Madison Emmett
MCEN 4151
Team Second Report
Teammates: Lara Buri,
Michael Guenther, Michael Johnson,
Cara Medd
April 9, 2018

Team Second Report

Context

This was for the team second image project. Our team was wanting to capture what happens when dry ice is mixed with water. We were wanting to focus on the fog that is produced during this process but I ended up liking the sublimation process more. The final image I chose combines the fog and bubbles caused from sublimation. To create this image, I helped with lighting and pouring water. Lara did a lot of camera work. Michael Guenther brought the dry ice and helped with setup and lighting. Michael Johnson helped with water clean-up and creating new setup ideas. The final image we took that I chose to use is shown in Figure 1.

Figure 1: Final image for team second.

Apparatus and Flow

In order to capture this image, our team created the setup shown in Figure 2.

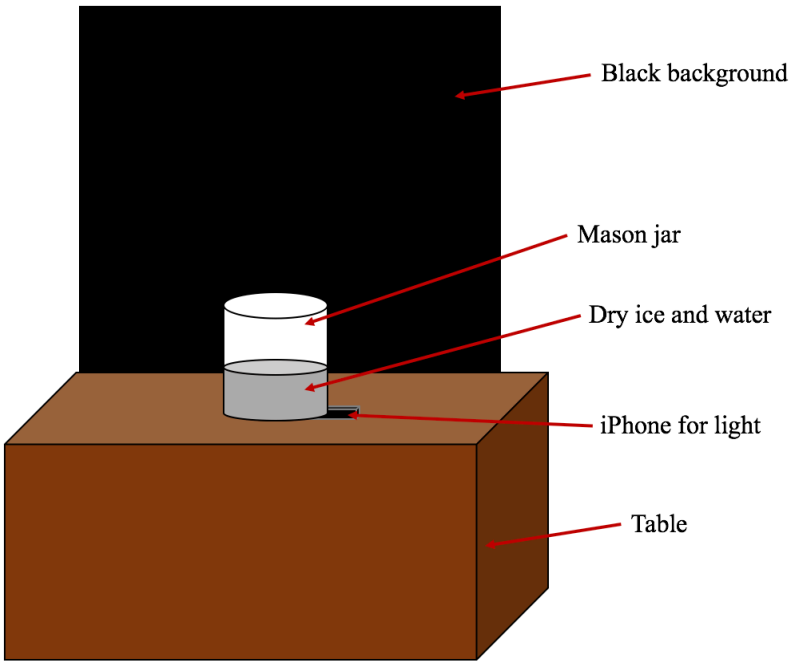

Figure 2: Team second setup.

We leaned a black piece of paper against the wall and set the mason jar on top of a table pushed up against the paper. The jar rested on top of an iPhone with its flashlight activated. The dry ice was added and the water was poured over the top of the dry ice until the chunks were completely covered. Then we took pictures of the results using a camera on a tripod.

The flow captured demonstrates dry ice sublimation in water. This process occurs at 194.65 K (-109.3˚F). The solid carbon dioxide changes to gas carbon dioxide and completely bypasses the liquid phase. The water speeds up the sublimation process to create the dense clouds of fog[1]. The CO_2 bubbles caused by this process rise up through the water and the light provided by the iPhone scatters off of the bubbles and water. This happens due to the different indices of refraction that exist between the gas bubbles and the liquid water[2]—CO_2 is around 1.0004, while H_2O is around 1.33. We can estimate the speed of the bubbles based on their movement with respect to the exposure time. Since there is motion blur, we will assume the bubbles moved about 0.5 cm from one frame to the next. Using this information along with the 1/200 shutter speed, we can ascertain that the bubbles were rising through the water at a rate that was faster than 1 m/s. From this we can determine the Reynolds number of the moving CO_2. Assuming the diameter of a bubble was 3mm wide, and the kinematic viscosity of the gas was 0.119 E-6 m^2/s, we can find Re:

$$Re = \frac{vD}{\upsilon} = \frac{(1)(0.003)}{0.119E(-6)} = 25210$$

In this situation, v is velocity, D is characteristic length, and υ is the kinematic viscosity. Since we are using the assumed values and the estimated velocity, this Re number is not exact, but it still falls into the turbulent flow region on the Moody Chart. Thus, the flow is turbulent, and becoming more turbulent over time.

Visualization Technique

We used standard dry ice from the grocery store and tap water. We would break the dry ice into pieces using a hammer and then arrange them in the mason jar with insulated gloves. The water was poured in after, completely submerging the solid carbon dioxide. The lighting we used was the LED light from an iPhone flashlight. The mason jar sat on top of the camera light so that the flow was illuminated from below. This made a cool effect that helped the bubbles and fog become more visible during the photography process.

Photographic Technique

The field of view was about two feet wide and the lens was about a foot and a half away from the mason jar. We used a Canon EOS Mark II camera at a focal length of 68 and F number of 2.8. The exposure time was 1/200 and the ISO was 800. The original image was 5616 x 3744 pixels, as seen in Figure 3. The final image was 3163 x 3192 pixels.

Figure 3: Original image.

To create the final image, I cropped the original image to a more appropriate size and position. I then used the burn tool in Photoshop to reduce the glare created by the light reflecting off of the bottom of the glass jar. The final image is shown in Figure 1 and Figure 4.

Figure 4: Final image.

What the Image Reveals

This image reveals the flow of dry ice sublimation in water. The solid carbon dioxide turns into gas and then bubbles up through the water and creates a fog on top. I really like the lighting that we used to make this image. I also like how the jar looks like a cauldron you might see as a decoration on Halloween. The fluid physics are shown really nicely and I like how the camera captured the motion blur of the bubbles as they rush to the surface of the water. I originally wanted to see the fog created by dry ice in water but I ended up liking this flow phenomenon better. I would like to improve some colorful aspects of this image if I were to improve it. The almost gray scale is nice but I think more vibrant colors would help draw in the audience more.

Citations

1 Dry ice. (2018, April 03). Retrieved April 08, 2018, from https://en.wikipedia.org/wiki/Dry_ice

2 RefractiveIndex.INFO. (n.d.). Retrieved April 08, 2018, from https://refractiveindex.info/?shelf=main&book=CO2&page=Bideau-Mehu