Modeling and design of polymer melts in extrusion-like processes

Daniel Hilger*, Florian Zwicke and Stefanie Elgeti

Chair for Computational Analysis of Technical Systems
RWTH Aachen University
Schinkelstraße 2, 52062 Aachen, Germany
e-mail: hilger/zwicke/elgeti@cats.rwth-aachen.de, web page: https://www.cats.rwth-aachen.de

ABSTRACT

In primary shaping processes of polymers–such as profile extrusion, injection moulding, or 3D printing– a molten polymer is forced into a prescribed shape. Subsequent to the shaping process, the polymer melt is cooled down and–as a result–solidifies. During the cooling and solidification stage the formed polymer part can experience warpage and thereby deviates from its geometric specifications [2]. These deviations are consequences of the nonlinear material behaviors of polymer melts and their strong temperature-dependences. Deviations from the specified geometry can be avoided by the use of numerical design methods in the design process of the shaping tools [3]. With the help of these methods, the geometry of the shaping tools is altered in such a way that the fully solidified polymer part meets the desired product specifications.

The success of numerical design methods relies on the accuracy of both the numerical methods and material models, which are utilized to describe the underlying process. The methods utilized in this work are motivated by the calibration stage in plastics profile extrusion. In the calibration stage, the already formed polymer melt solidifies as a consequence of air or water cooling. The problem description of this process needs to capture diverse physical effects: the viscoelastic flow properties of the polymer melt, free-surface movements at the surface of the polymer melt, and temperature-induced shrinkage of the formed polymer part.

We present a modeling approach for the solidification of polymer melts. The presented model considers the viscoelastic flow properties of polymer melts, temperature-induced shrinkage of the material, and the consequential free-surface movements. The viscoelastic flow properties are implemented in analogy to [3] and the free-surface movements are considered as described in [1]. The suggested model is implemented in the in-house finite-element solver xns. The models are valid for plastics profile extrusion, but also fused deposition modeling (FDM).

REFERENCES

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