Group Theta

Project 1

Fish Tank and a Fire Extinguisher

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Flow Visualization

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The purpose of our first group project was to capture images of the turbulent interaction of a three phase flow between water, monoammonium phosphate, and nitrogen. This interaction was created by spraying an ABC fire extinguisher into a fish tank filled with water. The images capture the interaction at different angles and different time frames of the interaction.

The basic flow in this situation is highly pressurized nitrogen propelling monoammonium phosphate into a stationary body of water creating a turbulent three phase flow. The size of the flow generally ranged from 6" to 10" in height and width. Turbulent flow is a chaotic flow where the boundary layer is distorted due to forces acting on it from the surrounding medium. Turbulent flow in a pipe is generalized by a Reynolds Number above 4000. To estimate the Reynolds Number, we assumed the flow in the tube was dictated by the pressurized nitrogen. The kinematic viscosity of nitrogen is 1.52E-5 m^2/s. We estimated the discharge to leave the nozzle at approximately 10 m/s. The diameter of the hose was approximately 0.0127 m. Using the formula, $\mathrm{Re} = \frac{VD}{\nu}$, where V is the fluid velocity in the hose, D is the hose diameter, and ν is the kinematic viscosity of the nitrogen, we found the Reynolds Number to be 8355. This Reynolds Number is much higher than 4000, confirming our suspicion that the flow was turbulent. All of the images were taken within two seconds of discharge from the nozzle. The spatial resolution in the majority of our images was excellent.

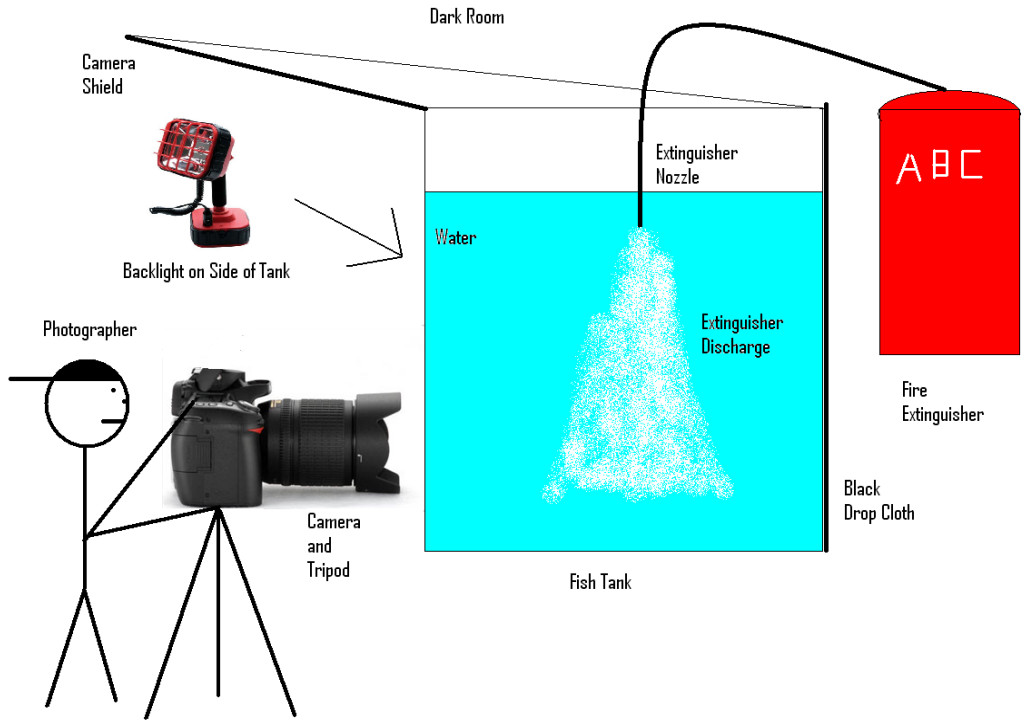

Figure 1 - Experimental Setup

In order to capture the image, we filled a fish tank with 12"of water. We positioned a black cloth on the backside of the tank and taped a shield to the edge of the tank to protect the camera from any possible spray. We then inserted the nozzle of the ABC fire extinguisher into the water and took images of it spraying downward and sideways. The fire extinguisher discharged monoammonium phosphate and

nitrogen into the water. The camera used did not use a flash when capturing the images. The light used was a halogen light positioned several inches from the left side of the fish tank on the same plane as the tank.

Matt Blessinger's Image:

Table 1 - Matt Blessinger's Image Settings

Photographic Technique	Value
Field of view	7 in. x 15 in./ 98 in^2
Distance from object to lens	10 in.
Lens focal length	31mm
Type of camera	Nikon D80 w/ AF-S Nikkor 18-135mm, 1:3.5-5.6G ED lens
Original picture size	3872 x 2592
Final picture size	960 x 2140
Aperture	F/4.0
Shutter speed	1/640 sec.
ISO setting	100

Table 1 gives all of the image and camera settings used to capture the flow of the fire extinguisher contents shooting into a fish tank. I set the lens' focal length to have a field of view that could capture the cloud of fire extinguisher particles. I set the Nikon's shutter speed to a 1/640 sec. because it allowed just enough light to reach the lens so the cloud could be seen but rest of the particles outside of the cloud would not. In addition it allowed a better still shot of the fluid motion so more detail would be visible. The other settings were automatically set by the camera. After the initial image was captured, several Photoshop techniques were performed to further highlight the fluid flow. In Photoshop I increased the contrast curve to brighten the fire extinguisher mixture and bring out the yellows. I then used the clone stamp tool to remove any stray yellow particles, ensuring a cleaner picture. I also cropped the photo to emphasize the actually fluid flow and remove the unnecessary parts of the setup.

To create the flow a short, 0.5 second, full throttle burst was shot out of the fire extinguisher. This created a full, robust flow that was also short in height. This allowed me to demonstrate how quickly the 3 phase fluid would rise to the surface after exiting the nozzle. I really liked how the image turned out. It shows the three phase flow really well, and it also shows the extreme buoyancy of the ABC fluid because the nitrogen bubbles start to instantly rise after they exit the nozzle. The nitrogen bubbles also contain the fire extinguisher powder in it, which is also very interesting. It is also easily seen the turbulence of the fluid because of its high velocity at the exit of the nozzle. To further improve the image I would increase the depth of field. I didn't expect the fluid to spread out so quickly in all directions, thus it was hard to have all particles in focus. For further experiments I would like to photograph the interaction of fire and the fire extinguisher mixture.

Dung Luu's Image:

The image was taken using a Nikon D80 digital single-lens reflex (DLSR) camera. An 18-135mm image stabilizing lens was mounted on camera. The distance that the object was away from the lens is approx. 10" from the fire extinguishers nozzle in the fish tank and the focal length of the lens was 44mm. The field of view is approximately 10" x 10". The size of the original is 3872 x 2592 pixels and final image is 2167 x 2565 pixels; the original image was shot in NEF format and converted to a TIFF for the final image. The aperture, shutter speed, and ISO setting was F4.5, 1/500 Sec., and 100, respectively. Minor Photoshop processing was done to the image. I used curves and cropped the image.

This particular image was chosen because it reveals the immediate buoyant force acting on the monoammonium phosphate while it was escaping from the nozzle. It also demonstrates hydrophobic properties of the monoammonium phosphate by how the small particles of monoammonium phosphate tend to group together. I like the color contrast between the black background and the monoammonium phosphate. I particularly like some of the air bubble encapsulating portions of the monoammonium phosphate flow which was probably caused by the nitrogen propellant escaping with the monoammonium phosphate. The part of the image that can be improved is the depth of field. The aperture could have been reduced to produce the depth of field sought after but the consequence of that would be motion blur from having to adjust the shutter speed to match the specific aperture or there would not be enough light.

Kevin McCoy's Image:

Size of the field of view	10" x 8"
Distance from object to lens	8 Inches
Lens focal length	31mm
Lens specifications	18.0-135.0 mm f/3.5-3.6
Type of camera	Nikon D80 Digital SLR
Original Image Size	3872 X 2592
Final Image size	1720 X 2472
Aperture	F/6.3
Shutter Speed	1/640 second
ISO Setting	100

The image has been altered slightly in Photoshop. The image was cropped. Then the contrast was altered to brighten the subject of the image. Next, the cloning tool was used to darken the surrounding water so the residual material was not visible.

The image captures a three phase flow of water, monoammonium phosphate, and nitrogen. The turbulent flow produces random flows which make for a stimulating image. Buoyancy is also shown as portions of the material can be seen starting to travel back upwards because its density is lower than water's. The monoammonium phosphate is also hydrophobic so the image doesn't actually appear to be under water other than the bubbling and buoyancy effects. I think the physics are represented well and would love to play with the phenomenon more once I get another fire extinguisher The exit speed of the discharge was

estimated, but I would be interested in determining that exit velocity experimentally. I believe the intent was fulfilled but a few improvements could be made. I think the contrast of the light disparity from left to right is striking but I still think the image needs more light on the right. An interesting extrapolation on the experiment would include a moving flow of water rather than the stationary setup we had. Then we could see the interaction of the fire extinguisher discharge with a moving water flow and I'm sure some interesting images would result.

Joseph Van Amberg's Image:

The size of the field of view was approximately 9" by 9". The distance from the object to the lens was approximately 12". The focal length of the lens was 31 mm. The type of camera used was a digital Nikon D80. The original image prior to cropping and editing had an image width of 3888 pixels and an image height of 2600 pixels. The final image had an image width of 2830 pixels and an image height of 1921 pixels. The aperture was set to f/2.0. The shutter speed was 1/640th of a second. The ISO was set to 100. The final image was cropped and had exposure and contrast in iPhoto, and had a curves adjustment and the clone stamp feature used in Photoshop.

This image reveals the turbulent flow interaction between water, monoammonium phosphate, and pressurized nitrogen from the fire extinguisher. The fire extinguisher is releasing the monoammonium phosphate and the nitrogen horizontally into the water. The image shows a great interaction between the monoammonium phosphate and the water, but the pressurized nitrogen is not particularly visible in this image. The physics of the interaction are easily visualized. The immediate turbulent interaction between the monoammonium phosphate and the water can be seen. Also, the dramatic difference in densities between the two can be seen as the monoammonium phosphate quickly begins to rise in the water. I did fulfill my intent with this image. I would like to improve upon the hose that is introducing the ammonium phosphate into the water. It looks as though there is a little bit of motion blur on the hose. To develop this further, it would be nice to have some of the nitrogen visualizing involvement in the interaction.

References:

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