Ferrofluid Fascination

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Context and Purpose

For the first team exercise, our group selected one of the more obscure materials on the proposed list of materials. Ferrofluid sounded and our team was interested in learning more about it. The purpose of this assignment was to work with our team for the first time and collaborate on a series of images, so we figured it was a good time to play around with the flow visualization possibilities. We obtained the ferrofluid and then went through a series of experiments and attempts before each arriving on a final image. Over the course of an hour, we used multiple types of magnets to manipulate the fluid and create different shapes and flows and photographed the various parts of the setup. We successfully learned how to work as a team and collaborate on a flow project.

Flow Description

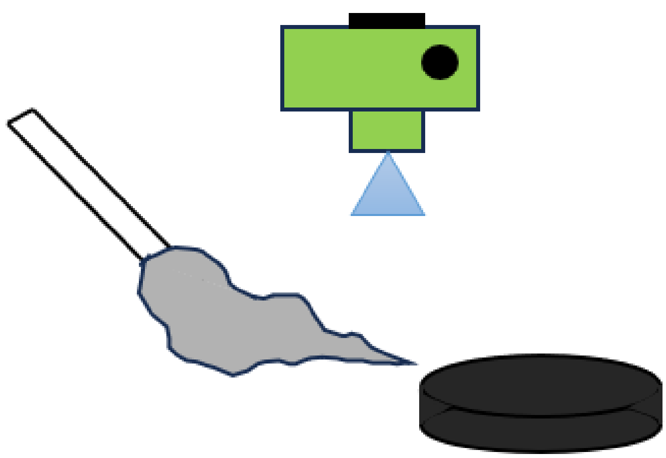

Figure 1: Sketch of setup used for image capture.

In this experiment we took the opportunity as a group to learn more about ferrofluids, and for me, specifically Magnetorheological Fluid. "Magnetorheological fluids are a class of smart materials whose yield stress increases considerably in the presence of externally applied magnetic field".[2] I struggled to visualize this transition from liquid to "solid" where the yield stress increased under magnetic stimulation, but I was able to get decent results with the materials we had. MRF does not behave consistently around a magnetic field, so a reynolds number approximation is not appropriate as it is considered non-newtonian. Research studies performed on this material states that the shear strength behavior is not well understood and has a nonlinear response to increasing magnetic forces.[3]

Visualization Technique

The initial technique our group intended to use was not able to be replicated due to difficulties obtaining magnets with sufficient strength. The lighting was all natural, with the sun being just above the flatirons around 4 o'clock in the evening which presented issues with shadows at certain frame angles. Our experimental setup was quite variable due to our initial plan not working, so we attempted several iterations of various vizualizationg techniques and experimenting with what magnets we had. Our equipment consisted of assorted small magnetic materials, a piece of dry-erase board, a small sheet of ⅜" acrylic, a large aluminum rod, ferrofluid (10% magnetite, 90% oil & distillates)[1], and magnetorheological fluid (MRF). For my technique, I collected MRF on the end of an aluminum rod and captured the changing behavior as the fluid approached the magnet.

Photographic Technique

Figure 2: Unedited image taken with this setup.

The image settings are described here as follows. The camera used was a Sony A7Riii with a Sony FE 16-35mm F2.8 GM lens. The Camera settings were an aperture of f/6.3, exposure of 1/200 second, focal length of 35mm, and ISO was 100. The subject of the image was approximately .3 to .4 meters away. The image resolution was 7980x5320. The raw image file was processed using Darktable, where brightness, RGB curve, and image size were edited to enhance the features.

Reflection

I wish our team had done more research into this and planned better, but as stated in the beginning section, we were learning how to work as a team and feel confident moving forward. The deadline for this assignment was unanticipated so we were a bit rushed to complete this. The biggest issue was the lack of strong enough magnets to get strong visual effects from the ferrofluid, which affected our abilities to capture the images we intended. I am a novice still at photography, so I again relied heavily on automatic camera functions for this image. I did get better with focus, but the depth of field was the main issue this time. I hope to consider this for the next image. Overall I see improvements in my photography skills so I am satisfied.

References

[1] Ferro Tec. (2015, November 4). Ferrofluid Safety Data Sheet. Educational Innovations, Inc. https://www.teachersource.com/downloads/msds/FF-310SDS.pdf

[2] Genc, S. (2022). Experimental studies on magnetorheological fluids. Encyclopedia of Smart Materials, 248–259. https://doi.org/10.1016/b978-0-12-803581-8.12095-8

[3] Tian, Y., Chen, K., Shan, L., Zhang, X., & Meng, Y. (2014). Unexpected shear strength change in magnetorheological fluids. APL Materials, 2(9). https://doi.org/10.1063/1.4894237