Viscoelastic Fracture of Rubbery Polymers: Experiments, Theory and Numerical Treatment

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Rubber-like materials exhibit rate-dependent viscoelastic response. Moreover, the fracture toughness of rubbery polymers is a rate-dependent phenomenon [1]. This effect manifests itself in terms of monotonically increasing fracture toughness with increased crack velocity examined in tearing tests. In this contribution, we carry out an experimental study for the identification of elastic and viscoelastic properties of various rubber compounds. Then, non-homogeneous specimens with existing crack and holes are tested at various loading speeds and the crack initiation and propagation is recorded. We propose a rate-dependent phase field approach for the failure of rubberlike materials. The ground state elasticity is modelled with the non-affine microsphere model whereas the superimposed viscous effects are incorporated into the model with a number of Maxwell elements [2]. The deformation gradient is multiplicatively decomposed into elastic and viscous parts. For the evolution of the viscous deformations, micromechanically motivated chain relaxation kinetics is derived. As a novel aspect, local phase field approach similar to damage mechanics formulation governs the failure of the superimposed chains whereas the degradation of the elastic network is governed by a classical Ginzburg-Landau type phase field approach in the sense of Schaenzel et al. [3,4]. We demonstrate the fitting quality of the proposed model by comparing them with the experimental results.

