Project 3

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Flow Visualization

Introduction

For our final image in Flow Visualization we chose to image a cologne spray. The phenomenon exhibited here is called Atomization. We chose to capture this phenomenon because we thought it would be challenging and it would create a dynamic photograph. It did prove to be a challenge but once we discovered what the best set up was to capture the image we were very pleased with our images. We chose this image as our final image because we felt it exhibited the phenomenon well. We also chose it because it emits a feeling of motion without compromising the intent of the image with too much blurring of the spray.

Apparatus

For this experiment we chose to observe the spray particles from a cologne bottle. In order to help display the spray particles three 60 Watt bulbs were placed 9 inches above the spray. Also, a black background was used to eliminate distractions. The cologne bottle was placed on a level surface between the background and the camera as shown in Figure 1. The camera was set on top of another level surface slightly higher than the cologne's surface. These level surfaces were needed in order to keep the image from becoming blurred from shaking from either part. The spray was fired perpendicular to the camera to see profile of the fluid flow.

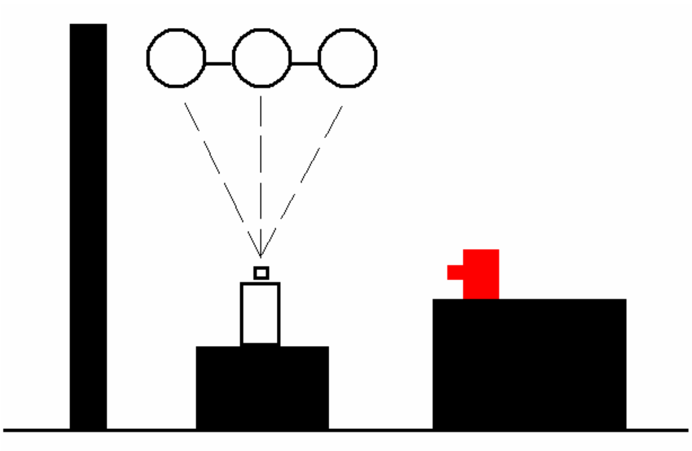

Figure 1: Apparatus

Physics

This image captures the phenomena of atomization. Atomization seems to be its own field within fluid dynamics study. It is used to analyze many different types of systems (such as airbrushes and carburetors and others listed below).

“Atomization is the reduction of infinitesimal particles (such as of a fluid) to a fine spray or mist, often by passing the particles through a nozzle.
An atomizer is an atomization apparatus; carburetors, airbrushes, misters, and spray bottles are only a few examples of atomizers used ubiquitously.” (http://en.wikipedia.org/wiki/Atomization)

This means that to “atomize” something you add energy to it to break some of the bonds holding the molecules together. It then becomes a group of small particles of liquid separated by a gas of some sort, as opposed to the stable liquid state where the liquid remains together due to its density being higher than that of the gas around it and its molecules being bound together. In our case the “atomizer” is the cologne bottle.

What makes atomization occur? In our case we are dealing with an aerosol can that forces the cologne out of a small nozzle at a fast velocity due to a large pressure differential between the propellant and the cologne. The narrow nozzle is where the atomization occurs. The basic physics concepts behind the functioning of an aerosol container are as follows:

- “The particles in a liquid are loosely bound together, but they move about with relative freedom. Since the particles are bound together, a liquid at a constant temperature has a fixed volume.
- If you apply enough energy to a liquid (by heating it), the particles will vibrate so much that they break free of the forces that bind them together. The liquid changes into a gas, a fluid in which the particles can move about independently. This is the boiling process, and the temperature at which it occurs is referred to as a substance's boiling point. Different substances have different boiling points: For

example, it takes a greater amount of heat to change water from a liquid into a gas than it does to change alcohol from liquid to gas.

- The force of individual moving particles in a gas can add up to considerable pressure. Since the particles aren't bound together, a gas doesn't have a set volume like a liquid: The particles will keep pushing outward. In this way, a gas expands to fill any open space.
- As the gas expands, its pressure decreases, since there are fewer particles in any given area to collide with anything. A gas applies much greater pressure when it is compressed into a relatively small space because there are many more particles moving around in a given area. "

(http://science.howstuffworks.com/aerosol-can1.htm)

In an aerosol can there is a propellant and a product (in our case the product is the cologne). The propellant is kept at a high pressure where the product is kept at a relatively lower pressure. To create the high pressure in the propellant it must be a substance that has a very low boiling point (below room temperature). The product, in comparison, must have a boiling point substantially above room temperature to ensure that it stays at a low pressure. The system is therefore kept in a state of higher pressure than its surroundings. There is then a nozzle system that, when engaged, allows an outlet to the system. The system wants to equalize the pressure so it forces out the substance (cologne) and due to the high gradient of pressure this happens very quickly creating a spray, or atomization, at the nozzle.

Visualization Technique

The visual technique was to light up the particles of the spray mist of a cologne bottle. The attempt was to have the particles refract light similar to a prism and have a black background to enhance the water droplets. Three 60 Watt light bulbs were the direct sources of light, however light through the window and background in the room may have added slightly.

The photographic technique for this case relied on the use of a Sony DSC-P200 Cyber-shot 7.2 Mega Pixels digital camera and some slight Photoshop processing. Our image was taken approximately .012 meters away from the object with a focal length of 8 mm. The ISO was set at 400 while the shutter speed was 1/1000 of a second. The aperture was set at a value of 2.8. The size of the field of view was 0.07 m x 0.05 m, $3.5x10^{-5}$ square meters. The pixilation of the image is 1512 x 1132 pixels. The spatial resolution of the image found from the field of view and the pixilation is 22 pixels/mm. Based on the estimated flow speed of 0.7 m/s and the shutter speed previously mentioned, the flow will move 7 mm in the exposure, corresponding to a motion blur across 16 pixels. This blur can be seen in the photograph. A few Photoshop processes were needed for this image. The contrast/levels and colors were slightly adjusted. Finally, the image was cropped to only show the fluid flow.

Conclusion

This image reveals the phenomenon of atomization very effectively. The beauty of the image comes from the feeling of motion it evokes. It also allows the viewer to stop time and see something that normally happens too quickly to see. We are very pleased with the image because it captures the phenomenon in a very effective and beautiful way. If we could do it again we would improve the image by using a higher pixilation and a darker background to improve the quality of the image. This would allow for more creativity in the presentation of the image because less detail would be lost in doing things such as adjusting the contrast.

Original

Pixel Dimensions X:3072 Y:2304 Resolution X:72 Y:72

Final Image

Pixel Dimensions X:1512 Y:1132 Resolution X:72 Y:72