Automated dynamic Young's modulus and loss factor measuremeats

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Session J. Shock and Vibration II: Measurement of Dynamic Moduli and Loss Factors of Viscoelastic Materials

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Invited Paper

1:30

J1. Dynamic testing of elastomeric materials. E. C. Hobaica (General Dynamics, Electric Boat Division, Groton, CT 06340)

Elastomeric materials display a very complex time-dependent response to stress. When attempting to characterize the behavior of such viscoelastic materials, the number of meaningful test methods are found to be limited and test results must be carefully applied over limited conditions. This presentation reviews the methods of obtaining dynamic properties of elastomers over the full range of frequencies that may be encountered. It starts with a brief discussion of viscoelastic behavior, covers the temperature–frequency equivalence postulated by Williams–Landel–Ferry, before reviewing test methods. It groups the methods by frequency. Methods discussed range from the torsional pendulum to wave propagation methods and include the Rheovibron, the Fitzgerald apparatus, and the transmitted force method among others. Particular attention is given the flexure wave apparatus used at Electric Boat.

Contributed Papers

1:55

J2. The measurement of the bulk modulus of polymers and its loss factor in the 1 to 10 kHz frequency range. Geoffrey L. Wilson (The Pennsylvania State University, Applied Research Laboratory, State College, PA 16801)

The bulk modulus and its loss factor are difficult to measure directly and are usually obtained indirectly from measurements of the Young's modulus and the shear modulus. This paper will discuss methods that have been used for the direct measurement in the frequency range of 1 to 10 kHz.

2:10

J3. The determination of the loss tangent of PVAc derived from measurements with a creep torsiometer. W. G. Knauss (California Institute of Technology, Pasadena, CA 91125)

Damping characteristics or energy dissipative characteristics of materials can be determined in a variety of ways. If a proven or acceptable constitutive description for a material at hand exists, virtually any physical measurement can be converted into a description of energy loss, provided the measurements are sufficiently accurate and are made over a suitable range of parametric interest. In many applications, particularly acoustics, deformations are so small that linearly viscoelastic behavior represents an appropriate constitutive description. Starting from a description of the apparatus shear creep measurements are converted exactly and approximately to loss tangent (storage and loss modulus) data. A comparison of the approximate and exact representation is made. The description of the test procedure and computations allows the comparison to other methods with respect to ease and accuracy of property determination.

2:25

J4. Automated dynamic Young's modulus and loss factor measurements. Walter M. Madigosky and Gilbert F. Lee (Naval Surface Weapons Center, Silver Spring, MD 20910)

A progressive wave apparatus featuring an automated data processor is described. The apparatus accurately determines the propagation constants of an extensional acoustic wave by exciting one end of a strip of material while the other end is suspended under constant tension. The apparatus is capable of making measurements in the frequency range of 100 Hz to 40 kHz, depending on the extensional wave velocity and attenuation in the material. As illustrations of the technique, measurements were made on several rubber compounds of different polymer type and compounding ingredients. Extensional sound speed, attenuation, modulus, and loss factor were determined over a frequency range of 1–10 kHz and a temperature range of 4°–47 °C. Applying the time–temperature superposition principle to the data, master curves were constructed and WLF shift constants were determined. The apparatus was found to be a fast and reliable method to determine the dynamic viscoelastic constants.

2:40

J5. High-frequency measurement of the elastic modulus of rubber by the Schlieren method. S. I. Hayek and S. Stanic (The Pennsylvania State University, University Park, PA 16802)

High-frequency measurements of the complex Young's modulus was achieved by use of Schlieren photography. A sample plate is immersed in a water tank and insonified by an acoustic beam. A laser beam is expanded and used to illuminate the acoustic field at right angles. The resulting diffraction of light by the sound field is imaged by a video camera. Calibration of the light intensity with the sound intensity gives a quantitative measurement of the sound intensity in the acoustic medium. Thus, the incident, reflected, and transmitted wave intensities are measured. These data are used to compute the complex Young's modulus of the rubber sample. Measurements were made for frequencies between 100 kHz and 2 MHz for a sample of rubber.

2:55

J6. Measurement of dynamic elastic moduli. S. Edelman and N. Newman (National Bureau of Standards, Washington, DC 20234)