Journal of Basic and Applied Engineering Research
Print ISSN: 2350-0077; Online ISSN: 2350-0255; Volume 1, Number 2; October, 2014 pp. 1-5

http://www.krishisanskriti.org/jbaer.html

Design and Development of Special Purpose Modified Viscometer for Measuring Viscosity of Ferro Fluid

Abdul Wahab Hashmi[1], Satish B. Purohit[2], Neha Solanki[3]

[1,2,3]*Mechanical Engineering Department, SGS Institute of Technology and Science, Indore-452002, India*

Abstract: **This paper focuses on the development of a special purpose viscometer for measuring viscosity of Ferro fluid. There are a large number of techniques available to synthesize different types of nanomaterial. The effect of external magnetic field on the property of Ferro fluid, like viscosity cannot be measured by conventional method. To measure the viscosity of Ferro fluid in static condition designer modified the existing redwood viscometer .As viscosity gets affected by the change in magnetic field around it, there should be some special arrangement to vary the magnetic field. Therefore modification is done on the conventional redwood viscometer. The modified viscometer to compare the viscosity of the Ferro fluid. One can get the desired viscosity of the Ferro fluid after setting the magnetic field.**

Keywords: **Ferro fluid; viscosity; magnetic field; smart fluid.**

The objective of this paper was to determine the viscosity of a Ferro fluid at different values of the magnetic field and to Existing Redwood viscometer is modified by designer for measuring viscosity of Ferro fluid. Experiment carried out in three trials 1.Without magnetic field 2.With magnetic field 3.With permanent magnetic strip.

1. INTRODUCTION

The objective of this paper was to determine the viscosity of a Ferro fluid at different values of the magnetic field and to Existing Redwood viscometer is modified by designer for measuring viscosity of Ferro fluid. Experiment carried out in three trials 1.Without magnetic field 2.With magnetic field 3.With permanent magnetic strip.

A magnetic colloid, also known as a Ferro fluid (FF), is a colloidal suspension of single-domain magnetic particles, with typical dimensions of about 10 nm, dispersed in a liquid carrier [1–3]. The liquid carrier can be polar or non polar. Since the nineteen sixties, when these materials were initially synthesized, their technological applications did not stop to increase. Ferro fluids are different from the usual magnetorheological fluids (MRF) used for dampers, brakes and clutches, formed by micron sized particles dispersed in oil. In MRF the application of a magnetic field causes an enormous increase of the viscosity, so that, for strong enough fields, they may behave like a solid. On the other hand, a FF keeps its fluidity even if subjected to strong magnetic fields (» 10 kg). Ferro fluids are optically isotropic but, in the presence of an external magnetic field, exhibit induced birefringence [4]. Wetting of particular substrates can also induce birefringence in thin FF layers [5]. In order to avoid agglomeration, the magnetic particles have to be coated with a shell of an appropriate material. According to the coating, the FF's are classified into two main groups: surfacted (SFF), if the coating is a surfactant molecule, and ionic (IFF), if it is an electric shell.

There are essentially two methods to prepare these nano particles, by size reduction [1] and chemical precipitation [6]. In size reduction, magnetic powder of micron size is mixed with a solvent and a dispersant in a ball mill in order to grind for a period of several weeks. Chemical precipitation is probably the most used method to prepare magnetic nano particles nowadays. Different procedures have been developed to achieve this goal. In general, these procedures start with a mixture of FeCl2 and FeCl3 and water. Co-precipitation occurs with the addition of ammonium hydroxide, and then the system is subjected to different procedures to peptization, magnetic separation, filtration and finally dilution.

The objective of this research paper is to develop such viscometer to measured viscosity of Ferro fluid. We have developed a modified viscometer for measuring viscosity of Ferro fluid. We have done a modification in existing redwood viscometer in three trials. First we have measured viscosity without magnetic field. In second and third trial we have measured viscosity with magnetic field then the modified viscometer is calibrated with conventional viscometer to compare the viscosity of the Ferro fluid. One can get the desired viscosity of the Ferro fluid after setting the magnetic field.

The damping coefficient of Ferro fluid is capable to the standards selected when the Ferro fluid is subjected to the magnetic field then the damping coefficient value changes considerably. It is thus possible to get the instant change in the viscosity and therefore the instant change in the viscosity and therefore the instant change in the damping characteristics of the viscous fluid. The Ferro fluid is therefore very useful in the applications of vehicle or industrial equipments. Shock absorber with the use of Ferro fluid the characteristics changes then passive to semi active

2. PREPARATION OF FERRO FLUID"

2.1 Preparation of Ferro fluid

There are several methods of synthesis of magnetite nano particles. After some initial trials, Ferro fluid is prepared using this methods: To get iron oxide particles of mostly nano spheres, the chemicals used are: Sodium hydroxide (NaOH), Iron chloride (FeCl3), Sodium hexametaphosphate (NaH2PO4), Double distilled water. Synthesis procedure is: Prepare 0.5 M NaOH solution in distilled water, Add 0.01 M solution of Fe (NO3)3, Stir till pH becomes 10.7, Wash the precipitate with distilled water several times till pH becomes ~8.7, Add 1 M HCl, Stir, Add 0.1 M solution of NaH2PO4, Stir, Add water and heat the solution to ~100 deg. Celcius, Wash and dry the precipitate in air at 100 deg. Celcius. Fe2O3 particles are obtained. Photographs (Photograph 1) of the Ferro fluid prepared by any one of these methods reveal the effect of a magnet. The Ferro fluid liquid turns into a paste like material in presence of a magnet [10].

Fig. 2. Photograph 1-preparation of Ferro fluid

In this case different shapes of Fe2O3 particles are obtained-ray diffraction analysis can be carried out to determine phase. It is reported that these particles can be converted into magnetic particles by annealing them in H2 gas at 350- 370 deg. Celcius for two hours. The α-Fe2O3 particles converted into gamma Fe2O3 without substantial change of particle size. Note that here particles have been~20 nm size. However by changing the reaction conditions, small particles can be synthesized. Different shapes can be achieved using different concentration of NaH2PO4 and solution pH

3. DEVELOPMENT OF A VISCOMETER"

3.1 Existing Viscometers

System components

1. Electrically heated water bath
2. Silver plated Oil cup with accessories
3. Temperature Regulator
4. Thermometer

These instruments are used for determining the viscosity of all oils, expressed in Redwood seconds at the temp. of test as called for by IP 70. Both the types of viscometers, Redwood no.1 and Redwood no.2 electrical heating models are available. The viscometers consists of a heavily silver plated both fitted with a heating tube or heating element and drain cock. The bath and cup assembly is mounted on a stand with leveling fee. Each unit is supplied complete with silver plated ball valve, spirit level and cover, the thermometer clip and receiver of capacity of 50ml.

A works certificate is issued for each cup which is calibrated against a certificate cup. Suitable for operation on 220V, 50Hz, single phase, AC.Supply. The following model available Redwood no.1 viscometer electrical heating complete with dimmerstat .Used for all oils having viscosity not more than 2000ecatthe test temperature. Redwood no.2 viscometer, electrical heating complete with Dimmer stat. Used for those oils, the viscosity of which exceeds 2000 sec by Redwood no.1 viscometer

4. DEVELOPMETNAL WORK"

4.1 Trial-1 Cylindrical viscometer

Designer has developed a cylindrical viscometer to measure the viscosity of ferrous and non ferrous fluid in a dynamic condition. Cylindrical Viscometer consists of two concentric cylinders with a little gap between them. Inner cylinder is rotating and outer is stationary. The gap is filled with testing fluid. Due to relative motion of the cylinders, the fluid gets sheared. This phenomenon of shearing is used to find out the viscosity of fluid. For non ferrous fluid it is just like a conventional rotational viscometer. And for ferrous fluid (ex. Ferro fluid), the change in viscosity according to varying magnetic field is obtained. To vary the magnetic field the special arrangement of winding has been done at the inner and outer cylinders. But in this experiment the sharing effect of the fluid has found too little and hence no considerable voltage or current change has observed so we dropped this idea.

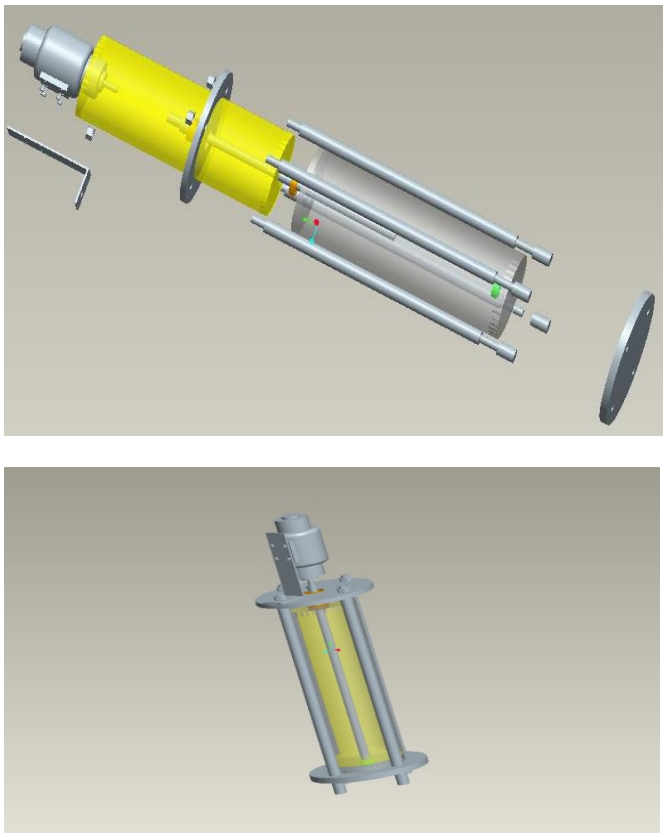


Fig. 4. Trial-1 Cylindrical viscometer

4.2 Trial-2 Modified Redwood viscometer with electrical winding

To measure the viscosity of Ferro fluid in static condition designer modifies the existing redwood viscometer. As viscosity gets affected by the change in magnetic field around it, there should be some special arrangement to vary the magnetic field. To achieve this, designer wound the copper winding around the redwood viscometer flask. Also inserted one metallic cylinder inside the redwood viscometer flask the clearance maintained between these two cylinders is 1mm radially. There is one pointer at the bottom is of inner cylinder to adjust the hole opening of the viscometer flask inner cylinder I made hallow to allow wooden block, raped with copper winding to insert into it. The winding on outside & inside of the cylinder for magnetic field in its vicinity when current passes through it. One can also vary the generated magnetic field by adjusting current and voltage. This viscometer is connected with rheostat for current adjustment.

The time required to collect the 50ml liquid for particular port opening is calculated, this is calibrated with the time required for collecting 50ml liquid from standard redwood viscometer with this procedure one can find out kinematic viscosity of liquid in seconds.

Fig. 5. Trial-2 Modified Redwood viscometer with electrical winding

4.3 Trial-3 Modified Redwood viscometer with permanent magnetic strip wound around the viscometer.

The readings obtained with trial-2 are not so accurate to overcome this and precise. Also there is too poor repeatability in the readings. To overcome this, designer modifies the Trial-2 viscometer by replacing their electrical winding with magnetic strips. This magnetic strip has constant viscosity and hence one have to change the strip for changing the magnetic field generated.

The readings obtained with this method are accurate also there is good repeatability in the readings. Following figure shows the basic diagram to modified redwood viscometer with permanent magnetic strip.

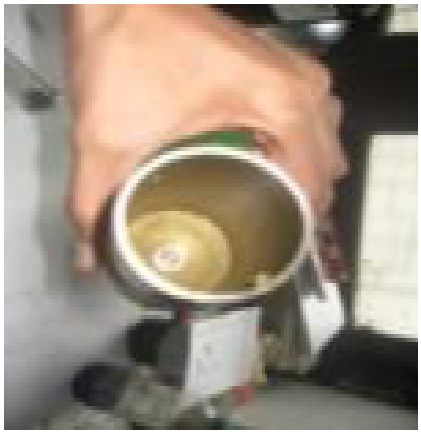


Fig. 6 Trial-3 Modified Redwood viscometer with permanent magnetic strip wound around the viscometer.

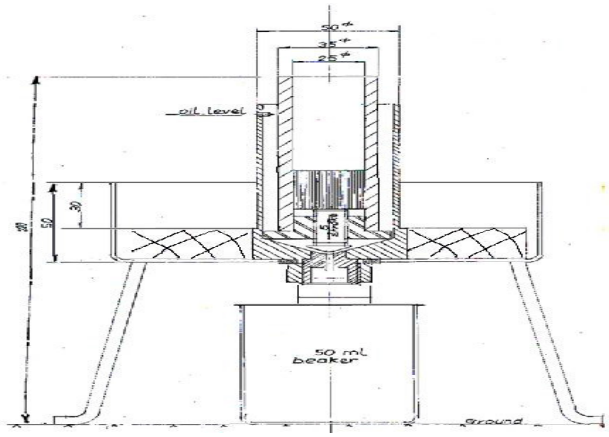
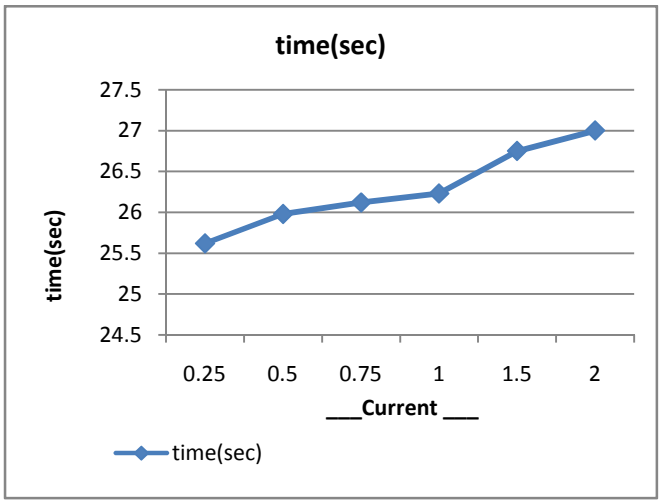


Fig. 7. Modified Redwood viscometer

5. RESULTS AND DISCUSSION"

The experiment conducted by trial-2 setup with its experimental procedure and obtained result is given below:

- First make an electrical connection of winding with rheostat, voltmeter and ammeter.
- Pass the measured quantity of electrical i.e. 10V, 1amp current in this case, through the winding.
- Allow fluid to flow down through the port opening. And note down the time taken to collect 50ml of fluid in the beaker.
- Now change the current passing through the electrical winding by adjusting the rheostat setting and note down the time required for collection 50ml of fluid.
- Calibrate this viscometer with standard redwood viscometer and find out the calibration constant.
- This calibration constant and the above readings of time give the viscosity of Ferro fluid in second for the particular magnetic field.



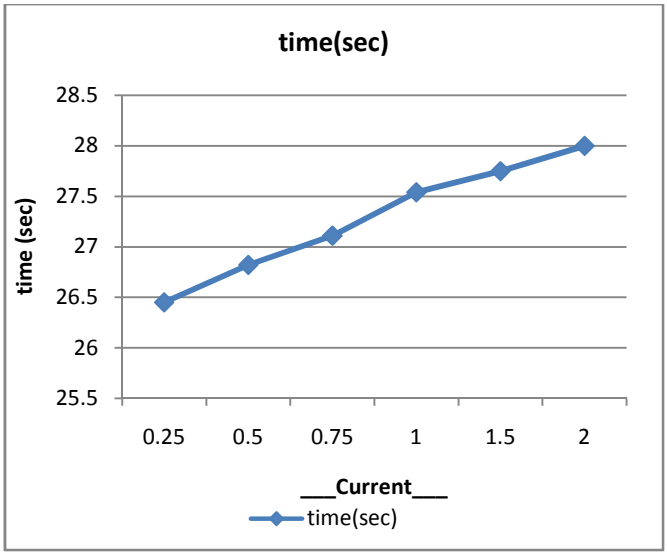


Fig. 8. Obtained by modified Redwood viscometer with a single electrical winding and double electrical winding

To conduct the experiment on this modified redwood viscometer with permanent magnetic strip; fill the clearance space of the viscometer with testing fluid. Note down the time required to collect 50ml Ferro fluid when allowed to flow

through the port opening. The experimental results obtained on modified redwood viscometer with magnetic strip for different port openings are shown in following table,

Table 1. Ferro fluid flow rate in sec with respect to pointer opening distance

Distance in mm	Time in sec		
	1	2	3
7	33.70	34.6	34.05
8	35.15	35.60	36.13
9	35.15	35.60	36.13
10	42	42.12	42.45
11	157.55		

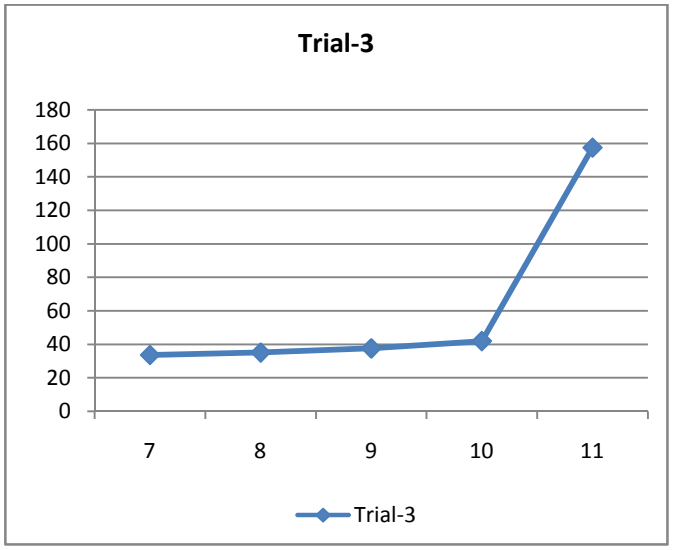


Fig. 9. Winding Ferro fluid flow rate in sec with respect to pointer opening distance

6. CONCLUSION AND FUTURE SCOPE"

The aim of this research was to determine the viscosity of a Ferro fluid at different values of the magnetic field. The theoretical objective of the work was to determine this 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 2 to 4A. The results of this research will be used to control the damping properties of a shock absorber used in the Automobile industry. From this analysis we can draw some conclusions such as,

- The Ferro fluid can be used to damp the vibration as it consists of dampening characteristics.
- The damping coefficient varies slightly with the method of preparation due to the difference in the particle size and the variation in the geometry of particles.
- The characteristics of Ferro fluid such as viscosity get affected by the change in magnetic field.
- This characteristic of Ferro fluid, changing the viscosity according to the change in magnetic field in the fluid, can be used as active vibrating absorbing system.

REFERENCES

[1] K kulkarni, Author, Nano technology principles and practices, Capital publishing company (**2007**).

[2] Seval Genc, Synthesis and properties of magnetorhelogical (MR) fluids, M.S. thesis in physics, Bogazici University, Turkey (**1994**).

[3] Macosko, C.W., and Rheology: Principles, Measurement and Application, Newyork: VCH publishers, Inc. (**1994**).

[4] Phule P.P., J.M. Ginder, and A.D. Jatkar, Synthesis and properties of magnetorhelogical fluids for Active Vibration Control. In material for Smart Systems, Boston, MA; Materials Research Society (**1996**).

[5] Auzans, E., D. Zins, E. Blums, and R. Massart, Synthesis and properties of Mn-Zn ferrite Ferro fluids, Journal of materials science. 34.6, pp. 1253-1260 (**1999**).

[6] Berkovsk, B.M., V.F. Medvedev and M.S. krakov, Magnetic Ferro fluid, Journal of magnetism and Magnetic, Begell House, Wallingford (**1996)**

[7] Afkhami, S., Y. Renardy, M. Renardy, J. S. Riffle, TG St Pierre, Albert Co, Gary L. Leal, Ralph H. Colby, and A. Jeffrey Giacomin, Numerical modelling of Ferro fluid droplets in magnetic fields. Proceedings of the 15th Intl. Congress on Rheol. The Soc. Rheol. 80th Annual Meeting, vol. 1027, 1, pp. 884 (**2008**).

[8] Lebedev, Alexander V., Andreas Engel, Konstantin I. Morozov, and Heiko Bauke, Ferro fluid drops in rotating magnetic fields. New Journal of Physics. 5, 1, pp. 57 (**2003**).

[9] Brousseau D, Wave front correction with a Ferro fluid deformable mirror, experimental results and recent developments. Ph.D. Thesis, Universite' Lavel. (**2008**).

[10] Hrovat, Davor. "Survey of advanced suspension developments and related optimal control applications." Automatica. 33, 10, pp. 1781-1817 (**1997**)

[11] Huke, B., and M. Lücke, Magnetization of concentrated polydisperse ferrofluids: Cluster expansion, Physical Review E 67, 5, pp. 051403 (**2003**).

[12] Ravaud R and Lemarquand G, Mechanical properties of a Ferro fluid seal. Three dimensional analytical approach based on the Columbian model.Prog. in Electromagnetic Res. 13, pp. 385-407 (**2009**).

[13] Satish B. Purohit,Characteristics of ferro fluid: Indian Journal of Science and Technology,pp.974- 6846 (**2011**)