Jeffrey Pilkington
Team Image 2
Flow Visualization
3/28/13

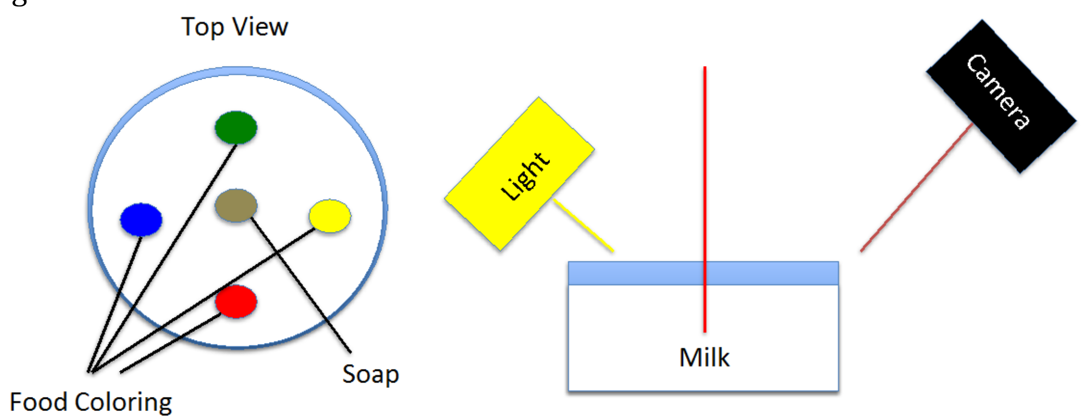
The Creature

Purpose:

This image was taken for the second team image for the flow visualization course at the University of Colorado. The team images allow a group to compile their individual resources and create images using advanced equipment and experimental setups. Initially the team attempted to image objects using Schlieren imaging. Unfortunately the team was unable to capture crisp images using Schlieren so the team decided to photograph how food coloring and soap act in milk. The intent of the image was to capture the beautiful patterns made by the materials and the shape of the resulting fluid flow. The change in surface tension drives the flow and creates the patterns. The dye colors were carefully chosen to create an aesthetically pleasing image. Dillon Thorse and Alexander Meyer assisted in capturing the image.

Experimental Setup:

A 1-gallon Tupperware bowl was used to hold the liquid in the experiment. The container was filled approximately ¾ full with whole milk from the grocery store. Yellow, green, blue, and red dyes were added equally spaced from the center of the container. A drop of Axe golden glitter shampoo was added to the center of the bowl with the Axe bottle. Once the soap contacted the surface of the milk, the dyes started to spread and photographs were taken. 2 500-Watt lamps from the ITLL media shack were used to light the container of liquid. The lights were placed at a 45° angle above the container of liquid. The camera was positioned on a tripod directly above the container of liquid. A schematic of the experiment is shown in the figure below.



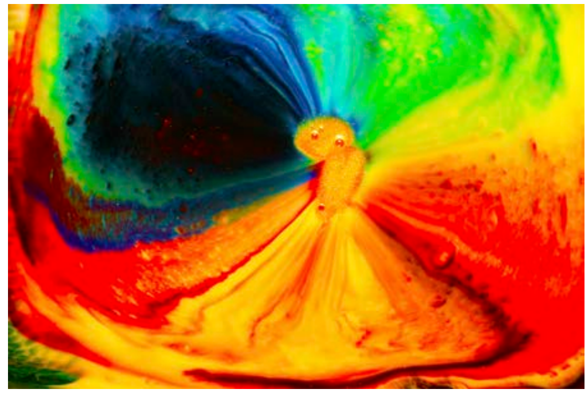
All liquids have surface tension, which is the tendency for the liquid molecules to stay together and resist change in position due to any external forces [1]. Soap is a surfactant, which is a substance that reduces the surface tension of a liquid [2]. Milk is also a colloid, which means that small fat particles are suspended in the liquid. The soap breaks down the molecules of fat in the milk and therefore decreases the surface tension of the milk. The bipolar nature of the soap causes the polar (hydrophilic) ends of the soap molecules to dissolve into the water and the non-polar (hydrophobic) ends to attach to the fat in the milk. [3] As the surface tension changes, the fluid moves in order to reach equilibrium. The surface tension of the milk near the drop is lower than the surface tension of the milk surrounding the soap so the milk near the drop of soap is forced away from the drop of soap. The dye is displaced along with the fluid and the colors spread out along the surface. Since the drop of soap is pushing milk away from it, convection occurs and milk and dye are pulled from beneath the surface and then pushed to the outside of the container. [4] Unfortunately there was no data that could be gathered from the image and the setup that would help to calculate a dimensionless number such as the Reynolds number. A video of the flow was recorded; it is possible to estimate the velocity of the flow (especially with the gold specs marking the flow lines). However this would not have helped with my image since the recording was taken with a different amount of soap during a different test run of the experiment. In addition to flow velocity, the Reynolds number also requires a characteristic length. Since the dye lines are very straight and there is almost no mixing between colors it is safe to conclude that the flow is in fact laminar. This photo was taken a significant amount of time after the soap was added so it is clear that this flow has a very low Reynolds number due to the lack of mixing.

Visualization Technique:

The visualization technique used in this experiment was marking the fluid activity with food dye. The food dye was purchased from the local grocery store and is made of propylene glycol. Red, blue, green, and yellow dye was used in this experiment. Using different colored dyes allowed for capturing how the fluid mixed and where different parts of the milk were moved when the soap was added. Axe golden glitter was used as the soap drop in the center of the container. The gold soap could easily mark the location of the surfactant and the gold glitter showed the exact speed of the fluid. The milk, soap, and dye were all used at room temperature in the ITLL. 2 500-Watt lights were used to light the fluid so that the image would be vibrant.

Photographic Technique:

The size of the field of view of the photograph was approximately 4in x 3in. The digital camera was positioned about 12in from the fluid. The photograph was taken with a Canon EOS 60D. The shutter speed was 1/25 s. The aperture was f/13.0 the focal length was 126mm with an ISO of 100. The photograph is 5184 x 3456 pixels. The image was modified using Adobe Photoshop. The saturation of the image was increased. The contrast was enhanced using curves. The before and after images are shown in the figure below.

Conclusion:

The image shows the affect of a surfactant on the surface tension of a fluid. The dye marks how the fluid is pushed away from the droplet of soap and is continually moving via convection until the mixture reaches equilibrium. I would perform further experiments to determine how the soap to milk ratio affects the speed of the moving fluid. It would have been interesting to view the fluid activity from beneath the surface in a clear container to see how the dye moves in the fluid. It was difficult to take measurements during the experiment to calculate any parameters about the physics of the image. If I had a second opportunity I would have conducted the experiment so that I could gather data about the flow phenomena.

References:

[1] John W. M. Bush (April 2004). "MIT Lecture Notes on Surface Tension, lecture 1" (PDF). Massachusetts Institute of Technology. Retrieved April 1, 2007.

[2] Rosen MJ and Kunjappu JT (2012). *and Interfacial Phenomena* (4th ed.). Hoboken, New Jersey: John Wiley & Sons. p. 1. ISBN 1-118-22902-9.

[3] "Bubbles, Bubbles, Everywhere, But Not a Drop to Drink". *The Lipid Chronicles*. Retrieved 08/01/2012.

[4] Anderson, David, Dr. "Cool Science." *Cool Science*. UCCS, n.d. Web. 29 Mar. 2013. <http://www.coolscience.org/CoolScience/KidScientists/tiedyemilk.htm>.