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ARTF 5200
Team Project #2

**Sparks!**

**Introduction**

For the second group image we were interested in visualizing various aspects of oxyacetylene torch welding. We had a number of interesting images different aspects of the process, ignition, various flames with different mixes and welding steel. I took a number of different images which captured smoke patterns and flame detail. It proved challenging to find the right capture settings and focus. The subject was extremely bright but not consistently so. Depending on how much gas was being used and the oxygen mixture the brightness varied significantly. Additionally, the temperature of the steel and its state changed the amount of visible light. I ended up using an image showing sparks being scattered as the flame melted through a plate of steel. I took several pictures of this happening with different settings. Some with a much higher shutter speed and larger aperture and some with a slightly slower shutter speed and a smaller aperture. I chose an image in the latter category since I felt it better captured the dynamic movement involved here. Other team members who helped with this set up were Faith Batrack, Chris Francklyn and David Gagne who was wielding the welding torch.

**Flow Apparatus**

The basic Oxy-Acetylene welding setup is shown in figure 1. The torch mixes the two gases with the ratio being controllable with a knob on the torch. Since we weren't actually welding, the filler rod was not used in our setup.

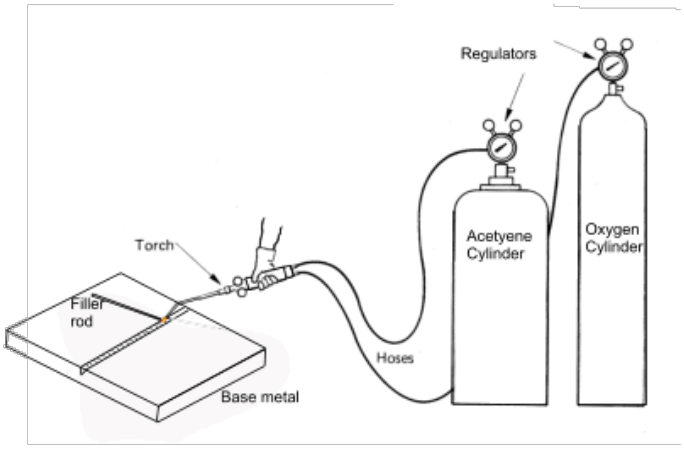


Figure 1: Oxy-Acetylene Welding Setup

The heat from the torch can reach 6000$^{o}$ F which can quickly turn steel molten [1]. Meanwhile the pressure from the fuel exiting the torch scatters the molten metal in a turbulent spray. The speed of the sparks varies with direction they're travelling. This occurs because the primary

force acting on them is the gas from the welding torch which is providing a force in one dominant direction while the trajectory of a given particle of metal is somewhat random, some is traveling back in the direction of the flame, perhaps as some of the flow from the flame bounces off the steel. Using the end of the torch as a reference it can be estimated that many of the sparks travelling primarily in the direction of the torch travel about 1.75". In the image one of the longer sparks is about 400 pixels long out of the 3000 pixel width which is less than one decade of spatial resolution. Fortunately there is a range of speeds and focus and some of the sparks are better resolved. For a spark to travel 1.75" in 1/160th of a second it would have to be traveling at about 15 miles per hour.

**Visualization Technique**

Since the object of interest here is itself incandescent no flash or external light was needed. I tried to make the background as clear as possible but given that it was a workbench it tended to be somewhat cluttered. However because it was so dark in the room and with some contrast curves adjusted the background becomes sufficiently obscured.

**Photographic Technique**

The image presented was taken with a Nikon D40 DSLR camera held on a tripod folded up to essentially be a monopod. The following settings were used in manual mode:

| Focal Length | Shutter Speed | f-stop | ISO |
|---|---|---|---|
| 50 mm | 1/160 sec. | f/2.8 | 800 |

I quite enjoyed playing with the variety of looks by trading off between f-stop and shutter speed, the main difference was the length of the streaks but subtle color differences also showed up. For this image I was standing beside David's left shoulder when shooting this, approximately 2 feet from the center of the fireworks. For an angle of view of about $40^{o}$ [2] the field of view can be calculated as 3'3" for the original unedited photo. I used Photoshop to modify the color curves a bit to highlight some of the variety of color in the sparks (which depends on the temperature of the metal). The main goal of the color curve adjustments was to increase the contrast and make the sparks really stand out. Additionally I cropped the image to remove some of the background clutter.

**Conclusions**

In the end, this image reveals a number of things. It is clear that the scattering of the molten metal is quite chaotic and that the speed depends on the direction relative to the torch. It also shows some nice scattering as some of the sparks split off. Unfortunately the focus is a bit beyond the center of the sparks but with the depth of field there are still a good portion of sparks which appear to be well in focus, slightly behind the steel plate. Since most of our time in the Duane Physics welding lab was spent trying to capture igniting flames we didn't have a lot of time to experiment with the welding process itself. I would have liked to try some different things

such as sending the flame at different angles, with different thicknesses and types of metal to name a few.  I believe a thicker plate of metal may have exhibited more sparks.  It would also be interesting to photograph other types of welding techniques to understand how the presence of this bright flame effects the ability to capture the sparks.

A big thanks to David Gagne for making this experiment possible in the Duane Physics Trades Teaching Lab, and for knowing enough to be able to exhibit a wide variety of behaviors possible with a welding torch.

[1] - https://en.wikipedia.org/wiki/Oxy-fuel_welding_and_cutting
[2] - http://en.wikipedia.org/wiki/Angle_of_view