Generation of Master Curves for Cured Rubber

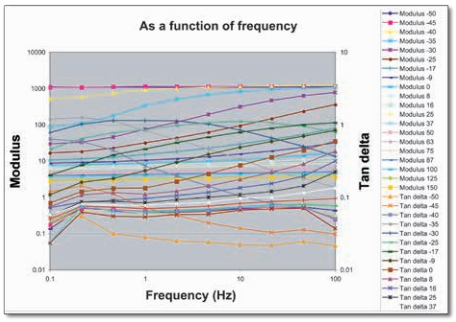
The Challenge:

Predict the Frequency Response of Cured Rubber Materials using Time-Temperature Superposition

Background

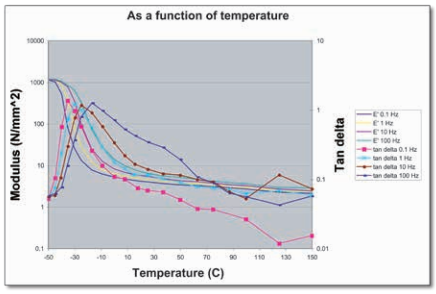
The Williams, Landel & Ferry model (WLF) uses time-temperature superposition to generate master curves that predict the dynamic behavior of materials at frequencies outside the range of practical measurement. This model relies on the observation that time and temperature have equivalent effects on the properties of viscoelastic materials.

The master curve is created with data from a dynamic mechanical analyzer (DMA) that produces modulus (E) and loss (tan delta) values over a moderate range of frequencies and temperatures. The master curve predicts the dynamic behavior of the material over a very wide frequency range at a constant (usually room) temperature.



These data can be sorted by frequency to show the glass transition of the different materials as a function of temperature.

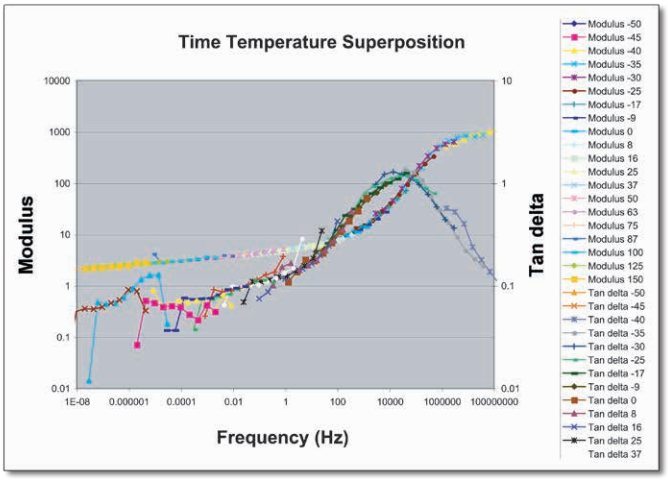
Time-temperature superposition can be used to predict the behavior of the material from $1x10^{-8}$ to $1x10^{8}$ Hz at a any chosen temperature.



Meeting the Challenge

Dr. Joey Mead of the University of Massachusetts, Lowell worked with the U.S. Army Research Laboratory and the Michigan Technical University to optimize the rubber bushings used in tank track applications. Tests were conducted on four rubber compounds to compare the measured material properties to real-world bushing successes or failures.

The ElectroForce® 3200 test instrument was used with a hot/cold chamber to measure the dynamic modulus and tan delta of the material over a frequency range of 0.1 Hz to 100 Hz at 25 different temperatures ranging from -50 to 150˚C.



Four samples were tested in this manner and the measured properties will be used to predict the durability of candidate bushing materials.

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