MCEN 4151: Flow Visualization

Section 001

Team Second Report

11/11/2019

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The Team Second Assignment allowed us to collaborate with our team members to create an experiment and visualize any fluid physics phenomena of our choice. After researching various interesting fluid physics experiments, we decided that using the high-speed camera to record bubble blowing would provide us with quality content. This was our first time using the high-speed camera, so we had to undergo training from Mo Woods at the Integrated Teaching and Learning Laboratory (ITLL). We were interested in capturing the interaction between different density fluids by blowing a variable air input to a mixture of water and soap.

In order to capture this effect, my teammates (Alejandra Abad, Nebiyu Tadesse, Jamie Frankel, and Dimario Cancanon) and I gathered all the appropriate materials which are listen in **Table 1**.

Materials	**Quantity**
Tub for mixing	1
Dish Soap	1 bottle
Water	Enough to fill up tub
Rubber band	1
High-speed camera	1
Industrial lighting set	1

Table 1. List of materials used to create the Bubble Blowing Experiment

In order to capture this effect, we went through the following procedure:

Step 1: Add water and soap to small sized tub—mix with finger.

Step 2: Set up photography lighting so that you are able to capture a high-quality image.

Step 3: Make sure high-speed camera is plugged in and set at the desired angle.

Step 4: Dip rubber band in water + soap mixture to gather a smaller sample size.

Step 5: Blow into the mixture at airflow rate of your choice.

Step 6: Watch and record the interaction between the air and the water + soap mixture.

The experimental setup can be visualized in **Figure 1**.

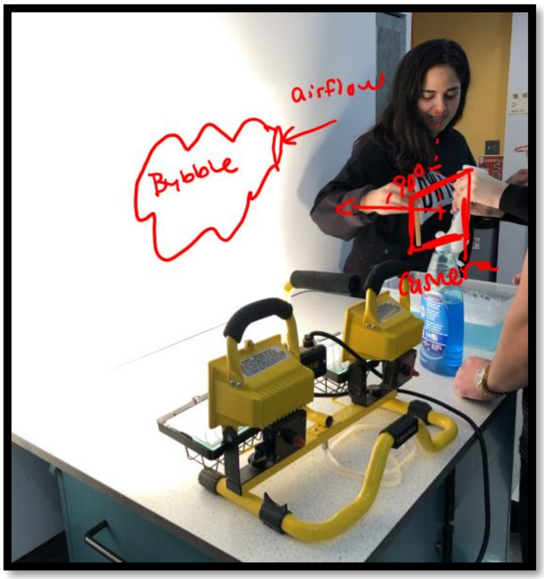

Figure 1. Photograph of the experimental setup

By following this procedure, we were able to visualize the effect of a variable airflow input on a water and soap mixture. Blowing air into the system, we see the formation of a bubble as a result of the pressure difference between water and soap and the air along with the surface tension of the soap film. **Figure 2** shows the bubble formation in its initial stage.

Figure 2. Bubble formation in initial stage

It can be seen in **Figure 2** how the bubble is formed by a mixture of pressure difference between the airflow input (high pressure jet) and the outer layer of the bubble (low pressure region). To determine the stability of the flow, an analysis of the Reynolds number was performed. The Reynolds Number can be calculated using Eq(1).

$$Re = \frac{\rho v D}{\mu} \quad (1)$$

where ρ = density of air [kg/m^3]

v = velocity of air [m/s]

D = diameter of cylinder [m]

μ = dynamic viscosity of air [kg/m-s]

By modeling the airflow as a cylinder, we can visualize the flow in **Figure 3**.

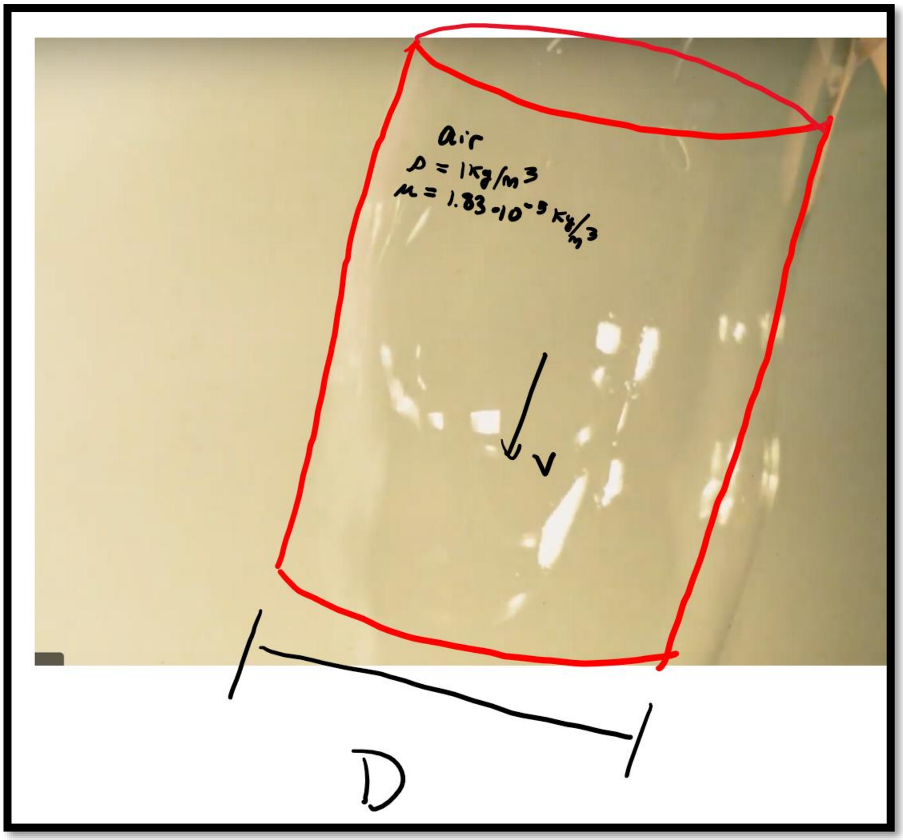

Figure 3. Airflow modeled as cylinder

Since air is the fluid that is under analysis, its properties are given:

$$\rho = 1 \text{ kg/m}^3$$

$$\mu = 1.83 \cdot 10^{-5} \text{ kg/m-s}$$

The diameter, D, of the cylinder was about 5 inches which D = 0.127 m in metric units. The velocity of the airflow at the streamline was estimated to be v = 1 m/s. This results in the following calculation:

$$Re = \frac{\rho v D}{\mu} = \frac{(1\ kg/m\text{^}3)(1\ m/2)(0.127\ m)}{(1.83 * 10^{-5} \frac{kg}{m * s})} = 6940\ > 4000\ (turbulent)$$

Since the value of the Reynolds Number is greater than 4000, the flow is considered to be turbulent, as presumed.

The video was captured about 2 feet away from the bubble at a resolution of 1280 x 1024, a sample rate of 900fps, and exposure of 1100. The high-speed camera in the ITLL was used to capture the video. I chose my specific clip of the bubble formation because I liked how you could see the turbulent nature of the flow along with the clarity and bubble explosion at the very end. I decided to add royalty free music that had an upbeat feeling to it because I felt that it matched the slow-motion movement that was occurring. During the post-production phase, I used Windows Video Editor to add a title, music, and filter to the video—besides this no other aspect of the video was altered.

Overall, I am very pleased with the outcome of my video. I was able to successfully capture the chaotic flow of the variable airflow input and the soap and water mixture. I also enjoy how the addition of the music through post-production made the video more enjoyable and provoked an uplifting feeling. The intent of my video was fulfilled but I do wish I was able to capture the video at slower speeds and with a bit more clarity.

References

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