Micromechanical Modelling of Rubber Toughened Glassy Polymers

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A common way to improve the toughness of a brittle polymeric material is to add rubber particles, which results in a change in mechanical behaviour. Representative volume elements (RVEs) can be used to study and model the influence of the rubber particles on the mechanical response. RVEs are micro-mechanical models of the local microstructure and its mechanical response is *representative* for the heterogeneous material. Studies using RVEs can provide vital insights in the interaction between rubber particles and the intrinsic response of the polymer matrix. The RVEs are not practically applicable when the performance of structural parts is assessed due to the orders of magnitude difference in length scale. The Gurson model can be used as an alternative to describe the effects of rubber particles on the macroscopic behaviour [1].

In this study, realistic 3D RVEs are used to facilitate the input for a macroscopic constitutive model for a series of rubber volume fractions. Simulations are performed for different macroscopic stress states ranging from pure deviatoric (shear) to pure hydrostatic (triaxial). Macroscopic dilatation is observed due to the hydrostatic component of the stress resulting in a non-linear dependence of yield stress with respect to the hydrostatic stress, see Figure 1. This non-linearity increases for higher rubber volume fraction. The yield function based on the Gurson model is used to describe the yielding behaviour of rubber toughened polymers and is implemented in the Eindhoven Glassy Polymer (EGP) model. The EGP model describes the intrinsic behaviour of glassy polymers [2]. The combination of the Gurson model and the EGP model results in a macroscopic constitutive model capable to describe the non-linear viscoelastic behaviour of rubber toughened polymers including its complex yielding behaviour with respect to the hydrostatic stress.

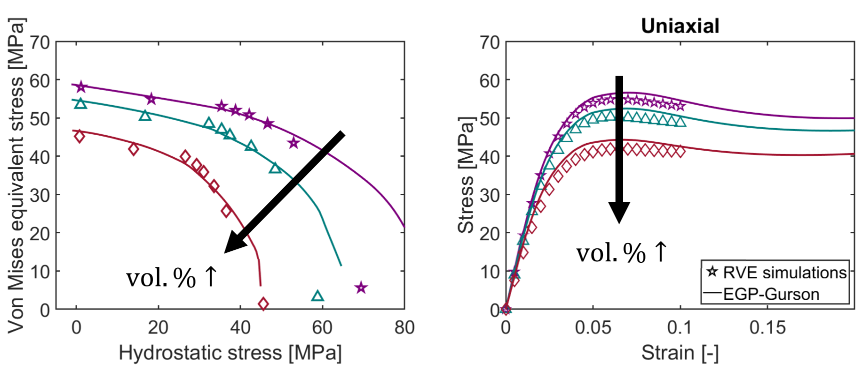

Figure 1: Left: Equivalent stress and hydrostatic yield stress for RVE simulations with various volume fractions and stress states. Right: Stress-strain curve for three different rubber volume fractions in uniaxial tension.

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