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Team First
Flow Visualization 2023
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The image was taken for the second team assignment for the fall semester of Flow Visualization. This assignment focused on collaborating with your team, whether that's doing similar projects or consulting teammates for advice on how to execute an idea. For this team assignment, the group decided to use a flume machine to see how a flow will interact with a toy car. This image was taken with help from AJ Terio, Ciaran Rochling, and Shane Maurry.

The apparatus used to create this photo was an Armfield C4 Tilting Flume machine, similar to the one pictured below. This machine works by pumping water through a channel to visualize different flow mechanics. The channel within the flume machine was 3 inches wide. Inside of this channel a toy car was placed on to a broad crested weir using adhesive pads. The weir was 13.5 inches long and was placed 24 inches away from where the water first entered the channel. The channel had a 2° incline to increase the speed of the water. The flume machine was then turned on until the flow fully developed over the toy car. It took the flow .75 seconds to pass the 13.5 inch weir. Converting inches per second to miles per hour gives a flow speed of 1.02 mph.

Figure 1: C4-MKII Multi-Purpose Teaching Flume

For this experiment, gravity was one of the primary forces that acted on the system. This caused the flow to continue down the channel to pass over the car. In addition, the centrifugal force that was used by the machine's pump to get the water out of the tank and up into the channel supplied an initial velocity to the flow. Adhesion and cohesion also played a role within the reaction between the adhesive pads and the toy car. The adhesion caused the car to stay in place while the force of the flow was pushing against the car. This then forced the flow to rise in level and go over the car. The cohesion within the adhesive pad made it so that the adhesive itself did not deteriorate as the forces were acting upon it.

A piece of information that will provide more insight into the flow is the Reynold's Number. This will provide whether the flow had laminar or turbulent behavior. The equation for the Reynold's number is:

$$Re = \frac{\rho u L}{\mu}$$

With ρ = the density of the water, u = the flow velocity, L = the channel diameter, and μ = the dynamic viscosity of the water. Substituting the values of the flow in this experiment and water properties yields:

$$Re = \frac{998\frac{kg}{m^3} * .46\frac{m}{s} * .08\,m}{9.75*10^{-4}\,Pa*s} = 37,668$$

This high of a Reynolds number means that the flow was turbulent (Engineering Library). This is not very surprising as the flow was moving quite quickly in a small area over the car.

Visualizing this flow was relatively simple. No dyes or additives were used within the water. The main source of lighting were the lights on the ceiling above the flume machine. However, additional lighting from an iphone flashlight was used about 8 inches above the car in order to capture more detail.

The image was taken using a Canon EOS REBEL T1i. With the settings

- Focal Length: 29 mm
- Aperture: f/4.5
- Shutter Speed: 1/250s
- ISO: 800

The camera was about 6 inches away from the toy car when the photo was taken. Google's photo editing software was used to enhance the colors, make the image brighter and crop the image. In addition, the magic eraser tool was used to get rid of one of the adhesive pads below the car. The original photo was 4752 × 3168 and was cropped to 4752 × 2496.

Figure 2: Original Image

I am pleased with how the edited photo turned out. The original image was quite dark so it was nice to see that more lighting was able to be added to the image without looking too unnatural. If this experiment were redone, I would use less water. This way the effect of the car's geometry on the flow could be seen. In addition, adding some glitter or floating particles could help better visualize the flow. Finally, more light would be added to the original image to allow for a higher quality end product.

Citations:

Armfield
https://armfield.co.uk/product/c4-mkii-multi-purpose-teaching-flume/

Celadon Technology
https://www.celadon.com.tw/en/faq/Celadon-Tech-faq-003.html

Engineering Library
https://engineeringlibrary.org/reference/laminar-and-turbulent-fluid-flow-doe-handbook

Pumptec
https://www.pumptec.com/blog/centrifugal-pumps-vs-positive-displacement-plunger-pumps