The Bauschinger effect in polymers

Citation for published version (APA):

Document status and date:
Published: 01/01/2009

Document Version:
Publisher's PDF, also known as Version of Record (includes final page, issue and volume numbers)

Please check the document version of this publication:
• A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
• The final author version and the galley proof are versions of the publication after peer review.
• The final published version features the final layout of the paper including the volume, issue and page numbers.

Link to publication

General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

• Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
• You may not further distribute the material or use it for any profit-making activity or commercial gain
• You may freely distribute the URL identifying the publication in the public portal.

If the publication is distributed under the terms of Article 25fa of the Dutch Copyright Act, indicated by the “Taverne” license above, please follow below link for the End User Agreement:
www.tue.nl/taverne

Take down policy
If you believe that this document breaches copyright please contact us at:
openaccess@tue.nl
providing details and we will investigate your claim.

Download date: 27. Dec. 2020
Introduction
During the processing of a polymer, the long molecular chains in the material orient themselves, resulting in a product with strongly anisotropic mechanical properties. To predict the performance of such products, it is essential that constitutive models capture the effect of orientation. Here, one of the simplest cases is considered: the effect of orientation in one direction on the uniaxial deformation behavior in that direction. While the difference between the mechanical behavior in tension and compression is small for isotropic polymers, it is enormous for oriented polymers, as shown in Fig. 1. This phenomenon is named after Johann Bauschinger, who described a similar effect in metals already in 1881.

Modeling the Bauschinger effect
Traditional models (Fig. 2a) describe a polymer’s mechanical response with a viscous flow stress, added to an elastic stress that represents the response of the entanglement network. Simulation results (Fig. 2b) show that, after the material has been oriented in tension, these models predict the yield point in compression to occur at positive stress levels. This is physically incorrect.

To resolve this issue, a deformation ($\lambda$) dependence of the viscous contribution is proposed. In order not to change the model predictions in the isotropic case, the elastic contribution is reduced accordingly, see Fig. 3a. Now, the experimentally observed Bauschinger effect is qualitatively described by the model. This is illustrated in Fig. 3b, where, after orienting the material in tension, the compressive yield stress is predicted to be of similar magnitude as that of isotropic material.

Orientation dependence of yield kinetics
Yield kinetics of polymers are indeed strongly influenced by orientation, as shown by the experimental data in Fig. 4. The nature of the effect differs between polymers: a shift for PC, but (mostly) a slope change for iPP. The physical cause for this difference is still unclear.

References
1. R.A. Duckett et al., J. Mater. Sci. 7, (1972), 480-482