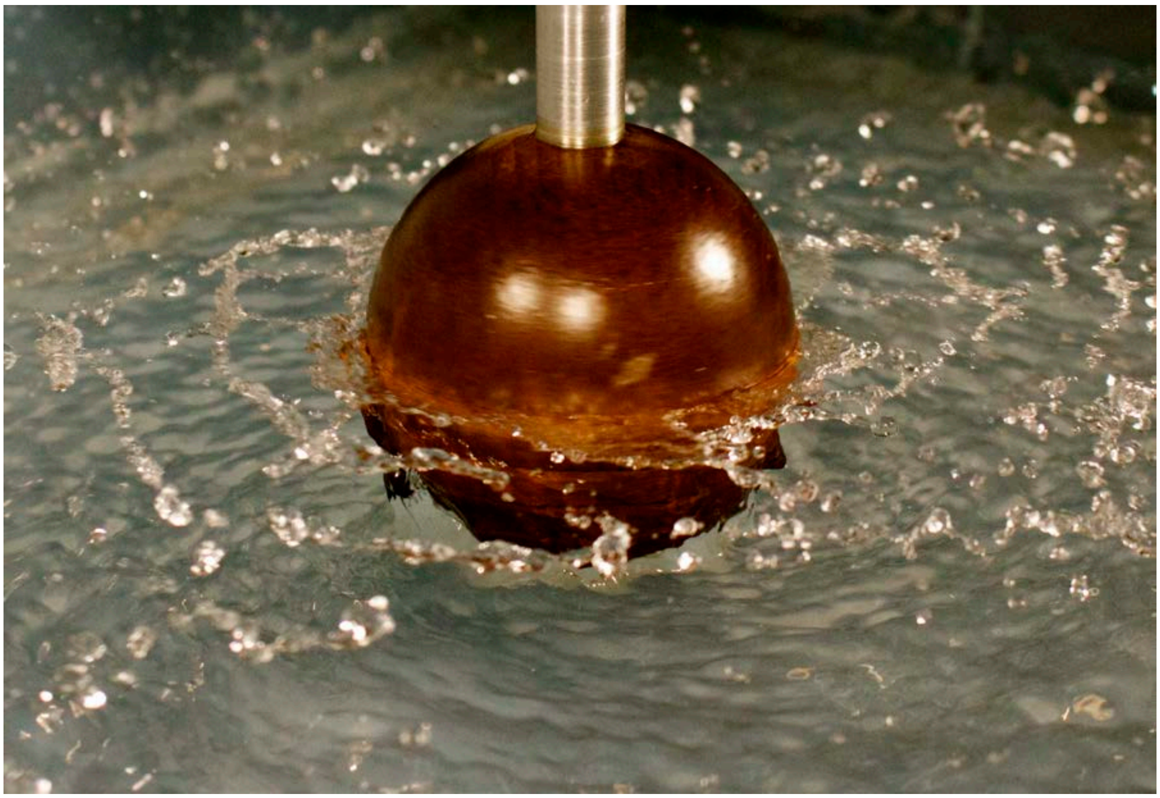
Team Photo #3



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05/01/2014
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Introduction

This photograph was taken for the purpose of the third team image for the Flow Visualization class of Spring 2014. After having Professor Tadd Truscott of the University of Brigham Young talk with our class, we wanted to try and recreate the "Egg Sprinkler Mystery" experiment. After some machining and much trial and error, we were able to capture several good images.

Physics

As can be seen in the image a very interesting phenomenon is occurring, one that has been studied before. Tadd Truscott and his associates of the Splash Lab project at Brigham Young University had previously performed this experiment, and we decided to try and recreate it. As stated by Splash Labs the results of this experiment are dependent upon: viscosity, immersion depth of sphere, angular velocity, and sphere diameter[1]. The liquid we were using was water, which has a viscosity at room temperature of 1.002 mPa*s[2]. The angular velocity was 1200 rpm, and we had decided upon this after some experimentation. This results in the water being shot off at an approximate velocity of:

$V_\perp = r^* \, d\phi/dt$ where, $d\phi/dt$ = 1200 rpm= 125 rad/s, r= 2.5 in = 0.0635 m
$V_\perp$=0.0635 m*125 rad/s
$V_\perp$= 7.9 m/s or ≈ 17.7 mph

The immersion depth we varied throughout the whole experiment, and for this particular image the immersion depth was approximately ¼"- ½". Finally the sphere diameter was 2 ½", and this was decided upon based off of randomness considering we had no experience with this phenomenon before.

By adding the angular rotation to the wood sphere the liquid begins to crawl up the perimeter of the sphere. As the ball spins the liquid also begins to spin because of the no slip condition. The friction between the wood and the liquid is what causes the liquid to rotate with the sphere. The reason the liquid rises is because of a speed difference between the bottom of the sphere and center of the sphere. Due to the Bernoulli principle this difference in speed creates a difference in pressures between the bottom and top of the sphere[3], which is the driving force behind the liquid rising. At the maximum diameter of the sphere the liquid sprays off. Also stated by Splash Lab there are three modes of ejection for this phenomenon: jets, sheets, and sheet break-up[1]. The image shown is a mixture between jet and sheet break-up.

Visualization Technique

In order to produce this image a good amount of setup had to be performed. We ordered several maple wood balls of 2.5" diameter from McMaster Carr that we ended up machining in order to be able to put it into the a mill. After machining the ball we applied a polyurethane stain to the wood to add color and make the surface smoother. We then placed a metal rod in the machined hole as seen in Figure 1, so that we could place the ball in the chuck of the mill. Next, we took a large plastic bin and filled it with ½”-3/4” of water. We then turned on the mill and went through a large range of angular velocities. We decided upon 1200rpm, and experimented with the immersion depth of the sphere. For this particular image the immersion depth was approximately ¼”- ½”. By turning the shudder speed up very high along with the ISO setting several cool images were able to be produced.

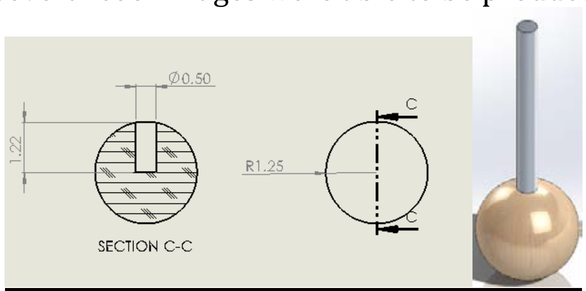

Figure 1-Setup

Photographic Technique

The field of view in this image is approximately 8-10”, taken away from a setup that was around 24” X 36” X 6”. The distance from the object to the lens is approximately 18-24”. The type of camera being used was a Canon EOS Rebel T31 and the lens on the camera was EF-S 18-55mm f/3.5-5.6 IS STM. The focal length for this image was 30 mm, the aperture was f/5.6, the shudder speed was 1/2500 s, and the ISO speed was 1600. The image was cropped in order to get rid of distracting elements that were originally in the image. The only other editing done was to change the coloring of the image. By increasing the amount of color it is easier to see the vortex at the bottom of the sphere.

Image Results

Overall I am very pleased with the image, and I am glad that we decided to try and recreate the experiment from the University of Brigham Young. I think this photo is really well time-resolved and I like how you can really see every aspect of this phenomenon. I like how you can see the vortex at the bottom, the water crawling up the side of the sphere, and the water droplets frozen in time around the outside. If I were to advance this experiment and try to get better images, I would add dye next time or use a different liquid than water. If we were using dye, it might have been a better visual indicator for both the vortex at the bottom, and for the liquid being sprayed. I think the physics of this phenomenon are well imaged and explained, via the referencing of Tadd Truscott and his team’s work on this phenomenon.

References

1) "Eggs in Milk." *Splash Lab*. WordPress, 17 Sept. 2012. Web. 24 Apr. 2014. <http://splashlab.byu.edu/2012/09/17/eggs-in-milk/>.
2) "Viscosity." Wikipedia. Wikimedia Foundation, 15 Apr. 2014. Web. 24 Apr. 2014. http://en.wikipedia.org/wiki/Viscosity#Water

3) Truscott, Tadd, and Ken Langley. "Cracking The Egg Sprinkler Mystery."YouTube. YouTube, 07 May 2012. Web. 29 Apr. 2014. <http://www.youtube.com/watch?v=s5XVqWA1mj4>.