Flow Visualization

Group Project 2

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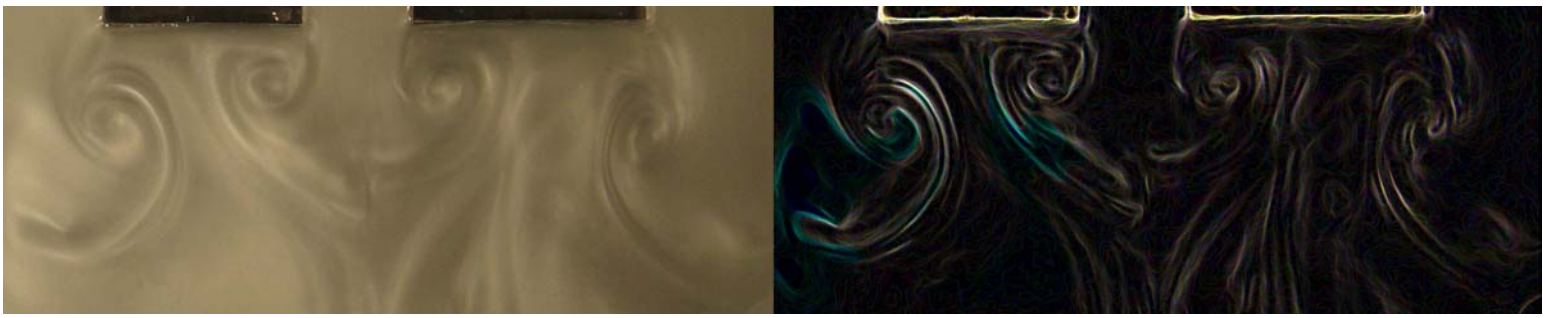

Context and purpose

This is the second group project. We worked with fish scales to visualize various fluid motions around various objects. The fish scales do this by creating a rheoscopic fluid. Each scale aligns itself in shear with the flow of the liquid. The purpose of the image is to see the circulating fluid motion in a port exit. In hybrid rocketry, the fuel port geometry is important in its performance. The geometry assists combustion stability as well. Figure 1 shows the brief description of fuel hot gas recirculating before the port entrance and the flame circulation after the port.

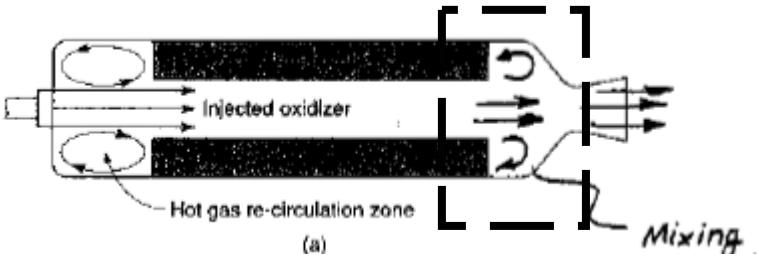

Figure 1: A stable Combustion Fluid Motion Schematic

Flow Apparatus

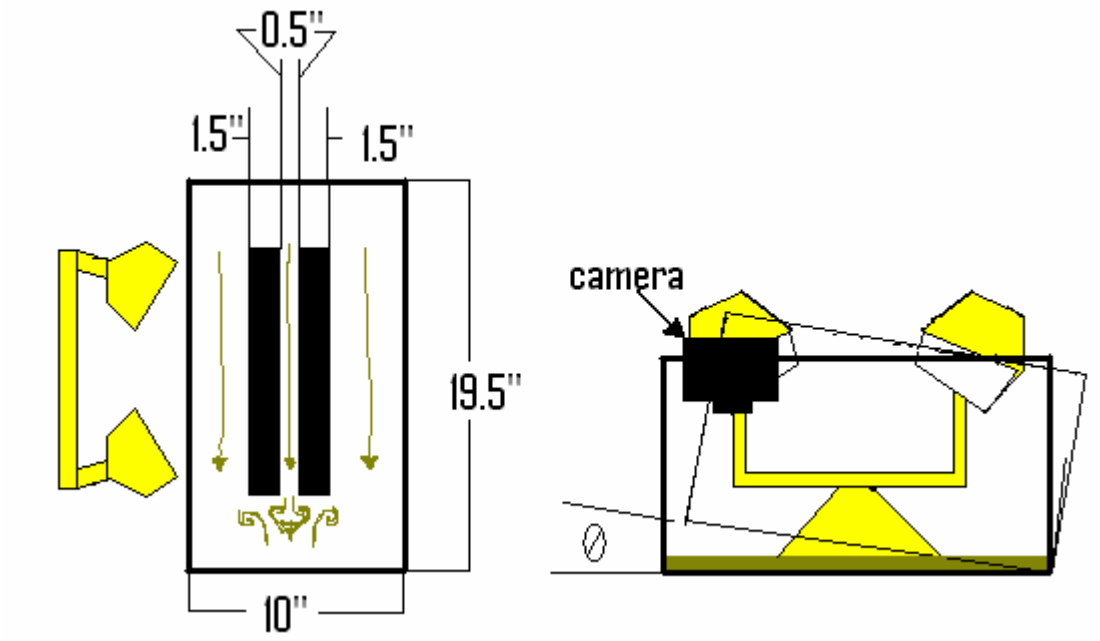

Figure 2: Flow apparatus
Left: top view, Right: side view

To set up our flow we used a fish tank. We put a dilution of water and fish scales into the bottom of the tank about an 1/2" deep. Next we placed two pieces of Plexiglas in

the bottom of the tank as shown above (they were slightly taller than the fluid level). Then to create the flow we gently tipped the tank (shown as theta in figure 2).

Physics

The image only shows the aft circulation where the dotted box is in Figure 1. We could not get the before circulation due to the visualization method and size of the fish tank. The edge of the port and the speed was good enough to create a fluid circulation motion Reynolds number was less than ~10^3 for this image. The actual system Reynolds number will be ~10^7 due to high fluid density and the speed. The low Reynolds number will allow the flow to be laminar, so the motion boundary can be visible with steady stream line. The physics and the flow motion were revealed in this image. There are two other flow motions that can be shown by improving the apparatus set up. These two motions are; the hot gas recirculation zone and the fuel port boundary layer as turbulent mixture. We could accomplish this by developing actual rocket inner geometry.

Visualization technique

To create this image we used a solution of Kalliroscope fish scales. Kalliroscope is a company that manufactures and sells rheoscopic fluids. Our solution was approximately 10% fish scale rheoscopic fluid in water. As shown above we had two lights on the system for this picture, they provided 500 Watts each. Our camera was positioned vertically above the bottom of the tank approximately 10".

Camera specifications

Size of Field of View: 4.5" X 2"
Distance from object to lens: 10"
Type of camera: Sony DSC P92
Final image resolution: X/ 96 Y/ 96
Final image pixel dimension: X/ 2592 Y/ 515
Photoshop: Stylize/ Glowing Edges/ edge width=2 edge brightness=20 smoothness=15
The following information was not recorded in the image file:

Focal length:
Aperture:
Shutter speed:

Conclusion

We really like this image because we feel it really captures the physical phenomena we were looking for and we also feel it's a visually interesting image as well. We chose to Photoshop the image in this way because we felt that the Photoshopped image revealed the flow in an interesting and informative way and by placing it next to the original image it is still apparent what is going on.

Original Image