Ferrofluid Fanaticism

By: Stella Meillon, Austin Sommars, Greg Kornguth, Leo Steinbarth

Flow Visualization Fall 2023 Section 001
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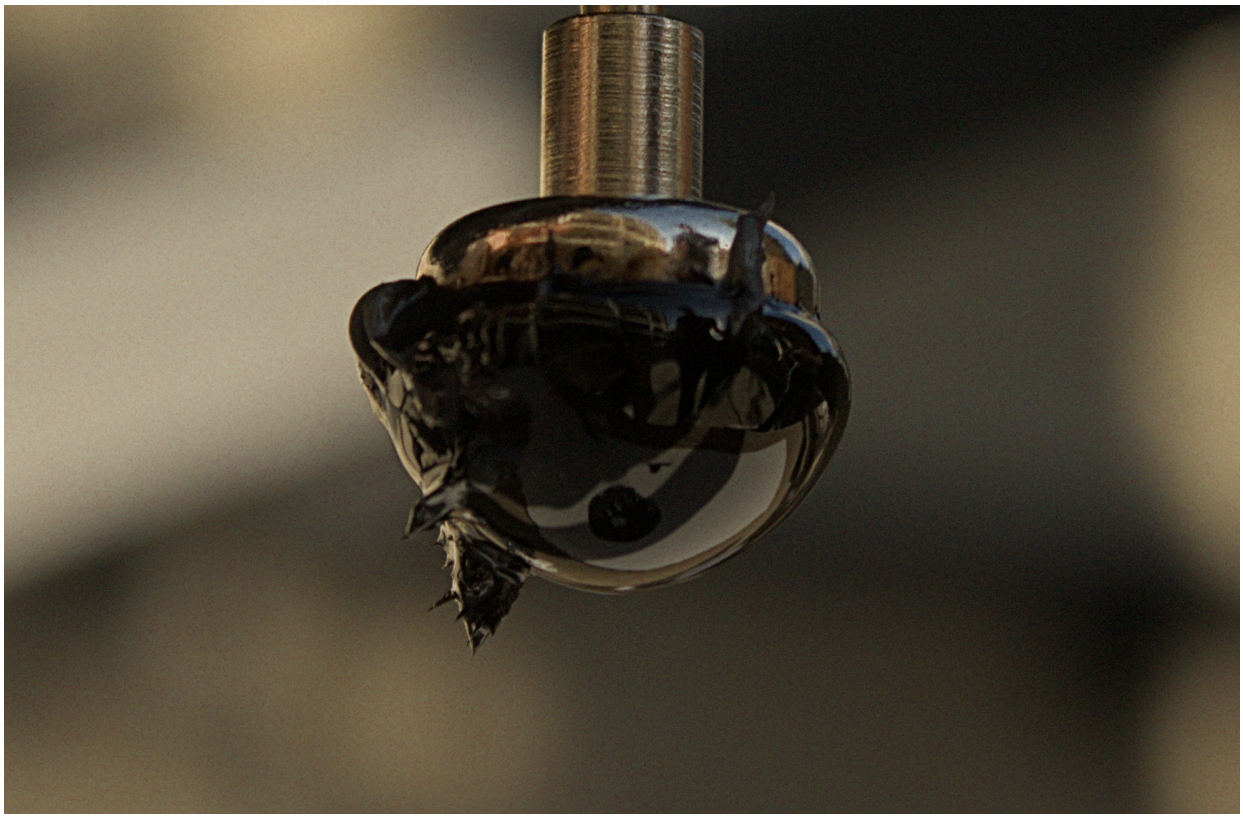


Context and Purpose

For the first team exercise, our group selected one of the more obscure materials on the proposed list of materials. Ferrofluid sounded cool but no one quite knew what we were going to do with it or how it worked. 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 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 and various objects 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

The flow visualized here demonstrates the surface tension of the ferrofluid, enabled by its magnetic properties. The magnetic properties also created a crystal-like formation protruding from the bubble of fluid. During our experimentation process, we tested many different properties of the ferrofluid. One of our magnets was a metallic bowl, and when we put the fluid in the bowl it spiked out in various directions. We added more fluid to the bowl and then vibrated the bowl, causing the surface tension of the fluid to shift and break. This happened when creating this image as well, because as I held the hook I shook the fluid and although none of it parted from the system, it formed a crystal as it descended down and shook around.

The physical properties can be described by ferrohydrodynamics, although the fluid being used was technically magnetorheological fluid. The spikes are a result of the fluid seeking the most stable orientation, called normal-field instability (Magcraft).

Visualization Technique

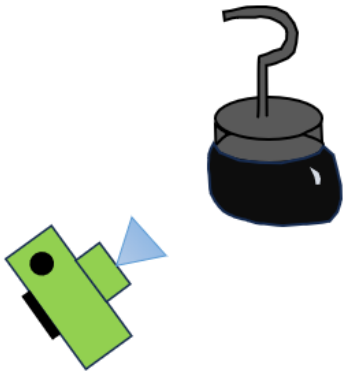
To create these images, we set up our experiment outside to benefit from the natural lighting. It was around 5 pm, and the lighting was perfect. We began by playing around with the fluid in different ways, and one of the first things I tried was to hold the metallic hook and dip it in the fluid. It was interesting to see how the fluid shifted every time I sent vibrations through the hook–the fluid would gyroscopically wobble in the opposite direction of my motions, demonstrating conservation of momentum.

Our equipment included various magnetic materials including a hook, a fridge magnet, and a magnetic parts bowl. We also used a piece of dry-erase board, a sheet of clear ⅜” acrylic, a magnetic rod, and the ferrofluid itself (90% oil/distillates, 10% magnetite), as well as magnetorheological fluid.

One person would create the setup and the others were taking pictures with varying settings. We rotated through these roles to each capture a few images and get a chance to play with the myriad properties of the ferrofluid.

Photographic Technique

Because each of our photos were not taken with the same setup, each of our visualization techniques were different. My setup consisted of someone holding up a metallic hook with ferrofluid, with a camera positioned slightly below.



My camera settings were as follows:

Shutter speed: 1/800; f/5.65; 55.0mm; 1000 ISO. These camera settings proved to be efficient for blurring the background of the image and keeping the subject (the magnet) in focus and in frame. The image was shot on Canon EOS Rebel T2i with a EF-S 18-55 mm lens. The focus distance was 0.39 m, and the original size was 5196x3462 pixels. The export size was 2093x1373 pixels.

As for image manipulation, I lowered the RGB color profile and increased the sharpness. I also changed the tone a little bit to where the image looked less silver and more bronze.

Reflection

In retrospect, I wish we did more research and planning before going into the experimental phase. We were unprepared for the fluid's behavior and thus spent more time than needed trying to figure out how to get it to behave the way we wanted. However, we learned as we continued to play with the fluid that if we added ferrofluid to an existing cluster in small increments, it would keep its shape. Also, once the magnet pulled away the fluid would lose its shape and go back to looking like a regular fluid.

Looking back, I would play more with the ISO to ensure the background wasn't so grainy. I also feel like the image is slightly too dark, which could be fixed with more editing in DarkTable. I did like the clarity of the image, although the crystal protrusion could be accentuated.

Overall I was pleased with the image and the experiment, and have learned more about ferrofluids and their properties. Going forward, I would change certain camera settings and plan out the experiment more beforehand.

References

1. Ferro Tec. (2015, November 4). *Ferrofluid Safety Data Sheet*. Educational Innovations, Inc. https://www.teachersource.com/downloads/msds/FF-310SDS.pdf
2. Magcraft. (2015, January 31). *What is a ferrofluid?*. MAGCRAFT Brand Rare Earth Magnets. https://www.magcraft.com/blog/what-is-a-ferrofluid#:~:text=A%20ferrofluid%20is%20a%20liquid,as%20the%20normal%2Dfield%20instability.