Flow Vis IV4: Ferrofluid

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MCEN 4151

Professor Hertzberg

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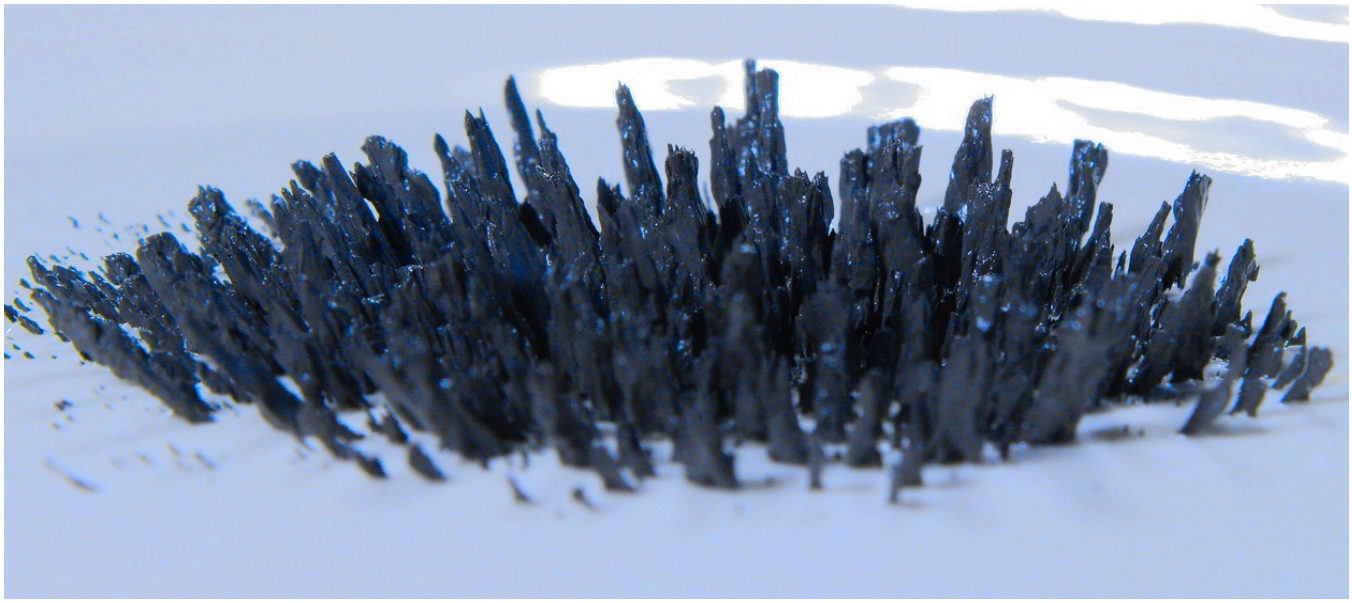

Introduction and Background

The purpose of this photo is for the "Flow Vis 4" assignment, which Professor Jean Hertzberg assigned for the course Flow Visualization at the University of Colorado at Boulder. This assignment aims to capture an image of the physics behind a magneto-rheological fluid on a plate reacting to a magnet placed underneath the plate. I attempted to record the magneto-rheological fluid's reaction from the strong magnetic pull of a magnet in a way that showed the aesthetics of the magneto-rheological fluid in addition to the flow phenomenon that seems to depict the fluid as static.

Team

This assignment was completed with the following team members:

1.) Bryce Dickson
2.) Tobin Price
3.) William Watkins
4.) John Whiteman

Procedure

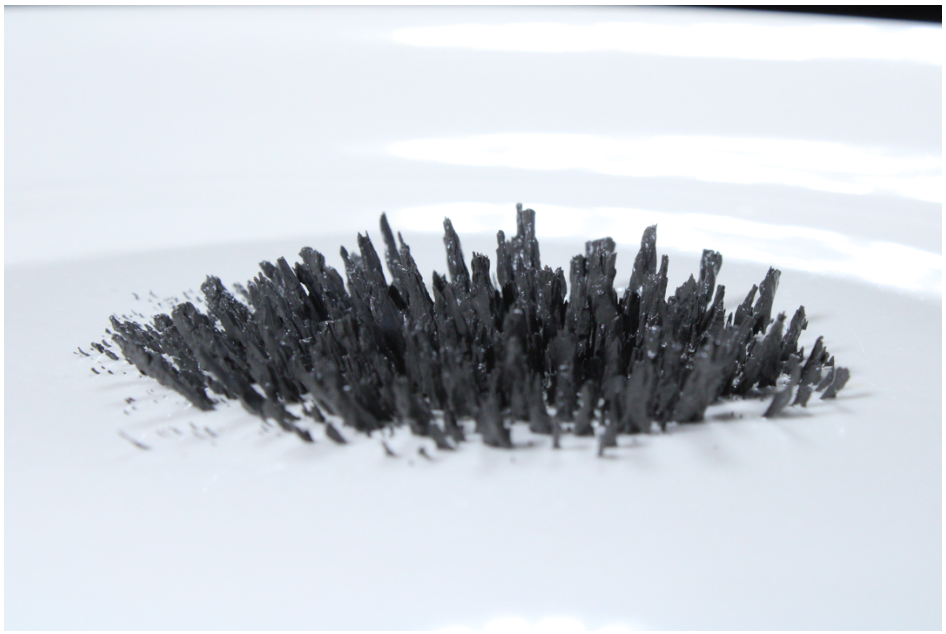

Figure 1: *Original Photograph of the experiment*

The experiment began with our team acquiring the magneto-rheological fluid provided by Professor Hertzberg (Reference Figure. 2 below). We then acquired a giant magnet at the ITLL (Integrated Teaching and Learning Laboratory) at the University of Colorado at Boulder. We began our experiment by placing roughly an ounce of the magneto-rheological fluid on a white ceramic plate (Reference Figure 1. Below for an image of the experimental setup). We then placed the magnet underneath the table. Initially, we placed the magnet underneath the plate, but this proved to be imprudent as the plate almost shattered. We had to be careful not to get the magnet stuck to the bolts underneath the table. Two team members held an LED light Tripod above the plate with the magneto-rheological fluid to ensure that we had ample lighting to photograph the fantastic phenomenon (Reference Table. 1 below for the complete materials list for this experiment). One team member photographed the magneto-rheological fluid using a Cannon Rebel T7 DSLR Camera. The last member moved the magnet underneath the table to change the size and orientation of the magneto-rheological fluid.

Materials

Table 1: *Required materials for the assignment*

Required Material	***Description***
Magneto-Rheological Fluid	Refer to Figure 2. below
LED Lights (x2)	Two White LED lights
LED Light Tripods (x2)	Two Tripods used to hold each individual LED Light
Camera	Cannon Rebel T7 DSLR Camera
Ceramic Plate	Any standard white ceramic plate
Large Magnet	Any large magnet that is strong enough to affect the magneto-rheological fluid.

Figure 2: *Photograph of the* Magneto-Rheological Fluid

The Physics behind the Phenomenon

A magneto-rheological fluid acts similarly to a ferrofluid as they both are reactive to a magnetic field and appear static. A magneto-rheological fluid will get stiff and rigid in a magnetic field as the particles get "jammed," which is why it is commonly used in brakes and clutches (Reference #2). This is due to the yield stress of these fluids, which will increase significantly while in contact with a magnetic field (Reference #3). These fluids seem to show drastic changes in viscosity under a magnetic field (approximately 106 times) (Reference #2). We were stunned that the magneto-rheological fluid seemed to form solid protruding spikes on the plate when we introduced the magnetic field by placing a magnet underneath the table.

Photography Technique

The Camera used in this experiment was a Cannon EOS Rebel T7 DSLR camera with an 18-55mm lens because it had the best resolution (refer to Table 2. below for camera specifications during the experiment). The Camera was not stabilized with a camera stabilizer; instead, it was held by a team member approximately 2 inches from the magneto-rheological fluid. The original image had a width of 6000 pixels and a height of 4000 pixels, while the edited image had a width of 5062 pixels and a height of 2166 pixels. The lighting used was two white LED lights, each

held by a team member approximately one foot above the plate antiparallel to the plate. I used the Camera's RAW setting that develops photos in the CR2 file. I transferred these photos into PNG using the software Irfanview. A YouTube video (reference #1) gave me a tutorial on downloading this software. This tutorial helped a lot. I used DarkTable to do the photo editing because of its powerful editing features. I edited the photo by adjusting the "RGB" curve and cropping the photo to emphasize the coin flow through the water, which made the photo much more aesthetically pleasing.

Table 2: *Camera Specifications for Cannon Rebel T7 used during the experiment*

Specification	*Description*
Aperture	f/0.0
Exposure	1/inf
ISO	0
Focal Length	0 mm

Conclusion

The objective of this assignment was to record an aesthetically pleasing visualization of the flow phenomenon that occurs when a magneto-rheological fluid is brought into the presence of a strong magnetic field. My team and I were able to illustrate this phenomenon in a way that shows not only the bizarre physical properties of this fluid but also the beauty in it. This photo shows magneto-rheological fluids' beautiful and abnormal properties as it is introduced to a magnetic field. For this experiment in the future, I want to take a photo with larger quantities of the magneto-rheological fluid to attempt to concentrate larger quantities in different areas. In addition, I would want to use different colored lighting and potentially have the magneto-rheological fluid emerging from paint or another colorful fluid.

Appendix:

1.) "How to Convert RAW Canon CR2 Pictures to JPG PNG or TIF". YouTube. https://www.youtube.com/watch?v=D6viyxBWbnA . Accessed on 11/02/22.

2.) ScienceDirect. "Experimental Studies on Magnetorheological Fluids" sciencedirect.com, 2022, https://www.sciencedirect.com/science/article/pii/B9780128035818120958

3.) SpringerLink. "Magneto Rheological Fluids Based Smart Automobile Brake and Clutch Systems" link.springer.com, 2019, https://link.springer.com/chapter/10.1007/978-981-15-0434-1_13