Karman Vortex Street

Finn Ostrem

Credit: Kyle Samples, Dylan Cook, Andrew Van Der Volgen

MCEN 4051 – Flow Visualization, Fall 2015

Prof. J. Hertzberg

Introduction

This image was taken for the second group assignment for our Flow Visualization course. There are many different approaches that could have been taken in order to show a phenomenon with fluids. The phenomenon that was chosen for this image was the amazing effect of Karman Vortex Shedding. This is caused when a laminar or turbulent flow hits a cylindrical shape in order to create a different turbulent flow in the shape of Karman Vortex Shedding. There were three members that helped create this image with the use of materials and ideas. Credit should be given to these team members who are: Kyle Samples, Dylan Cook, and Andrew Van Der Volgen.

The Setup

This image was captured using the open channel water flume in the Integrated Teaching and Learning Lab at the University of Colorado Boulder. We were able to use this flume in order to achieve the flow shown in the images for this project. To get this image, we used a pen casing for the cylinder shown in the image and highlighter ink in order to show the flow that was happening. In order to get the dye into the flume, we used a syringe and a long tube inserted into the position slightly below the cylindrical pen. To create the flow, the undiluted highlighter fluid was pushed out of the syringe into the water in the flume towards the pen casing. The injection speed is estimated at .1 m/s. This set up can be seen in Figure 1. In order to capture the images that are shown in this series, the camera was facing perpendicular to the pen casing, places about 2 inches from the edge of the flume.

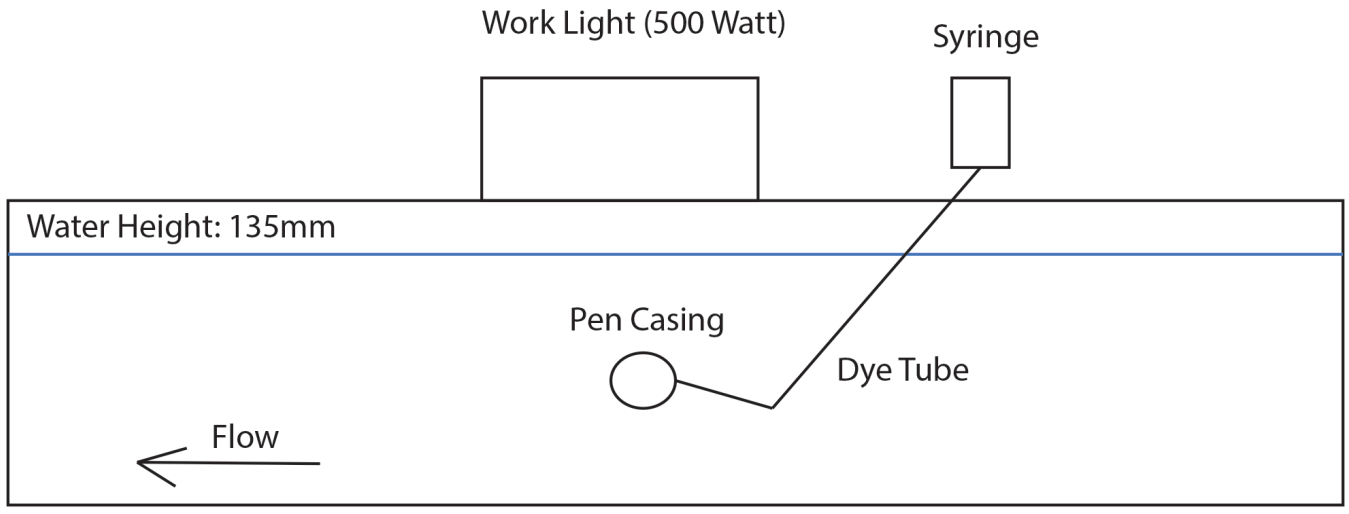

Figure 1: Flume Set Up

Understanding the Phenomenon

Karman Vortex Shedding happens when a cylindrical object creates a turbulent flow within another flow. The shedding is what occurs beyond the cylindrical object. A Karman Vortex Street can be seen in Figure 2. This is the phenomenon attempted to be replicated in the image taken for this assignment.

There are many different aspects that create this vortex pattern. First is the constant speed of the fluid that is used as a medium. For this assignment, many different flow rates were experimented with. The idea flow rate of water that was used for this image was about 5.5cm/s. Another very important factor is the Reynolds Number calculation. The Reynolds Number must be calculated for the steady flow of the water as well as the highlighter fluid that was injected to show the flow. The Reynolds Number can be seen in Equation 1. In this equation, the U represents the velocity of the fluid, D represents the diameter of the flow, which is around the pen casing, and v represents the kinematic viscosity of the fluid.

$$Re = \frac{UD}{v} \qquad Equation\ 1$$

$$\frac{\left(.055\frac{m}{s}\right) * (.008\ m)}{9.025 * (10^{-7})(\frac{m^2}{s})} = 485.53 \qquad Reynolds\ Number\ of\ Water$$

$$\frac{\left(.1\frac{m}{s}\right) * (.008\ m)}{9.025 * (10^{-7})(\frac{m^2}{s})} = 886.4265 \qquad Reynolds\ Number\ of\ Dye$$

Using both of these Reynolds Numbers, a comparison can be made between a large and small flow. The flow of dye coming out of the tube is faster than that of the surrounding water. This is due to the pressure that was put on the syringe in order to push it into the flow of the water. These two different Reynolds Numbers are both expected to have vortex shedding after the pen. These two different cases can be seen in Figure 3 and Figure 4 to give an example of the expected Karman Vortex Street. Figure 3 shows a Reynolds Number of 300, which is very close to those calculated in this set up. Figure 4 shows a Reynolds Number of 4,000, which is far from the numbers calculated, but shows a flow somewhat similar to that shown in the image captured for this project.

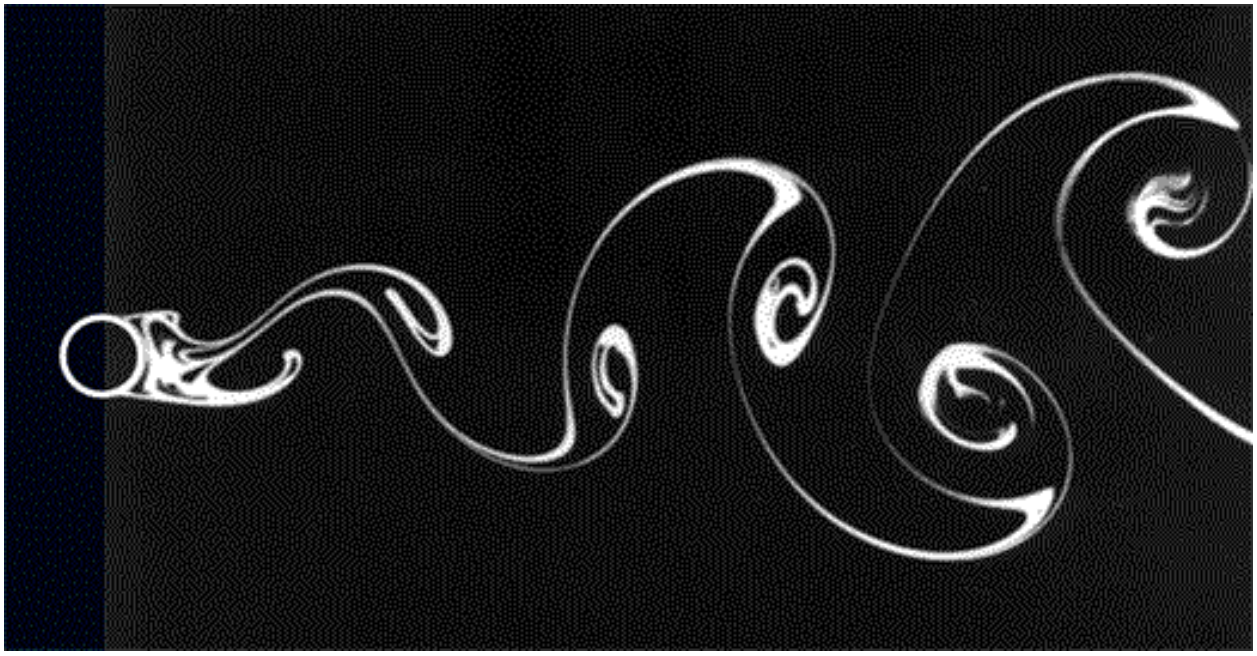

Figure 2 Karman Vortex Street

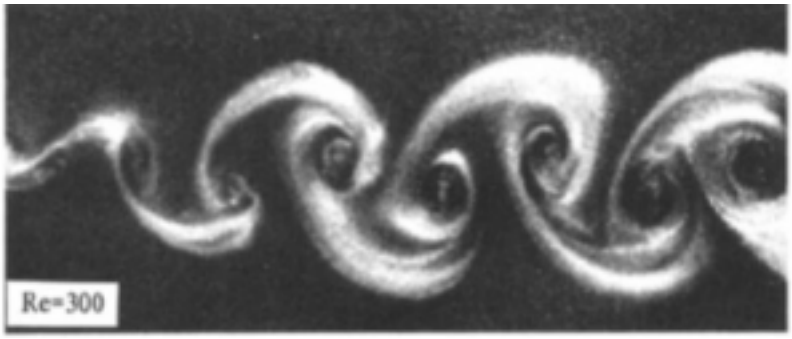

Figure 3 Reynolds Number 300 Vortex Street

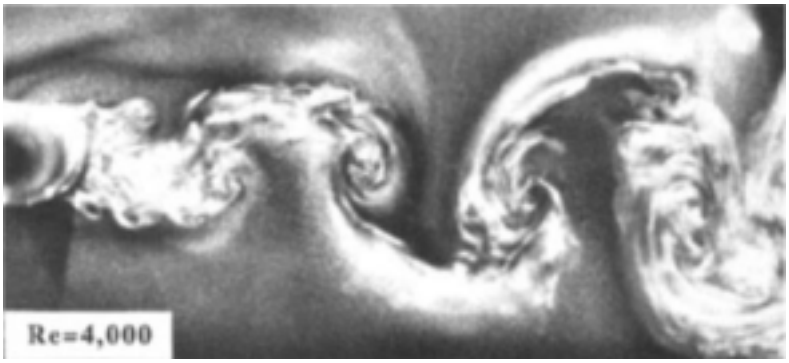

Figure 4 Reynolds Number 4,000 Vortex Street

This set of images has no post processing done to them. The objective in doing this is to see the vortex develop and then dissipate throughout the stages of the image. I feel that this objective was captured very well. The flow is a bit noisy due to the dye used, but it can be seen how the vortex develops as it is initially inserted into the flow of the water, and how it changes as the vortex returns to steady state with the rest of the water further down in the flume.

Photographic Technique

Field of View: 6” wide by 4.5” tall

Distance: This was about 2”

Lens Focal Length: 32in

Camera: Canon EOS Rebel SL1

Aperture: 5

Shutter Speed: 1/320

ISO: 400

Image Size: 5184x3456

Post Processing: None, GIF created

References:

[1] VAN DYKE, M. *An Album of Fluid Motion*, The Parabolic Press, Stanford, 2002.

http://mydev.info/karman.html

[2] Williamson, C.H.K. *Vortex Dynamics in the Cylinder Wake,* Annual Reviews Inc. 1996.

http://www.annualreviews.org/doi/pdf/10.1146/annurev.fl.28.010196.002401