APPLICATION**NOTE**

Influence of the Heating Rate on the Glass Transition Temperature of Elastomer Materials for the DMA GABO EPLEXOR® Series

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Introduction

Elastomer materials are employed in almost all technical fields due to their high elasticity. An essential property of elastomer materials is the capability of storing deformation energy and releasing it back to the entire system, when necessary. One measure of this property consists of the material-immanent restoring forces, which – depending on the system – can be generated from the energy stored and can easily amount to 90% or more of the energy stored. This "valuable" property is restricted, however, to a narrow temperature range that defines the operating and working temperatures for the respective application. For this reason, the temperature behavior of elastomer materials is of central importance.

So-called temperature sweeps are used to record the thermal behavior of elastomer materials, which can generally be parameterized at different heating rates. A high heating rate of 5°C/min, for example, is preferable to a heating rate of 1°C/min since a result is delivered in a shorter time and testing is therefore faster and more cost-effective. However, the question arises as to how to evaluate the results for different heating rates.

This Application Note addresses this question and examines the heating-rate dependence of the DMA GABO EPLEXOR® series.

Measurement Conditions

Four temperature sweeps on samples of the same rubber compound were carried out from -80°C to 20°C at heating rates of 1, 2, 3 and 5°C/min with the DMA GABO EPLEXOR® 500 N (figure 1).

1 DMA GABO EPLEXOR® 500 N

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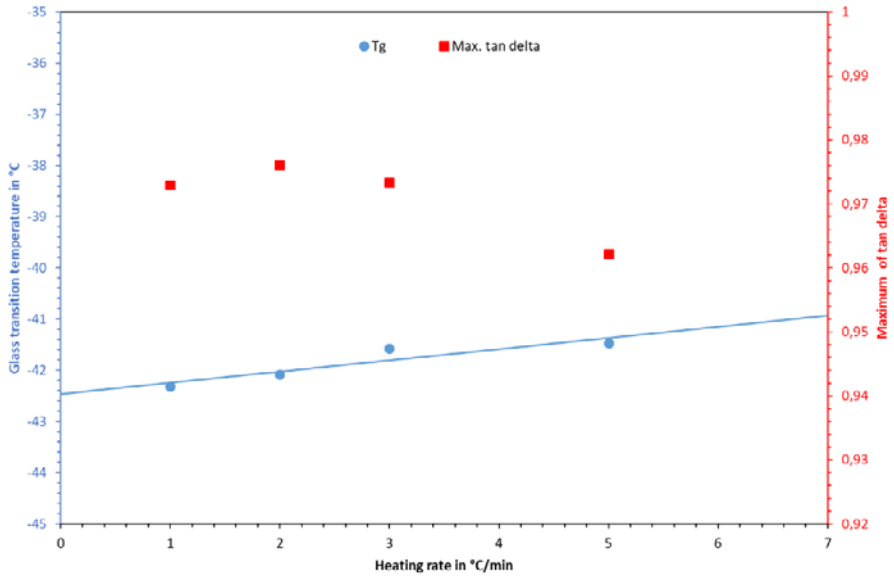
Measurement Results

The lower operating temperature of elastomer materials is limited by the glass transition temperature, T_g. The T_g characterizes the temperature at which elastomer materials change from a hard and relatively brittle state to a rubber-like elastic state. In practice, the T_g is defined as the maximum of the loss factor tanδ. The heating-rate dependence of the T_g is depicted in figure 1.

Figure 2 shows that the T_g is shifted to higher temperatures with higher heating rates. For a temperature sweep, the T_g amounts to -42.3°C at a heating rate of 1 °C/min and to -41.4°C at a heating rate of 5 °C/min. This corresponds to a positional change of the T_g of approx. 1°C. The maximum of the loss factor, tanδ, has changed by 0.01 at most. This observation can be illustrated by the poor thermal conductivity of most plastics. This causes a shift in material-specific transition effects, such as relaxation maxima or glass transition temperatures, to higher temperatures (in the case of positive heating rates) or to lower temperatures (in the case of negative cooling rates). A higher heating rate leads to "drag effects" and the sample lags behind the furnace temperature. A heating rate of 1°C/min will therefore correctly reflect the sample-specific effects, while a high heating rate will cause a shift of these effects on the temperature scale.

Summary

These minimal shifts of the T_g's position and the maximum of the loss factor, tanδ, as a result of the different heating rates are due to a very good temperature distribution inside the DMA GABO EPLEXOR® series, achieved by using a fan in the measuring chamber. A direct consequence of these findings is the reduction of the measuring time needed for temperature sweeps via the use of higher heating rates, for example, 5°C/min instead of, for example, 1°C/min. A prerequisite for this is knowledge of the heating-rate dependence of the T_g of the materials tested.



2 Heating-rate dependency of the glass transition temperature, T_g

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