MICROMECHANICAL MODELS OF FILLER REINFORCED RUBBER

R. Klauke, J. Meier, M. Klüppel

Deutsches Institut für Kautschuktechnologie e. V.
Eupener Straße 33, 30519 Hannover
Rainer.Klauke@DIKautschuk.de, Manfred.Klueppel@DIKautschuk.de

The objective of the poster is to show physically motivated models for hydrodynamic reinforcement, stress-softening and temperature dependent behaviour in rubberlike materials. In order to achieve this goal, experimental data, like unaxial and biaxial stress-strain-curves from S-SBR with 65 phr of Silica GR 7000 are analyzed in respect of the above mentioned phenomena to find mechanisms and explanations which are used as a starting point for further modelling. The formulation of the model is based on an extended tube-model of rubber elasticity [1,2]. The consideration of reinforcing filler-clusters leads to the Dynamic Flocculation Model [3] which is founded on elementary cluster-mechanics. It is shown that stress-softening can be modelled by modificating the stretch-ratio in the energy-density of the tube model according to the distribution of hard and soft filler-clusters and in respect of the cluster-size. In this context the factor Xmax(l) according to [4] is introduced which enable the model to describe the relation between inner and outer stretch-ratios in filled polymers, also denoted hydrodynamic reinforcement.

This context is used for the analytical description of hydrodynamic reinforcement. With the mathematical formulation of cluster-breakdown and –reaggregation and the difference of distribution between soft (broken) and hard (yet-unbroken) clusters, hysteresis and stress-softening can be simulated, obtaining very good results in respect to experimental data.

[1] G. Heinrich et al., Advanced Polym. Sci. 85, 33 (1988)
[2] G. Heinrich, M. Kaliske, An Extended Tube-Model for Rubber Elasticity: Statistical-Mechanical Theory and Finite Element Implementation, Rubber Chem. Technol. 72, 602 (2000)
[3] M. Klüppel, The Role of Disorder in Filler Reinforcement of Elastomers on Various Length Scales, Adv. Polym. Sci. 164, 1 (2005)
[4] M. Klüppel , J. Meier, M. Dämgen, Modeling of stress softening and filler induced hysteresis of elastomer materials, p. 171 in P.-E. Austrell and L. Kari (eds), Constitutive Models for Rubber IV. Taylor & Francis Group, London, 2005.

Dipl.-Ing. Rainer Klauke (SK)
am DIK seit 12/2005

Lebensdauer mehrachsig belasteter Elastomerbauteile