Brad Samuels   MCEN 4151   Group Project 3 Report

This image was taken using the flume channel, downstairs in the ITLL. My group decided to use the flume to visualize the effects of an overshoot weir, which causes water flow to back up behind it before it speeds up as it flows over the top. This type of device is used in many real world devices to limit the flow of water in a dam, creating the possibility for both mitigating the flow rate of the channel as well as implementing devices to receive mechanical energy from the flow for storage. For my image, I was trying to visualize the effects of the increase of Reynolds number over the top of the weir. Specifically, I wanted to know how far upstream the flow starts to speed up, and the effects of depth on channel flow velocity.

The flume itself is a 4-inch wide, 5 foot long channel where water flows from right to left (in the perspective of the image). A pump at one end forces water up into a chamber on the right side of the channel from below. The chamber immediately releases water into the flume, and a valve allows the control of flow rate from the pump. Another knob is used to adjust the tilt of the flume, and for this image it was kept as level to the ground as possible. The height of the water in the image is about 6 inches, and the width of the image is about 13 inches. The only forces acting on the fluid in this image are the pressure difference created in the pump far upstream, gravity causing the stream over the weir to fall rapidly. In calculating the Reynolds number, the viscosity used was that of water (1.004 m^2/s)[1], the velocity used was estimated based on flow rate (0.0011 m^3/s) and cross-sectional flow area at various points in the stream (0.0122 m^2 upstream and 0.0041 m^2 over the weir), and the length scale used was 2 m, the approximate length of the flume channel. Based on these parameters, the Reynolds number on the upstream side of the image was 0.18, and the Reynolds number of the flow over the weir was 0.53. Both of these numbers indicate laminar flow, but the sharp jump over a length scale of an inch or so indicates shear stress acting on the fluid surroundings.

The visualization technique used was simple food coloring dropped into the weir from the top. The food coloring spread out over the top of the flow as a film very rapidly, while only very dense portions of the drops managed to break through the surface and disperse through the liquid. The dispersion of the dye itself does not represent the motion of the fluid at all, because phenomena cause the dye to billow downward through the fluid in response to the forces of gravity and viscosity. The increased velocity of the fluid can be inferred by the stretching of the dye's "natural" dispersion in the direction of the flow. This effect happens very little through most of the image, but intensely and rapidly manifests itself in the immediate vicinity of the weir. This leads me to believe that the weir itself is subject to significant shear forces in response the buildup of water behind it and the jet of water flowing over it. The image was lit from the back with bright tungsten lights behind a semi-transparent white plastic backdrop. It was also lit from the top with florescent lighting.

The image was taken with a PENTAX X90 DSLR camera from about 2 feet away. The focal length of the lens was 15 mm. The final dimensions of the picture were 4000 pixels wide by 1986 pixels tall, cropped down from 4000 x 3000 pixels. The f-stop of the camera was f/4, the exposure time was 1/100 sec, and the ISO speed was 320. These features gave sufficient image quality with minimal motion blur, although I wish I had used a shorter exposure time and given the chance to do this again, I would take that into account. No flash was used, as the side of the weir is plastic and would reflect the bright flash back into the image. Photoshop processing consisted of minimal curves adjustment to increase contrast, followed by color inversion. I thought the inverted colors brought out the food coloring more, which is what I wanted the image to focus on.

This image reveals the extreme changes in channel flow over a weir. These changes include primarily velocity (and by proxy Reynolds number) which could have an effect on the shear stress felt by the weir itself. In large channel flows such as rivers, the shear stress effects would have to be considered during weir design to avoid failure. I like the way my image turned out overall. I feel like the physics of the fluid are shown insufficiently for analysis, however, as the particle tracer does not track fluid flow accurately. For full analysis, a different image technique such as using hydrogen bubbles to track the motions of streamlines should be used. Artistically, however, I'm quite pleased with my image.

References:

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http://www.engineeringtoolbox.com/water-dynamic-kinematic-viscosity-d_596.html