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Flow Visualization
Film 4200-001
2/11/14

Get Wet Report

The following report details a study of surface tension driven flow generated by combining soap to milk with food coloring dropped in to visualize the flow phenomena. This experiment was conducted for the first assignment of Flow Visualization. I conducted the study in partnership with engineering student Adam Sokol. Inspiration for the experiment was drawn from a video posted on Vine.

Materials:

1) 5 inch diameter, half inch deep ceramic dish with round edges
2) ½ cup whole milk
3) 6 drops neon purple food dye
4) 6 drops neon blue food dye
5) 8 drops neon green food dye
6) Standard size Q-tip
7) 0.02 fluid ounces of dish soap

Procedure:

For visual representation refer to the figure on the final page. Pour milk into the dish until a fully opaque layer of milk fills the bottom (1/2 cup for 5 inch diameter dish). Drop 6 drops of neon purple food dye into the center of the dish, followed by 6 evenly spaced drops of neon blue food dye in a circle 1.5 inches from the center of the dish. Then, drop 5 drops of neon

green food dye along the edges of the purple dye, one drop in the center of the purple dye, and 2 more just beyond the ring of blue drops. Next take the Q-tip, submerge the tip into the dish soap and then sink it into the center of the dish where most of the drops are coagulated. Press firmly on the Q-tip and hold it for 20 seconds. After this, rotate the Q-tip clockwise 360 degrees in a three second span and then 360 degrees counter-clockwise in another three seconds. Following this, lift the Q-tip halfway out and back into the liquid 8 times and then reposition the Q-tip to a spot where the food dye has converged and press the Q-tip down into the liquid firmly for 20 seconds. Finally, repeat the last step at any other spots where dye is converging until the solution becomes fully mixed. The sun was shining very brightly on a cloudless day in Boulder, Colorado during early afternoon. It is also important to note that wind played an influential role in driving surface motion of the liquids.

The flow is really caused by an interaction between the soap and the milk. The food dye is simply used to visualize the movement that is occurring. Milk contains proteins and fats that chemically react when in contact with soap.[1] Soap, a surfactant, effectively decreases the surface tension of milk where the soap makes contact. The milk at the edge of the

[1] http://www.stevespanglerscience.com/lab/experiments/milk-color-explosion

dish maintains its surface tension and thus pulls molecules outward from the center, including the drops of food dye that rest on the surface because of their lower density.[2] Refer to figure on final page. As the droplets move across the milk, beautiful patterns begin to form. As the process proceeds, turbulent soap rises in small pockets of untouched milk causing smaller ripples of flow to push the food dye. Each time the Q-tip is moved the soap on the tip causes more reactions until the solution is too diluted.

Due to the bright, harsh light of the sun, the ISO had to be set very low (100). Next the image had to be captured at a very close distance in order to observe the phenomena best. This meant that the depth of field was going to be very shallow, so the F stop had to be turned up to 16 to compensate. With the Canon T5i and the EF 17-40mm lens, the best magnification is achieved when zooming all the way in (40mm) and setting the focus distance to its minimum value (.28m). The shutter was set at 1/160 to properly expose the image. The white balance was set to daylight.

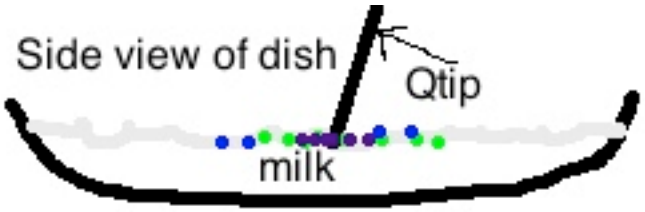
Camera: Canon T5i (DSLR)
Lens: Canon zoom lens EF 17-40mm 1:4 L USM

Resolution: 1920 x 1080
ISO: 100
F: 16
Shutter: 1/160
Focal length: 40

[2] http://www.nipissingu.ca/education/jeffs/4284Winter/PDFS/MagicMilk.pdf

Field of View: 4.5 inches wide
Distance from object to lens: 5 inches
Frame rate: 29.97fps

At first the flow is very organized, like a ripple in a pond the flow grows out from the center. But as the soap and milk drift about, causing the food dye to form more randomized shapes, the patterns become more and more beautiful and mixture begins to take form as a work of art. For a very brief moment there is a natural perfection to the chaos controlled by science. The next instant it is all gone forever, diluting into a murky haze. The camera is a wonderful creation in that it can immortalize the fleeting moment. The fluid physics are very clearly illustrated in the image. It would be interesting to see this experiment conducted on a much larger scale and also to study the subsurface effects (resurfacing soap “aftershock” effect).



higher surface tension pulls molecules out from center

top view