Rocket Power:

Flow Visualization MCEN - 4228

11/08/07

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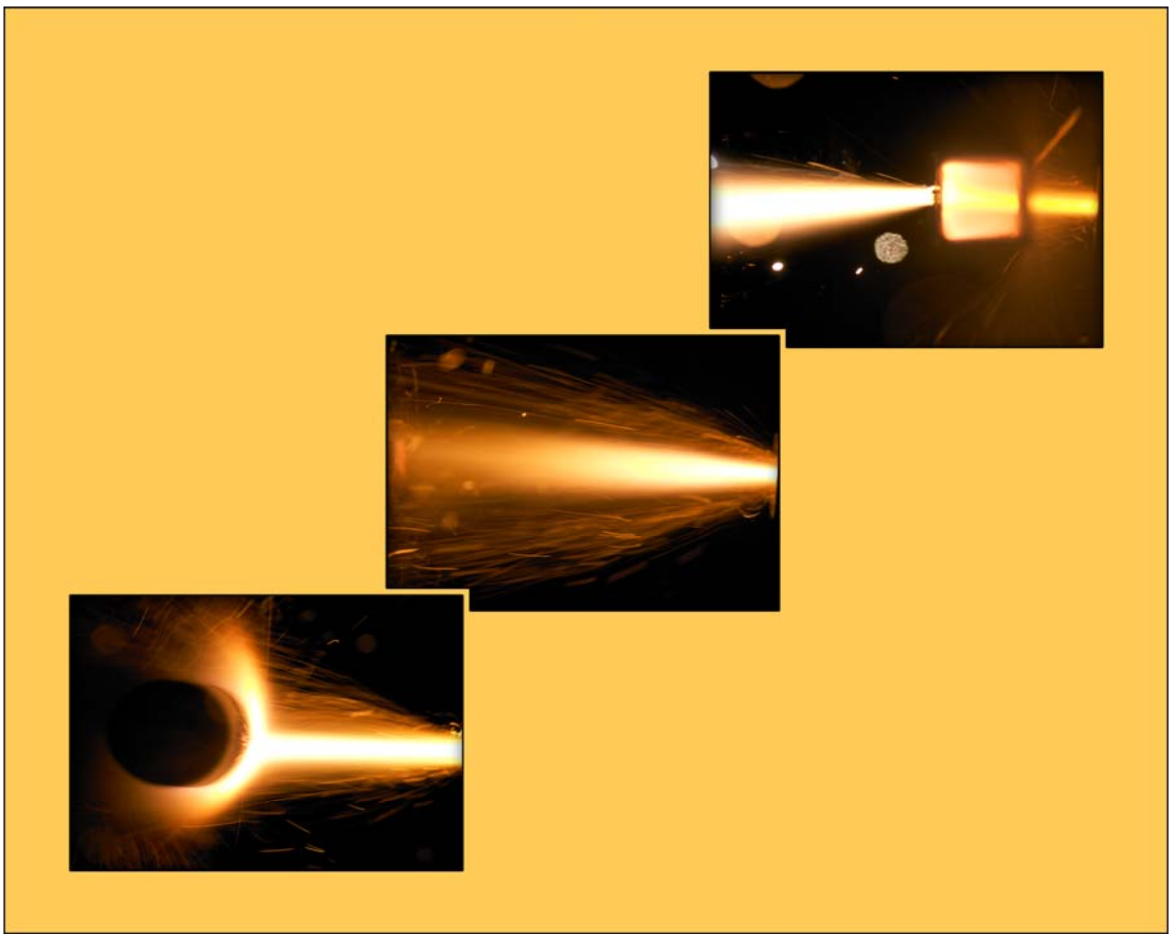
Group ETA



The purpose of this image was to explore the visualization of a high velocity propellant as it flows over a stagnant object. We chose both a circular and squared object to insert into the flow, using both solid and hollow objects. We wanted to see the thermal and fluid flows that occurred at extremely high Reynolds numbers. Initial tests from the somewhat pricey model rocket engines caused some recalibrations in our setup so that we could capture a viable image. Surprising amounts of thrust were generated which caused our stagnant object to sometimes be propelled outside of the field of view. After correcting some of these issues we were able to capture some impressive images, the triad of which is shown in the final layout.

The apparatus that was required for the image was two stable platforms that can hold both the model engine and the object in the flow. We used clamps to hold the metal bars in place while maintaining positive control, and clamped the engine directly to a flat non-flammable surface. We also connected the engine ignition wires to a firing apparatus that was physically controlled. The set-up was performed in an isolated dark environment that allowed for illumination from the engine propellant as it was expelled. A figure of the setup is shown below:

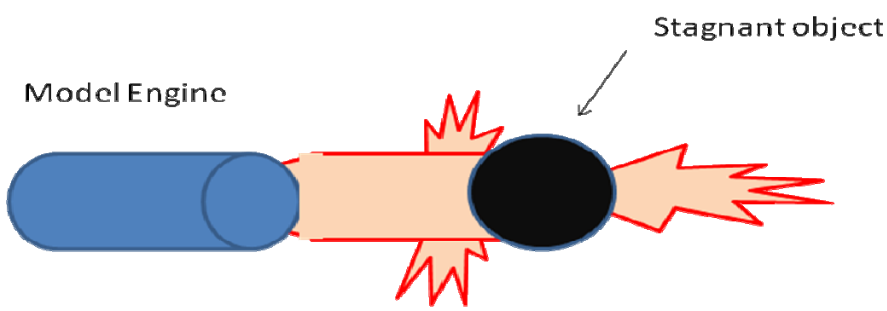


Figure 1 – Rocket Engine and Rod Setup

To give the proper amount of reference for the images, the circular rod is approximately 2.5 inches from the engine, while the square hollow rod it approximately half an inch. The characteristic dimension for each rod is approximately 3 cm in diameter, while a rough approximation of the propellant velocity is 150 mph. This gave an approximate Reynolds number of 2 million. Each engine can burn for up to 6 seconds while using all of the fuel, the firing of which is extremely loud, hot, and violent. The engines also introduce tremendous amounts of smoke and toxins into the air once burned off. As can be seen in the circular rod image the propellant immediately is deflected away from the surface with only a minor amount of flow attempting to continue around the rod. Of the three images this is the best view of any type of typical high Reynolds number evaluation of a fluid flow. The middle image actually forced the metal rod out of the way and continued to burn uninterrupted. The retreating rod can be seen in the far left of the picture. The final, right image, is quite interesting, as it had so much heat that it immediately melted away the aluminum on the entrance and exit while being focused out the other side. The melted aluminum can actually be seen on the exit portion of the rod as it has slightly coagulated on the exterior of the propellant cavity.

The key lighting feature that we used to capture the image was to isolate all exterior light and focus solely on the light created by the burning fuel. The camera utilized no flash, but instead used a shutter speed that showed the passing flow while allowing the necessary light.

The following information is provided to describe the photographic specifications:

- Size of the field of view- 8 inches by 4 inches

- Distance from object to lens- 1.5 feet

- Thrust: 1” Round Steel Pipe

Image Date	11/2/07 4:12 PM MST
Camera Model	Canon EOS 10D
Serial Number	620312005
Shutter Speed	1/750th second
Aperture	F2.8
Exposure Bias	0ev
Focal Length	100mm
ISO Speed Rating	ISO 800
Aspect Ratio	3:02
Orientation	Landscape
Depth	16-bit
Color Profile	Adobe RGB 1998

- Thrust: No Obstruction

Image Date	11/2/07 4:17 PM MST
Camera Model	Canon EOS 10D
Serial Number	620312005
Shutter Speed	1/500th second
Aperture	F2.8
Exposure Bias	0ev
Focal Length	100mm
ISO Speed Rating	ISO 800
Aspect Ratio	3:02
Orientation	Landscape
Depth	16-bit
Color Profile	Adobe RGB 1998

- Thrust: Square 1” Aluminum Pipe

Image Date	11/2/07 4:31 PM MST
Camera Model	Canon EOS 10D
Serial Number	620312005
Shutter Speed	1/750th second
Aperture	F2.8
Exposure Bias	0ev

Focal Length	100mm
ISO Speed Rating	ISO 800
Aspect Ratio	3:02
Orientation	Landscape
Depth	16-bit
Color Profile	Adobe RGB 1998

The type of engines that were used for the images were Estes B6-4, Class 7.2.3. The photo used is the original taken, and was placed in a matte in Adobe Photoshop.

The images show both the power and beauty that rocket thrust contains in a scale that is available to all model makers, both fathers and sons, mothers and daughters. There is so much force that is created by these small engines that we usually lose understanding as our tiny model rockets get launched far out of view into the atmosphere. Here was can see and feel how hot and dangerous they are while they are firing. I love how we totally accidentally captured the hollow square rod being almost instantaneously melted as the propellant was moving unhindered from the engine. Seeing the propellant being both contained by the circular hole that was created then again spraying in all directions as it continues on travelling is amazing to see. If it wasn't for the high cost of these engines I would enjoy continuing this exploration into the dynamics of rocket thrust. Yet, if I could continue the exploration I would like to find out exactly how much thrust and heat the engine is generating, so the exploration may be strictly quantitative.