THERMAL CONDUCTION AND MAGNETIC PROPERTIES OF MAGNETORHEOLOGICAL ELASTOMERS DISPERSING SENDUST PARTICLES

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Abstract. A new magnetic functional material that is an elastomer dispersing micrometer-size sendust particles has been developed in this study. Sendust is a material which is the alloy composed of Fe, Si and Al, and has a high initial magnetic permeability and small hysteresis. Thermal conductivity of this new magnetic functional material was investigated by using the steady-state parallel-plate method while the magnetic properties of the materials were evaluated by using the BH analyzer.

1. Introduction

Magnetorheological elastomers are kind of magnetic functional materials that exhibit their functions in response to an applied magnetic field. The magnetorheological elastomers are basically composed of iron particles and carrier. The iron particles are embedded in the matrix [1]. When an external magnetic field is applied during the curing process to form chain-like clusters of iron particles in the material, magnetorheological elastomers with thermal conductivity anisotropy and magnetic anisotropy can be obtained [2,3].

In this study, we focused on sendust as dispersed particles in the magnetorheological elastomers, because sendust made of Fe, Si, and Al has a high initial magnetic permeability and low hysteresis. A new magnetorheological elastomer composed of sendust particles and silicone has been developed and its thermal and magnetic properties were investigated experimentally.

2. Experiments and sample preparation

Samples of magnetorheological elastomer made of sendust particles and silicone were prepared. The sendust particles were spherical particles whose average diameter was 16.8 μm (Sanyo Special Steel Co., Ltd., PST-S) and the base carrier was silicone elastomer (Dow, Sylgard184). We prepared two types of magnetorheological elastomer samples. The first one was a mixture of sendust particles without applying a magnetic field, basically the sendust particles are randomly and evenly distributed. The second one was produced with a uniform magnetic field, and the sendust particles formed chain-like clusters in the direction of the applied magnetic field inside the material. The volume fractions of the sendust particles in the samples were 5, 10, and 15 % and the size of the specimens was 40 mm square for the thermal conductivity experiments, while the volume fractions were 5, 7.5, and 10 % and the size of the specimens was 30 mm square for the experiments measuring magnetic properties.

To obtain the thermal conductivity of the samples, the steady-state parallel-plate method was used. Figure 1 shows the schematic of the core part of the experimental apparatus for steady-state parallel-plate method. The magnetization of the samples was measured by using the BH analyzer (Denshijiki Industry Co., Ltd., EMD-80M25M). The direction of the thermal conductivity and the

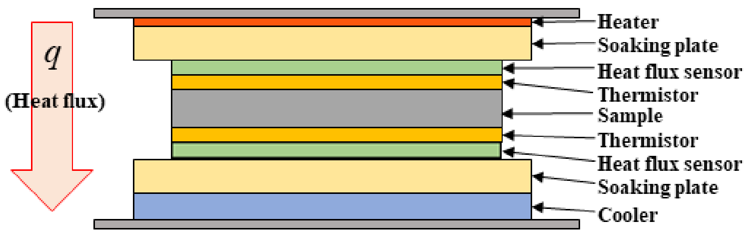

Fig. 1. Schematic of the experimental apparatus using the steady-state parallel-plate method.

applied magnetic field of magnetization measurements was set as the following three cases: perpendicular to the surface of the sample with randomly distributed particles (Random), parallel to the chain-like clusters in the samples (Parallel), and perpendicular to the chain-like clusters in the samples (Perpendicular).

3. Results and discussion

The larger the volume fraction of sendust particles dispersed in the sample, the higher the thermal conductivity. In addition, compared with the Random case, the Parallel case shows the higher thermal conductivity, while the Perpendicular case shows the lower thermal conductivity. Based on the Random case, when the particle volume fraction is 15%, the thermal conductivity increases by 43% in the Parallel case, and when the particle volume fraction is 10%, the thermal conductivity decreases by 10% in the Perpendicular case. These results are dependent upon the cluster structure formed inside the sample. When the volume fraction of the particles is relatively low, the chain-like clusters exist in isolation. However, when the volume fraction of the particles becomes high, the anisotropy of the thermal conductivity decreases because the contact between particles also increases in the direction perpendicular to the direction of the applied magnetic field due to the coalescence of chain-like clusters.

Figure 2 shows the magnetization of the samples when the volume fraction of the particles is 10%. From Fig.2, the initial permeability in case of Parallel takes larger value than those in the other case. The saturation magnetization does not depend on the microstructure inside the sample, and it only depends on the volume fraction of sendust particles.

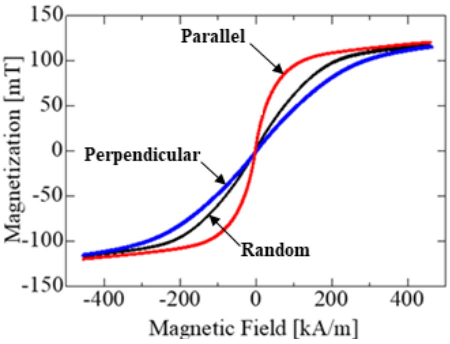

Fig.2. Magnetization-magnetic field curves of the samples when the volume fraction of the particles is 10 %.

Conclusions:

A new magnetorheological elastomer in which sendust particles are dispersed in a silicone material have been developed, and experimentally shown their thermal conductivity anisotropy and magnetic properties. The thermal conduction and magnetic properties of the magnetorheological elastomers with sendust particles depends on the microstructure like cluster formation inside the material except the saturation magnetization.

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