Motion of Fire

Team Project 1

Flow Visualization
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The purpose of our image was to see flame behavior under windy conditions. Additionally we used this project to learn how the team interacted together. We intended on capturing the constant motion of the flame at different angles and times. To accomplish this we setup different size pools of liquid and used different photographic techniques to generate multiple images.

The photographs were captured on a 4ft by 6ft concrete block, down on a patio where the fire wasn't exposed to the full speed of the wind. Our pools of burning liquid at largest got right around 2 ft by 2.5ft, but sometimes were smaller, down to about 1.5 ft. The cameras, for image one, were held about 3 feet off the ground and looked down at about a 45 degree angle at the fire. For images two, three and four the camera was about six inches off the ground and about 3 feet from the pool.

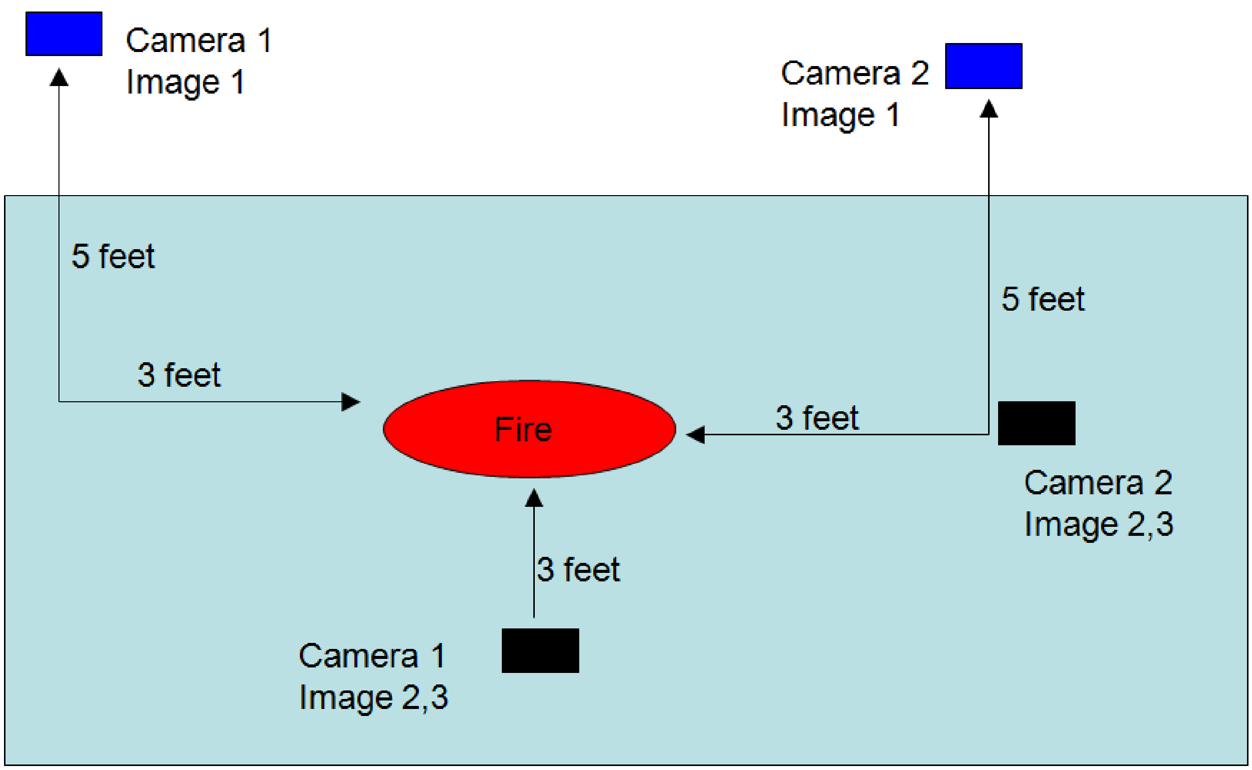
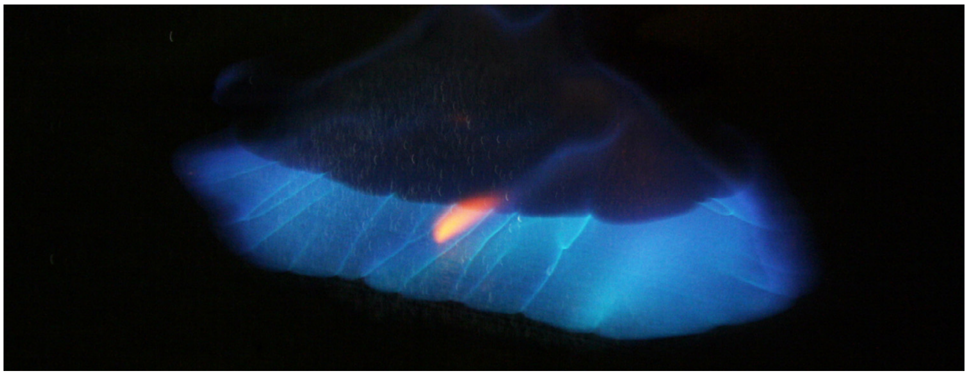


Figure 1: Apparatus set-up (overhead view)

The density of the Naphtha was about .76-.79 g/cm^3 as a liquid [1], the velocity of the flames can be estimated to be about 33-41 cm/s [2], and the viscosity can be assumed to be about 1. The diameter of each flame ranges from about ¼ inch to about 1 foot. This gives us a range of Reynolds numbers from about 2610-1.30e5 [3]. This means the flames are either turbulent or transitioning. The exact Reynolds number of fire is very difficult to accurately determine. The flame is constantly changing, and different flames of the total fire move with different speeds.

The flow technique used for this project was simply a calm pool of burning liquid. The liquid used is white gas fuel or Naphtha. It is a volatile liquid hydrocarbon mixture used commonly for portable camping stoves. The liquid was purchased at REI in a Coleman Camp Fuel bottle. During the night that the images were captured there was approximately 10-20 mph winds. Lastly, the photographs were captured at nighttime with the liquid primarily as the light source and a small overhead florescent light as the secondary source. It would have been preferred if the overhead light could have been eliminated, but it was not possible.

Image One (Joe Duggan):



- 0.5 seconds after ignition
- Field of view 20 cm
- Distance from object to lens about 1 m
- Focal Length 55 mm
- Canon EOS Rebel XS
- Original image size was 6000 x 2291 pixels final image size was: 1280x489 pixels.
- Aperture f 5.6, shutter speed 1/20s, ISO setting 400
- Photoshop "Curves" was used to modify the final image, to intensify the blues. This was necessary to better visualize the phenomena due to the inherent trade off between exposure time, and blurred image (and the naturally high speeds of the flame propagation). The final image was cropped, eliminating mostly the top portion of the original picture.

This image showcases the ignition moment of a pool of flammable liquid. It is when the flame is at it's most uniform and blue, while it spreads in a radial fashion from the point of ignition. Most interestingly, the flow visualized here is a combination of the flow of Naphtha vapors as well as the travel of the catalyzing reaction seen as blue flame. This mix of phenomena allows for a very interesting (but somewhat difficult to scientifically analyze) image.

Image Two:

Figure 2: Image by Melissa Lucht

- Field of view 1 X 1.5 feet
- Distance from object to lens 3 feet
- 80mm, Nikon AF Nikkor, focal length 80mm
- Digital, Original Image width 3008 pixels, height 2000 pixels. Final image width 5562 pixels, height 3894. Taken with a Nikon D-50.
- Aperture f 5.7, shutter speed 1/60s, ISO setting 1600
- I cropped the actual image and upped the resolution to make it clearer. I also messed with the contrast and brightness to make the flame glow a brighter orange/yellow.

The image reveals the motion of flame. Fire is in constant motion, never sitting still; this particular image shows the movement of the flame within a moderately windy atmosphere. As you can see the concrete beneath the actual flame is in crystal clear focus while the flame seems to be a blur. The flame is blurry because the fire is in motion and too much motion to actually be caught in a clear focus. I like this particular image because the flame is only on the one side of the picture and black is taking the rest of the negative space. The flame is alone in the picture so it brings your attention straight to that, its simple not busy. The flame looks almost as if it is flowing out of the frame, I like this because it makes your eye move and keeps your attention of the photograph. The fluid physics are shown well here you can actual see the flow movement in the flame. I think we fulfilled the intent we were going for, we wanted to capture fire burning and the flame. Since this is our first of our three projects, we were talking about developing the idea of a flame that is a different color by burning a chemical that would cause this phenomenon.

Image Three:

Figure 3: Image by Lucy Dean

- Field of view 1 X 1.5 feet
- Distance from object to lens 3 feet
- Focal Length 55mm
- Canon EOS Rebel XS
- Digital, Original and final Image width 3888 pixels, height 2592 pixels. Taken with a Canon Rebel XS.
- Aperture f 7.0, shutter speed 1/400s, ISO setting 1600
- Photoshop was used to enhance the contrast of the image, using the curves tool.

The image shows the flame moving. I really liked this image because of its shape. I think it looks like a dragon. The motion of the fire can be clearly seen by the blur of the flames as them move. This image shows how a fire moves and parts of the flame break off and rise faster, because the gas is warmer than the surrounding air, and create shapes for just a moment. The intent of the image was realized. Next time, I would like to be able to capture the flame a little more clearly; try and avoid more motion blur.

References:

1. http://www.ilo.org/public/english/protection/safework/cis/products/icsc/dtasht/_icsc13/icsc1380.htm
2. http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6V2B-4B3MMNF-1&_user=918210&_rdoc=1&_fmt=&_orig=search&_sort=d&view=c&_acct=C000047944&_version=1&_urlVersion=0&_userid=918210&md5=318c0df1c38ee3e24bfc7aef83f5cc6b
3. http://www.efunda.com/formulae/fluids/calc_reynolds.cfm#calc