Flow Visualization

Team Second Report

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1 Introduction

The purpose of the "Team Second" project is to our second chance to work as a team to create some stunning flow visuals. After the discussion with all teammates, we have decide to play with ferrofluid this time. Our team met at DIDL at idea forge

at Fleming Building at CU-Boulder. In the following sections, I will introduce the experiment setup, the flow physics behind the image, as well as my post processing procedure.

2 Experiment Setup

The untouched original image as show below, it was taken before the actual experiment where we were trying to create the Saffman-Taylor figuring instability. The glass container were used to store all the ferrofluid we have, we placed some magnets under the glass container to excite the ferrofluid. It formed a beautiful "flower" shape. A simple demonstration of magnets as shown below:

Figure (1) Original, untouched image.

Here is a detailed dimension of magnets:

- small magnet: cylinder, 1.8 cm in diameter, 3 mm height
- large magnet: hollow cylinder, 6 cm outer diameter, 2.6 cm inner diameter, 1 cm height

The image was captured on Sony A7RIII with Sony FE 35mm f/1.4 lens. Here are some details of the image info:

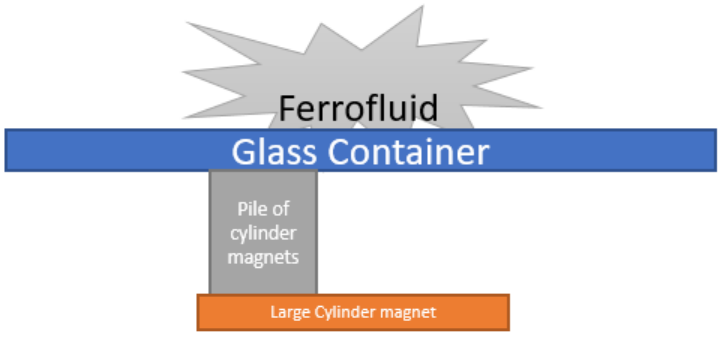

Figure (2) Magnets layout demonstration.

- 35mm
- f/1.4
- 1/60 sec
- ISO 1600

The lightning we used is an Neewer dimmable 14 inches continuous ring light, the power rating on it is 50 W and color temperate rate is 5500 K. The lightning was not idea therefore I have increased the aperture size and bumped up ISO to maximum the lights goes into the camera. Also a large aperture would bring the focus on the actual object and create nice bokeh on the background.

3 Flow Physics

The ferrofluid, also called portmanteau of ferromagnetic and fluid, is a liquid that is strongly magnetized when present of a magnetic field. It is made of nano level magnetite particles with surfactant. When the ferrofluid is excited by the magnetic field, an interfacial instability occurs magnetic field exceeds the critical value. This instability is called "Normal Field Instability", and forms the peaks on the surface

of the ferrofluid. This critical value for the magnetic for the phenomenon can be calculated by the following equation:

$$H_{critial} = \frac{2(\mu_0/\mu + 1))^{\frac{1}{2}}}{\mu_0(\mu_0/\mu - 1)}(\rho g \gamma) \tag{1}$$

where ρ is the density of the fluid, g is the gravity acceleration constant, γ is the surface tension, μ_0 is the permeability constant $\mu_0 = 4 * 10^{-7} N/A^2$, and μ is the magnetic permeability. The critical magnetic field magnitude is around $10^4 A/m$.

4 Post Processing

For post processing, first I have cropped large portion of unnecessary background to help audience better focus on the ferrofluid flower. Then I changed the image to gray-scale since the color of ferrofluid on the top of glass is not pleasuring.

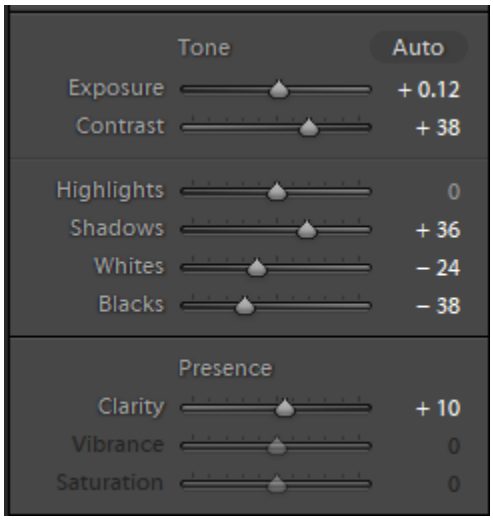

Figure (3) Lightroom Setting 1

Next, I tweak some values on the shadows, whites and blacks to create better contrast.
Also I have used some noise reduction tool since I have cropped the image for large portion and ISO was high as well.

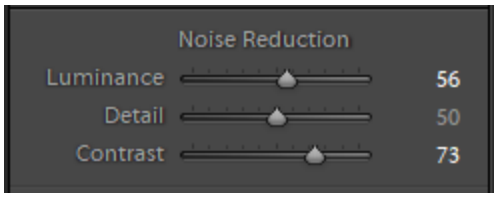

Figure (4) Lightroom Setting 1

5 Acknowledgements

Special thanks for Cyron brought ferrofluid from Professor Hertzberg, Galen brought glass panes and wood blocks for supporting, Kevin brought tripod for this experiment.

6 Reference

https : //*en.wikipedia.org*/*wiki*/*Ferrofluid*
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