MCEN 5151: First Cloud Image Report

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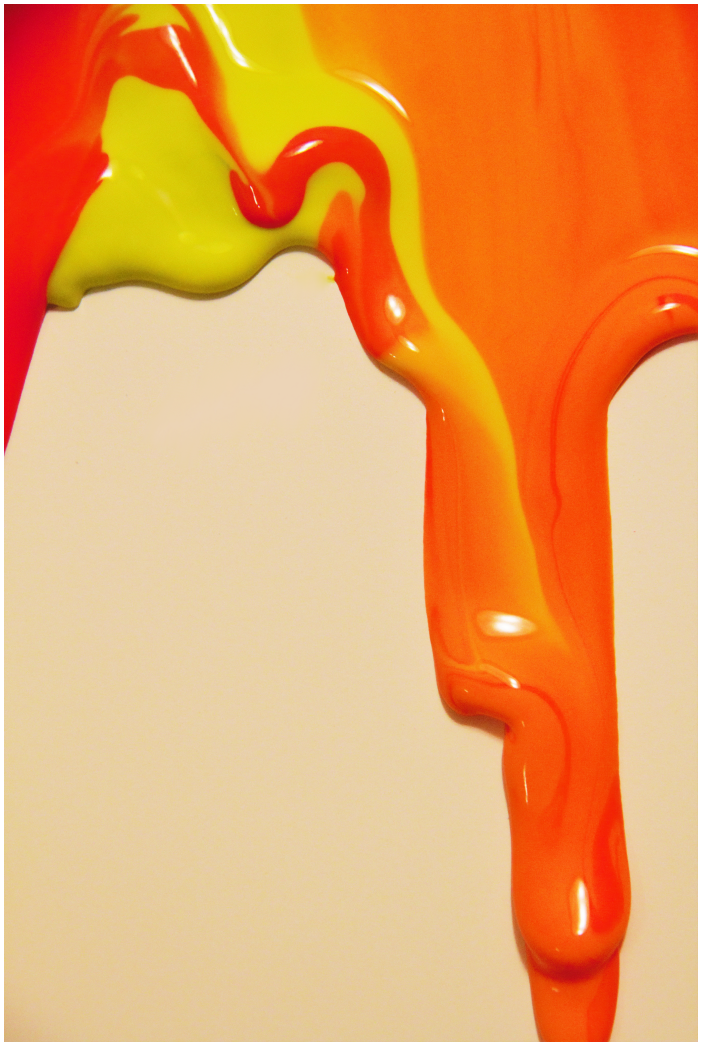

1. Introduction

This report is a general overview of the first team assignment on MCEN 5151 Flow Visualization, in which Alex, Daniel and I took an active part developing various images of the non-Newtonian fluid—oobleck. This assignment was intended to provide a stage where students can work together on things that they are interested in and gain some practical experience on imaging techniques and scientific observation.

2. Image Basics

This image on the cover is one of hundreds of oobleck images our team has made and I think it particularly reveals the shiny, glossy finish of the oobleck. We made a whole bowl of oobleck by commingling cornstarch and water until it got viscous enough to have properties of solids and liquids. Then we decanted the oobleck into a couple of cocktail glasses and colored them with food dye. Finally we splashed the oobleck of different colors onto cardboard pieces and made attempts to take images from different angles. The image I choose has an ISO of 1600 and I edited it with Polarr Editor to polish the surface of the big oobleck droplet and make it even glossier.

3. Fluid Physics

In this assignment, our team has presented a very typical non-Newtonian fluid, a shear thickening fluid to be exact, the oobleck and the name oobleck was actually derived from the book "Bartholomew and the Oobleck" by Dr. Seuss that was published in 1949. As a non-Newtonian fluid, the oobleck does not have an important feature that Newtonian fluids have—a linearity in the relation between the shear force and

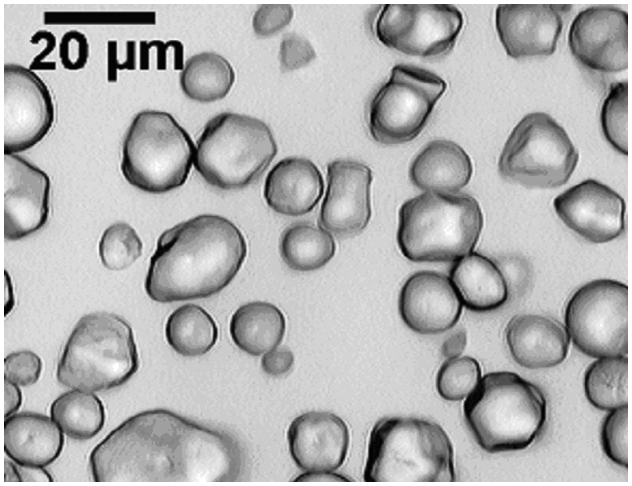

Figure 1: Micrograph of the cornstarch particles[1]

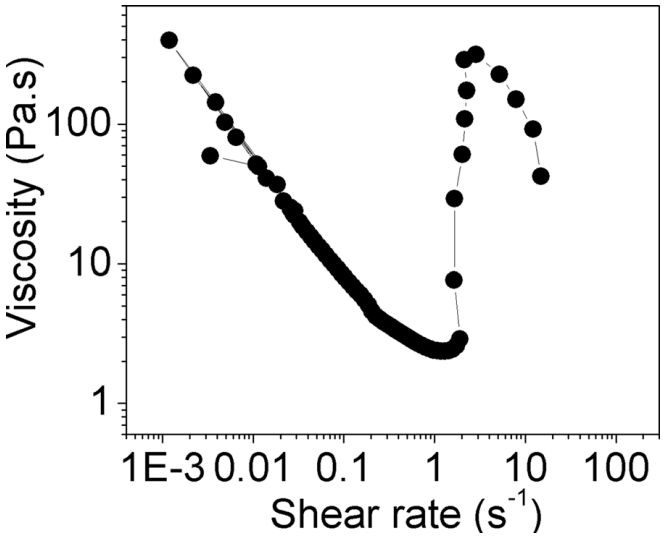

Figure 2: Apparent viscosity vs shear rate when performing a step stress test in a vane-in-cup geometry. [1]

the shear rate, which can be denoted as $\tau = \mu \frac{du}{dy}$, where τ is the shear force and μ is the viscosity. The oobleck is perhaps the best-known example of of a shear-thickening suspension: cornstarch particles suspended in water.[1]

Stress tests show that the viscosity decreases with increasing applied stress at low stresses, exhibiting shear-thinning behavior. As the stress goes up, the viscosity increases and shear-thickening behavior can be observed. The property of shear thickening can explain some magical things people can achieve with the oobleck. For example, a person is able to walk on a large tub of oobleck without sinking.[3] From our observations, when the oobleck in the bowl turns "solid" enough, it "holds" your fist when you punch the surface and bounces your fist off without leaving cornstarch mud among your fingers.

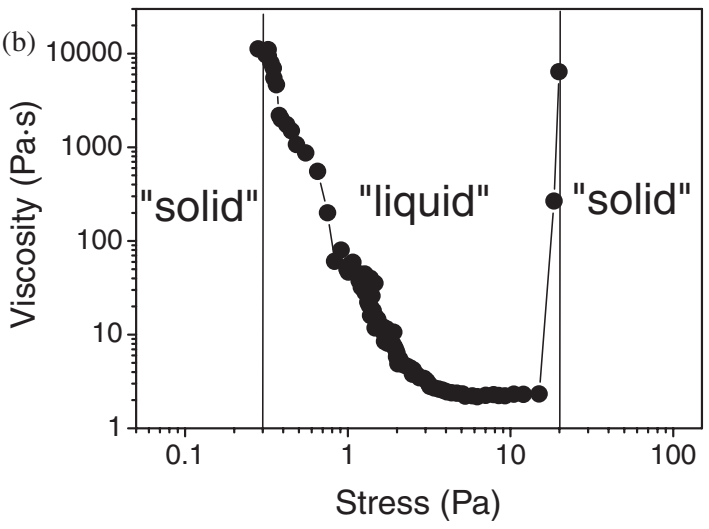

Figure 3: Viscosity as a function of applied stress, showing the reentrant jamming

4. Photographic Techniques

Cardboard pieces with oobleck on them were placed against the back of a chair and a tripod has been set up for the camera. This image was taken in household indoor light condition, which, technically, wasn't really suitable for taking images with such a high contrast. The original image wasn't interesting because it looked fairly dim; the oobleck splash wasn't impressive and did not stand out. Luckily, glitches like these can be improving by retouching the image with softwares. I edited the image to increase its sharpness and change the diffusion of the light.

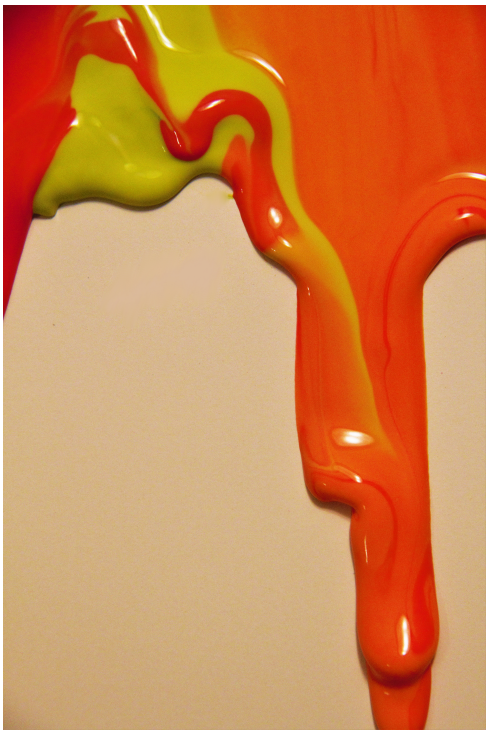

Figure 4: The original image

5. Conclusion

This image reveals interesting properties of the typical non-Newtonian fluid—oobleck and exhibits a scene of a high contrast. Personally, I think the focal length of this image is excellent and it makes the ridges on the splash visible. In general, the image demonstrates what we are trying to observe and the physics behind the flow.

6. References

[1] Fall, A., Bertrand, F., Ovarlez, G., & Bonn, D. (2012). Shear thickening of cornstarch suspensions. *Journal of Rheology*, *56*(3), 575. doi: 10.1122/1.3696875

[2] Fall, A., Huang, N., Bertrand, F., Ovarlez, G., & Bonn, D. (2008). Shear thickening of cornstarch suspensions as a Reentrant jamming transition. *Physical Review Letters*, *100*(1), . doi:10.1103/physrevlett.100.018301