Synthesis and Characterization of Magnetic Fluids for Localized Polishing of Freeform Surfaces

Kyle Hogan King, Ashif Sikander Iquebal, Satish T.S. Bukkapatnam
School of Industrial Engineering

Introduction

In this study, magnetic fluid samples are prepared while changing the concentration of ammonia present in the mixture. The concentration of iron particles, abrasive material, surfactant, and carrier fluid are held constant throughout the experiments. The effects of the ammonia change within the mixture are studied qualitatively and quantitatively through a series of experiments. A significant improvement was found as compared to the original fluid used in terms of segregation over time in a resting state and within a magnetic field. Improvements were also made in the force that is applied by the fluid when a magnetic field is being applied.

Background and Motivation

Figure 1: Magnetic fluid being sloshed back and forth with the use of electromagnets.

- The use of electromagnets in combination with magnetic fluid could be of great use with many applications for localized polishing of freeform surfaces.
- Current polishing techniques use hand-held polishers, which are difficult to control accurately and difficult to use in certain situations.
- Complex geometries such as exhaust manifolds (Fig. 2) and products consisting of differing surface roughness such as biomedical implants (Fig. 3) are difficult to polish currently, but with the use of magnetic fluids it is possible to more precisely and accurately polish these materials and products.
- Current magnetic fluids have issues with separation under the presence of a magnetic field as well as not providing the needed force to polish materials sufficiently.

Figure 2: Exhaust manifold

Figure 3: Knee Implant

Objectives

- Optimize current fluid being used
  - Vary concentrations of material being used in the current fluid
  - Determine when certain materials should be added to the mixture
- Test the new fluids properties
  - Pressure tests of fluid in the presence of a magnetic field
  - Measure the viscosity
  - Qualitative study of the fluids movement and segregation over time

Materials and Methods

- A Viscolite 700 was used to measure the viscosity of the magnetic fluids. The Viscolite 700 was clamped above a graduated cylinder and 30mL of fluid was added. The Viscolite was then dropped into the graduated cylinder in order to take the measurements. The setup is shown in Figure 4.
- A pressure transducer combined with an Arduino Uno was used to measure the amount of pressure applied by the fluids while in the presence of a magnetic field. A schematic of the setup is depicted in Figure 5.
- A qualitative study was also performed on each fluid to determine how well the fluid moves and how it segregates in a magnetic field with the use of a motor spinning a magnet.

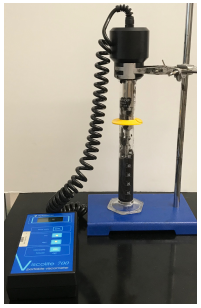

Figure 4: Experimental setup for viscosity measurements.

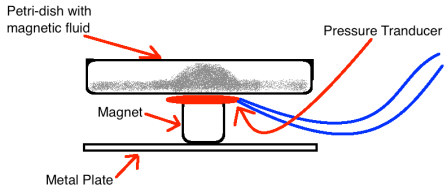

Figure 5: Schematic of the experimental setup for the pressure tests.

Results

- The magnetic fluid with a 55% increase in ammonia, exhibited significant improvement in segregation within a magnetic field, movement speed within a magnetic field, while keeping a similar quality of down force applied by the fluid when in the presence of a magnetic field.

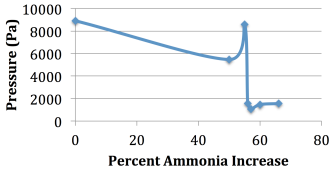

Figure 6: Pressure applied by the magnetic fluids in the presence of a magnetic field according to the percent ammonia concentration increase from the initial fluid.

Ammonia %	Movement Speed	Separation
Initial Fluid	Standard	Standard
50	Better	Better
55	Best	Better
56	Worse	Best
57	Worse	Best
60	Worse	Best
66	Worse	Best

Table 1: Qualitative observation of the magnetic fluids in terms of the movement speed of the fluid and the separation of the magnetite particles from the entirety of the fluid according to the percent ammonia concentration increase from the initial fluid.

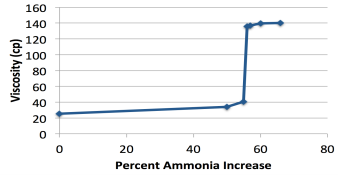

Figure 7: Viscosity of each fluid according to the percent ammonia concentration increase from the initial fluid.

Conclusions and Future Work

- The magnetic fluid created in this study showed great improvement in terms of segregation in a resting state and within a magnetic field as well as a strong down force that is able to be applied within a magnetic field.
- Looking into the future of this work it is recommended to look further into the concentrations of the surfactant as well as the carrier fluid to decrease the segregation of the fluid over time.

Acknowledgements

This work is supported by the National Science Foundation under REU Site Grant **(# EEC 1757882)**. Any opinions, findings, conclusions, or recommendations presented are those of the authors and do not necessarily reflect the views of the National Science Foundation. We also acknowledge the significant support for summer research and enrichment activities by Texas A&M College of Engineering's Undergraduate Summer Research Grant Program.