Team Project 3: Heat

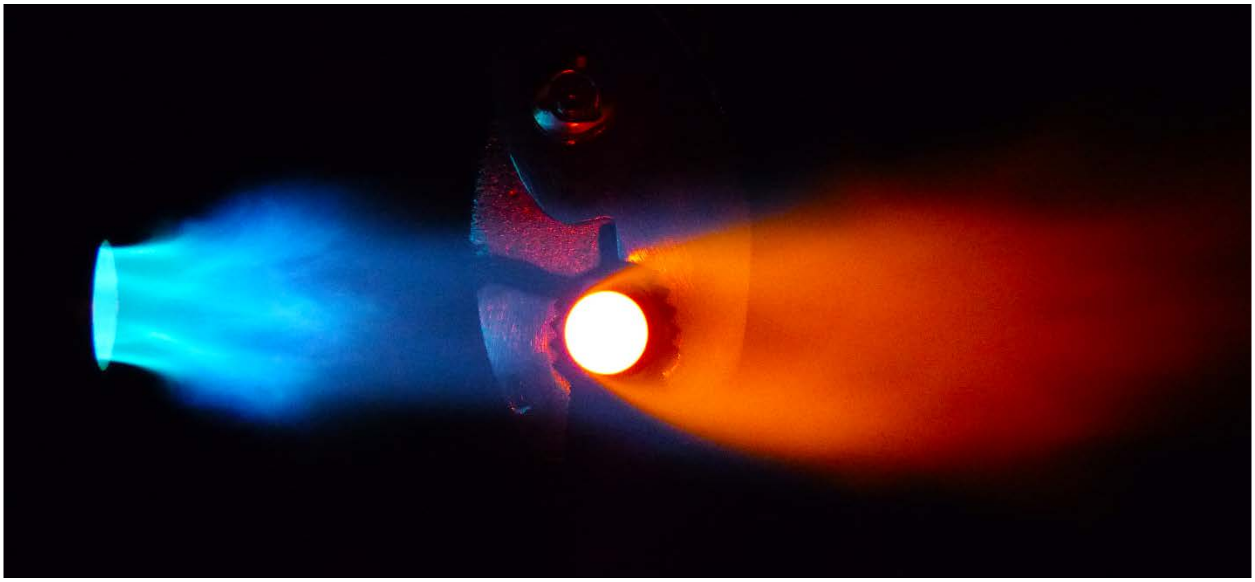

Figure 1: Final image for Team Project 3.

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Introduction

The goal of this assignment was to capture a flame heating up a stainless steel bolt. For our Measurements course, my group had recently purchased a torch and several bolts. We set out to heat cycle the bolts and then run material property tests on them to see the effects. After we completed our experiment, we decided to take some pictures of the scene in a dark basement. The results were very appealing. Special thanks to Samuel Moy for holding the bolt with a pair of pliers and Jon Cook for holding the torch.

Physics

The torch is releasing methylacetylene-propadiene propane, or MAPP, gas. This flame burns at a temperature of around 2925°C, which is hot enough for some welding puposes[1]. When we put the torch flame up to the stainless steel bolt, the bolt immediately begins heating up and taking energy from the flame. The blue flame represents the high energy heat (estimated around 2925°C) that the bolt is absorbing energy from. As the flame passes over the bolt, it loses energy and cools down. The boundary layer for this cooling is very visible as the flame turns from blue to red. The red color is due to the fact that the flame is wearing away the surface of the stainless steel. Stainless steel has specific properties that allow the surface to be resistant to oxidation and therefore does not rust. This happens because stainless steel has enough chromium to form a passive film of chromium oxide on the outside that prevents any oxygen from entering the steel's structure[2]. Little bits of this chromium oxide layer are being ripped off the steel and burned away in the wake behind the bolt. This is what allows the boundary layer to have such a defined visualization. The bolt would not produce the red boundary layer until the bolt was hot enough for erosion to occur.

Experimental Setup

We were in a basement that was virtually blacked out from any light sources. We set up a large table to work on and had a black board standing up against a side of the table. The board was slightly dirty so we hung a black sweatshirt off of it. We placed a pot of ice water on the table and had one person holding the bolt over it with a pair of pliers and another person torching the bolt. After each minute or so, we decided it would be best to let the bolt cool off so we would drop the bolt in the water. We were very careful with the torch flame. The following image shows the setup.

Figure 2: Experimental setup for Team Project 3.

Image Capture

This image was taken using a Panasonic Lumix DMC FZ70 16.1 MP camera. Because we were in a dark room while photographing the only light source, the ISO was set to 1600. The shutter speed was fast (1/125 s) because I wanted to capture an instant in time rather than have motion blur. This means the aperture was wide open to get enough light (f/4.2). I put the image into Adobe Photoshop and upped the saturation to bring out a red color instead of the yellow. The original photo is displayed below.

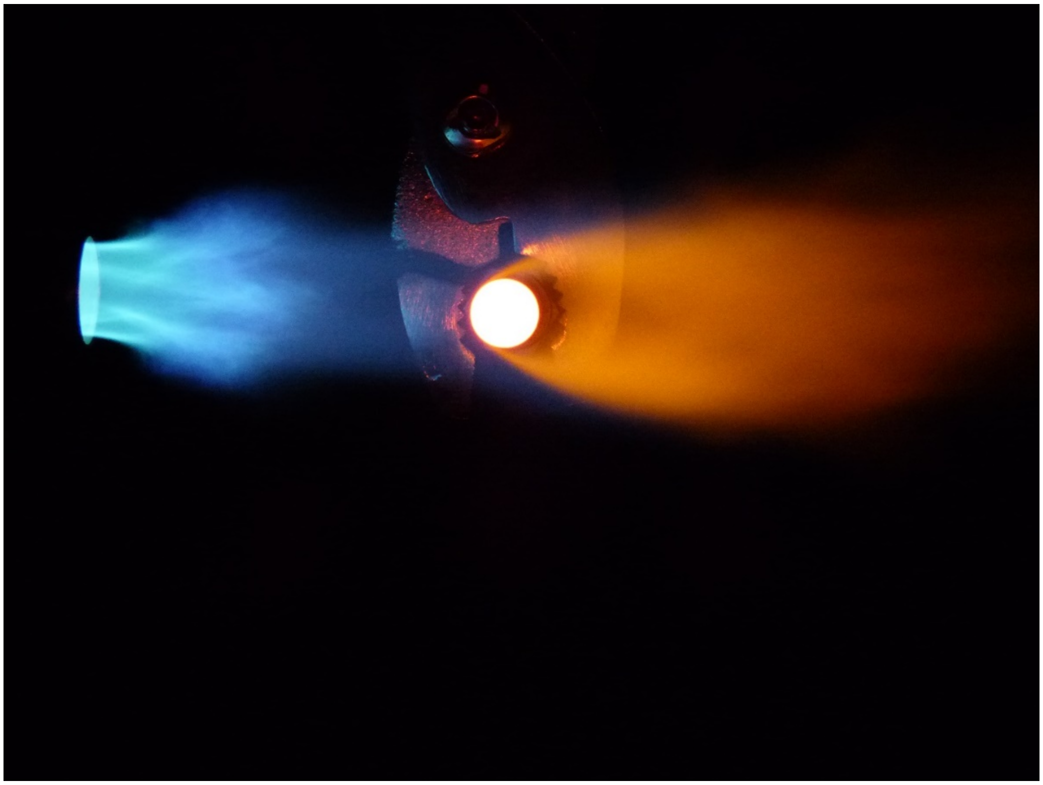

Figure 3: Original unedited photo.

Conclusion

It was very interesting to see the energy transfer from the flame to the torch and leave behind a wake of flaming erosion. I am very happy with my final photo and feel like I have learned more about boundary layers and metal surfaces. If I were to conduct a similar experiment in the future, I would try to hide the pliers and use a metal surface that produces another color, perhaps copper.

References

1. Wikipedia page on MAPP gas. 12/11/2015.
   https://en.wikipedia.org/wiki/MAPP_gas

2. Wikipedia page on stainless steel. 12/11/2015.
   https://en.wikipedia.org/wiki/Stainless_steel