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Flow Visualization ATLS

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Disruption Created by a Bike Tire

In this project we sought out to visualize the airflow over a bike tire. I was working with my teammate on this project, Chris Leong. We wanted to show what it looked like when air hit a tire so we could see the disruptions and changes in the trajectory in the air with fog. Initially we wanted to see the airflow over the entire bike and the rider, but we couldn't get enough volume of fog to make that happen, so we settled for a smaller scale.

Our flow apparatus consisted of a bike, held up by one team member, a fog machine, an alarm clock light, and a camera operated by the other team member. As seen in figure one, the camera looks over the tire and light, as the fog flows over the tire. In the beginning of the video the flow isn't steady so the forces are changing very dramatically at that point. After a few seconds however, the flow becomes steady and you can see the air hitting the tire and flowing off of it. The normal force that is created when the air hits the tire causes the air to flow along the surface of the tire. The tread pattern on the mountain bike makes it more complicated with its ridges. Also something you have to consider is the difference in speed between the air that is farther away from the tire and the air that is closer. This causes more complexity. We set the fog machine in front of the tire and put the red light underneath the flow so that the fog would scatter

light and could be seen better on camera. To calculate the Reynolds number the fog coming out of the fog machine was estimated to be about 10 miles an hour or about 4.47 meters per second, the diameter was taken from the fog machine to be about 6 inches or 0.1524m, and the kinematic viscosity estimated to be viscosity at 20 degrees C which is 1.5×10^{-5} . This gave a Reynolds number of 45415 which means the flow was very turbulent since we got a very high Reynolds number. This is supported by the very chaotic flow shown in the video. According to Science Learning Hub there are two types of drag that act on a cyclist, the first being the one we observe here: pressure drag. This is caused by air being pushed closer together by the front facing surface of the tire. This causes the air to push back on the tire, and thus drag. Additionally as described by Science direct we see the No-Slip Condition, which means the velocity of a fluid at a surface must be the same velocity as the particles at that surface, and this is why we see the air speed up as it is farther away from the tire as it is less affected by this principle. What we see is a combination of these principles, and we see very pretty vortices in the photo.

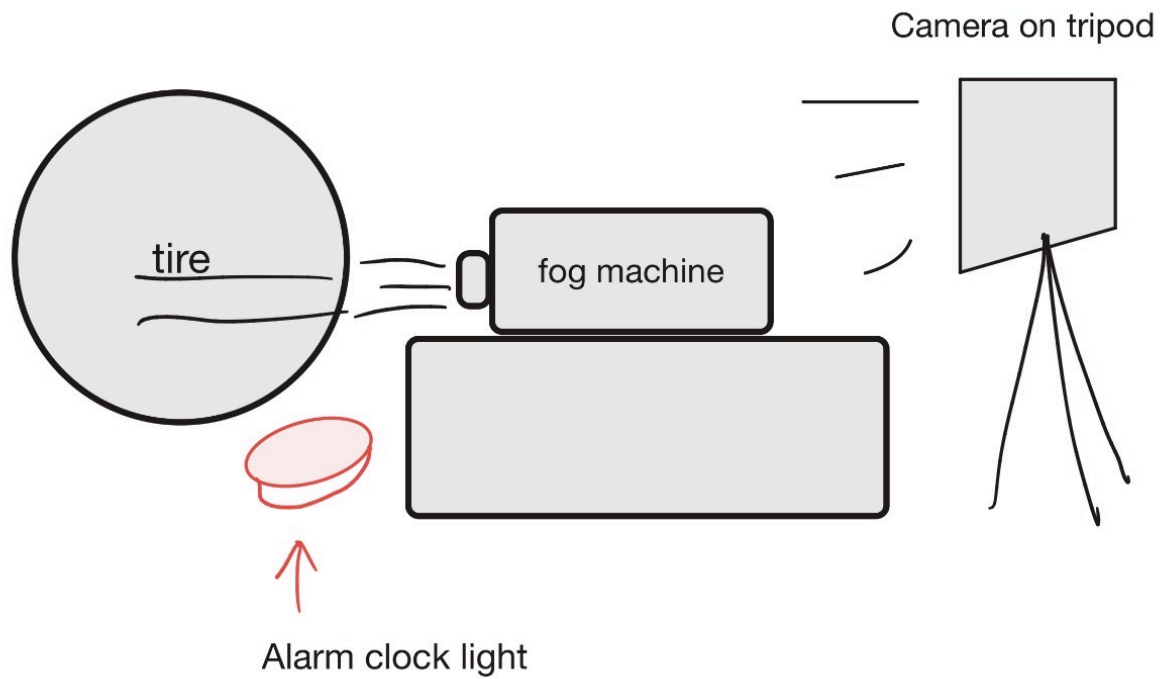


Figure 1: Setup

We used fog to create a visual representation of air flowing over the tire. The shot was lit by a red alarm clock light that was under the tire and shone up through the fog. We were in a garage where the air was relatively still. The tire was pretty close to the fog because we found it didn't travel very far.

$$Re = \frac{UD}{\nu} = \frac{\left((4.47 \frac{m}{s}) \cdot (0.1524m) \right)}{\left(1.5 \cdot 10^{-5} \left(\frac{m^2}{s} \right) \right)} = 45415.2$$

We decided to use fog as our visualization because we felt like it would give the best visual representation of what was happening in the video. We also chose to do red light in a dark area because it brought out the fog the best on camera. The original pixel count was 1920X1080p shot at 60 fps on a Sony a7ii mirrorless full frame camera. The Lens was a Tamron 17 - 28. We

decided to zoom as much as we could, to 28 mm to increase the quality of the final result because the low light made the shot really grainy, which is why we also chose f 2.8 to let more light come in while still making the shot as clear as possible. The video was cropped to keep the alarm clock out of the shot, and I color corrected it a little to have more red contrast so it was easier to see the flow.

The video revealed how chaotic and exciting the flow of air of something you use everyday is. I like that the image is cool, but the object that is shown is seen as mundane in everyday life. I enjoy mountain biking so I thought this image was a really cool way to visualize what happens when you ride. This photo fulfilled the intent to show this phenomenon, however it wasn't as good as I would have liked. In the future I would have liked to better show the fog without having such a low resolution video. I think the fluid flow is represented well here you can see what is happening very well. I think having splitters on the fog machine would have been a good idea because it would have made for a better cross section.

Works Cited

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