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Get Wet Report

Introduction

For this "Get Wet" assignment, I opted to photograph a laminar flow from a plastic vessel through a small hole. The resulting photo, post-processing, shows a glass-like stream with interesting black and white nuances and juxtaposition. I will be detailing the setup of my image in this report. I will also describe the flow phenomena and driving equations behind these flows.

Background

In this photo, I used a 20 ounce, square based plastic bottle as a vessel for the fluid. A 0.5 mm hole was drilled with a micro-bit, 2 cm from the bottom of the bottle. In this process I aimed to maintain as much straightness as possible when drilling the hole to ensure good angle and flow coming from the bottle.

The goal for this image was to photograph a laminar flow exiting the vessel. This way, the stream would look like it was still and not flowing.

Laminar flow can be described as the fluid particles moving in layers, with each layer experiencing little to no mixing. The resultant flow looks nice and smooth. Laminar flow is determined based on the Reynold's number of the fluid, described by **Eq.1**.

$$Re = \frac{\rho u D_h}{\mu} = \frac{u D_h}{\nu} = \frac{Q D_h}{\nu A}, \quad (1)$$

Where:

D_h is the diameter of the pipe (m);

Q is the volumetric flow rate (m^3/s);

A is the cross-sectional area (m^2);

u is the average speed (m/s);

μ is the dynamic viscosity of the fluid (kg/(m*s));

ν is the kinematic viscosity of the fluid;

ρ is the density of the fluid (kg/m^3).

In fluid flow systems, laminar flow occurs when the calculated Reynold's number is below 2,040. However, the transition to laminar ranges from Reynold's numbers from 1800 – 2100.

In the setup, I aimed to maintain a low volumetric flow rate so that I could achieve a lower Reynold's number to get in the laminar flow region. The only force acting on this fluid was gravity.

No specific visualization technique was used other than a dark background and lighting. This would be unnecessary in this case as the whole point of laminar flow is to visualize it as being still.

Image Setup

For the actual image itself, I lit the bottle from the front and sides with an attempt to get some cool reflections off the stream. The picture was taken with a OnePlus 6T camera with the lens ten inches from the bottle, taken landscape.

Conclusion

All in all, I thought this was a very interesting experiment with a positive result.. I was surprised how easily laminar flow was achieved out of the 0.5 mm hole in the bottle. I believe my hole selection was a good size to maintain a small volumetric flow rate. This made it easy to get a Reynold's number within the laminar flow region. Going forward, I will attempt this experiment with multiple size holes, as well as dying the liquid to get a better visualization of what is going on in the bottle and the flow out of the hole.