

MCEN-4228-010
Flow Visualization
Get Wet Report



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Introduction

The art of flow visualization is the process of making the physics of fluid flow visible. Fluids are usually defined as transparent substances that readily flow under applied shear. The use of flow visualization takes out the guess work from the phenomena of physics. The “Get Wet” assignment is designed to introduce the student to some of the techniques and approaches used in flow visualization. It is also intended to have the student gain experience in observing flows and drawing conclusions about them from the observed behavior. For the assignment, I chose fire because every flow is different from the other due to the sensitivity of the medium in which it burns. I intended to use a controlled flame to show how a fire moves around a solid object. The purpose of the image is to observe the behavior of fire over a solid surface, more specifically, to examine the flame structure at the interface between the fluid flow and the object. After a substantial number of photographs, I chose my final image based on two basic Flow Visualization criteria, the image exhibits a flow of physics and aesthetics aspects of the photograph.

Flow Apparatus

Safety was the largest factor when attempting to reproduce the image. To create the results similar to the photograph, the spherical object was set six inches in from of a black background on a fire retardant material. Also, to minimize any risks, the photographs were taken outside a building to help ventilate the fumes and were taken during the evening, after the sun had set, to minimize any “noise” or other distractions from the physics of the fluid. Three people were present during the shoot session. One person stood by with a bucket of water, another person sprayed the object with hairspray and ignited the object, and the last person photographed the events. The photographer laid flat on the ground and placed the camera 14 to

16 inches in front of the object. In my image, the flow has barely been ignited, and the flame is beginning to cover the grapefruit. Due to the location, outside effects on the flame may result, such as wind blowing out the flames. Below is a diagram of the set up that created the final image results.

Figure 1: Set up of final image

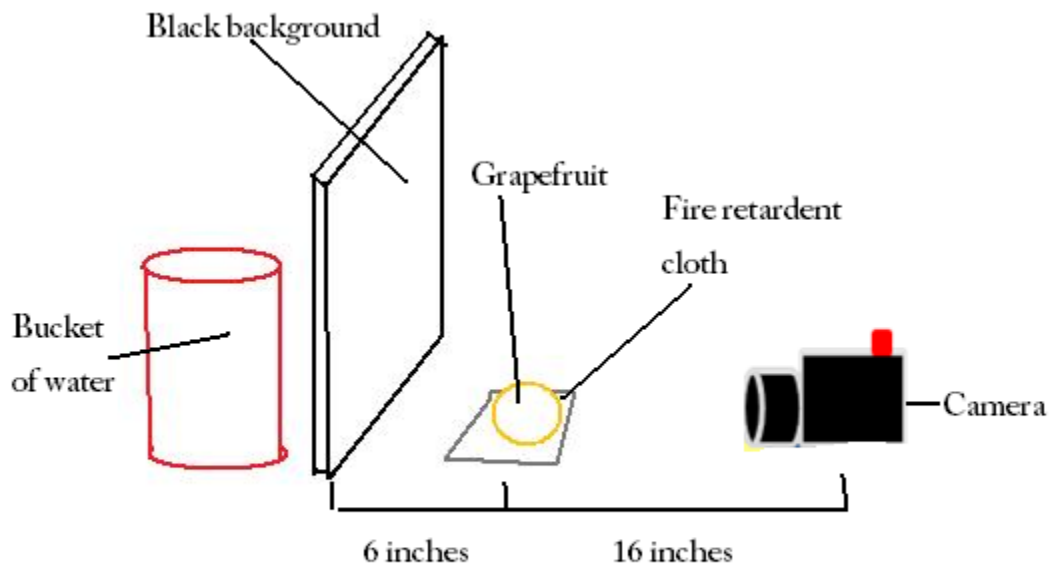


Figure 1: Schematic of setup

Visualization Technique and Flow Description

The visualization technique is just fuel (hairspray) burning on a spherical object, for our assignment, we used a grapefruit as the object. When looking at the photographs provided, it is important to notice that flash was not used, and the lighting provided is from the solely from flame. Fire is the “rapid burning of combustible material with the evolution of heat and usually accompanied by flame” (Britannica.com). The heat starts a chemical reaction using the oxidizing agent. From the photographs, the blue color is where the oxygen and the hairspray are mixing

and combusting. Further along the same streamline, the blue becomes orange and red colored flame that is seen is primarily caused by blackbody radiation. The yellow/orange part is where soot and other materials are and burning off of the grapefruit.

Figure 2: Estimation of Reynolds Number

$\rho =$	1.2041	kg/m ³
$V =$	2	m/s
$D =$	0.016	m
$\mu =$	0.0000178	Kg/(m*s)
$Re =$	2164.67416	

The calculated Reynolds number for air moving around a grapefruit is roughly 2200. (see Figure 2 for assumptions). From analysis of the Reynolds number and the photograph, the flow starts laminar and quickly becomes turbulent as the fire heats up the fluid and quickly expands the air and fuel mixture. The result can be seen above the grapefruit, where the flow is beginning to be a transitional flow state where the Reynolds Number is greater than 2300.

Photographic Technique

A Pentax *ist DS 6.1 mega-pixel digital SLR camera was provided by a student. The lens used was a SMC Pentax-FA 28-80mm F3.5-4.7, which allows users the option of manual focus. The camera was also chosen based on availability, functionality, and the requirements for the project. The field of view shown in the RAW file picture is approximately 10" X 8". An outline of the grapefruit can provide an example size. Circumference of the grapefruit is well outlined, and gauging the size of the grapefruit, a person you can get a feel for the size of the picture. The distance from the fire to the lens is roughly 14 inches to 16 inches. While taking pictures of the

flame, the distance provided enough of a safety zone to keep the camera equipment safe, as well as the operator. The data for the final image is as follows: f-stop=f/4.5, max aperture=f/2.8, focal length=58 mm, shutter speed=1/160 of a second and ISO image sensitivity rating of 1600. The resolution on this RAW photo is an 8bit, 3008x2008 pixels. My final image was made more dramatic using the “curves” tool in Adobe Photoshop. Temperature was decrease to 3700 to highlight the blue combustion. Brightness was increased to +85, Color Saturation was set to +10, and Clarity was increase to the highest level of +100 to give the physics of the fluid flow a more defined path. After cropping the picture down to size, the result is an 8bit, 2078x2008 pixel photograph.

Revelations

The image reveals the way a fire flows around a spherical object. I really enjoy how there is the solid that is burning in the bottom of the picture directly on the grapefruit and how the flow is laminar until it exits the boundary layer above. My image is better than I had expected it to be. I happen to really like the original unmodified image the most. Due to the setup, I thought focus and lighting would be the most difficult part of the assignment. However, the hairspray provided enough combustible fuel to give off enough light. Photoshop took the longest, because there are many different ways to be artistic. It also showed me how long it takes to get an image you are happy with.

Original image before Adobe Photoshop

