Ferro Ferro - Flow Visualization IV4, Team Assignment 3

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MCEN 4151 – Flow Visualization

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https://www.youtube.com/watch?v=22uJU-3dihE

Introduction

This was the fourth project for the flow visualization course. I wanted to capture the beautiful and interesting phenomenon of ferrofluid. I initially set out to take a video of peaks of ferrofluid forming when in contact with a magnet; however, I found that when putting two magnets together in parallel, a unique phenomenon occurred, so I decided to capture that phenomenon instead. Thank you to Will Dietz, Kelsie Kerr, and Ryan Wells for the setup and capture of this video.

Apparatus setup

The apparatus used in this experiment is straightforward. It consisted of setting two connected magnets under a pyrex dish and dropping ferrofluid around the magnets with a pipet. The video was taken directly above the magnets. The view of the camera is the same as the view shown in figure 1.a. below. Additionally, the apparatus setup from the side view is also shown in figure 1.b. below.

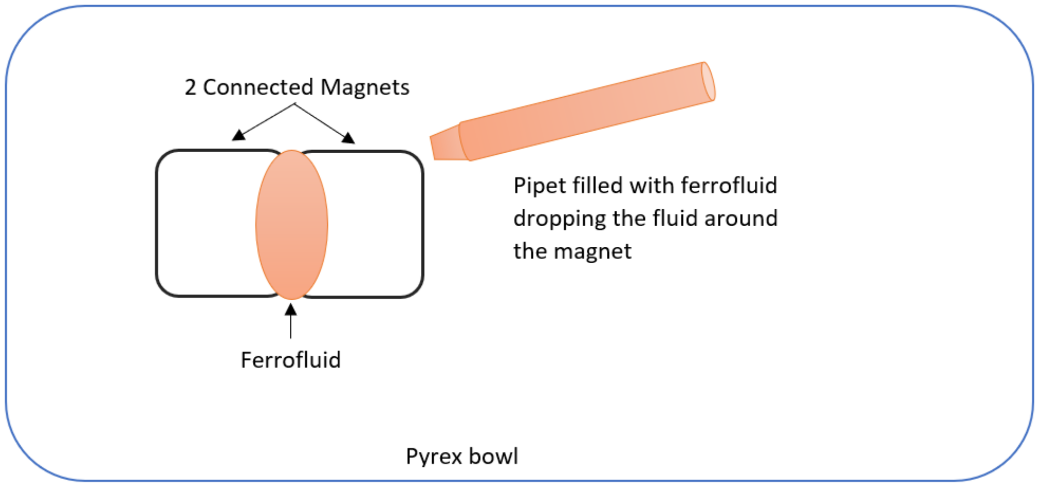

Figure 1.a. Top View

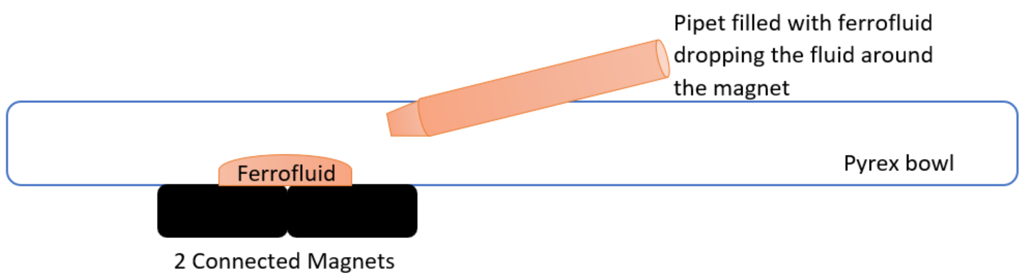

Figure 1.b. Side view

Figure 1: Apparatus Setup from the top view (a) and side view (b)

Flow Phenomenon

Ferrofluid is a colloidal mixture of insoluble ferromagnetic nanoparticles, such as Co–ferrite ($CoFe_2O_4$) and magnetite (Fe_3O_4), suspended in an organic fluid, typically water or oil (1). The fluid outside of a magnetic field will behave as any other fluid but is a temporary, uniform magnet when in contact with one. The typical instability observed when ferrofluids are in contact with a magnetic field is the normal-field instability. Peaks will form on the surface of a pool of ferrofluid when the ferrofluid is exposed to a vertically oriented and uniform magnetic field (1). The bubbles created in this video are likely due to this instability.

When two magnets are connected in series, meaning one is connected to the other as shown in figure 2.a. below, the magnetic fields combine to make a larger magnet, but the magnetic field remains mostly unchanged (2). However, when connected in parallel, as shown in figure 2.b., the magnetic field has opposing directions on each side of the magnet, meaning that the area where the two magnets connect has a magnetic field of approximately zero as the field is equal and opposite. That is why the traditional spikes created by ferrofluid interacting with magnets are not present. Additionally, the fluid likely moves to the center of the magnet due to the kinetic energy of the ferrofluid being expelled from the pipet and the desire for particles to move toward stability.

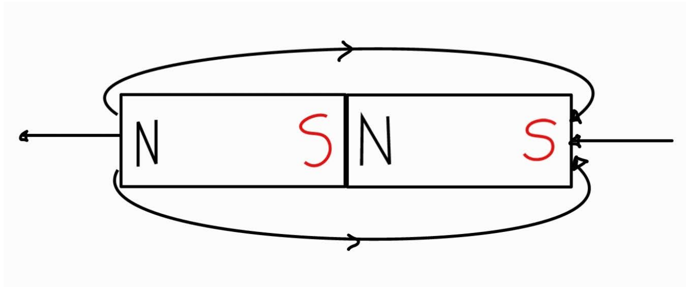

Figure 2.a. Magnetic field of two magnets in series

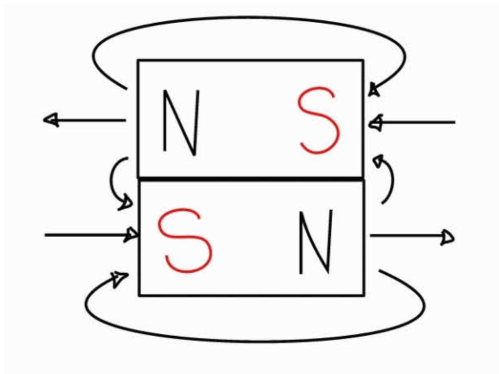

Figure 2.b. Magnetic field two magnets in parallel

Figure 2: Magnetic Field of two magnets connected in series (a) and parallel (b).

Imaging Techniques

The ferrofluid used in this visualization was from Ferrotec Corporation, Catalog Number EFH1. A plastic 3mL pipet was used for piping ferrofluid onto a 9” x 12” pyrex disk. Three IFB756 lights were used to light the video and were positioned two feet from the setup on the sides and back of the apparatus, pointing approximately 15° up from the horizontal. Each light has 288 0.06-watt LEDs and was set to a color temperature of 3100K. The setup of the lights and camera can be seen below in figure 3.

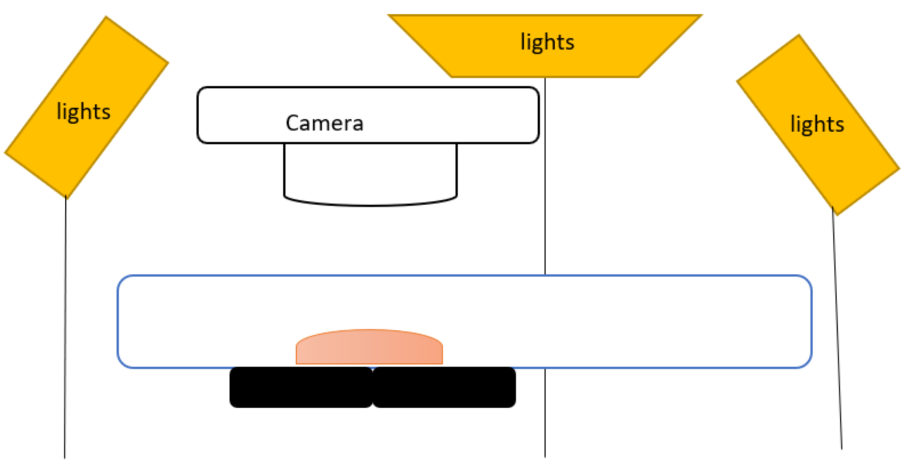

Figure 3: Setup of camera and lighting around the apparatus

A Canon EOS Rebel T7i camera with an 18-55 mm lens was used to capture this flow. The field of view was 10 cm with a focal length of 34 cm. The ferrofluid and magnets are approximately 15 cm from the camera. To capture this video, I used an aperture of f/9.0, an exposure of 1/60, an ISO of 400, and a frame rate of 24 frames per second. I used these specs because they allowed for a bright, crisp image without overexposing the image. Additionally, I used a focal length of 55 mm as I found it was the best length to get the framing that I wanted while still being able to focus on the flow. The number resolution of the video was 1920 × 1080 pixels. Limited editing was done to the video. I trimmed the video to the desired length and added a title screen and music.

Conclusion

I enjoy this image because it demonstrates a phenomenon I have never seen before and did not expect when I initially set out to take this image. I believe I did a good job of capturing the flow aesthetically and showing something unique. The only thing I would change would be to use a paper plate rather than a glass bowl to reduce reflections.

Bibliography

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