Finite Element Analysis of Magnetorheological Shock Absorber

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Abstract

The vibration isolation theory of vibration isolation equipment is briefly described. Based on the magnetic effect, the force state of the elastic body in the vibration isolation equipment is determined. The initial design and analysis of the vibration isolation equipment are carried out. The finite element analysis software ANSYS , The simulation of the magnetic circuit inside the vibration isolation equipment is carried out, and the closed magnetic circuit can be formed inside the vibration isolator.

Keywords

Magnetorheological elastomer, vibration isolator, ANSYS, vibration control.

1. Introduction

Magnetorheological elastomer is a new branch of magnetorheological materials, is a solid form of magnetorheological fluid, usually by physical and chemical means, the magnetic particles dispersed in a high polymer matrix viscoplastic state and in. Because the particles are fixed in the matrix, there is no problem of particle settlement. [1]At the same time, when the external magnetic field is applied, the particles inside the elastomer are magnetized, which will produce interaction force, which will change the elasticity, shear storage modulus and loss factor of the elastomer. The macroscopic expression is damping and stiffness controllable.[2] Magnetorheological elastomers in overcoming the disadvantages such as easy sedimentation, poor stability of magnetorheological fluid and retains the characteristics of magnetorheological materials with controllable stiffness and damping, with both advantages of magnetorheological fluid and elastomer, which in some areas of vibration control of magnetorheological fluid than is expected to have more extensive application prospects. In this paper, according to the elastic moduli of magnetorheological materials, which can be regulated by external excitation current, magnetorheological elastomers are used as basic elements, and a stiffness controlled and damping value real-time controlled vibration isolation equipment is analyzed by finite element software.[3]

2. Working principle of magnetorheological elastomer

2.1 Magnetic effect of magnetorheological elastomer of magnetorheological technology.

Under the action of the magnetic field, the particles of the magnetorheological elastic body are magnetized and the interaction force is produced. When magnetorheological elastomers are deformed, these magnetic forces form reverse torque inside them, and enhance their resistance to deformation. This capability changes with the change of magnetic field. From the macroscopic view, the modulus of elasticity varies with the magnetic field, that is, the stiffness of the magnetorheological elastomer varies with the magnetic field. Therefore, magneto - induced modulus and magnetic damping [4] will be produced by magnetorheological elastomer in an applied magnetic field. This phenomenon is known as the magnetic effect of the magnetorheological elastomer. At the same time, the internal soft magnetic particles have a small remanence, so the magnetorheological elastomer has a good reversibility under the action of the magnetic field.

2.2 Page Working mode of magnetorheological elastomer

According to the different direction of the magnetorheological elastomer and the direction of the external magnetic field, it can be divided into different working modes. Figure 1 shows the two commonly used methods currently used for magnetorheological elastomers, and the magnetorheological effects of these two modes are also the most obvious.

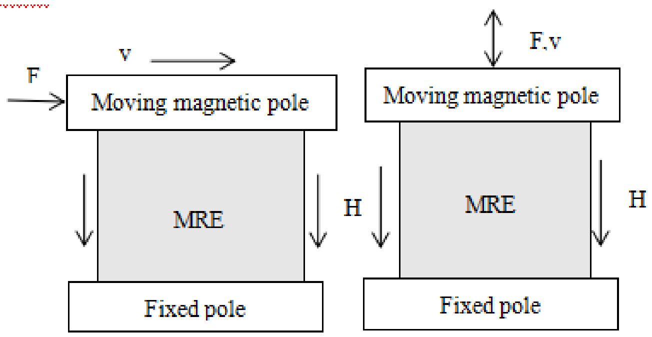


Figure. 1 Working mode of magnetorheological elastomer

Fig. 1 (a) is a shear mode. Under this working mode, the direction of the applied magnetic field is parallel to the direction of the particles, and the direction of the external load is perpendicular to the chain direction, and the particle chain is cut, so it is called the shear mode. Figure 1 (b) for extrusion type magnetorheological elastomer in this mode, the external chain direction of magnetic field direction and particle is parallel to the loading direction and the outer chain direction is parallel to the matrix particles by extrusion, so called extrusion.[5] The magnetorheological elastomer shock absorber has strong nonlinearity in this working mode, but its structure is simple, and it can withstand large loads.

2.3 Stiffness Damping Model of Magnetorheological Elastomer

The elastic element used in this paper is not a simple elastomer, but is a kind of viscoelastic intelligent composite material. The usual rubber elastic element is to use viscoelastic damping material to reduce vibration. In recent years, the experimental results show that a large number of rubber elastic components are not fully conformed to the assumption of viscous damping. The viscoelastic material of rubber has the damping characteristic of internal friction, that is, the phenomenon of strain lag behind the stress.Under the condition of vibration, the hysteresis loop is formed by the stress - strain cycle. The area contained in the hysteresis loop indicates that the work consumed by the internal damping represents the energy consumed in a cycle. In this case, the damping characteristic accords with the assumed property of the structural damping.

3. Performance Analysis of Magnetorheological Elastomers

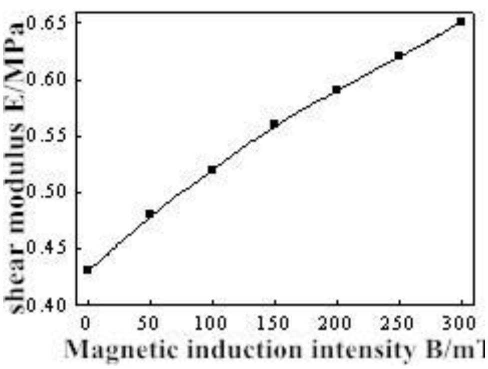


Figure 2 Relation between shear modulus and magnetic field change

The change of the shear modulus of the magnetorheological elastomer is shown in Figure 2 as the magnetic induction intensity is different. It can be seen from the figure, the numerical shear elastic modulus of materials in the zero field is 0.43MPa, with the increase of magnetic field strength, shear modulus of elasticity linearly increases when the magnetic flux density is 300mT, shear modulus of elasticity of the material is 0.65MPa, 51% higher than under zero field.

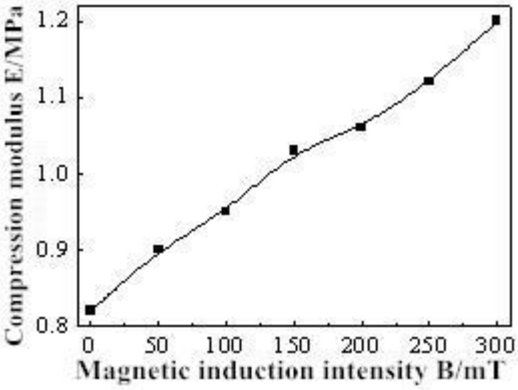


Figure 3 The relationship between the compression modulus and the magnetic field change

The change of the compressive modulus of the magnetorheological elastomer is shown in Figure 3 as the magnetic induction intensity is different. It can be seen from the figure, the numerical shear elastic modulus of materials in the zero field is 0.8MPa, with the increase of magnetic field strength, shear modulus of elasticity linearly increases when the magnetic flux density is 300mT, shear modulus of elasticity of the material is 1.2MPa, 40% higher than under zero field.

Normally, the magnetorheological elastomer is regarded as an incompressible material, and its compression modulus is according to the formula:(1).

$$E = \frac{\sigma_n}{\lambda - \lambda^{-2}} \quad (1)$$

In the formula：E is the modulus of elasticity, σn is the compressive stress, λ the compression strain.

When the compressive strain of the material is small, the nonlinear amount of the compression force can be taken into account. The relationship between compression stress and compression strain can be obtained by formula (1), and the strain generated by compression can be expressed by the compression displacement, as shown in Figure 4. It is shown that the shrinkage force in equal pressure, a variation of elastic magnetic force under the environment of distance change under zero field is small, can explain the elastic modulus of magnetic force under preparation increased, and that the magnetic force can adjust the external elastic modulus to adjust the magnetic rheological elastomer.[6]

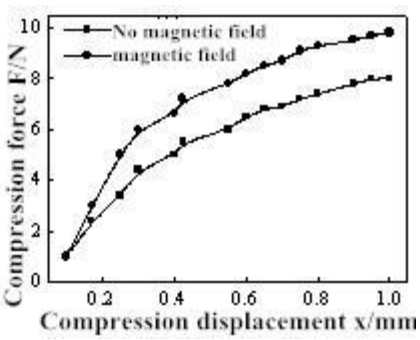
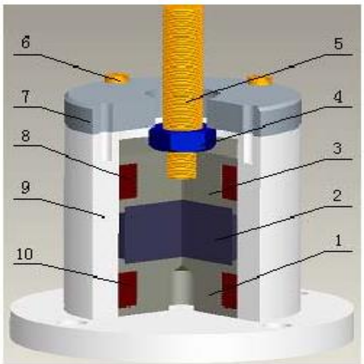


Figure. 4 The relationship between the compression force and the change of the compression displacement

From Figure 2 and Figure 3 can be seen in contrast, MRE than the same volume, the magnetic field is equal, no magnetic field under the condition of magnetorheological elastomer compression elastic modulus is greater than the shear modulus of elasticity; magnetic field environment, increase the amount of increase in the amount of compression modulus of magnetorheological elastomers than elastic shear modulus. Therefore, it can be concluded that the elastic modulus of magnetorheological elastomers is more variable under compression condition, and the output force is greater under the same conditions, so that the adjustment range of the mechanism performance can be improved.

4. Structure of Magnetorheological Shock Absorber



1—Lower conducting magnet 2—Magnetorheological elastomer 3—Upper magnets 4—Nut 5—Screw 6—screw fastener 7—Cover plate 8—Coil winding 9—External magnetic cylinder 10—Lower coil winding

Figure. 5 A three-dimensional diagram of a magnetorheological elastomer isolation system

The basic principle of vibration isolation system for magneto rheological, magnetic wire leads to the DC excitation current source, coil power lines will be formed based on the vibration isolation system, guide magnet winding end and the other end windings under the guide magnet, so as to form a relatively uniform magnetic field in the elastic body. Under the influence of magnetic induction intensity, the elastic modulus of vibration isolation system changes, and then changes the stiffness and damping value of MR damper, resulting in smaller vibration.[7] The vibration isolation effect of the vibration isolation system is related to the magnetic induction intensity of the elastomer, that is, it is related to the current of the inlet coil, and then it can adjust the stiffness and damping value of the MR damper by adjusting the external current value.

4.1 Simulation and Analysis of MRF Isolation System

This paper mainly uses the finite element analysis software ANSYS to analyze the magnetic field formed between the upper and lower conducting magnets. When the current flows through the coil windings on the two conducting magnets, the relationship between the two conducting magnets The magnetic field distribution of induced magnetic field in MRF.

This section uses the Multiphysics module in ANSYS to perform magnetic field analysis on magneto-rheological elastomers, When defining and assigning materials, enter their respective permeability values for the core, magnetorheological elastomer, and air, respectively; the unit selected for meshing is the 6-node triangle in PLANE53; and when applying the boundary, select Magneto-rheological elastomer upper and lower surface as the boundary surface; and then after the solution and post-processing, the resulting magnetorheological elastomer damper magnetic flux density contour and magnetic field distribution vector diagram shown in Figure 6 and Figure 7 shows.

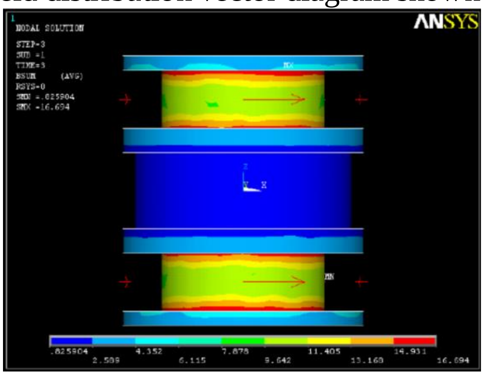


Figure. 6 magnetic flux density contour map

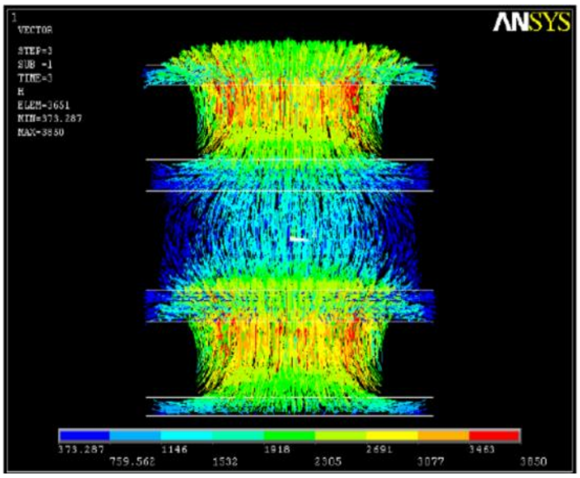


Figure. 7 vectorgraph of magnetic field distribution

After processing, the vector magnetic density map and the magnetic induction intensity distribution map are obtained. As shown in Figure 7, the magnetic flux density map of the whole magnetic circuit is clear. The magnetic field of the whole magnetic circuit is clear, and the coil generates a vertical downward magnetic field. The closed magnetic circuit is formed through the upper conducting magnet, the magnetorheological elastomer and the lower conducting magnet, which is consistent with the theoretical magnetic circuit loop, which proves the feasibility of the scheme.

5. Summary

Magnetorheological materials have unique mechanical and electrical coupling characteristics and related high technical characteristics for the rapid change of rheological properties under the external magnetic field. Because of its fast response and good reversibility continuous control field in recent years, magnetorheological materials are widely used in automobile, construction, vibration control etc MR technology is a new technology, its application research is one of the frontier research field of intelligent materials and structures, have great in the field of aviation, aerospace, construction, fluid transmission and control, machinery manufacturing, vehicle shock absorber and other potential applications as a new technology, although it is still not mature, but can meet the future application prospects and may bring huge economic benefits.

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