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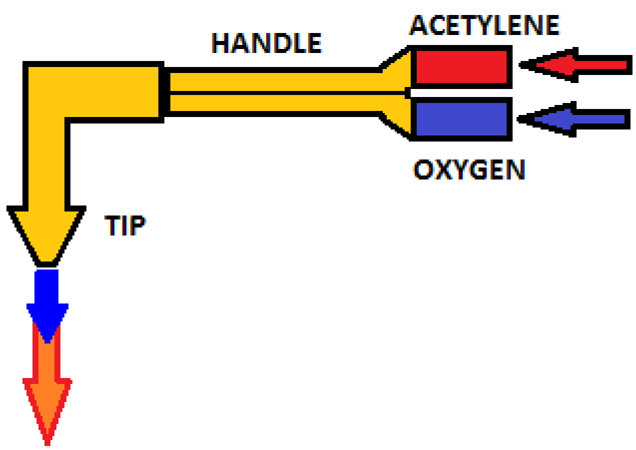
Team Second Image Report

Flow Visualization MCEN 4151

The video I created was part of the team second image gathering. We desired to capture the brief moments of when an acetylene torch is ignited in order to better understand what is happening as far as flow phenomenon and thermodynamics in the moments that happen faster than the naked eye can see.

The acetylene or oxyacetylene torch we used in the video is used commonly in the welding and cutting of steel and other metals. The torch itself is made of brass, and is comprised of a handle, a tip where fuel and oxygen is combined, and the gas inlets at the opposing end with valves to control each gas individually.



Normally a torch of this type is lit by turning on (allowing gas to flow from the pressurized tank/container, through the torch tip) the combustible gas (a hydro-carbon in gas form at room temp/press) by opening the valve at the back. Then a sparker, typically flint over hardened steel, is struck near the tip, and the gas ignites, bursting flame from the tip. In order to achieve the high temperatures required to melt steel, pure oxygen is then added by opening the second valve on the torch, and the desired temperature is reached by adjusting the amount of oxygen allowed to flow in. Typical temperatures that this type of torch reaches is 6,330 degrees F, almost 2000 degrees hotter than propane/oxygen torch. This is required in welding and cutting metals, as it is necessary to bring the metal above its melting temperature, so (for welding) when the metal cools the two pieces are now permanently bonded together as one.

In the video, which was shot at 2000 frames a second, we can see a flame initiated by the spark race back to the torch tip. In order to determine what is happening in these moments we will analyze the video, and make inferences from what we see. First, the initial flame is blue in color. Blue flame represents fuel burning in a pre-mixed environment, with little to no black body radiation emitted from burning soot particles. Since the fuel is pre-mixed it does not act like a diffusion flame, with laminar flow characteristics, but perhaps in a manner that would be better described as turbulent. Diffusivity is a characteristic of turbulent flow, and characterizes the flow as high energy, which accelerates the homogenization of fluid mixtures. What this means for our combustion process is that there is the potential for enhanced mixing, which would maintain the burn and maintain the turbulent flow environment, which requires high amounts of kinetic energy (created by the energy released during combustion). We can also closely calculate the speed that the flame travels using the distance covered and the frame rate of the recording. Doing this we can approximate the speed at just over 20m/s, which is much less than the speed of sound (343m/s), but relatively high with respect to another relative flame speeds, like that in an internal combustion engine of 16.5 m/s. If we assume flame speed is an indication of flame efficiency, we can say that this is a relatively efficient pre-mixed flame occurring in atmospheric air.

In order to effectively visualize flame moving this fast, we utilized a high speed digital video camera and shot at 2000 frames per second. The lights were dimmed in the room so that the light from the spark and flame would be some of the only light the camera sees. Though no extra techniques were utilized to visualize the flame, steps were taken to ensure crew and device safety. First, all the filming was performed in a welding lab, void of any flammable material, and vented to remove any combustion gasses. We also made sure all sensitive filming equipment was an appropriate distance and shielded from any sources of heat/flame. More importantly, all involved were wearing closed toed shoes and long pants, they were clad in leather welding aprons, sleeves/shirts, gloves, and were wearing safety glasses and torching masks/shields. This was to ensure that no stray spark could burn them or ignite their clothing, and so that their eyes, face, and skin was protected from the flame and energy generated.

As stated above, the photographic technique used was a high speed digital camera. The field of view was approximately 20-25 cm, which was limited by the camera itself, because at faster frame rate captures, it reduced the size of the capture area in order to compensate for effective data intake and storage. As we increased the frame rate, we were forced to move the camera farther away for the reason previously mentioned in order to keep the event in the field of view. In order to compile the footage and play it back with the music I desired I used After Effects by Adobe. The program was very effective in allowing me to achieve my desired effect, but I had a rather slow learning curve with the software, and would strongly recommend the tutorials available online to anyone attempting to use After Effects.

The video reveals “the birth” of a torch flame, an event that can’t be seen by the naked eye. It also is a beautiful display of a self-propagating turbulent flow phenomenon. I am very satisfied with the footage and the presentation, and what the video is able to display for physical flows. If I were to do this again or continue the idea with other types of flames, I would like to use a higher image quality high-speed camera in order to create video footage that is more descriptive and more pleasurable to look at as well.