Darwin Millard
830 12 4439
Flow Visualization
Sept. 25, 2007

Project 1: Get Wet

For the first Get Wet project I decided to work with water and funnels. One day when I was filling a tank with a funnel I discovered that if you fill the funnel in a particular way, water forms a bell as it exits the funnel. To get this phenomenon to occur you have to fill the funnel to the brim while also maintaining a constant vortex flow. The mass of the water pushing down and the adhesion affects of surface tension cause the water to cling to spout of the funnel. Since the flow is spinning as it exits the funnel, the water forms a bell. The bell is three dimensional and with the proper lighting geometric diamond patterns form on its surface.

To get the desired image I designed a very simple apparatus. I stacked four standard concrete cinder blocks into two columns and placed a two by four across the top. I then constructed a very cheesy ring stand by duct tapping a cardboard ring to the 2X4. For the funnel I used a standard six inch funnel that has two rings in the spout (I have no idea if the rings assist or hinder the phenomenon). The physics involved in this phenomenon are quite interesting. The bell is very difficult to form and without the correct amount of water on top and the proper flow the funnel will simply empty. Surface tension, the vortex flow, and the mass of water in the funnel are the key elements of this phenomenon. The surface tension causes the water to stick to the spout as it exits the funnel and the vortex causes the stream to spin. However, without the mass of water pushing down on the flow the bell does not form.

To make an estimate of the Reynolds number I considered the entire structure to be approximately one meter above the ground, neglected poring velocity and only considered acceleration from gravity for the free stream velocity, and assumed a control volume of a perfectly round pipe at the spout. The Reynolds number is determined by dividing the product of your free stream velocity and your pipe diameter by your fluid's kinematic viscosity. Water has density of 1000**kg/m^3** and a viscosity of 0.894E-3**kg/m*s** this gives you a kinematic viscosity of 8.94E-7**m^2/s**. I determined the free stream velocity to be about 4**m/s** and measured the spout diameter to be 1**cm** $\pm$ 0.03**cm**. From this the Reynolds number just inside the spout was calculated to be 4.359E4, which is extremely turbulent. As soon as the stream reaches the air, however, there is a change in the physics. The liquid to air surface causes the water to slow down due to viscous drag. Therefore, when the bell forms the stream is in laminar flow with a Reynolds number roughly around 3000.

To take the photographs of this phenomenon I placed the apparatus out side so I could get lots of light so I could take time frozen shots of the flow. I placed the apparatus so as much naturally accruing sun light would shin straight down through the funnel as possible. In order to get the lighting I needed I took my photographs between the hours of 12 pm and 3 pm.

The size of field of this image is only about six to seven inches below the spout and close up. The camera is set up between 18 and 24 inches away from the flow. The lens I was using has a focal length of 80**mm**. The camera I used for this image was the Canon Digital Rebel XTi which has a maximum image size of 3880 by 2690 pixels. This picture was shot with the shutter speed set at 1/400 of a second, and the aperture and exposure values were F9.0 and +0.5 respectively. I used a film speed or ISO value of 400 and only used photoshop to turn the image 90 degrees as well as try and bring out the diamond pattern, I cannot remember exactly what I did.

In the process of making this image I learned a few things. One thing I learned was that it is not easy to get the phenomenon you want to occur when you want it to. If you do not pore in the water in the right way the bell only forms halfway or not at all. However, I think the effort was worth it. During all the attempts I made I discovered that if done properly, the stream tries to form a double bell. Because the stream is spinning the bell crosses over itself, when this occurs the laminar stream breaks up and the bell dissolves. Sometimes though, when almost all the water is out of the funnel, the bell successfully crosses over itself and forms two. This is the image that I chose to present. It shows everything I tried to see: the diamond pattern, the bell formation, the double bell, and the dispersion. If I did this image again I would try using florescent liquid and a black light beam shinning directly down through the spout of the funnel.

Bell Flow Apparatus