Get Wet Report Write Up

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Flow Visualization: MCEN 4151-001

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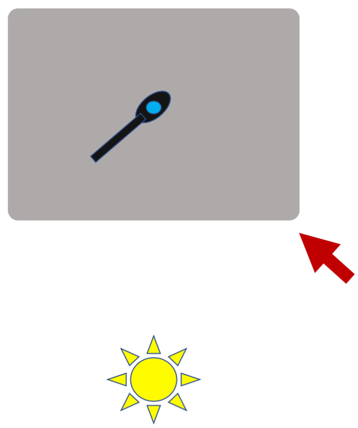
This was the initial assignment for Flow Visualization, and the purpose was to become familiar with taking photographs or video of fluid flows. My fluid flow was a gravity-driven stream of water from a sink facet impacting a concave spoon and then scattering into a thin film and water droplets. My inspiration came from washing spoons and getting wet when the spoon redirected the flow of water. I was trying to capture a close-up image of the water scattering in all directions because of the spoon. I also wanted to see the ring where the thin water layer transformed into water droplets as the water flew away from the center of the spoon.

My set up included a regular kitchen sink with and a spoon. As seen in the diagram below, the spoon was held underneath the facet by my roommate about one foot below the nozzle. There was an overhead light about 5 feet before the sink represented by the sun symbol. As shown with the red arrow, the camera was positioned at the corner of the sink about 1.5 feet away from the spoon and slightly above the spoon looking down.



Once the facet was turned on, the water impacted the spoon, and the vertical flow was diverted in all directions horizontally. Once the water starts to flow, the forces do not change with time. The spoon exerts an upward force on the water. The water exerts intermolecular forces between the water molecules and pushes the water up the sides of the spoon and finally into the air. Within about 1 inch of the rim of the spoon, there is a thin sheet of water, but then transitions to water droplets because the speed of the water decreases[1].

As seen in the image, the gravity-driven flow from the facet appears to be turbulent because the stream is not transparent and looks as if there are some bubbles. If the Reynolds number is greater than 4000 it would be confirmed that the gravity-driven flow is turbulent. The Reynolds number is calculated by:

$$Re = \frac{uD}{\nu}$$

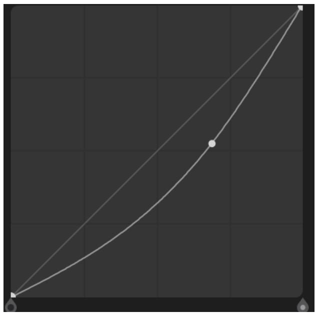
Where u is the velocity of the stream, D is the diameter of the stream, and ν is the kinematic viscosity of the water. In order the find u, the velocity, the equation

$$m_{dot} = uA$$

must be used where m_{dot} is the mass flow rate of water, and A is the cross-sectional area of the flow. From my measurements, $m_{dot} = 1.4 * 10^{-4} \frac{m^3}{s}$ by using a measuring cup, and $A = 1.34 * 10^{-4} m^2$ by measuring the diameter of the stream to being 13 mm. Therefore, the velocity of the stream of water was $u = 1.05\frac{m}{s}$. Now solving for the Reynolds number, $Re = \frac{1.05\frac{m}{s} * .013\ m}{1.05*10^{-6}\frac{m^2}{s}}$, $Re =\ 13000$. The flow was confirmed to being turbulent because $Re > 4000$.

For this project my goal was to photograph something that could be seen in everyday life. Because of this, I did not use any dye, smoke, or other medium to make the flow stand out more. I felt that using natural water was best. In the diagram above, the sun symbol represents where the lighting was located. There was an overhead light about 5 feet before the sink that was turned on. I did not use the flash on the camera.

I wanted to capture the water as it was redirected from the spoon and while the water was in the air. The size of view is 6 inches across the frame. The camera lens was 1.5 feet away from the spoon. My lens focal length was 39 mm, which made the image focus more on the spoon and water. I used a digital Canon EOS Rebel T6i camera with a 18-55 mm lens. The original image was 6000 by 4000 pixels and the edited image was 5088 by 2308 pixels in order to crop out most of the sink. The shutter speed was set to 1/320 in order to get a still image of the water, and the camera set the aperture to 5 and ISO to 6400. In iPhotos, I cropped the image to remove the distracting sink. I slightly reduced light and increased the color. I also changed the curve to make the spoon shinier and the background darker. Seen below is a screen shot of the final curve settings.



Seen below is the original image.

The image reveals close up how the water flow is redirected by a spoon and where the water droplets begin to form. I like how large I made the image so that the water droplets appear large and the viewer does not have to squint. I also like how the brightest part of the image is at the center of the image and darkens as you move to the border of the image. I dislike how the background is not one solid color, but it is interesting how the water stream from the sink separates the darker section on the left from the lighter background on the right. I think the fluid physics is shown pretty well, but if I had better lighting I would have liked a faster shutter speed to make the image even more clear towards the far water droplets. I fulfilled my intent and am very happy with my final edited image. In the future I would put a solid colored board in the back to make a solid colored background. To develop this idea further I would try the experiment with larger and smaller spoons to see if the thin layer of water would break up closer or farther away from the spoon edge for various spoon sizes.

References

1. Eggers, Jens. "Physics of Liquid Jets." *Semanitics Scholar*, pdfs.semanticscholar.org/ea4a/737e9246cfb0989efb1abbbbd3524fe0ca36.pdf.