PREDICTION OF THE TRANSIENT EFFECTS AND LONG-TERM BEHAVIOR IN GLASSY POLYMERS

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ABSTRACT

The objective of this work is to model the mechanical behavior of glassy polymers during non-monotonic loadings involving transient effects, long-term dwell and necking instabilities. The microstructure of a glassy polymer has a strong influence on the mechanical properties and it is typically described by network models. The most popular approach is the 8-chain model, which is here referred as the BPA model, cf. Arruda and Boyce (1993). The BPA model is able to capture the monotonic loading well, but for transient effects after loading rate changes and for long-term behavior, the response of the BPA model is found to deviate significantly from the experimental data, cf. Dreistadt *et al.* (2009).

In order to improve the predictions under these conditions, an extension of the BPA model is proposed in this work. Compared to the original BPA model, the isotropic hardening effect in relation to kinematic hardening is substantially increased in the Extended BPA (EBPA) model. In addition to the overestimated recovery, the BPA model is not able to reproduce creep and nonlinear behavior during unloading. These shortcomings are primarily a consequence of neglected viscoelastic effects and thus, the single elastic spring in the BPA model is replaced by the Kelvin-chain. For the proposed changes, only three new material parameter are required, when the extended model retains the simplicity of the original BPA model.

The EBPA model is calibrated to experimental data both for homogeneous and inhomogeneous deformation. The data acquired from the cold drawing of the dumbbell-shaped polycarbonate specimen contains the load-displacement diagrams for monotonic as well as non-monotonic loadings involving several loading cycles and long-term recovery. The numerical treatment of the proposed model associated with the finite element analysis is also discussed.

References

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