Flow Visualization – Team Second Champagne

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Introduction

For the second team project in the Flow Visualization course my team and I took slow motion video of a champagne bottle opening. To create this video I worked with several team members Daniel Bateman, Jeremiah Chen, and Jason Savath. The help of my teammates was crucial in creating my video. I also need to acknowledge the incredible amount of help that professor Hertzberg and Truscott provided. The use of professor Hertzberg's equipment and professor Truscott's camera was essential in creating this video. In this video many different fluid phenomenon take place. This paper is intended to illustrate how this video was made and the physics-taking place.

Setup and Physics

The setup for this video is not to complicated and would be easy to replicate. First one person will need to be the one to fire off the cork. At the time of fire the operator will need to shake the champagne bottle and coordinate with the cameraman to countdown for fire. A fish tank about 2 foot long, 1 foot wide, and 1 foot high was used to capture the flow. To keep good focus a mark was made on the tank for the bottle positioning. The camera was placed about 1 foot from the tip of the bottle. A black cloth was pinned to a board and used as the background. Four construction lights were used for back lighting in conjunction with two lights. It is important to nut use florescent lighting because it is not a constant source of light and will flicker on and off in slow motion. Black plastic was laid out to capture any extra spray that was not collected by the fish tank. A towel was hung from the ceiling to stop the cork. The towel was placed about four feet from the end of the bottle. In the image bellow you can clearly see the setup.

Image 1 – Setup

There are many interesting and complicated events that occur during the course of the video. At the beginning, the bottle is closed and the pressure inside is about 90 psi. (PAYNE, 2012) When the cork was released from the bottle it is traveling at nearly 50 mph. The crok only weighs about 1 oz or 30 g. The pressure in the bottle is created due to C02 that is dissolved into the liquid. By shaking the bottle I slightly increased the pressure between the liquid and the cork because the disturbance releases C02 from the champagne. The corks conical shape is compressed into the neck of the bottle to create a sealing pressure. By overcoming the sealing forces and friction created by the cork, the bottle quickly releases the C02 pressure and forces to cork to become a projectile. The crok is slowed due to aerodynamic drag and gravity pulls it down at an acceleration of $9.81 \frac{m}{s^2}$. The cork is additionally pushed by some of the liquid and vapor that is moving at a greater velocity then the cork and smashes into it. This can be seen in image 2 below.

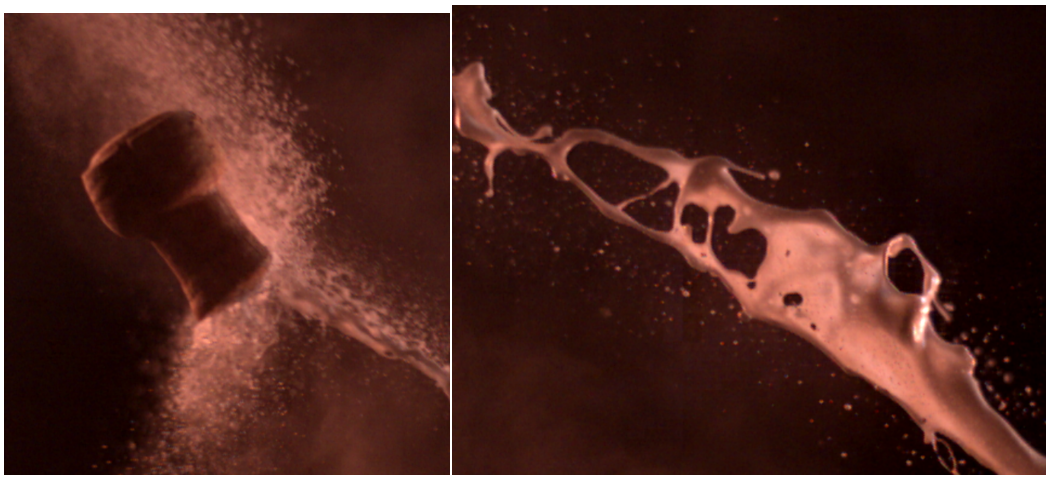

Image 2 – Initial Spray

A stream of fine champagne bubbles quickly follows the cork out of the bottle. It is fascinating to see the bubbles form a thin sheet and then pull apart. As the surface tension between the bubbles in the sheet breaks, the bubbles pull together. The force causes fingers of spiraling bubbles, as seen above in image 2. There are also many bubbles and champagne particles that are on there own. They are fascinating because they sparkle and refract light like a prism that allows individual wavelengths of light to be seen. (Hecht, 2001) The rainbows of light add a small amount of color.

As the film continues a second wave of champagne bubbles burst out of the end of the bottle. The new wave moves at a slower velocity and creates an interesting s shape do to this. This second stream is due to the change in pressure in the bottle allowing for more C02 that was dissolved in the champagne, to escape and flow out of the bottle. The temperature and pressure changes also helped to condensed some fluid creating a fog. The fog was then pull out of the bottle trapped in the bubbles. The Fog created a hole in the bubbles. Due to the shear forces from fog flowing out of the relatively small hole created, a mushroom cloud was formed.

The fog continued to increase the size of the hole until the fog was released. Below is an image of this event.

Image 3 – Gas Release

Visualization Technique

For this video my team and I were fortunate to be able to work with an extremely high quality high-speed camera. The amazing phantom camera captured our video in stunning detail. My team and I tried front and back lighting. The front lighting provided a quality video but the back lighting was really brilliant. With the back lighting the small droplets really sparkled and acted like small prisms. To achieve the best contrast possible the team tried several different options. The team and I tried black fabric, a white painted wall, and LED lights. All backgrounds produced good contras but the black background produced the best results. The LED light background was used for a close up shoot, were a lot of light was required. Though the use of video editing I was able to crop the video to help the viewer focus on the fascinating fluid mechanics. I used music to help the viewer feel immersed in the experience.

Photography Technique

The camera used for this video is called the Phantom 2512. This is an incredible high-speed camera. For the video we shot at full resolution 1280 x 800. The frame rate was an outstanding 25,000 frames per second (fps). The Phantom 2512 has the ability to go up to 1,000,000 fps at a reduced resolution. The raw video is 9.68 GB. The focal length was set to 50mm. The frame for this video is about 12 inches by 10 inches. The back lighting provided enough light to clearly detail the

fluid mechanics and allow for good focus. The quality of the videography must be totally accredited to professor Truscott.

Image 2 – Original vs. Edited Image

Conclusion

In conclusion my team second video was a joy to make. Professor Truscott's camera was better then I could have imagined. The detail and focus was incredible. With so much going on during the opening of a champagne bottle having the ability to capture it in slow motion was a treat. During the editing process I found myself watching the video over and over again. Each time I watched it I found something new to admire. Having the chance to work with an experienced videographer really showed me how little I know. The only thing I wish we did differently is to have the lighting positioned better from the start and more options for background materials. We thought that we had done a good job with our setup before the photo shoot but after learning during the shoot I believe my team and I could produce even more spectacular videos if we shoot again. Overall I am extremely pleased with the video I was able to produce for this project.

References

Hecht, E. (2001). *Optics, Reflection, Refraction and the Prism.* Saint Louis, MO: Addison-Wesley.

PAYNE, E. (2012, 12 31). *Open with caution: How that bottle of bubbly could leave you blind*. Retrieved 11 11, 2016, from Daily Mail: http://www.dailymail.co.uk/health/article-2255210/How-bottle-bubbly-leave-blind.html