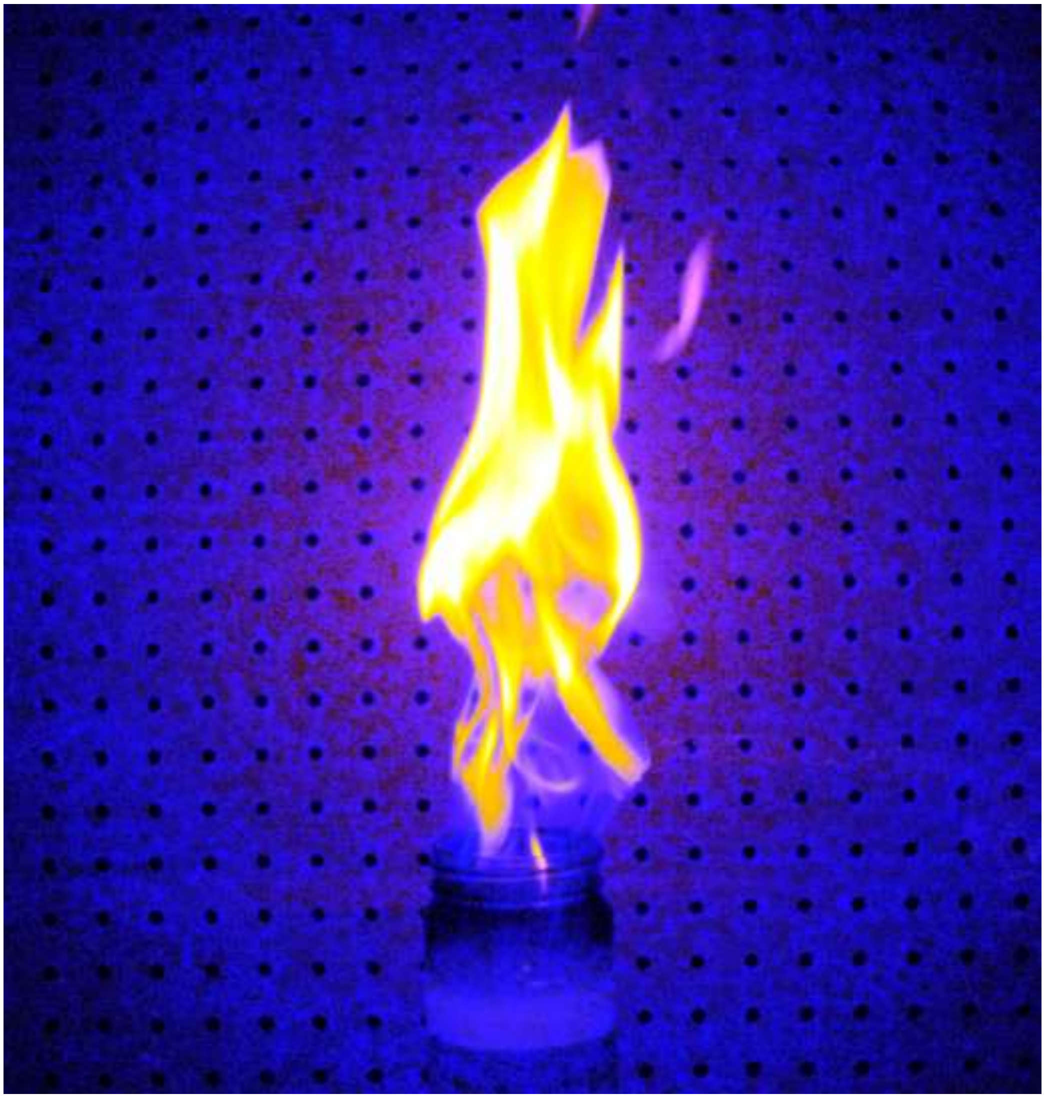
Team Project 2
Fire



Matt Feddersen
MCEN5151
Professor Hertzberg

I. Introduction

This image was submitted for the Group Project 2. For this image, I really wanted to get an interesting image of fire. Something that has always been intriguing to me is what would happen if fuel was mixed with water and ignited. It is something commonly seen on the big screen, but does it actually look like that? After finding that flames can be sustained from fuel on top of water, I started snapping pictures and playing with the flame a bit. One interesting thing I found was that 87 octane fuel couldn't sustain a flame in the jar I was using; 91 octane fuel burned perfectly. After playing with fire, I had a lot of good images and selected the one I did because it included the entire flame and had a very interesting flame.

II. Flow Apparatus

In order to create the flame in my image, I used a jar that was 6.5 inches tall with a body diameter of 3 inches. The neck had a slightly smaller diameter of 2 inches. I filled the jar half-full with water and then added about .75 inches depth of 91 octane gas on top. After the jar was ready to go, I dropped a match into the jar to start the fire. Even though there was water in the jar, the fuel was still able to burn because it sat on top of the water due to buoyancy effects. The reason gas will rest on top of water is that it has a lower density than water. Gas has a density of approximately 680kg/m^3 and water has a density of 999kg/m^3. Looking at the image, you can actually see the gas sitting on the water in the jar; it is more obvious in the original because the colors aren't distorted.

III. Flow Explanation

The flame that was photographed can be classified as a diffusion flame. A diffusion flame is a flame in which the combustion is controlled by the mixing phenomena of fuel and the oxidizer.[2] These flames have no fundamental characteristic property as even the oxidizer-to-fuel ratio has no meaning. Rather than use equations to qualify the flame, the appearance of the flame is used. The flame will either be laminar or turbulent; Figure 1 shows a comparison of a laminar and turbulent flame. The turbulent flame is characterized by a higher flame with a rapidly changing shape. As a flame becomes more and more turbulent, liftoff becomes a possibility. Liftoff is when the flame essentially detaches from the reaction zone. The flame in my image is definitely a turbulent flame. The flame is big, and the boundaries are rapidly changing. Looking at the base, the flame seems very thin, so the flame is well into the turbulent region, and close to achieving lift-off.

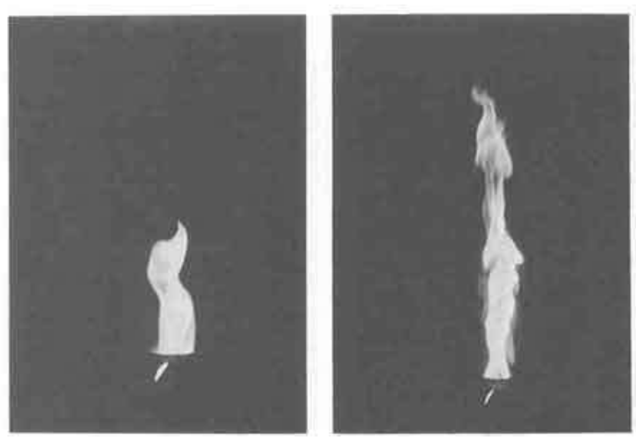


Figure 1- Laminar and turbulent flames. Take note of the size difference. Photo from cookstove.net

Despite having enough fuel to start a major fire, the flame remained small. The flame never grew overly large on its own because it was limited by the oxygen that could reach the surface of the fuel to combust the fuel. The neck of the jar was considerably smaller than the body and the surface was about 2 inches below the top of the jar which meant that there was not enough oxygen reaching the surface to create a large flame. In addition, natural convection would carry the hotter air out of the jar; the colder, fresh air would not easily reach the surface of the fuel. This made the experiment really easy to control because the flame size was very predictable. A larger flame was created by using a long straw to blow into the jar. By blowing air into the jar, there was more oxygen to combust and the surface was disrupted, creating more surface area of fuel to burn. The extra oxygen and increased surface area created a significantly lager flame as seen in the comparison in Figure 2. In addition to the larger flame, also note that the background is noticeably lighter from the flame.

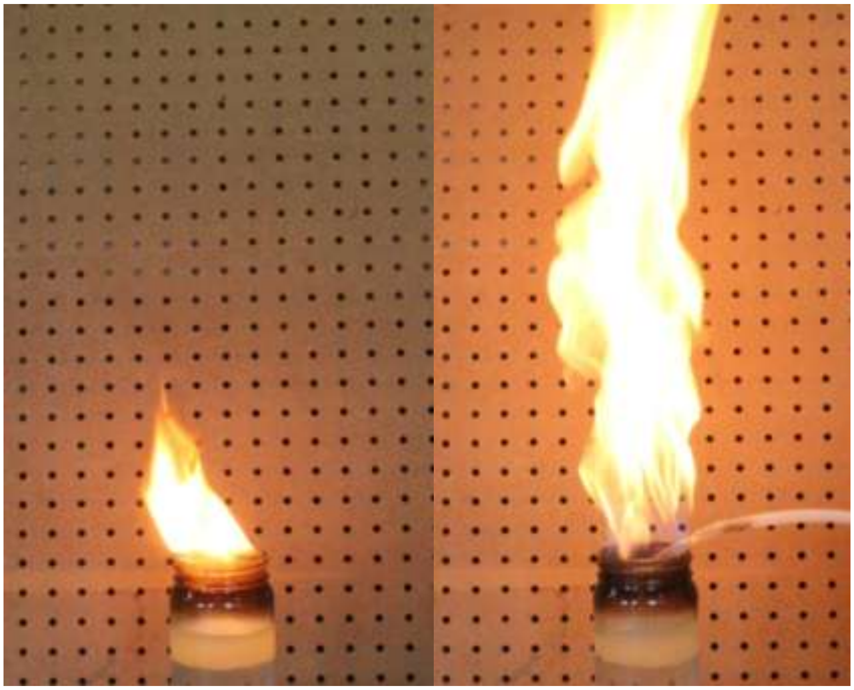


Figure 2- Side by side comparison of flame size with and without straw.

As previously mentioned, the 91 octane fuel burned stronger than the 87 octane. Both fuels are of the octane family, and thus will have the same heat of combustion; this means that the fuels contain the same amount of energy. The difference between the fuels is the additives in the fuels. These additives don't give the fuel any extra energy, but rather make the fuel more resistant to combustion.[3] This means that 91 octane will be able to handle higher temperatures and pressures than 87 octane. These attributes are ideal for combustion engines because the resistance to combustion at high temperatures and pressures will prevent the fuel from combusting before the spark is emitted from the sparkplug. An engine will obviously perform its best when combustion occurs as planned, not when the combustion occurs early. High performance cars require higher octane fuel because they have higher pressures in the cylinders prior to combustion; also the engines are more precise and a slight disruption in the ignition timing will have a big effect on the performance. Another theory for why the two fuels exhibited such a significant difference is that the 87 octane had been sitting in the garage for a long time and the 91 octane was much fresher.

IV. Visualization Technique

The final image, and the images I liked the most, was shot in the dark where the only source of light was the flame. By having the flame as the only source of light, the flame really stands out, and is the entire focus of the image. Additionally, the flame light creates a nice gradient on the background. This gradient really brings the viewer's eyes to the flame. The background is just a simple pegboard (holes are spaced 1 inch apart), it appears really grainy partially due to the post-processing of the image, but also because the pegboard is textured. The background gives a good perspective to the image and also adds some texture to what would have otherwise been a boring background. The key to the flame looking its best is definitely having a completely dark room; the gradient on the background really helps to accent the flame.

V. Photographic Technique

The photographic technique of the image was largely dictated by the nature of the image. The camera used for this was a Canon EOS Rebel T2i. Since the flame was to be the only source of light, manual mode was used to ensure that a flash wouldn't pop up. To get a crisp image of the flame and still have enough light, an F-stop of f/2.8 was paired with an exposure time of 1/50 seconds. The camera was positioned about 4 feet away from the flame and was slightly zoomed in. The field of view is about 2 feet high and three feet wide in the original image. The final image is 2384x2504 pixels. It was cropped from the original image to have the flame fill the frame and be centered. Once input into Photoshop, the auto-sharpen feature was used to make the image appear just a bit sharper. Then the curves feature was used to manipulate the colors into the colors on the final image. The final colors were chosen because the flame remained a bright warm color, and the background appears much colder. This contrast really emphasizes the warmth of the fire.

Figure 3- The original and edited image of the flame.

VI. Conclusion

This image features a beautiful flame with great accents. The image reveals the great complexity of fire. There is no other substance known to man that can reproduce the behavior of a fire. I really like the shape of the flame, and the colors of the flame itself. The slightly different yellows shown in the flame really help to make the image appear three dimensional. Additionally I like the pegboard as the background because it makes the image appear more industrial. My intent was fulfilled with a great image of a flame resting on water. It appears to me that the giant flames in the bay of a movie are indeed realistic, especially with wind fueling the fire and natural waves to create extra surface area of fuel. I wish that the top of the jar didn't have soot on it; the black top on the jar just takes a little bit away from the image. Something that could be done to take the image idea to a new level is varying the surface height of the gas in the jar and do side by side comparisons. I would be very interested to see side by side comparisons varying fluid height, octane, and even jar shape. Every time I look at the images, I go back and forth between which one I like more, the edited or unedited. I really like the colors of the edited image, but the natural colors of the unedited image are so beautiful. Fire is, and always will be, nature's television.

VII. References

1. Munson, Bruce R. *Fundamentals of Fluid Mechanics*. New York: John Wiley, 2009. Print.
2. Glassman, I. *Combustion Third Edition*. New York,NY: Academic, 1996. Print.
3. Wusz, Tim. "Octane Explanation." *RUNYARD.ORG John's Index Page*. Web. 08 Apr. 2011. <http://www.runyard.org/jr/CFR/OctaneExplanation.htm>.