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# Simulation And Analysis of the Magnetic Circuit of the Tester For the Yield Stress of Magnetorheological Fluid

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**Abstract*:*** *This paper analyzed the working principle of the tester for yield stress of magnetorheological fluid based on the pulling test , combined with the Ohm's law of magnetic circuit and Ampere circuital theorem, calculated the magnetic circuit of the tester,using finite element software to simulate and analyze the magnetic circuit.*

**Keywords*:*** *magnetorheological fluid ,pulling test,yield stress tester,finite element analysis*

## I. INTRODCUTION

Magnetorheological fluid(MRF) is a kind of intelligent material which is sensitive to magnetic field. In the absence of an external magnetic field, the magnetorheological fluid shows the fluidity of liquids ; When the external magnetic field is applied, the viscosity of the MRF is increased, the liquid thicken, harden, until the loss of liquidity, present the properties of solid,that maintain the shape or has the ability of resistance to shear deformation,represents the characteristics of modulus of elasticity increased significantly. After the magnetic field disappears, the flow property is recovered rapidly, and the change the viscosity is reversible and continuous[1].

Since the rheological property of MRF is continuously and rapidly (response time less than 5 ms) and less affected by temperature changes, MRF is widely used in civil engineering, aerospace engineering, mechanical and electrical engineering, precision machining, control engineering and medicine, and so on.

The yield stress of MRF is the dividing point of the transformation of the solid - liquid properties of MRF. It is one of the main performance parameters of MRF. The key to the study of the mechanism and application of MRF is correctly tested yield stress[2].

## II. WORKING PRINCIPLE

The structure of the test device is shown in Fig. 1. The tester adopts the way of pulling. The container is placed in a uniform magnetic field that produced by electromagnetic core and coil.The tooth pulling block is inserted in the magneto-rheological fluid. The weight plate is connected with the measuring block by string that around the two fixed pulley. To lift the measured block by putting weights in the weight plate. Due to there is friction in the rolling bearing of pulley, the weight of plate and weights can not be passed all to the measuring block. Therefore, it is necessary to measure the friction force according to the size of the added weight firstly. And then deduct it from the measurement results. The implementation method is to measure three times and averaged. The specific formula of the tension conversion to the yield stress of the magneto rheological fluid is as follows:

$$\tau = \frac{\Delta F}{2S}$$

Where, $\Delta F$ is the weight difference between the gravity and the pulley friction, $S$ is the lateral area of the pulling block..

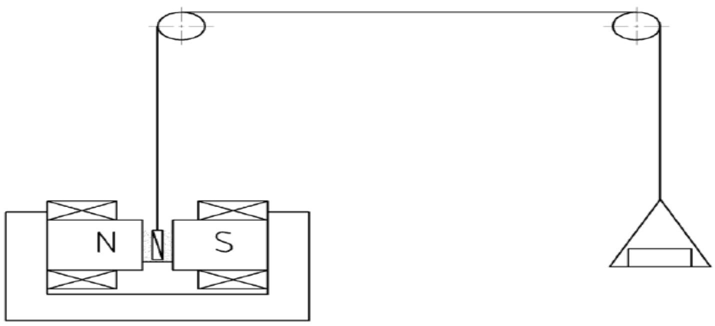


**Fig. 1:** schematic diagram of yield stress testing device

## III. MATERIAL SELECTION

Selected the MRF-132- DG that produced by the Lord Company,the magnetization curve is shown in Fig. 2. The material of magnetic flux circuit, electromagnetic core and container are all Steel_1008, the magnetization curve is shown in Fig. 3[3].

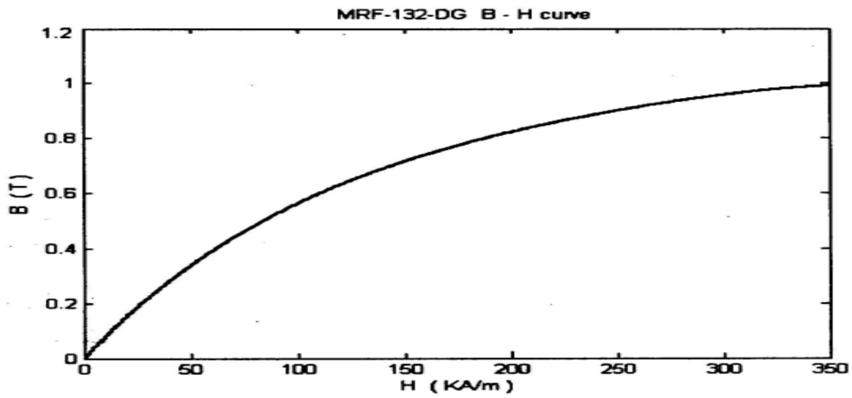


**Fig. 2:** the magnetization curve of MRF-132- DG

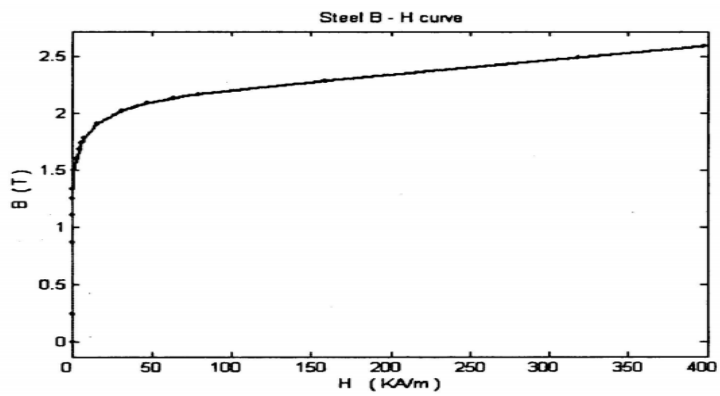


**Fig. 3:** the magnetization curve of Steel_1008

## IV. SIMULATION ANALYSIS

Maxwell Ansoft is a very effective electromagnetic field analysis software developed by Ansoft company[4]. It has been widely used in various engineering fields. Maxwell 2D is a powerful, accurate and easy to use two-dimensional electromagnetic field analysis software. It includes field, magnetostatic field, eddy current field and temperature plant analysis module. It can be used to analyze the characteristics of static, steady-state, transient, normal operating conditions and fault conditions of motors, sensors, transformers, magnetic devices, actuators, and other electromagnetic devices[5]. In this paper, a two-dimensional static magnetic field analysis of the magnetic circuit of the test device for the yield stress of the magnetorheological fluid was made by using the 2D Maxwell module.

## 1. Model Parameter

Both two coils are wound 500 turns of copper wire and applied to the excitation current of I = 1A, I = 2A, I = 3A in turn,calculates the magnetic induction intensity of the magnetic rheological fluid in the container. The simulation results are shown in fig. 4-fig.6.

The following assumptions are presented for a simplified model:

(1) Neglects the leakage flux of working gap of magnetic circuit.

(2) The contact surface of the combination of the magnetic yoke is high machining accuracy, and in a compressed state. Neglects the reluctance of the combination of the magnetic yoke.

(3) The magneto rheological fluid is uniformly distributed in the working space. That is to say the magnetic permeability of the magneto rheological fluid in the working gap is the same.

(4) The influence of the insulating frame of the coil on the magnetic field is neglected.

(5) Neglects the influence of the air gap between the coil and the magnetic yoke on the magnetic circuit.

## 2. Simulation Result

The simulation results show that the magnetic induction in magnetic circuit, magnetic core and container is higher than the magnetic induction in magnetic rheological liquid. As shown from figure 4 to figure 6, when the excitation current applied is I=1A, the magnetic induction intensity of the magnetic rheological fluid is about B=0.2T; when the excitation current applied is I=2A, the magnetic induction intensity of the magnetic rheological fluid is about B=0.4T; when the excitation current applied is I=3A, the magnetic induction intensity of the magnetic rheological fluid is about B=0.5T. The simulation results show that the magnetic field in the working range is a uniform magnetic field, and the magnetic induction intensity increases with the increase of the excitation current.

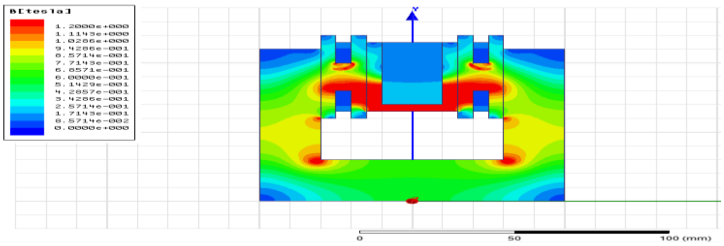

**Fig. 4:** the distribution of magnetic circuit structure in I=1A

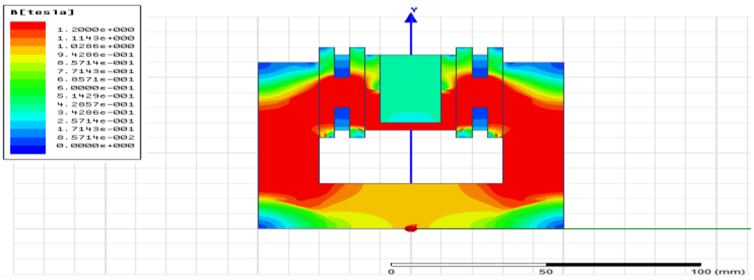

**Fig. 5:** the distribution of magnetic circuit structure in I=2A

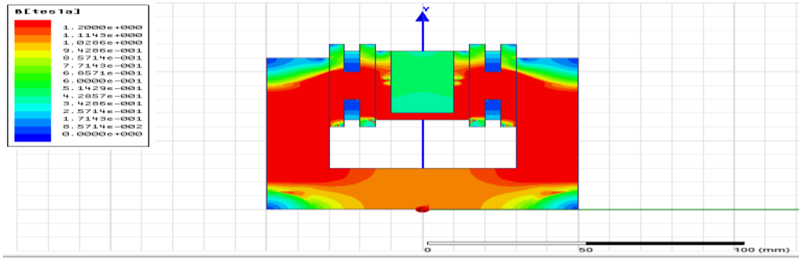


**Fig. 6:** the distribution of magnetic circuit structure in I=3A

## V. CONCLUSION

According to the structure of the test device for the yield stress of the magnetorheological fluid,build the magnetic circuit model ,then simulate and analyze by finite element method. The simulation results show that the magnetic field in the working space of the magnetic rheological fluid of the experimental device is a uniform magnetic field. And the expected magnetic field can be obtained by changing the excitation current.

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