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Magnetorheological elastomer preparation device

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Abstract: In order to study the performance characteristics and various preparation methods of magnetorheological elastomers, a large number of papers have been collected. Based on the preparation principle of magnetorheological elastomers, the distribution of magnetic field is analyzed by simulation. The magnetorheological elastomer sample was prepared by establishing the model and designing the experimental device, which accords with the requirements of the experiment.
Keywords: Magnetorheological elastomer, simulation, experiment.

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1. INTRODUCTION

Magnetorheological material is a new kind of intelligent material, which is rich in variety. According to the matrix from liquid to solid state, it is divided into magnetorheological fluid, magnetorheological gel, magnetorheological plastic body, magnetorheological elastomer and so on. The main purpose of this paper is the magnetorheological elastomer. Magnetorheological elastomers consist of a mixture of micrometer-sized ferromagnetic particles and a high-molecular polymer. And it is cured in a magnetic field environment so that the particles in the matrix have a chain or columnar structure. The elastic modulus of this material can vary with the applied magnetic field intensity, so it can be widely applied in the field of variable stiffness devices. Compared with ordinary magnetorheological fluids, magnetorheological elastomers not only have high-tech features such as controllability, reversibility, rapid response, but also have unique advantages such as good stability.

At present, researches on magnetorheological elastomers at home and abroad can be traced back to the 1995 Shiga preparation experiments, after which the performance of MREs was gradually improved [1]. Many studies have used various rubber materials as the matrix material for the MRE, the earliest used natural rubber. With the development, people have used various materials such as polyurethane, silicone rubber, and butadiene rubber to prepare MREs and studied their performance. Jung made magnetorheological elastomer samples using natural rubber and carbonyl iron powder [2]. By comparing the isotropic and anisotropic storage

modulus, it is found that the rheological efficiency of the magnetic field is as high as 60%. Wei uses polyurethane as a matrix to prepare different samples [3]. The results show that the shear modulus can reach 4.9MPa under the applied magnetic field, and the relative MR effect can reach 121% at 800mT. Y. Hu prepared MRE based on a mixture of polyurethane and silicone rubber [4]. By optimizing the preparation conditions, its shear modulus can reach 0.5 MPa in 0.2T magnetic field, which has higher rheological effect than pure silicone rubber or polyurethane MRE. T.L. Sun studied cis-polybutadiene rubber-based MREs with a relative MR effect of up to 80% [5]. Fan added an appropriate amount of maleic anhydride modified butadiene rubber to the mixed system [6]. It was found that the damping of MRE decreases after adding butadiene rubber, and the MR effect decreases. WH Li used polydimethylsiloxane (PDMS) as a matrix to make new MREs [7]. As the composition of iron particles increases, the MR effect gradually increases, and the initial modulus of the sample also shows an increasing trend.

In the process of preparing MRE, we should not only consider the mechanical properties of the matrix itself, but also study the viscosity of the matrix, the magnetic saturation intensity of the particles, the particle size and so on, as well as the magnetic field force among the particles. The conductive mechanism of MRE is similar to that of conductive polymer. It mainly depends on various soft magnetic conductive materials to obtain electrical conductivity.

2. 2. PREPARATION PRINCIPLE AND DEVICE

The main characteristic of MRE is that its mechanical and electrical properties can change with the change of the external magnetic field. The concrete manifestation is that the elastic modulus increases, the conductivity increases along the direction of the particle chain, and the magnetostrictive properties. Based on the characteristics of the MRE, the shape of the particle chains in the MRE can be predicted based on the magnetic field lines of the magnetic field. Figure 1 shows the lines of magnetic force generated by a uniform magnetic field consisting of two magnets. The MRE forms a straight chain of particles in this magnetic field environment. Using the simulation software COMSOL to simulate the magnetic field, as shown in Fig.2, the magnetic field between the magnets is a uniform parallel magnetic field.

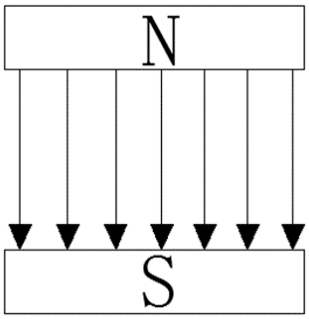

Fig.1 Magnetic field lines

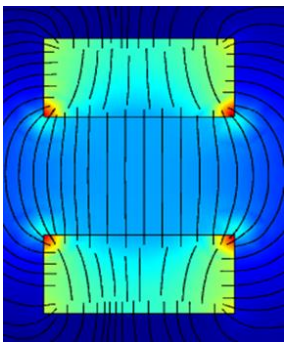

Fig.2 Simulation

3. APPARATUS

Based on the above principles, a magnetic field device for preparing an MRE is designed, which mainly includes a permanent magnet, a magnetic plate, a bolt nut, and an MRE. The permanent magnets are made of NdFeB magnets with a size of 40*40*20. The surface is galvanized. The detected magnetic induction intensity is 115mT. The structure is simple, the volume is small, the weight is light, and no excitation current is needed. No cooling system is required. There is no electromagnetic noise, and the magnetic field strength is stable. The magnetic column used for the aluminum products, the number of 2, the size of 80 * 80 * 5, four corners have four through holes, fixed by bolts and nuts to adjust its position.

The preparation material of MRF consists of four parts: ferromagnetic particles, carrier liquids, surfactants and additives. The type, size, and content of ferromagnetic particles have a great influence on the performance of MRFs. After this study, the carbonyl iron powder of MRS-MRF-35 was used. The average particle size was 3.14. Its shape was spherical, and the relative permeability was high. The base carrier fluid generally selects the material with smaller viscosity to facilitate the uniform dispersion of the carbonyl iron powder particles. Therefore, the dimethyl silicone oil is selected as the carrier, and the viscosity and temperature performance is the best among the liquid lubricants, and can be in the temperature range of -50°C-300. Used between °C. Due to the poor stability of MRF, surfactants were added during the preparation to prevent the sedimentation of particles. Sodium lauryl sulfate was used this time. The additive was formulated with dimethyl silicone oil and its composition was polyvinylpyrrolidone, which was used in a mass ratio of 10:1. Figure 4 is a MRE physical map prepared.

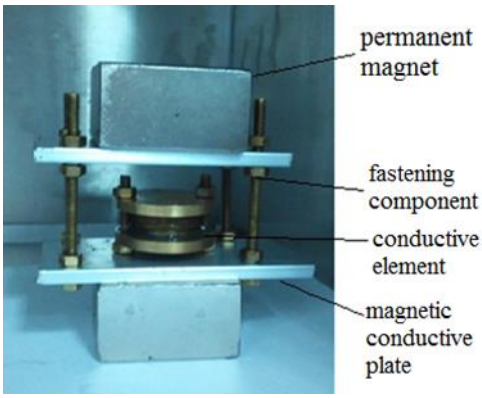

Fig.3 Preparation device

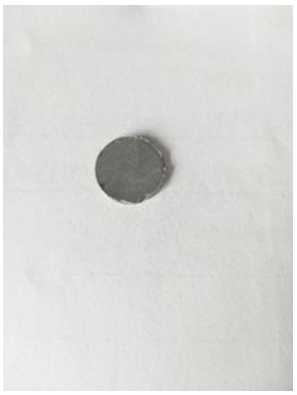

Fig.4 Physical map

4. CONCLUSION

In this paper, by collecting various preparation methods of magnetorheological elastomers, the performance characteristics of MRE are studied. Starting from the characteristic mechanism of magnetorheological elastomers, the preparation principle and simulation were analyzed, and the preparation device was designed.

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