Team 2 Project-Flame in a bottle
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Introduction

In this assignment, I decided to do a fire-flame experiment. I tried to capture the fire explosion moment. Fire is always a hot topic in art and fluids area.There are tons of art that describes fire. So, in this class, I wanted to get a fire picture by myself. I was inspired by an fire explosion video on youtube and I decided to make my own flame picture. There is a saying that 'Fire is, and always will be, nature's television.'

Materials

Material	Amount
1 gallon jar	1
70% Rubbing alcohol	10-15 ml
Matches	1 stick

Table 1. Materials list

Procedure

The experiment procedure is straight-forward. First of all, pouring the rubbing alcohol around the inner surface of the jar. And shake the jar in order to let alcohol evenly distributed on the surface of the jar. After that, throw a ignited match inside the jar and capture the firing moment.

Fluid dynamics

From the picture, the flame color is blue. Usually, the blue color fire indicated that the combustion is efficient. Two things are happening. First, the flame is very hot. Second, it is gas molecules that are glowing rather than pieces of soot. Very hot gas molecules glow blue. The less hot or less efficient parts of the flame show (typically) green, yellow, orange or reddish.The blue color also indicates that the fuel burning is

clean.When there are dirt involved in burning, the color of the flame will usually turn into other colors.[1] Besides that, the fire is turbulent based on its appearence. The turbulent flame is characterized by a higher flame with a rapidly changing shape. In my photo, the flame is big and the boudary of the flame varies a lot. Based on these features, the fire can be catogrized as turbulent flame.[2]

Fig.1 Typical turbulent fire

The alcohol I used is isopropyl alcohol (C_3H_8O). When it burns with enough oxygen, it will form carbon dioxide and water, according to formula 1.

$$2\ C3H8O + 9\ O2\ =\ 6\ CO2\ +\ 8\ H2O$$
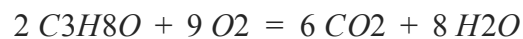
Formula.1

In order to ensure there is enough amount of oxygen compared with the alcohol, there are several calculations need to be done.The mass of the alcohol can be determined by using eqn.1.The volume of the jar is 1 gallon. The density of the $C3H8O$ in room temperature is 0.79g/ml. So that the mass of 10 ml 70% rubbing alcohol is calculated to be 5.6g. Using the similar method, the mass of air is calculated to be 4618g. The oxygen fraction in air is 0.233 in room temperature.[3] The mass of oxygen is about 1076g.[Eqn.2] From the formula.1, the molar ratio between oxygen and C3H8O is 4.5:1. From the molar ration, the mass ration can be

calcuated as 0.53 [Eqn.3], which means that when the mass ratio between the oxygen in jar and rubbing alcohol is greater than 0.53, then the combustion is efficient. In this case, compared with the small amount the alcohol, the amount of the oxygen is so great, which ensures the efficient combustion.

$$denity = mass/volume$$

Eqn.1

$$Mass\ of\ oxygen = Mass\ fraction\ of\ oxygen * Mass\ of\ air$$
Eqn.2

$$Mass\ ration = Molar\ ratio * Molar\ mass\ ratio$$
Eqn.3

Camera settings

   The shutter speed is very critical, since the firing moment happend so fast, it only took less than 1 second. Also, the ISO setting is very important because the light sensitivity is very critical in order to clearly capture the outlook of the fire.

Camera	Canon EOS Rebel T5
Shutter Speed	1/400 sec
ISO	3200
Focal length	30mm
Lens	EF-S18-55mm f/3.5-5.6 IS
Resolution	72 Pixel per Inch
Image Size	5184x3456 (pixels)

Table 2. Camera settings

Post-processing

I use curve tool to edit the contrast and brightness of the picture in photoshop. The post-pocessing I did is limited, because I wanted to keep the natural beauty of the fire flame. I am pretty comfortable with the final image. The feature of the fire flame is clearly preserved and the contrast and brightness of the picture is adjusted to a aesthetically-pleased level.

Fig. 2 Original picture

Fig. 3   Edited picture

Reference

[1]Ashwani K. Gupta,FLAME CHARACTERISTICS AND CHALLENGES WITH HIGH TEMPERATURE AIR COMBUSTION

[2]Glassman, I. Combustion Third Edition. New York,NY: Academic, 1996. Print

[3]http://homepages.cae.wisc.edu/~hessel/faqs/what_are_approximate_mole_and_ mass_ratiosOfN2AndO2ForAir.htm