

# Simulation of Thermomechanical Couplings of Viscoelastic Materials

F. Neff<sup>1</sup>, T. Miquel<sup>2</sup>, M. Johlitz<sup>1</sup>

<sup>1</sup>Universität der Bundeswehr München, Munich, Germany

<sup>2</sup>École polytechnique, Palaiseau, France

## Abstract

Nowadays, elastomers are basic materials in modern technical applications and constructions. For example they are used as bearings in automotive and aerospace industries. Several established models can be used to simulate the mechanical response of elastomers under mechanical loadings. Usually, these models are developed under isothermal conditions. On the one hand large dynamic loads cause a selfheating of the elastomers and on the other hand material parameters of elastomers show a big dependence on temperature. Concerning this an isothermal approach is not sufficient and leads to the motivation of a thermomechanical coupled model.

Using COMSOL Multiphysics® software, a new model was implemented with the Physics Builder functionality, which provides a thermomechanical coupling. It consists of two independent physics interfaces, one for the mechanical, viscoelastic behavior and one for the heat transfer. With the multiphysics coupling features it is now possible to add the effects of thermal expansion and dissipation or rather selfheating. It provides the possibility to model the temperature dependence of the mechanical material parameters as well. Thus, this model is fully coupled.

The mechanical interface is built with respect to the approach of finite multiplicative viscoelasticity. Elastomers behave nearly incompressible regarding external mechanical stress or strain conditions. For modelling volumetric phenomena like thermal expansion the deformation gradient is split into a volumetric and an isochoric part. In comparison to linear viscoelasticity the linear springs of the rheological model are now modelled with hyperelastic, e.g. Neo-Hookean, behavior. This approach is formulated by using another multiplicative split of the isochoric deformation gradient. The stress tensor is decomposed into an equilibrium and a non-equilibrium part. The non-equilibrium part describes the relaxation behavior. Hence this part also describes the amount of dissipated mechanical energy. The Heat Transfer in Solids interface provides the energy balance. Neglecting the coupled formulation, this balance reduces to the heat transfer equation. With the coupling feature, dissipated mechanical energy due to cyclic loadings or relaxation processes is added to the energy balance. That causes for example an increase in temperature under adiabatic boundary conditions if an elastomeric body is loaded dynamically.

The big advantage of the used formulation and implementation in COMSOL is the flexibility for the user. Users could add only the couplings being interesting for the specific problem.

# Reference

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- [5] E. H. Lee, Elastic-Plastic Deformation at Finite Strain, J. Appl. Mech., Vol. 36, pp. 1-6 (1969)

## Figures used in the abstract

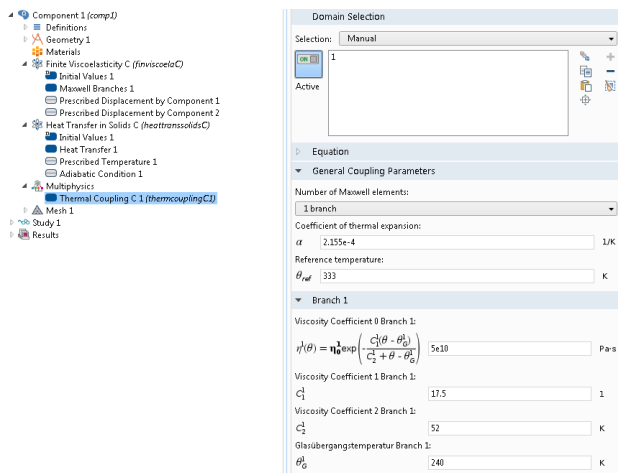


Figure 1: Layout of the new model in COMSOL Multiphysics.

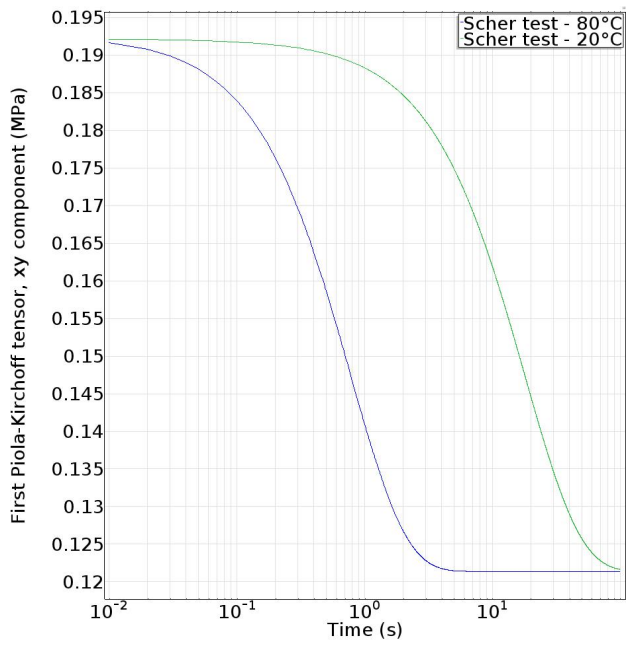


Figure 2: Temperature dependence of the relaxation time.

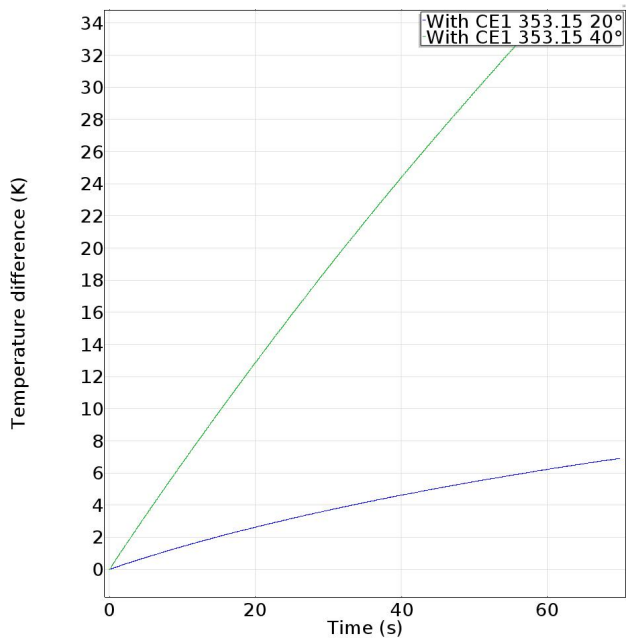


Figure 3: Selfheating under cyclic loadings.

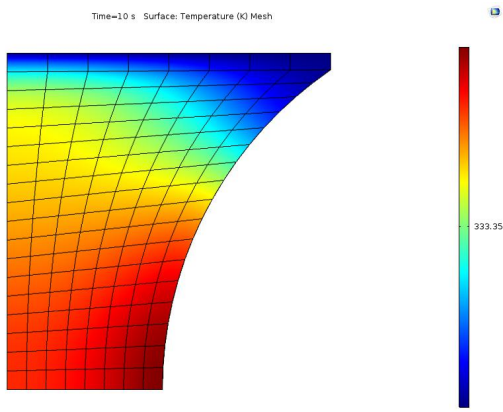


Figure 4: Selfheating of an hourglas-sample.