Wax On, Wax Off

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Context and Purpose

In this image I was inspired by memories of living in Florida and driving in the rain often. I would notice the distinct difference between my car before a car wash and my car long after a car wash, and how they were very different experiences. On one hand, I could drive in torrential rain and not use my windshield wipers and see clear as ever! On the other hand, was as if I was partially blind and my wipers couldn't keep up, even at max speed. I wanted to take a deeper look into this and understand better why this behavior occurs, and most importantly – how it works.

Flow Description

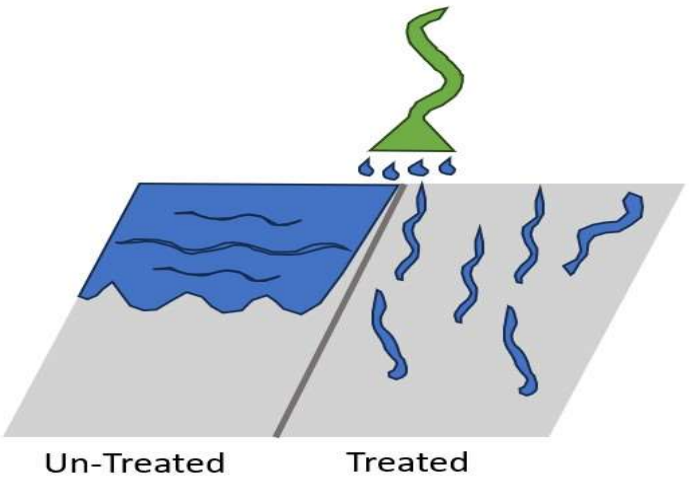

Figure 1: Sketch of setup used for image capture.

Shown in Figure 1 is the experimental setup used to capture the image. It consists of a flat plate (my car's back window, made of glass), where half of the plate is coated with a surfactant solution, and the other has only been cleaned with alcohol. The surfactant used was Turtle Wax ICE Spray Wax [3]. A hose with a gentle flow of water was then directed towards the plate to capture the behavior of the fluid on both sides of the plate. Credit to AJ Corne for assisting in the setup of this image.

The flow of water is not time dependent as it was constant. The Reynolds number changes only as a factor of velocity as all other variables are constant. The water is solely affected by the surface friction properties of the flat plate which is displayed by comparing the treated and untreated portions of the plate. Untreated, the plate has a higher surface friction, and therefore the water has a lower velocity as it slowly travels down the plate in a "blanket-like" fashion. Treated with a surfactant to reduce surface tension, the water rapidly forms into "beads" and collects until a "snake" is formed and rapidly travels down the plate [1]. The most prevalent feature in this experimental setup is the surface area of reflective material. Although flowrate is constant, the lower surface friction area can reflect significantly larger amounts of light in mirror-like quality.

As a rough estimate we can compare the change in Reynolds number with the velocity of the water on the plate [2].

$$Re_{Untreated} = \frac{UD}{v} = \frac{\left(.05\frac{m}{s}\right)*(.1\ m)}{1.004*10^{-6}\frac{m^2}{s}} = 5000$$

And

$$Re_{Treated} = \frac{UD}{v} = \frac{\left(.15\frac{m}{s}\right)*(.1\ m)}{1.004*10^{-6}\frac{m^2}{s}} = 15000$$

As you can see, the Reynolds number is linearly dependent because all that is changing is the velocity of the water.

Visualization Technique

The most difficult part of this image was getting the frame and focus to matchup and give a result that I was happy with. The lighting was natural, as the sun was setting below the homes nearby and provided the opportunity for photos free of sun flares. The continuous flow of the hose allowed for several attempts to capture several angles. I was not aware of any better visualization techniques that would improve the image quality while allowing for several gallons of water to be disposed.

Photographic Technique

Figure 2: Unedited image taken with this setup.

The image settings are described here as follows. The camera used was a Sony A7Riii with a Sony FE 16-35mm F2.8 GM lens. The Camera settings were an aperture of f/18.0, exposure of 1/640 second, focal length of 23mm, and ISO was 20,000. The plate was approximately .3 to .4 meters away. The image resolution was 7980x5320. The raw image file was processed using Darktable, where brightness, RGB curve, and image size were edited. I am a novice at photography, so I relied heavily on automatic camera functions in this image. I did also manually try different focus lengths but struggled to focus on the water and not the glass.

Reflection

Overall, I am satisfied with this image. It was the first assignment and really forced me to learn my newly acquired camera. Key areas for improvement are focus and lighting. I think improving those areas would significantly improve the quality of this image. This could be achieved by using a tripod and capturing the image in an indoor, controlled environment. I was happy to see the results I imagined be displayed quite well. There are several surfactant related ideas I could create at a more macro level to show the inner physics details of the phenomena.

References

[1] Encyclopædia Britannica, inc. (2023, September 20). *Surfactant*. Encyclopædia Britannica. https://www.britannica.com/science/surfactant

[2] Hertzberg, J. B. (n.d.). *Report guidelines - flowvis.org*. Flow Visualization: A Course in the Physics and Art of Fluid Flow. https://www.flowvis.org/wp-content/uploads/2022/09/ReportGuidelines22.pdf

[3] *Ice spray wax*. Turtle Wax US Store. (n.d.). https://www.turtlewax.com/products/ice-spray-wax-20fl-oz