Megan Borfitz | Image-Video 2 Report
MCEN 4151-001 Flow Visualization | 12 October 2020

Context

The purpose of my video is to visualize wave formation due to different wind speeds generated by a hair dryer. I used natural outdoor lighting and light reflection and refraction to visualize the waves that formed. The reflections and concentrations of light that appeared on the ground beneath my container helped to visualize the shape of the wind-driven surface waves [1].

Flow Visualization Apparatus

In order to create the flow seen in my video, I used a CHI® Tech 1875 Series Hair Dryer placed on a flat surface next to a clear glass dish as seen in Figure 1.

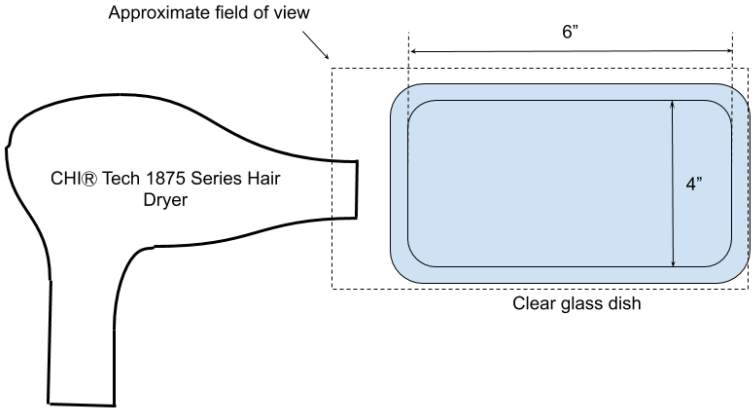

Figure 1. Flow visualization setup featuring a hair dryer and a glass dish filled with fluid

I set the hair dryer to cool and low speed, then I gradually angled the hair dryer down until it was level with the dish. This introduced air flow gradually to the dyed water in the dish. After I saw the waves fully formed and that they were somewhat consistent in appearance, I turned the hair dryer to high speed. I kept it at the same angle relative to the glass dish and on cool (instead of hot). This produces the waves in the second part of the video.

The waves that I produced in my video can be compared to the beginning stage of ocean waves. They start on calm water and begin to be influenced by small winds [2]. These waves start to form at wind speeds of about 3 feet per second in which the friction imposed on the water is enough to begin to form small ripples [2]. These small waves propagate into larger waves for several reasons. First, since the water becomes rougher, there is even more friction between the wind and the water and so the waves begin to get bigger [2]. This uneven surface produces small regions of low and high pressure, resulting in further wave propagation [2]. As the waves grow, gravity becomes an even bigger factor as the weight of the wave tends to pull the crests down toward equilibrium or the water pressure tends to push the troughs up [2]. In addition to this, surface tension also resists wave formation as it tends toward evening out the tension in the crest and the compression in the trough [2]. However, based on the scale of my experiment, the waves forming here probably do not have very much gravitational or surface tension influence.

Visualization Technique

In order to visualize the wind-driven wave formation, I mixed two drops of Safeway brand red food color into my dish filled approximately three-quarters of the way with tap water (note a dish depth of about 1.5 inches). This gives the red tint seen in the video and helped

visualize the concentrations of light on the bottom surface which the dish was sitting on. I set the dish on top of a water-resistant semi-transparent plastic sheet and put a white piece of copy paper beneath it to better visualize the wave formation through light refraction on a white background.

I took this video outside around 3 PM in late September with some clouds present. This gave nice diffuse, yet abundant, lighting so that there were fewer distracting reflections, but still enough light so that the refractions gave a clear picture of the waves.

Photographic technique

With regards to the field of view (seen in Figure 1), I tried to set my camera as close as I could to get the entire dish in the frame while maximizing the resolution. Because of the way my phone camera was balanced, I had some unevenness in the field of view where I cut off some of the far end of the dish and included more space at the close end. However, this turned out alright since the part that I cut off appeared to be just the edge of the glass dish and not the inner part where the waves were forming. Therefore, I could fix the framing in post-editing.

I estimate that my camera was about 8 to 12 inches from the subject. I used the slow-motion camera on my Samsung Galaxy S8 and recorded at a frame rate of about 30 frames per second. The frame width and height on my original video was 1280x720 pixels. In post-processing, I 'cropped' (by adding a mask in DaVinci Resolve) the video to focus just on the dish and the wave formation. I also adjusted the S-curve on the colors to add contrast. Figure 2 shows the comparison of an example from the original video and an example from the final video side-by-side.

Fig. 2 a. Example from original video

Fig. 2 b. Example from edited video

Figure 2. Comparison of original video (left) with edited video (right)

Conclusion

This video reveals wave propagation at two different wind speeds. I like that I was able to edit out the distracting background in the final video. I also like how the light naturally reflects and refracts off the water in a way that lets me see the shape and motion of the waves. I think the fluid physics are shown well in that the viewer can see the shape of the wave. In these ways, I fulfilled my intent of visualizing wave formation and shape.

To improve this experiment, I could try to take measurements of the hair dryer air speed so that I know what realm of wave formation my experiment falls into. Another direction that this experiment could take is to perform it in a larger tub of water. This may remove some of the reverberating effects that appear to take place as the waves bounce off the far wall of the container.

Sources

[1] Dr. Hertzberg. In-class critique of IV-2 assessment of fluid phenomena.

[2] “Wave Watching for Beginners.” *The Wave Watcher's Companion: Ocean Waves, Stadium Waves, and All the Rest of Life's Undulations*, by Gavin Pretor-Pinney et al., Perigee, 2010, pp. 18–20.