Team Project 1 Report

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Flow Visualization

11/02/2015



Purpose:

The purpose of this project was to work with groups from class and capture an interesting and beautiful image of fluid flow. For our project we produced a fire tornado. Luckily our Professor had a personal tabletop flame tornado apparatus that she let us borrow. Initially we placed the apparatus outside but the flame produced was not big enough. We then took a fan and placed it at various spots, which circulated more oxygen into the system creating a bigger and more dramatic flame tornado. After doing some research we decided to add another element to this experiment and drop flame color crystals to produce a bluish green colored flame. The colored flame tornado was then captured with a camera and used as the final image. Chris O'Brien, Ian Macfarlane, Gamal Elbialy, and myself collaboratively created this image and report.

Safety:

Since flames and combustion fluids were used to capture our images, a few safety precautions were necessary. First, the experiments were conducted outside which is a well-ventilated area, diluting any fumes that may have been inhaled or considered dangerous. We also kept a fire extinguisher nearby in case any unwanted objects were set aflame. Additionally we used oven mitts when handling any objects that may have been heated by being near the open flame. In order to achieve the desired colors of flames, different chemicals were added to the fuel. These chemicals include: Copper Sulfate, Ammonium Chloride and crystalline silica. According to the MSDS these chemicals have the possibility of irritating the nose, mouth and throat when ingested but by conducting the experiment outside we eliminated that risk. [2] Along with these chemicals a gelled fire starter was used as our main fuel. Again, this fuel was safe to burn in a ventilated area as long as it is not ingested.

Flow Apparatus:

The device used to create the flame is a Tempest Table Top Torch device. This device, which can be purchased at <u>www.tempesttorch.com</u>, creates a nice controlled fire tornado.



Figure 1: Tempest Table Top Torch

The image above shows the apparatus used for our experiment. The Tempest torch is 2 feet tall with 1.5 feet of that height being the glass containing the flame. As seen in the image, there are openings at the corners of the glass, which allow the device to create a tornado like flame. The Tempest Table Top Torch's website describes this phenomena as a Natural Venturi Effect.

The Venturi Effect is caused by a pressure difference. Pressure decreases as the air is forced into the small openings in the side of the glass, leading to an increase in the velocity of the air [1]. We were able to increase the amount of air being pushed into the openings with the use of a fan on the air circulating outside the apparatus. This action heightened the Venturi Effect. The Venturi Effect along with the placements of the slots in the glass create the vortex shape of the flame.

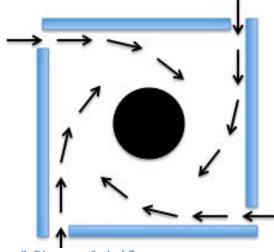


Figure 2: Diagram of wind flow

The diagram above shows how the use of the Venturi Effect and the slots in the glass come together to create a vortex. Once the wind vortex has been created and the fire is lit, the flames follow the wind pattern creating the fire tornado captured in the images.

Visualization technique:

The following materials were used for this experiment: The Tempest Table Top Torch, one BIC Multipurpose Lighter, Westpointe Table Top Fan, RUTLAND One Match Gell Fire Starter, and RUTLAND Rainbow Flame Crystals. We acquired the Tempest Table Top Torch from our professor and the other items were purchased from McGuckin's Hardware Store.

We placed the Tempest Table Top Torch apparatus outside on a second story balcony to conduct the experiment. We waited for the sun to go down at around 8:00 PM on Sunday the 18th of October in order to take away any light from the background of the image. It was partially cloudy that day so there was little to no light from the Moon. The Schematic of the set up can be seen in figure 3.

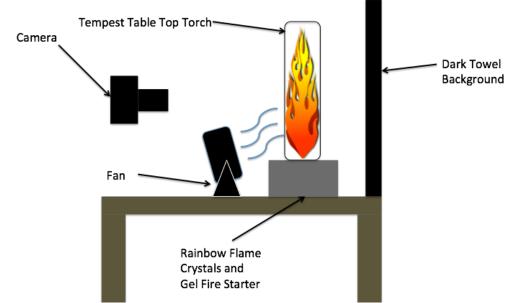


Figure3: Set up of Experiment

Next, the flame was started. Once the flame stabilized, the crystals were added. The crystals contain metal compounds, each of which give off different colors as they heat up. The heat causes electrons within these crystals to gain energy and jump up in energy levels. This excitation is not stable, and therefore as the electrons fall back to their ground state, energy is released in the form of light. Each crystal emits a different color; this is because the size of the gaps between the different energy levels is not the same in all of them. Small energy gaps result in low energy light, while large energy gaps result in high energy light [3].

Photographic technique:

The following camera settings were used when taking this photo:

- Field of View: about 15x3 inches
- Exposure Time: 1/125 sec.
- Aperture: f/5.6
- Focal Length: 28 mm
- ISOS: 3200
- Distance from lens to object: 1.5 feet
- Original image dimensions: 4608x3072 pixels

After the picture was taken I used Photoshop to do the post processing. I first tried to make the background completely dark by using clone stamp. You could see some of the fibers of the dark towel background in the image so I played with the program to get rid of those. I could see the metal columns of the Tempest Table Top Torch so I cloned stamped those as well. This made the fire tornado

stand out. I then played with the curves option on photo shop. I couldn't decide what I liked the best and ended up choosing the auto options which changed the image's colors. I liked this setting best because it brought out the colors of the flame and contrasted well with the black background. You can see the original and final images in figure 4 and figure 5 below.



Figure 4: Original Image



Figure 5: Final Image

Conclusion:

The final image reveals the beauty of flame and how you can form the shape of the fire. I accomplished the goal of our experiment by capturing the tubular tornado flame in the image. Not only did I capture the flame twisting in a circular motion, I can also see the flame tornado spinning up the glass column. There are a couple things I wish I could have done better. One would be taking a high-speed camera and capturing the motion of the flame tornado instead of simply an image. Capturing the motion would show more of the flame physics. Another way I could improve the image is in post processing. I wanted to get rid of the circular opening on the bottom of the flame but could not achieve this.

Sources:

[1] http://www.tech-faq.com/venturi-effect.html

[2]http://www.wildwoodovens.com/wp-content/uploads/Rainbow_Stick_msds.pdf

[3]<u>http://www.chemicalconnection.org.uk/chemistry/topics/view.php?topic=3&headingno</u> =5

Appendix:

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ammonium nitrate, acids, alkalis, oxidizing and reducing agents. Hazardous Decomposition or Byproducts

Thermal or acid decomposition may release toxic and hazardous

fumes of chlorine,	hydrogen chloride	, ammonia and oxides	of nitrogen.

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Section VI - Health Hazard Data			Inhalation?		Skin7	incestion?	
Health Hazards (Acute and Chronic)			Yes		Yes	Yes	
Ingestion: irritation of mouth, esophagus and	aastric system						
Inhalation: may irritate nose, throat and lungs							
Eyes: direct contact may irritate or burn eyes							
Skin: may cause irritation, especially under p		ct. May result	in dematitus				
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Medical Conditions Generally Appravated by Exposure							
Respiratory or skin disorders.							
Emergency and First Aid Procedures							
Ingestion: drink large amount of water. Call a	a physician.						
Inhalation: move to fresh air. If breathing cea		ficial respiratio	n. Contact a ph	ysician.			
Eyes: flush with water for 15 minutes. Conta				,			
Skin: flush with water. If irritation persists, co							
Section VII - Precautions for Safe Handling	and Use						
Steps to Be Taken in Case Material is Released or Spilled							
Sweep up. Avoid breathing dust.							
Waste Disposal Method							
Dispose of in accordance with local, state, an	d federal regula	tions.					
Precautions to Be Taken in Handling and Storing							
Protect from moisture. Store tightly closed in	cool dry place.						
Other Precautiona							
Keep out of sewer or stream, may be harmful	to water organi	isms.					
Section VIII - Control Measures							
Respiratory Protection (Specify Type)							
NIOSH/MSHA approved respirator for dust.	•						
Ventilation	Local Exhaust				Special		
	Sufficient to k	eep dust belo	w TLV		As needed.		
	Mechanical (General				Other		
	Sufficient to k	eep dust belo	w TLV		As needed.		
Protective Gloves	•			Eye Protection			
Rubber gloves.				Face shield, g	oggles.		
Other Protective Clothing or Equipment							
Work clothes designed to minimize skin expos	sure.						
Work/Hygienic Practices							
Wash with soap and water before eating, drin	king or using to	ilet facilities.					
		Rainbow F	lame Crystals				
NAME OF PRODUCT: Rainbow Flame	e Sticks						
This product contains the following chem	icals subject t	o the reportie	o requirement	•			
of the Comprehensive Environmental Re			w				
of 1980 (CERCLA). These chemicals are	a also subject	to reporting	under Section				
304 of Title III, SARA.							

CAS Number	Chemical	%.WT	Reportable Quantity
12125-02-9	Ammonium Chloride	15	5,000 lbs.
01344-73-6	Copper Sulfate, tri-basic	15	

******No reportable quantity is assigned to the broad class of copper compounds