

Design of MR Brake and Testing Viscosity Variation of MR Fluid in Magnetic Field

Onkar Jadhav¹, Dnyaneshwar Sonawane², Shubhangi Tambore³, Nikhil Chougule⁴

U.G. Student, Department of Mechanical Engineering, SAE College, Kondhawa, Pune, Maharashtra, India¹

U.G. Student, Department of Mechanical Engineering, SAE College, Kondhawa, Pune, Maharashtra, India²

U.G. Student, Department of Mechanical Engineering, SAE College, Kondhawa, Pune, Maharashtra, India³

U.G. Student, Department of Mechanical Engineering, SAE College, Kondhawa, Pune, Maharashtra, India⁴

ABSTRACT:In this research an automatic Magneto rheological (MR) brake is fabricated tested and also MR fluid is prepared. The proposed brake consists of single rotating disk immersed in a MR fluid and enclosed electromagnet. The purpose of this paper was to determine the variation of viscosity of a MR fluid for different values of the magnetic field. When magnetic field is applied to the MR Brake, the MR fluid solidifies as its viscosity varies as a function of the magnetic field applied. This controllable viscosity produces shear friction on the rotating disk generating braking torque. A prototype MR brake is then built and then tested and the experimental results are obtained.

KEYWORDS:Electromagnet, Magneto Rheological fluid, MR Brake, Magnetic field, viscosity.

I. INTRODUCTION

Magneto-rheological fluids (MRF) are suspensions of particles which can be magnetized, and exhibit fast, strong, and reversible changes in their rheological properties when a magnetic field is applied. Therefore, MR fluids hold great potential in many applications that require an electromechanical interface, such as clutches brakes, valves, dampers and robotics.

Various industries including the automotive industry are full of potential MRF applications. Magneto-rheological fluid technology has been successfully employed already in various low and high volume applications. A structure based on MRF might be the next generation in design for products where power density, accuracy and dynamic performance are the key features. Additionally, for products where there is a need to control fluid motion by varying the viscosity, a structure based on MRF might be an improvement in functionality and costs. Two aspects of this technology, direct shear mode (used in brakes and clutches) and valve mode (used in dampers) have been studied thoroughly and several applications are already present in the market. Excellent features like fast response, simple interface between electrical power input and mechanical power output, and precise controllability make MRF technology attractive for many applications.

MR fluid having constituents like Liquid carrier, that contains Mineral oil, synthetic hydrocarbon oil, silicone oil, water, glycols, etc. Magnetic particle contains Carbonyl iron, iron/cobalt alloys; nickel alloys 20-40% by volume. Its typical size is 1-10 micron [5]. And other additives like Suspending agents, thixotropes, anti-wear and anti-corrosion additives, friction modifiers.

Initially MR fluid devices were used for Hydraulic control applications. Then it introduced for Servo valves applications. Nowadays it is used commercially for damper and shock absorbers applications. It is also used as actuators in some application. Furthermore some researches show that it is also beneficial for clutches and brakes.

II. DESIGN OF MR BRAKE**A. Design of Parts:**

Detailed modeling of each component is as follows:

2.1 Casing: It's an inclosing shell which is used to protect the inner components like core, disc etc. It protects parts of MR brake from dust and foreign particles. To draw the casing part design was selected to draw the sketch by using the line command. After that the shaft command is used in vertical direction to complete the 3-D drawing of the casing & the casing is as shown in fig – 2.2

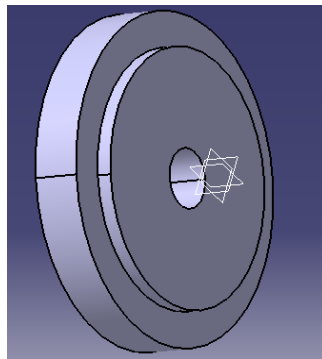


Fig - 2.2: 3-D view of casing

2.2 Shaft: Shaft is a mechanical component for transmitting torque and rotation, usually used to connect other components of a drive train that cannot be connected directly because of distance or the need to allow for relative movement between them. To draw the shaft we had drawn circle then pad it by 139mm after that I had drawn the another circle as shown in fig- 5.4.

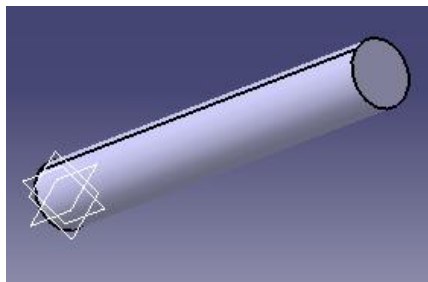


Fig-2.4: 3-D view of shaft

2.3 Disc: The brake disc is made up of cast iron. This is connected to the axel or the shaft. To retard the wheel, friction material in the form of brake pads, mounted on a device called a brake caliper, is forced electromagnetically against both sides of the disc. Friction causes the disc and attached wheel to slow or stop. For drawing the disc first we had drawn the sketch and pad it. The 3-D view of the disc is as shown in the fig - 2.5.

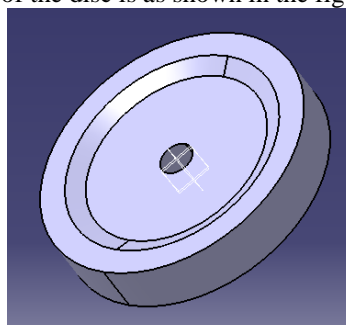


Fig – 2.6: 3-D view of disc

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 10, October 2015

5.2.6 Core:For drawing the core first we had drawn the cross-section of the core as per the dimensions as shown in the fig – 5.13. And then to generate the 3-D view of the core I had used the shaft command in Vertical direction & then the 3-D view of the core was generated & as shown in fig– 5.14.

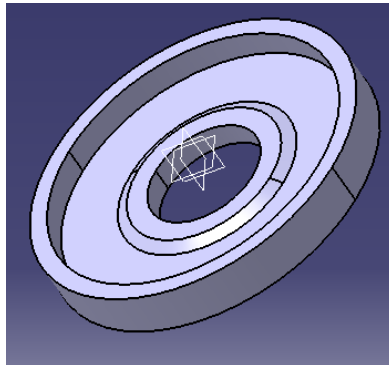


Fig – 5.14: 3-D view of core

B. Assembly of MR Brake:

To draw the assembly of the MR brake we had used the following procedure:

1. To draw the assembly drawing we had selected the Assembly Design workbench after opening the CATIA software.
2. Then we had selected the existing component command then clicking the product shaft part is obtained.
3. Then for reference we had fix it by using fix component command.
4. Then had called the other component i.e. the disc & by giving the coincidence constraint command by selecting the axis of both shaft & disc we had coincide the shaft & disc.
5. After that we had called the casing &by using coincidence constraint & contact constraint we had joined it in the both sides of the discs.
6. Then we had called for the core & by using the coincidence constraint & contact constraint we had fixed the core on casing.

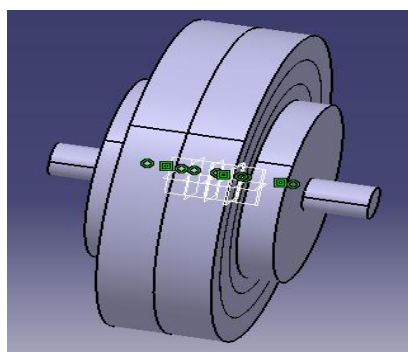


Fig. 5 Assembly of MR brake

III. METHODOLOGY AND WORKING

Working:

1. Operation of MR brake is based on the MR effect which changes the viscosity of working fluid and by creating magnetic field it tends to behave as a solid.
2. Coils are present in the gap which creates magnetic field in it. Coil is supplied with the 12VDC power supply; value of the current is set between 0-3A. Magnetic field strength and the viscosity are mainly depending on the current in the coil.
3. Viscosity of the fluid changes which makes it solid and influences torque and braking action takes place in rotor.

4. When the current in the coil is equal to zero there is no magnetic field and brake has torque equal to minimum M_{min} . M_{min} is equal to the torque caused by bearings, seal and viscosity of carrier liquid.
5. When current $I= 3$ Amp the magnetic field in the coil is not equal to zero($H \neq 0$) then the brake has highest possible value of torque M_{max} , that is depend on the maximum current in the coil and construction of the brake.
6. Voltage- to- current transducer is used to control the brake. With the help of this transducer it is able to control the voltage signal (0-5) V to current signal (0-3) Amp that is needed to supply coil.
7. The test set up is as shown in fig. 6.

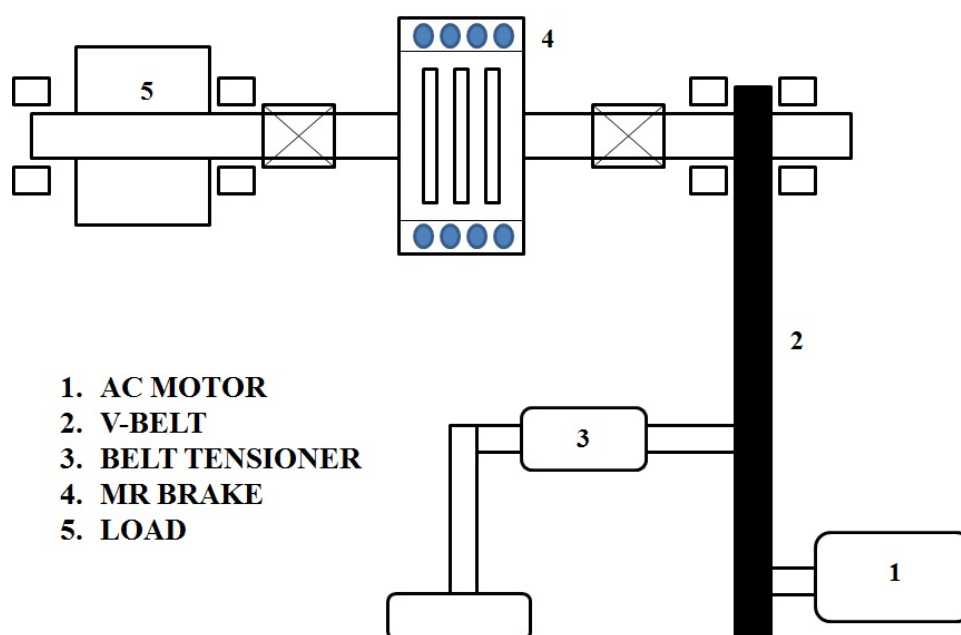


Fig. 6 Test setup for testing magneto rheological brake.

IV. EXPERIMENTAL RESULT

The results obtained were plotted and a dependence of MR fluid viscosity from magnetic induction was found.

Three different regions may be recognised in the plot. In the first region as a magnetic induction increases the viscosity of the MR fluid slightly decreases. In the second region, the increase in the viscosity is directly proportional to changes in the magnetic induction. This is the most working relation that could be easily applied to the active control of the fluid properties. In the third region, a considerable increase in the viscosity was observed. In this region a partial clogging of flow is observed.

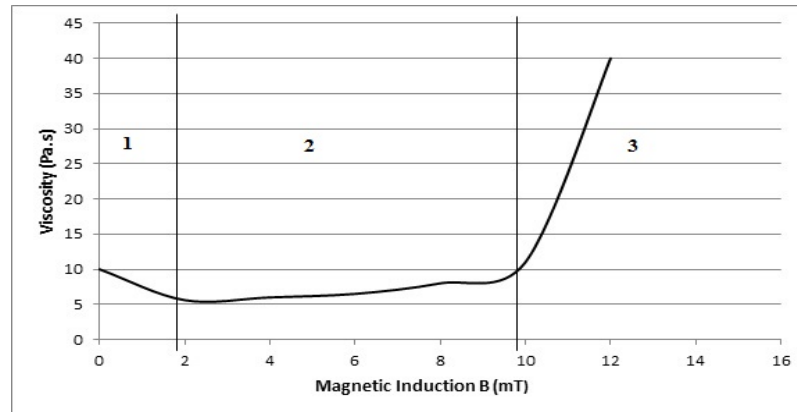


Fig. 7 Plot of dependence of MR fluid viscosity from magnetic induction

V. CONCLUSION

In this work, a magneto rheological brake is introduced as possible substitute for the conventional hydraulic brake. Since Magneto rheological brake is an electromechanical device, it has several advantages over Conventional hydraulic brake, such as actuation delay, ease of software control implementation and lower system weight.

The aim of this research was to determine the viscosity of a MR fluid at different values of the magnetic field. The objective of the research was to determine the range of viscosity variations that is useful for control purposes. A practical result was the finding of the value of current that locks the flow for different parameters of the coil. This current lies in a range from 1.5 to 3A.

REFERENCES

- [1] "A performance evaluation of an automotive magneto rheological brake design with a sliding mode controller", Park E.J., DilianStoickov, Luis Falcao da Luz, Afzal Suleman, Dep of MECH University of Victoria, 3800 Finarty Road, 2006.
- [2] "Multidisciplinary design optimization of an automotive magnetorheological brake design", Park E.J. Park, Luis Falcao da Luz, Afzal Suleman; Dep of MECH University of Victoria, Canada;2007.
- [3] "Design of a Magnetorheological Brake System Based On Magnetic Circuit Optimization", KeremKarkoc; BSc-Bogazici University, TURKEY, 2005.
- [4] "Design and Experimental Evaluation of a Magneto-rheological Brake", W.H.Li and H.Du.
- [5] "Smart Materials: Magneto Rheological Fluid", Mr. Vinayak D Dabade, Prof. Y.R Patil, Prof. M. V.Kharade, Prof.P.F.Patil,, Machine Design, Dr. J JMagdum College of Engineering Jysingpur, India.
- [6] "Lord Corporation ,Magnetorheological (MR) Solution", Cary, Nc,2007. Available:http://www.lord.com
- [7] "Road Accident in India", Government of India Ministry of Transport and Highways Transport wing New Delhi; 2011.
- [8] "Kordonski W., January 1993, Elements and Devices Based on Magnetorheological Effect", journal of intelligent system and structures,4,65-69.
- [9] "Construction and Operation ofMagnetorheological Rotary Brake" by SlawomirBydol, Archiwum process control club 2002, poz.20.
- [10] "synthesis and magneto mechanical properties of MR grease" published in ijert by M. Hari Prasad.