IDENTIFICATION OF MAGNETOSTRICTIVE COMPOSITES AT LOW FREQUENCIES OF MAGNETIC FIELD CHANGES

Jerzy Kalet, Daniel Lewandowski, Rafał Mech,

Wrocław University of Technology, Institute of Materials Science and Applied Mechanics
Wybrzeże Wyspiańskiego 27 25, 50-370 Wrocław, Poland.
Corresponding authors: jerzy.kaleta@pwr.wroc.pl, daniel.lewandowski@pwr.wroc.pl, rafał.mech@pwr.wroc.pl

1. Introduction

The role of Smart Magnetic Materials (SMM) is still increasing. One type of SMM are Giant Magnetostrictive Materials (GMM), which can be represented by i.e. Terfenol-D [1]. The biggest difficulty with mechanical application of GMM is its brittleness. On the other hand, increase of frequency generate meaningfully eddy currents [2]. These disadvantages tend to search new solutions in a form of composites materials with giant magnetostriction (GMMC).

The matrix for GMMC most often is an epoxy resin with magnetostrictive material inside (in a form of powder, flakes, or tiny rods made of i.e. Terfenol-D) [3, 4]. The main objective of this work concerns the research on the dynamic response of composite materials with epoxy matrix reinforced by high volume fraction of Terfenol-D powder with different types of polarization at low frequencies of magnetic field changes.

2. Specimens

The magnetostrictive composites were prepared using Terfenol-D powder (Gansu Tianxing Rare Earth Functional Materials Co., Ltd, China) and an epoxy resin as the matrix which was compound of resin Epolam 5015 and hardener Epolam 2016. Specimens presented in this work containing 70% of Terfenol-D particle volume fractions and have different polarization directions. For each case the particles and resin were homogenously mixed together and deaerated. Moreover one of samples was polarized perpendicular, and other was polarized parallel to the main axis of specimen. This effect was obtained by using respectively permanent magnets and coil during composites curing process. Container with mixture was placed between two magnets or inside coil and after that placed on MTS hydraulic pulsator, where samples were pressed with force of 10[kN] through 4 hours up to the preliminary resin binding. This process allowed to reduce excess of epoxy resin from samples and to obtain high volume fraction of Terfenol-D particles. Schemes of this processes was shown in (Fig. 1a and b) respectively for perpendicular and parallel polarized specimens, more details one can find in [5].

Fig. 1: Schema of polarization during curing process a) parallel, and b) perpendicular to the main axis of the sample. F - direction of force during curing process, H - direction of magnetic field during curing process.

3. Experimental Setup

In this section we described measurement setup, and principles of experiment. The experimental setup which was shown in (Fig.2), consists: original steel casing with coil, which was responsible for applying magnetic field to specimens, frequency generator and high power amplifier PA04 APEX, which were respectively responsible for changes in frequency of actuator work and value of magnetic field generated by coil. Moreover setup consists signal amplifier to gather data from power amplifier to pc, laser displacement measurement head KEYENCE LK-G152 to measure displacement which was generated by specimens and also PC for acquisition all of the data, which were which
subsequently have been treated using the program HPVee

4. Results

In this section we described measured magnetomechanical properties of manufactured specimens and solid Terfenol-D sample. Results obtained for the dynamic tests of composite materials and solid material of Terfenol-D, as cores of actuator. Tests were carried out for low-frequency magnetic field changes, it is in the range of 1-5 [Hz]. (Fig. 3) and (Fig. 4) shows the summary results for the samples made of composite material and solid Terfenol-D.

5. Conclusions

In this work, dynamic properties of epoxy-bonded Terfenol-D composites have been investigated. By evaluating the effects of polarization direction, it was found that the composites with perpendicular polarization show highest magnetostriction value, in comparison to the others, such as parallel polarized and without polarization in the entire frequency range.

6. References