Team Second Report
MCEN 4151-001: Flow Visualization

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Introduction

As a team we chose this image strategy because we are all intrigued about the flow profile of a given car profile. Through the last couple years I have become very intrigued about the different profile shape effects on the drag force of the car. The drag force is a very important variable, because at high speeds the car's structural integrity will be affected. Also, due to the drag force the fuel efficiency is affected, because it requires more fuel to maintain that speed. The intent of this image was to get a visualization of the flow profile of the selected car model, similar to a smoke machine performed to analyze the flow profile. This assignment was completed with the help of: Aj Corne, AJ Terio, and Ciaran Rochling. The final image can be seen in Figure 1 below.

Figure 1: Flow Profile of model car in the C4 Tilting Flume Channel

Flow Apparatus

The flow apparatus that was used in our experiment was the C4 Tilting Flume Channel in the ITLL [2]. This machine allows the principles of fluid mechanics to be visualized in an open channel flow. The width of the C4 Tilting Flume Channel was 3 inches, and the length of the flow was approximately 40 inches. In order to create the desired output, a wood block was placed into the flow channel, as seen in Figure_. This woodblock allowed us to place the model car on top of the block and visualize the flow profile after passing through the car. The model car was placed on the woodblock using double sided tape, and pressed down firmly. With the car placed within the open channel, the water was turned on and the flow began. We tried different levels of volumes of water, and decided on one that allowed us to visualize the drop off after the model car.

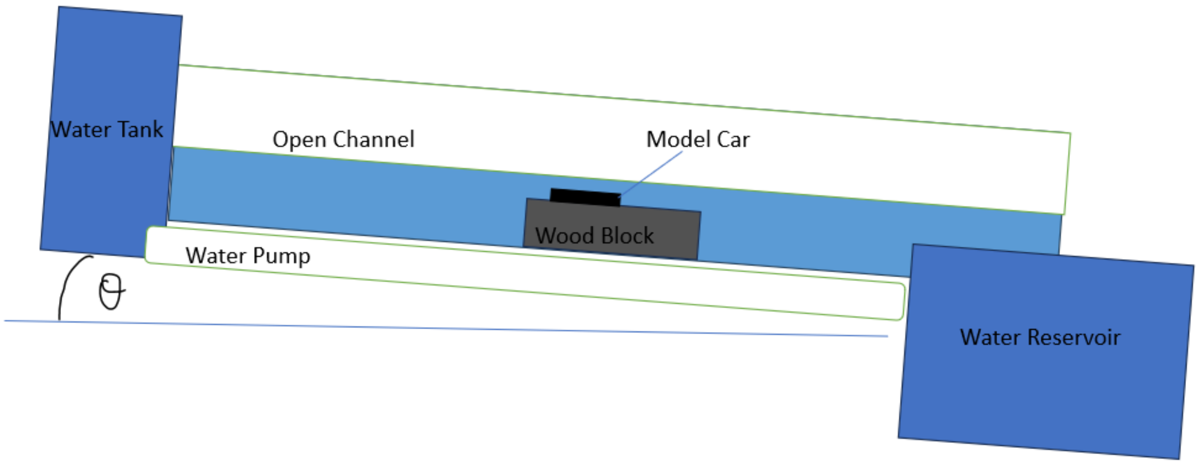

Figure 2: Digital drawing of the C4 Tilting Flume Channel

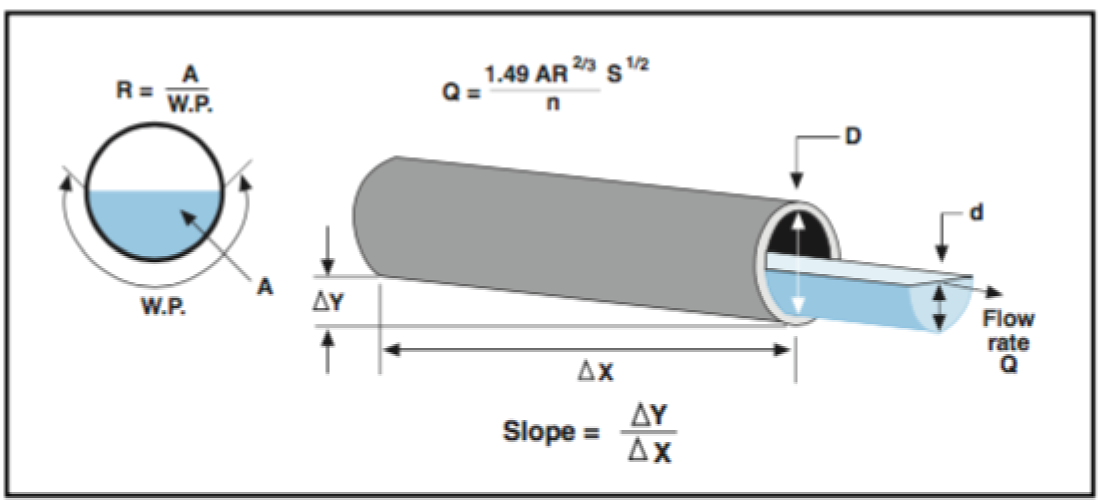

Figure 3: Calculation for the Hydraulic Radius

$$Q = \frac{KAR^{\frac{2}{3}}S^{\frac{1}{2}}}{n}$$

$$K = Constant\ Dependent\ Upon\ Units = 1$$

$$A = Cross\ Sectional\ Area\ of\ Flow$$

$$R = Hyraulic\ Radius$$

$$S = Slope\ of\ Channel$$

$$n = Surface\ Roughness$$

$$\boldsymbol{Q = \frac{KAR^{\frac{2}{3}}S^{\frac{1}{2}}}{n} = 0.345\ meter^3/second}$$

Figure 4: Mathematical breakdown of flow rate for the setup depicted above

The equation above is derived from the open channel flow website [3]. The Manning Formula allowed me to calculate the open channel flow within the specified region described above. The above equation states that the flow rate within the open channel was 0.345 meter^3/second. This number seems responsible given the cross sectional area of the pen channel and that we observed that water was moving just fast enough to create the flow profile over the car.

Visualization Technique

The visualization technique of this photo did not involve any: dye, or smoke. This was because we were not allowed to put any substance into the Flume Channel. This is due to the water being recycled within the system and it would be impossible to get the particles out of the Flume Channel. The source of lighting that was utilized was the overhead lighting in the ITLL and an iPhone camera light. This allowed us to produce a highlight on the side profile of the model car, and allows for the flow profile to be better visualized.

Photographic Technique

The image was taken on a Canon EOS R6 Mark II with the following specifications:

Lens Focal Length	45mm
ISO	10,000
Shutter Speed	1/300s
Aperture	f/5
Image Size	6000 x 4000 pixels

Table 1: List of all settings used for picture collection

The setup for the image can be seen below:

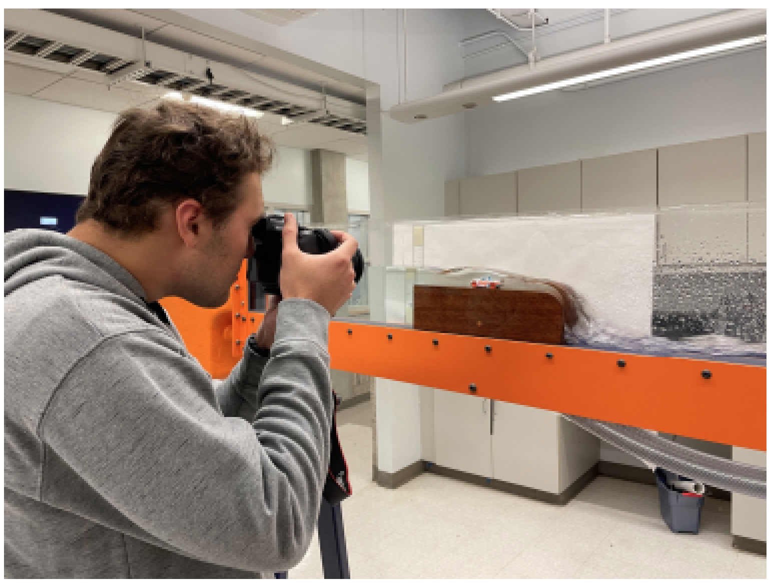

Figure 5: Setup for collection of all photographs

Conclusion

The image reveals the relationship between the cars front profile, and the flow profile that flows along that. I like how crisp the image turned out even with the moving weather, the car has stayed in focus. If the experiment was redone I would like to add some dye into the water just to see where the flow is stopping due to the car profile. This would allow us to visualize where the car has the highest force of drag acting on it. This would be a very neat way to test different profiles of cars, in order to determine the best car model.

References

[1] Hertzberg, Jean. "Flow Vis Guidebook." Flow Visualization, 13 July 2023, www.flowvis.org/Flow%20Vis%20Guide/overview-3-lighting/

[2] "C4-MKII Multi-Purpose Teaching Flume." *Armfield*, 6 Feb. 2023, armfield.co.uk/product/c4-mkii-multi-purpose-teaching-flume/.

[3]"Manning Formula for Determining Open Channel Flows." *Manning Formula for Determining Open Channel Flows | Open Channel Flow*, www.openchannelflow.com/blog/manning-formula-for-determining-open-channel-flows. Accessed 17 Dec. 2023.

Appendix