

Group Assignment #1: WD-40 Turbulent Flame

Photo taken 10/18/07



Jake Dembeck

Robert Irmiger

David Levine

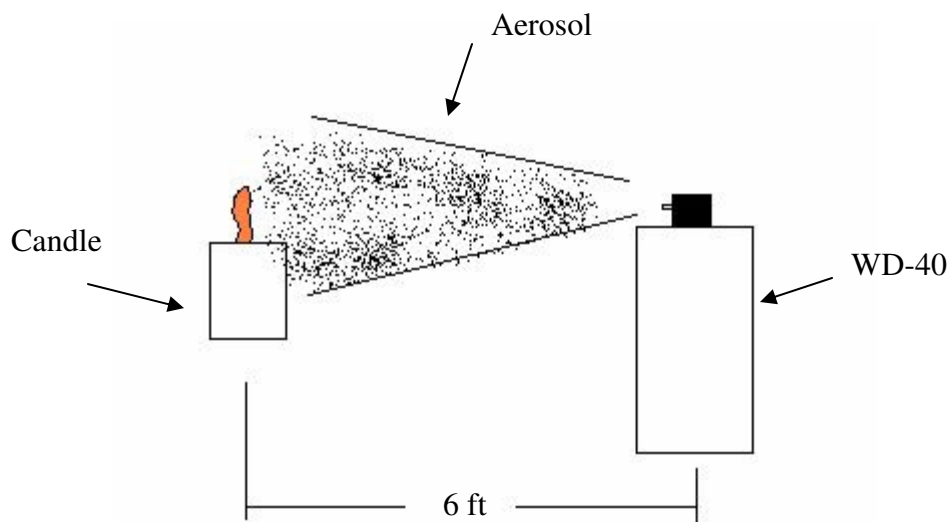
John Miller

Brittany Moore

The purpose of this image is to display a phenomenon that most people see on a regular basis. My group decided to take photos of fire in order to show the intricacies of the flow that are always present, but are rarely seen due to the speed of the combustion process. Due to the nature of fire we did have to take some safety precautions to ensure the safety of everyone in the group while taking the photos. All photos were taken in the center of a parking lot far away from flammable material. Also there was always water and sand present to put out a fire if it became out of control. We tried taking photos with a variety of different chemicals and setups, but it was difficult getting an in focus picture due to the fact that fire is constantly changing in all 3 dimensions.

To acquire the desired effect of the fire we used the cleaner/lubricant WD-40 which has active chemicals which are flammable. We lit a candle and had the entire team stand on one side of the candle while one person sprayed the WD-40 into the lit candle creating a continuous flame to take photos of. The distance from the WD-40 to the candle was approx. 5 feet, and the distance from the camera to the flame was approx. 8 feet. A

diagram is shown below:



Based on the material safety data sheet provided by the WD-40 company, the main ingredients in WD-40 are Stoddard solvent, liquefied petroleum gas, mineral oil, and inert ingredients. Of these ingredients we are igniting the liquefied petroleum gas which

is a very flammable substance. Liquefied petroleum gas is a saturated hydrocarbon which means that the carbons have only single bonds with hydrogen and follows the general formula of C_nH_{2n+2} . When liquefied petroleum gas burns, it reacts with the oxygen in the atmosphere to create water and carbon dioxide. However since WD-40 also contains other elements this is not the exact reaction, and other byproducts are also created during the combustion. The flow shown in the photo is of WD-40 that is being ignited, and then flowing around, a candle. The type of combustion shown in the image is known as rapid combustion meaning that a great deal of energy is released quickly usually in the form of fire. As seen in the final image, the fire is a turbulent flow. This is due to the fact that the WD-40 is first being forced out of the can at a high speed, and then when ignited is further accelerated by the chemical reaction taking place with the oxygen creating instabilities in the air. This means that the Reynolds number is on the order of, or greater than the turbulent threshold of 6500.

The visualization technique used was the ignition of the WD-40. The liquefied petroleum being sprayed creates the flow, and when it ignites the fire displays the intricacies inside the flow as it burns. All of the pictures were taken at night so as to minimize unwanted light in the photograph. Also the flash on the camera was turned off so as to not illuminate the unwanted background of the flame. All of the light in this photo is a result of the flame being shown in it.

The camera used to take this picture was a digital Nikon D80. This camera has the capability of taking a picture measuring 2592 pixels high by 3872 pixels wide. The camera had a focal length of 100mm. To make sure we could capture the flame with minimal blurring an aperture of F/5.6 was used, and the shutter speed was 1/500 sec. The ISO was set to 100. The images field of view is approximately 5 feet with the camera located approximately 8 feet from the flame at an oblique angle. To enhance the image I cropped the photo and then used Photoshop's curves function to increase the brightness of the flame so as to make a better contrast with the background. This also brings out more detail inside of the flame. I also used the healing brush to remove some faint distractions in the background.

Overall this image does an excellent job of showing a turbulent flow in the form of a flame originating from aerosol WD-40. My favorite aspects of the image are the flame

itself making the transition from the aerosol particles to a turbulent flame around the candle. I also like how the flame interacts with the candle, and adds an extra dimension to the image. The only aspect of this image that I don't like is the background below the image. We were photographing the flame on asphalt, and even though we were not using the flash the flame provided enough light to make some of the asphalt visible. I am very satisfied with my image, and feel that I have photographed exactly what I wanted to. If I were to pursue this idea I might try photographing many types of flammable aerosols looking for similarities and differences based on the flammable chemicals that are burning.