

Project 2

The goal of this project was to visualize an interesting fluid flow phenomenon. The flow phenomenon that was visualized was the formation of vortex rings. Smoke makes for very intricate and complex flow that is very interesting to observe. When smoke is forced through a circular opening, rings of smoke can form, known as vortex rings. These rings have complex physics that involve reverse flow about the circular shape that is formed. If photographed well, the patterns formed can make for amazing images.

To make the vortex rings an apparatus named the zero launcher was used. The apparatus consists of a reservoir of fluid designed to create fog that forces this fluid past a hot wire that vaporizes it. The vapor is then passes to a chamber with an elastic backing and a circular opening. The elastic backing is struck by a trigger mechanism that forces the vapor out of the circular front opening. From there physics take over and the vortex ring is created. A picture of the apparatus can be seen in Figure 1 below.

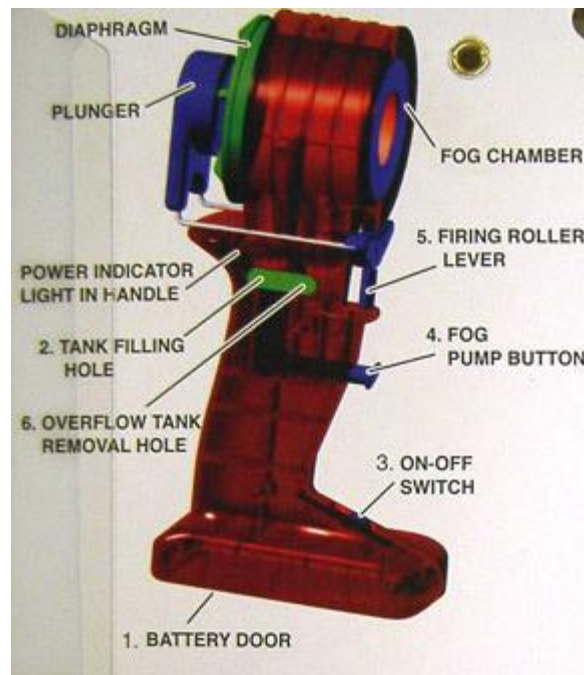


Figure 1 – Apparatus

The formation of the vortex ring occurs mainly because of friction. This is difficult to conceptualize because usually friction is thought of on a large scale with heavy object. In this case the friction isn't between two objects, it is between the vapor and the stationary surrounding air. [1] When the vapor ring exits the opening of the apparatus, vapor around the edges is slowed by the opening while the air in the middle of the opening stays at the same speed as before. This creates the initial doughnut shape right outside of the opening. The rotation continues in a circular pattern after exiting because the outside edge of the circular flow grabs the stationary

surrounding air. As the circular motion continues it propels itself forward. As the vapor ring continues to move the ring is held together due to the low pressure in the middle of the vapor ring. [1]

The opening of the apparatus is 1.25 inches in diameter and moves with an initial velocity of approximately 1 foot per second. The flow started in a laminar phase but quickly turned to a mixture of transitional and turbulent flow. The mixing of the vapor and the air make the flow difficult to classify.

To visualize this flow the apparatus described above used. The fluid that was vaporized was a combination of Propylene Glycol, Glycerin and Water. This is a common fluid used to create the fog in stage fog machines. The image was taken in a dark room so the light could be completely controlled. The way the picture was lit was by using a remote flash. The flash was positioned very close to the apparatus that shot the vortex rings. The flash was facing the rings through to translucent blue plastic shell of the apparatus, which created the blue and green colors seen in the picture. The flash was at an angle of approximately 120 degrees from the face of the camera and was placed behind the apparatus.

In the photograph the smoke ring is about one foot in length and was taken from a distance of approximately one to two feet. The lens used was a Canon Zoom Lens EF-S 18-55mm 1:3.5-5.6. The photograph was taken with a focal length of 55 mm. The camera used was a Canon Digital Rebel XT. The original size of the photograph was 3456 x 2304 pixels, the cropped version is 3456 x 2132 pixels. The exposure setting were an aperture of f/25, a shutter speed of 1/200 sec and an ISO of 200. In Photoshop minor adjustments were made to improve the image. First the image was cropped to eliminate a plastic piece of the apparatus. Second the color curve and brightness/contrast settings were adjusted to help see the flow inside of the ring.

This image was able to capture the formation of vortex rings, which is very interesting to look at with the bare eye, but also very difficult to capture with a camera. When looking at the picture you can see exactly how the ring moves. The physics that can be seen create an interesting picture to look at. The positioning of the light made the physics visible while also creating interesting colors that add to the picture. In the background of this picture there is an old ring that is fading. It created an interesting downward pattern that shows how the ring eventually dissipates into the surrounding air. The picture did fulfill my intent, which was pretty broad. I like the combination of the physics and colors created in this picture. I would ideally like to have the ring a little clearer, possibly a little less bright. Any further adjustments to the brightness started to take away from the rest of the picture. If I could do this picture again, I would change the direction the rings were being shot to see how they would change.

References

[1] "Science." ZeroToys.com. 10 Mar 2009 <<http://www.zerotoys.com/shtml/science.shtml>>.