Get Wet

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MCEN 4151 - Flow Visualization

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Get Wet Report

This image was produced for the Get Wet assignment for MCEN 4151. The purpose of this assignment was to "get your feet wet" by making a picture of fluids that demonstrate a phenomenon and is a good picture. Creating this image provided an opportunity to experiment with camera settings and apply what has been taught in class. The intent of my image was to capture the movement of the flames produced in a campfire. The fire was set up and managed by a local Boy Scout troop.

The flow apparatus used in the image was a campfire set up in a fire ring. The logs for the fire were set up in a teepee formation, see Figure 1. The flow of the fire was shaped by the logs that it flowed around as well as the wind that was acting on it. Each of the logs in the image is approximately 12'' in length.

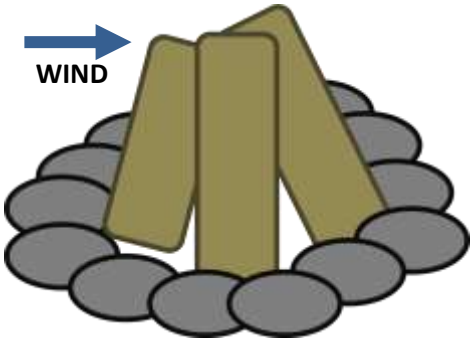

Figure 1: Campfire in a fire ring set up teepee style with the wind blowing from left to right

From the color of the original image you can determine the temperature of the fluid. The carbon particles burning in the image emit light based on their temperature. For example dazzling white light indicates a temperature of 1,500˚C[1] and just visible red light indicates a temperature of 525˚C. Between these two values there are several breakdowns of red, orange and white light. In the original image, Figure 2, the fire at the bottom of the image, the base of the fire, is bright white indicating that it has a temperature of approximately 1400˚C. The flames in the top right of the image are clear orange indicating that the temperature is approximately 1,200˚ C. This demonstrates the temperature gradient across the fire and as the fuel for the fire, the wood, is used up the fire will start to die down and the temperature will decrease and the flames will become more red than white.

The speed of the sparks can be estimated by knowing that the shutter speed was 1/30 of a second and measuring the length of the spark streak in the image. The velocity can be calculated by using the equation $Velocity = \frac{distance}{time}$ and unit conversions can be used to find the velocity in meters per second. Picking a spark path the distance traveled is 1.5 inches using the logs as a reference point. From this, $V = \frac{1.5\ inches}{1/30\ second}$. To convert the velocity to meters per second the following equation is used: $V = \frac{d\ inches}{t\ seconds} * \frac{0.0254\ meters}{1\ inch}$ The velocity of a spark is 1.14 meters per second. The density of the air at 1,300˚ C is approximately 0.2206 $\frac{kg}{m^3}$ [2],

1,300˚C is the average temperature of the fire based on the color of the flames.

The visualization of the fluid was done by shooting at night to illuminate the flames. The wood burning in the image is pine and no accelerant was used when the fire was lit. At the time the image was taken a moderate breeze was blowing from left to right. The lighting used in the image is only the flame emission from the campfire and the camera was hand held.

A Cannon EOS DIGITAL REBEL XS digital camera was used to take the picture with a shutter speed of $1/30^{th}$ of a second, an F-stop of 5.6 and an ISO speed of 800. The shutter speed was fast enough to limit motion blur but slow enough to capture the motion of the sparks. An F-stop of 5.6 and an ISO value of 800 allow enough light to hit the sensor to create a bright and well lit image that keeps the entire field in focus. The focal length was 55 mm. The original image was 3888 by 2592 pixels and the final image is 2706 by 2592 pixels wide and tall respectively. Photoshop was used to crop the original image and to make it black and white. By cropping the image the fire was more centered in the image and the amount of blackness surrounding the fire was reduced to draw the viewers' attention to the movement of the flames. I chose black and white for this picture to emphasize the motion of the sparks as well as to minimize the impact of the logs that are mixed in with the fluid flow.

The image reveals the motion of a campfire as well as the path that sparks travel along. I like the image in black and white because it simplifies the complex motion of the fire and really brings out the motion of the sparks traveling independently of the flames. In black and white I don't like how so much of the distinction in the flame color is lost, especially in the bottom of the image. I would also like the image to be a bit sharper and have less motion blur. The fluid physics are fairly well represented in the motion of the fluid but in black and white it is harder to identify the temperature of the fire.

References

1. "Fire II: Color and Temperature." *Smashing Color*. Smashing Color, n.d. Web. 12 Feb. 2013.

2. "Dry Air Properties." *Dry Air Properties*. The Engineering ToolBox, n.d. Web. 12 Feb. 2013.