Characterization and Modeling of Elastomers

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Outline

- **I**ntroduction
- **M**echanical behavior of rubber
- **M**odeling with LS-DYNA
- Summary

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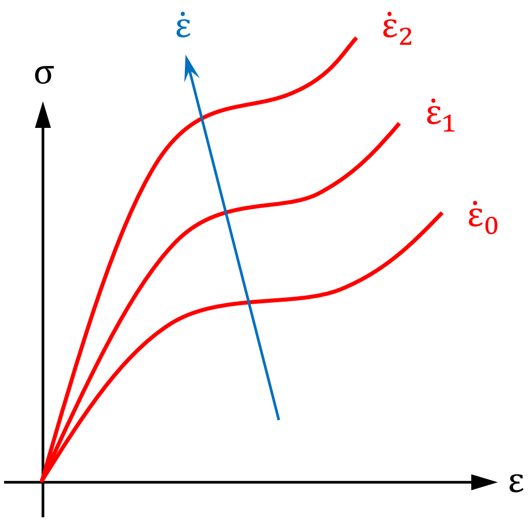
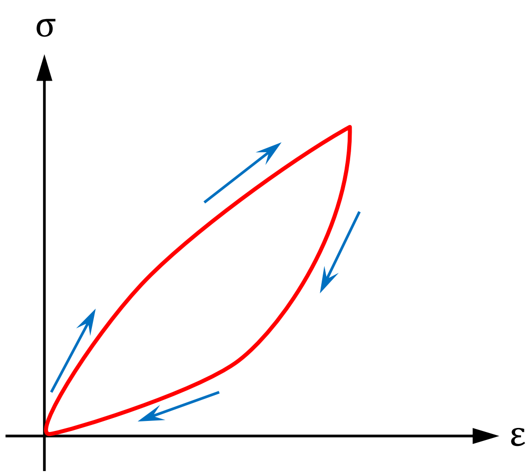
- Essential mechanical behavior of elastomers that should be considered in material models

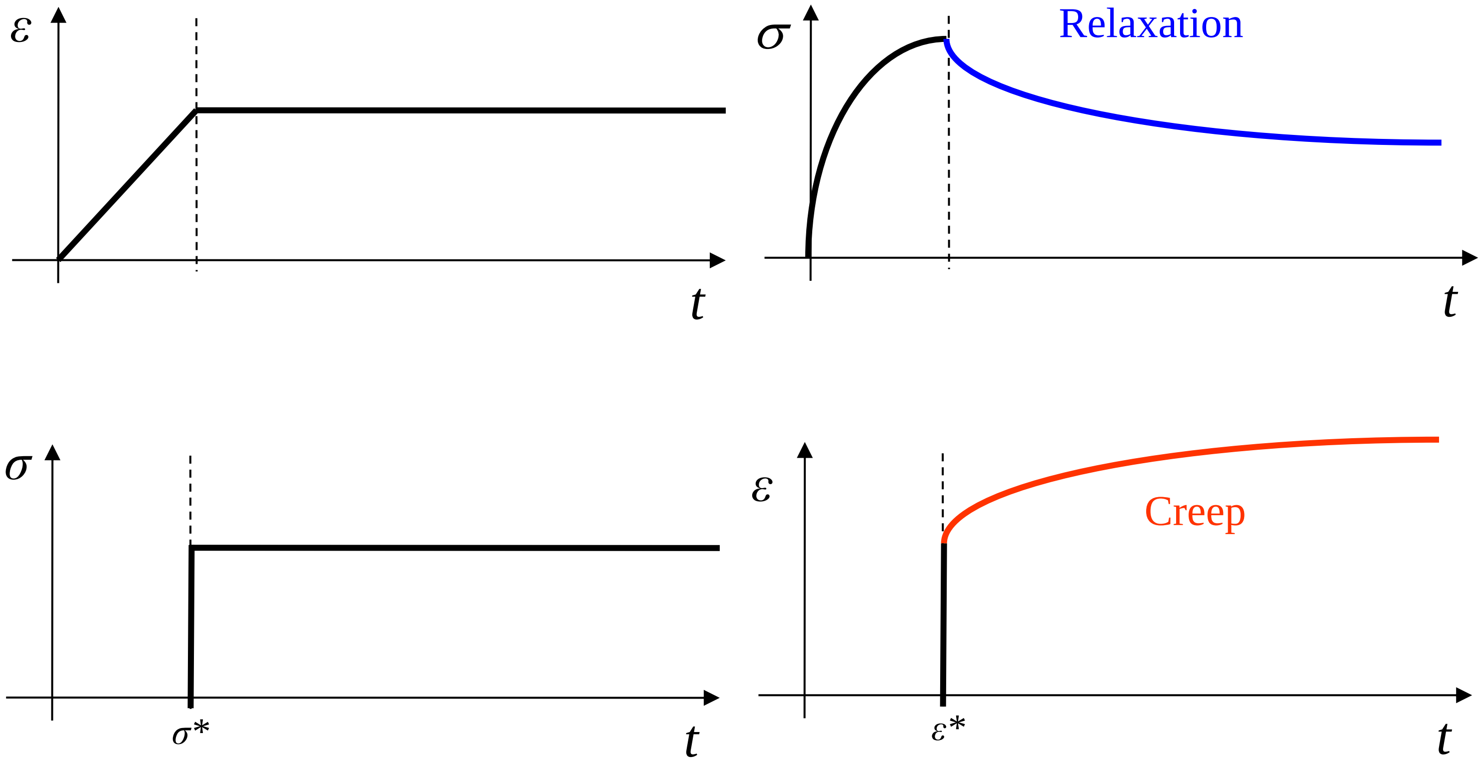
Strain-rate dependency



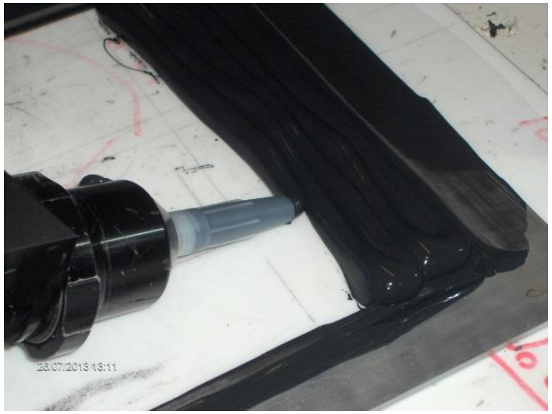
Hysteresis loop

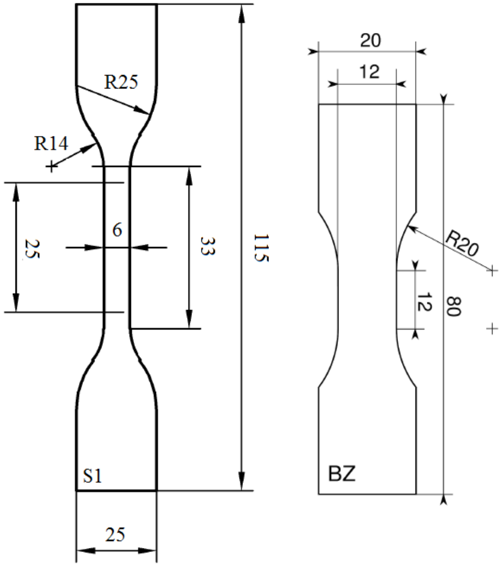


- Mechanical behavior of elastomers



- Rubber-like glue based on silicone:
  - Wide temperature range
  - Excellent environmental resistance
- Applications:
  - Civil engineering
  - Glass facades → structural glazing
- Current issues:
  - Long-term behavior
  - Dynamic behavior





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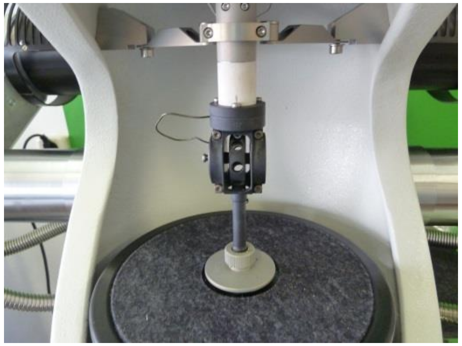
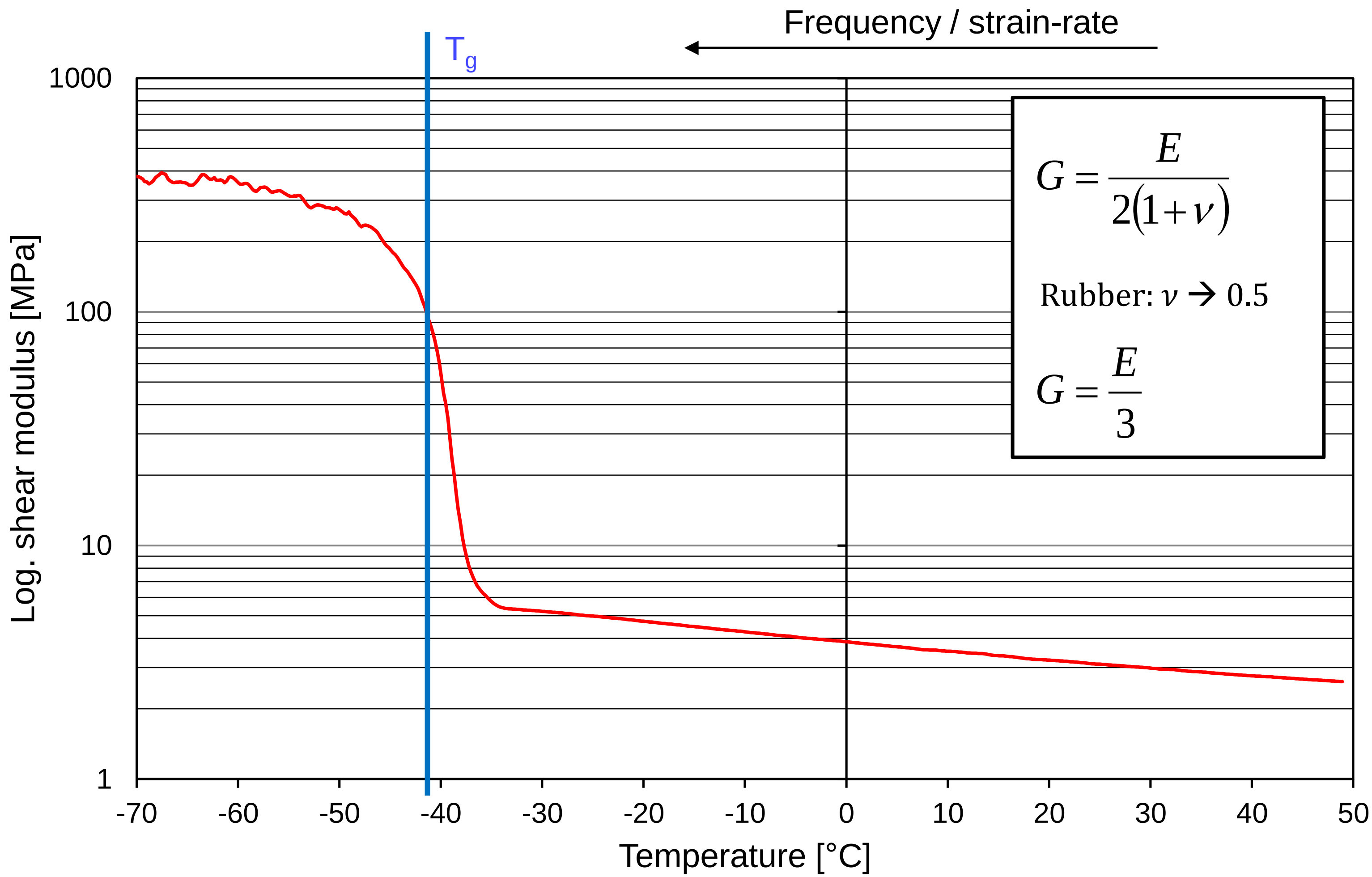
- Investigation of the frequency- and temperature dependency via **D**ynamic **M**echanical **T**hermal **A**nalysis

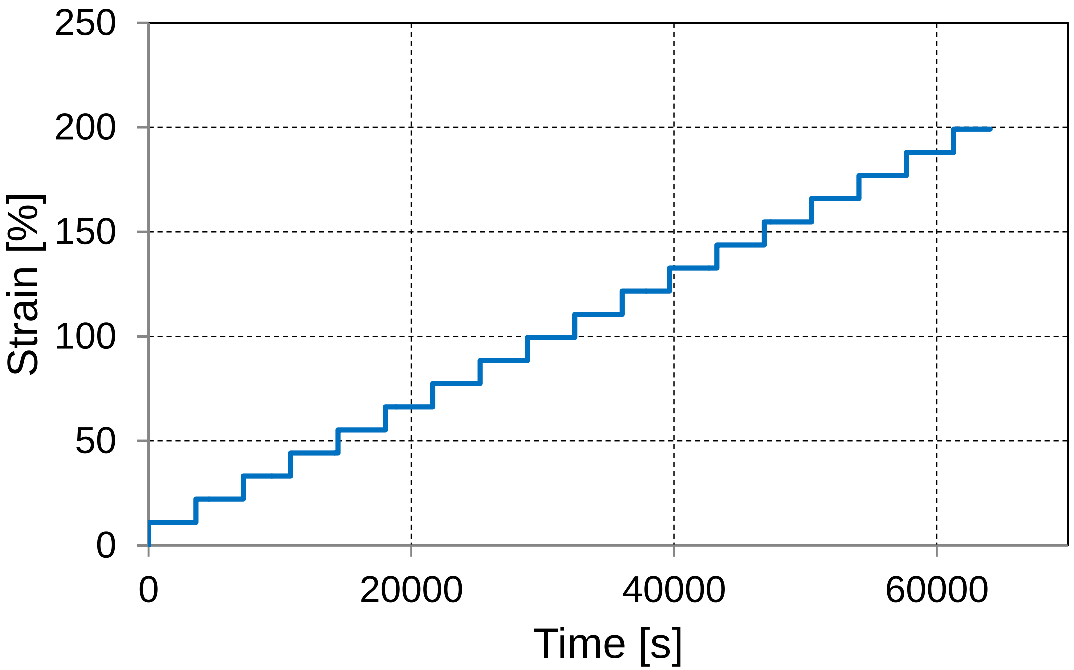


- Shear, tensile, compression and bending tests
- Harmonic loading of specimen
- Modulus as a function of temperature and frequency
- Glass transition temperature T_g

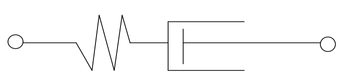
Mechanical behavior of rubber: glass transition



- Relaxation behavior of rubber

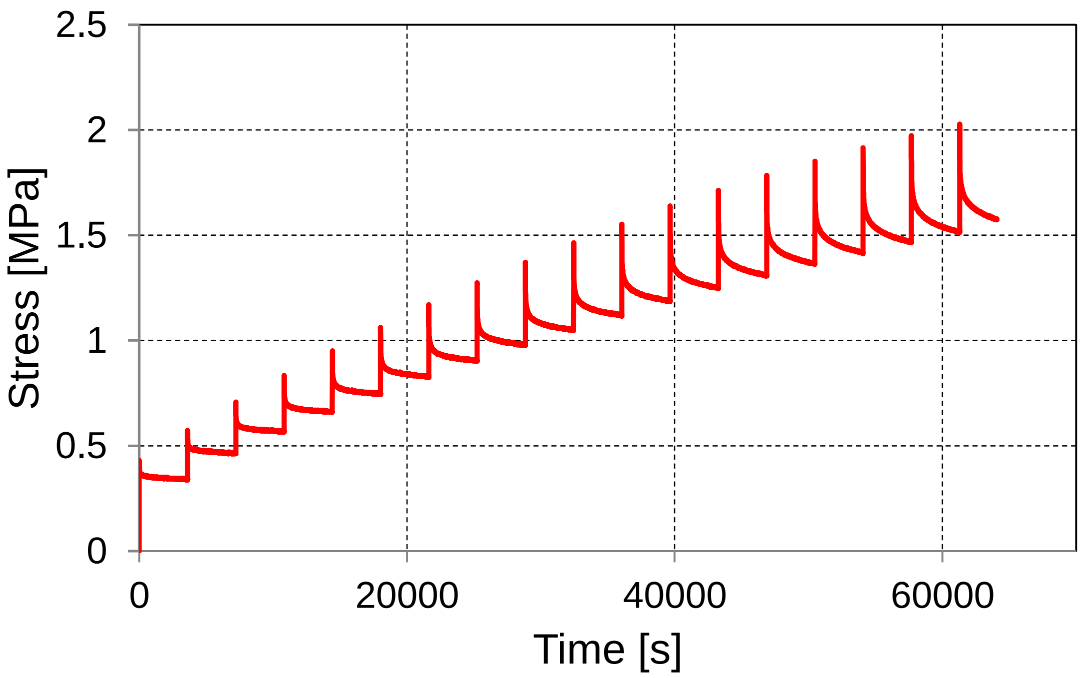


<u>Uniaxial tension</u>
for i < X
add +5% strain;
hold strain const. for 1 h;
i=i+1;
end



Relaxation of stress can be observed

➢ Relaxation behavior of rubber



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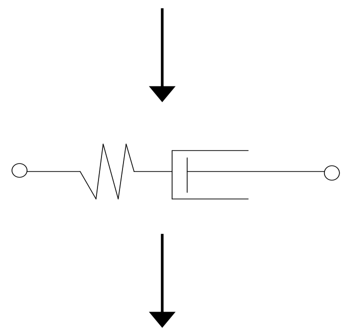
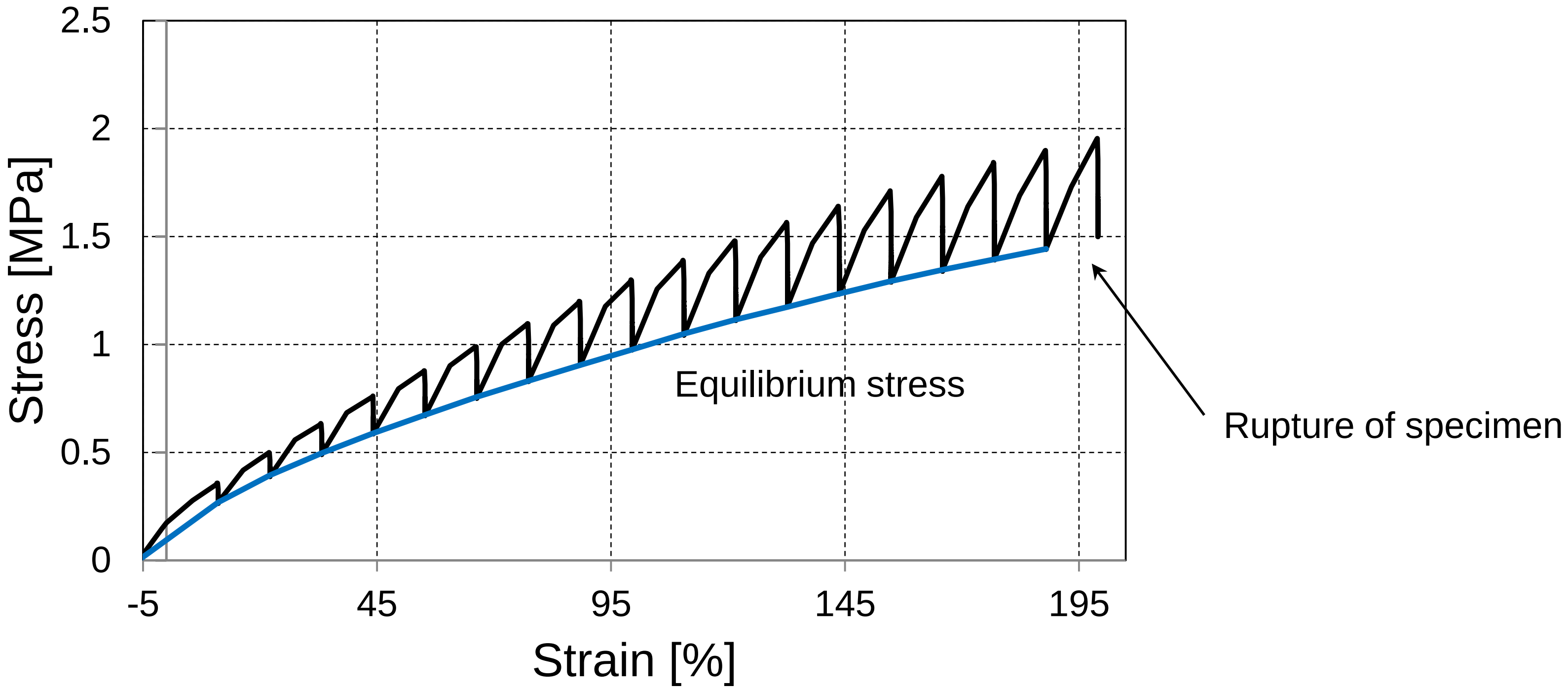


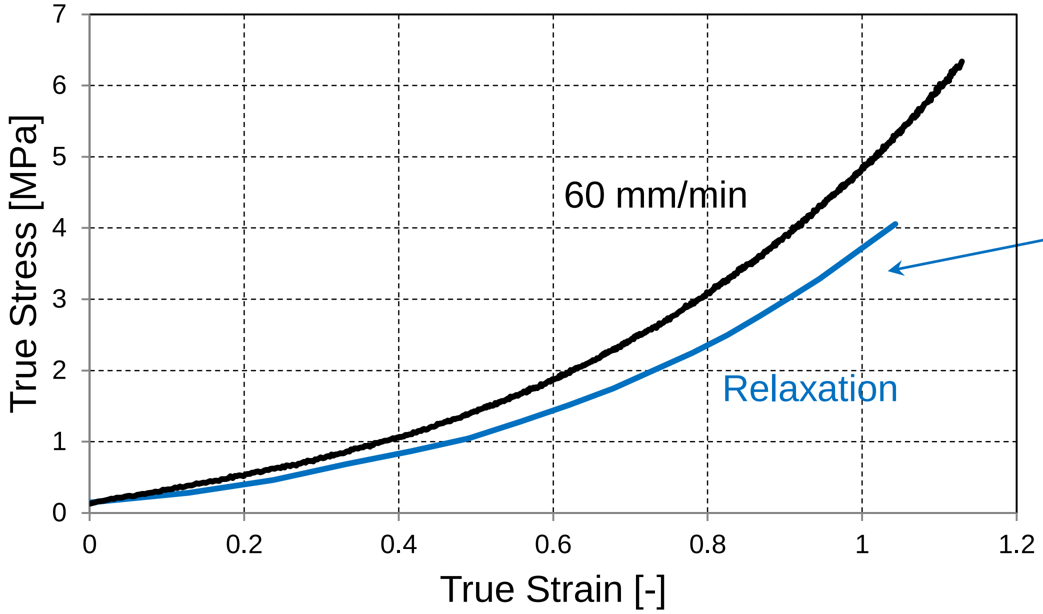
Relaxation of stress can be observed

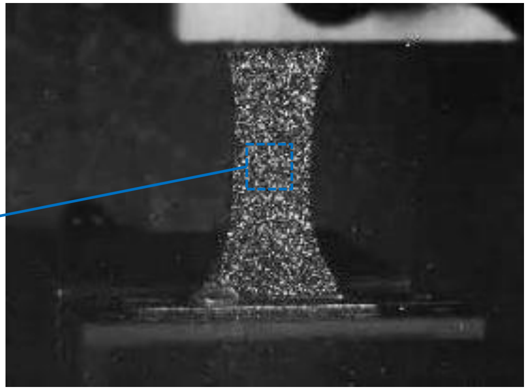
Mechanical behavior of rubber: relaxation

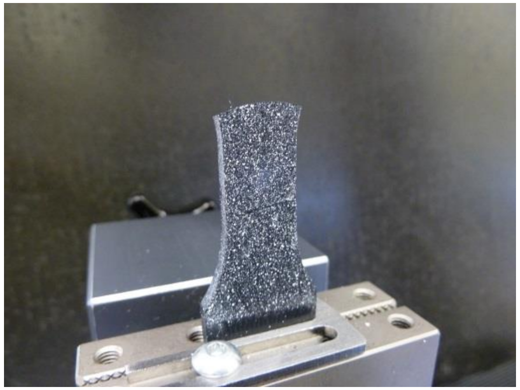
- Stress vs. strain curve from a relaxation experiment



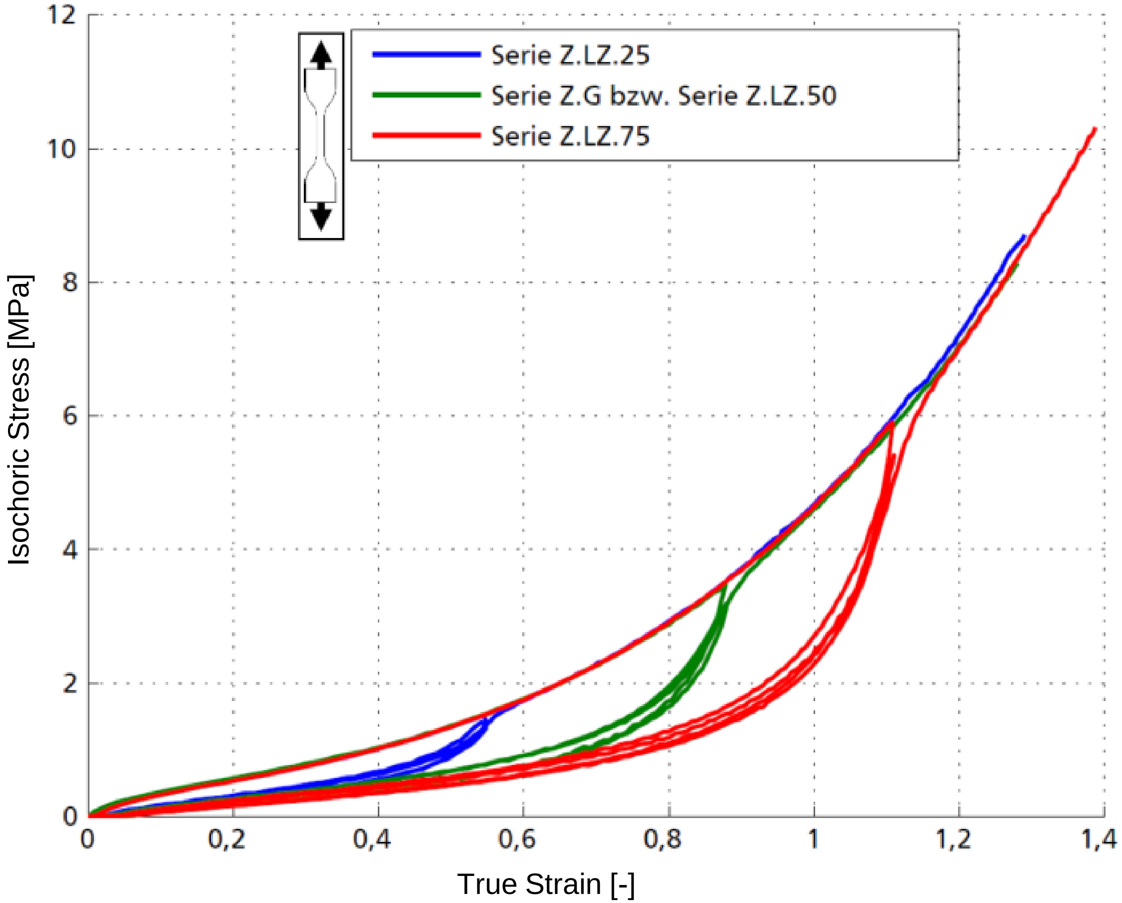
- Optical measurement (3D GOM Aramis 12M)



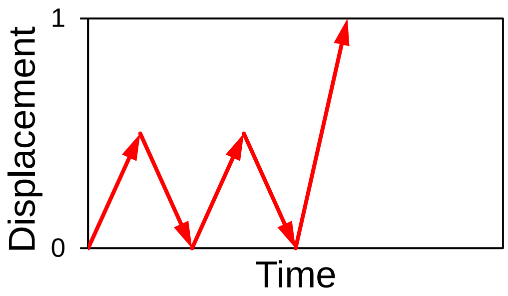




- Investigation of the **Mullins effect**



Cyclic tensile test



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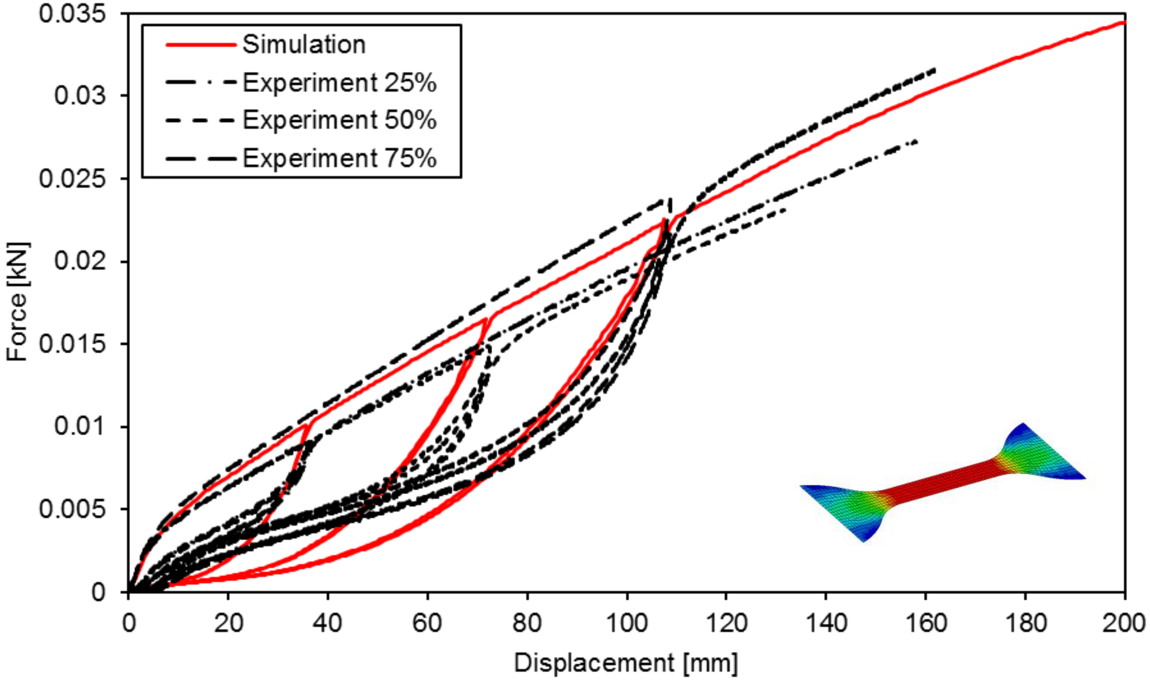
- Cyclic loading using MAT_SIMPLIFIED_RUBBER with elastic damage $\sigma_i^d = (1-d)\sigma_i$ where d → $d = d(W/W_{max})$



- Uniaxial tensile tests are the basis for cyclic tests
- Loadcurve describes material behavior
- Strain-rate effects were not taken into account
- One set of parameters is used
- Elastic damage is modeled with 2 parameters (HU, SHAPE)

Modeling with LS-DYNA

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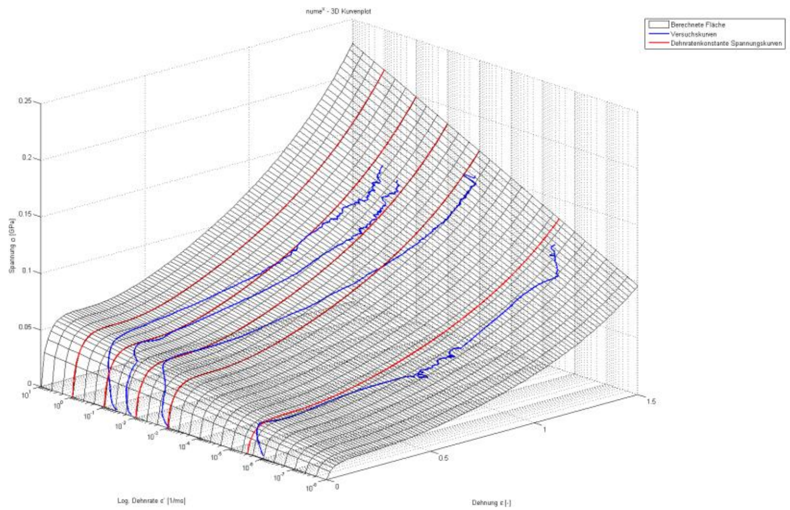
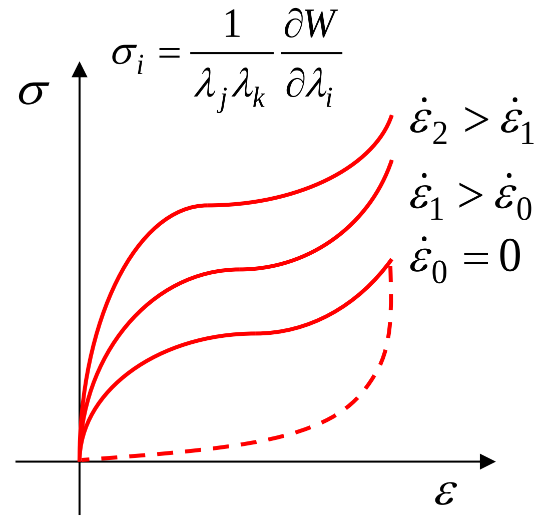
- Strain-rate dependent hyperelasticity
- Input of loadcurves from experimental tests





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- Tabulated hyperelasticity (MAT_181)
  - Direct input of experimental results
    → no time-consuming parameter identification
  - Elastic damage with help of one loadcurve or two parameters
  - Limited modeling of viscous behavior
- Hyperelasticity coupled with **nonlinear** viscoelasticity needed!