Global Journal of Researches in Engineering: C
Chemical Engineering
Volume 19 Issue 1 Version 1.0 Year 2019
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

Investigation into the Effects of Surfactant on Itakpe Iron Concentrate Magnetic Fluids

By Lukman Y, Anakhu E. A., Ajayi P. R., Audu L. M. & Sule T.U.N
Ahmadu Bello University (ABU)

Abstract- This research work encompasses the potentials of Itakpe Iron concentrate for Magneto-rheological behavior under the effect of a liquid soap as surfactant. The concentrate was first ball milled to size reduce it then subjected to magnetic strength from a locally made electromagnet, with the iron concentrate in-situ the magnetic fluid. Magnetic fluid potential increased as iron concentrate increased in the fluid but viscosity of the fluids was affected by increased surfactant concentration. These positive signs of magneto-rheology under low magnetic influence puts Itakpe Iron concentrate a candidate material for magnetic fluid potential and application in automobile shock absorbers, brakes etc.

Keywords: magneto-rheological, itakpe iron concentrate, temperature, in-situ, magnetic bits.

GJRE-C Classification: FOR Code: 290699p

INVESTIGATIONINTOTHEEFFECTSOFSURFACTANTONITAKPEIRONCONCENTRATEMAGNETICFLUIDS

Investigation into the Effects of Surfactant on Itakpe Iron Concentrate Magnetic Fluids

Lukman Y [α], Anakhu E. A. [σ], Yesufu I. S. [ρ], Ajayi P. R. [Ѡ], Audu L. M. [¥] & Sule T.U.N [§]

Abstract- This research work encompasses the potentials of Itakpe Iron concentrate for Magneto-rheological behavior under the effect of a liquid soap as surfactant. The concentrate was first ball milled to size reduce it then subjected to magnetic strength from a locally made electromagnet, with the iron concentrate in-situ the magnetic fluid. Magnetic fluid potential increased as iron concentrate increased in the fluid but viscosity of the fluids was affected by increased surfactant concentration. These positive signs of magneto-rheology under low magnetic influence puts Itakpe Iron concentrate a candidate material for magnetic fluid potential and application in automobile shock absorbers, brakes etc.

Keywords: magneto-rheological, itakpe iron concentrate, temperature, in-situ, magnetic bits.

I. Introduction

Magnetic fluids are stable colloidal homogenous suspensions of magnetic nanoparticles around 10 nm in diameter) in an appropriate carrier (aqueous or non-aqueous) liquid. They are super magnetic because they are attracted by a magnetic field but retain no residual magnetism after the field is removed. Typical magnetic fluid consists of three main elements: magnetic particles, carrier liquid and surfactant. The quality of each determines the performance of the final product. The technological advances made in the last few years have greatly increased the quality of magnetic fluids and variously enhanced properties to serve the requirements of brakes, seismic dampers, human prosthesis [http://en.wikipedia.org/wiki/Magnetorheological_fluid, 2013], etc. The whole family of magnetic fluid consists of a large number of different types. The two most common magnetic fluids that have been widely used commercially are ferrofluid (FF) and Magneto-rheological fluid (MR fluid) [Wang, 2014]. Another smart fluid, the Electro rheological fluid (ER fluid) which has almost the same function as MR fluid.

The history of MR fluids dates to the 1940s when it was discovered by Jacob Rabinow of the US National Bureau of Standards fluids. Rabinow was inspired by Willis Winslow following a seminar on electrorheological (ER) Fluids (Rao, 2001). A decade later saw MR patents surpassed that of the ERs and by the 1990s MR fluids moved from research and development to industrial application in areas of Shock absorbers and polishing machine (Claracq *et al*., 2003). In recent times, MR fluids have found application in automobile and aerospace technology and they possess higher field induced particles than ER fluids, hence the preference for ER fluids (Jolley *et al*., 1996; Wereley, 1999).

Magnetic fluids can be made into solid structures at room temperature and turned liquid at slightly elevated temperature when paraffin based ferrofluid is used as the carrier liquid. Heating the fluid and cooling in the presence of a magnetic field will find application in solid magnetic nanostructures such as the gear-like structure (Jolley *et al*., 1999). Magneto-rheological applications are generally classified as Shear mode where clutches and breaks are used; flow mode which includes shock absorbers and damper in medical devices and squeeze mode in vibration isolation systems in artificial limbs (Choi and Han, 2013). Several studies on magnetic fluid have been carried out with great engineering interest at room temperatures and more focus on the external magnetic field (electromagnets). However, other works have reported findings in small temperature ranges of 40 – 45^{o}C in biomedical applications. This research therefore focuses on the effect of temperature (from room temperature to 70 ^{o}C and Iron concentrate of up to 25%) on permanent magnetic influenced ferrous particles in-situ Motor oil.

II. Material and Methods

a) Equipment used

The Materials and Equipment used in this research work are listed in Table 1.

Author α σ Ѡ: Department of Chemical Engineering Technology, Auchi Polytechnic, Auchi. e-mail: yusuflukman55@yahoo.com
Author ρ: Department of Quantity Survey, School of Environmental Studies Auchi Polytechnic, Auchi.
Author ¥: Department of Chemical Engineering, Ahmadu Bello University (ABU), Zaria.
Author §: Department of Minerals & Petroleum Resources Engineering Tech., Auchi Polytechnic, Auchi.

Table 1

S/NO.	MATERIAL/EQUIPMENT	MANUFACTURER	SOURCE
1	Motor Oil	Ammasco synthetic 5w/30	Zaria Market
2	Magnetic Stirrer bars	3 mm (1/8") x 12 mm (½"),VWR Octagon Spinbar	Chemical Engineering Department, ABU Zaria
3	Weighing Balance	Sauter Mode	Chemical Engineering Department, ABU Zaria
4	Thermometer		Chemical Engineering Department, ABU Zaria
5	Viscometer	Fann Instrument Company, Model 35	Chemical Engineering Department, ABU Zaria
6	Iron Concentrate		Itakpe Iron Mining Site, Kogi state Nigeria
7	Ball milling Machine	Kere Soesterberg, 057748	Chemical Engineering Department, ABU Zaria
8	Scanning Electron Microscope	Q30	Kaduna Geological Centre.

b) Ball-milling the Iron ore

Iron ore concentrates at different sizes were put in a milling machine and milled for approximately 50 hours until the size of the sample was reduced to very tiny(nano) particles.

c) SEM Analysis

A scanning electron microscope (SEM) analysis was conducted to get the following information about the sample (iron ore concentrate); external texture, chemical composition, crystalline structure, orientation of materials making up the sample.

d) Experimental Procedure

First a basis of 100g was taken as the primary measurement for the process. According to literature, the volume of a typical magnetic fluid is 5% magnetic solids, 10% surfactant and 85% carrier but for the purpose of this research work, different ratios will be experimented to get a relationship between the viscosity of the magnetic fluid and volume of surfactant.

100g (100% loading) of oil with 0g (0% loading) of the iron concentrate and 0g of surfactant was measured, the behaviour of the oil without magnetic solids or surfactants at 200 RPM of the oil was then taken at room temperature using the viscometer. An external magnetic field in form of an electromagnet was wound around the cup of the viscometer. It was then placed on the magnetic stirrer which also served as the heat source with constant temperature.

III. Results and Discussions

The viscometer used for this process measured shear rates in millipascal-seconds (mpa-s) equivalent to centipoise (cP).

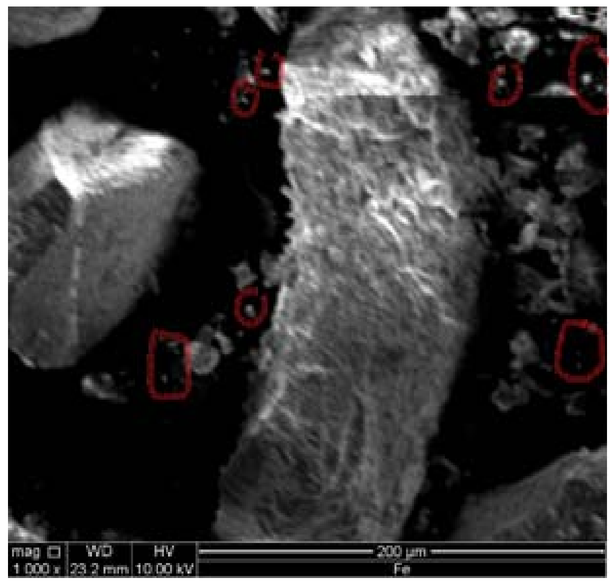

Figure 1: SEM Surface Image of Itakpe Iron Concentrate

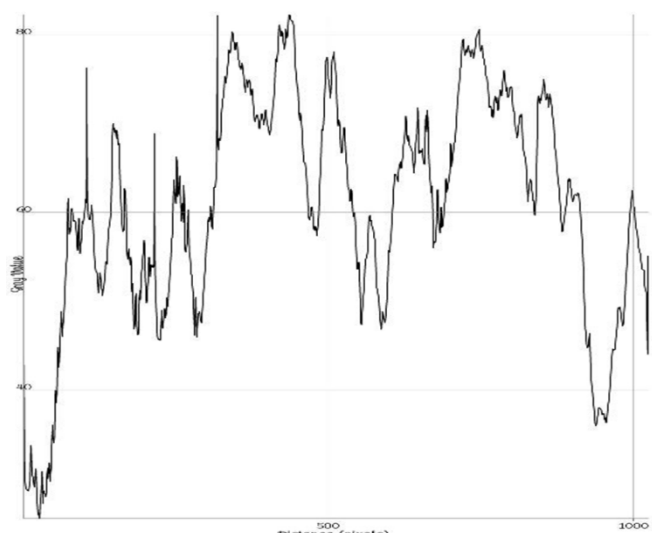

Figure 2: Profile plot of SEM analysis of the iron concentrate

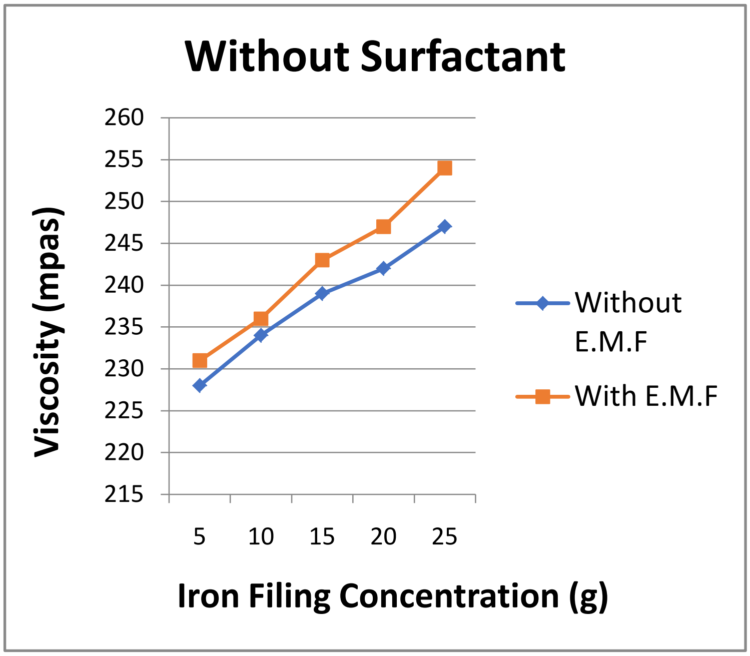

Figure 3: Effect without surfactant on the viscosity of the magnetic fluid under the influence of electromagnetic field

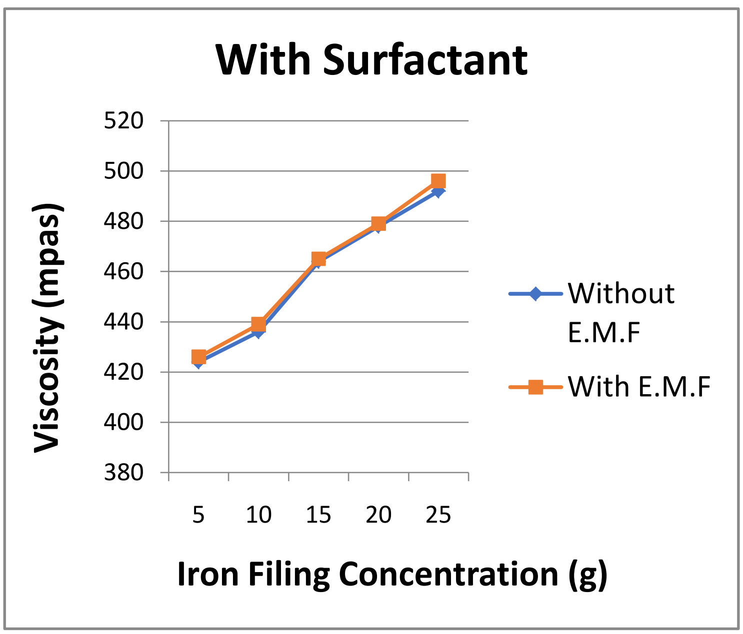

Figure 4: Effect of Surfactant on Magnet Influenced Iron concentrate in Motor Oil

Figures 1 shows the morphology of the ball milled iron concentrate. Particles size distributing varies from about <5 to 100 μm as seen from the scale of the microscopic image. The smaller particles (< 10 μm, circled in red) fall in the range of particles generally used for magnetorheological studies (Joseph and Suresh, 2014). Figure 2 shows the total dispersion of the iron particles inside the iron concentrate. This gives the microscopic overview of the relationship between the distance and gray value of the iron concentrate particles.

Figure 3 showed that at different loading (i.e. concentration) of the iron filings in the magnetic fluid, its viscosity also changed. From the experimental procedure, as the loading was increased, the fluid naturally became denser and it was assumed that the increase in density meant the viscosity will increase. The figure above confirmed that assertion as it is seen that as the iron filing concentration increased, the viscosity also increased without the effect of an electromagnetic field (E.M.F), and with the effect of an E.M.F. This implies that an influence of an E.M.F affects the hydrodynamic behavior of a magnetic fluid by increasing its density and hence its viscosity. From the figure 4, just like figure 3 it was seen that at different loading (i.e. concentration) of the iron filings in the magnetic fluid, its viscosity also changed. Also from the experimental procedure, as the loading was increased, the fluid naturally became denser and it was assumed that the increase in density meant the viscosity will increase. But in this case, it was quite different because of the addition of liquid soap which served as the surfactant. As the iron filing concentration increased, the viscosity also increased as usual even similar to figure 2 but here it was more uniform because of the influence of the surfactant.

The addition of the surfactant reduced the surface tension of the fluid and also prevented aggregation or clumping of the iron particles at the bottom of the fluid, allowing them to be suspended and stable in all parts of the fluid (i.e. there's no separation between the solid and liquid nor agglomeration of particles is seen even under a strong magnetic field [www.sigma-hc.co.jp, 2015]. Also, it increases the shear stress (thickness) of the fluid and hence the viscosity.

IV. Conclusions and Recommendations

1. The Iron concentrates although with wide distribution of particle size showed prospects of magneto-rheology.
2. Magneto-rheology increases with Iron concentrate content in the motor oil up to 25%.
3. Surfactant has more influence on the viscosity of the fluid when under influence of weak magnetic effect.

a) *Recommendations/Future work*

1. A more efficient method to size-reduce the iron concentrate to uniform size in Nano scale rather than ball-milling for plenty hours.
2. Electromagnetic effect with higher and known magnetic strength will be used for future studies.

Conflict of Interest

There is no conflict of interest associated with this work.

References Références Referencias

1. Carlson, J. D., Catanzarite, D. M., and St. Clair, K. A. (1996). Commercial magneto-rheological devices. International Journal of Modern Physics B 10: 2857–2865.
2. Choi, Seung-Bok and Han, Young-min (2013). Magnetorheological Fluid technology, Application in Vehicle Systems. CRC Press, Taylor & Francis Group 6000 Broken Sound Parkway NW, Suite 300.
3. Claracq, J., Sarrazin, J., and Montfort, J. P. (2003). Viscoelastic properties of magnetorheological.
4. Fluids. *Rheologica ACTA* 43: 38–49.
5. Jolly, M. R., Jonathan, W. B., and Carlson, J. D. (1999). Properties and applications of commercial magnetorheological fluids. Journal of Intelligent Material Systems and Structures 10: 5–13.
6. Jolly, Mark, R., Carlson, J David., Munoz, Beth C. (1996). A model of the behaviour of magnetorheological materials Smart Mater. Struct. 5 (1996) 607–614.
7. Jordan, Andreas., Scholz, Regina., Wust, Peter., Fahling, Horst., Felix, Roland (1999). Magnetic fluid hyperthermia (MFH): Cancer treatment with AC magnetic field induced excitation of biocompatible super paramagnetic nanoparticles. Journal of Magnetism and Magnetic Materials 201 (1999) 413-419.
8. Joseph, Aswathy and Mathew Suresh (2014). Ferrofluids: Synthetic Strategies, Stabilization, Physicochemical Features, Characterization, and Applications Volume 79, Issue 10; Pages 1382–1420.
9. Karakoc, K., Park, E. J., and Suleman, A. (2008). Design considerations for an automotive magnetorheological brake. *Mechatronics* 18: 434–447.
10. Li, W. H., Chen, G., and Yeo, S. H. (1999). Viscoelastic properties of MR fluids. Smart Materials and Structures 8: 460–468.
11. Tao R., (2001). Super-strong magnetorheological fluids. J. Phys.: Condens. Matter 13 (2001) R979–R999 PII: S0953-8984(01)21212-0.
12. Wereley, N. M., Kamath, G. M., and Madhavan, V. (1999). Hysteresis modeling of semi-active magnetorheological helicopter lag damper. Journal of Intelligent Material Systems and Structures 10: 624–633.
13. Zahn, Markus (2001). Magnetic fluid and nanoparticle applications to nanotechnology. Journal of Nanoparticle Research 3: 73–78, 2001. Kluwer Academic Publishers. Printed in the Netherlands.