Flow Visualization Spring 2012
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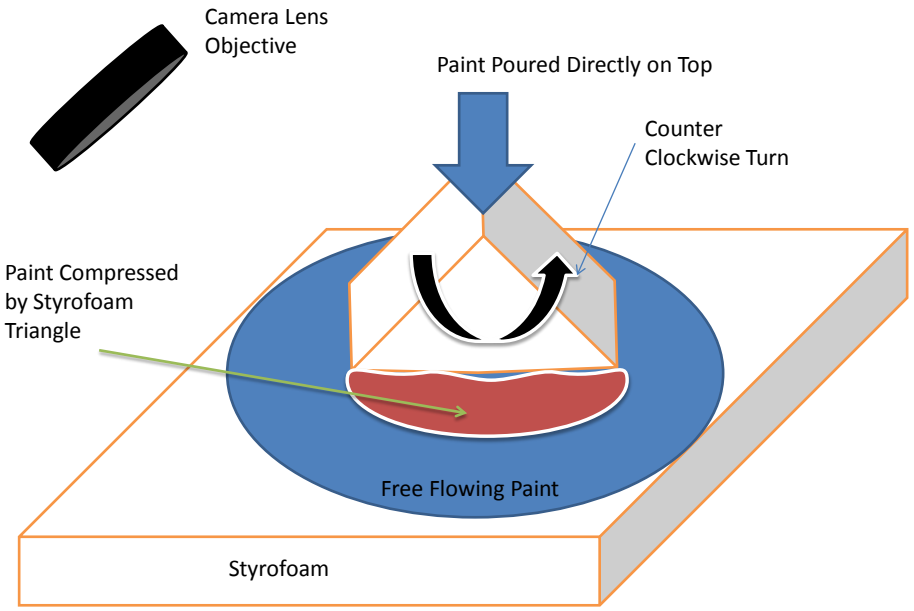
Team 3 – Thixtropic Paint

For the team 3 assignment we decided to image some sort of non-Newtonian fluid. With some research we ended up with deciding on using standard house hold paint. In our case, the paint we used was mixture of washable Crayola colored paints and a white house paint. There were around 9 different colors used in the creation of this image. The intent was to visualize how paint portrays a Thixotropic non-Newtonian fluid quality and how the paint is pressure sensitive. This was accomplished by pouring the paint on top of a surface and then pressing the paint to observe how the paint does not naturally mix. The whole setup was placed on Styrofoam to give the paint a flatter surface. Several pictures were taken of the paint but this image was chosen due to its clarity as wells as the absence of shadows and reduction of glare from the sun.

The experiment setup that was used can be referenced below in the following schematic.



Schematic 1

Initially, the experimental apparatus was setup by me and the two members of my group. The key was to somehow get a picture that would show the specific Thixotropic qualities of the paint. For this experiment, the paint was applied directly to the top of the Styrofoam tetrahedral and allowed to flow down the sides. The paint was also allowed to pool around the tetrahedral. More so, we added approximately 9 different colors as well as multiple layers of each color to really get a good picture of the non-mixing. The last step before image was to turn the tetrahedral counter clockwise nearly 180˚. This allowed for visual evidence that the paints act differently under pressure versus the free flowing paint.

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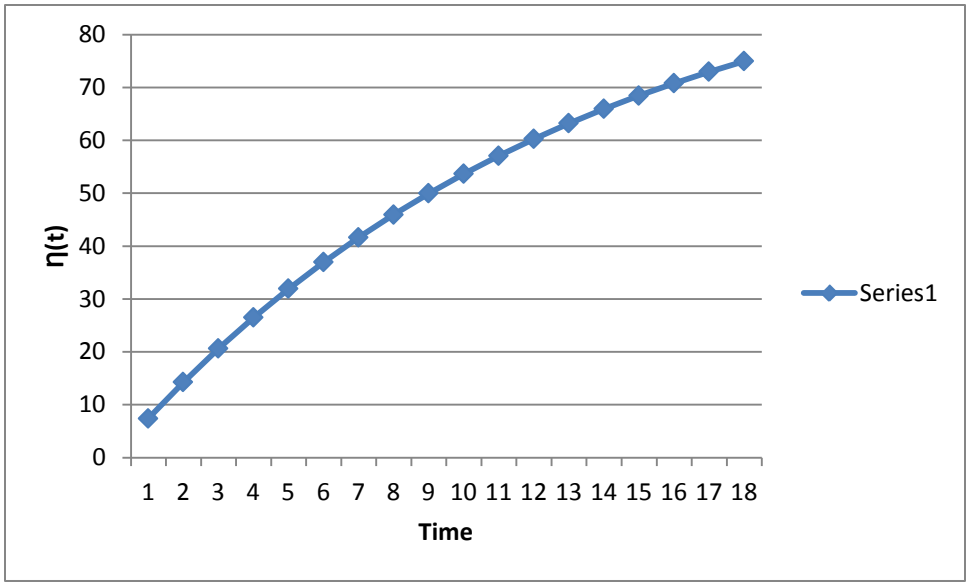
The physics of the paints Thixotropic reaction are relatively complicated because it happens on a molecular level. This is important because this what give the fluid that interesting quality. In short, Thixotropic means that under normal conditions the fluid will be very viscous and thick, and then when it is otherwise stressed it becomes much less viscous, thin and flows more easily. Research in the field has come up with several mathematical advances that can be used to calculate the viscosity of the Thixotropic material. For the physics of this image a alternate version of the Moore model will be used. This altered mathematical model will show how the shear stress of the fluid will change with time.

$$\eta(t) = \eta(0) + [\eta(\inf) - \eta(0)][1-e^{-t/\tau}]^{1}$$

For our purposes we will estimate the following variables to show it behaves like a Thixtropic fluid. In the above equation there are several values to be estimated. For starters there are two types of η, sheared out viscosity at time zero and infinity. Then there is merely just t, time being sheared in seconds; and τ for the shear stress in Pa. For the calculation we will simply assume no sheared out viscosity at time zero, and 100 at infinity with a measured time of 10 seconds with a shear stress of 13. Results are displayed in the graph below and show that viscosity is decreasing with the duration of stress.



The most crucial part of visualization for this image was mostly finding the right mixture of lighting. There was a severe problem when it came to photographing because the apparatus was done outside on a rather sunny day so the glare was casing a lot of imaging problems. Luckily after several

[1] "Paint and Coating Testing Manual: Fourteenth Edition of the Gardner-Sward ... - Google Books", n.d., http://books.google.com/books?id=ri6FkY2xvgcC&pg=PA342&lpg=PA342&dq=shear+stress+equilibrium+for+paint&source=bl&ots=U90gF35iyq&sig=wTM85fh6XItxGBSrxuDnD5FJEls&hl=en&sa=X&ei=TzKfT5y_Eoac2AWb5dnFAg&ved=0CCUQ6AEwAA#v=onepage&q=shear%20stress%20equilibrium%20for%20paint&f=false.

attempts we managed to get cloud cover and the glare disappeared. This is when we took the picture. We also took multiple pictures of same image due to the fact most of the zoomed images were fairly blurry. But we managed to get the right shot with the right amount of light and distance from the paint. Another problem we ran into was the fact of shadows appearing from where we took the images. This was easily fixed by moving the whole setup ever so slightly. We finally got the perfect image after several trials with enough sharpness and quality to visualize the properties we were trying image.

The size of the image was roughly taken in the field of view of ~1x1ft and around 2 ft from the lens objective of the camera. In order to capture the final image flow a Canon EOS DIGITAL REBEL XSi was used. The resulting image was 4272x2848pixels with an exposure time of 1/500sec.More so the F-stop used was set at f/4.5 with an ISO of 125. Ultimately, the final image was given with the focal length of 34mm with not flash. Once the final image was chosen it was imported into GIMP2 and the colors were inverted to give better visualization of the colors mixing and not mixing.

Overall, the image was somewhat idea for showing how paint can act as a Thixotropic fluid. The final image was also able to show the paint interacting with and without stress. Not only that it was able to show how stress can even cause the colors to mix and how the paint became less viscous when it was stressed for some time. The physics of the fluid were then able to be recognized by these two different phase states in the same image. More so I really like this post processed image because it really allows the colors to identify from each other and makes the glare unnoticeable. I definitely fulfilled my intent with this image but next time I would like to use paints of the same type as in all washable or all permanent. In the future, I would go in the direction of applying more stress and having a more uniform setup to possibly show the properties of a Thixotropic fluid with time.

Sources:

"Paint and Coating Testing Manual: Fourteenth Edition of the Gardner-Sward ... - Google Books", n.d. http://books.google.com/books?id=ri6FkY2xvgcC&pg=PA342&lpg=PA342&dq=shear+stress+equilibrium+for+paint&source=bl&ots=U90gF35iyq&sig=wTM85fh6XItxGBSrxuDnD5FJEls&hl=en&sa=X&ei=TzKfT5y_Eoac2AWb5dnFAg&ved=0CCUQ6AEwAA#v=onepage&q=shear%20stress%20equilibrium%20for%20paint&f=false.