Team Second Image 2016

MCEN 4151 : Flow Visualization

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Introduction

For the second team image, the team consisting of Alex Rosenberry, Katie Yarnell, Preston Marcoux, and myself set out to experiment with capturing the physics behind fluid motion of fire. Having a team involved with the production of the fire photos made it easy to experiment with many different angles and setups throughout the photoshoot. After taking hundreds of pictures and looking back through them all, the image I have chosen for my final image can be seen in Figure 1 below.

Figure 1: Final Image

Image Setup

For this image poi, displayed in figure 2 below, were utilized to hold a flame for an extended period of time while enabling us to give the flame source motion. Poi are usually used in visual performances by professional dancers, they can be spun in patterns that leave behind beautiful flowers and circles. In our case, I have some experience using them, but I am no professional, and the team was more focused on the motion of the fire, rather than the poi itself. No additional lighting was necessary for this photo because the contrast is already perfect with the darkness of the night in the background. Katie, with her camera on the tripod was set up roughly 4 to 5 feet away from myself holding the poi. For this image we made a flaming pendulum. I was holding the top of the chain still while the flame took the place of the swinging mass. The photo setup and motion are outlined below.

Figure 2: Un-burnt poi

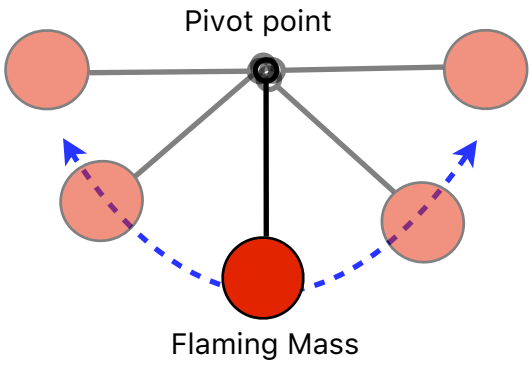

Figure 3: Motion of examined fire

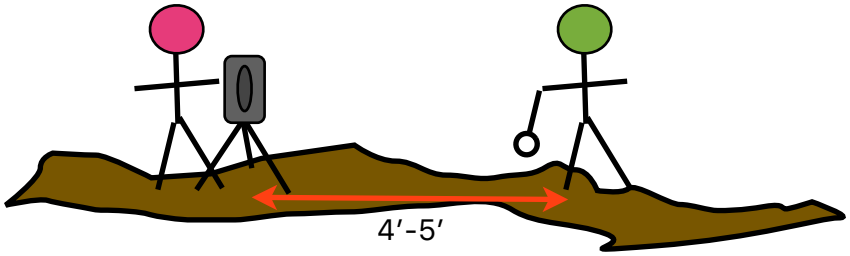

Figure 4: Photograph setup

The Physics

The examined pendulum is unique because it is on fire. The poi is made out of kevlar rope which is a highly flame retardant material. Kevlar rope is made from thermoset fibers which start to degrade at 500°C, making it a perfect material to be soaked in fuel and burnt. The fuel of choice is kerosene, it is relatively cheap and it's vapors burn at a measly 65°C, which is far lower than the kerosene rope that is holding the fuel. The photo displayed in figure 1 was captured just after the top of each swing where the mass sits motionless for a fraction of a second. The part that is the most interesting to me is how the flame creates a visible vortex ring of fire as the poi leaves the vapor plume behind. The vortex propagates vertically due to the heat of the burning kerosene. The fluid paths of this motion are displayed below in figure 5.

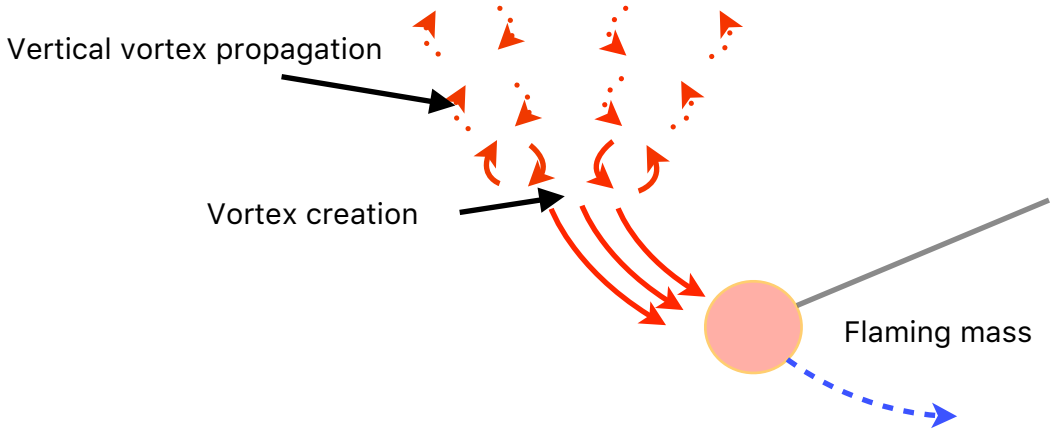

Figure 5: Vortex creation and propagation

The Camera

Using a Nikon 18-140mm lens. with an ISO was set to 800, the f-stop to f/10, and the exposure time 1/1600 of a second, the Image was captured beautifully by Katie Yarnell. Field of view of the image is roughly three to four feet across, and was cropped to roughly two feet for the final image. The original image is displayed below in Figure 6. Very few manipulations were applied to the photograph after it was taken. The image was cropped, and a few dust specks were removed. Katie was able to obtain a very sharp image of the fire with her camera settings and the setup we created.

Figure 3: Original image

Conclusion

Capturing the magic fire in motion is difficult to say the least. With the light of the burning fuel being so bright, and changing so quickly, it took the perfect set of camera settings to freeze time while still acquiring enough light to get a good image. If I were to make another attempt at photographing fire, I wouldn't change much. I know that there are types of fuel that change the color of the flame, that would add an interesting effect to the poi pattern possibilities. Overall I am very pleased with the outcome of the teams effort in this fire photographing experiment.