems leads to new developments in lightweight and material design. The importance of rolled and extruded aluminum products for e.g. battery housings opens new fields of application. However, strongly directional deformation processes, such as rolling and extrusion, produce materials with anisotropic mechanical properties. This is especially the case for Aluminum sheets, which develop an alloy-dependent texture during the rolling process. The texture can have a considerable effect on the results of follow-up processes, such as deep drawing.

It is therefore necessary to consider the anisotropic material behavior during the forming process.

This can be realized by texture-based FEM simulations. However, due to the considerable numerical efforts necessary for full-field solutions, such as crystal plasticity FEM (CPFEM), current applications of FEM methods in forming simulations of industrial-sized parts either neglect anisotropic material properties or incorporate a fixed texture by special material models (e.g., Barlat, Cazacu, Hill, ...).
To address this major issue, we use a mean-field approach by implementing a viscoplastic self-consistent (VPSC) model into a FEM simulation framework, which is numerically more efficient than full-field methods. Nevertheless, the number of considered grains per finite element is a limiting factor. Therefore, our work studies the influence of a reduced, i.e. clustered, number of input grains on the simulation performance. This is done via a comparison of simulation results for cup drawing as well as the respective numerical effort needed.

Keywords: VPSC, FEM, Process Simulation, Deep Drawing

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