iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 6 **Issue:** VI **Month of publication:** June 2018

DOI: http://doi.org/10.22214/ijraset.2018.6190

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue VI, June 2018- Available at www.ijraset.com

Modelling, Fabrication and Testing of Magneto-Rheological (MR) Valve

Mr.Vinay V.N.[1], Nagesh Jeerankalagi[2], Vyasa Hegde[3], Rahul S.Rachotti[4]
[1]Assistant Professor, Department of Mechanical Engineering, KLE Institute of Technology, Hubballi, Karnataka
[2,3,4]Students, Department of Mechanical Engineering, KLE Institute of Technology, Hubballi, Karnataka

***Abstract**: Magneto-Rheological(MR) valve are semi active control devices that use MR fluids to produce controllable flow rates. 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 advantages of MR valve over conventional valve 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. Magnet- rheological (MR) fluids are controllable fluids belonging to the class of active materials that have the unique ability to change the dynamic yield stress when acted upon by a magnetic field. This property can be utilized in MR valve where the flow rate can be changed with the change in rheological properties of the fluid magnetically.*

***Keywords**: MR fluids, permeability, silicone oil, micron sized iron particles, white lithium grease, semi active control device.*

I. INTRODUCTION

Smart fluids belong to the class of field responsive composites and they have the capacity to undergo significant, reversible and controllable transformations with respect to their material characteristics. These materials have the ability to change from a liquid to a solid almost instantly when subjected to electric or magnetic field. Smart fluid comprises a suspension of micro-meter-sized particles in a dielectric carrier liquid. These smart materials are commonly referred as magneto-rheological (MR) fluids, electro-rheological (ER) fluids and Ferro-fluids. MR fluids are the dispersions of fine, magnetically soft, multi-domain particles, in a hydraulic or silicone oil carrier fluid. The apparent yield strength of these fluids can be changed significantly within milliseconds on the application of an external magnetic field. MR fluids possess rheological properties, which can be changed in a controlled way. ER fluid also exhibit changes in their behaviour under the influence of an applied electric field. Er fluids are also known as electro-viscous fluids, where rheological effects were used to depict the changes observed in the mechanical properties of the fluid due to electrostatic stress. Ferro-fluids consist of colloidal suspension of mono domain ultra-fine magnetic particles dispersed in either aqueous or non-aqueous liquids. These materials have multiple properties (chemical, electrical, magnetic, mechanical and thermal) or can transform energy which can be altered or tuned using external fields. Most everyday materials have physical properties, which cannot be significantly altered; for example, if oil is heated it will become a little thinner, whereas a smart material with variable may turn from a liquid state which flows easily to a solid. Each individual type of smart material has a different property which can be significantly altered, such as viscosity, volume or conductivity. As each smart material has a different property which can significantly be altered. Thus, the property that can be altered significantly determines what type of applications a particular smart material can be used most effectively. A valve is a device that regulates, directs or controls the flow of a fluid (gases, liquids, fluidized solids,) by opening, closing or partially obstructing various passageways. Valves are technically fittings. In a general open valve, fluid flows in a direction from higher pressure to lower pressure.

II. PROBLEM STATEMENT

Normal valve like bypass valve has more number of moving parts which results in wear and tear of parts. Which causes leakage in valve over time and becomes tough to operate. But in case of MR valve there are no moving parts which eliminates the wear and tear of the parts and also minimises the leakage. Higher pressure capacity could be achieved using the MR valve structure. Faster control response can be obtained here.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue VI, June 2018- Available at www.ijraset.com

A. Objective

There are 3 main objectives behind taking up this project. They are as follows,

1) To design fabricate and analyze of magneto-rheological valve.

2) To calculate flow discharge rate by varying the current supply.

3) To analytically calculate the magnetic flied intensity and cross-check with the ANSYS result.

4) To reduce the human effort and reduce the leakages in the valve.

III. DESCRIPTION OF MAGNETO-RHEOLOGICAL (MR) FLUID COMPOSITION AND EXPERIMENTAL SETUP

The composition and electrical components of the present work are detailed below,

A. Composition of MR fluid

Magneto-rheological fluid(MR) is composed of following ingredients.

1) Metal Particles-Iron particles

2) Carrier Fluid-Silicone oil (300 CS-viscosity)

3) Additive-Grease AP3

B. Electrical components

1) Battery : The selected battery is Lithium ion because of its discharge, availability and less weight with cost effectiveness.

Table 1 Battery specification

Sl.no	Particulars	Magnitude
1	Voltage	12V
2	Typical capacity	7Ah
3	Maximum current discharge	7A

2) *Ammeter:* To measure the amount of current supplied we have used DC ampere meter (ammeter)..

a) Type-DC

b) Measuring range-DC (0 to 8A)

3) *Voltmeter:* To measure the battery voltage capacity we have used DC voltmeter, which has the maximum capacity of 30V (DC).

a) Type-DC

b) Measuring range-DC (0 to 30V)

Fig.1 Ammeter

Fig.2 Voltmeter

A rheostat is a variable resistor which is used to control current. It is used to vary the resistance in a circuit without interruption. We have varied the current ranging from 0A to 2.5A to carry out the experimental part of our project.

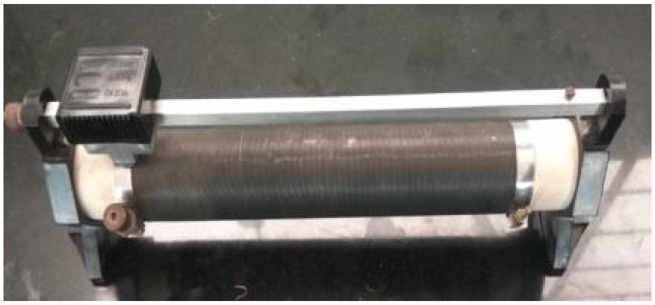
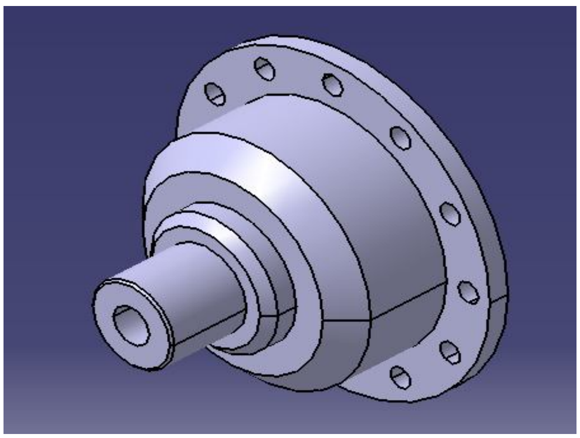


Fig.3 Rheostat

IV. MODELLING OF MR VALVE

The part modelling of MR valve and its assembly is carried out using CATIA V5. The images of modelled partsare shown below.

A. Modeling of Each Components



\

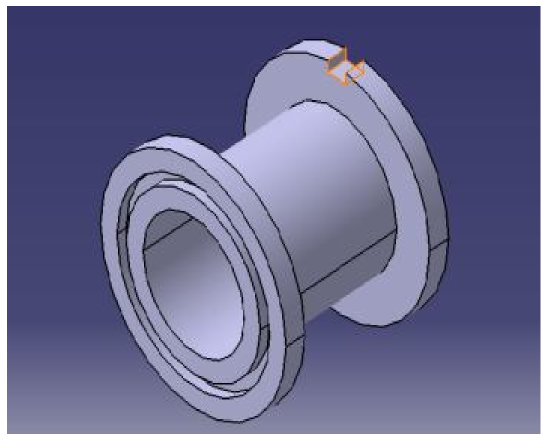


Fig.4

Shield

Fig.5 Bobbin.

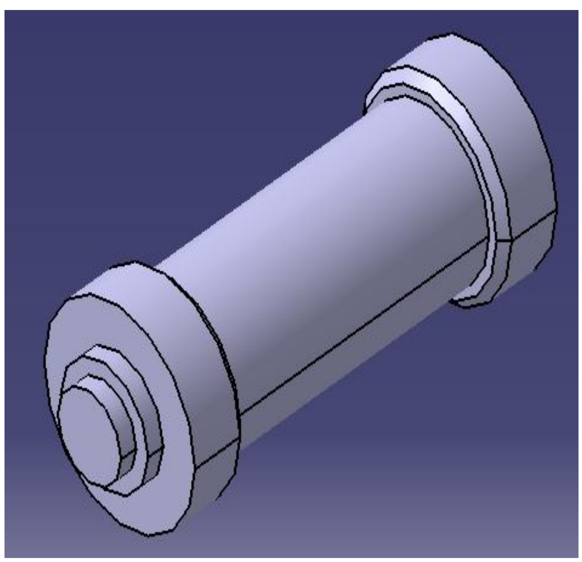


Fig.6 Core

V. EXPERIMENTAL SET UP FOR TESTING OF MAGNETO-RHEOLOGICAL (MR) VALVE

A. Experimental Set Up

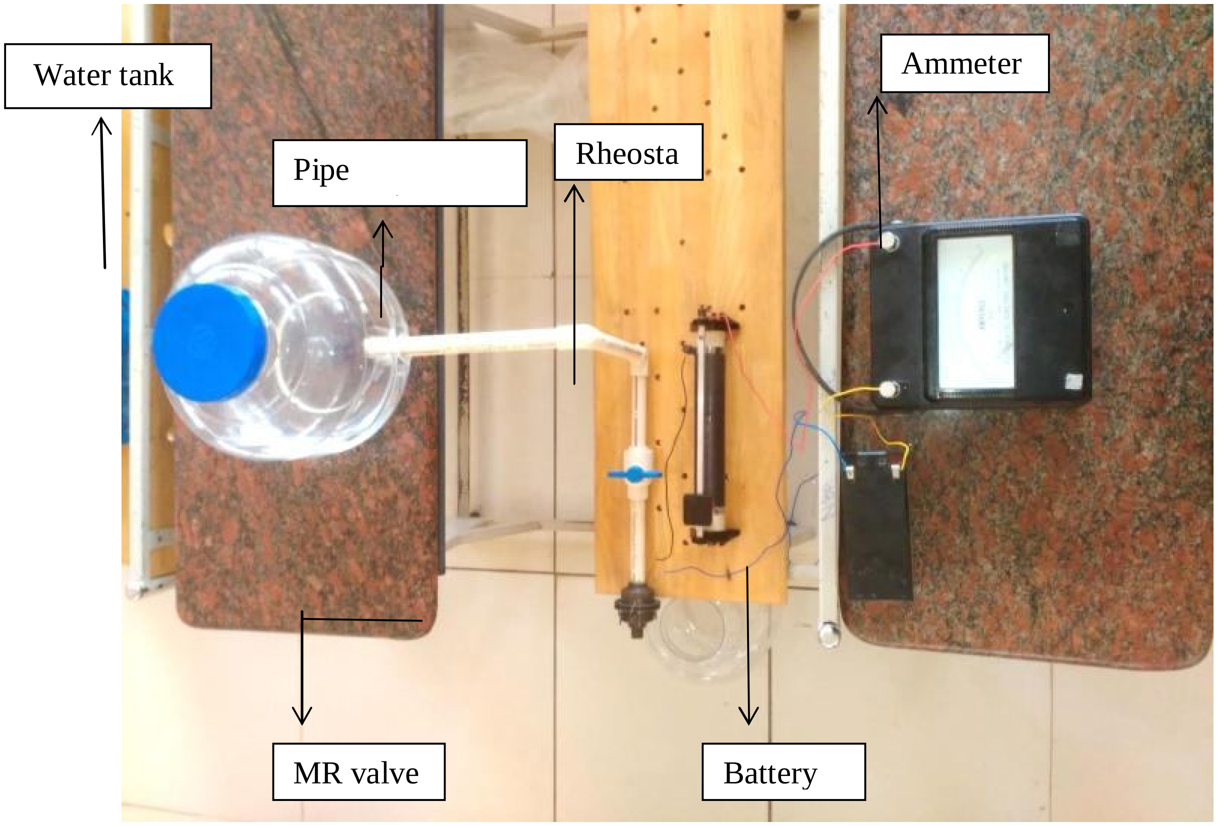


Fig. 7 Experimental set up of Magneto rheological valve.

B. Experimental Procedure

The steps followed for testing is detailed below,

1) The MR valve with pre- defined volume of MR fluid is taken and filled in the space between bobbin and core.
2) Electrical connections are made to connect battery(power house), Ammeter, Rheostat and Magneto-rheological valve.
3) The power supply from the battery is internally connected to the ammeter, rheostat and the Magneto-rheological valve.
4) The supply is switched ON and the current is varied through ammeter by using a rheostat.
5) Power supply to solenoid produces magnetic field in turn iron particles inside the MR fluid gets perfectly aligned in a straight line.
6) The perfectly aligned iron particles oppose the flow of water in the valve.
7) Now water is allowed to flow in the MR valve.
8) The flow of water is opposed by the MR fluid which is turned into solid when we supply the current.
9) The amount of flow rate is calculated with the help of stop watch.
10) Now by varying the power supply flow rate can be varied.
11) The above said procedural steps are repeated for various predefined combination of MR fluid.
12) The obtained flow rate values are analysed by means of tabulation and graph.

C. Sedimentation test of MR fluid

Sedimentation is a process by which the denser particles tend to settle down in the fluid in which they are present as a mixture and come down to rest as a result of gravity. The other reasons for sedimentation maybe centrifugal force or electromagnetic force, which can capture the particles away from the turbid fluid leaving the fluid to be supernatant. The rate of sedimentation is determined by neglecting the magnetic forces and the effect of magnetic field on the MR particles. The density difference between

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue VI, June 2018- Available at www.ijraset.com

the carrier oil and the iron particlescauses the sedimentation of the iron particles, these iron particles tend to settle down. By observing the ratio of change in the distance between the two layers with respect to time sedimentation ratio can be determined
In our experiment we have taken 3 samples of fluid for sedimentation test they are as follows

1) Sample 1-75µ (micron) Fe particle.
2) Sample 2-106µ (micron) Fe particle.
3) Sample 3-150µ (micron) Fe particle.

VI. RESULTS, CALCULATIONS AND ANALYSIS OF MR VALVE.

A. Sample MRF1

For 106µ Fe particle size
Composition

Table 2 For Size Of 106 Micron Of Mrf3 Fluid Sample

Sl.no.	Constituent	Weight in grams	Percentage in Weight
1	Fe particles of size 106µ	36	45%
2	Silicon oil	39	49%
3	Grease	5	6%

Sl No.	Voltage V	Current in amp	Water collected at outlet in ml	Time in sec	Actual Discharge Qact(ml/sec)	Velocity mm/sec
1	2	3	25	153	0.163	3.24
2	2	4	25	168	0.148	2.94
3	2	5	25	193	0.127	2.56
4	2	6	25	225	0.111	2.20

B. Sample MRF2

For 106µ Fe particle size
Composition

Table 3 For Size Of 106 Micron Of Mrf4 Fluid Sample

Sl.no.	Constituent	Weight in grams	Percentage in Weight
1	Fe particles of size 106µ	28	35%
2	Silicon oil	48	60%
3	Grease	4	5%

Sl No.	Voltage V	Current in amp	Water collected at outlet in ml	Time in sec	Actual Discharge Qact(ml/sec)	Velocity mm/sec
1	2	3	25	145	0.172	3.42
2	2	4	25	159	0.157	3.12
3	2	5	25	179	0.139	2.76
4	2	6	25	202	0.123	2.44

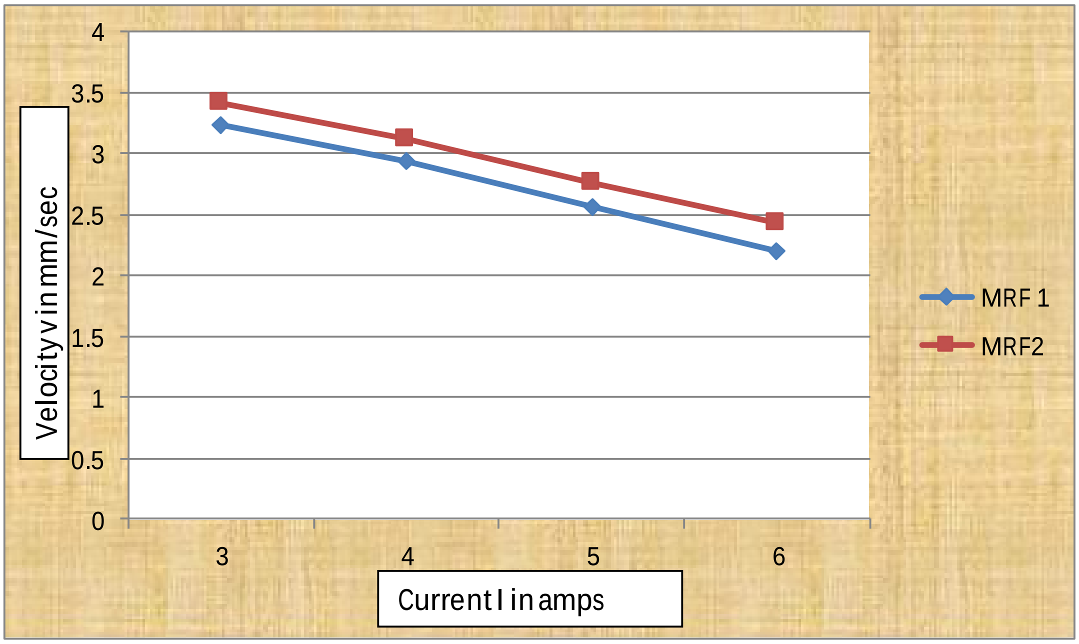


Fig 8 velocity of water v/s current, for mrf3 and mrf4

The relationship between the velocity of water and current is shown in the fig 8.3.1. Thus it is clear that as current supply increases the velocity of water decreases and it is minimum at the current of 6amps. Thus we can notice that the maximum velocity of water for 106microns is less than that of 75 microns.

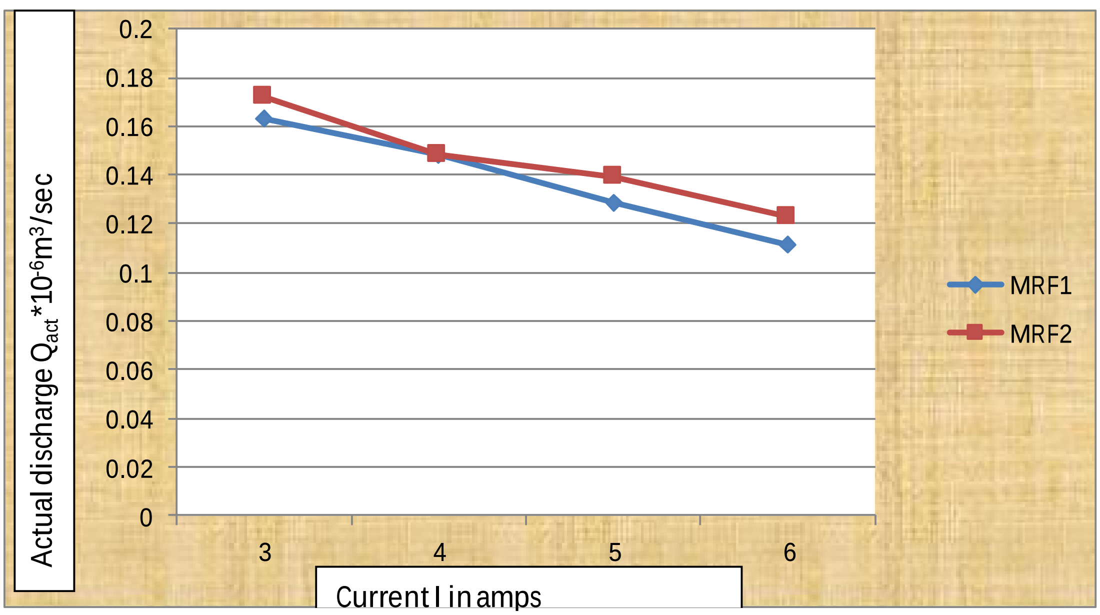


Fig 9 Actual discharge of water v/s Current, for MRF3 and MRF4

The relationship between the actual discharge of water and current is shown in the fig 8.4.1. Thus it is clear that as current supply increases the actual discharge of water decreases and it is minimum at the current of 6amps. Thus we can notice that the maximum discharge of water for 106microns is less than that of 75 microns.

C. Sample MRF3

For 150µ Fe particle size

Composition

TABLE 4 FOR SIZE OF 150 MICRON OF MRF5 FLUID SAMPLE

Sl.no.	Constituent	Weight in grams	Percentage in Weight
1	Fe particles of size 150µ	28	35%
2	Silicon oil	48	60%
3	Grease	4	5%

Sl No.	Voltage V	Current in amp	Water collected at outlet in ml	Time in sec	Actual Discharge Qact(ml/sec)	Velocity mm/sec
1	2	3	25	195	0.135	2.54
2	2	4	25	212	0.117	2.32
3	2	5	25	237	0.105	2.08
4	2	6	25	271	0.092	1.83

D. Sample MRF4

For 150µ Fe particle size

Composition

TABLE 5. FOR SIZE OF 150 MICRON OF MRF6 FLUID SAMPLE

Sl.no.	Constituent	Weight in grams	Percentage in Weight
1	Fe particles of size 150µ	36	45%
2	Silicon oil	39	49%
3	Grease	5	6%

Sl No.	Voltage V	Current in amp	Water collected at outlet in ml	Time in sec	Actual Discharge Qact(ml/sec)	Velocity mm/sec
1	2	3	25	216	0.115	2.28
2	2	4	25	228	0.109	2.16
3	2	5	25	252	0.094	1.96
4	2	6	25	294	0.085	1.70

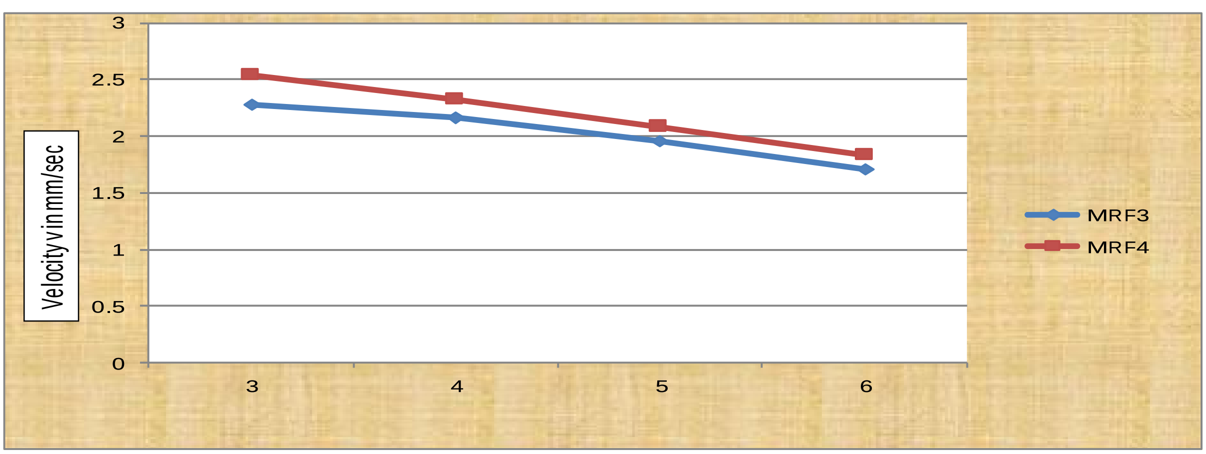


Fig 10 Velocity of water v/s Current, for MRF5 and MRF6

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue VI, June 2018- Available at www.ijraset.com

The relationship between the velocity of water and current is shown in the fig 8.5.1. Thus it is clear that as current supply increases the velocity of water decreases and it is minimum at the current of 6amps. We can note that the velocity of water for 150 microns is least when compared to the 106 and 75 microns.

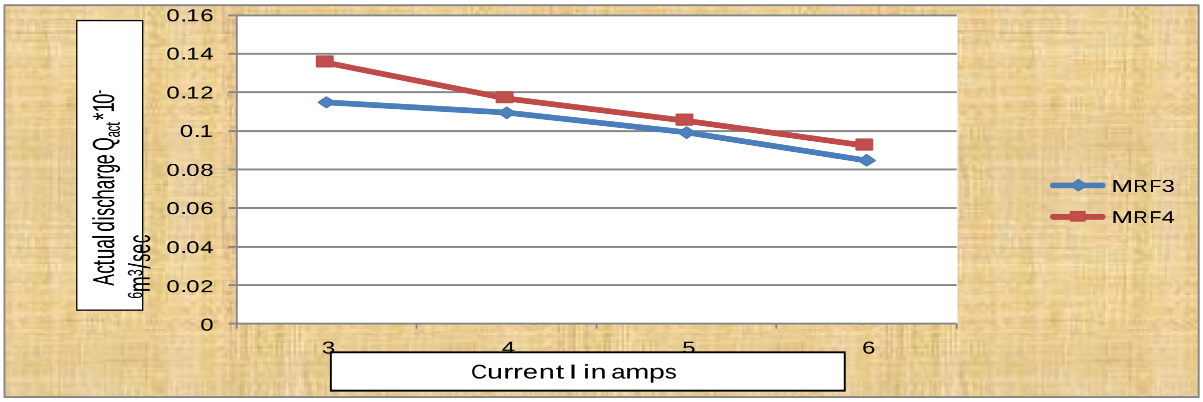


Fig 11 actual discharge of water v/s Current, for MRF5 and MRF6

The relationship between the actual discharge of water and current is shown in the fig 8.6.1. Thus it is clear that as current supply increases the actual discharge of water decreases and it is minimum at the current of 6amps. We can note that the actual discharge of water for 150 microns is least when compared to the 106 and 75 microns.

E. Calculations

1) Volume occupied by MR fluid in valve

$V = \frac{\pi}{4}(D_o^2 - D_i^2)*L$ ---------------------------- (1)

Where, $D_o =$ Outer diameter of core in mm = 20mm

D_i = Inner diameter of core in mm = 16mm

L = Inner Length of core in mm = 34mm

Volume occupied by MR fluid in valve = 3.845ml

2) Magnetic field strength (B)

$B = \frac{I*N}{L}$ ---------------------------- (2)

Whereas B = Magnetic field strength in A/m.

I = Current in Ampere.

n = Number of turns. i.e., n = 130.

L = Length of core in m. i.e. L = 0.02m

The following table shows the change in magnetic field strength for various values of power input.

Table 6: Magnetic Field Strength

Sl. no	Current (I) In ampere	No of turns (N)	Length (L) in m *10^-3	Magnetic field strength(B) in A/m
1.	3	130	56	4642.85
2.	4	130	56	9285.7
3.	5	130	56	11607.14
4.	6	130	56	13928.57

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue VI, June 2018- Available at www.ijraset.com

3) Velocity (v)

$$\mathbf{v} = \frac{\mathbf{Qact}}{\mathbf{A1}} \text{ ----------------------------- } (3)$$

Where, Qact = Actual discharge in m/sec

A1 = Area of the valve outlet

4) Qact= $\dfrac{\textit{water conducted at outlet}}{\textit{time}}$ ----------------------------- (4)

F. Analysis of Magneto Rheological Valve Components

Using ANSYS workbench the magnetic field analysis is carried out for Magneto rheological valve components.

1) Analysis of shield

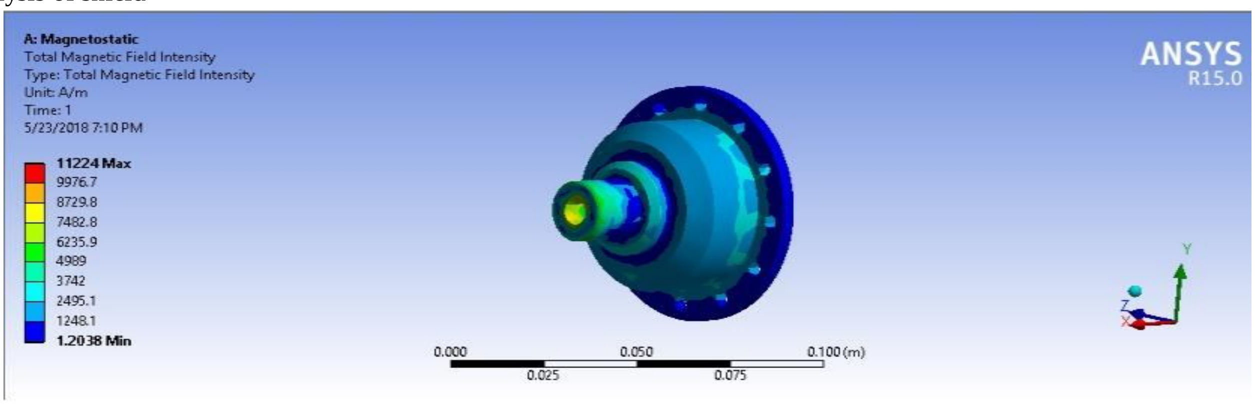


Fig 12: Shield Analysis

2) Boundary conditions

Current: 6 amps

Voltage: 2 volts

Number of turns: 130

Material Applied: Gray Cast Iron

Results:

Maximum magnetic field: 11224 A/m

3) Analysis of Bobbin

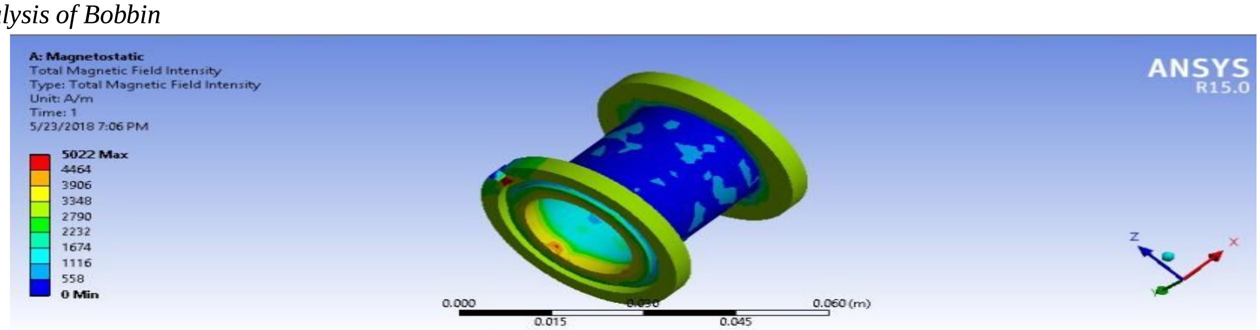


Fig 13: Bobbin Analysis

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue VI, June 2018- Available at www.ijraset.com

4) Boundary conditions

Current: 6 amps
Voltage: 2 volts
Number of turns: 130
Material Applied: Gray Cast Iron
Results:
Maximum magnetic field: 5022 A/m

5) Analysis of Core

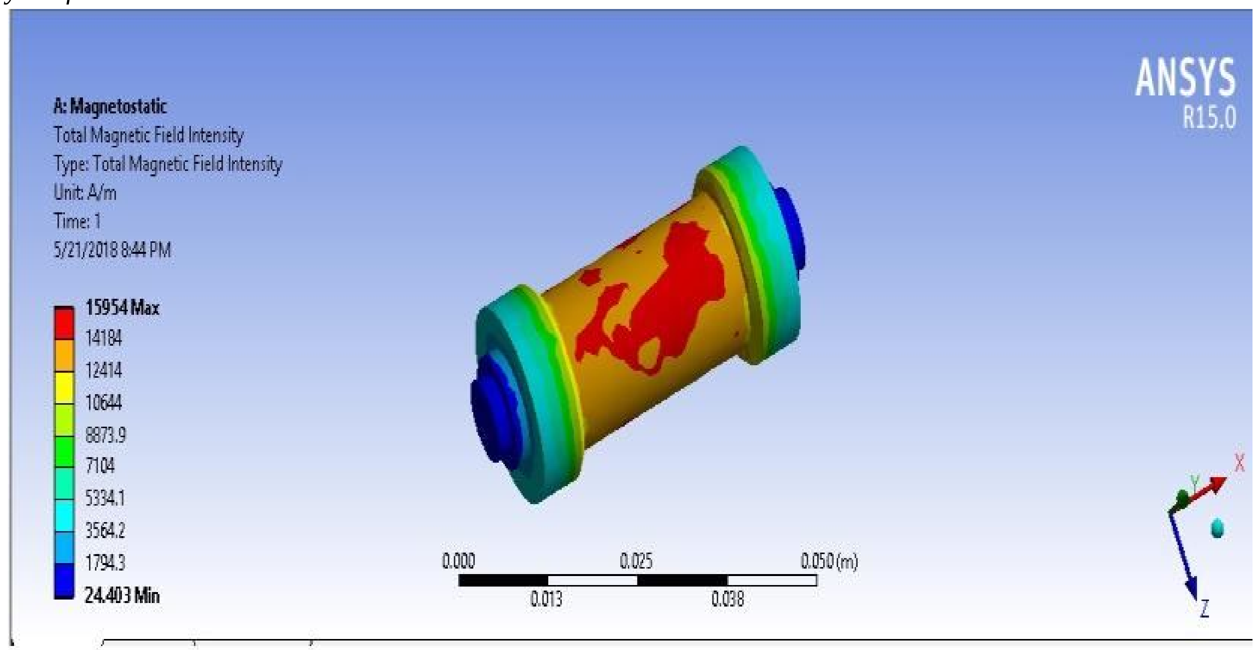


Fig 14: Core Analysis

Boundary conditions:
Current: 6 amps
Voltage: 2 volts
Number of turns: 130
Material Applied: Gray Cast Iron
Results:
Maximum magnetic field: 15954 A/m

VII. CONCLUSION

The MR valve and entire experimental setup is designed and fabricated according to pre-defined standards and specifications. In the present work 75, 106 and 150µ sized iron particle were chosen to prepare MR fluid of various composition. The prepared MR fluid with predefined proportionate constituents will be filled in the MR valve for testing and to study the effect of flow rate of water. From the experimental test, it is observed that the MR valve with the MR fluid prepared of 150µ iron particle size gives minimum flow rate, i.e. it gives less flow rate compared to other MR fluids (75µ, 106 and 150µ) prepared. Another concluding remark is magnetic field strength & magnetic flux in MR valve is directly proportional to current through the solenoid .Here the effort is made to study the effect of MR valve replacing conventional valve settings for various magnitude of current.

VIII. ACKNOWLEDGEMENT

This project and research would not have been possible without the valuable guidance of Mr. Vinay V.N , Assistant Professor, KLE Institute of Technology, Hubballi, Karnataka. We would also like to thank Dr. Sharanabasappa C Sajjan, Head of Department, Mechanical Engineering, KLE Institute of Technology, Hubballi, for providing us with a conducive atmosphere and the much-needed encouragement to work on this project.

REFERENCES

[1] Ashwani kumar,bharati.,smart fluids: properties and application in vibration control systems, assistant professor ,mechanical engineering department chandigarh college of engineering and technology(degree wing),sector-26,chandigrah India, assistant professor Applied science department, chandigrah university, gharuan Punjab ,India

[2] A. Grunwald and A. G. Olabi , Design of magneto-rheological (MR) valve ,Dublin City University, School of Mechanical and Manufacturing Engineering, Glasnevin, Dublin 9, Ireland

[3] Grivon Daniel, Civet Yoan, Pataky Zoltan and Perriard Yves, Design and Comparison of different Magneto-Rheological valves configurations, IEEE International Conference on Advanced Intelligent Mechatronics (AIM) July 7-11,Busan, Korea .

[4] W. H. Li, H. Du and N. Q. Guo, Finite Element Analysis and Simulation Evaluation of a Magnetorheological Valve Centre for Mechanics of Micro-Systems, School of Mechanical & Production Engineering, Nanyang Technological University, Nanyang Avenue, Singapore.

[5] Hardeep Singh, Harjot Singh Gill and S. S. Sehgal Synthesis and Sedimentation Analysis of Magneto Rheological Fluids Mechanical Department, Chandigarh University, Gharuan, Mohali - 140413, Punjab, India. Indian Journal of Science and Technology, 2 December 2016

[6] H. X. A. D. H. WANG AND W. H. LIAO Design and Modeling of a Magnetorheological Valve with Both Annular and Radial Flow Paths Smart Materials and Structures Laboratory, Department of Automation and Computer-Aided Engineering. The Chinese University of Hong Kong, Shatin, N.T., Hong Kong, China. Key Laboratory of Optoelectronic Technology and Systems of the Ministry of Education of China, Chongqing University, Chongqing, China 400044