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Group Project 1

The purpose of these images is to be attractive images that demonstrate the flame phenomena being observed for the first group project. The intent of the first image is to create an image that demonstrates the billowing effect caused when a flame comes in contact with a horizontal barrier above it such as a ceiling. The intent of the second two images is to demonstrate the effect of burning fuel flowing down a free surface.

The flow in the case of the first image is flame impinging on a surface above it. The setup for the first image is as follows:

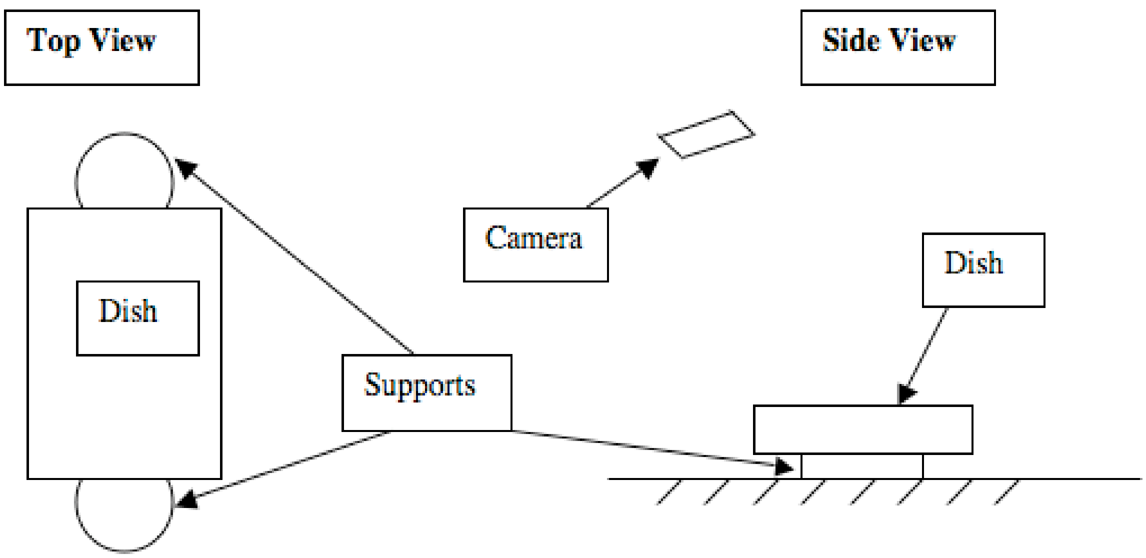

Figure 1: Diagram of setup for image 1

The Pyrex dish used was 15" x 10.5" x 2.25" and the supports were disk breaks with an 11" diameter and a 2" height. The camera was about 2.5' above the dish. The dish was coated with ethyl alcohol on its inside, then flipped upside-down, placed on the supports and the alcohol was lit. The blue flame in the picture is the alcohol burning while the more yellow flame is caused by a small pool of alcohol that dripped onto the concrete floor, and is thus burning whatever fuels are coating the floor. To calculate the Reynolds number we estimated the viscosity of air at the flame temperature of alcohol which we took to be 1400 C. The kinematic viscosity is then 26.4 x 10^{-5} m^2/s. Then using the diagonal length of the dish as the characteristic length, 18.3" or .46 m, and a velocity of 1 m/s, we calculated the Reynolds number to be 1700. This is in the laminar region which makes sense in this case as the slow, boiling motion of the flames caught under the dish did not appear to be turbulent. The flames spilling over the edges however, have a velocity of more around 3 m/s, which corresponds to Re = 5200, which is in the turbulent region and accounts for the much more erratic behavior of the flame.

The flow in the second two images is burning alcohol flowing down a steel strip. The setup is as follows:

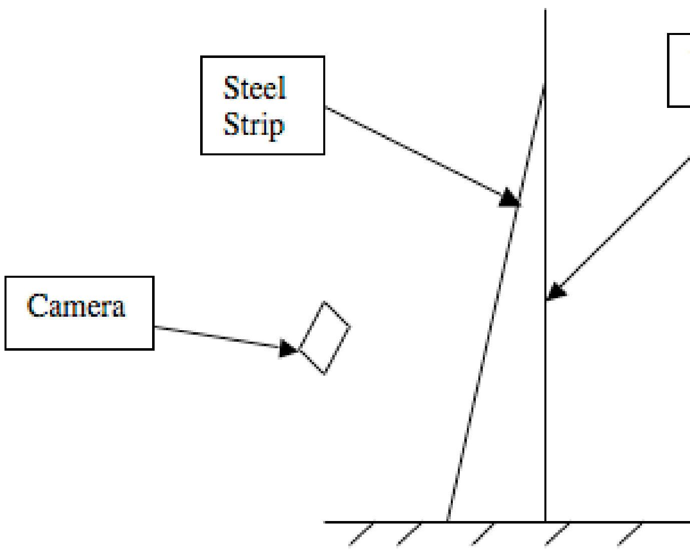

Figure 2: Setup for images 2 and 3

The thin steel strip was 1" wide and 6' tall. It was placed at an angle of about 80 degrees from horizontal against the wall. The camera was about 3' away from the strip. Ethyl alcohol was poured over the top of the strip and then quickly lit. The burning alcohol flowed down the strip (picture 2) and then reached the bottom and pooled (picture 3). The blue flame is the alcohol and the more reddish flame is most likely caused by the rust on the steel strip. In picture 2 it is apparent that the width of the flame increases the farther away from the leading edge of the flow it is. This is most likely because the alcohol above the leading edge has heated up more and is thus burning better. Once the whole strip was burning (picture 3) the flame width appears uniform all along the strip. The flow at the leading edge of the alcohol had a velocity of about .5 m/s and the ethyl alcohol has a viscosity of 1.5×10^{-6} m^2/s at room temperature (as the leading edge has probably not heated up much). Using the width of the strip as the characteristic length, .0254 m, we get Re = 8500, which is in the turbulent range. This makes sense, as this is a gravity driven flow on a nearly vertical free surface.

The visualization technique for all three images was simply the alcohol flame in a dark room. The alcohol was 95% pure ethyl alcohol, in this case Everclear. The flame was the only light in the room.

The camera used to take this picture was a Canon S30 3.2 mega pixel digital camera. The images are all 2048 x 1536 pixels. The shutter speed and aperture was 1 second and 5, respectively, for all three images. This accounts for the slightly blurred effect of the flames in each image as well as the shallow depth of field. The focal length for the first image was 10.3 mm and was 7.1 mm for the second two images. The ISO was set to Auto for each image and was thus likely to be 50 as that is the default for most photos. Photoshop was used to adjust the white balance of each image and to remove several spots from the pictures.

These images illustrate the flow of flames impinging on an overhead surface, and the flow of a burning fuel freely flowing down an open surface. I like the colors in my images, but in the future I would strive to time-resolve the images a little better to eliminate the flame blur. I would also like to try to create vortexes in the flames. For now, I believe I have fulfilled the intent of my images as I have demonstrated the flows I wished to, and I have created some beautiful images.

References

1. http://yarchive.net/explosives/cool_flame.html

2. http://www.me.utexas.edu/~ezekoye/rsch.dir/firesite/science_thermodynamics.html

3. http://www.engineeringtoolbox.com/9_422.html

4. http://www.engineeringtoolbox.com/24_601.html