Flaming Ice Sphere

Figure 1: Final Photograph

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Introduction

The image seen in Figure 1 is the final product of the team second assignment. For this assignment we decided to focus on a subject that fascinated many of us, fire. However, since the flow of flames had been done previously in this class, we wanted to make our images unique in some way. To do this our group decided to use a unique subject to light on fire, a sphere of ice. We were interested to see if the physics of the flame would change at all with this extreme interface between hot and cold. If nothing else, it did create aesthetically pleasing photos as seen on the previous page.

Experimental Setup

There wasn't much setup to this experiment since the flame was outputting light. For that reason we used a completely dark room with the flame placed directly on a concrete floor. The orientation and positioning of everything can be seen in Figure 2 below.

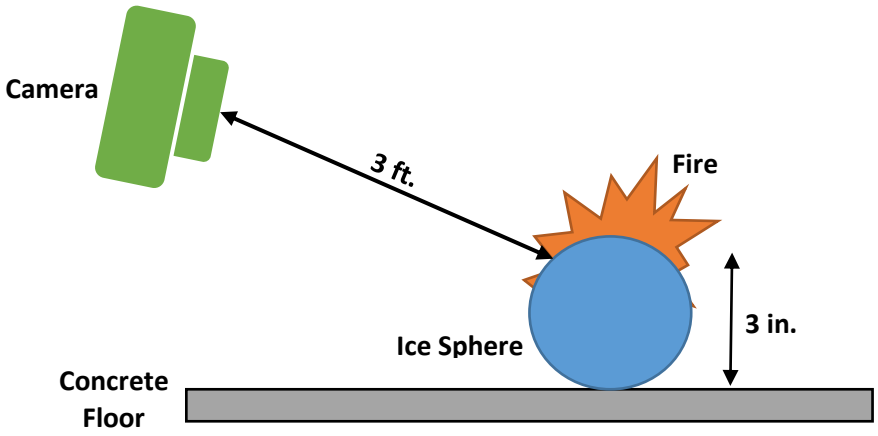

Figure 2: Setup of Flaming Ice Sphere Experiment

As discussed previously and seen in Figure 2, the setup it relatively simple. To begin, an ice sphere (D_{sphere} = 3in) was placed directly on a concrete floor or other flame retardant surface. Then the ice was covered in Ronsonol lighter fluid until the ice was completely coated. You want to add enough lighter fluid to coat the entire sphere but not too much where you start to create puddles of fluid below the ice. This ensures that the majority of the flames are located on the ice sphere itself. The lights were then turned off completely, creating an entirely black environment. The ice was lit, and the picture was taken approximately 3ft away from the flame. Different positions will create differing perspectives of the flame overall.

Explanation of Fluid Flow

Due to the nature of flames, they are always changing shape and direction throughout their cycle of burning. This is a known fact that essentially everyone has experienced, and the burning ice sphere is no different. At the start, the flame was large and quite bright but as the fuel burned off the flame decreased in size and brightness until it died out.

One of the first things that is noticed in the final picture is the difference in the "brightness" of the different parts of the flame. Looking at Figure 1, you can see that the base of the flame is a dark grey while the top of the flame is closer to white. These are actually color differences of the flame and can be seen in better clarity in the unedited photo (Figure 3). These color differences are due to variance of temperature throughout the flame. The flame is a dark blue towards the concrete and at the base of the ice sphere. This is a location closest to the fuel source and therefore is burning the hottest and purest [1]. Once we move further up the flame, the color turns to a more orange color mostly due to a reduction in flame temperature overall. This color change can also be due to an increase in airborne soot at higher heights, thus creating a less pure burning reaction.

Another quite noticeable element in the image of Figure 1 are the two arm-like fire balls reaching out on the left side of the picture. This was a unique element that didn't happen very often throughout the experimenting process. However, I happened to capture it in this image, one of the reasons I chose it. I believe this is a result a slight breeze in the testing environment. This was done inside a garage, however a door was left open allowing a draft to blow through. The wind would be blowing from the right to the left side of the image. As the wind blew, the fire expanded on the sides of the ice sphere, stretching in the direction of the wind. The wind provided an enriched oxygen environment which enabled the flame to grow in size. There is no flame between the "arms" because the ice sphere was large enough to block the wind.

Visualization Techniques

For this experiment no unique technique was really used to bring out the flow. Ronsonol lighter fluid was used to create and maintain the flame on the ice sphere. Beyond that no additional lights or anything was used for visualization. Everything in the image was all natural artifacts of the flame itself.

Photographic Techniques

There were several choices that I had to make to enable the picture to turn out as expected in the end. To begin, I wanted the background to be relatively dark so that the focus on the flame and ice sphere themselves. However, I also needed the shutter speed to be decently fast so

there wasn't too much motion blur. Some blur was fine, but more crisp flame details were better to get insight on the flow. This was mostly achieved by using a high ISO in the end.

The picture was shot with a Nikon D5500 camera. The settings used were: ISO 20,000, shutter speed – 1/400 sec, and aperture – f/6.3. The high shutter speed was used to help reduce motion blur in an environment with minimal light. However to compensate for the fast shutter speed, a really high ISO was used. This image came while testing the ISO, so that is why it is so high. I could have probably gotten by with a lower ISO overall if I adjusted the shutter speed and aperture. A focal length of 55mm was used to get good details. The original photo has a size (in pixels) of 6000x4000 and the edited photo is 4967x3348.

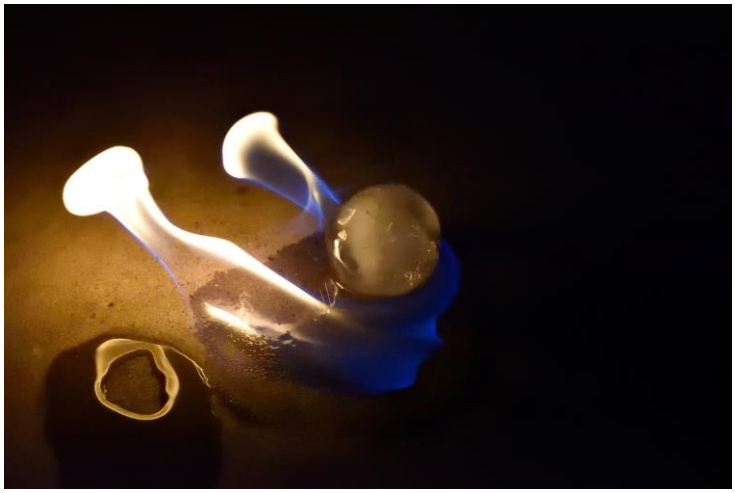

Figure 3: Original Image

Not too much post-processing was done overall. The most noticeable change is I converted the original image to black and white. I did this because the colors weren't anything super attractive. Additionally, with such a high ISO, the greyscale hid the graininess of the image a little. The image was also cropped slightly to eliminate some of the black space that didn't add much to the image overall.

Conclusion

Overall this assignment gave me some good experience in photographing flows in very low light conditions. It is quite different from objects that are nicely lit, but some good photographs can result from this. I really like how the image turned out in the end. Some of the unintentional artifacts of the photo, like the puddle, made the image really unique overall. In the end the ice didn't change any of the physics of the flame flow, but it did create an interesting subject at the heart of the photograph.

References

[1] Christopher W. Schmidt; Steve A. Symes (2008). The analysis of burned human remains. Academic Press. pp. 2–4. ISBN 0-12-372510-0.

[2] Jozef Jarosinski; Bernard Veyssiere (2009). Combustion Phenomena: Selected Mechanisms of Flame Formation, Propagation and Extinction. CRC Press. p. 172. ISBN 0-8493-8408-7.

[3] “Chemistry and Physics of Fire.” Chapter 1, maiif.org/wp-content/uploads/2017/08/Guide-for-Conducting-Marine-Fire-Investigations-Chapter-1.pdf.