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MCEN 4228
Flow Visualization

Team Project 3

This is the final team image, but we ended up working alone due to schedule differences. My original idea was to just have one picture of the lighter's flint striking to make sparks just before they ignite the gas. The best method I had to do this by was just having the camera button part way down so the focusing was done and then trying to line up the picture with the strike, taking into account any delays in the shutter activation. It was a long, tedious process that was hard to control, and naturally I got pictures of many more stages in ignition than just the sparking. So, this led to my idea of matching up the best photos in a line to show the different stages of combustion from a lighter.

There was not much in the way of an apparatus, but I had the lights in my room out while I held the lighter up against the dark background of my black bed sheets. I wanted to be sure that everything would be completely black except for the flame, so I also didn't use a flash. Each picture was cropped down and scaled to look about the same size, so each image ended up being about the size of a real lighter flame (~3 cm tall). Combustion will occur in a lighter when the oxidant (oxygen) and the fuel (butane) mix and are ignited by a heat source; the sparks from the flint [1]. The amount of heat required to ignite this vaporized fuel in air is called the flash point [2], and the amount of heat to keep the fuel burning for at least five seconds is called the fire point [3]. In this lighter sequence, a couple of the flame pictures seem to look a lot bigger than normal flames we expect to see from a lighter, such as the middle picture in color. This is because the butane is being forced out under relatively high pressure, resulting in a buoyant force and causing the initial gas parcel to rise up quickly [4]. The flame that is combusting the gas rises with it, acting as visualization for the flow of the gas, and we see a large flame with a plume on top. This flame plume will burn out when it consumes all the gas, and the remaining flame is the small, recognizable lighter flame that is in equilibrium with the flow of gas from the lighter, as shown in the final picture.

The visualization technique for this series of shots was the flame itself; it followed the flow of the gas and air mixture that was fueling it. As I stated before, I didn't use any flash because I wanted to have completely black backgrounds and have the flames be the complete center of attention. There was a small amount of ambient light in my room that was hard to completely eliminate, but it didn't affect the outcomes of the pictures because of the high shutter speeds that I will talk about in more depth later.

These shots were all considered macro shots, so the field of view was only about 6cm and the flames were about 4cm away from the lens. The focal length was at the smallest setting I had on my Sony CyberShot H20, which was 6.3mm. The f stop was fairly wide at 3.5 to absorb as much light as I could, because the shutter speed for the photos varied between 1/1000s and 1/2000s. This was to ensure I wouldn't get too many flame remnants or motion blur, and that the focus would be as crisp as possible. Some of the shots were a little blurry after all, so I increased clarity all the way and brought contrast all the way down for each picture, and increased the temperature of the golden flame in photoshop. Other than that, the only modification was cropping each picture

down from 3648 x 2736 pixels so they all could fit in one frame that is 4744 x 1848 pixels. My roommate consolidated the pictures for me in Gimp under my direction, and his help was much appreciated.

This image reveals the stages of lighter combustion and shows the buoyant forces acting on the gas by the shape of the flame. It actually turned out to be my favorite image despite the fact that the plan for the final picture changed midway through the experiment. The physics are clearly shown and I think they also came through powerfully and effectively. One question I had dealt with the star shaped spark in the golden flame image. I wonder if it is just a remnant of the flint that is caught sparking in the air, but it would be interesting to know for sure. Also, if I had more time I would probably get more accurate shots to show each stage most effectively. As it was the time required for a good shot was completely random and I had little control of the final images, so it would be nice to set up some kind of apparatus to synchronize the camera with the lighter ignition. Other than that I think it was a great overall image and I believe the idea was realized.

References

1. "Combustion." *Wikipedia, the Free Encyclopedia*. Web. 03 May 2010. <http://en.wikipedia.org/wiki/Combustion>.

2. “Flash Point.” *Wikipedia, the Free Encyclopedia.* Web. 03 May 2010. <http://en.wikipedia.org/wiki/Flash_point>.

3. “Fire Point.” *Wikipedia, the Free Encyclopedia.* Web. 03 May 2010. <http://en.wikipedia.org/wiki/Fire_point>.

4. “Buoyancy.” *Wikipedia, the Free Encyclopedia.* Web. 03 May 2010. <http://en.wikipedia.org/wiki/Buoyant_force>.