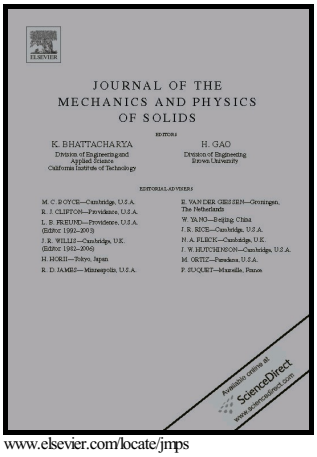

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Modelling multi-scale deformation of amorphous glassy polymers with experimentally motivated evolution of the microstructure

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Abstract

Novel experimental data, obtained recently using advanced multi-scale experiments, have been used to develop a micro-mechanically motivated constitutive model for amorphous glassy polymers. Taking advantage of the experiments, the model makes use of a microstructural deformation gradient to incorporate the experimentally obtained deformation of the microstructure, as well as its evolving orientation. By comparing results from the model to experimental data, it is shown the the proposed approach is able to accurately predict glassy polymer deformation over a wide range of length-scales, from the macroscopic response (mm range) down to the deformation of the microstructure (nm range). The proposed model is evaluated by comparing the numerical response to experimental results on multiple scales from an inhomogeneous cold drawing experiment of glassy polycarbonate. Besides the macroscopic force-displacement response, a qualitative comparison of the deformation field at the surface of the specimen is performed. Furthermore, the predicted evolution of the fabric orientation is compared to experimental results obtained from X-ray scattering experiments. The model shows very good agreement with the experimental data over a wide range of length scales.

Keywords: Elastic-viscoplastic material, Multi-scale, Glassy polymer, Experiments

1. Introduction

Due to favourable mechanical and manufacturing properties, glassy polymers are commonly used for containers or substitute for glass in the electronics and automotive industry. In such applications, glassy polymers are load carrying which implies that they risk being subjected to complex deformation phenomena, such as necking, deformation hardening and evolving anisotropy. The ability to accurately predict these phenomena is evidently of great importance when simulating the mechanical response of polymer structures. Many existing models are capable of capturing the global, macroscopic response of polymer structures in a

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