



Get Wet Report: Flow Visualization of Incense Smoke

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Introduction

This image was taken for the Get Wet project as part of The University of Colorado's Graduate Mechanical Engineering course Flow Visualization. This was the class's first individual project. Teams are assigned for later projects. The intent of this project is to introduce the student to fluid flow photography. There are many techniques to visualize flow. Some as simple as taking a picture, others more complex like Schlieren images using mirrors to see different densities. Lighting techniques are very useful to highlight images like this one. Here, a simple picture was taken of the smoke rising from an incense candle. The goal was to capture **laminar flow**, a state of flow where particles move in smooth, parallel motion. The opposite of laminar flow is turbulent flow, which involves mixing – or turbulence – of a fluid. We see this most often in rising smoke, so the intent here was to capture very still, very smooth motion.

Flow Apparatus

The scale of the picture is only a foot tall. The top few inches of the incense candle are shown, solely to show the burning object of origin, but also add a hint of color to the otherwise monochrome picture. The smoke is most well-lit here, highlighting the subject matter. The laminar flow is due to many forces acting together in unison. While the flow is technically transient (moving with respect to time), we can assume the laminar flow is steady-state.

We can describe laminar flow numerically using the nondimensional Reynolds Number (Re). ¹Reynolds describes flow as the ratio between inertial forces over its viscous forces

$$Re = \frac{VL}{\mu}$$

where V is the velocity of the fluid, L is the length of flow, and μ is the fluid viscosity. ²For low Reynolds numbers (i.e. below 2000) we can say this flow is laminar, where the viscous forces dominate the flow. At higher Re numbers, inertial forces begin to control the flow, and mixing between layers begins. This is known as turbulence.

Methods

The method used for this picture is rising smoke. I sourced the incense from my roommate who got the incense in Malaysia on a summer visit. He now stinks up the house frequently. Despite my objections, I did find some use for the incense. I set the stick in front of a black back drop, sourced from my own room. One of my picture frames used a black back versus white or cork as many others do. The lighting used here was specifically meant to highlight the smoke. I set up a flashlight to the immediate right side of the smoke angled upwards to 1) get just the base of the incense while mostly capturing the smoke column but also 2) to give the feel of

upward motion, as once this candle was lit, the laminar flow of the smoke made it hard to capture any motion. The room was dark, but to add some back lighting, an addition flashlight lit up the ceiling to give a uniform dispersed light to the picture and allowed me to control exactly how much light was used.

The picture itself was taken with my Olympus OM-D EM1 camera with an m.Zuiko 14-150mm f/4.0-5.6 lens. This camera is a micro 4/3rds mirrorless camera at 16 MP. This picture was taken at 3456 x 4608. The camera was mounted on some books for height correction and stabilization. The image was shot about 4' away at full zoom (ISO 2000 150mm f/5.6 1/8s). There was very little post production done here, as the image was mostly monochrome. Some white balance was brought up and a red color correction was adjusted as well to highlight the ember.

Discussion

The image reveals stability in motion. We so often link moving objects with high energy, turbulent, or time varying. From other perspectives, though, motion can be synergy, fluid, slow. Think a racecar blowing past the spectators as 100 mph, vs the perspective of the driver. This image shows how slow is steady, and motion can be relaxing. We see the ideas of laminar flow, which is non disturbed and steady.

References

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