Geoff Duckworth
Flow Visualization
Group Submission 2
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This report documents the image created for Professors Hertzberg and Sweetman's Flow Visualization course at the University of Colorado at Boulder. The image was created for submission as the second group project. For this project, the group included Brian Larsen, Mark Rizzuto, and Geoff Duckworth. In the series of images and video created for this project, we were interested in seeing and exploring the characteristics of combustion and detonation. Detonation is hard to create safely, so mostly what we dealt with was very fast combustion. In the past we had played with taking pictures of flames, but this time we were more interested in what might be inaccurately described as an "explosion."

The setup for these images was simply a 5.5" diameter by 12" long polycarbonate tube resting on a 0.125" aluminum plate. The plate was held above the work bench by two scrap aluminum blocks which allowed for an igniting flame to be introduced underneath. A 0.5" hole was cut in the plate to allow a flame to ignite from underneath. In some trials the ignition was from below as described, but in the video submitted the ignition source was a lit match dropped in from the top of the tube. In all trials, the combustible material was 250 microliters of methanol. The methanol was dripped onto the aluminum bottom surface in a circular, distributed pattern, and then allowed to evaporate for approximately 30 seconds before ignition. This was so that we could observe the combustion of the vapors instead of the liquid. In trials where just the liquid burned, the flame was much less interesting.

In this video, the field of view is approximately 5.5" by 12" and the high speed video camera was placed about 3 feet from the flame. The video camera was the high speed camera supplied by Greg Potts in the Durning Lab. For this video, due to the limited light supplied by the combustion, we were only able to shoot as high as 100 frames per second and still get good exposures. Image manipulation after the fact simply consisted of cropping, and very light color enhancement. Lighting was supplied exclusively by the combustion itself. The room was darkened while the combustion took place.

This video provides a slowed down glimpse of something that is typically so fast that we see it as almost instantaneous. Even a still image is hard to get of this kind of combustion, because it's hard to snap the shutter at just the right time. When we were taking still images, the only way that we were able to capture anything was to use a 3 or 4 second exposure. This resulted in a time averaged image of the entire combustion, which was interesting, but was not exactly what I was looking for. The high speed video allows the viewer an opportunity to carefully observe the characteristics of the combustion. In the video, one can observe how as the match falls into the cylinder, there is some inefficient (yellowish) burning, and then once the match hits the bottom plate, the flame propagates outwards very quickly. Once the initial rapid combustion occurs, most of the oxygen that initially existed in the cylinder has been used up, so the flame can only persist according to the rate at which oxygen can reenter the cylinder. This is why there is the initial burst of flame, and then the slower burning afterwards. I found it very interesting to be able to observe this first hand, as it is what I had suspected was occurring, but couldn't be sure until I saw it myself. As far as future development of this concept, more light would allow for a faster frame rate, and better time resolution of the image. Unfortunately, since the only light source is the flame itself, more light would require a bigger flame, which would be progressively more dangerous. However, since we used only 250 microliters of methanol in this series, I imagine we could use quite a bit more before we were really being dangerous.