Swell: Team Second Report 2018

MCEN 4151

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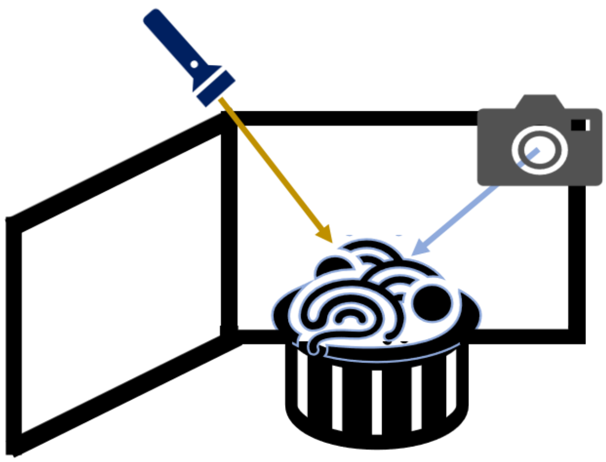
The conception of this video was developed through our team wanting to experiment with dry ice and bubble formation. We set out to build an experiment in which dry ice bubbles would form and pop during the sublimation process whereby dry ice transforms from solid to gas through the medium of dish soap and water. Ziwei helped set up the experiment such that there were no distractions in the shot and held the light, while Joe placed the dry ice and poured the dish soap and water into the pot to complete the mixture.



A pot was used to initiate the experiment. First the dry ice was place inside. Next, the water and dish soap were mixed in as well. The reaction of these ingredients caused the carbon dioxide from the dry ice as well as water vapor to be trapped in soap bubbles as the dry ice sublimated. Upon popping, these bubbles released the CO2 and water vapor into the air creating a nice smoky reflection. The video was taken as the dry ice-soap water mixture overflowed from the pot, emerging as new bubbles in a multiplying array [1]. Focus adjustment was used to capture different depths of bubble creation. This setup provided a good visualization of bubble formation [2]. In the video, droplets fly upward and reach their peak at about eye level which is approximately two feet above the drum head. Since the bubbles are moving about 5 cm/sec as seen in the video playback, we will use an equivalent fluid velocity of $0.05\,\frac{m}{s}$. Also, knowing the bubble diameter is 4 cm = 0.04 m and the kinematic viscosity of water is $1.004 * 10^{-6}\,\frac{m^2}{s}$,

we can calculate the Reynold's number as follows [3]:

$$Re = \frac{uD}{v} = \frac{\left(0.05\,\frac{m}{s}\right)(0.04\,m)}{1.004 * 10^{-6}\,\frac{m^2}{s}} = 1.992 * 10^3$$

Since turbulent flow occurs for $Re > 3{,}000$, and Re = 1,992, for this experiment, the flow is laminar and stable [3]. This discovery makes sense as the fluid particles appear to be somewhat static and uniform in the video until popping. The field of view in this video varies but is usually approximately ten inches wide and 7.5 inches tall. The shutter speed of 1/60 s was sufficient to capture the video without causing motion blur and was set to be twice the frame rate which was 30 fps. The stability of this flow is due to the lack of perturbation in the standing fluid and is only disrupted by the carbon dioxide overcoming the surface tension of the bubble whence the bubble succumbs to the pressure differential across its membrane [2]. This effect is an appealing visualization of dry ice.

The dry ice was sourced from King Soopers as well as the dish soap. Approximately 4 fluid ounces of dish soap were used along with a 8" X 5" X 4" block of dry ice. Lighting was provided by a hand-held flashlight that was reoriented for various angles. The video was shot in a fully dark garage except for the supplied light, and the temperature was approximately 60 degrees Fahrenheit. A backdrop of three plywood boards was used to block light from diffracting off other objects in the room.

I used a Canon T6i DSLR to achieve this shoot. The lens was held at about seven inches from the bubbles and the focal length of the lens was $f = 35mm$ which is the maximum zoom for the kit lens used. I used an aperture of f/5.0 which gave a narrow depth of field and made the center of the image pop. The fast shutter speed of 1/60 sec gave a crisp video with low motion blur. An ISO of 400 was utilized to allow for proper exposure with moderate lighting provided by the flashlight. Corel Video Studio was the tool used for editing and transitions. I tried to keep the editing minimal to enhance the focus of the video as the fluid flow phenomenon.

This video was a helpful aid in showing the process of dry ice becoming entrapped in soap bubbles and escaping under pressure differentials. I like the movement of the dry ice vapor as the bubbles pop as well as the bubble formation patterns. If I were to retry this video, I would use a tripod to achieve more stable footage and would try a fixed lens to take in more light with a higher aperture. It would also be fascinating to capture a slow-motion video of the dry ice bubbles as they pop, revealing the unfolding motion of the soap bubble sheet as it unravels. Overall, I am happy with this experiment and enjoyed creating a new visualization of a classic dry ice experiment.

References

[1] Abramson, H.N. "The Dynamic Behavior of Liquids in Moving Containers." NASA SP-106, 1966.

[2] Moiseyev, N.N. & V.V. Rumyantsev. "Dynamic Stability of Bodies Containing Fluid." Springer-Verlag, 1968.

[3] "Reynolds Number". www.grc.nasa.gov.