Kevin Helmholtz Instability

The purpose of this assignment was to understand dynamic behavior between two fluids with different densities. This phenomenon is commonly known as Kevin-Helmholtz instability of fluids. A great example of this phenomenon is a lava lamp which can be seen in figure 1. Kevin-Helmholtz instability occurs when velocity shear is present within a continuous fluid, another word it occurs when there a large enough velocity difference across the two fluids. Because of different densities moving at various speeds will manifest form of waves at interface between two fluids.

Figure 1. Lava lamp- a example of Kevin-Helmholtz instability

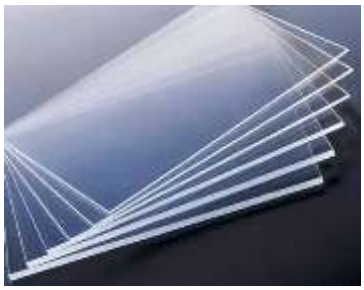

Figure 2. Acrylic panels

This was our first team assignment we decided to analyze the phenomenon discussed above because it is very interesting and also we wanted to have a better understanding of the physics which supports this phenomenon and also we wanted to build some sort of an apparatus. We used a clear acrylic panels and necessary adhesive to attach each panel which can be seen above in figure 2. 22 x 7 x 4 (l x w x h) was the rough dimensions of the box as seen below. Two 1/2 inch holes were drilled on the top panel to pour-in and drain the fluids out of the box. In order to do this experiment we needed two fluids with different densities, therefore we used vegetable cooking oil and water. In order to add the contrast we added about 10 drops of blue food dye prior to pouring oil into the box. Once the box was filled with both fluids two corks were placed. Prior to capturing images of Kevin-Helmholtz instability we had to let the box sit still for overnight in order to let the bubbles to disappear and rise to the top.

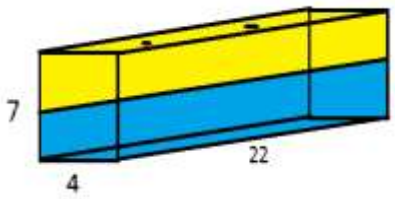

Figure 3. Apparatus sketch

Once most of bubbles were equalized and necessary equipment were set up we began observing and capturing the images of dynamic behaviors between two fluids by tilting the box. In order to have a dramatic affect we had to position the apparatus vertically then rotate the apparatus 90 degrees abruptly without slamming onto the table. As you see in (figure 4) my final image, we were able to create instability between two fluids. I was able to capture series of photos which represented the fluids in motion. Even though my images were in focus it appeared a bit blurry, it was only because there was so many tiny bubbles were forming from abruptly force applied to the box. Lastly only visualization technique used for final image was dying the water with blue food dye to create a strong contrast between oil and water.

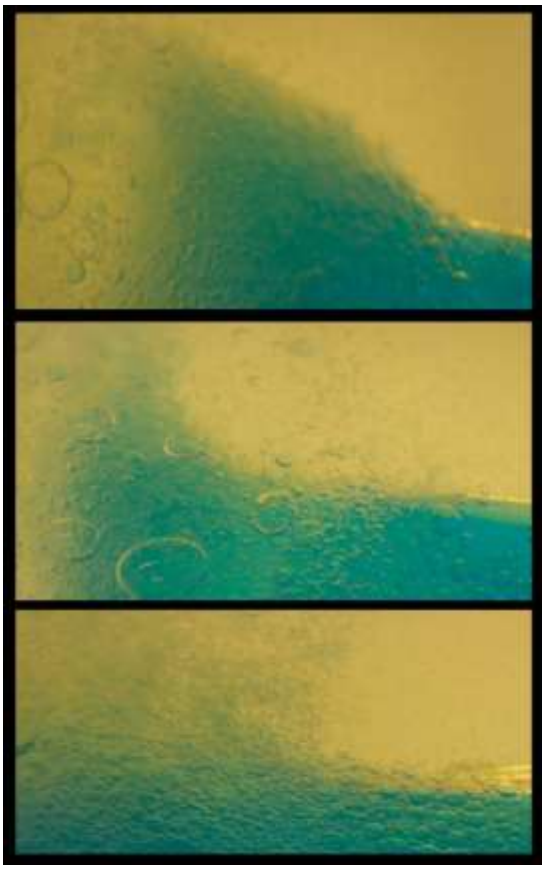

Figure 4. Final image

The detailed photographic technique used to create my final image will be presented in this section. An actual size of the field of view is approximate 3” x 2” and the distance from object to lens was about 1ft ± 1inch. Canon Rebel t2i Digital Single Lens Reflex camera with a macro lens were used to capture the final image. The exposure specs of aperture, shutter speed, and ISO settings were set to f/2.8, 1/200sec, 1000 ISO. Photoshop was only used to crop and aligned the images vertically with a black background. No other manipulations were used to enhance the quality of the image.

My final image depicted Kevin-Helmholtz instability as apparatus was tilted abruptly to provide fluid in motion. Because of density difference between oil and water, the waves were formed on the interface layer between two fluids. I like my final image because it represented interesting phenomenon and plus our team had a great time making the apparatus. It was a challenging and a great learning experience of taking photos of fluids in motion. I thought the light setting could be improved a little along with design of the box for future work. Redesign the box such a way that there's no air trapped inside the box. I believe that can help creating fewer bubbles. Although I was not successful at finding the background physics or mathematical expressions that can support the phenomena but I felt the fluid physics were well understood.