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PREPARATION AND TESTING OF MAGNETO RHEOLOGICAL FLUID

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***ABSTRACT*- This paper represents the introduction to the Magneto Rheological (MR) fluid and its basic properties. The main aim of this paper is to prepare the magneto rheological fluid for the MR damper which is used in vehicle suspension system. MR fluids are a class of smart material. A MR fluid is a very useful constituent material for the engineers which are involved in the design of brakes, damper, clutches and shock absorber system. This paper also emphasis on the details of preparation, testing and validification of magneto rheological fluid for its effective use and testing of MR damper. Now a day's increasing vibration affect the vehicle ride comfort. To improve ride comfort of vehicle suspension system magneto rheological fluid is very necessary in magneto rheological damper to reduce the vibrations or shocks.**

Keywords: **magneto rheological, damper, smart material**

I. INTRODUCTION

A. Basics of MR fluid

The discovery of Magneto Rheological (MR) fluid is attributed to Jacob Rabinow in 1940's. Magneto rheological fluids are a class of controllable fluids which can be simply referred as a smart material. Nowadays they are stable exhibit many attractive properties such as high yield stress and low viscosity. Because of this magneto rheological fluids are recently used in suspension of high class vehicle. Magneto rheological fluids are mixture of micron sized ferromagnetic particle and grease in appropriate carrier oil. MR fluids manifest a change in rheological properties on the application of external magnetic field. Rheology is branch of science that deals with the study of deformation and flow of matter such as magneto rheological fluids, blood, paint etc. under the impact of a stress. The rheological property of controllable fluids turns on properties of the carrier oil, attention and density of particles, particle size and shape, external magnetic field and temperature etc.

B. Property of MR fluid

The typical properties of magneto rheological fluids are as shown in Table 1.

Table 1 Properties of MR fluid

Property	Range
Density	3 - 4.5gm/cm^3
Initial viscosity	0.2 – 1.0 (Pa.s) at 24^{0}C
Magnetic field strength	160 – 240 (KA/m)
Maximum yield stress	50 – 100 (KPa)
Reaction Time	10 – 20 millisecond (ms)
Stability	Good
Working temperature	-50^{o}C – 150^{0}C
Supply voltage and current	12V and 0.1 – 2A

C. Working of MR fluid

Basically MR fluid can be works on the three modes according to applications. These three modes are as follows:

- Flow mode
- Direct shear mode
- Squeeze mode

As per the applications these above modes are used such as flow mode can be used in shock absorber and damper, direct shear mode is useful in brakes and clutches, and squeeze mode is used for controlling small movements with large force.

For the application of magneto rheological damper flow mode can be used as follows:

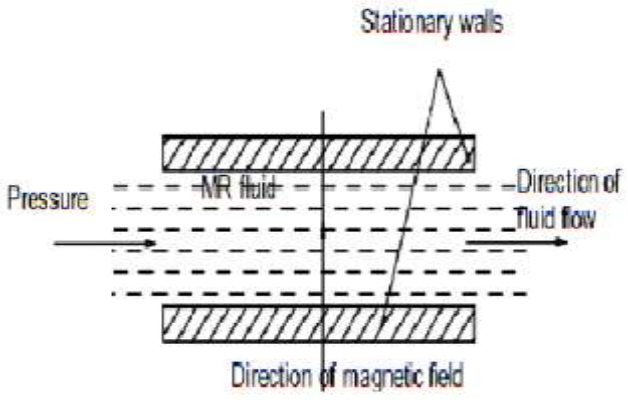


Fig.1 Flow mode of MR fluid

In flow mode fluid is presents between two stationary walls referred as north and south poles. The flow of fluid can be controlled by applying external magnetic field perpendicular to stationary walls as shown in fig 1.

The magnetizable iron particles are typically micron sizes which are suspended within the low viscosity paraffin oil. These particles are distributed randomly in normal condition that is before applying magnetic field as shown in below figures:

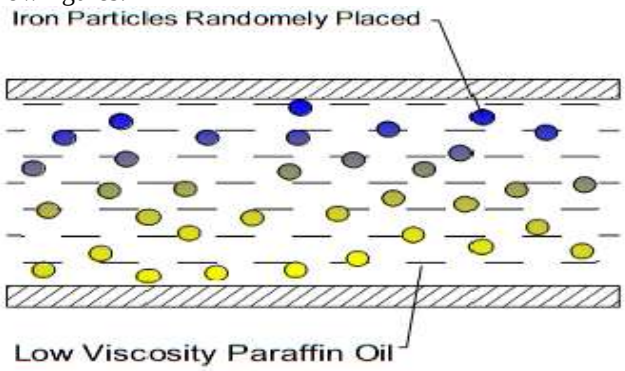


Fig. 2(a) Before applying magnetic field

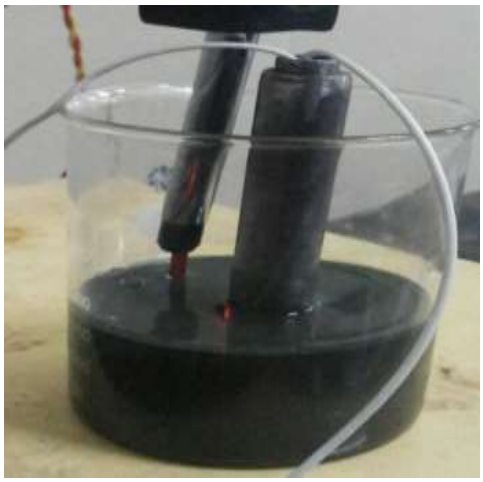


Fig. 2(b) Actual schematic of MR fluid before applying magnetic field

At this state MR fluid act as a free flowing fluid that is it travel in any direction. In case of magneto rheological damper fluid will travel from lower chamber to upper chamber and vice versa form holes grooved on periphery of piston. Figure 2(b) shows the actual schematic of MR fluid before applying magnetic field.

As the magnetic field is applied to fluid, the micron size particles align themselves along line parallel to the direction of magnetic flux as shown in below figure 3(a):

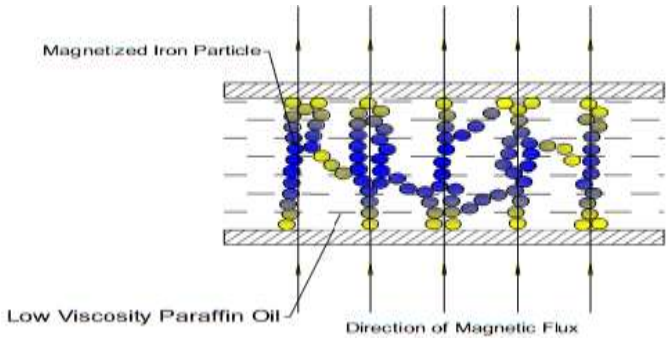


Fig. 3(a) After applying magnetic field

Figure 3(b) shows the actual schematic of MR fluid after applying magnetic field.

Fig. 3(b) Actual schematic of MR fluid after applying magnetic field

II. PREPARATION OF MR FLUID

A. Constituents of MR fluid

As per the application of MR fluid, formulation will be depends.

Carrier oil	Magnetic particle	Additives
Low viscosity paraffin oil	Electrolytic iron powder	Grease
Silicon oil	Iron alloy	Arabic gum
Water	Nickel alloy	

For the preparation of 100ml MR fluid following constituents are required with specified quantity as follows:

Constituents	Quantity
Low viscosity paraffin oil	68ml
Iron particle (50 microns)	112.32gm
All purpose grease (AP3 grease)	6.75gm

As per the requirements of MR fluid these above quantity will be changes. For preparation of 'X' ml MR fluid each quantity of constituents should be multiplied by (X/100) factor.

B. Preparation procedure for MR fluid

For the preparation of MR fluid two accessories are required as mechanical stirrer and beaker with above constituents. Following are the steps for preparation of MR fluid.

1. First take the low viscosity paraffin oil and all purpose grease (AP3 grease) with correct quantity in a beaker.
2. Stir this improper mixture of low viscosity paraffin oil and grease with the help of mechanical stirrer for proper mixing.
3. Then wait for 2hrs so that grease gets completely soluble in paraffin oil.
4. After that add iron particles of 50 micron size in above mixture and again stir it with the help of mechanical stirrer for 15 to 20 min. for proper mixing.

In the preparation of MR fluid AP3 grease is added into low viscosity paraffin oil to avoid settlement of iron particle. Following figures shows the prepared MR fluid:

Fig.4 Prepared MR fluid

III. EXPERIMENTAL SETUP OF MR FLUID TESTING

A. Basic requirements

For the testing of MR fluid following instruments are required.

1. Guassmeter and teslameter
2. Electromagnet
3. Electrical circuit (Step down transformer, Ammeter and Rheostat)

Guassmeter and teslameter is a magnetometer that used to measure the strength of magnetic field measured in units of gauss and teals respectively. The guassmeter has a

probe which is kept in a MR fluid to measure magnetic field intensity. The electromagnet is a device of electrical winding wounded on a core in which magnetic field is produced by applying external electric current. This electromagnet is used for to magnetize the iron particle present in a MR fluid. The electrical circuit is required to vary a current of electromagnet. The step down transformer is used to convert the 230V AC supply into 12V DC supply. Following figure shows an experimental setup for testing the MR fluid.

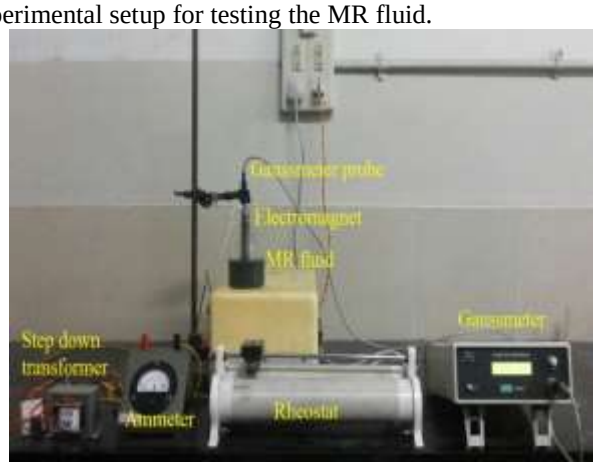


Fig.5 Experimental setup

B. Results of MR fluid

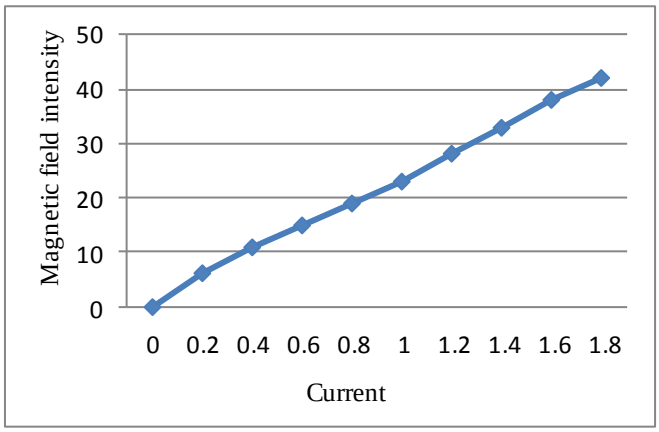
Following table shows the reading obtained while testing the MR fluid and respective graph.

Table 2: Value of Magnetic Field intensity in gauss for

Current (A)	Magnetic field intensity in gauss
0	0
0.2	6
0.4	11
0.6	15
0.8	19
1.0	23
1.2	28
1.4	33
1.6	38
1.8	42

Above table shows magnetic field intensity in gauss by varying the current.

Below graph shows the relation between magnetic field intensity in gauss and current in ampere.



Graph 2 Magnetic field intensity vs. Current

C. Validification of MR fluid

Magnetic field is created due to moving charges in a winding. Each electron in a winding creates its own magnetic field. "The amount of current in a winding is directly proportional to magnetic field intensity". The graph shows that as the current increases magnetic field intensity also increases. There is a linear proportion between current and magnetic field intensity. This graph follows the above statement so that the prepared MR fluid is used for applications.

IV. MAGNETO RHEOLOGICAL DAMPER

A. MR damper working

Dampers are an integral part of any suspension system. Magneto rheological damper is the assembly of piston and cylinder with electrical winding placed on periphery of the piston bobbin. The two terminal of electrical winding are carried out through piston rod. The electrical winding produces magnetic field when the current is passed through it. There are 4-6 holes grooved on periphery of the piston bobbin to allow MR fluid passing from lower chamber to upper chamber and vice versa.

Fig.6 MR damper winding

When the current is passed through the electrical winding it produces magnetic field. Because of that MR fluid gets magnetizes and iron particles align themselves along a line parallel to the direction of magnetic field. The micron size iron particle gradually blocks the flow of MR fluid from lower chamber to upper chamber by gradually increase in current and we get desired damping that means the shock are absorbed by MR damper. The testing of MR damper is carried out on a universal damper testing machine as follows:

Fig.8 Experimental setup for MR damper testing

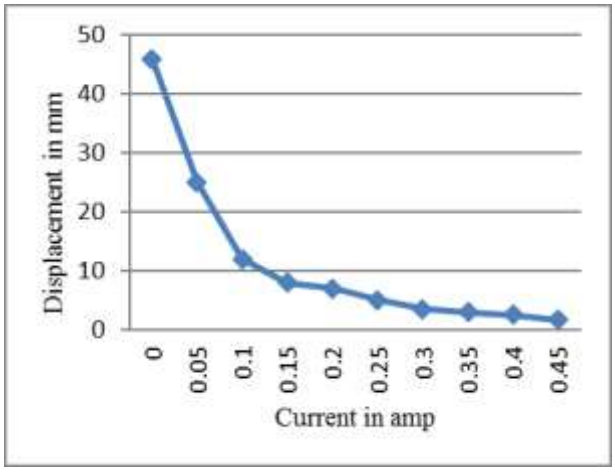
The piston of MR damper is moves up and down in cylinder containing a MR fluid. The up and down motion to piston is carried out by above setup.

B. Results of MR damper

From the testing of MR damper with MR fluid following readings and graph are obtained.

Table 3: Value of Displacement for various current

Current (A)	Displacement (mm)
0	46
0.050	25
0.100	12
0.150	8
0.200	7
0.250	5
0.300	3.5
0.350	3
0.400	2.5
0.450	1.7



Graph 2 Displacements vs. Current

The above graph shows that if the current of electrical winding increase gradually the displacement goes on decreasing.

V. CONCLUSION

The experimental result shows the good efficiency of prepared MR fluid in presence of external magnetic field. The MR fluid is tested on guassmeter which shows the result as magnetic field is applied to MR fluid; it changes the physical state that is liquid state to semi-solid state. Guassmeter shows reading of magnetic field intensity by varying the current. Graph 1 shows that as current increases then magnetic field intensity of MR fluid also increases. For our application we have used MR fluid in magneto rheological damper which shows better damping performance under the influence of external magnetic field. Graph 2 shows that as the current increases gradually to electrical winding of MR damper then displacement goes on decreasing so that we get sufficient damping.

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