Brock Ewing

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Flow Visualization

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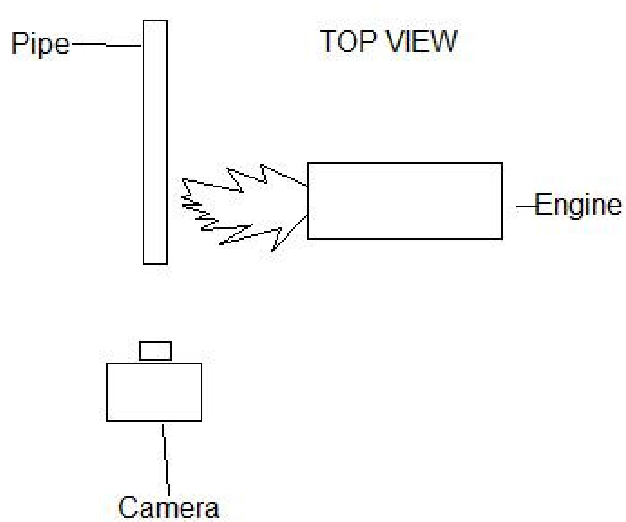
Group Image #2

Rocket Engine Thrust Flow

For this image, our group wanted to show the flow of a stationary rocket engine. We were interested not only in the flow of the thrust flame on its own, but also of the flow over and around various objects. Since an actual rocket engine is extremely expensive and nearly impossible to come by, we decided to do the experiment on a much smaller scale and use a model rocket engine. We placed differently shaped pipes behind the rocket engine and observed the flow over and through the pipes.

For our setup, we clamped a model rocket engine to a cinder block so that when it was ignited the engine would not move. Then we placed the camera perpendicular to the rocket thrust about 3 feet away. The pipes were placed 1 inch behind the engine and in line with the camera. A schematic of the setup is below:



The flow witnessed during this setup was a very high turbulent flow in all cases. In the unobstructed case we witnessed a very high speed flow that exited the nozzle at a small diameter and quickly expanded to a larger diameter. For the obstructed flow on the left, there is a cylindrical pipe behind the engine flare that is causing it to divert around the cylinder. The fact that it disperses the flare so much rather than allows it to smoothly flow over the top of it shows that it is moving at an incredibly high speed and that the cylinder diameter is greater than the flow height. In the final image on the right, a hollow, square tube was place blunt side facing the engine. In less than a tenth of a second the engine flare melted through the aluminum pipe and created holes on either side of the pipe to flow through. These holes decreased the diameter of the flow and concentrated it at its output at the other side of the piping. This made for a very bright flare. Although it is hard to judge the velocity of the flow, based upon the streaks of the sparks it can be estimated to be about 60 m/s. This makes the Reynolds number for this flow somewhere on the order of 10^6, well within the turbulent flow range.

To visualize our rocket flow, we simply used the flare output as our lighting source. No other lighting source was necessary or even wanted. By using the flare as the lighting source, we were able to directly track the flow with no difficulty.

Because there are three pictures in this image, some of the camera specs change from photograph to photograph. For each of the three pictures, the field of view is 3 in by 2 in. The object is 3 in from the lens. The focal length in 100 mm. The images were taken with a Cannon 10D digital camera. The aperture was F2.8. The ISO was 800. The shutter speed was 1/750 for the first and third images and 1/500 for the center image.

The three images were put side by side in photoshop to highlight the differences in the flows based on the varied obstructions.

This image reveals a lot about rocket engine flow. With the two obstructed images and the unobstructed image all side by side, we are able to see how the flare reacted the various shaped objects. Because the flow was so fast it did not smoothly flow around the objects, but rather deflected wildly or burned right through. Even though the engine we used was merely a little toy rocket engine, the great force and velocity can be clearly seen in these images. Although I consider the images a success, they did not fulfill my intent. I had intended to see a more uniform, controlled flow around our object, however, the speed of the flow was just too great. Perhaps a time averaged photograph could be another image that would go along well with the existing ones. To develop this idea further, I would like to put more object behind the engine. We did not do this because the engine only burned for a very short time and it got expensive doing lots of different objects.