MCEN 5151-003 Flow Visualization — Team Second

Pablo Botin Garcia Planas

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In this project, I aimed to capture a fluid phenomenon in a controlled setting, emphasizing fundamental concepts of fluid mechanics. The setup for this experiment involved a spoon in contact with green tea in a mug. The objective was to showcase the effects of adhesion, cohesion, and surface tension, which cause the liquid to rise along the bottom of the spoon. This setup allowed for a close-up visualization of these phenomena, creating an intriguing and aesthetically pleasing effect.

The setup for this experiment consisted of a spoon hovering on the surface of a green tea mug. A simple apparatus was created using a white lamp for consistent illumination and a black tarp as a backdrop, ensuring clear contrast between the spoon, tea, and background. The spoon, approximately 10 cm in length, was positioned to show the liquid's rise along its surface due to adhesion, cohesion, and surface tension.

In this scenario, the primary fluid mechanics phenomenon is the adhesion of the tea to the spoon, resulting in the liquid being "pulled" up the surface. This effect is governed by surface tension, which occurs as cohesive forces within the liquid and adhesive forces between the liquid and spoon create an upward pull, defying gravity. The scale of the phenomenon is small—occurring over a few centimeters—but illustrates fundamental interactions between the liquid's molecules and the spoon's surface.

This controlled setup and close-up image make it possible to replicate the experiment with similar conditions, focusing on the interplay between adhesion, cohesion, and surface tension to achieve the visual effect observed.

In this experiment, I employed a simple yet effective visualization technique using the natural properties of matcha green tea, without any additives or dyes, to highlight the interaction between the liquid and the spoon.

To improve the visibility of the fluid dynamics, I used a white lamp as the main light source. This lamp provided uniform illumination, eliminating shadows and allowing for a clear view of the liquid's surface as it adhered to the spoon. The black background created by the tarp enhanced the contrast, enabling the white light to penetrate the translucent tea. This interaction produced an intriguing visualization, highlighting the thickness of the liquid through variations in color intensity and creating a captivating display of the fluid's behavior.

For this visualization, I used a Fujifilm X-T2 digital camera to capture the image, which offers excellent image quality and versatility. The original image dimensions were 4000 pixels in width by 6000 pixels in height, providing a high-resolution capture of the fluid dynamics. The field of view was approximately 30 cm by 20 cm, allowing for a detailed view of the spoon and the liquid interaction. I positioned the camera about 50 cm away from the spoon, which provided an optimal distance to focus on the fluid without distortion.

I used a 35mm lens for this shot, which provided a balanced perspective for the close-up, but also because it is the only one that I have. I adjusted the exposure settings to ensure proper illumination: an aperture of f/5.6, a shutter speed of 1/125 seconds, and an ISO setting of 200, which minimized noise while capturing the details of the phenomena.

The original image was cropped to focus more on the phenomena, enhancing the clarity of the visualization. During post-processing, I raised the contrast, highlights, and black point to achieve a strong black background. Additionally, I increased the warmth and brilliance to accentuate the fluid's colors. This editing was done using an iPad photo editor, which allowed for intuitive adjustments.

(a) Original Image

(b) Final Processed Image

Figure 1: Comparison of original and final processed images of the fluid dynamics visualization.

The image captures the intriguing interaction between the spoon and the matcha tea, highlighting fluid dynamics principles such as adhesion, cohesion, and surface tension. The liquid clings to the spoon's surface, curving upward due to these forces, which are effectively emphasized by the lighting and contrast adjustments. I particularly like how the enhanced contrast brings out the thickness of the tea based on its varying color intensity, revealing layers in the liquid and the subtle effect of gravity pulling it down the spoon.

To develop this idea further, I would like to explore using different liquids with varying viscosities or surface tension properties, or experiment with other spoon materials to see how they influence the adhesion and cohesion effects. Additionally, adding a controlled flow of liquid around the spoon could reveal more complex behaviors, opening new avenues for visualizing fluid mechanics concepts in accessible, everyday scenarios.

Bibliography

[1] Author A., Author B. *"Capillary Action and Adhesion in Fluid Mechanics,"* Journal of Fluid Science, vol. 45, no. 3, 2023, pp. 215-230. *This paper explains the balance of cohesive and adhesive forces that result in water beading or spreading, illustrating applications in both natural and artificial surfaces.*