

Team Image 1

Flow Visualization



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Purpose

This project is for the “Team Image One” assignment in the Flow Visualization Class with Professor Jean Hertzberg at the University of Colorado Boulder. Amazing fluid flow phenomenon occurs around us every day; however, most go unnoticed. This experiment is focused on vortices created from fire tornadoes. The flame will be created using a Tempest Table Torch and flame colorant salts in the form of crystals will be used to give color to the flame and help better visualize the different parts of the vortices. This flow was captured in collaboration with Chris O’Brien, Ian Macfarlane, and William Olson.

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.

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.



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 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 increases 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.

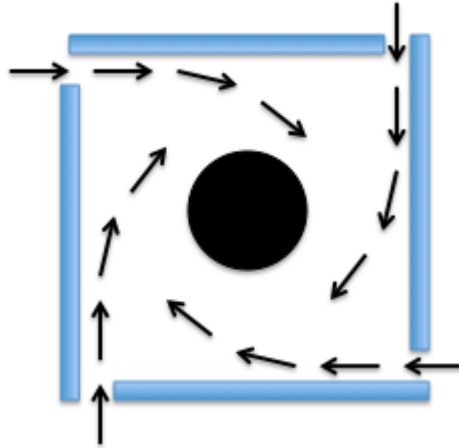


Figure 2: Air flow in Tempest Torch

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.

The flow was fairly laminar, and therefore had a Reynolds number of less than 2000. However, it should be noted, experimentation with the fan created turbulent flow at times.

Visualization technique:

The following materials were used for this experiment: The Tempest Table Top Torch, a lighter, a desk fan, RUTLAND one match Gel Fire Starter, and RUTLAND Rainbow Flame Crystals.

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 so there was little to no light from the Moon.

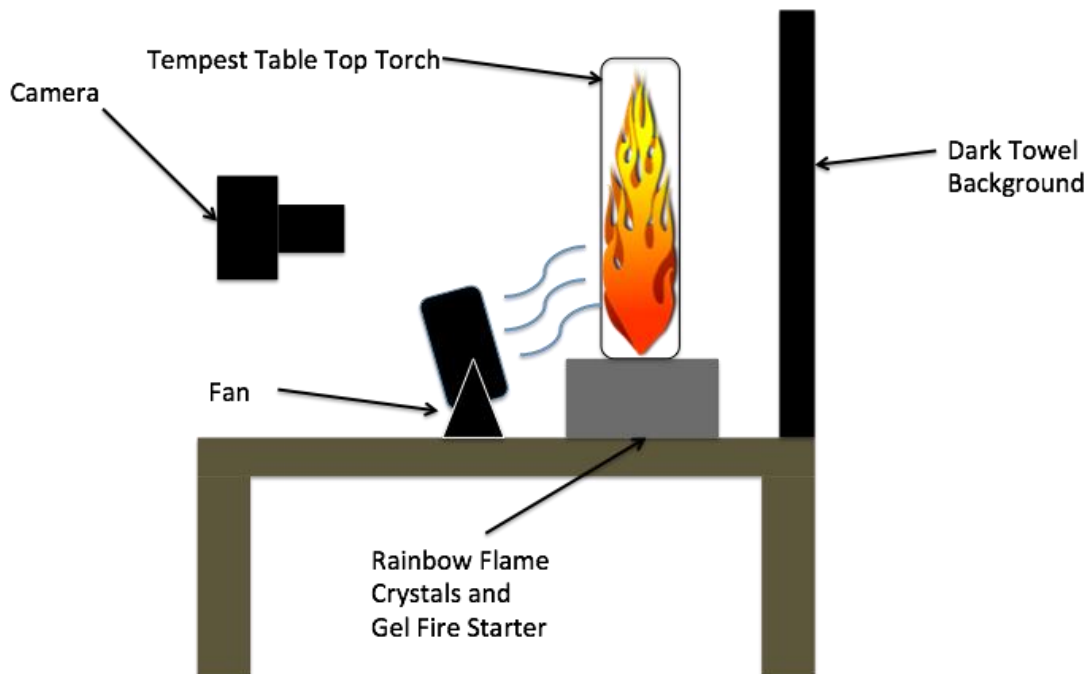


Figure 3: Experiment schematic

The flame was then started. Once the flame stabilized, the crystals were then added. [3] These crystals contain metal fragments 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 is 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 image was taken using a Nikon DSLR D3300 Camera. Because the image was taken in a dark area, an ISO of 1600 was used. Aperture and shutter speed were set to f/4 and 1/80 sec. respectively. The original image had dimensions of 6000 x 4000 pixels. The combination of these settings lead to the following image:



Figure 4: Original image.

The image was then modified using Photoshop. First, the image was cropped to 1362 x 3018 pixels. The only other changes made were to contrast and brightness. This was done to bring out more of the details in the vortices.



Figure 5: Final image.

The image demonstrates a fire tornado due to the effects of the Venturi effect that was caused by the Tempest Torch.

Summary:

The image reveals a lot of interesting phenomena; however, it might be better illustrated using a video. In addition to capturing the experiment with a video, the addition of smoke particles would help show how the vortices started. These particles would rotate around the Tempest Torch compartment illustrating the effects of the Venturi effect. From an aesthetic point of view, the picture fulfilled my intent. The post processing procedures really brought out the

colors in the image and gave it a very interesting look. However, as mentioned, with the implementation of a video, better understanding of the underlying physics would be clearer.

Sources:

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

Tech-faq. "The Venturi Effect." *The Venturi Effect*. Tech-Faq, n.d. Web.

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

US Department of Labor. "Nanomaterials. Preparation of Material Safety Data Sheet (MSDS)."

Rainbow Stick MSDS (n.d.): n. pag. Sept. 2004. Web.

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

Chemical Connection. "Exciting Electrons." *Making the Chemical Connection at the University of Edinburgh*. The University of Edinburgh, n.d. Web