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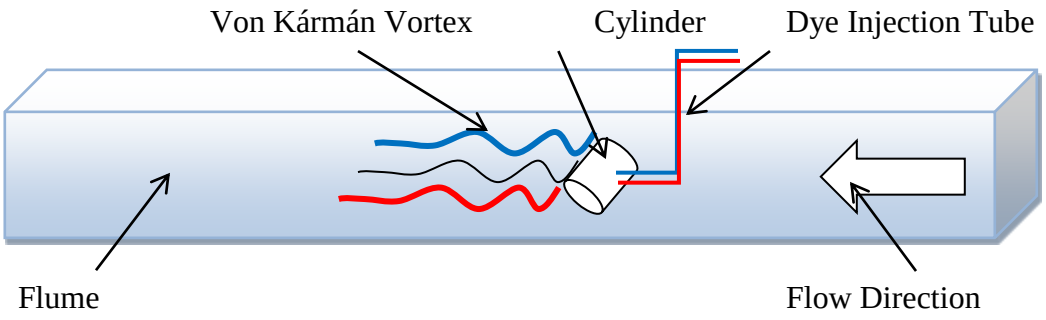
Team Image 1 Report:

This image was taken for my first round group project. Our group decided to set up an experiment where we could photograph Von Kármán vortices that occur when a fluid flows around a cylindrical object. The team had seen images of this effect in books as well as on the internet and was excited to try to produce an experiment that would allow us to capture an image of it.

Using the flume in the ITLL, a 38 mm diameter section of PVC pipe was cut and fit tightly between the walls of the flume. The flume is 77.8mm wide and had a flow height of about 230mm with a total length of about 2 meters. The flow rate for this image was measured at 15 L per 6.5 seconds or 2.3L/second. The diagram below shows our experimental setup.



The water in the flume was close to room temperature. Depending on the size of the cylinder, Von Kármán vortex streets appear over a large range when the flow has a Reynold's between 47 and 10^7. The Reynold's number is unitless number that indicates the ratio of inertia forces in a fluid to its viscous forces. For the Von Kármán flow it is calculated by the equation, $Re = \frac{Vd}{v}$. V is the velocity of the fluid, d is the diameter of the cylinder and v is the kinematic viscosity. The kinematic viscosity is 0.9 (m^2/s)x10^{-6} for room temperature water and the flow velocity was determined to be .128 m/sec. This results in a Reynolds number of 5405.

To visualize the flow of the water in the flume around the cylinder, the team decided to inject a water-dye solution approximate 1 cm upstream of the cylinder. A syringe pump was used to keep the flow rate of both dyes consistent. Red and blue dyes were used to help indicate the flow going above and below the cylinder. The dye dilutions were 25 drops blue dye per 60mL water and 23 drops red dye per 60 mL of water. The image flow was backlit through a white plastic sheet that had been attached to the back side of the flume. 60mL syringes were used with a syringe pump ejecting the dye at around 2mL per second. No flash was used on the camera as the image was already well lit with spotlights from the back.

The image was captured with a Canon EOS 10D DSLR camera. The camera was about 1 meter from the flow and was fixed on a tripod. The total field of view was about 40 cm wide and 25 cm tall. The camera was manually focused and had a shutter speed of 1/1000 second. The aperture value was f/4.5 with and ISO of 400 and a focal length of 70mm. The final edited image was 2918 pixels wide and 1154 pixels tall. Once cropped to the desired size, I edited out the dye injection tube that was present in the original image. I then inverted the colors and enhanced the saturation of the blues to give it a cooler more liquid feel. I also like how the PVC pipe turned out white in the edited image as it was actually white in the shot but the camera captured it as dark relative to the bright background.

Overall, the image does a good job revealing the physics of Von Kármán vortices and the instabilities they create in fluid flows. Unfortunately the dye diluted quickly in the turbulent flow and thus did not allow one to fully visualize the vortex development as well as a more viscous fluid might have. To further investigate this, it would be interesting to run a similar experiment on a narrower flume with a more viscous fluid like corn syrup. A slower flow speed might also prevent the quick dilution but the higher flow rate was chosen in order to make capture multiple oscillations of the vortex.