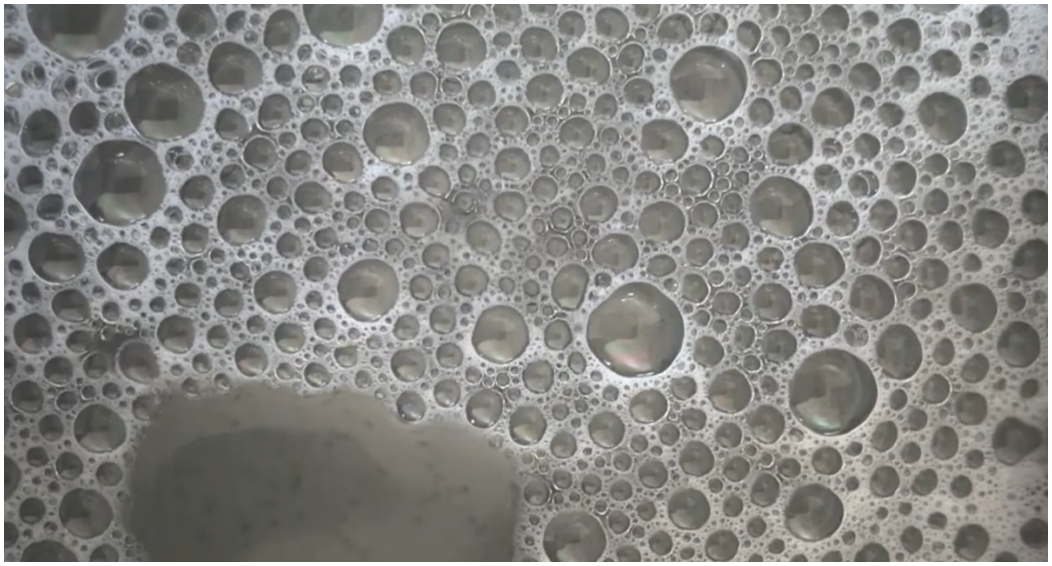

MCEN 4151- Flow Visualization

Get Wet Report- Shifting Bubbles

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Section 001

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I. Background

For this project, I set off to capture an image of bubbles in a mug. I set out to take my image during late afternoon or early evening, so the light shining off the bubbles was very colorful and complex. I was using diluted dish soap and water to produce bubbles. As I was trying to produce bigger bubbles by swirling the liquid around in the mug, I realized that the bubbles had a lot of interesting movement as they popped, so I shifted my focus to capture a video instead.

II. Experimental Setup

The video was shot on my iPhone, which made capturing the correct focus a bit difficult. I realized early on that I would have the best result if I figured out the distance from the medium that the camera wanted to focus at, as opposed to using the phone's automatic focus. Once I had a rough idea of where the phone should be, I stacked up various jars to hold the phone in place, as shown in figure 1. I also placed the mug on a piece of cardboard that had been painted black, to best capture the light shining off the bubbles.

Figure 1

III. Fluid Dynamics

The bubbles sticking to each other as well as the walls of the mug can be explained by the "Cheerios Effect." The bubbles stick to the walls of the mug because the wall of the mug warps the air- water interface. Since the bubble is buoyant, it wants to rise vertically. However, the bubble is constrained to the meniscus of the water- air interface, so it can't just float away. In order for the bubble to rise, it moves upward along the meniscus until it reaches the wall [1].

The bubbles themselves stick together because each bubble slightly deforms the surface of the water, which forms a local meniscus. This local meniscus has enough influence on surrounding bubbles, that they also rise along the meniscus and stick together forming a "raft" of bubbles [1]. This explains why the bubbles flow towards each other and end up forming an empty space. Since there is no deformation along the surface of the empty space, the bubbles are more attracted to one another.

IV. Photographic and Visualization Techniques

The fluid flow was captured using marked boundary techniques [2]. The image captures a distinct boundary between the lighter colored air bubbles and the darker liquid around them. The bubbles themselves are Mrs. Meyers Clean Day dish soap, the basil scented variety, as shown in figure 2.

Figure 2.

There were no specific methods of lighting used other than the ambient afternoon lighting coming through a west and a north facing window.

Since I was shooting on an iPhone 11 pro, the field of view was pre- set for me, and I was unable to change it. I chose the distance of the object to the lens based on where the image looked the most focused as I moved my camera towards and away from the subject. I wanted to avoid the iPhone's automatic zoom, so placed the phone where it would impose its own zoom as little as possible. The original image size was 511x 900 pixels. The processed image is 443x 786 pixels. The unedited video was shot at 29.97 fps, during processing I sped up the clip 2x to get a playback speed of 59.94 fps. During processing I also applied the auto filtering effect setting in iMovie. I'm not positive what this does, but it made the image more blue, which I thought looked nice, and brought out some of the depth in the image.

V. Conclusion

The video reveals the active nature of bubbles; something that I hadn't paid much attention to before. I like the playback speed; I feel like it is slow enough to capture the popping of the bubbles, while not being so slow that it becomes boring. I would have preferred to have had a higher resolution video that captured the light reflecting off the bubbles a bit more. I think I succeeded in capturing the movement of the bubbles, albeit at a lower resolution than I would have liked. If I were to try this again, I would like to use a camera instead of a phone, which I think would give the image more depth as well as increasing resolution.

VI. References

[1] Vella, Dominic, and L. Mahadavan. *The '"Cheerios Effect"' - Harvard University*, Sept. 2005, softmath.seas.harvard.edu/wp-content/uploads/2019/10/2005-13.pdf.

[2] Hertzberg, Jean. "Overview 2: Visualization Techniques." *Flow Visualization*, 13 July 2023, www.flowvis.org/Flow%20Vis%20Guide/overview-2-choices-2-and-3/.