Investigation and Simulation on Magnetic Hysteresis Properties of Magneto-Rheological Fluid

Jianbin Zeng[1], Youguang Guo[2], Jianguo Zhu[2] and Zhiwei Lin[2]

[1] School of Electrical Engineering, Shenyang University of Technology, China
[2] Faculty of Engineering and Information Technology, University of Technology, Sydney, Australia
Jianbin.Zeng@gmail.com

***Abstract*—Magneto-Rheological fluid (MRF) materials are used in many device as a smart material. However the application of this material is limited to damper or vibration absorber because of lacking understanding of its magnetic hysteresis properties. This paper systematically reports our recent study on measurement and simulation on magnetic hysteresis properties of MRF materials. The measurement was completed by using a single sheet tester with an MR fluid sample container. A large-scale atomic/molecular massive parallel simulator (LAMMPS), which combined Stoner-Wohlfarth hysteresis model, was employed for simulating the magnetic hysteresis properties of MRF material. The experimental and simulation results are compared, analyzed and discussed. The results will be useful for modeling of magnetic hysteresis properties of MRF materials.**

***Index Terms*—Magnetic hysteresis, Magnetic field measurement, Magnetization**

I. Introduction

Owing to the capability of rapid phase changing under magnetic field excitations, the Magneto-Rheological Fluid (MRF) materials are being used in various devices as "smart" materials. However, because of the lack of understanding the magnetic properties and phase changing mechanisms, the application of MRF materials in industry is still limited to dampers, or vibration absorbers [1]. To understand the phase changing mechanisms such that new applications can be developed, it is essential to study the magnetic properties of this materials.

Maxwell-Garnet equation is a part of effective medium theory. It was often used to evaluate the approximately effective permeability of a dilute composite with spherical inclusion (particles), such as MRF material. It treats magnetic property of particles as linear and interaction between particles it not taken into account [2, 3]. This approximation is acceptable when the applied magnetic field on MRF material is constant. However, the magnetization process of MRF material on alternating or rotating magnetic field is more complex than it working on constant applied magnetic field. The magnetic hysteresis and nonlinearity of magnetic property must be taken into account on calculation of magnetic property. Hence the measurement and modeling of MRF's magnetic properties is essential to exploration on MRF's application.

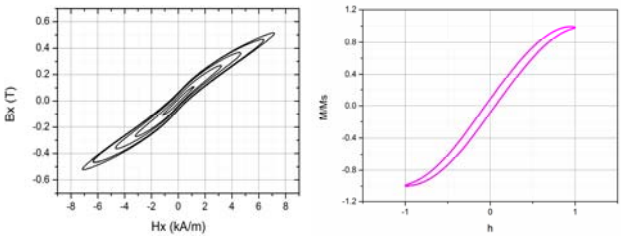
II. Experimental and Simulation

A kind of MRF which manufactured by LORD Ltd. USA, Modeled MRF-132DG, was used in magnetic hysteresis properties investigation. The magnetic hysteresis property of MRF was measured under 1&2D magnetic excitations by using a single sheet tester (SST) [4].

For simulating the magnetic hysteresis properties of MRF materials, an extended large-scale atomic/molecular massive parallel simulator (LAMMPS) was employed. It is an open source software package for large-scale atomic/molecular simulation. It provides not only an embedded routine for large-scale and 3D Brownian dynamic simulation but also an extensive library of potential functions and force fields. In this paper, the function of the magnetic force and Stoner-Wohlfarth hysteresis model was added to this software package. Hence, it not only can simulate the aggregation of magnetic particle of MRF materials under applied magnetic field but also the magnetic hysteresis properties of MRF materials.

III. Results for Measurement and Simulation

Fig.1 illustrates the measured H-B hysteresis loop (a) and simulation result (b) of MRF material with 10Hz sinusoidal excitation.



(a) (b)

Fig. 1 measured and simulated hysteresis loops under alternating field

More results and discussion will be presented in the full paper.

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