DESIGN, FABRICATION AND AN INVESTIGATION OF VIBRATIONAL CHARACTERISTICS OF MR DAMPER

Vinay .V.N[1], Khandoba G M [2], N R Suraj[3], Karthik K[4], Kiran R H[5]

[1] Assistant Professor,Mechanical Engineering, K.L.E.Institute of Technology, Hubli, Dharwad, India
[2 3 4 5] Undergraduate Student, K.L.E.Institute of Technology, Hubli, Dharwad, India

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Abstract -***Magneto-Rheological (MR) dampers are semi- active control devices that use MR fluids to produce controllable dampers. In the present work, experimental setup is designed and fabricated as per standards. Magneto rheological fluid samples are prepared. In this silicone oil is used as a carrier fluid and is mixed with micron sized iron particles. In order to reduce sedimentation, white lithium grease is used as an additive in the MR fluid samples. Considering the permeability, magnetic flux strength and magnetic flux intensity, variation of vibration amplitude for different samples of MR fluids is studied. The advantage of MR dampers over conventional dampers are that they are simple in construction, compromise between high frequency isolation and natural frequency isolation, they offer semi-active control, use very little power, have very quick response, has few moving parts, have a relax tolerances and direct interfacing with electronics. Magneto- Rheological (MR) fluids are controllable fluids belonging to the class of active materials that have the unique ability to change dynamic yield stress when acted upon by a magnetic field. This property can be utilized in MR damper where the damping force is changed by changing the rheological properties of the fluid magnetically. Semi-active control devices have received significant attention in recent years because they offer the adaptability of active control devices without requiring the associated large power sources.***

Key Words: *MR damper, MR fluid, Vibration Amplitude*

1. VIBRATION

A motion which repeats itself after a certain interval of time may be called as vibration. Vibration is the motion of a particle or a body or a system of connected bodies displaced from the position of equilibrium. Vibration occurs when a system is displaced from a position of stable equilibrium. The system tends to return to this equilibrium position under the action of restoring forces. The system keeps on moving back and forth across its position of equilibrium.

1.1 DAMPER

The dampers or shock absorbers are widely used in automotive vehicles to dissipate the vibration energy of sprung and un-sprung mass under resonance conditions. Many types of dampers have been designed to meet the comfort and control requirements of passenger vehicles. The main types are passive, semi-active and active dampers. Among them, the passive damper is commonly used due to minimum cost and simple design principle. In passive damper the damping rate is fixed it cannot be changed where as in semi active damper the damping rate can be changed with a little amount of power. And in case of active damper, the damping rate can be changed with higher consumption of power [1].

1.2 Magneto-rheological damper

Recently, various semi-active suspension systems featuring MR fluid damper have been proposed and successfully applied in the real field, especially in vehicle suspension systems. MR fluid dampers applied to control unwanted vibration and shock for various systems including-landing gear, helicopter lag dampers, vibration isolation systems, vehicle seat suspension systems, civil structures, military equipments, prosthetic limbs. The main advantages are that they need very less control power, has simple construction, quick response to control vibration.

A MR Damper or MR shock absorber is filled with MR fluid, a smart material, which is controlled by a magnetic field, usually using an electromagnet. This allows the damping characteristics of the shock absorber to be continuously controlled by varying the power of the electromagnet. The magneto rheological damper models are accurately represent the behavior of MR fluid for better understanding the operation and working principles of the device. The magneto-rheological fluid is a type of smart fluids whose rheological properties change in the presence of magnetic field. It consist of ferromagnetic particle size (micron or nano meter range) mixed with carrier fluid typically a synthetic or hydrocarbon based oil.

2. MR fluid

Magneto rheological (MR) fluids are basically non colloidal suspensions of micro sized magnetisable particles in an inert base fluid along with some additives. Thus there are basically three constituents in an MR fluid:

1. Base fluid
2. Metal particles
3. Stabilizing additives

1. Base fluid

The base fluid is an inert or non magnetic carrier fluid in which the metal particles are suspended. The base fluid should have natural lubrication and damping features. For better implementation of MRF technology the base fluid should have a low viscosity and it should not vary with temperature. This is necessary so that MRF effect i.e. variation of viscosity due to magnetic field becomes dominant as compared to the natural viscosity variation. Due to the presence of suspended particles base fluid becomes thicker. Commonly used base fluids are hydrocarbon oils, mineral oils and silicon oils.

In the present work silicone oil is used as base fluid in preparing MR fluid.

2. Metal particles

For proper utilization of this technology we need such type of particles which can magnetized easily and quickly. Metal particles used in the MR- technology are very small. Size of the particle is approximate of the order of 1µm to 7µm. Commonly used metal particles are carbonyl iron, powder iron and iron cobalt alloys. Metal particles of these materials have the property to achieve high magnetic saturation due to which they are able to form a strong magnetizing chain. The concentration of magnetic particles in base fluid can go up to 50%. (approx).

Here the metal particles of size ranging from 75µ and 106 µ is chosen for preparing MR fluid of various composition. The size of the iron particles have the influence on the viscosity of MR fluid.

3. Stabilizing additives

Additives form the third component of the Magneto rheological fluid and are used in the fluids for many purposes, e.g. prevention and minimization of sedimentation, prevention and minimization of coagulating of the particles, maintain a coating on the particles in order to enhance re-dispersibililty and to enhance anti-oxidation.

The prevention of sedimentation is one of the most important aspects. For the practical reason, the sedimentation rate is to be kept at minimum possible level. White lithium grease is a good additive with carrier liquid silicone oil [3]. This white lithium grease is used in many automotive applications and easily available in automobile spare part shops. White lithium grease is thus used as an additive for the sample.

For the practical reason, the sedimentation rate is to be kept at minimum possible level. White lithium grease is a good additive with carrier liquid silicone oil.

1 Heat and Water Resistant- Provides lasting lubrication and durability under stressful conditions.
2 Rust & Oxidation Inhibitors- For superior metal protection.
3 High Purity.
4 Non-Conductive.
5 Provides instant access to current safety information should an accident or OSHA inspection occur.

This white lithium grease is used in many automotive applications and easily available in automobile spare part shops. White lithium grease is thus used as an additive for the sample and as a stabilizing additive.

All the three constituents of an MR fluid define its magneto rheological behavior. Changing any one constituent will result in change in the rheological and magneto rheological properties of the MR fluid.

An optimum combination of all the three constituents is necessary to achieve the desirable properties of an MR fluid.

Synthesis of Magneto Rheological fluid

The synthesis of magneto rheological fluid is under three important headings,

1. Segregation of iron particles
2. Weighing of Fe particles, silicon oil and grease
3. Mixing of MR fluid using an electrical stirrer.

1. Segregation of Fe particles

The iron powder obtained after machining is chosen as the base metal for the preparation of MR fluid. Iron particles are obtained from the waste of the cast machined products such as nut and bolts, etc. Later these iron particles are taken for the grinding to grind it to the finer size particles. The iron powder after grinding is taken to the sieve shaker to obtain the iron particles of different sizes ranging from 212 microns to less than 53 microns.

Weighing of Fe particles, silicon oil and grease. From the obtained samples of the iron powder we have considered 75 micron sized powder and 106 micron sized powder to prepare MR fluid.

Weighing of Fe particles, silicon oil and grease

To prepare the M R Fluid samples, the material composition is fixed. From the literature survey it is found that there are two methods by which the constituents of the MR fluid are selected.

(1) Volume percentage (2) Weight percentage

(2) Mixing of MR fluid using an electrical stirrer.

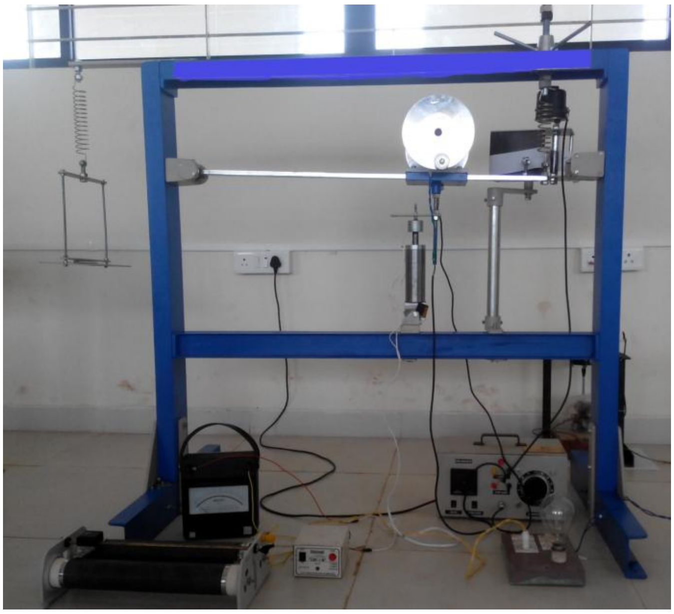
The ferrous particles, silicon oil and grease are added with different weight ratios to get different samples of MR fluid. The ferrous particles acts as metal particles, silicon oil acts as a base or carrier fluid owing to its low viscosity changes vs. temperature, low toxicity and thermal stability properties and grease as the additives.

For the preparation of MR fluid an electrical stirrer is designed and fabricated as shown in figure 6.3. The stirrer has controllable speed as the fluid constituents need to be stirred at 900 rpm continuously for 12 hours constantly to have proper mixing of constituent to get MR fluid. After stirring the mixture of ferrous particle, silicon oil and grease for 12 hours continuously at the speed of 900 rpm constantly the MR fluid is ready.

A fluid thus, prepared, looks like a black color continuous fluid which appears similar to black liquid paint. This prepared fluid is the Magneto Rheological Fluid.

Experimental set up to study vibration characteristic of MR damper

The vibration characteristic of MR damper is studied by an experiment conducted on forced damped vibration of spring mass system. In this system an exciter unit is coupled to D.C variable speed of motor which can be varied with the speed control unit. Speed of the rotation can be known from the speed indicator on the control panel. The damper is connected to the exciter. Amplitude of the vibration can be recorded on the strip chart recorder. The solenoid of the piston is connected to the electrical source by means of wire through a rheostat and an ammeter. Rheostat is connected to resist the current flow which is measured by means of ammeter.



The experimental set up used to study the vibration characteristics of MR damper is shown in figure 8.1.1. The interconnectivity of various parts and links is explained as below,

1. The main frame houses the MR damper, cantilever beam, motor exerting eccentric load, helical spring.
2. Near to free end of cantilever beam MR damper is mounted in vertical position
3. Exciter acts as an intermediate link between cantilever beam and MR damper, and this exciter will transfer the force from eccentric loader to piston of MR damper.
4. Eccentric loader near to free end of cantilever beam exerts the longitudinal force on to piston of MR damper. The speed of the rotating eccentric loader is controlled using RPM regulator.
5. Solenoid in turn is linked to the external circuit comprising of Rheostat (To control input voltage), ammeter (to measure power supply).
6. Strip chart recorder is used here to display the magnitude of vibration of MR damper

RESULTS AND DISCUSSION

1. Sample MRF1

Sl. no.	Constituent	Weight in grams	Percentage in Weight
1	Fe particles of size 106µ	95	35%
2	Silicon oil	160	60%
3	Grease	15	5%

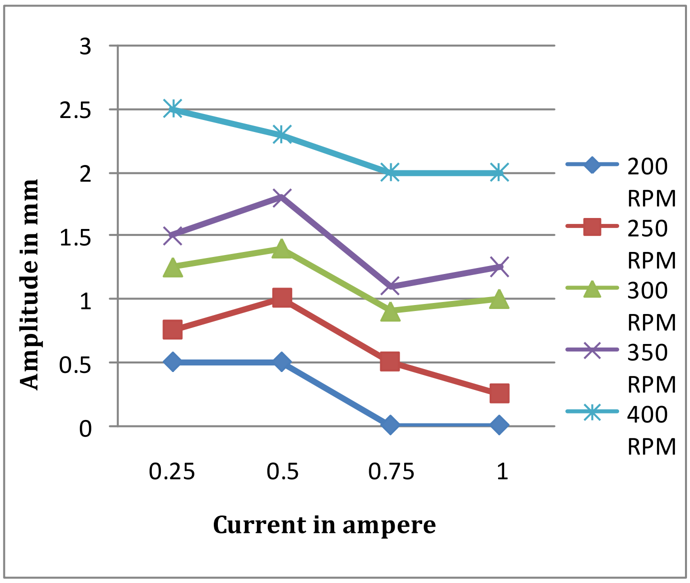


Fig 1 Amplitude of vibration v/s current for MRF1.

2. Sample MRF2

Sl. no.	Constituent	Weight in grams	Percentage in weight
1	Fe particles of size 75µ	95	35%
2	Silicon oil	160	60%
3	Grease	15	5%

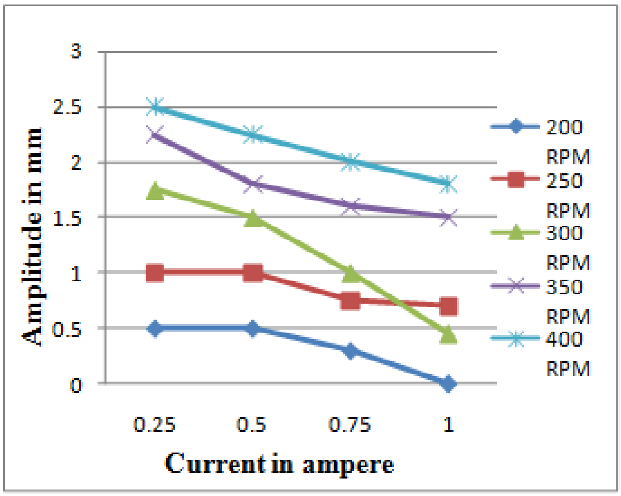


Fig 2 Amplitude of vibration v/s current for MRF2.

3. Sample MRF3

Sl. no.	Constituent	Weight in grams	Percentage in weight
1	Fe particles of size 106µ	70	25%
2	Silicon oil	185	70%
3	Grease	15	5%

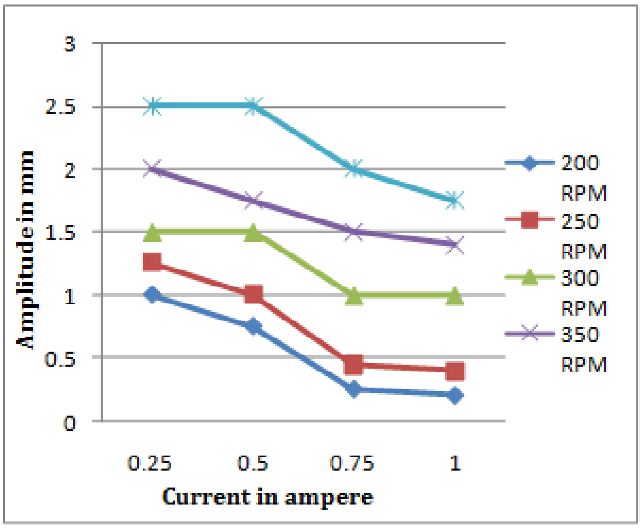


Fig 3 Amplitude of vibration v/s current for MRF3.

4. Sample MRF4

Sl. no.	Constituent	Weight in grams	Percentage in weight
1	Fe particles of size 75µ	70	25%
2	Silicon oil	185	70%
3	Grease	15	5%

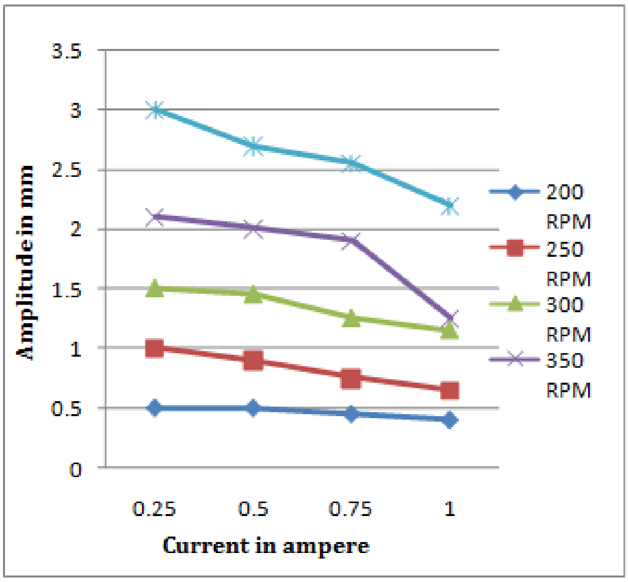


Fig 4 Amplitude of vibration v/s current for MRF4.

5. Sample MRF5

Sl. no.	Constituent	Weight in grams	Percentage in weight
1	Fe particles of size 106µ	40	15%
2	Silicon oil	215	80%
3	Grease	15	5%

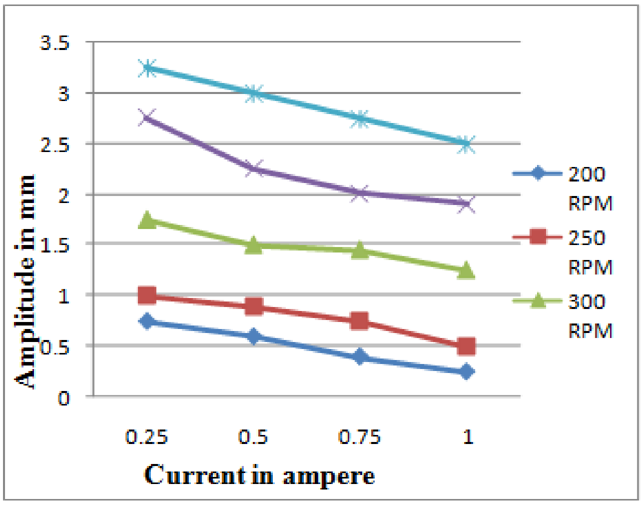


Fig 5 Amplitude of vibration v/s current for MRF5.

6. Sample MRF6

Sl. no.	Constituent	Weight in grams	Percentage in weight
1	Fe particles of size 75µ	40	15%
2	Silicon oil	215	80%
3	Grease	15	5%

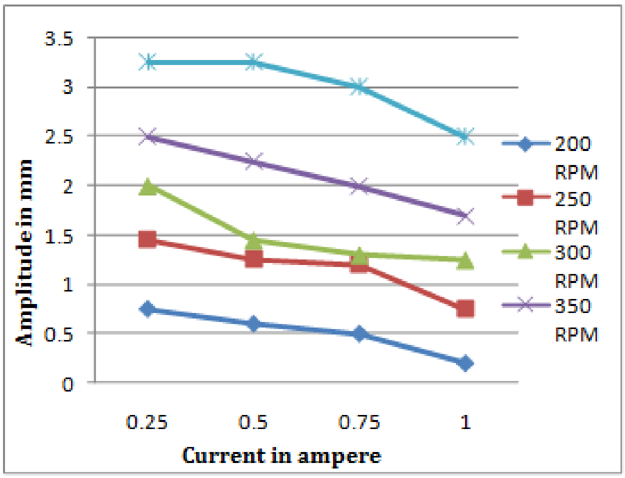


Fig 6 Amplitude of vibration v/s current for MRF6.

3. CONCLUSIONS

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BIOGRAPHIES

Vinay V N
Asst. Professor
Dept. of Mechanical Engg.
KLEIT, HUBLI

Khandoba G M
Undergraduate Student,
KLEIT, Hubli

N R SURAJ
Undergraduate Student
KLEIT, Hubli

KARTHIK K
Undergraduate Student
KLEIT, Hubli

KIRAN R H
Undergraduate Student
KLEIT, Hubli