Team Project 3

Three Dimensional Vortex

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Image Intent:

The purpose of this image is to visualize a vortex ring in a three dimensional photo. The image is intended to be both beautiful and stimulating and show the physics of a vortex. The vortex is created using fog generated by a fog machine that is ejected from a vortex generator. Fog is used to mark the flow.

Flow Formation:

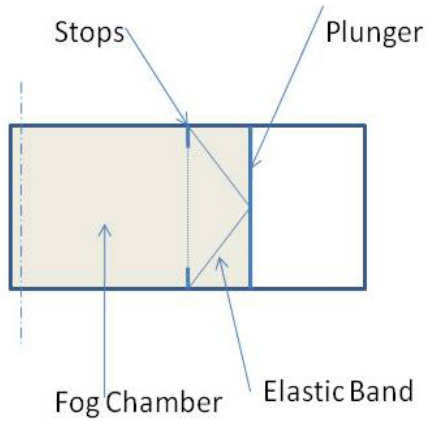

Figure 1 (Top View)

The flow is generated using a vortex generator, which is a toy used to create what can essentially be described as smoke rings. Instead of using smoke for this particular image, the flow was seeded using the fog generated by a fog machine. The vortex generator is a cylinder with a radius of

about 4 in. and a length of about 1 ft. There is a fog chamber at the end from which smoke rings are ejected from. The fog chamber has one open end and is closed at the other end by a moveable plunger. The fog chamber is filled with a thick fog with the plunger pulled back about one third of the way. At this point the fog chamber is pointed in the direction of the flow. The plunger is then released and then forced forward until reaching the stops (illustrated in figure 1) by two elastic bands. This decreases the volume of the fog chamber and forces the fog out in the shape of a vortex.

During the imaging of this flow, multiple shots of the same ring were imaged. By calculating the distance and time between the images of the vortex the speed of the flow can be calculated. Using this method, it is clear that the flow is moving at approximately 3 ft./sec. This speed doesn't remain constant due to the flows interaction with the surrounding air. The flow is actually experiencing a negative acceleration, if the positive direction is considered to be moving away from the vortex generator. The velocity at which the air leaves the bucket is inversely proportional to the diameter of the hole

Flow Phenomenon

The vortex ring imaged is created when a plume of fog is ejected from the vortex generator. The air being ejected from the generator is moving at a higher velocity than the ambient air as it moves through it. The moving mass of air experiences higher levels of friction force on its' outer most edges, which causes this layer to be peeled back. The moving mass of air also creates a lower pressure zone at its' trailing edge. The higher pressured ambient air forces the layer of fog that has peeled off into the lower pressure zone creating a rotating flow and the toroidal shape.[i] As the vortex ring moves through the air it also increases in diameter. This can be attributed to a loss of air mass due to drag from the surrounding air. The moving air within the vortex ring will have a slightly lower pressure than the ambient air, which will decrease the interchange of gas molecules between the moving air and the stagnant air. This is why the vortex ring will last much longer than after the rest of the plume has dissipated.[ii]

Three Dimensional Imaging Technique

In order to understand the physics behind three dimensional imaging, it must be understood that even a single human eye by itself is incapable of depth perception. It is because humans have two eyes that they are capable of seeing depth perception. The human brain uses the two slightly different images seen from slightly different angles in order to create depth perception.

Stereo imaging, or three dimensional imaging, can be created using a similar technique. In order to acquire a three dimensional image, two cameras must be used to take a picture of the same object, or in this case, flow, from slightly different angles. The separation of the camera must be proportional to the object distance in a ratio of about 1 to 40.

To view the two different images captured as one single image with the illusion of depth, each eye must be restricted to viewing only one image. In order to do this, the two images are superimposed over each other with altered colors. In one image, all of the red is filtered out and in the other image all of the green and blue are filtered from the image. The viewer must wear glasses with a red filter over one eye and a cyan filter over the other. This lets each eye only see one of the images and produces a 3 dimensional effect.[iii]

In order to capture the dramatic smoke rings in a three-dimensional photography, having the correct equipment is necessary. John Hart, a guest lecturer for the MCEN 4228 Flow Visualization class assisted our group with the photographic technology. The imaging set up consisted of two identical Sony Cybershot V3 7.2 mega pixel cameras, which were wired together side by side about 18mm apart with one upside down. The images are captured with a Carl Zeiss Vario-Sonnar 2.8-3.7/6-72 Lens and a 4x Optical zoom onto a 1/1.8-inch Super HAD CCD. There is a controller (basically a mini computer) on the right side that the wires are connected to, which allows for one button to trigger both cameras in simultaneously. It is necessary that both cameras be set with the same settings including ISO and Exposure, Shutter Speed, Aperture, Focal Length, and Distance to subject. The Shutter Speed was 10/1000 sec, the Aperture was set to f/2.8, the ISO was 800, the Focal Length was 10.8mm and the Distance to subject was 1.5meters. We used two settings for photos, the first was a single shot that proved to be difficult because the smoke rings moved at varying speeds meaning it was difficult to capture a single ring in a single shot. We then switched the camera to a multiburst mode that took multiple (4) photos in rapid succession. This proved more useful because at least one of the photos had the smoke ring in it. The smoke rings were shot both perpendicular to the lens as well as diagonally directly towards the lens. We hung a black drop cloth as a background and lit with a work light. After taking the photos, we used a free program called Stereo Photo Maker to arrange the photos from the two cameras together. This program is a free download (from the website http://stereo.jpn.org/eng/stphmkr/). There are many options the program software offers to shift, change, and edit the photos in order to create the desired effect. It is important that the 3-D technical requirements are fulfilled; for example, there cannot be a horizontal and vertical shift of one of the photos because the 3-D version will not function properly and it causes the photo to appear blurry and often becomes painful to look at.

My Image:

This particular image was only slightly modified after the two images were filtered for their color and superimposed. The only modifications after this point were to crop out distracting elements from the photo. The cropping reduced the image from 3072x2304 pixels to 1775x958 pixels.

Image Likes and Dislikes

I think that this image shows a very interesting flow in a unique format. It is especially interesting to see images in 3d and it is also very stunning to look at. I think that the impact may have been improved if less concern had been devoted to creating a three dimensional image and more

concern had been devoted to the framing. Because the image had to be cropped so much, a lot of image quality was lost which was disappointing.

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[i] Experiments with Vortex Rings in Air R. H. Hernández *et al* 2006 *Europhys. Lett.* **75** 743. Online Available: http://iopscience.iop.org/0295-5075/75/5/743/?ejredirect=.iopscience

[ii] "Vortex Ring Structure at Late Stages of Formation" Dazen Fabris Department of Mechanical, Materials, and Aerospace Engineering, Illinois Institute of Technology,Chicago, Illinois 60616, Dorian Liepmann Department of Mechanical Engineering, University of California, Berkeley, California 94720-1740

[iii] "The Art of Stereo Photography" Bob Manekshaw. Online available: http://www.photostuff.co.uk/stereo.htm