Team Photo 2

Molasses flowing over plastic suspended in water

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MCEN 4151: Flow Visualization

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Purpose

The purpose of this assignment was to satisfy requirements for the second team photo assignment and experiment with flow visualization techniques within a group. The requirements of this assignment were to make an aesthetically pleasing picture of fluids that demonstrate a phenomena being observed. For the purpose of this lab, the project chosen was to suspend plastic pieces in water and then pour molasses over them. The intent was to observe this phenomenon of molasses flowing as well as capture this fluid flow in a new and interesting way.

Flow Apparatus

The experiment was performed in a cylinder glass container. The container was chosen to give a clear surface for the molasses to be visualized from as to not distort or take away from the phenomena. Glass was chosen instead of plastic since the camera would be taking images close to the surface of the container and the surface therefore needed to be as clear as possible. The size of this container is approximately 6 inches tall with a diameter of 4 inches filled with about 5 inches of room temperature water. Room temperature water was used instead of warm water as to not encourage the molasses to diffuse any quicker than it normally would. The molasses used in the image is Grandma's original unsulphered molasses and can be purchased at a local grocery store. The plastic piece used was obtained from a scrap pile in a machine shop but is clear, hollow round stock of Kel-F with a diameter of approximately 1 inch, thickness of $1/16^{th}$ of an inch, and length of about 2 inches. The plastic piece was suspended in the water by looping fishing wire through the smooth, hollow plastic piece and tying the fishing wire around the arms of the chair on which the glass container was sat on. After the apparatus was set up, molasses was then poured over the plastic piece suspended in the water with a spoon while avoiding catching the fishing wire with the molasses to make the suspended effect more dramatic. About 3 spoonfuls of molasses were used and the molasses was released about half an inch above the surface of the water to have enough velocity on the flow of molasses without the molasses splashing when it hit the surface of the water.

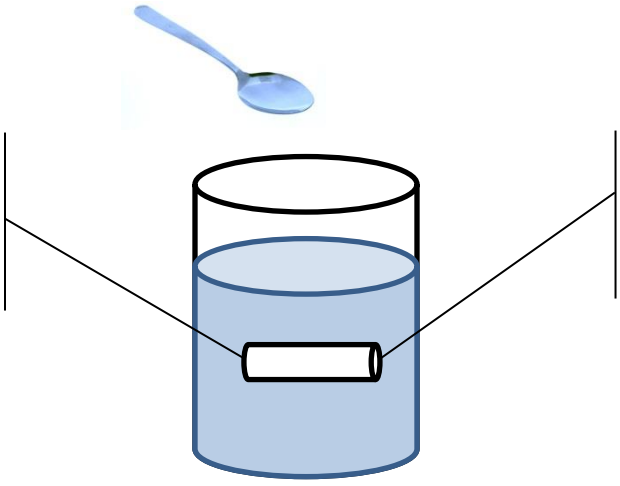

Figure 1: Flow Apparatus Setup

Flow Dynamics

This image was generated using a combination of solid and fluid visualization. By placing a solid in the water, the molasses was able to move over the plastic very gradually and hold on long enough to capture the image. Because the fluid is very viscous, the gradual flow as well as the strings and coning effect were able to be observed. Also, because the plastic piece was clear and had a similar index of refraction to water, the fluid flow of the molasses was not distorted significantly. The coning effect of the molasses at the top of the image above the plastic piece is due to the viscous pile up and surface tension of the molasses on the plastic before it starts to flow. The strings are also due to the high viscosity of the molasses, meaning that it has high resistance to gradual deformation by shear or tensile stress. Molasses has a viscosity value of about 5 -10 Pa*s as compared to water which has a viscosity of about 8.9*10^-4 Pa*s[1]. The flow of the molasses can also be characterized to further explain the visual effects of it. Laminar and turbulent flow can be characterized by the Reynolds number. The Reynolds number can be calculated as seen below:

$$Re = \frac{UD}{v} = \frac{\left(0.1\frac{m}{s}\right) * (0.008m)}{1.004 * 10^{-6}\ \frac{m^2}{s}} = 796$$

In this equation, the velocity of the molasses (U) was estimated to be 0.1 m/s, the diameter (D) of the string of molasses was estimated to be 8 millimeters and the viscosity of water at room temperature, approximately 20 degrees Celsius, is 1.004*10^-6 m^2/s. The number given by this equation represents laminar flow which makes sense from the smooth lines of molasses seen in the image taken.

Visualization Technique

We had a team of four people to set up the apparatus, pour the molasses over the suspended plastic piece, and photograph the phenomena. However, since the phenomena would stick around for a very long amount of time, there is plenty of time for photographing, and the entire experiment could be set up and photographed by one individual. If the photographer wanted to achieve the look of the phenomena seen in this image, they would need to go about this quickly. The photograph used to represent this experiment was taken early on before the molasses started diffusing in the water. This was done to demonstrate the early viscosity of the fluid and to capture the lines and coning effect mentioned earlier.

[1] *Wikipedia*. Wikimedia Foundation, n.d. Web. 18 Nov. 2015.

In this setup, a white background was used. This was achieved by placing a white window curtain behind the container. The curtain was draped over a chair outside. It is clear that the white curtain used in this image has texture to it but depending on what the artist hopes to achieve with the image, a plain white curtain could also be used. A white backdrop was chosen over a black one since the color of the molasses is quite dark. The glass cylinder container was then placed on the curtain with the curtain also behind it for the background. The lighting used was just natural sunlight outdoors. This experiment was performed on a sunny day, mid-day, to achieve enough lighting. Once the apparatus was all set up and the experiment performed, the camera was placed about 6 to 7 inches from the side of the container horizontally and manual focus was used to zoom in and focus on the molasses.

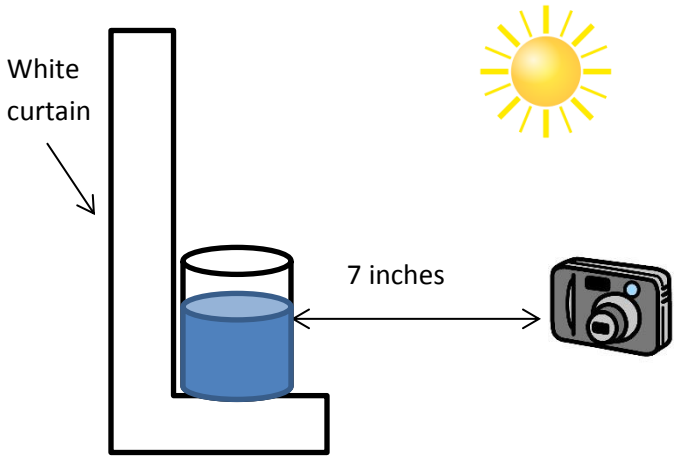

Figure 2: Camera Setup

Photographic technique

This photograph was shot using a Sony α 5000 E-mount camera with an attached 16 – 50 mm power zoom lens. This point and shoot mirrorless camera has manual focus capabilities with an ISO up to 16,000.[2] The image size shot is 5456 x 3632 pixels and the final image after processing is 800 x 1796 pixels. The focal length used for this shot was 50 mm which is equal to 75 mm for a 35mm equivalent range. The image was captured using a shutter speed of 1/160s and the ISO was only 160 to reduce blurring and noise. These settings in addition to the setup described earlier and the exemption of the flash led to the photo in figure 3 below. Use of an open – source photo editing program Gimp was then used to create the final image. The image was cropped to focus only on the phenomena (the molasses) and to get rid of the container and plastic piece. The image was then saturated a little but most importantly the contrast was increased to make the molasses stand out more against the white backdrop. The post – processing after image is also shown below in figure 3:

[2] "Sony α5000 E-mount Camera with APS-C Sensor." *Sony*. N.p., n.d. Web. 16 Oct. 2015.

Figure 3: Raw image (left) and processed image (right)

Conclusion

The project was successful in experimenting and understanding flow visualization techniques within a team. Being able to work on a team allowed us to create more original and complicated experiments as well as collaborate on understanding the physics behind the fluid flow. There were various attempts made on this project which resulted in understanding the experiment and discovering what methods worked or did not worked such as the various plastic piece setups and what would or would not distort the phenomena in the image. This experiment is another proof of the importance of having a good apparatus and flow setup to create a proper image of the phenomena.

The image revealed important fluid concepts in an artistic and new way. I really enjoyed that I was able to capture the coning and viscous strands in this image. I was also able to capture the varying colors in the molasses given from the varying thicknesses of it being poured. I also think my focus is nice on the focal point of my image. If I were to perform this experiment again, I might try to take the image closer to the container so I wouldn't have to crop so much and the image might look more resolved. I would also try to increase the lighting as the image is a little dark. However, I was able to capture a lot of interesting physics of fluid flow in this image and I feel like because of this, I fulfilled my intent with this photograph. If I were to develop this idea further, I would try smaller plastic pieces (perhaps tiny squares) that the molasses could completely submerge and flow over to hopefully make the image look even more dramatic and less distorted.