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Improved mechanical properties of magneto rheological elastomeric composite with isotropic iron filler distribution

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Abstract

In this work, mechanical property of magneto rheological elastomeric (MREs) composite is investigated using iron as filler distribution. The MREs composite were fabricated using irregular shaped iron particles with size range varies from 50 -150 µm in matrix of elastomeric polymer. The matrix such as ZA22 was considered with 1:1 catalyst ratio as the binder with 30 Vol % of filler content. The fillers were incorporated within the matrix of elastomer using silicon oil as additive binder in the composite. The open circuit solenoid coil was designed as the magnetic circuit for magnetic flux intensity. Various magnetic field intensities were induced to observe the mechanical properties of the MREs composites. Hysteresis loss was observed in MRE samples due to dissipation of energy during compression of the composite material. Improved engineering strength of the MRE is observed on varying magnetic field of intensity and constant at 0.3 Tesla.
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Keywords: iron filler; magneto rheological elastomer; magnetic field intensity; isotropic distribution.

1. Introduction

Magneto rheological elastomeric composite are the new group of smart materials that can alter the properties under the influence of external stimulus [1]. These materials can characterize by reversible change of mechanical and rheological properties under the influence of external magnetic field. These behaviors of changeable properties are known as magneto rheological effect. Traditionally it is composed of MR fluids and foams [2]. The magneto rheological composite materials primarily consist of non-magnetic matrix and with magneto active particles such as iron as filler. In MR fluids the matrix is liquid fluid, which contains magnetic particle such as iron in suspended form. The main obstacles with these materials are the settlement of particles with respect to time [3]. However, the MR with foam like matrix are solid state materials with very low intrinsic modulus [4]. MREs are composite with magnetic particles are incorporated inside the elastomer matrix.

Elastomers are soft polymers with high expansion, widely used in numerous application including gaskets and vibration damping materials [5]. The key properties of elastomer are the hardness that opens up wide flexibility on various applications. The hardness can be preferred on choice of elastomeric matrix and the cross linking factor. The main advantage is that control of mechanical properties of the MRES composite at the time of application. The most suitable example in this is the vibration-mitigating effect of material that can vary in frequency [6]. The most interesting option of this material is to feel the touching surface of elastomer through haptic sensation by modifying the hardness.

MRE are composite materials that consist of elastomer matrix with magnetized particles such as iron filler. When magnetic field is applied, the filler particles are polarized and induce magnetic force of attraction towards each other as a result the materials stiffen [7]. When the magnetic field is switched off,

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the material comes back to original state and it becomes softer in nature. The magnetic interactions between particles in MRE composite depend on the magnetization orientation of each particle and their spatial relationship in coupling the strain and magnetic intensity of materials. This leads to magneto-mechanical phenomena of MRE composite materials. Earlier researchers [8] have studied the effect of volume fraction of filler particles within elastomer of the matrix. According to the investigation the optimal volume fraction of the filler contents is 35 %. Although MR materials have analogous mechanical behaviors, still MREs have unique properties that differ from others. MREs have a controllable field dependent variable, very short response time. MREs have application in developing adaptive tuned vibration absorbers.

In this article an attempt is carried out for the investigation on mechanical properties of MREs with isotropic filler distribution of iron particles within elastomer of the matrix. The mechanism behind the isotropic distribution and magnetic induced forces within the MREs under the application of external magnetic field is discussed here.

2. Experimental Section

2.1. Materials and methods

The matrix of the MREs composite silicon elastomer (ZA 22) is supplied by Czech chemical company. The reactant and catalyst are silicon based with ratio 1:1. This matrix is room temperature based material with viscosity 4000 mPa.S and tensile strength of 4 MPa with 380 % of the elongation at rupture. The chemical cross linking of the matrix ZA 22 is shown in Fig.1 (a) and (b). Heat resistant of the elastomer exists in the range of -50 to 180 °C.

The filler is chosen as iron filler with irregular shape and the size range from 50 to 150 µm. The microscopic image of filler and particle distribution is shown in Fig 2 (a) and (b).

The MRE composites were fabricated with 30 V % of filler content within silicon elastomer of the matrix. Silicon oil is used as additive for iron particles well mixing in the elastomer matrix. The samples were cylindrical shaped with diameter of 16 mm. The filler particles were mixed with silicon oil and stirred slowly for about 5 min before mixing with the matrix. Silicon oil induces better homogeneity and good dispersbility of filler particles within the elastomer of the matrix.

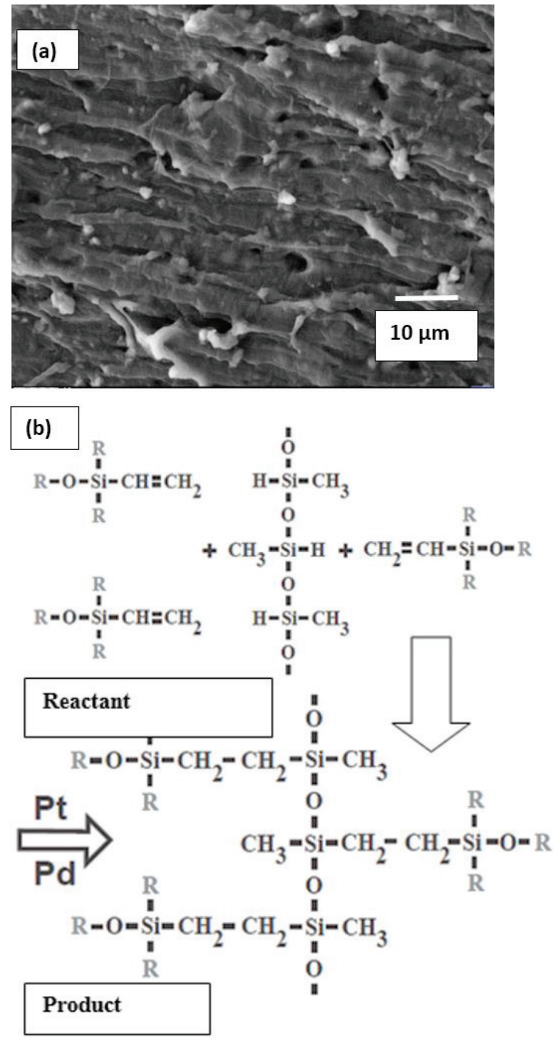

Fig. 1. (a) Scanning electron microscope image of elastomer matrix. (b) Polyaddition chemical reaction product (ZA 22 elastomer matrix). R is the alkyl group radical with catalyst platinum and palladium.

The fabrication of composite formation is shown in Table 1. Average 5 samples were fabricated for each category of specification.

The mechanism of formation and mixing of each components of MRE composite is shown in Fig. 3 (a). After stirring well for 30 min slowly and then after homogenization, samples were cured at room temperature without and with influence of magnetic field. The magnetic lines of force of attraction for sample fabrication are shown in Fig. 3 (b). The photographic image, sample dimension of MREs composite is shown in Fig. 3 c.

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