A Viscoelastic-Viscoplastic Model for Semicrystalline Thermoplastics under Long-Term Loading

Patrick Zerbe*†‡, Benjamin Schneider†, Michael Kaliske‡

† Corporate Sector Research and Advance Engineering
Robert Bosch GmbH
Robert-Bosch-Campus 1, 71272 Renningen, Germany
e-mail: patrick.zerbe@de.bosch.com, web page: http://www.bosch.com

‡ Institute for Structural Analysis
Technische Universität Dresden
Georg-Schumann-Straße 7, 01187 Dresden, Germany
web page: http://www.tu-dresden.de/isd

ABSTRACT

Thermoplastic components subjected to long-term quasi-static loads in common operating conditions show increasing deformation with time, so-called creep, which may be critical in terms of their design. Such deformation, however, recovers partially during unloading phases affecting the deformation behavior during later reloading. Experiments with and without periodic unloading on a semicrystalline thermoplastic demonstrate this behavior. Based on these experiments, a viscoelastic-viscoplastic material model is presented for further analyses with the nonlinear Finite Element Method (FEM).

As the experiments show large deformations, a finite strain approach from [1] is used where the constitutive model is formulated in a logarithmic strain space. It allows a formulation similar to the geometric linear, small strain theory. Hence, the model rheology may be based on an additive decomposition of viscoelastic and viscoplastic strain components to separate recoverable from irrecoverable deformation. The viscoelasticity is represented by a generalized Maxwell model and the viscoplasticity by typical creep evolution equations, e.g. [2], without incorporating a yield surface. An isotropic damage model treats further deterioration of the material for both model components. Another observation from the experiments is a significant amount of volume change over time. Therefore, volumetric flow is considered in both model components. Here, special attention is given to the viscoplastic part formulated through a Huber [3] flow potential as described in [4].

A predictor-corrector scheme allows for efficient calculations and implementation as subroutine into a FEM software. Simulations with the implemented method are presented and compared with experimental results demonstrating the applicability of the model.

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