Assignment 3, Team Project 1 – “Soap Film Visualized Filmed in High Speed”

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1 Objective

The objective of this project was to visualize the fluid dynamics of a soap film during bubble generation and collapse using microsecond filming. This was accomplished using a soap and water solution, a polycarbonate cylinder as a soap film boundary, and a high speed camera filming at 600 frames per second. Soap films are an aesthetically pleasing and physically complex phenomena, and the resulting video from this project visualizes the creation and collapse of a spherical bubble with cylindrical characterestics.

2 Setup and methods

Filming was performed using an Olympus I-Speed camera mounted on a tripod. Lighting was from a single angel with 1500 watts of light passed through a diffusing screen, and ambient light was neglible. Video was captured at 600 frames per second using an f-stop of 2.4 for maximum exposure.

The soap films were created using a 10% (vol/vol) mixture of Palmolive dish soap in tap water and a polycarbonate cylinder. The polycarbonate cylinder dimensions were 10 inches in diameter and 8 inches in length with as-sawed surface roughness on the ends. Soap films were generated by placing the cylinder end in the Palmolive/water solution and withdrawing quickly, allowing air to flow through the cylinder (Figure 1). This formed a cylindrical film that developed into an elongated bubble.

3 Discussion

Soap film dynamics were extremely complex when viewed at 1/10th speed. Using the methods described in the setup, the Reynolds number was determined to be approximately 1 X 10^5, well within the

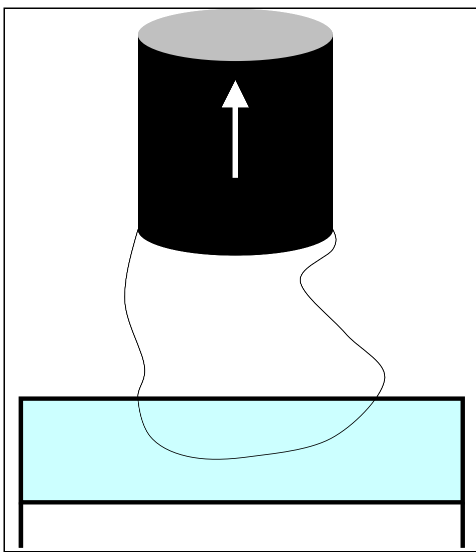

Figure 1 - Setup for soap film generation

Figure 2 – Cylindrical soap film

Figure 3 – Spherical bubble before collapse

turbulent regime. This adds to the complexity of the observed phenomena, as most bubble dynamics analyses are performed under laminar flow conditions.

The bubble during formation resembles a cylindrical soap film (Figure 2) and near the point of collapse, an elongated spherical bubble (Figure 3). The dynamic nature of the film is due to the balance of forces from surface tension, gas flow pressure, and the inertia of the soap film mass.

The collapse of the soap film was not consistent or predictable and is likely due to multiple mechanisms. The expanding film thins, and therefore becomes less stable, leading to film collapse[1]. In addition, the Rayleigh criterion (length greater than diameter) is exceeded during the generation of the cylindrical film, which is another known soap film instability[2]. Both mechanisms contribute to the instability of the soap film, and the inconsistent dynamics of the movement of the cylinder also contribute greatly to the unpredictability of the soap film collapse.

4 References

1. Gramfich, C.; Homsy, G. M., Linear stability of an expanding spherical liquid film. *Colloids and Surfaces a-Physicochemical and Engineering Aspects* **2006,** 282, 11-23.
2. Xu, S. C.; Chang, L. W.; Xu, L., Analysis of instability of a cylindrical soap film of finite dimensions. *Langmuir* **1998,** 14, (2), 533-535.