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A MECHANICAL ANALYSIS OF MAGNETORHEOLOGICAL COMPOSITES USED FOR DAMPING OF THE VIBRATION

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ABSTRACT

This work concerns mechanical testing of magnetorheological composites composed of carbonyl iron particles and ureathane elastomer. The aim was development of manufacturing method for magnetorheological elastomers (MREs) with variable stiffness for the smart damper. Experimental and numerical studies were targeted to receive the magnetorheological materials of the optimal composition and structure, in the aspect of achieving maximum efficiency in the selected vibration frequency range. The relationship between the microstructure of produced MREs and their ability for damping of the vibration has been established.

Keywords: magnetorheological composites, smart materials, mechanical analysis, damping.

INTRODUCTION

Magnetorheological composites based on elastomers (MREs) belong to the group of smart materials. They are a class of materials with rheological properties rapidly varied by the application of a magnetic field. The change of their properties depends on the magnitude of the magnetic field applied and is immediately reversible (Carlson, 2000). The MREs consist of magnetically permeable particles (such as iron or other ferromagnetic particles) added to a viscoelastic polymeric material prior to crosslinking. The MREs contain ferromagnetic particles having sizes from few to few hundreds of μm. Pure iron has the highest saturation magnetization of known elements and it has also high permeability and low remanent magnetization, providing high, short-term inter-particle attraction. Application of magnetic field to the polymer composites during crosslinking of the matrix locks the columnar particle chain structures during the final cure giving special anisotropic properties. The formation of columnar particle structures within the elastomers corresponds to a low dipolar energy state. Shearing of the cured composite under applied magnetic field requires additional energy because of the particles displacement from this low energy state (Zhou, 2003). Changes of the properties in MREs under the influence of the magnetic field depend strongly on the microstructure formed during the curing of elastomer matrix, also as a result of magnetic field. Interactions between particles in a magnetic field bring them closer, resulting in increased stiffness of the material (Boczkowska 2012).

RESULTS AND CONCLUSIONS

The rheological properties, described by the storage modulus G', loss modulus G'' and loss angle tan(δ) as a function of frequency, were studied without and in a magnetic field of 160 kA/m, for MREs with different volume fraction of carbonyl iron particles. Selected results are shown in Fig 1. The samples were cured in the magnetic field of 240 kA/m, and the particle chains were oriented parallel to the direction of the MF applied.

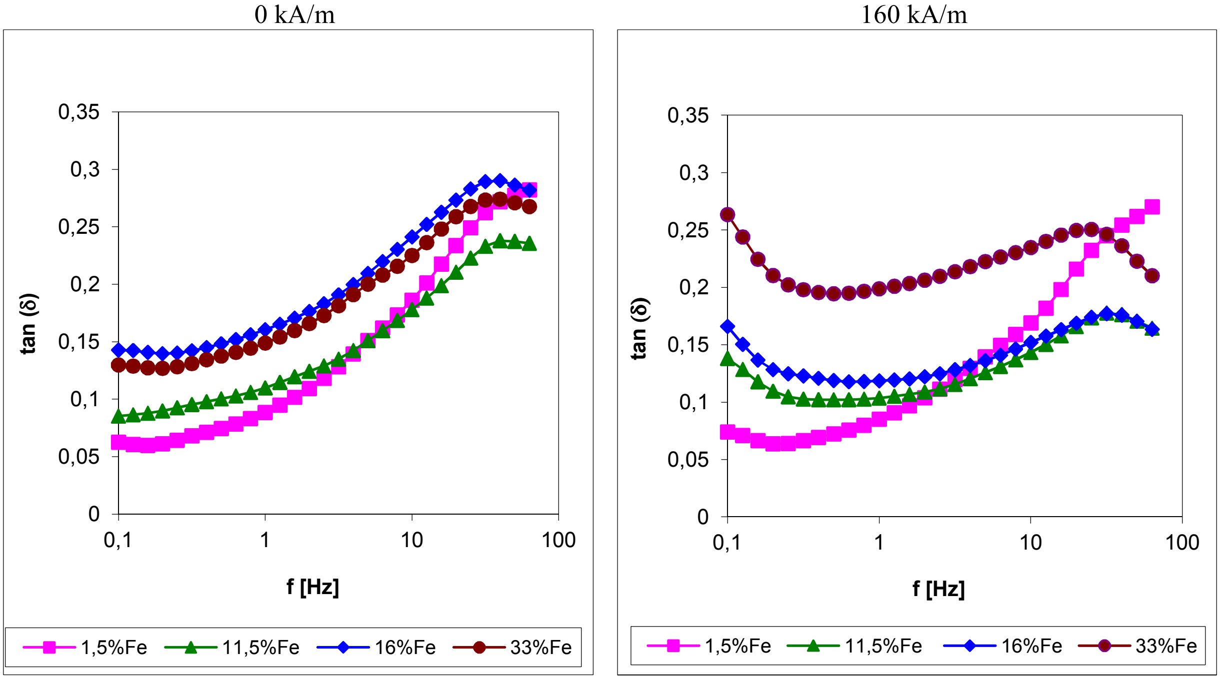

Fig. 1 - Changes in damping factor tan(δ) as a function of oscillation frequency (at constant strain of 0.1%) for the MREs with PU matrix and different content of Fe particles

This study shows that the values of tan(δ) clearly increase for the low oscillation frequency, and with the increasing of particles volume fraction. The higher the value of tan(δ), the greater energy dissipated, and the material exhibits better damping properties.

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