MCEN 4151: Flow Visualization
Third Team Report
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Figure 1: Final Image for Third Team Image Assignment

This image was taken to fulfill the requirements of the third team image assignment for the Flow Visualization course at the University of Colorado at Boulder. My team decided to work on our own projects for this assignment, so I took this photograph on my own. My intent in taking this photograph was to capture an artistically interesting vortex.

This image was captured using a very simple setup, shown below in figure 2. The setup consisted of a cardboard box with a quarter-sized hole cut out of one side. Inside the box was a large plastic dish with two pounds of dry ice. The dry ice was covered in hot water and the box was closed. A matte black plastic sheet was hung behind the setup as a backdrop. The camera was set up on a tripod at the same height as the hole, but about six inches to the left side of the box. The room was completely dark except for a single LED headlamp aimed right at the hole in the side of the box. Tapping the side of the box with my hand caused a three inch diameter vortex ring to shoot out of the hole in the box. Adjusting camera settings for lighting and shutter speed allowed me to capture the final image.

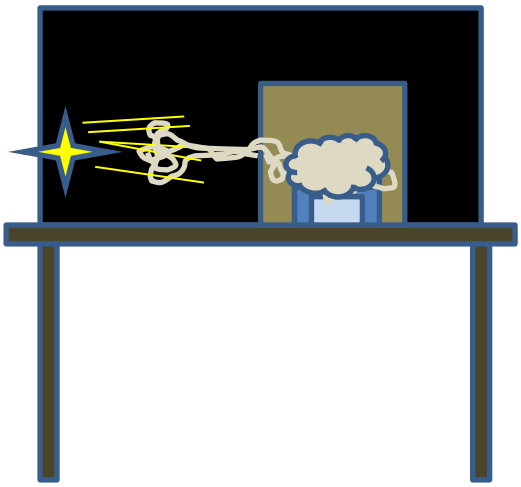

Figure 2: Diagram of Photographic Setup

The vortex was travelling relatively quickly. I would estimate it was moving about 3 feet per second. Using a speed of 3 feet per second, a distance traveled of 0.5 feet, and the dynamic viscosity of air at room temperature, I estimate the Reynolds number at 9,000.

$$Re = \frac{UD}{v} = \frac{3\ \frac{ft}{s} * 0.5\ ft}{1.643 * 10^{-4}\ \frac{ft^2}{s}} = 9{,}000$$

A Reynolds number of 9,000 places this flow in the turbulent regime. A turbulent flow in a vortex ring is characterized by strong shedding into the wake of the vortex[1]. A similar vortex was produced by Weigand and Gharib and documented in their paper, "Turbulent Vortex Ring/Free Surface Interaction." Their vortex with a Reynolds number is shown below in figure 3.

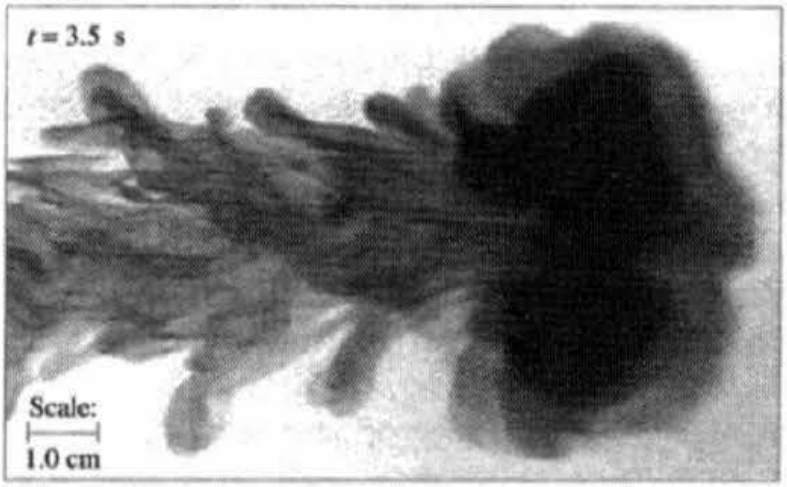

Figure 3: Vortex Ring with Reynolds Number of 7500. Weigand and Gharib[1].

The field of view in my final image is about 18”x11”. The distance from lens to vortex is about 1’. The lens used was a Nikon Nikkor 18-55mm set to a focal length of 32mm. The camera used was a Nikon D3200 DSLR. The aperture was set to f/4.8, with an exposure of 1/500 second, and an ISO of 6400. I settled on using a shutter speed of 1/500 second in order to freeze the motion in the image. Using such a fast shutter speed and poor lighting forced me to use an ISO setting of 6400. The high ISO setting led to the graininess of the photo. The original image was 6016x4000 pixels, but was cropped down to 5988x3598 pixels. No other editing was done to the image. The original image is shown below in figure 4.

Figure 4: Original Image

I like this image because it reveals the periodicity of vortex shedding. I also like that this vortex is turbulent – I feel that it adds to the artistic value of the image. I fulfilled my intent of capturing an artistically interesting image. If I had to do this project again I would like to automate the timing of the vortex to give precise measurements. This would allow for a more accurate calculation of the Reynolds number. I would also like to experiment with changing the diameter of the hole in the box to see how it affects vortex generation.

References

On the decay of a turbulent vortex ring

Weigand, Alexander and Gharib, Morteza, Physics of Fluids (1994-present), 6, 3806-3808 (1994), DOI:http://dx.doi.org/10.1063/1.868371