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Constitutive Modelling of Time-Dependent Phenomena in Rubber-Like Materials

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Rubber-like materials exhibit highly nonlinear and inelastic mechanical behavior consisting of nonlinear stress-strain behavior up to large strains, hysteresis, the Mullins effect, and permanent set. A dependence on time and rate is also observed. While typical viscoelastic materials such as thermoplastics show both relaxation and rate dependency, industrial rubbers show significant relaxation as well, but their rate dependency is only very weakly pronounced over a wide frequency range [1, 2, 4]. Beyond that, the relaxation time of these materials depends on the loading rate of the previous loading sequences. In [2], these properties were attributed to a so-called time-rescaling behavior of the material.

The Model of Rubber Phenomenology (MORPH) [1] offers one possibility to simulate the time-independent behavior of rubber-like materials and this contribution deals with possibilities to include time-dependent effects. One of the approaches is based on an idea presented in [2], which is adopted in MORPH to simulate time-rescaling behavior. The extended model is applied to two different rubber-like materials – an industrial rubber [4] and a polyurethane-based adhesive [3] - and the corresponding material parameters are identified. The results of the parameter identification are presented and the applicability of the modelling approach to simulate time-dependent phenomena is evaluated.

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