Proceedings of the 7th International Conference on Mechanics and Materials in Design
Albufeira/Portugal 11-15 June 2017. Editors J.F. Silva Gomes and S.A. Meguid.
Publ. INEGI/FEUP (2017)

PAPER REF: 6849

INFLUENCE OF FILLER PARTICLE DISTRIBUTION ON THE MAGNETORHEOLOGICAL EFFECT IN MAGNETOACTIVE ELASTOMERS

Michał Królewicz(*), Jerzy Kaleta
Department of Mechanics, Materials Science and Engineering, Wroclaw University of Technology, Wroclaw, Poland
(*)*Email:* michal.krolewicz@pwr.edu.pl

ABSTRACT

This research analyses how magnetic particle distribution affects selected mechanical properties of magnetoactive elastomers. The composites were based on a thermoplastic elastomer matrix filled with 60 μm iron particles. Isotropic and anisotropic magnetoactive elastomers were subjected to a dynamic mechanical analysis based on cyclic tension via a modular DMA test stand. During the testing, a 430 mT magnetic flux, generated by an array of cylindrical permanent magnets, was applied to the specimens. The study revealed a pronounced relationship between the material's internal structure and its response to a magnetic field.

Keywords: smart materials, magnetorheological elastomers, MRE, MR effect.

INTRODUCTION

Magnetoactive elastomers (MAE), also commonly known as magnetorheological elastomers (MRE), are novel smart magnetic materials. Filled with magnetically active particles, such as iron, these composites change their properties (such as stiffness) when subjected to an external magnetic field. Such behavior, known as the magnetorheological effect (Kordonsky, 1993), makes MAEs highly applicable in all areas connected with energy dissipation such as vehicle suspension systems, dampers, shock absorbers, etc.

In this study the authors investigated influence of the filler particle arrangement in the matrix on the magnetorheological effect in magnetoactive elastomers based on a thermoplastic SEBS elastomer matrix (Tefabloc, Mitsubishi CPPE). Irregularly-shaped iron particles (ASC300, Höganäs AB) with the average size of 60 μm were used as the magnetically active compound. At the manufacturing stage a 400 mT electromagnet was used to create a polarized (anisotropic) filler structure in selected samples. Dynamic mechanical analysis (DMA) was performed on isotropic and anisotropic material samples with 20 vol.% iron content, via a modular test stand based on ElectroForce Multi-station TestBench from Bose. Standard flat specimens with a cross-section of 2x4 mm and a parallel length of 30 mm were subjected to cyclic tensile loading with 4 to 6% strain (fixed prestrain value of 5% plus a sinusoidal strain of 1%). Various loading frequencies, from 0.1 to 25 Hz, were used, with 1 Hz as the reference value. To observe the magnetorheological effect, a 430~mT magnetic flux acted on the specimens. It was generated by a custom-made Halbach array of cylindrical permanent magnets (Hiptmair, 2015), which made it possible to change the flux direction during the experiment (Fig. 1). The tests were conducted in a field parallel (0°) and perpendicular (90°) to the samples.

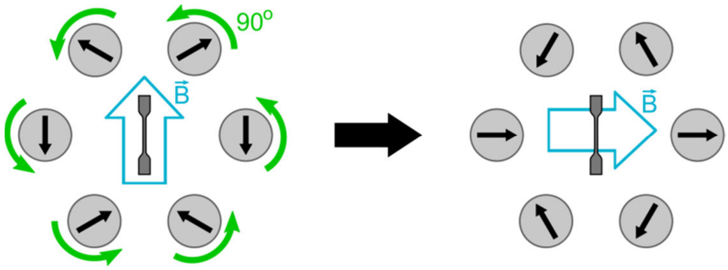

Fig. 1 - Scheme of magnetic flux direction change from parallel (0°, left) to perpendicular (90°, right) via rotation of cylindrical permanent magnets

RESULTS AND CONCLUSIONS

The DMA results, in the form of force-displacement graphs (hysteresis loops) at 1 Hz are shown in Fig. 2. The area of each loop represents the amount of energy dissipated by the material. It is clearly visible that the magnetorheological effect, in the form of hysteresis loop changes, is much more pronounced in anisotropic MAEs. The influence of the field direction was also observed, but mostly in the polarized materials.

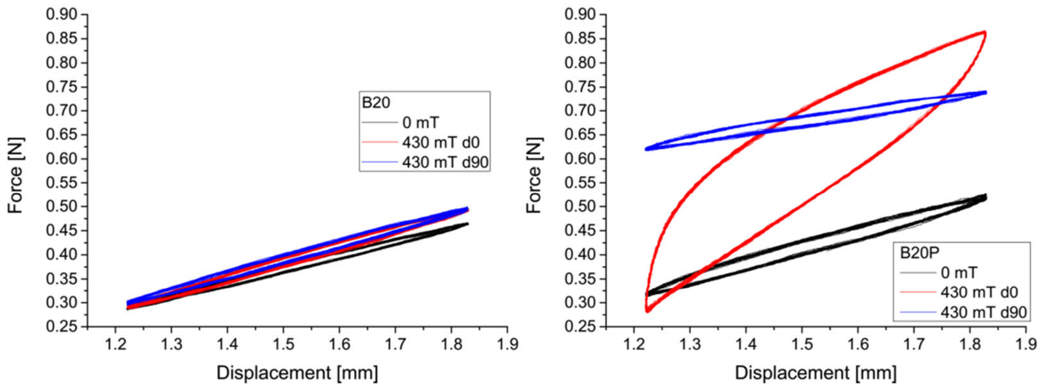

Fig. 2 - DMA results for the isotropic (left) and anisotropic (right) MAEs

This research revealed a significant influence of magnetic filler distribution on the magnetic field-induced changes in the magnetoactive elastomers. The magnetorheological effect was observably higher in the materials with anisotropic (field-oriented) iron particle structure.

ACKNOWLEDGMENTS

The authors would like to express their gratitude to Professor Z. Major and MSc. F. Hiptmair from the Institute of Polymer Product Engineering of the Johannes Kepler University in Linz, Austria, for helping with the investigations and lending all of the equipment.

REFERENCES

[1]-F. Hiptmair, Z. Major, R. Haßlacher, S. Hild. Design and application of permanent magnet flux sources for mechanical testing of magnetoactive elastomers at variable field directions. Review of Scientific Instruments, 2015, p. 86:085107.

[2]-W.I. Kordonsky. Magnetorheological effect as a base of new devices and technologies. Journal of Magnetism and Magnetic Materials, 1993, 122(1-3), p. 395-398.