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Flow Visualization Project 1

The goal of this first project is to get an introduction to flow visualization by simply doing it. The final goal is to get an appealing picture of any desired fluid flow. The fluid flow to be examined in this paper will be the transitional flow of air. As the air transitions from a laminar to turbulent flow interesting patterns can form. To help visualize these patterns smoke produced by a hookah will be used.

To create the desired pattern a subject will inhale smoke from a hookah and then exhale at a reasonable speed as to create the transitional patterns. The flow pattern will be created by the exhaled smoke in an open room. The air will be as still as possible to attempt to slow the diffusion of smoke into the air. The flow starts as a calm laminar flow out of the subject's mouth. This laminar flow has a Reynolds number of approximately 570. This was found by approximating the characteristic dimension of the subject's mouth to be ¾ inches and the velocity of the smoke to be 1 mph. The Kinematic Viscosity of air at standard atmosphere and 70 degrees F is 1.64 e -4 ft^2/s. Since the Reynolds number is less than 2300 the flow is classified as laminar [1]. As the smoke leaves the subjects mouth patterns known as eddies begin to form. These patterns are spiral shaped vortices that are created when reverse flow interacts with the forward flow [2]. The formation of eddies indicates that the fluid is transitioning from the laminar to turbulent region, which also indicates that the Reynolds number is increasing. As the flow continues the larger eddies form until the smoke becomes more turbulent and begins to diffuse. The interaction with the surrounding air and other instabilities eventually causes the change in the smoke. The time that it takes this transition to occur is in the range of 1 to 3 seconds.

To visualize the flow of air, smoke was used. The smoke was created by a smoking device called a hookah. This device heats tobacco while the smoker inhales the smoke which is pulled through water then into a hose. The smoke was then exhaled

at a speed which would produce enough smoke while demonstrating the formation of vortices. The surrounding air needed to be calm to help visualize the flow. If there was too much air flow in the surrounding room the already fast fading smoke would not be able to form the vortices. A hookah was used because of its capability of producing a large amount of thick smoke in a single inhalation. To capture the smoke on camera a couple of things were done. First the subject sat in front of a dark background to help see the light colored smoke. Second the shot was taken at night so that the only light on the smoke would be the flash from the camera.

The relative size of the picture in inches would be about 7 x 14 inches. The lens was approximately 2 feet away from the subject. The focal length was 55 mm and the lens has the capability of 18 – 55 mm. The picture was shot with a Canon EOS Digital Rebel XT, which is a Digital SLR type camera. The size in pixels of the original shot was 3456 x 2304 and the final shot was 3022 x 2206. The aperture value was f/5.6. The shutter speed was 1/6 second. The ISO was set at 400. Once the image was acquired, the picture was first cropped in Photoshop, then adjustments were made to the brightness. After that a custom gradient map was applied to create the blue and white photograph.

This image is able to show the formation and dispersion of the spiral vortices that can occur while smoking. It shows the different stages of laminar and turbulent flow while maintaining its visual appeal. I like that each separate spiral can be seen from the point where it just starts to separate from the laminar flow to the point where you can barely make out where it was once in the turbulent flow. I also like having the small part of the face in the picture for perspective on the size of the flow. It informs the viewer on the size of the flow without using something that didn't belong with the flow. Because of the nature of the fluid flow, if this picture was taken a hundred more time with approximately the same conditions, there would be a hundred completely different pictures. This demonstrates the randomness of turbulent flow, which is another aspect that I like about this flow. It would be possible to get a better picture than I did however with these conditions it would

probably be up to chance. Every picture is dependent upon variable conditions that will greatly affect the final picture. With more time and better planning more pictures could have been taken, which could have led to better picture.

References

[1] "Laminar, Transitional or Turbulent Flow." The Engineering Toolbox. 28 Jan 2009 <http://www.engineeringtoolbox.com/laminar-transitional-turbulent-flow-d_577.html>.

[2] "Eddy (Fluid Dynamics)." Wikipedia. 28 Jan 2009 <http://en.wikipedia.org/wiki/Eddy_(fluid_dynamics)>.