A Novel Dilatometer for the Investigation of PVT-$\dot{T}$-$\dot{\gamma}$ Behavior of Semi-Crystalline Polymers

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Introduction

The heterogeneous microstructure of semi-crystalline polymers strongly depends on the thermal-mechanical history experienced during processing. For the prediction of material properties that are closely related to this microstructure, such as specific volume (figure 1), a realistic computational model is required. Therefore, a novel experimental set-up is developed that provides the input data for this model as a function of the thermal-mechanical history.

Methods

A dilatometer based on the principle of confined compression is designed to study the influence of the thermal-mechanical history on specific volume.

Figure 2 Schematic representation of the dilatometer showing polymer sample (blue), cooling channels (grey), and locations for temperature measurement (violet).

The annular shape of the sample, with a radial thickness of 0.25 mm, enables rapid cooling and applying a uniform shear deformation. Temperatures are measured at 6 locations. The axial displacement of the outer cylinder is a measure for volumetric shrinkage of the sample. To compensate for the thermal-mechanical expansion of the set-up, the displacement signal taken from a calibration measurement is used for correction. Limitations to the use of the confined compression technique [2] are investigated by comparing measurements performed on a confining fluid set-up.

Figure 3 Radial (left) and axial (right) deformations of piston and housing at a sample pressure of 1000 [bar].

Conclusions

A dilatometer is designed to measure specific volume as a function of thermal-mechanical history that is characterized by:

- maximum applicable sample pressure $P = 10^3$ [bar]
- cooling rates can be reached to $\dot{T} = O(10^2)$ [K/s]
- uniform sample deformation with $\dot{\gamma} = O(10^3)$ [1/s]

References: