

## Nonlinear Plastic & Rubber Simulation

Psylotech's nonlinear viscoelastic simulation process addresses challenges with polymer simulation, including time, history, rate, temperature, hydrostatic pressure and large deformation effects. The solution combines **1/**data generated on a proprietary instrument and **2/**a simulation software add-on module for the major finite element codes.

## Novel Test

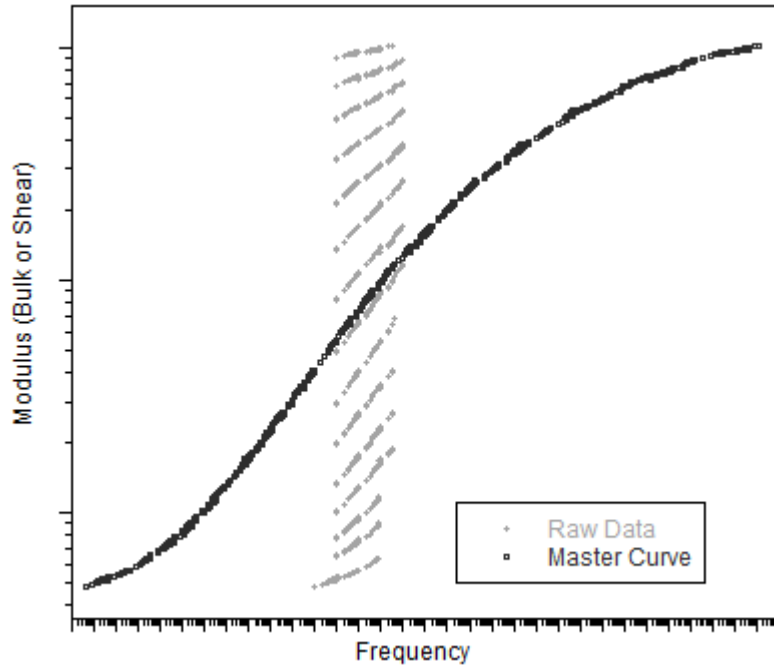
Psylotech's polymer test system generates an accurate, complete, thermodynamically consistent data set for effective finite element analysis. The instrument is highly differentiated from alternatives:

1. **Axial + transverse strain measurement** informs direct bulk & shear modulus calculation. Any mechanical loading can be split into dilatational and distortional components, so these two properties fully define the material for FEA.
2. Proprietary, **ultra high resolution sensors** enable effective rubbery and glassy force measurement, while also accommodating thermal strains substantially larger than mechanical strain perturbations.
3. **Local strain measurement** on tensile specimens bypasses contact point stress and friction errors from traditional beam-bending dynamic mechanical analysis.

Contract tests are conducted as isothermal frequency sweeps. Temperature inside a vacuum-insulated, forced convection, environmental chamber is controlled from a specimen mounted thermocouple. Dynamic shear & bulk modulus are calculated by:

$$G^* = \frac{\sigma_{11}^*}{2(\epsilon_{11}^* - \epsilon_{22}^*)} \quad \kappa^* = \frac{\sigma_{11}^*}{3(\epsilon_{11}^* - 2\epsilon_{22}^*)}$$

## Experimental Data Post Processing



Axial and transverse strain are concurrently measured on the same sample with the same loading & processing history. Therefore, bulk and shear properties can be effectively inferred. To generate master curves, isothermal frequency sweeps are shifted vertically and horizontally. The unique shifting process checks for self-consistency and thermodynamic viability:

1. Poisson's ratio is maintained within a reasonable range
2. Inferred loss modulus is compared to measurements
3. Prony series relaxation times are always positive

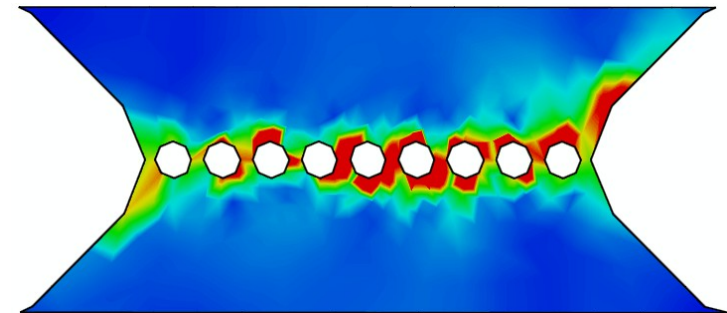
The result is a complete mathematical description of a viscoelastic material's time and temperature dependence for FEA.

## Simulation Software Module

Viscoelastic material properties are incorporated into a nonlinear simulation software module, accommodating:

1. **time**, including rate and history effects
2. **temperature**
3. hydrostatic **pressure**
4. **large deformation**

The module is a material definition based on Knauss & Emri's Free Volume reduced time model (1981), modified for shear by Popelar & Liechti (1997). It is currently available for Abaqus™, where Psylotech is a Simulia™ software partner. Add-on modules for the other major finite element codes will follow.



## About Psylotech

Psylotech provides **1/**contract testing services, **2/a** nonlinear viscoelastic simulation software add-on module, and **3/**instrumentation for simulation. For structural plastics, rubbers and composites, Psylotech offers a complete simulation solution, consisting of contract test data and software to unlock the value of that data. Additionally, under-microscope load frames offer unprecedented speed, stroke and resolution for micro & nano scale universal testing.