Team First: Ferrofluid

Blake Chin
Assisted by: Faisal Alsumairi, Robert Drevno, Matthew Knickerbocker, and Abishek Kumar

MCEN 4151: Flow Visualization
October 14, 2019

Introduction:

My team and I wanted to explore and observe ferrofluid. Ferrofluid is a fluid that becomes magnetized when in contact with a magnetic field. The ferrofluid was provided by Dr. Jean Hertzberg. To better visualize the effects of the ferrofluid, we poured India Ink on top of it. The final image was captured with the assistance of Faisal Alsumairi, Robert Drevno, Matthew Knickerbocker, and Abishek Kumar. Abishek provided the team with his office space to test our experiment, Matthew supplied the India Ink, and Robert brought the glass containers to place the fluids in. The final product was an image that looks cellular, while still showing the impact of magnetic forces on a fluid.

Fluid Physics:

When a magnetic field is applied to the ferrofluid, spikes are formed on top of the fluid. Magnetic field lines are visually shown through the spikes. Ferrofluid that is farther from the magnetic field shows less of this effect. This decrease in spikes is caused by a weaker magnetic field when it is farther from the magnet. Thus, gravity and surface tension take over as the main force acting on the fluid. The India Ink was poured on top of these spikes. Since the ink is less dense than the ferrofluid, the colored ink remained on top, despite mixing the fluids together. Van der Waals forces between the ink molecules keep them together and result in a cellular look near the bottom portion of the picture, while the middle half shows a larger spread of ink due to gravity having a stronger effect.

Experimental Setup:

A glass bowl was used as the container with ferrofluid poured inside. A magnet was then placed underneath the bowl to initially see the effect of the magnetic field on the fluid. As mentioned previously, the spikes coming from the fluid due to the magnet were shown as the team observed. Green India Ink was then poured directly onto the spiked region of the fluid. A member of the team then moved the magnet in a circular motion with the magnet maintaining contact with the bottom of the bowl. The magnet and bowl were then placed on a table with white paper as the background. The bowl rested on the magnet, causing an incline on the bowl. This forced the remaining ferrofluid not affected by the magnet to flow to the bottom, along with the green ink. Red India Ink was then poured onto the spiked area, approximately 3 inches above the fluid. When pouring the red ink, the flow was slow and roughly 2 tablespoons of ink were poured in. The bowl remained on an incline as the ink flowed off of the spiked region, due to gravity. The team tried using a flood light and camera flashes, however none of the images came

out as desired. The entire team agreed that the overhead fluorescent lighting already in the room was best.

Photography Techniques:

The camera used to capture the final image was a digital Canon PowerShot SX530HS. A medium shutter speed of 1/60 was used, with an aperture of f4.5 and an ISO of 640. This produced an image that was 640x480 pixels. The captured image was when the lens was approximately 4" from the fluid. Post-processing of the image was done in GIMP. The image was cropped to include less of the reflecting light and bowl. The contrast was turned down, while the brightness was turned up to produce a darker red color in the ink.

Figure 1. Original Raw Image

Conclusion:

The final image shows the effect of magnetic field lines and surface tension on a ferrofluid. I like how well the ink showed a cellular pattern near the bottom half of the image. I dislike the amount of wasted space in the original image. In the future I will try to get even closer to the subject being captured to increase the quality of the final image. I believe that the main intent of finding out more about ferrofluid was realized especially through the use of pouring ink on top to better visualize the effects. In the future, I would like to repeat this experiment with different contrasting colors, and utilize more than two colors of ink.

References:

Ferromagnetism-
https://en.wikipedia.org/wiki/Ferromagnetism

Van der Waals Forces-
https://en.wikipedia.org/wiki/Ferromagnetism