MCEN 4151- Flow Visualization

Get Wet Written Report

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The purpose of this assignment was to get "our hands wet" on making a good photo of any combination of fluids, and/or any fluid that demonstrates the phenomenon being observed. As seen below in **Photo 1,** I chose my final get wet image as the fog filled bubble landed on a tree branch. At first my intent was to capture a good photo of a fog-filled bubble as it breaks its surface tension and releasing the fog into the surrounding. Unfortunately being an inexperienced photographer I was having a very tough time following the bubbles along while trying to keep the focus on a moderately windy day. After awhile I noticed the bubbles were landing on a tree branch and I was able to observe the multiple layers of fog forming inside the bubble while little fog particles were constantly in motion without disrupting the surface tension of the bubble.

Photo 1 Get Wet Final Image – Fog Filled Bubble

Photo 2 Fog-Bubble Machine

The flow apparatus used for this assignment is known as fog-filled bubble machine, which can be seen above in **Photo 2**. This fog machine is often used for Halloween parties. I was fortunate enough to borrow one from my friend's fog –bubble machine and shared the machine with a fellow classmate Steven Hendricks for this assignment. This fog-filled bubble machine has a power cord and two containers: one of the containers is located in the front of the machine to fill the bubble solution and other container is in the rear to fill the fog liquid. This machine also had two switches: on/off switch and the switch to control the size of the bubble (small/large). For this experiment because of the windy condition it was difficult to make the larger bubbles, therefore the size of the bubbles was set to small. Once both containers were filled with proper solutions the machine was plugged into the wall and turned on. Once machine was warmed up, a little circular tube attached to a mechanical arm was lowered to the bubble solution container and then it was raised back to its initial position then the fog was pushed into the circular tube thus producing bubbles filled with fog. It was observed that the diameters of the small bubbles varied from *3.2* to *3.75 inches*.

There are a few interesting fluid phenomena which can be observed from fog filled bubble image. One of which is known as thin film effect or soap bubble effect. This phenomenon is closely related to surface tension and shape. The reason that you cannot blow a bubble with a pure water is the fact that water molecules has a certain amount of surface tension, although surface layer of water behave similar to an elastic film it needs a dissolved surfactant such as soap is needed to stabilize a bubble[2]. Soap molecules are composed of long chains of carbon and hydrogen atoms and surface layer of soap is extremely flexible. As seen in **Figure 1**, once soap molecules are mixed with water molecules, the chemical reaction will occur and this reaction will cause the pull of surface tension to decrease thus stabilizing a bubble - typically to about a third that of pure water and during this process a thin wall will be formed [2]. Another factor to consider is the shape. The spherical shape of a bubble is also due to surface tension as well. The sphere has the smallest possible surface area for a given volume, therefore taking up a spherical shape minimizes the free surface of a bubble [1].

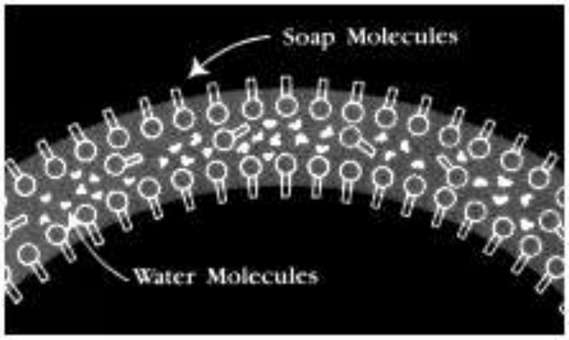

Figure 1 Chemical Reaction of Water Molecules and Soap Molecules

A surface tension gradient between two fluids due to mass transfer is known as the Marangoni effect. The Marangoni number is a dimensionless scale that can be used to describe the relative effects of surface tension and viscous forces which can be seen below in **Equation 1[3]**.

$$Mg = -\frac{d\sigma}{dT}\frac{1}{\eta * \alpha} * L * \Delta T \quad \textit{(Eq. 1)}$$

$\sigma: Surface\ tension, (N/m)$
$L: chracteristic\ length, (m)$
$\eta: dynamic\ viscosity, (\frac{kg}{s^2 * m})$
$\alpha: thermal\ diffusivity, (\frac{m^2}{s})$
$\Delta T: temperature\ difference, (°C)$

The following section will discuss the detailed photographic technique used to produce the final image. Canon Rebel EOS T2i Digital Lens Single Reflection (DSLR) camera with macro lens was used while the distance from the object was near *0.3* to *0.5 ft*. It was shot front of my house using the natural lighting. The camera was set to Av (Aperture priority) so that camera can automatically decide depth of field. The diameter of this particular bubble in the final image was approximately *3.2 inches*. The original and final image pixel dimensions were *6144 x 4096*, aperture and shutter speed was set to *f/5.6* and *1/160sec*. The ISO was set to auto mode. Photoshop CS5 was used to edit the contrast/brightness and hue/saturation of the image. Although very small adjustments were made from original image in order to bring out the darker contrast of the tree branch and gloominess of the fog inside the bubble.

Based on observation, the final image did revealed the one of interesting fluid phenomenon known as soap bubble effect and refraction on the surface of the bubble due to surface tension gradient. I enjoyed working on this assignment because through this opportunity I have learned a lot about photography and some of intricacy techniques involved beyond just capturing a photo. I wish that I had researched on the phenomenon before getting into taking photos of object. I had hard time coming up with control setting while thinking of what kind of physical phenomenon is occurring due to fluid in motion. As an inexperienced photographer I would like to learn more about capturing images of fluid particles in motion in a more control environment while exploring with unbounded creativity.

References

[1] Boys, C. V. (1890) "*Soap-Bubbles and the Forces that Mould Them,"* Dover publications, Mineola
[2] Hipschman, R. (1995) http://www.exploratorium.edu/ronh/bubbles/bubbles.html
[3] Isenberg, C. (1992) "*The Science of Soap Films and Soap Bubbles,"* Dover publications, Mineola