Group Project 1: Soap Film Tunnel Experiment

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Introduction

Soap film tunnel is commonly used to carry out hydrodynamic experiments especially to study two-dimensional flows. From the soap film experiments, it is possible to examine the transition between laminar and turbulent flow, the flow shear layer, and the vortex formation. The primary purpose of this project is to make a video of soap film in order to visualize the fluid phenomena that are happened in the soap film as the velocity of the soap film increases.

Experimental Setup

The concentration for the soap solution was made up of 1 part of glycerin, 10 parts of soap, and 200 parts of water. A 500 Watts of light bulb was used. The primary reason for using light at high power was because we wanted to have a full spectrum of light so that more colors of light can be seen as the light reflected of the soap film. The following image shows the soap film apparatus.

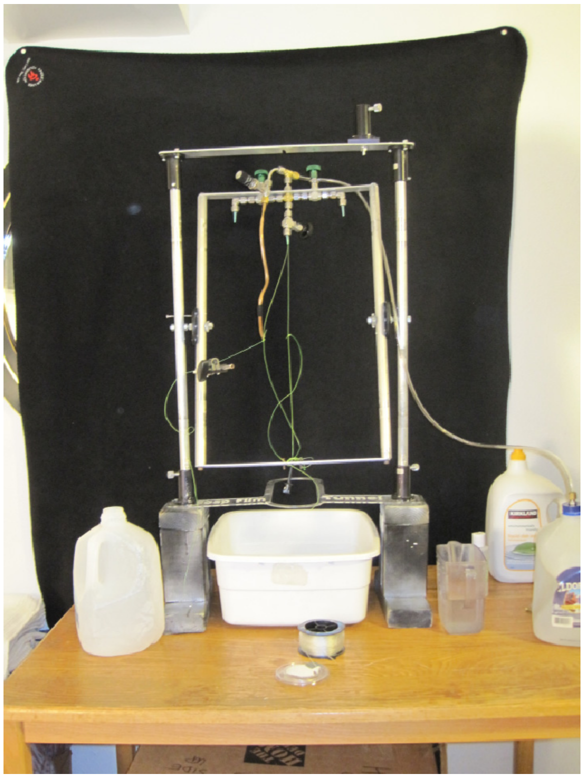

Figure 1: Soap Film Tunel Apparatus

The 500 Watts of light bulb was put on a light stand and it was pointed at the white board on the ceiling. The light that reflected of that white board would then shine into the soap film. This was done to enhance the visualization. The velocity of the soap solution was varied in order to examine different types of shape formation in the soap film.

Discussion

The video shows that there is a vortex formation as the soap solution came contact with the string surfaces. Vorticity phenomenon is observed because the fluid is rotational. The video also demonstrates there is color variation within the vortex ring. This is primarily due to the difference in soap film thickness. When light strikes the soap film, some lights reflect off of the top surface and some reflect off of the bottom surface (1). These two reflections will combine and produce interference of light, see figure 2 (1). This wave interference is the color that you actually see when looking at the soap film. When the soap film thickness is extremely thin compared to the wavelength of incident light, you cannot observe any color and the soap film would be transparent (1). This has been observed during our soap film experiment. At the top of the film, the color was transparent. Then color was observed in the soap film as we went down in length. This makes sense because due to the gravitational effect, the film thickness would be at its minima at the top and at its maxima at the bottom of the film.

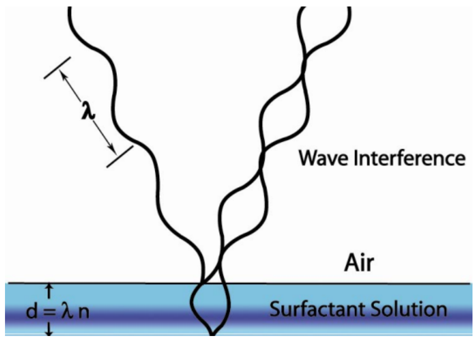

Figure 2: Light Wave interference (1).

Based on the video, there is also a shear layer of fluid outside of the vortex formation. Shear layer arises due to differences in velocity gradient (2). From the vorticity concept, Beizaie and Gharib were also able to visualize the Karman vortex sheet using soap film tunnel experiment (3). This was done by placing an object in the soap film (3). This Karman vortex sheet is also known as vortex shedding behind a cylinder. In order to calculate Reynolds number to determine whether the flow is turbulent or laminar, one must obtain a value for the film viscosity. Often time, this is difficult to know because there are two different types of viscosity: the bulk and surface viscosity (4). Fortunately, Roshko showed that by performing a vortex shedding behind a cylinder experiment, it is possible to obtain a relationship between Strouhal number and Reynolds number (4). Based on this relationship, Reynolds number can be calculated and consequently viscosity can be found via Reynolds number equation. Therefore, it would be useful to carry out Roshko's experiment next time to determine if the flow is laminar or turbulent.

Visualization Technique

A 500 Watts of light bulb was used in this experiment. This light bulb was used in order to capture all the fluid phenomena that were happening in the soap film tunnel. To minimize light interference from the wall that was directly behind the soap film apparatus, that wall was covered with a black cloth. When the light bulb was directly pointing toward the soap film, it was really hard to see what was going on in the soap film because it was transparent. Therefore, we allowed the light bulb to shine toward the white board on the ceiling and that light would reflect off of the white board and go into our soap film. By doing this, we were able to see more color variation in the soap film. The depth of field was about 5 ft by 5 ft and the distance from the object to the camera was about 6 feet.

Photographic Technique

A Sanyo XACTI VPC-FH1 video camera was used to make the video. Originally, the data size for this video was around 85.91 MB. By using Quicktime Pro, we were able to compress this file down to

10.27 MB. I did not edit the original video at all except for compressing the data file. The following table provides more information about the video.

Table 1: Details about the Video

Format	H.264, 640x360, millions
Movie FPS	30.00
Playing FPS	30.00
Data Size	10.27 MB
Date Rate	2.92 mbits/sec
Duration Time	29.56 seconds
Size	640x 360 pixels

Conclusion

Overall, I think my video is really interesting because it shows vortex formation and how the color changes with thickness of the film. Although I would like it better if I can add music to the video and tune the color up a little since it looks a little bit saturated. So for the next experiment, I probably will try to learn how to do video editing. Furthermore, I would like to figure out how to measure the velocity in order to carry out Roshko's experiment to determine if the flow is laminar or turbulent. Lastly, I will also try to see if I can visualize Kelvin-Helmholtz instability and Von Karman effect in the soap film by placing an object in the soap film and allowing the fluid to flow over it.

Works Cited

1. **Balsma, E.** Soap Film. *Delft University of Technology.* [Online] [Cited: 3 12, 2010.] http://www.de-monstrare.nl/pdf/Soap%20film.pdf.

2. *Wake-shear layer interaction using a soap film tunnel.* **Bocanergra-Evans, Humberto and Allen, James J.** 2005, Physics of fluids, Vol. 17.

3. *Fundamentals of a liquid (soap) film tunnel.* **Beizaie, M. and Gharib, M.** 1997, Vol. 23, pp. 130-140.

4. *A liquid film (soap film) tunnel to study two-dimensional laminar and turbulent shear flows.* **Gharib, Morteza and Derango, Philip.** 1989, Physics D, pp. 406-411.