SDU

COMSOL CONFERENCE
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Finite Element Based Improved Characterization of Viscoelastic Materials

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Overview

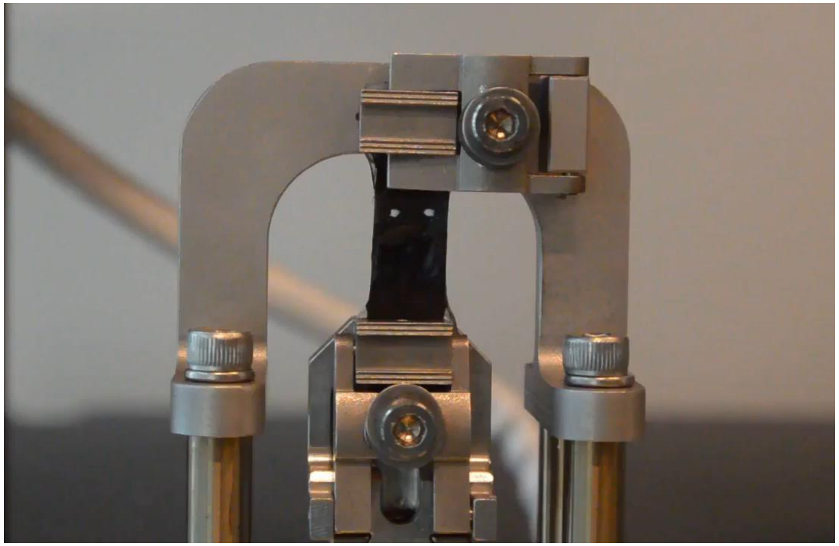
- Introduction
- Dynamic Mechanical Analysis
- Image Processing
- Theory
- COMSOL Implementation
- Results
- Conclusion

Introduction

- Viscoelastic Material
- Material Characterization
- Hyper-elastic Models

Dynamic Mechanical Analysis

Measurement of Force and Displacement



Dynamic Mechanical Analysis

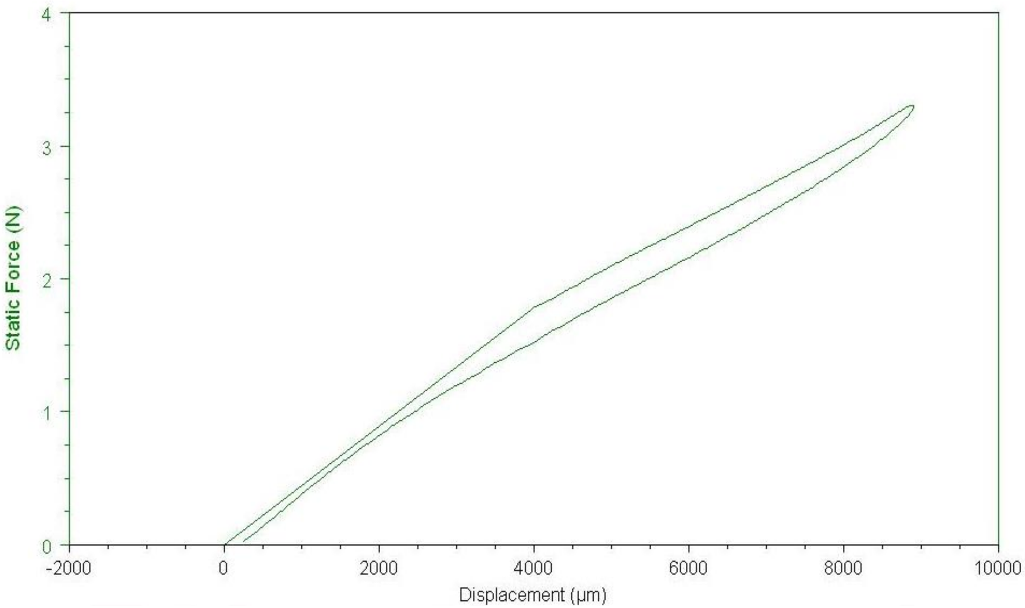


Fig 1. Dynamic Mechanical Analysis Result

Image Processing

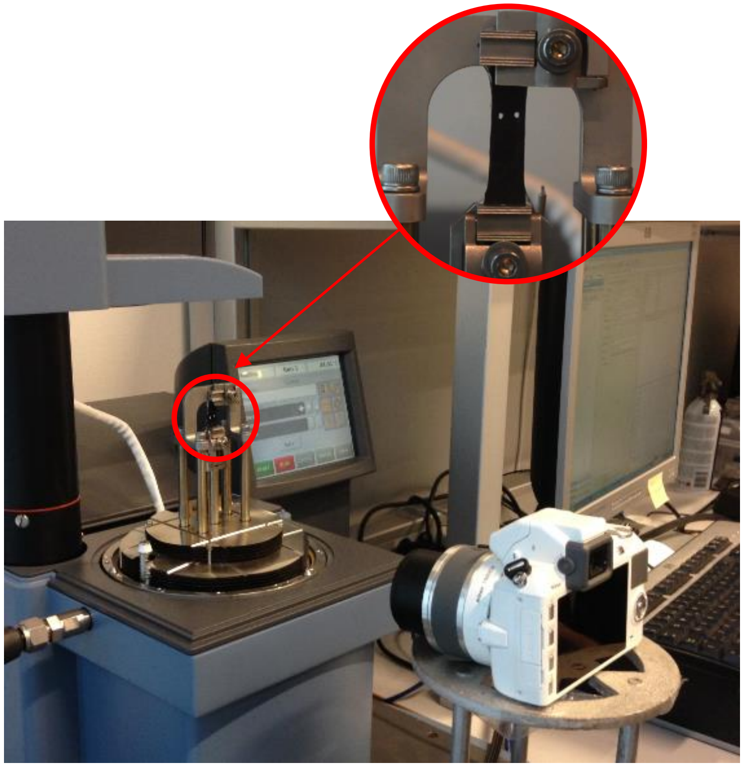


Fig 2. Image Processing Setup

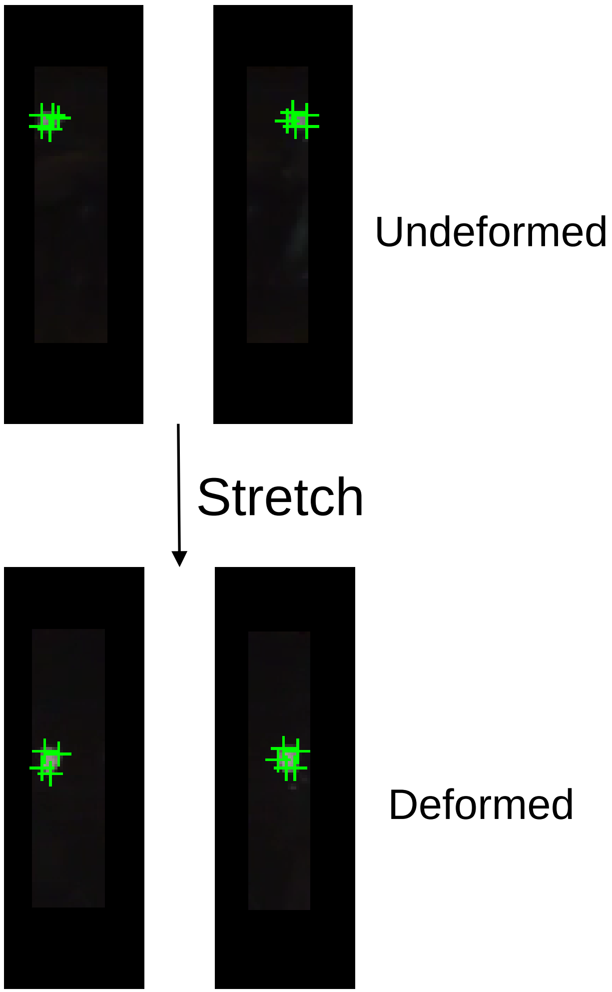


Image Processing

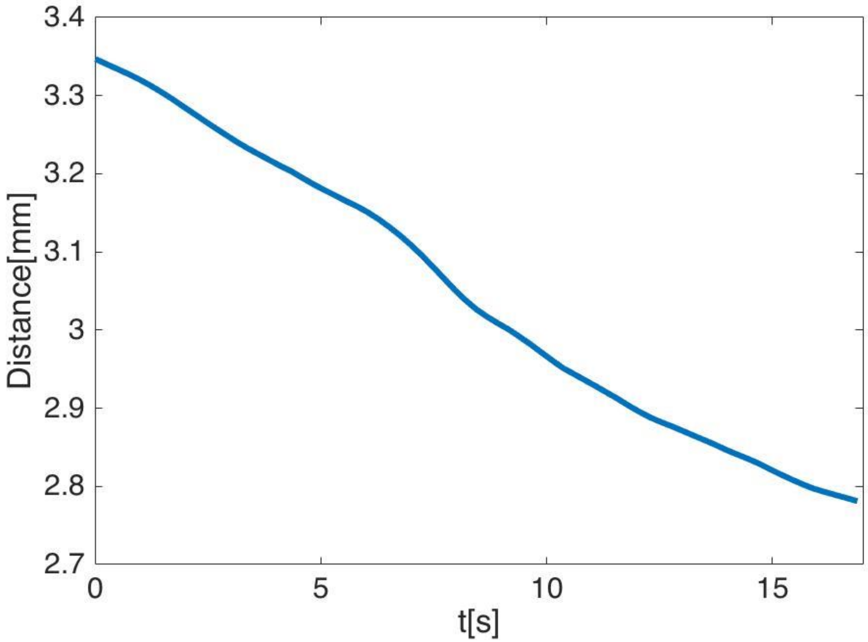
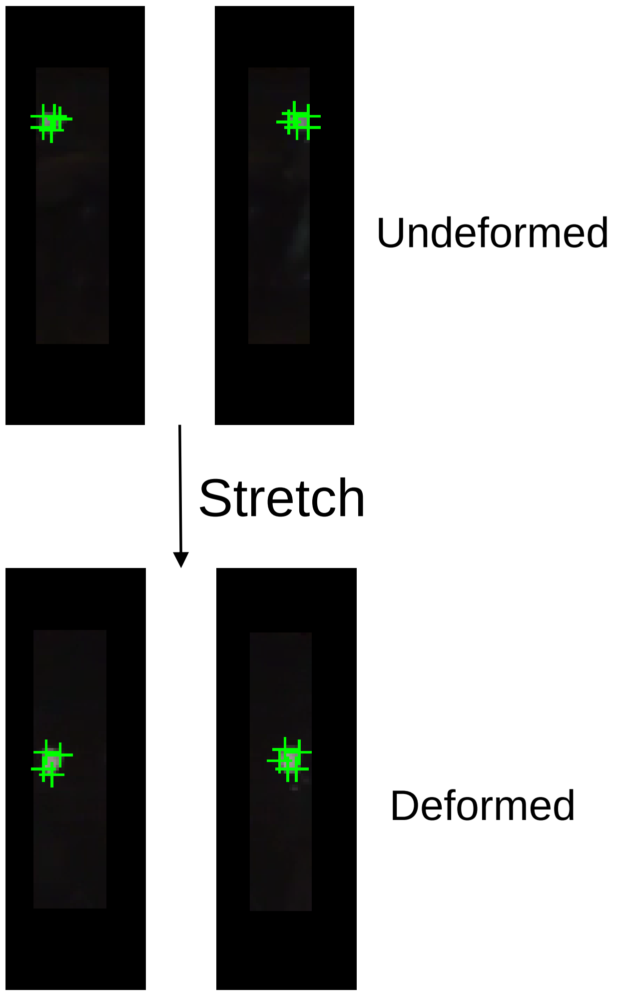


Fig 3. Distance between two dots



Theory

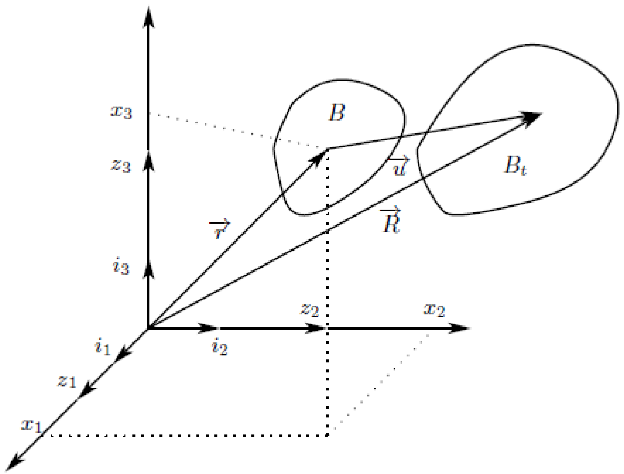


Fig 4. General coordinate system with deformed and undeformed bodies.

$$\delta I = \int_{t_1}^{t_2} \int_B \left(\rho_R \frac{\partial u_i}{\partial t} \frac{\partial \delta u_i}{\partial t} - \delta W \right) dB dt$$

Mooney-Rivlin model

$$W = C_{01}(\bar{I}_2 - 3) + C_{10}(\bar{I}_1 - 3) + D_1(J-1)^2$$

Yeoh model

$$W = \sum_{i=1}^{n} C_{i0}(\bar{I}_1 - 3)^i + \sum_{k=1}^{n} C_{k1}(J-1)^{2k}$$

Arruda-Boyce model

$$W = D_1\left(\frac{J^2-1}{2} - \ln J\right) + C_1 \sum_{i=1}^{5} \alpha_i \beta^{i-1}(\bar{I}_1^i - 3^i)$$

COMSOL Implementation

- Time Dependent Weak Form PDE
- Global ODEs and DAEs
- Domain Point Probes
- Boundary Conditions

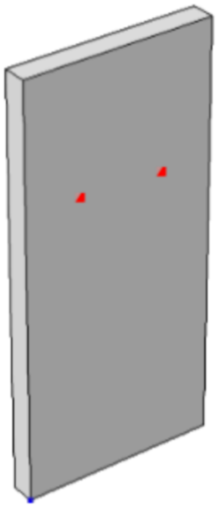


Fig 5. Geometry model including two probes.

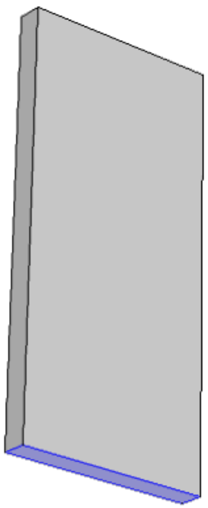
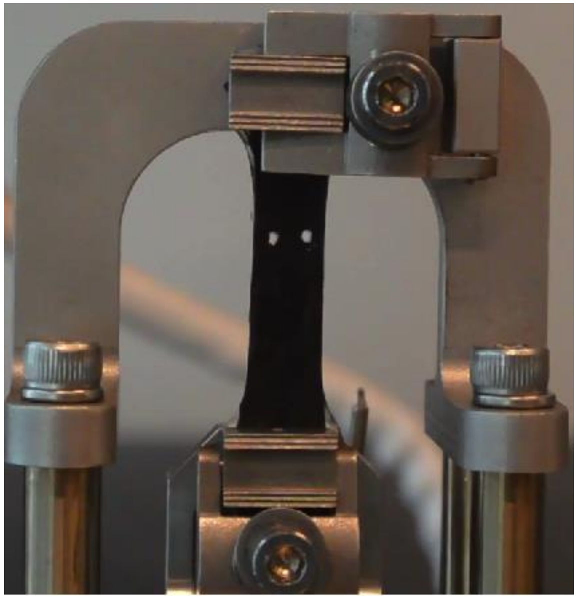


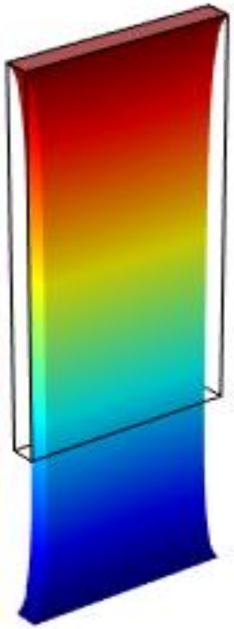
Fig 6. The time-dependent lower boundary condition.

COMSOL Implementation

Results

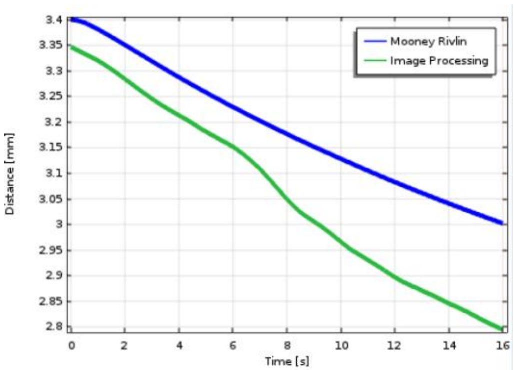
Comparison between DMA Test and Numerical Model

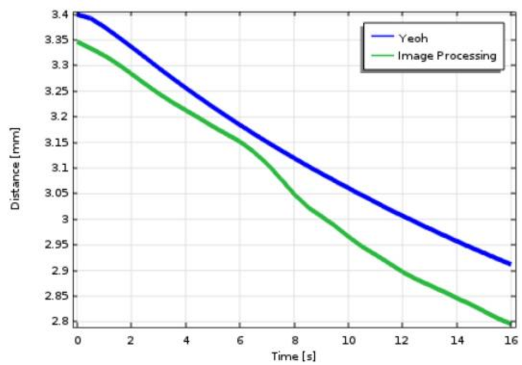


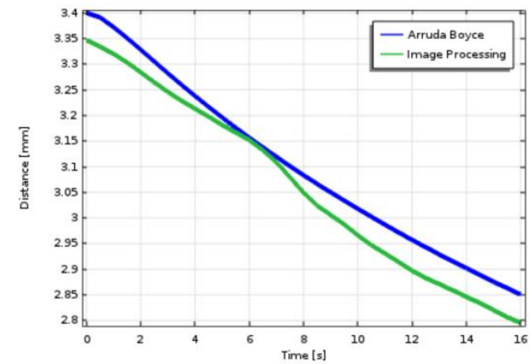


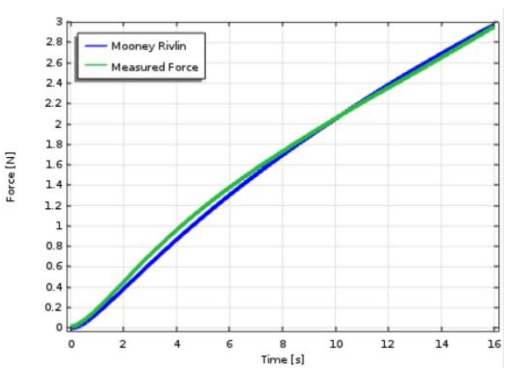
Results

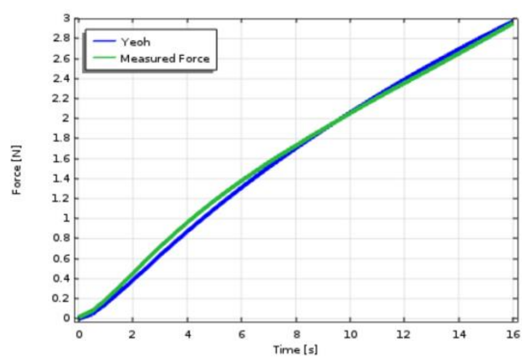
Comparison of Different Hyperelastic Models

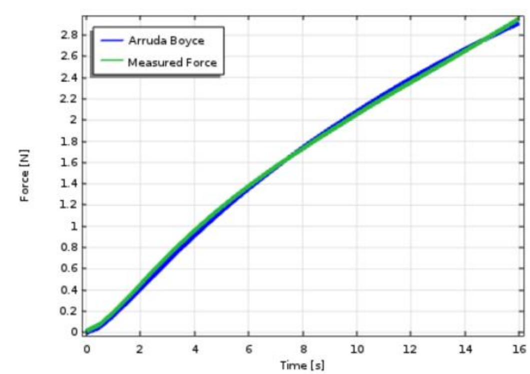












Conclusion

From the results of the *COMSOL* simulations, all of the hyperelastic models exhibit the correct trend of the non-linear behavior of the material. However, the Arruda-Boyce hyper-elastic material model proves to be the most accurate of the chosen.

Thank you!