Heat Build-Up in Materials Subjected to Cyclic Loading

Keywords: DMA, Temperature, Viscoelastic Properties, Heat-build up, Cyclic loading

Figure 1. Metravib DMA+2000

Introduction

Fatigue fracture is one of the most important failure mechanisms in materials like rubber, polymers, composites etc, which lead to intensive structural degradation and hence failure of a loaded structure.

In case of viscoelastic materials, that are subjected to cyclic loading, the released energy between stress and strain magnitude is dissipated in the most part as heat, resulting in a heat build-up phenomenon of the specimen The heat build-up phenomenon, in-turn, notably quicken the structural degradation of materials.

Considering the significance of the heat build-up phenomenon, it is important to evaluate the impact of this effect for materials subjected to the cyclic loading. This note focuses on the capability of Metravib's DMA and its Heat-Build up module of measuring the

amplitude of heat build-up of specimens subjected under cyclic loading.

Materials & methods

The material tested is a type of durable synthetic rubber, commonly used across many industries, such as Tire Industries. The specimens used were of the standard Goodrich Cylindrical Blocks, i.e., diameter - 18mm and height - 25 mm.

The specimens were studied in compression mode Figure (2). The peak to peak displacement of 4.45 mm was applied on the specimen, with -250 N of static force to make sure that the specimen stayed in contact with the specimen holders.

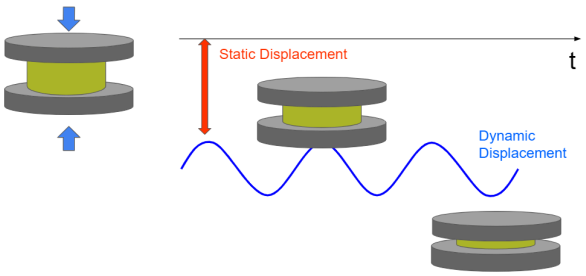

Figure 2. Schematic diagram of Compression test mode

Since the goal of this measurement is to measure the amplitude of temperature rise inside a specimen subjected to cyclic loading, the heat-build up module, specific to Metravib, was chosen (Figure3) . This dedicated specimen holder is designed to follow the specimen's surface temperature during the test and to insert a needle thermal probe in the core of the specimen at the end. The parameters used for the test are mentioned in Table 1.

Dynamic displacement peak to peak (m)	0.00445
Frequency (Hz)	30
Static Force (N)	-250
Temperature (˚C)	55
DMA	DMA+2000
Test Mode	Compression Heat-Build up

Table 1. Test parameters

Figure 3. Heat build-up module (HBU)

Results

Figure 4 shows the results obtained for the durable synthetic rubber, subjected to cyclic loading. The storage modulus (E'), loss factor

(Tan δ), surface temperature and core temperature of the sample are plotted as a function of the number of cycles.

The sudden increase in temperature at around 50 000 cycles represents the difference between the surface temperature (65˚C) and the temperature inside the specimen (125˚C), as a result of the heat build-up phenomenon of viscoelastic materials.

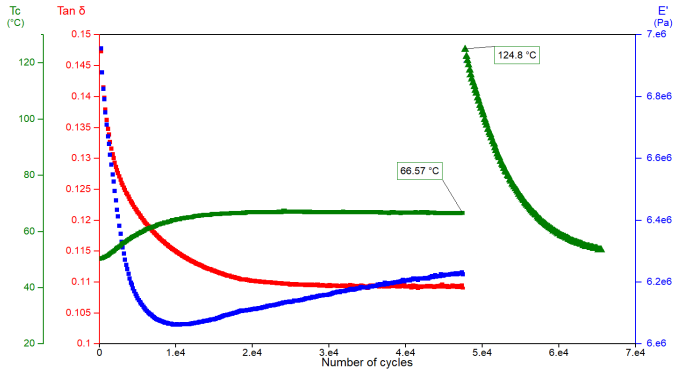

Figure 4. E', Tan δ and Tc as a function of number of cycles at 30˚C

This difference in surface temperature and temperature inside the specimen confirms that accounting for heat build-up can be of capital importance in the design and performance analysis of viscoelastic materials.

Conclusions

This note shows the capability of the specific heat build up module designed by Metravib. Temperature measurement inside the material has brought important information on the difference between the latter and the surface temperature i.e., ~60˚C, indicating the heat build-up and the correlated viscoelastic properties is a key measurement for the optimization of materials that undergo high mechanical sollicitations.

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