Abstract of PhD Thesis on

Constitutive Modelling for Strain-rate Dependency of Natural and High Damping Rubbers

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The microstructure and the mechanical behavior of natural rubber (NR) and high damping rubber (HDR) were investigated. In studying the mechanical behavior, most of the attention was paid to the compression regime, whereas some tests in tension were carried out for comparison. The mechanical tests revealed the existence of Mullins' effect, strain-rate dependency, hystersis and residual strain effects in all the specimens. In NR, the extent of these effects were found to have a inherent relation with the presence of microstructural voids. The presence of all these effects was also found to be significant in HDR. In addition, the strain-rate dependent high initial stiffness feature at low compressive stretch levels also became evident from the experiments. However, the microstructural observation of the current study could not explain these features of HDR. This promted for the need of considering a phenomenological approach to reach a general constitutive model for NR and HDR as well.

To this end, a constitutive model based on phenomenological motivation was introduced to model the strain-rate dependency effect. An improved hyperelasticity model was proposed to represent the rate-independent elastic responses including high initial stiffness characteristics. A comparative evaluation was carried out to display the better performance of the proposed hyperelasticity model over the conventional ones over the strain range in representing elastic response of NR and HDR. The hyperelasticity relation was incorporated in a finite deformation rate-dependent model structure. A parameter identification scheme was proposed to identify the parameters for the equilibrium and the instantaneous responses from the experimental data. To this end, the difficulties of direct application of infinitely fast or slow loading rate on such highly viscous material to obtain these responses and thereby to identify the nonlinear elastic parameters were overcome. To do this, experimental results were extrapolated and the proposed hyperelasticity model was used. The proposed scheme was applied on three types of specimens. Numerical simulation of the test results at different deformation modes followed by sensitivity studies verified the adequacy and the robustness of the proposed model and the parameter identification scheme.