This Calls for A Celebration

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Image 1 Assignment

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MCEN 4151-001

I. Introduction

This image was created for the first image or video assignment for the Flow Visualization course at University of Colorado Boulder. I wanted to experiment with a viscous fluid, and when I chose the sparkly pink glue I decided to use a wine glass to highlight the movement of the glue to keep a party-like theme. The focus of the photos I tried to capture was the dripping movement of the glue as it went down the glass whether it be right on the side or as it was dripping off the bottom of the wine glass.

II. Flow

The glue flowed down the outside of a clear wine glass as seen in the representative image, Figure 1. I dropped glue out of the bottle in waves so that 'drips' would be at differing heights on the wine glass. The flow started from the very top of the wine glass and went to the end of the cup area, around 4 inches from the ground, and there the glue would fall off the cup.

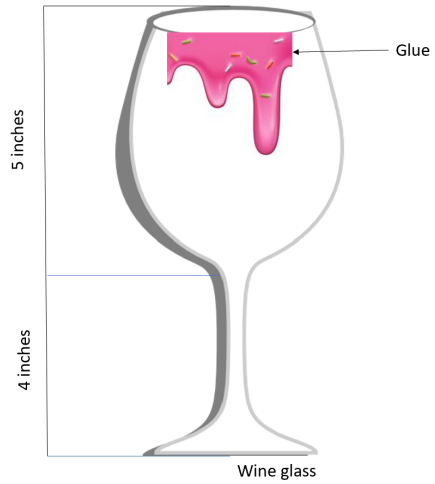

Figure 1. Flow apparatus set up.

In this flow analysis there are forces acting on the fluid, Elmer's glue. There is gravity which is the force that drives the downward motion. Another acting force is friction. The glue is sticky, and even though the surface of the glass is smooth there is still a great deal of friction acting upon the fluid. Friction and shear forces are the reason the glue dripped so slowly down the glass.

Table 1 below displays a few property values found for generic water-based glues as well as a few estimated values to be able to perform basic calculations for the Reynolds number of the flow. To estimate the diameter of the flow I measured the area where the glue was flowing and then assumed the flow was perfectly circular to obtain a diameter value. For the velocity of the flow, I looked up some average values of glue velocity and estimated what I thought fit the flow I observed when taking these images.

Property	Value	Units	Reference
Density (ρ)	1.1	g/cm^3	[1]
Dynamic Viscosity (μ)	5,000	$cP = cm.g.s$	[2]
Velocity (U)	.0002	$\frac{m}{s}$	*Estimated*
Diameter (D)	.35	in	*Estimated*

Table 1. Property values for Elmer's glue.

Equation 1 below shows the relationship between kinematic viscosity, dynamic viscosity, and density. Equation 2 then shows how to calculate the Reynolds number using the velocity of the fluid, the diameter of the flow, and the kinematic viscosity.

Kinematic Viscosity $$v = \frac{\mu}{\rho}$$ Eq. 1

Reynolds Number $$Re = \frac{U*D}{v}$$ Eq. 2

First, I calculated the kinematic viscosity using the values from Table 1 for the dynamic viscosity and the density of glue. This calculation is shown below. Next, I used that value along with the other values in Table 1 to calculate the Reynolds number using Equation 2. The calculation is also shown below.

$$v = \frac{5000\ cP * .001 \frac{N.s/m^2}{cP}}{1.1 g/cm^3 * 10^3 \frac{kg/m^3}{g/cm^3}} \qquad v = .00455 \frac{m^2}{s} \sim .005 \frac{m^2}{s}$$

$$Re = \frac{.0002 \frac{m}{s} * .35\ in * .0254 \frac{m}{in}}{.00455 \frac{m^2}{s}} \qquad Re = 3.9 * 10^{-4} \sim 4 * 10^{-4}$$

The calculated Reynolds number is quite small. Values of Reynolds numbers that are under about 2100 are typically classified as laminar flow. This means that the fluid will most likely flow without lateral mixing while neighboring layers of the fluid mix saying that the overall direction of the flow was down toward the ground rather than having horizontal mixing of layers. The flow that was observed supports laminar flow because no vortices were observed and the flow consistently moved downwards.

III. Visualization Technique

The wine glass is made of clear, smooth glass. The liquid used was pink, sparkly elmer's glue. It was used at room temperature and was poured over the wine glass which was also at room temperature. The lid was removed from the glue bottle to allow for larger initial drops of glue to slide down the glass. There was a large white poster board set up behind the glass and taped to a wall outside. The glass was set on an outdoor side table.

The main source of lighting was natural light due to the flow being set up outside on a south facing porch between around 5 and 7pm. Additional lighting was added by using a headlamp pointing from the right along with a phone flashlight pointing from the opposite direction. Camera flash was also used in the chosen image.

IV. Photographic Technique

While shooting the size of the field in view was smaller than 4 inches tall and about 6 inches wide. The final image had a distance from the object to the lens of about 6 inches with the camera angled upward. This technique was used to enhance the bulbous look of the glue dripping down, as well as decrease the amount of flash spots on the sparkles inside the glue. I used the basic lens that came on the digital Nikon D3500 DSLR camera. The original image width and height was not much different from the final dimensions. The original was 4496 by 3000, and the final was resized to be 1300 by 867. The settings of the camera were mostly the same as to the automatic settings except the exposure was turned up to about a 1.3. The original image can be seen in Figure 2.

Figure 2. Original image.

Editing of the image to bring it to the final form was mostly focused on the coloring of the image. The saturation was increased as well as the prominence of the reds in the image. Sharpness was also increased slightly.

V. Final Thoughts

The image reveals a playful visualization of a viscous fluid in laminar flow. I like the coloring created through editing as well as the shapes of the glue that were able to be captured. Also, the small air bubbles on the left side add to the image and make it more interesting. The angle of the image is also something I like about the display of this flow. An aspect I would improve in the future is a way to get the same lighting without having shine marks on the glue itself. I did not find this image to have extremely distracting flashes, but I would like to find a solution to this all together in the future for a cleaner image. Another improvement would be to find a more accurate way to measure the speed of the fluid flow to better the calculations made for the Reynolds number. This would improve the way fluid physics are shown. To develop this idea further I could experiment with various kinds of glasses to see how different surfaces and surface finishes impact the shape and speed of the flow. I could also compare varying kinds of glue to see how water content or other factors change the behavior of the flow.

VI. Works Cited

[1] SuLian. "What Is Water-Based Pu Glue?" Bigger Adhesive, 18 Sept. 2020, https://www.biggeradhesive.com/article/what-is-water-based-pu-glue.html#:~:text=The%20relative%20density%20of%20the%20water-based%20PU%20glue,adjust%20the%20mold%20clamping%20force%20to%20prevent%20waste.

[2] "Viscosity Guide For Paints, Petroleum & Food Products." *Refina*, http://pyrobin.com/files/Viscosity%20Chart.pdf.