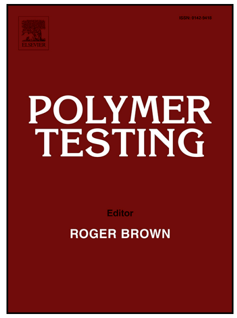

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COMPRESSION AND FREQUENCY DEPENDENCE OF THE VISCOELASTIC SHEAR PROPERTIES OF FLEXIBLE OPEN-CELL FOAMS

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ABSTRACT

The shear dynamic mechanical behaviour of selected melamine resin and polyurethane open-cell foam materials in a broad range of static uniaxial compression up to almost full material densification was investigated. In situ computed tomography (CT) and stereo light microscopy images were qualitatively analysed to study the foam deformation kinematics. Using a rotational rheometer, storage and loss shear moduli were measured at different temperatures and the results were then transformed to an extended frequency range of up to 10^4 Hz using the frequency-temperature superposition. A different and in some cases strong dependence of storage and loss shear moduli upon frequency and compression was found. As a potential possibility of using the results, a novel idea of the so called Compressible Constrained Layer Damping (CCLD) as an adaptive vibration damping element was briefly presented. The findings could be also relevant for any application of precompressed foam materials under shear dynamic load.

Keywords: compression-dependent viscoelastic shear properties; flexible open-cell foam; Compressible Constrained Layer Damping; frequency-temperature superposition; adaptive vibration damping; in situ computed tomography

1. INTRODUCTION

Damping layers of dynamically stressed structures made of foam materials are often pre-compressed (e.g. during assembly or due to the application conditions). At the same time, the layers often experience shear components of the oscillating deformation. This applies for example to thin structures that are subjected to bending vibrations, such as acoustic panels or housings [1,2]. An advanced design of such structures should therefore take into account the compression dependence of viscoelastic shear properties of the damping layers. However, the necessary information on viscoelastic shear behaviour at varying compression levels is not found in the literature.

Another motivation for the investigations of the compression dependence of viscoelastic shear properties described here results from a novel idea of the so called Compressible Constrained Layer Damping (CCLD). CCLD is an extension of the well-known Constrained Layer Damping (CLD) method with the incompressible viscoelastic damping layer replaced by a compressible one. Through actively altering the thickness of a sheared viscoelastic layer (Figure 1) the damping and stiffness behaviour of the overall structure could be adapted [3]. While the CCLD principle could be applied with a variety of viscoelastic layer materials, flexible foams appear to be most feasible due to their low density as well as a large reversible deformation range and high energy absorption properties. The morphing of the structure could by realised by a hydraulic fluid, compressed air or vacuum applied directly to the viscoelastic layer. Since this actuation principle requires a fluid flow within the cell structure, an open-cell structure appears to be a necessary prerequisite for its implementing. At the same time the low bulk modulus (in the following referred to as compression force deflection according to ASTM 3574) of open-cell foams and the resulting large actuation range for a given pressure range is a further advantage.

The application of the CCLD can support the consistent implementation of the lightweight design principles, which is one of the important prerequisites for the achievement of improved energy efficiency and new performance levels of future vehicles, machines and facilities [4,5]. Since the lightweight-focused design often leads to problematic vibration susceptibility [6,7], the objective of the presented research is to deliver design parameter for an innovative, almost weight-neutral system for adaptive vibration control of lightweight structures.

FIGURE 1: Fig1_CCLD_Principle.jpg (Single column size)