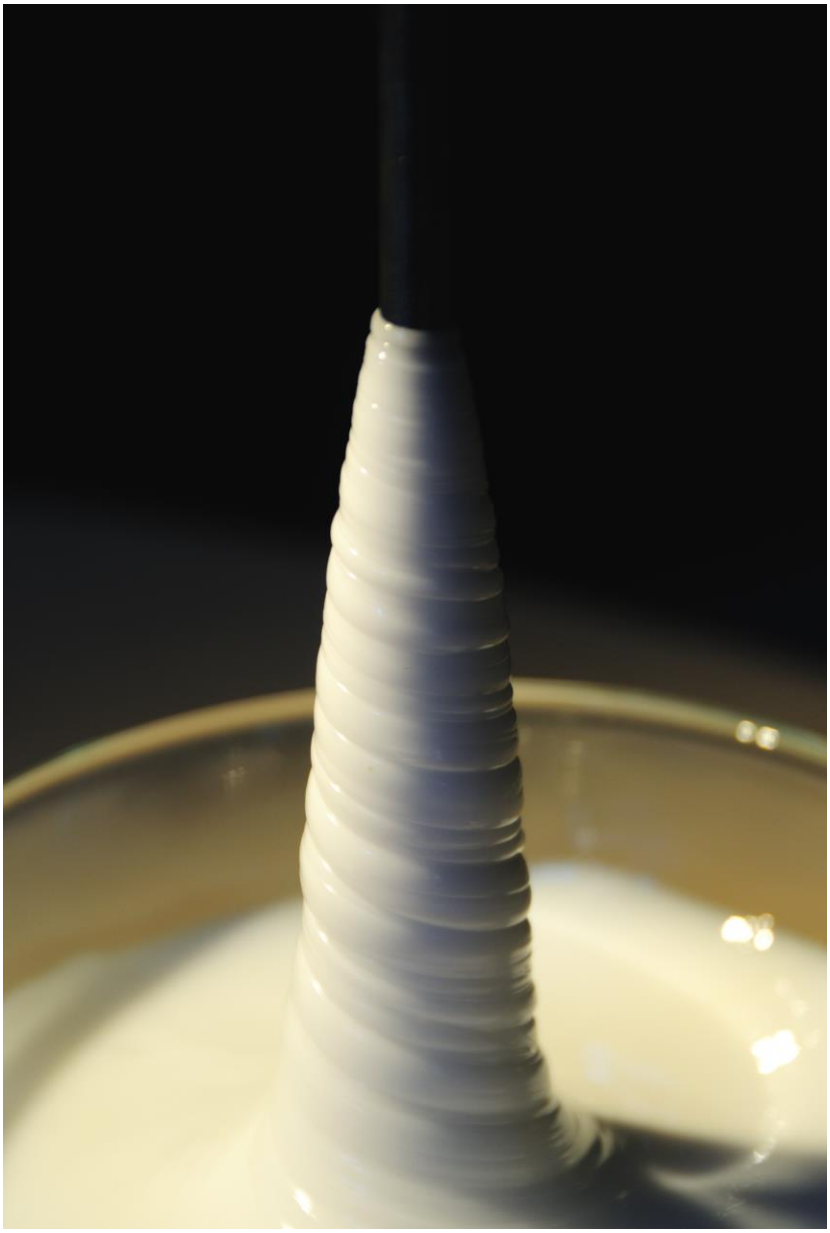
Get Wet 2016

Peter Brunsgaard



Flow Visualization

Professor Jean Hertzberg

2016

Introduction

The purpose of this assignment was to explore a fluid flow from an artistic perspective. The flow observed in this report is known as the Weissenberg Effect and can only be observed with non-Newtonian fluids. Weissenberg effects are seen when a non-newtonian fluid is put into torsional shear making the fluid climb up whatever is applying the shear. It took many iterations to get the fluid to exhibit the effects in an artistic way, but ultimately the phenomenon was observed very clearly.

The Apparatus

As mentioned earlier, the Weissenberg effect only applies to non-Newtonian fluids. In a normal Newtonian fluid, inertial effects on the fluid are most prevalent, forcing the liquid out and away from the rod. In the case of non-Newtonian fluids, applying a torsional force creates shear between the bonds of the polymer causing them to bond and display properties more commonly seen with solids.

A non-Newtonian fluid was created using basic non-toxic household materials. A teaspoon of Borax laundry detergent dissolved in water was mixed together with Elmer's school glue diluted with water creating "slime". The Borax bonds the polyvinyl acetate molecules into one large flexible polymer chain shown in Figure 1.

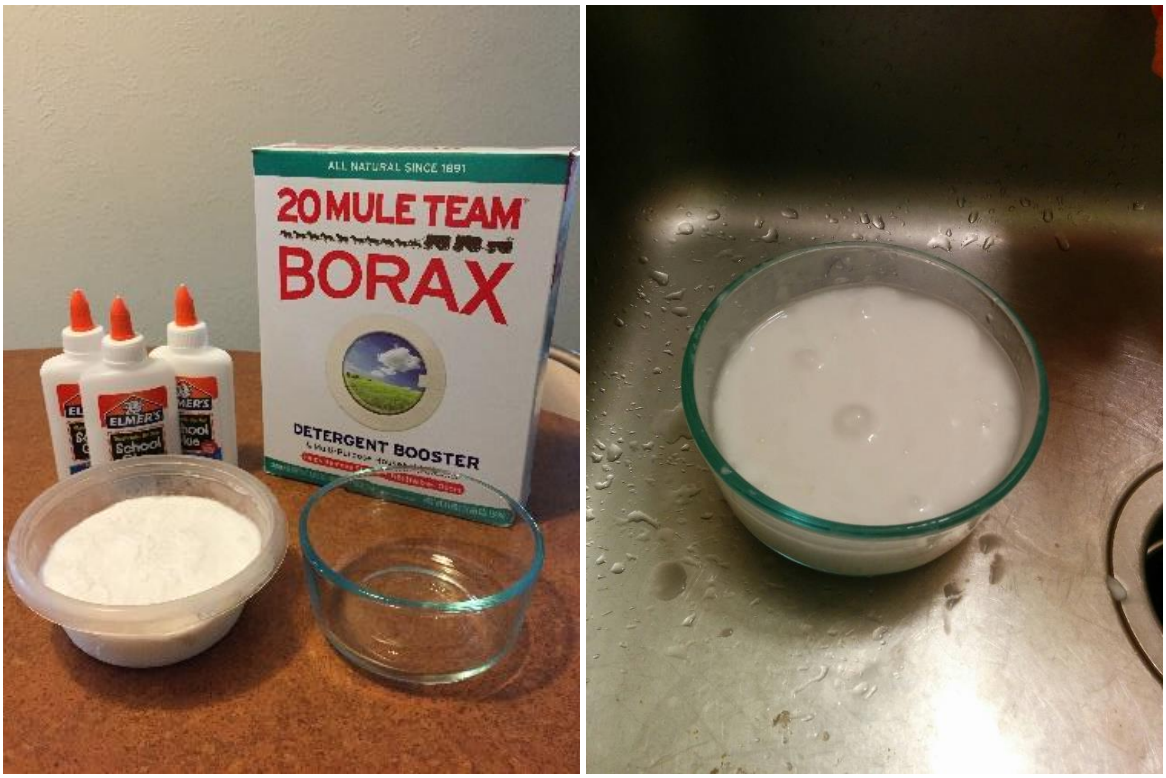


Figure 1: Slime supplies and the finished product.

The effect was created using the setup shown in Figure 2. Slime was placed in a round glass bowl, left to briefly settle and release the air pockets in the slime. A ⅜" steel rod was then placed in the center of the bowl and slowly spun while the slime climbed the rod.

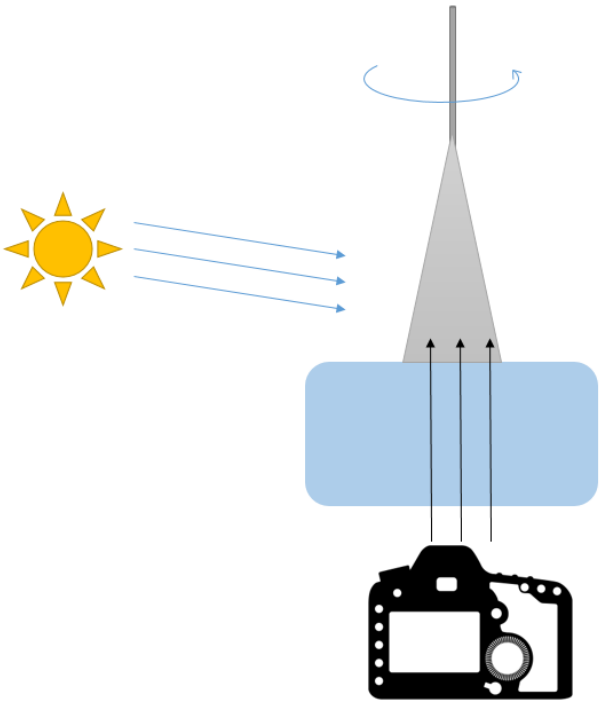


Figure 2: Photo setup

Visualization Technique

As described earlier, the experiment used a slime composed of a combination of Elmers school glue and Borax, a natural detergent. The decision to leave the slime in its natural white color was made to increase the contrast between the bright whites and shadows, resulting in a photo that exemplifies the ridges of the flow. Due to late afternoon lighting, a simple desk lamp was used as the only light source outside of natural lighting. The desk lamp pointed to the rod 90 degrees to the left of the camera. This lighting helped to create a dramatic effect on the fluid flow. The image itself was taken using manual focus while the rod was being spun slowly. Luckily, when the slime sheared apart, it simply resettled in the bowl and was ready to try again within a few minutes.

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. Since there was not a tripod available at the time, the image was taken manually with the camera looking down from the top of the flow. Focus was set to automatic to compensate for the lack of a steady tripod. The object was about 24” away from the lens with a focal length of 112mm. Image resolution was large at 4288 x 2848 shooting in a 12-bit compressed RAW format. The desk lamp lighting coming in from the side necessitated a low ISO at 280 as there was plenty of external lighting. Another advantage of the lamp lighting was a relatively quick shutter speed of 1/125s as there was enough lighting to keep the image light enough. A low aperture setting of f/5.3 was used in combination with the fast shutter speed in order to eliminate the distractions in the background and get a pure black backdrop. The fluid flow was essentially frozen over the exposure period.

Camera	Nikon D5000 (DSLR)
Lens	VR 18-200mm f/3.5-5.6G
Original Image Size	4288 x 2848
Final Image Size	2616 x 3889
Field of View	~ 8” x 4”
Focal Length	112mm
Aperture	f/5.3
Shutter Speed	1/125s
ISO	Auto (ISO 280)

The image was edited slightly from the raw shot using GIMP. In order to maintain the scientific validity of the photo, it was simply cropped to a resolution of 2616 x 3889 which eliminated the distractions from light diffraction on the glass. The only other manipulation came in the form of adjusting the image’s contrast curves. The whites were made slightly brighter, and the low end blacks were made to be slightly brighter in order to show the ridges on the flow more clearly.

Figure 3: Unedited image

Image Intentions

The image was incredibly effective in showcasing the Weissenberg effect. I really like the wavy effect created in the fluid plume and the way that the slime reflects the light to give movement to the image. If I were to try and develop this idea further, I would try to use different colored slimes to get a better idea of the fluid flow as it climbs the rod. Unfortunately, the Weissenberg effect is not incredibly well documented which makes it hard to mathematically analyze the flow effects. In the future, it would be more effective to use a non-Newtonian fluid with well documented properties to analyze the flow.