UNIVERSITY OF COLORADO, BOULDER

Ferrofluid Tree

Team Image 2

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Flow Visualization

Introduction

The image pictured on the front page was created for the CU Boulder course Flow Visualization for the second team assignment. The image captures movement of ferrofluid up a steel structure in still form. The presence of an electromagnetic field causes the ferrofluid to climb and take the form of varyingly-sized spikes as it reaches higher points along the steel structure.

Apparatus & Flow

This setup was a part of a senior design project in 2012, and it's currently kept in the ITLL. The setup includes a steel dish filled with approximately 1 cup of ferrofluid, a 6-in tall steel "tree", an electromagnet beneath the dish, and a cart on which it all sits. Our group added a black poster board behind the initial setup to provide a good backdrop for our imaging. A tripod was positioned directly in front of the steel tree; opposite of the black poster board. There was no additional lighting besides the overhead florescent lights in the ITLL.

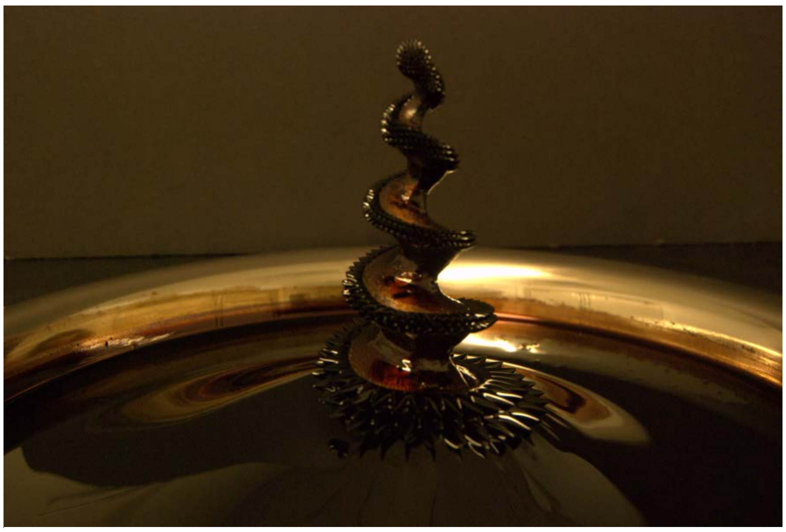

Figure 1: Experimental setup

Ferrofluid was a really fun fluid to work with, because there is hardly anything similar to it. It's a mixture of tiny particles that, when combined, form a liquid, but have the magnetic properties of a solid. The fluid was first created so a liquid could be forced through a pump in space by means of magnetic force.

As the ferrofluid climbs up the tree, the fluid takes the form of spikes. These spikes occur because of the normal field instability. The instability is caused by the vertical alignment and uniformity of the magnetic field which is the reason a series of hexagonal peaks begins to form. As the magnetic field increases, the hexagonal peaks morph into square peaks due to the change in intensity of the magnetic field. The size of the spike is related to the surface tension between the steel tree and the fluid; the magnetic field draws causes the fluid to be pushed out from the tree, while the surface tension draws the fluid back in toward the tree. You can see this demonstrated in figure 1 above.

Technique

I chose the aperture priority option on my digital Nikon DX40 (focal length of 55mm), and opted for an f-number of f/5.6. The ISO was set to 1600 to help increase the light exposure, and the resulting shutter speed was 1/13s. The flash was not necessary because of the overhead lighting in the ITLL, so it was not used. The original image can be seen below.

Figure 2: Original image. (3900 x 2613 pixels)

I kept the post-processing minimal because I really liked the original image. The only thing I did to edit the image was integrate an s-curve to increase the contrast, and bring out the warm, rich hues.

Conclusion

I really enjoyed working with ferrofluid, and I think it's a very good fluid for flow visualization. I wanted to focus on two main aspects of this ferrofluid setup; the uptake of fluid at the bottom, and the progression of the spikes as the fluid climbs up the steel tree. I really liked how this image turned out, and I don't think I'd change much if I did it again. The only things I may alter are the framing (pan right slightly to capture more of the uptake) and the orientation of the setup to the lighting (as to minimize the reflection of the lights on the steel structure.)

References

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