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PREPARATION OF MAGNETO-RHEOLOGICAL FLUID

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Abstract: Magneto-Rheological Fluid (MRF) technology is an old " newcomer" coming to the market at high speed. 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 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 on 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. This paper presents the state of the art of a valve with a control arrangement based on MRF technology. The study shows that excellent features like fast response, MR valve controls the leakage, and MR valve design is very simple and compact

***Index Terms* – Rheological, magnetic field, flux density**

I. Introduction

A magneto rheological fluid (MR fluid) is a type of smart fluid in a carrier fluid, usually a type of oil. When subjected to a magnetic field, the fluid greatly increases its apparent viscosity, to the point of becoming a viscoelastic solid. Importantly, the yield stress of the fluid when in its active ("on") state can be controlled very accurately by varying the magnetic field intensity. The upshot of which is that the fluid's ability to transmit force can be controlled with an electromagnet, which gives rise to its many possible control-based applications.

MR fluid is different from a ferrofluid which has smaller particles. MR fluid particles are primarily on the micrometer-scale and are too dense for Brownian motion to keep them suspended (in the lower density carrier fluid). Ferro fluid particles are primarily nano particles that are suspended by Brownian motion and generally will not settle under normal conditions. As a result, these two fluids have very different application.

1.1How It Works

The magnetic particles, which are typically micrometer or nanometer scale spheres or ellipsoids, are suspended within the carrier oil are distributed randomly and in suspension under normal circumstances, as below.

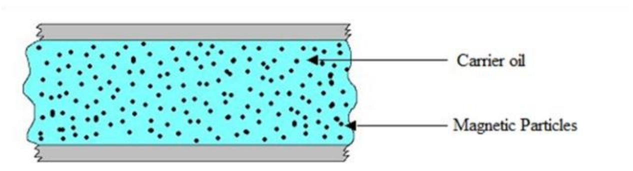


Fig 1.1 MR-Fluid (before magnetization)

When a magnetified applied, however, themicroscopicparticles (usuallyinthe0.1– 10 µm range) align themselves along the lines of magnetic flux, see below. When the fluid is contained between two poles (typically of separation 0.5– 2 mm in the majority of devices), the resulting chains of particles restrict the movement of the fluid, perpendicular to the direction of flux, effectively increasing its viscosity.

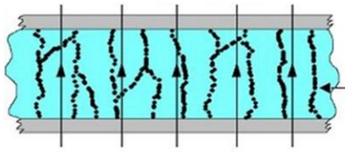


Fig1.2 MR-Fluid (after magnetization)

1.2 Modes of Operation and Applications

An MR fluid is works in one of three main modes of operation, these being flow mode, shear mode and squeeze-flow mode. These modes involve, respectively, fluid flowing because of pressure gradient between two stationary plates; fluid between two plates moving relative to one another; and fluid between two plates moving in the direction perpendicular to their planes. In all cases the magnetic field is perpendicular to the planes of the plates, to restrict fluid in the direction parallel to the plates. The applications of these various models are numerous. Diagram of each valve are mention below. And, the flow which acting the direction also show in the diagram. Movement of plates is also mention in the diagram. In the flow mode two plates are fixed, shear mode and the squeeze mode are move related to other plate.

1.2.1 Difference between MRF and ERF

Ever since some industrial issues were solved, both the technical and the commercial benefits for various MRF applications have become very promising. As a result, MRF development is ongoing continuously. Approximately sixty years ago, in the 1940s, Jacob Rabinov discovered the MRF effect at the US National bureau of Standards. At the same time W. Winslow was working on a competitive technology called Electro Rheological Fluid (ERF). Since the time when both technologies were discovered in the 1940s, more research work has been carried out on ERF than on MRF. There are some similarities between the two different technologies regarding the required power, but in the case of ERF, thousands of volts and some mile-amperes are required, and in the case of MRF, normally between 2 and 24 volts and some amperes are required. The electro-rheological (ER) effect depends on an electrostatic field and the magneto rheological (MR) effect depends on a magnetic field. MRF products have between 20- and 50-times higher control effect than the equivalent ERF products. Also, with MRF technology today there is better stability about contaminants. All these MRF technology advantages have created a very high level of interest to introduce products based on MRF technology during the most recent couple of years.

Table .1 Gives an Overview of The ER And MR Key Features.

Representative Feature	MRF	ERF
Max. Yield Stress	50-100kPa	2-5kPa
Power Supply	2-24V @ 1-2 A	2-5kV @ 1-10 mA
Response time	some millisecond	some millisecond
Operational Field	~250 kA/m	~4kV/mm
Energy density	$0.1 J/cm^3$	$0.001 J/cm^3$

Over approximately the most recent five years more MRF publications than ERF Publications have been presented in the public domain. At the beginning of the development work on MRF, non-predictable behavior, such as in-use thickening, sedimentation and abrasion were described. This created some challenges for the industrialization of the first application based on MRF, especially for an automotive application. During the most recent few years the stability, sedimentation, and abrasive

Behaviors has been studies in several universities and companies in the USA (Lord Inc.), in Europe (DEA, BASF, Bayer) and in Japan (Bridgestone Inc., Sigma Inc.) Recently MRF applications such as dampers, clutches, active bearings have already come to the market or are close to the start of serial production.

1.2.2Base fluids

The Base fluid has the function of the carrier and naturally combines lubrication (in combination with additives) and damping features. For the highest MRF effect the viscosity of the fluid should be small and almost independent of temperature. In this way the MRF effect will be the dominant effect when it is compared with the natural physical viscosity varying with temperature and shear stress. Basically, in the off-state (without any magnetic effects) MR fluids behave like the base fluid in accordance with their chemical compositions. There are different types of liquid which can be used as the carrier fluid i.e. hydrocarbon oils, mineral oils or silicon oils. As with any type of particle suspended in a fluid, the base fluid will have a higher viscosity when the concentration of metal particles is very high. The fluid will appear to be "thicker." So even in the off-state, the fluid with the powder will have an increased viscosity.

1.3.3 Metal particles

In the on-state (with a magnetic field in place) the Metal particles are guided by the magnetic field to form a chain-like structure. This chain-like structure restricts the motion of the fluid and therefore changes the rheological behavior of the fluid. The MR-effect is produced because of this resistance to flow caused by the chain-like structure. The metal particles are usually made of carbonyl iron, or powder iron, or iron/ cobalt alloys to achieve a high magnetic saturation. The amount of metal powder in MRF can be up to 50% by volume. The particle size is in the μ− meter range and varies depending on the manufacturing processes. The particle size can be chosen to achieve various purposes. In the case of carbonyl iron, the particle size ranges between 1-10 μ−

meter. Larger particles and higher fractions of powder in the MR fluid will provide higher torque in the on-state, but at the same time the viscosity of the MR fluid in the off-state will also be higher under these conditions. The material specification, especially the permeability is also a very important factor for controlling the MR-effect.

2.IRON-OXIDE

The classical way of preparing ceramic oxide compounds (ferrites) in which the oxides (or) carbonates of semiconductor components are mixed and annealed at high temperature (>1200deg c) has some inherent disadvantages such as production of chemically in homogeneous coarse powders because of high sintering temperature. To avoid such events, various chemistry based synthetic methods have been adopted namely sol-get techniques, co-precipitation method, hydrothermal synthesis, micro emulsion synthesis etc., to obtain ceramic products with superior microstructure.

So, sol-get combustion technology is applied to prepare homogeneous and sub- micron sized powder of oxide compounds. Reason for the combustion of sol-gel technique and self-combustion has been to use the heat generated by an exothermic combustion reaction to supply the high temperature needed for sintering the metal oxides, thus allowing a low-cost preparation method. The main feature of SGS method is the intimate mixing of constituent ions, so that nucleation and crystallization can occur at relatively low temperature.

2.1 PROCEDURE FOR MAKING IRON-OXIDE

1. Iron nitrate (4.04g) and citric acid (4.2g) were dissolved in distilled water (50 ml) and stirred vigorously.
2. During stirring, ammonia solution is added drop wise and PH of the solution is raised to about 10.
3. The obtained sol was heated at 80deg c in a hotplate, with continuous stirring.
4. After a period, self-combustion takes place.
5. The ash formed is collected and calcinated in furnace at 700deg c-800deg c for a period of 2hrs

2.2 SCANNING ELECTRON MICROSCOPE TEXT RESULT

In this SEM image is taken for iron-oxide that show the text result for 50 micro meters and 20 micro meters.

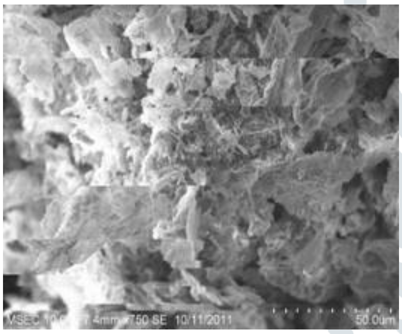


Fig 1.3 Text result for 50 micro meters

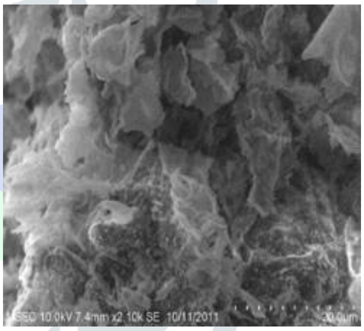


Fig1.4 Text result for 20 micro meters

3.FERRO FLUIDS

Ferro fluids are colloidal suspension of magnetic nano particles. Ferro fluids respond to external magnetic field enabling the solution location to be controlled through the application of magnetic field. fe3o4 (magnetite) nano particles can be prepared by mixing fe (II) and fe (III) salts together in a basic solution. the practical must remain small and separated from one another to remain suspended in the liquid medium. Surfactants are user to prevent the nanoparticles form approaching and another too closely. Once prepared, ferrofluid have the captivating property of exhibiting spikes when placed in the proximity of a strong magnet.

3.1PROCEDURE FOR MAKING FERRO FLUID

Add 4ml of 1m ferric chloride and 1mlof 2m ferrous chlorides to a100ml beaker. Add a magnetic stirring bar and begin stirring. Continue the stirring throughout the slow addition of 50ml of1m aqueous ammonia solution for over a period of 5 minutes. After, an initial brown precipitation, a black precipitate will be formed (magnetite). Turn off the stirrer and immediately used a strong magnet to remove the stirring bar, outside the beaker. Allow sometime to settle the magnetic particle, then decant (pour-off) and discard the clear liquid without losing a substantial amount of solid. You can speed the setting process by pulling a magnet under the container.

Transfer the solid to a Petridis with the aid of few

amounts of water from squeezer. Use a strong magnet to attract the ferrofluid to the bottom of Petridis. Discard as much amount of clear liquid as possible. Rinse again with water from a wash bottle and discard the rinse as before. Repeat the rinsing three times. Discard any track amount of liquid, move the strong magnet around the fluids, it will look like a spike.

3.2 BALANCING EQUATION

$2FeCl_3 + FeCl_2 + 8NH_3 + 4H_2O \rightarrow Fe_3O_4 + 8NH_4Cl$

$FeCl_3$- Ferric chloride Fe_3O_4- Iron powder

$FeCl_2$- Ferrous chlorides NH_4Cl- ammonia chloride NH_3- ammonia solution

H_2O- Concentrated hydrochloric acid

4. VICOSITY TEST- HALL EFFECT APPARATUS

The viscosity of the various types of fluids is found in Hall Effect apparatus. By varying the magnetic field, the variation of viscosity of the fluid is noted. The Ostwald viscometer is placed in-between the two magnets, which produce the require magnetic field. The electric current and the magnetic field is varied and the viscosities are found out. The distance between the magnets can be varied according to the requirement.

Table no: 2 Hall Effect test for MR fluid

SL NO.	COMPOSITION	MAGNETIC FIELD	CURRENT (amps)	TIME (sec)	VISCOSITY (centistokes)
1	50ml silicon oil +0.1g iron powder	500	1.03	836	213.04
2		1000	1.76	852	217.49
3		1500	2.62	896	228.72
4		2000	3.87	921	251.97

Table no: 3 Hall Effect test for Ferro oxide

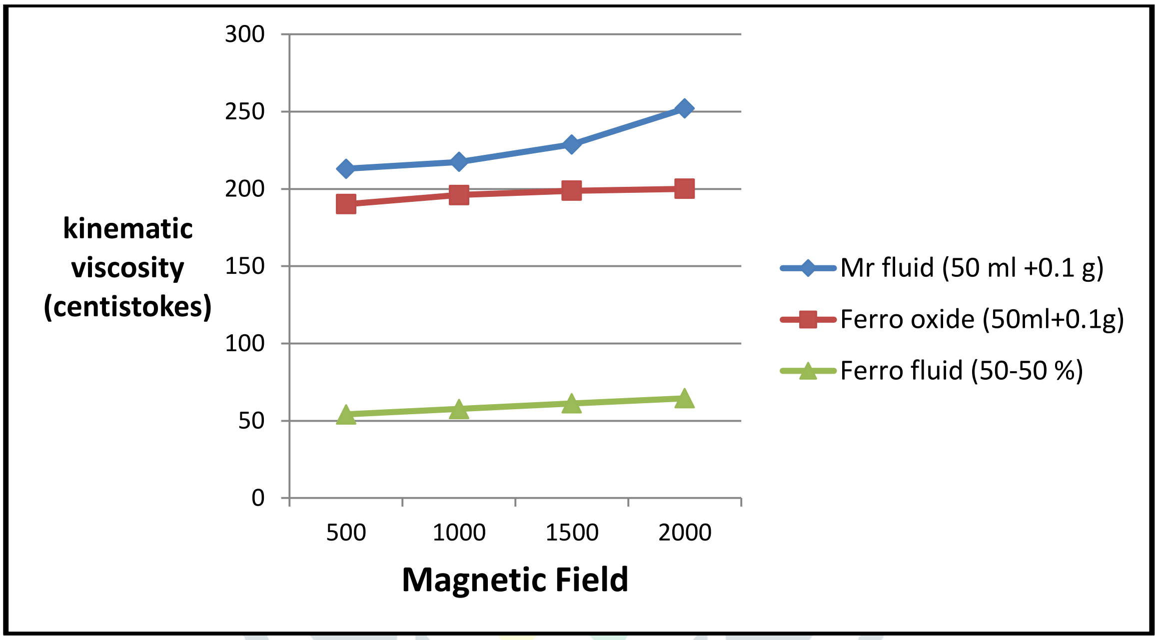
SL NO.	COMPOSITION	MAGNETIC FIELD	CURRENT (Amps)	TIME (sec)	VISCOSITY (centistokes)
1	50ml silicon oil + 0 1g Ferro oxide	500	1.03	745	190.17
2		1000	1.76	768	196.04
3		1500	2.62	779	198.85
4		2000	3.87	784	200.13

According to the above tables (table no.4 &5), the viscosities of the prepared fluids have been found to be increasing in the presence of the magnetic field.

Table no: 4 Hall Effect test for Ferro fluid

SL NO.	COMPOSITION	MAGNETIC FIELD	CURRENT (amps)	TIME (sec)	VISCOSITY (centistokes)
1	Silicon oil + Ferro fluid (50-50%)	500	1.03	212	54.11
2		1000	1.76	226	57.69
3		1500	2.62	240	61.26
4		2000	3.87	253	64.58

FIG 4.1 MAGNETIC FIELD VS VISCOSITY OF THE FLUID



4.1 INFERENCE:

The above graph (Fig.27) shows that in the presence of magnetic field the viscosity of the fluid increases. Also, by increasing the field the viscosity increases continuously.

5.CONCLUSION

In my project MR Fluids was prepared. To prepare that the following materials are required, they are Ferro fluids, Ferro oxide, and iron power. By mixing each of them with silicon oil and some additives we got MR fluids. With the help of SEM instrument the particle size is analyzed for Ferro oxide. Remaining work of my project is to design MR valve and analyze the magnetic coil by using FEMM V4 software. Finally, we correlate the experimental result with numerical result.

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