Team Second 2016

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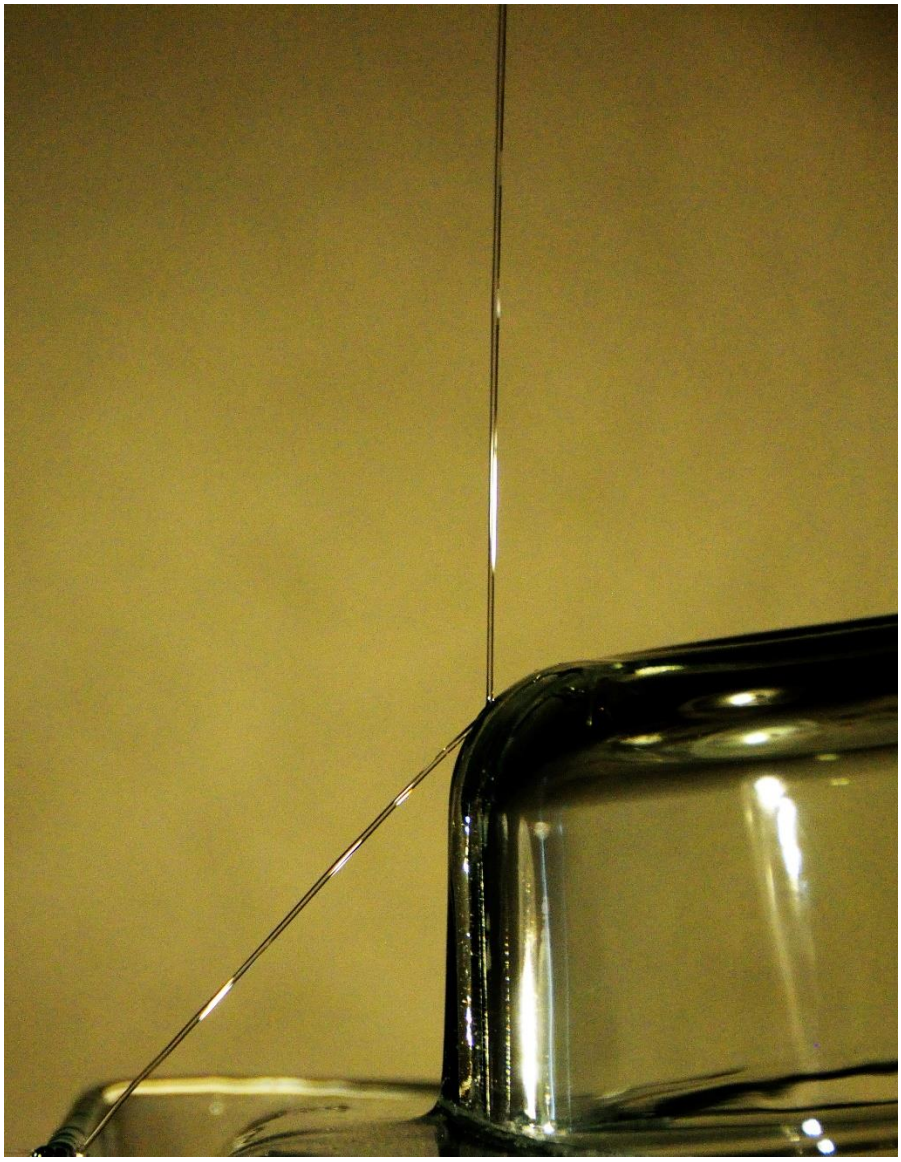

Flow Visualization

Professor Jean Hertzberg

2016

Introduction

The purpose of this assignment was to explore a fluid flow from an artistic perspective. The project chosen for the "Team Second" assignment was intended to explore the perceived "bounce" witnessed as a result of the Kaye effect with shear thinning fluids. A shear thinning fluid is simply a fluid where the viscosity decreases with an increasing shear rate. This experimental setup was intended to capture the Kaye effect bouncing off of an angled edge, rather than to capture the effect on a flat surface.

The Apparatus and Analysis

The Kaye effect being shown in the image is a phenomenon where a shear thinning fluid, such as dish soap, hitting a pool of the same fluid will cause the stream to "slip" and bounce away from the pool. At this interface, a high shear rate of the fluid making contact with the pool causes the interface to become a low viscosity interface and force the incoming stream to slip and divert away from the surface. The incoming fluid stream will impart a vertical force onto the fluid pool and form a dimple or divot that causes the redirection of the fluid. This is known as the Kaye effect. The image captured for this project is taken from a side profile so the dimple is not visible, but is shown in Figure 1 from Michel Versluis' paper titled "Leaping Shampoo and the Stable Kaye Effect".

The apparatus for this flow visualization was quite simple. Clear Palmolive dish soap was used as the shear thinning fluid with an approximate viscosity of 85 mPas (cP). The dish soap was dropped from a height of 2 feet above a glass Pyrex dish onto the dish's rounded edge. The fluid stream hits the dish at an angle of 88.8° from the horizon and bounces off of the dish at an angle of 216.5° giving a total ΔΘ of 127.7° between input and output streams. Using basic kinematic Equations (1) and (2), the fall time of the stream is 0.64 seconds, giving an impact velocity of 6.62 ft/s or 2.02 m/s.

$$d = v_i t + \frac{1}{2} a t^2 \qquad \text{Equation (1)}$$

$$v_f = v_i + at \qquad \text{Equation (2)}$$

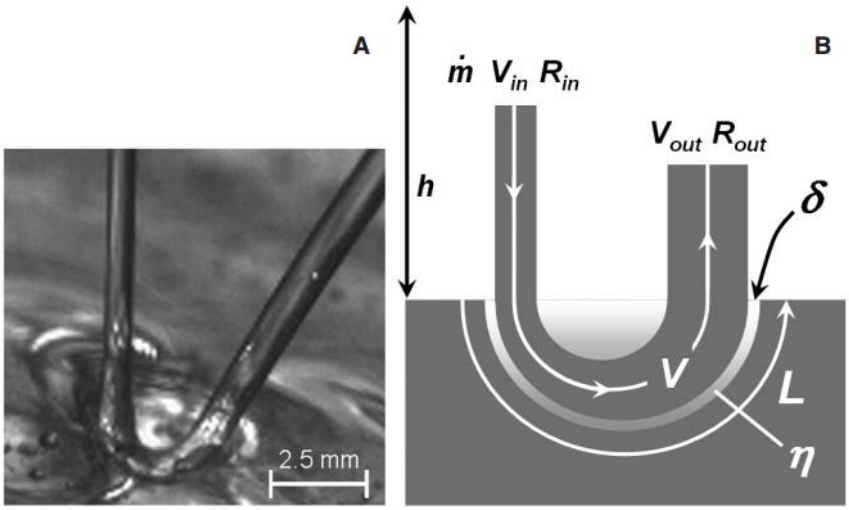

Figure 1: A photo showing the dimple effect of the Kaye effect from Michel Versluis' paper titled "Leaping Shampoo and the Stable Kaye Effect".

The image was taken using a glass Pyrex dish with curvature on the corner of the dish. The curvature of this dish was the medium that the dish soap interfaced with in the setup. This dishware was placed on a baking sheet to capture the excess dish soap post bounce. There were two desk lamps used to illuminate the flow, one at about a 30 degree offset to the left of the camera and another at a 120 degree offset from the camera, both facing the setup. Above the setup was a simple fluorescent light fixture that provided diffused light from directly above the setup. Clear Palmolive dish soap was poured directly from the bottle with a small, continuous stream slowly drizzled back and forth across the curved surface.

Photographic Technique

This photograph was taken on a Nikon D5000 DSLR camera using a Nikon VR 18-200mm f/3.5-5.6G lens, on loan from Johanna Heilman. The camera was set on a tripod and the camera was set looking at the fluid from a horizontal reference point. Focus was manually set to focus at the location that the dish soap hit the dishware. The object was about 4' away from the lens with a zoomed focal length of 104 mm to capture both the initial approach and the bounce from the Kaye effect. Image resolution was large at 4288 x 2848 shooting in a 12-bit compressed RAW format. A desk lamp was shining onto the dishware from a 30 degree offset to the left of the camera. Another desk lamp was placed at a 120 degree offset to the left of the camera, shining directly onto the setup. An overhead light was turned on directly above the flow shining down on the setup. A fast shutter speed of 1/400s was used in order to try to eliminate any potential motion blur in the fluid flow and get a crisp image. The fluid flow was essentially frozen in time over the exposure period as a result of the quick shutter speed and the light exposure was compensated for by using a relatively high ISO of 1600.

Table 1: Camera settings

Camera	Nikon D5000 (DSLR)
Lens	VR 18-200mm f/3.5-5.6G
Original Image Size	4288 x 2848
Final Image Size	2208 x 2848
Field of View	~ 1' x 2'
Focal Length	105 mm
Aperture	f/5.3
Shutter Speed	1/400s
ISO	Auto (ISO 1600)
Flash	2 desk lamps, overhead lighting

The image was edited slightly from the raw shot using GIMP 2. In order to maintain the scientific validity of the photo, it was cropped to a resolution of 2208 x 2848 which eliminated a large amount of the negative space and brought the image focus onto the fluid flow itself. The image's contrast curves were altered to try to achieve a greater contrast between highlights and shadows of the fluid stream and the background.

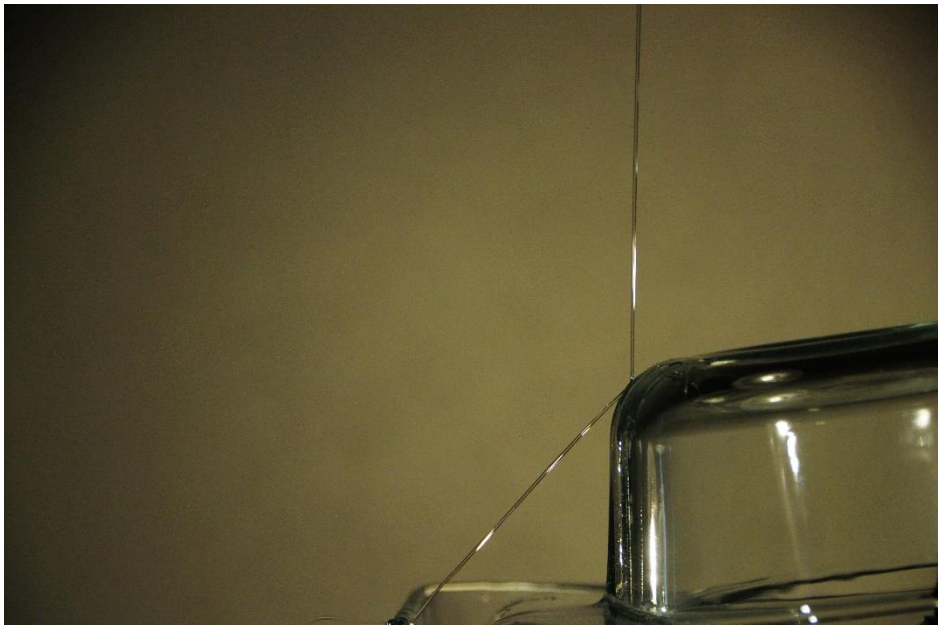

Figure 2: Unedited image

Image Intentions

The intention of this image was to capture the entrancing effect visible from the Kaye effect with shear thinning fluids. Although leaning more on the scientific feeling, the image manages to draw the eye in the direction of the fluid flow which exemplifies the flow phenomenon. If I were to build upon this photoshoot, I would try to accomplish a completely black background with a well illuminated fluid stream as I believe the background detracts in some ways from the image intent. I might also try to capture the fluid bouncing off of multiple surfaces, as my team mates succeeded in capturing.

Acknowledgements

Special thank you to Johanna Heilman for lending her DSLR camera for the photoshoot. Thank you to Jeremy Parsons, Max Scrimgeour, and Joseph Straccia for helping brainstorm ideas for an effective setup. Thank you to Professor Jean Hertzberg for enabling this project.

Works Cited

Viscosity Chart, http://thesuccesstechnic.weebly.com/uploads/7/2/1/3/7213446/flux-high-viscosity-b0000-visc-chart-1.pdf

Versluis, Michel, Cor Blom, Devaraj Van Der Meer, Ko Van Der Weele, and Detlef Lohse. "Leaping Shampoo and the Stable Kaye Effect." *Journal of Statistical Mechanics: Theory and Experiment* (n.d.): n. pag. *IOP Science*. 20 July 2006. Web. 11 Nov. 2016.