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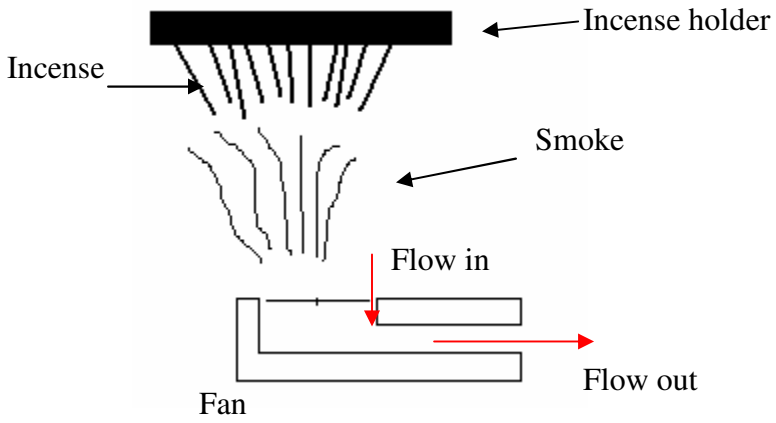
Photo taken 9/8/07
ME # 916-375

Assignment #1: Get Wet

The goal of this image was to create and photograph a laminar air flow using incense smoke to make the flow visible. To do this my initial intent was to use a large fan roughly 26in in diameter. I immediately realized that the lowest setting on the fan pulled the smoke too quickly and dispersed the smoke at the tip of the incense. I then decided to use a small heating fan to pull the smoke from multiple sticks of incense. The most difficult aspect of capturing the image was getting the smoke into focus. The flow was 3D, and constantly changing making it had to take multiple photos at once.

To create this flow I used a small 7in fan to pull smoke from 11 sticks of incense. A setup of the flow is show below:



As seen in the photo the flow is laminar and is being pulled from the tips of the incense into the fan. The fan has a fairly low velocity which creates the smokes smooth and curvy features that exist in a laminar flow. The incense sticks were being held at a distance of 6in away from the fan, and the space between the tips of incense varied between 0.25in and 1in apart. To estimate a Reynolds number for the flow I found the properties of air at 68 degrees F. The density of the air is 1.164 (kg/m^3), and its viscosity is 18.24x10^-6 (N*s/m^2) (Kreith, A26). I was able to estimate the Reynolds number to be approximately 9700 which is below the turbulent Reynolds number that is around 5x10^6. This number was based on a flow velocity of 0.3 m/s. Also using this velocity

and the shutter speed I calculated that the time resolution to be approximately 1.5x10^-3 meters.

To make the flow created by the fan visible I used the smoke created by burning incense. The smoke was then pulled into the fan and passed out the other end so as not to disturb the constant incoming flow. For lighting I used the flash on my camera. I also used black cloth as a back drop to create a contrast between the smoke and the pictures background.

To create this photo I used a field of view that was approximately 8in wide and 7in tall. The distance from the lens to the spoke was approximately 13in. At the time I took the photo the focal length was 13mm. The camera I used was a Canon PowerShot A70. The camera takes digital pictures at 20448 pixels wide X 1536 pixels high. The aperture was set to F/4.5, and the shutter speed was 1/200 sec. The ISO setting was set to automatic meaning the camera chose the setting based on the current conditions. This setting was not recorded to the image file. After I had my photo I used Photoshop's curves function to create a greater contrast between the smoke and the background. I also used the healing brush and the clone stamp tools to clean up some light areas and take out the tips of the incense that were originally in the picture.

This photograph shows how air is pulled into a fan, which is a flow that is normally invisible to the human eye. The photograph has also been altered in such a way that the smoke/flow is highlighted with minimal distractions in the background. The aspect that I like most about my image is how the uneven spacing of the incense creates smoke trails that intertwine with each other. My least favorite aspect is the darkness of the picture. I used a flash to take the picture instead of a background light. The flash also lit up the black background which I then had to Photoshop out to create the effect I wanted. I believe the smoke does an excellent job of showing a laminar flow and created the exact effect that I was looking for. To expand on this idea I would try to use a different lighting scheme, and then try to use 2 or 3 colors of smoke. This would create an intertwining of multiple colors and would make a more artistic image.

References

1) Kreith, Frank, and Mark S. Bohn. Principles of Heat Transfer. Pacific Grove: Brooks/Cole, 2001.

2) Munson, Bruce R., Donald F. Young, and Theodore H. Okiishi. Fundamentals of Fluid Mechanics Fifth Edition. John Wiley & Sons, 2006.

3) "Fluid Preliminaries." Efunda: Engineering Fundamentals. 20 Sept. 2007 <http://www.efunda.com/formulae/fluids/overview.cfm>.