

Purple Oobleck Man - Flow Visualization Team Assignment 1

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INTRODUCTION

This image was taken for the first team project, and our goal was to capture the strange physics of the non-Newtonian fluid, Oobleck. I knew that Oobleck acts as a liquid until in compression, but I did not realize that it acted the same in tension, and aimed to capture that phenomenon by dropping a spoonful of Oobleck into a bowl. Thank you to Will Dietz for helping execute the experiment by using the spoon to drop the Oobleck into the bowl and for purchasing the required material to mix the Oobleck. Additionally, thank you to Ryan Wells and Will Dietz for the experimental setup of the lighting and backdrop and to Kelsie Kerr for borrowing the lighting used to take the image.

APPARATUS SETUP

This image utilized a few simple object: Oobleck, a pyrex bowl, and a metal spoon. Oobleck is made of corn starch and water. The oobleck was 2 cups corn starch and 1 cup water, but corn starch was added in 1 tablespoon increments until there was no unsaturated water left. The Oobleck sat in a Pyrex bowl, and collaborator Will Dietz scooped a spoonful of oobleck lifted it approximately 2.25 inches above the rim of the bowl, and let the Oobleck fall back into the bowl as I captured the image. An image of the apparatus can be found below in figure 1.

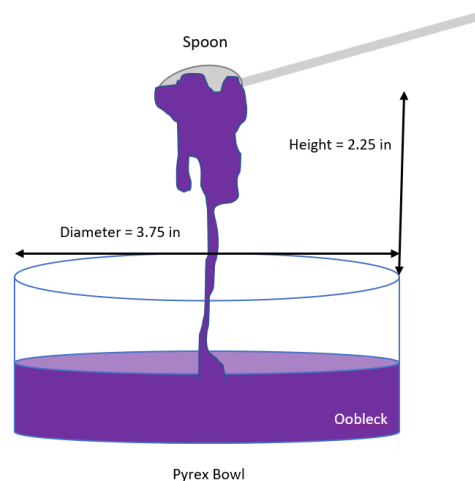


Figure 1: Apparatus setup

FLOW PHENOMENON

Oobleck is considered a non-Newtonian fluid. A Newtonian fluid's viscosity will remain constant regardless of the stress. Water, for example, is a Newtonian fluid. As such, non-Newtonian fluid's viscosities will change in response to stress. Oobleck, the mixture of corn starch and

water, is an example of shear thickening, meaning that when under no stress, the mixture behaves like a liquid, but under mechanical stress, it becomes thicker and acts like a solid. There are two theories for how shear thickening occurs: lubrication-based hydrodynamic interactions and frictional contact forces. The hydrodynamic interaction theory suggests that when a fluid is stressed, incompressible clusters of particles are created, causing the viscosity to increase (1). Figure 2 below shows the formation of hydroclusters in response to stress.

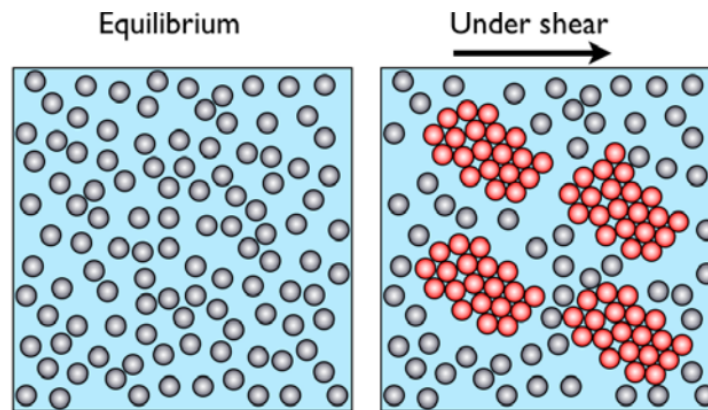


Figure 2: Schematic of Particles Forming Hydroclusters Under Shear (2)

The frictional force theory says that when contact forces press particles together and increase the particle-to-particle interactions, it makes it harder for the particles to move apart, increasing viscosity (3). Figure 3 shows how viscosity rises in response to friction. According to Blair lab, the primary driving force is friction, with hydrodynamics being a secondary driver (4).

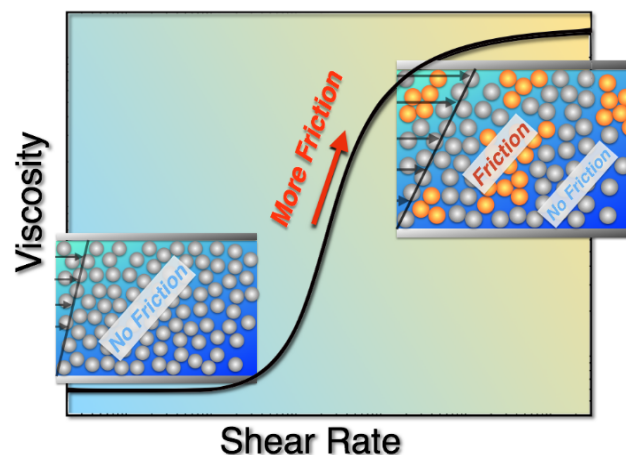


Figure 3: Schematic Representation of Shear Thickening Caused by an Increase in Frictional Contacts (4).

In this image, the oobleck is under tension, and we can see that both liquid and solid properties are displayed. Closer to the spoon, we can see the oobleck is behaving as a solid with holes and

cracks displayed. As the oobleck falls, the oobleck begins to flow over itself, creating individual droplets. Finally, just before it hits the bowl's outer rim, the flow becomes laminar, telling us that there is a stress gradient on the oobleck that decreases as it falls. Due to the constantly changing viscosity, a Reynolds number can not be accurately calculated to describe the flow of the fluid.

IMAGING TECHNIQUES

In order to make the oobleck, Argo corn starch and Red and Blue HY-TOP Assorted food coloring was used to color the Oobleck purple. I mixed in 10 drops of red and 15 drops of blue food dye to achieve the desired color of purple. The color purple was arbitrarily chosen based on personal preference. Two IFB756 lights were used to light the image and were positioned at 45° from either side of the camera. Each light has 288 0.06-watt LEDs and were set to a color temperature of 5600K. A diagram of the camera and lighting positions is shown below in figure 4.

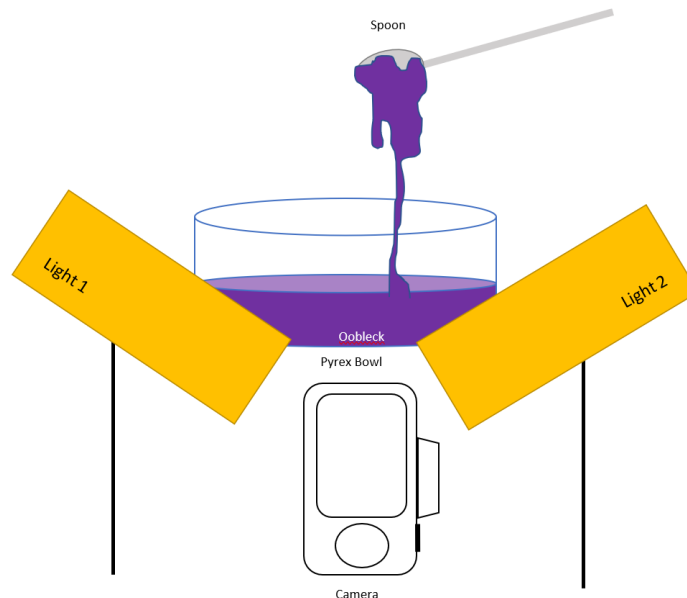


Figure 4: Diagram showing the lighting and camera positions

A Canon EOS Rebel T7i camera with an 18-55 mm lens was used to take this image. The unedited image has a field of view of approximately 4.5 inches wide because the diameter of the bowl is 3.75 inches. The apparatus was positioned approximately 1 foot from the lens. The camera specs were set to a focal length of 50mm, an ISO of 400, an aperture of f/14.0, and an exposure of 1/125. I used a focal length of 50mm because I found it to be the best length to keep everything in the frame and in focus. Additionally, I used the setting listed above because the lighting was very bright, and I wanted to underexpose the image to maintain all of the details in the oobleck. This image's editing was done using darktable. I cropped the photo to the desired size, and added an S-curve. Additionally, I set the color contrast to 1.63 green-magenta

contrast and 1.61 blue-yellow contrast. I set the contrast to +0.15, the brightness to -0.08, and the saturation to +0.38. Finally, I set the shadows to +36.84, the highlights to +47.37, and the white point adjustment to +10.0. The original and edited images can be seen below in figure 5.



Original: 4010 X 6016 pixels

Edited: 1164 X 3719 pixels

Figure 5: The original image and the edited image, image size is displayed underneath each in pixels.

I love how this image came out because it looks like a little alien man. It is a playful but interesting and weird image. However, I wasn't sure how I was going to crop the photo when I took it, so when I decided to do a very tight crop on the oobleck, I had to cut out a large portion of the frame. If I were to retake this image, I would frame it so that the original image cropping more closely matched the edited cropping. Additionally, I would drop the oobleck from a taller height or use a more shallow bowl, so the bowl could be removed while still capturing the laminar flow toward the bottom of the image.

Bibliography

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