



**Ian Macfarlane
Group Project 1
2 November 2015
Flow Visualization**

Purpose:

The purpose of this image is to capture the physics and beauty of combustion. Many wouldn't think as fire or flames first when thinking of fire but the burning of a fuel and the flames reaction with the gases and air above can be captured. Using a apparatus that is later explained we were able to capture what is well known as somewhat of a fire tornado or small fire whirl. Along with the fire whirl our intentions were also to burn other chemicals in order to create different colors within the flame. The final image above that I have chosen shows the different colors caused by the addition of said chemicals. The moment the photo was captured was directly after a strong whirl and although it doesn't capture the intense whirling it shows the flame at its extended height and vibrantly shows the multitude of colors within the flame. This photo was taken and the report was worked on with the collaboration of my team including: Chris Obrien, William Olson and Gamal Elbially.

Safety:

Due to the fact that the use of flames and combustion fluids were used in order to capture our images a few safety precautions were necessary. First the experiments were conducted outside, this provided an area that can be considered well ventilated, which diluted any fumes that may be inhaled or considered dangerous. Along with conducting the experiment outdoors a fire extinguisher was kept nearby in the case that any non-desired objects were set aflame. Along with these oven mitts were used when handling any objects that may have been heated from being near the flame. Lastly 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 this 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.

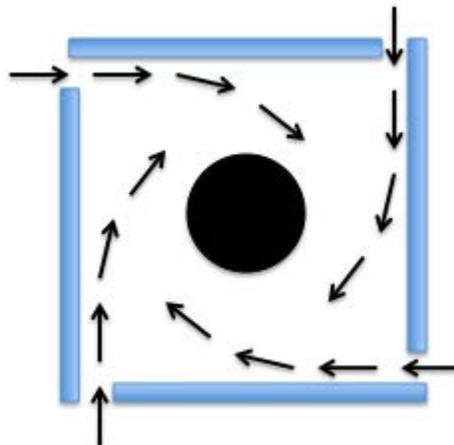
Flow Apparatus:

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



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

A Venturi Effect is an effect caused by a pressure difference. Pressure decreases as the air is forced into the small openings in the side of the glass, which leads to an increase in the velocity of the air.[1]. By increasing the amount of circulating air outside the apparatus up by the use of a fan, we were able to increase the amount of air being pushed into the openings therefor increasing the Venturi Effect. The Venturi Effect along with the placements of the slots in the glass are what then creates the vortex shape of the flame.



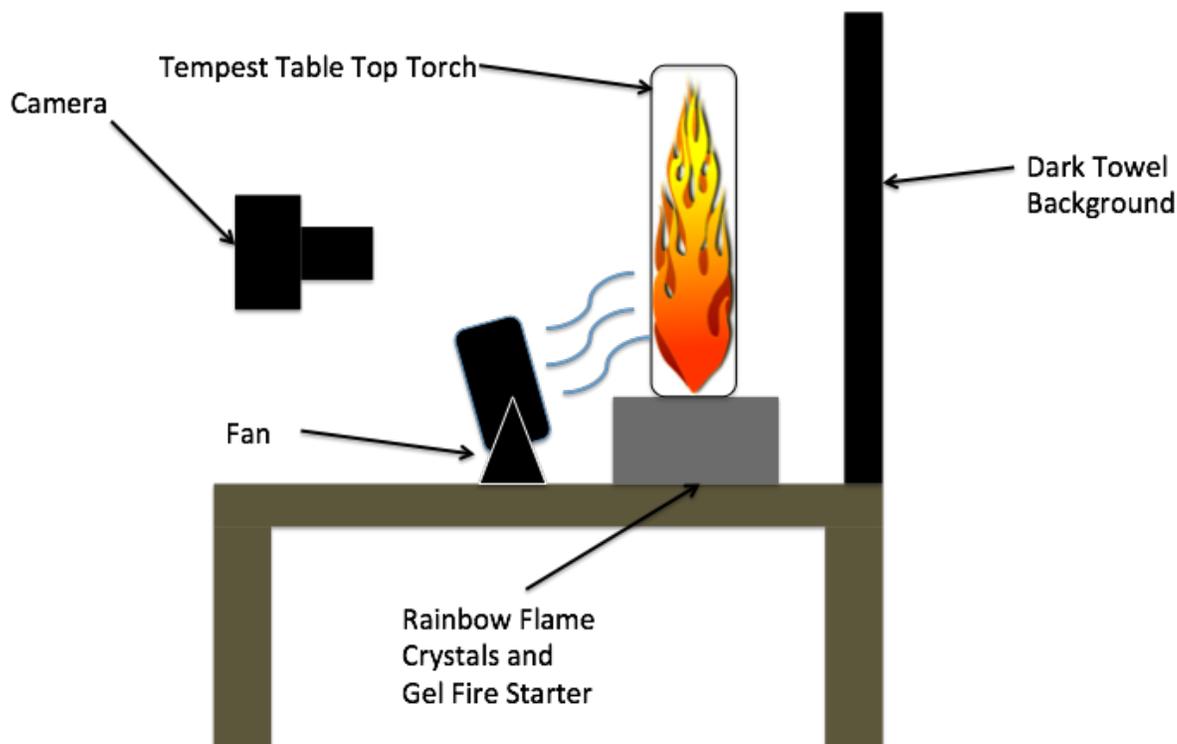
The diagram above helps show how the use of the Venturi Effect and the slots in the glass come together to create a vortex. Once the wind vortex has been created and the fire is lit, the flames follow in the wind pattern creating the fire tornado captured in the images.

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. For this experiment we acquired the Tempest Table Top Torch from our professor and then everything else from McGuckin's Hardware Store.

For this experiment we decided to place the Tempest Table Top Torch apparatus outside on a second story balcony to conduct the experiment. Since we are using flame we decided to not use any light for our image. We waited for the sun to go down at around 8:00 PM on Sunday the 18th of October. It was partially cloudy that day so there was little to no light from the Moon.

The flame was then started. Once the flame stabilized, the crystals were then added. These crystals contain metallic compounds which each give off different colors as they heat up. This 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 gaps between the different energy levels are not the same between all of them. Small energy gaps lead to low energy light, while large energy gaps lead to high-energy light.



Photographic technique:

The following camera settings were used when taking this photo:

- Exposure Time: 1/125 sec.
- Aperture: f/4.5
- Focal Length: 28.0 mm
- ISO: 6400
- Distance from lens to object: 1.5 feet
- Original image dimensions: 4608x3072 pixels
- Cropped image dimensions: 1284 x 2576 pixels

Some post processing was done in order to finalize the photo. Photoshop was used to edit the photo. It was cropped down to a size that better focused on the subject of the frame. Along with cropping the exposure and contrast were adjusted in order to remove the structure of the tempest torch. Lastly the curves in Photoshop were slightly adjusted in order to give the flame somewhat of an appealing transparent look.

Summary:

Overall the tempest torch and the use of the chemicals used allowed for us to capture great images of combustion. In the future a better camera could allow us to capture video, which would better explain the physics involved in a fire swirl. Using a dark background in an area, which was not very lit, allowed us to get good photos of the flame.

Sources:

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

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

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

Original Image

