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On the Properties of Magnetorheological Elastomers in Shear Mode: Design, Fabrication and Characterization

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Abstract

Magnetorheological elastomers (MREs) are novel class of magneto-active materials comprised of micron-sized ferromagnetic particles impregnated into an elastomeric matrix, which exhibit variable stiffness and damping properties in a reversible manner under the application of an external magnetic field. Characterization of highly complex behavior of these active composites is a fundamental necessity to design adaptive devices based on the MREs. This study is mainly concerned with in-depth experimental characterizations of static and dynamic properties of different types of MREs using methods defined in related standards. For this purpose, six different types of MRE samples with varying contents of rubber matrix and ferromagnetic particles were fabricated. The static characteristics of the samples were experimentally evaluated in shear mode as a function of the magnetic flux density. The particular MRE sample with highest iron particles content (40% volume fraction) was chosen for subsequent dynamic characterizations under broad ranges shear strain amplitude (2.5-20%), excitation frequency (0.1-50 Hz) and applied magnetic flux densities (0-450 mT). The results revealed nearly 1672% increase in the MRE storage modulus under the application of a magnetic flux of 450 mT, which confirms the potential of the novel fabricated MRE for control of vibration and noise in various engineering applications.

Keywords: Magnetorheological Elastomer; Fabrication; Characterization; Shear, Elastic and Loss Moduli

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1. Introduction

Elastomers are rubber-like solids with viscoelastic properties, which are widely used as reliable and cost-effective passive damping treatments for attenuation of noise and vibration in many engineering applications. Such elastomers, owing to their fixed parameters, are known to be effective in a limited frequency range. Magnetorheological elastomers (MREs) are a class of smart composite materials, which exhibit reversible and rapid variations in their dynamic properties under the application of an external magnetic field. MREs are comprised of micron-sized ferromagnetic particles prearranged or suspended into an elastomeric matrix. Owing to their rapid response [1], the elastic moduli of these flexible smart composites can be effectively controlled in nearly real-time in response to varying external excitations. The MREs thus provide greater potential for suppression of vibration in an active manner in a wider range of frequencies [2, 3]. Moreover, MREs exhibit additional desirable features, such as low power requirement, fail-safe character, insensitivity to contaminants and no sealing issues (as generally