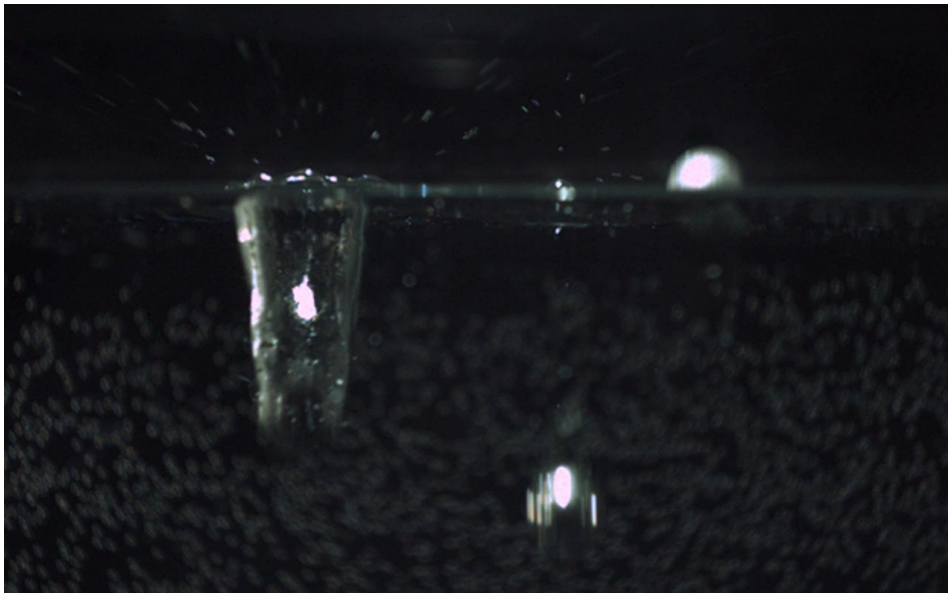
Team Project #2



Elizabeth Crumb

Flow Visualization – MCEN 4151

April 9, 2013

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This image is a part of a video that was taken for the second team assignment for Flow Visualization, MCEN 4151. The intent of this image was to capture a vapor jacket around a hot steal ball when it was dropped into water. The balls that were available for this project were small and when dropped into the tank they fell very quickly making it difficult to capture a good image. Working in a team allowed group resources and knowledge to be pooled to produce more captivating images and allowed a more difficult experiment to be undertaken. Working with the team was especially helpful for this project because many things needed to happen in a short amount of time. Everyone in Team 5, Jon Horneber, Shea Zmerlikar, Matthew Bailey, and Patrick Cotter, participated in the creation of this image.

The video for this assignment is of three half inch steel balls. The center ball is at room temperature and the balls on either end were heated in an oven at 700 degrees Celsius for approximately an hour. The balls were then placed in U-shaped aluminum trough laid across the top of the fish tank seen in Figure 1. Then, when the high speed camera was ready, the balls were dumped from the trough into the water. As the balls enter the water the hot balls leave behind a large pocket and the room temperature ball leaves very little mark. The hot balls also leave behind a large wake compared to the room temperature ball.

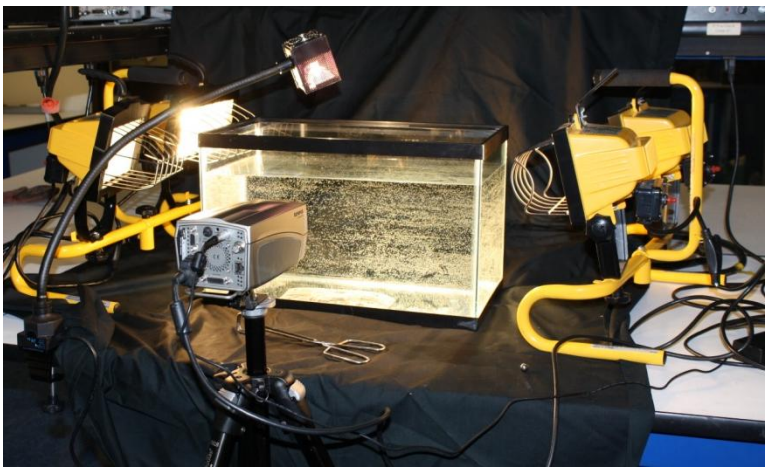

Figure 1: Fish tank, light and camera set up, Photo Courtesy of Patrick Cotter

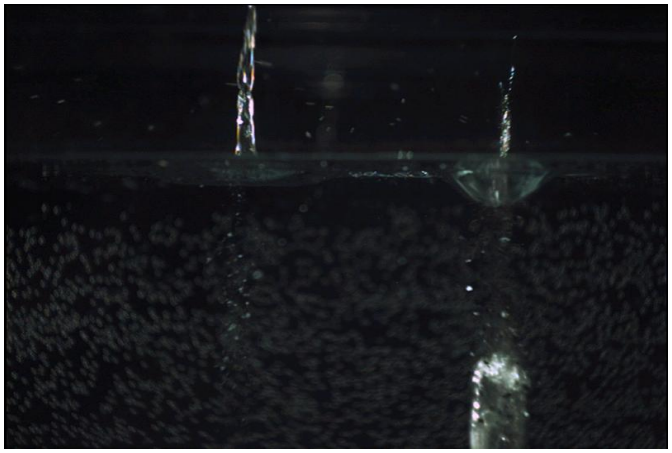

Figure 2: Still image from the video of the jets left behind after the balls were dropped. Note the lack of the jet for the center, room temperature, ball.

The high speed camera was set on a tripod and the focus was set before the balls were dropped into the water using something that was at approximately the same distance from the camera. The fish tank was filled with water shortly before the video was taken so it didn't have time to degas resulting in some bubbles being visible in the video. A black backdrop was used to minimize any distractions and lights were placed on either side of the tank and above the water to provide the maximum amount of light for the video because at higher frame rates the camera needs more light.

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When the hot balls enter the water they vaporize the water around them creating a pocket of air behind the ball as if falls, as can be seen in the photo on the cover page. The room temperature ball enters the water and since it doesn't vaporize the water around it there is minimal disturbance in the water. As the hot balls fall through the water they cool off and eventually the balls stop evaporating the water around them and the pocket begins to shrink. At this point the void left by the vaporization is filled by the surrounding water. As the water rushes in it is forced up due to too much water and a jet is formed, as shown in Figure 2.

As the hot balls fall through the water the water that is vaporized around them increases the impact of the ball and it is as if a much larger object were dropped into the water. The water is in a concave up shape, as illustrated in Figure 3, and the surface tension in the water attempts to restore the equilibrium of the system by bringing water into the gap. As the water comes together the liquid at the top of the jet moves fast and has enough energy to rise above the surface of the water forming the Worthington jet[1].

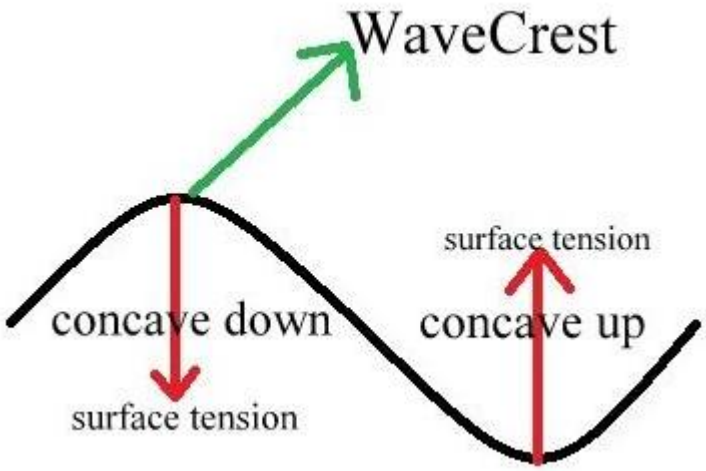

Figure 3: Forces of surface tension[1]

The image was formed using an Olympus I-Speed high speed video system that was checked out from the Mechanical Engineering Durning Lab. The video was taken at 300 frames per second and the camera was approximately 6 inches from the fish tank and the balls were 4 inches from the front edge of the tank. The lighting included the overhead lights as well as two sets of work lights and one North Star video light. There was no post processing other than slowing the video down and then repeating it at full speed.

I like how the image reveals how the balls interact with the fluid and the striking differences between the waters interaction with the hot balls and the interaction with the room temperature balls. It would be better if there were fewer bubbles in the video and more light to allow the video to be shot at a higher frame rate. I think the video is an awesome representation of the physics that are going on and it would be interesting to look into the effect of varying temperatures on the interaction with the water as well as looking at how dropping the balls from different heights change the waters reaction.

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References

1. "Worthington Jet." News. N.p., n.d. Web. 07 Apr. 2013.