DMA TESTING OF RUBBER BLENDS

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ABSTRACT
Rubber blends dynamic-mechanical characteristics has been investigated. The aim of this work is to present DMA testing on Diamond Pyris DMA testing machine, characterisation of thermal dynamic mechanical properties of rubber blends. Dynamic mechanical analysis (DMA) is a powerful technique for the characterization of the viscoelastic properties of polymers. DMA measures the modulus (stiffness) and damping (energy dissipation) properties of materials as they are deformed under dynamic stress. These measurements provide quantitative information about the performance of materials. The technique can be used to evaluate a wide variety of materials such as thermoplastics, composites, thermosets, elastomers, films, fibers, coatings and adhesives.
Polymeric materials exhibit viscoelastic behavior, which means that they simultaneously possess both solid-like as well as liquid –like characteristics. The degree to which the polymer exhibits more solid-like or liquid-like properties is dependent upon temperature as well as time or frequency.
The methodic used in this experiment is not normalized. It deals of developed methodics Institute of Material and Technological Research, Faculty of industrial technologies in Puchov, which serves to a detection impact temperature rising values at constant frequency on modulus.

1. INTRODUCTION

Dynamic mechanical analysis (DMA) is a powerful technique for the characterization of the viscoelastic properties of polymers. DMA measures the modulus (stiffness) and damping (energy dissipation) properties of materials as they are deformed under dynamic stress. These measurements provide quantitative information about the performance of materials [2]. The technique can be used to evaluate a wide variety of materials such as thermoplastics, composites, thermosets, elastomers, films, fibers, coatings and adhesives [1]. DMA is a valuable technique because of its high inherent sensitivity and is the most sensitive thermal analysis technique for the measurement of the glass transition event, Tg. Secondary relaxation events readily observed by DMA cannot be detected by any other thermal technique. DMA results are relatable to important mechanical properties such as impact resistance and toughness.
Diamond DMA offers also frequency multiplexing operation and Synthetic Oscillation Mode [3]. The use of this technology makes it possible to perform frequency multiplexing

experiments while dynamically heating even at relatively fast rates (e.g., 5 C/min). In the SO mode, a complex stress sine wave is applied to the sample and this complex
stress wave contains five (5) simultaneous frequencies. The resulting complex strain and stress sine waves are deconvoluted using Fourier transform technology and compared to compute the quantitative viscoelastic properties.

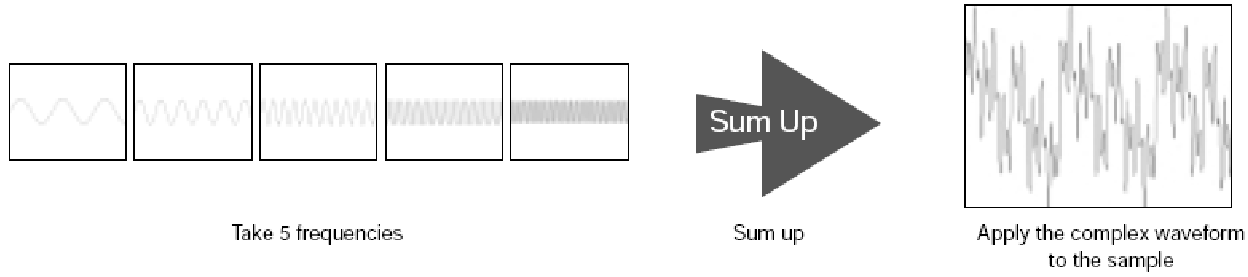

Figure 1. Synthetic oscillation technique

With the SO mode, the sample is subjected to all five frequencies instantaneously. The advantage of performing frequency multiplexing and Synthetic Oscillation DMA experiments is that much more informative sample characterization information can be generated.

2. EXPERIMENTAL PART

Figure 2 Diamond Dynamic Mechanical Analyzer (DMA)

Experiment was performed on Diamond Dynamic Mechanical Analyzer (DMA) using synthetic oscillation technique (1Hz, 2Hz, 4Hz, 10Hz, 20Hz) for one rubber mixture. The Diamond DMA uses Fourier Transform (FT) technology to reduce signal noise, providing unsurpassed sensitivity for the detection of very weak transitions. By increasing number of measurement data points, more accurate viscoelastic data can be obtained. (U.S.A. Patent 5287749, 5452614) [3].
Sample preparation: from the 2nd stage mixture is pressed out sheet with 25mm thickness, rubber plate 150 x 150 mm is cuted out, samples are pressed out with given curing time and curing temperature and are all conditioned at room conditions for 16 hours before testing. Testing sample is cutted out according to asked shape and dimensions, Figure 3.

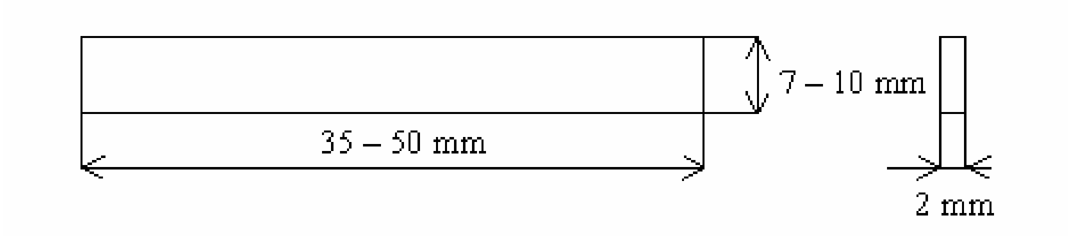

Figure 3. Sample shape and its required dimensions

Measurements:

- Sample cutted out according to Figure 3
- Performing dynamic tensile test according to required results (rising temperature, frequency synthetic oscillation mode (1Hz, 2Hz, 5Hz, 10Hz, 20Hz), constant loading 1N)
- Saving measured data and evaluating results

3. RESULTS AND DISCUSSION

On the text figures are presented measurements of synthetic oscillation for one rubber mixture. On the Figures. 4, 5 and 6 are presented dependence temperature vs logE*, dependence temperature vs logE´´ and dependence temperature vs log E´.

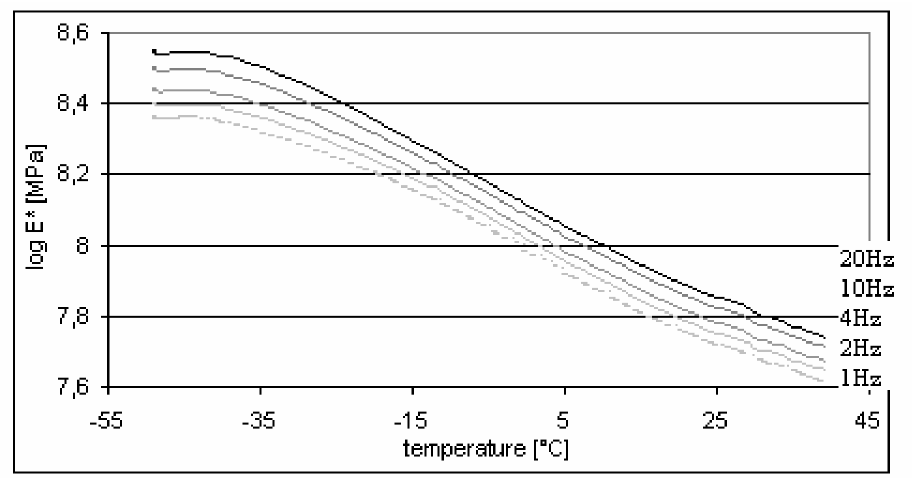

*Figure 4 Dependence temperature vs logE**

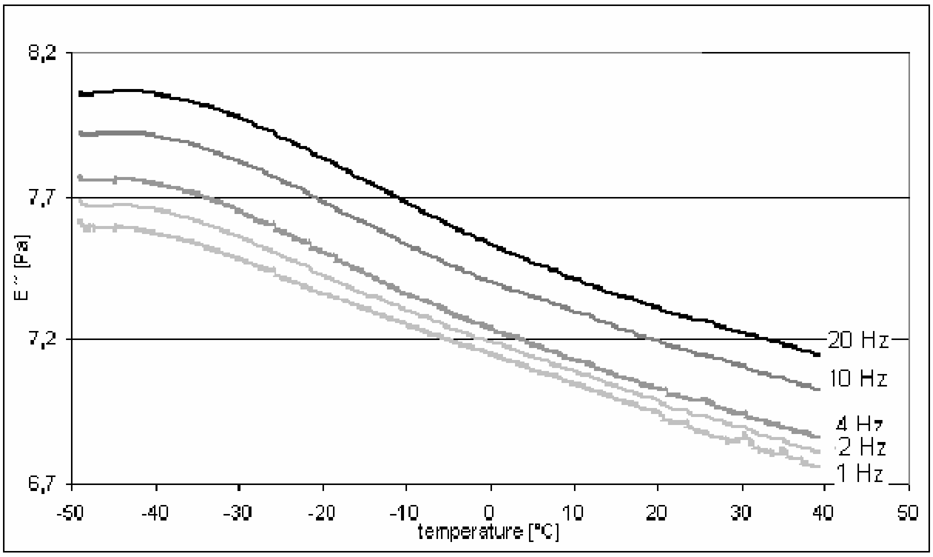

Figure 5 Dependence temperature vs logE´´

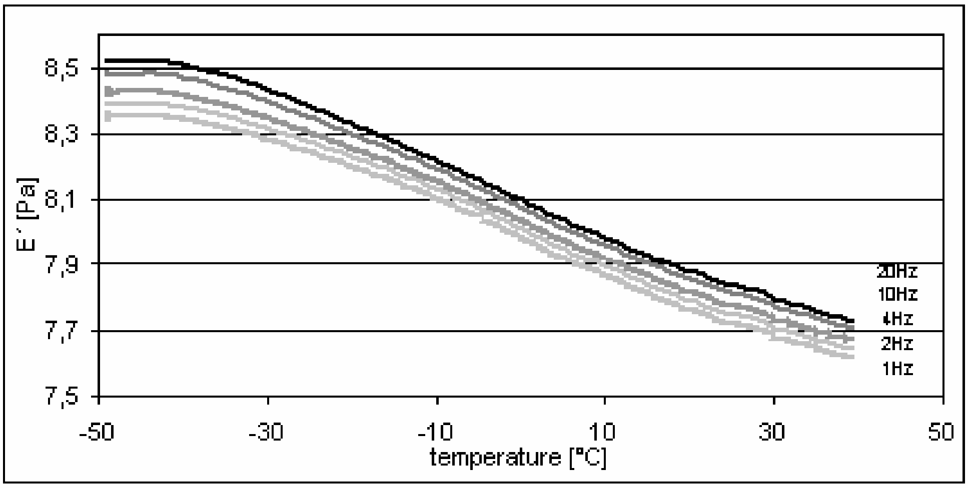

Figure 6 Dependence temperature vs E´

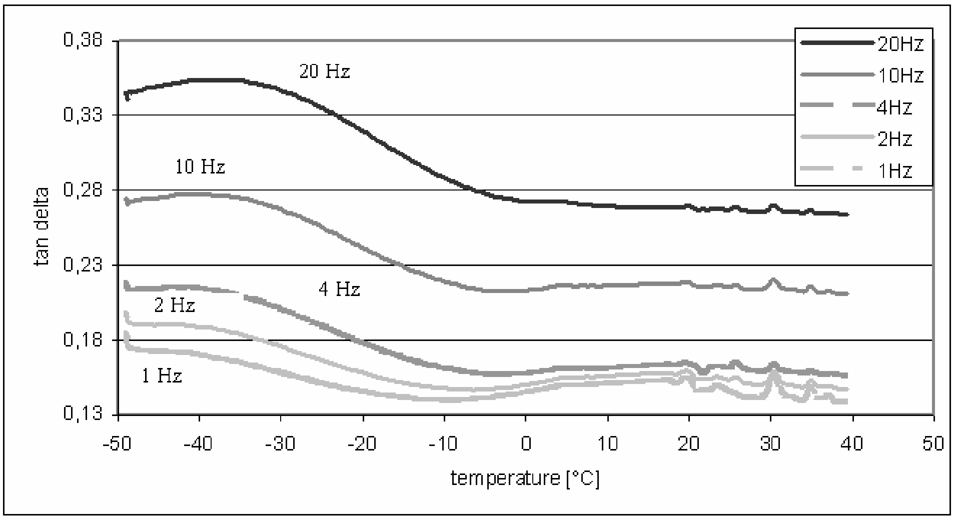

Figure 7 Dependence temperature vs tan delta

As we can see from all dependences, synthetic oscillation mode allows to obtain measured data points exactly at the same time, at the same temperature for all given frequencies.

On the Figure 8. are resented dependences temperature vs. tan δ for all given frequencies with Tg values. In Table 1. are listed all Tg for all given frequencies.

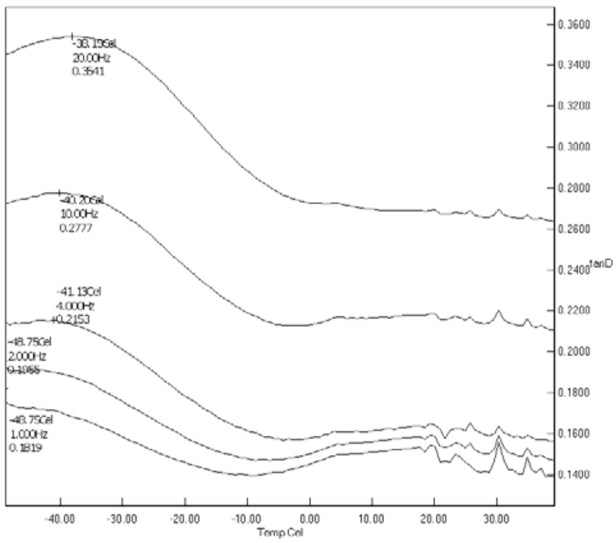

Figure 8 Dependence temperature vs tan delta with Tg values

Table 1. Tg values for all measured frequencies

Tg value					
	1Hz	2Hz	4Hz	10Hz	20Hz
t [°C]	-48,75	-48,75	-41,13	-40,20	-38,15
$\tan\delta$	0,1819	0,1955	0,2153	0,2777	0,3541

The temperature and frequency dependent function tan δ, the ratio of E" to E', is a useful measure of the viscous characteristics of the polymer relative to its elastic properties. These measurements present a powerful technique used in DMA analysis. This method is the most preferable for polymer testing. With using synthetic oscillation we can significantly reduce time and costs of all experiment.

4. REFERENCES

[1] Menard, K.: Dynamic Mechanial Analysis – A Practical Introduction, CRC Press, Boca Raton, 1999

[2] Koštial, P.: Fyzikálne základy materiálového inžinierstva I. 1.vyd. Žilina: ZUSI, 2000. ISBN 80-968278-7-1

[3] Manual Diamond Pyris DMA