Measurement of the dynamic properties of rubber compounds

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It is known that elastomeric and reinforcing materials used in the mechanical rubber goods (MRG) industry possess a combination of viscoelastic properties [1]. The dynamic mechanical properties of viscoelastic materials are normally characterised [1, 2] by the complex dynamic modulus

\[ E^* = E' + iE'' \] (1)

where \( E' \) and \( E'' \) are the real and imaginary parts of the dynamic modulus, or by the compliance

\[ J^* = \frac{1}{E^*} \] (2)

and also by the phase shift \( \delta \) between the stress and strain

\[ \tan \delta = \frac{E'}{E''} \] (3)

Measurement of these quantities is necessary for the correct selection of viscoelastic materials operating under the dynamic loading conditions characteristic of tyres and many MRGs.

To measure the dynamic characteristics of viscoelastic materials, including rubbers, the Bruel & Kjear company has developed an instrument [3, 4] for dynamic mechanical analysis (DMA) that makes it possible to carry out measurements at different tensile, compressive, shear, and flexural strain amplitudes and at different times, temperatures, and frequencies. A computer is used to select and maintain the test regimes and to process the results. A block diagram of the measuring apparatus is presented in Figure 1.

Harmonic vibrations of the electromagnetic vibrator are excited by a powerful amplifier. The nucleus of the vibrator is a permanent magnet which vibrates under the action of changes in the magnetic field of the coil. The measurers are piezoelectric gauges fastened by a small permanent magnet. The signal is recorded by a two-channel analyser which is connected to a computer.

The instrument makes it possible to obtain values of the tensile and shear modulus and the compliance, and to determine the mechanical losses at prescribed values of the amplitude of stress or strain.

The results obtained using DMA can be used to investigate the influence of different components of the composition (the type of rubber, fillers, plasticisers, and other ingredients) on the properties of the rubbers, and make it possible to assess the compatibility of rubbers. Use of DMA data when developing the formulation of rubber compounds makes it possible to estimate their service properties and predict the behaviour of materials depending on the conditions of their application. The use

![Figure 1 Block diagram of measurement of complex elastic modulus: 1 — input signal amplifier; 2 — vibrator; 3 — input signal gauge; 4 — specimen; 5 — output signal gauge; 6 — output signal amplifier; 7 — two-channel analyser; 8 — computer](image)
Thus, the use of results obtained by DMA makes it possible, at an advanced level, to develop the materials and the construction for articles such as tyres, conveyer belts, V-belts, hosing, shock absorbers, and seals operating under conditions of dynamic loading.

REFERENCES

2. J. Ferry, Viscoelastic properties of polymers, Izdatinlit, Moscow, 1963, 535 pp. (trans. from English)

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