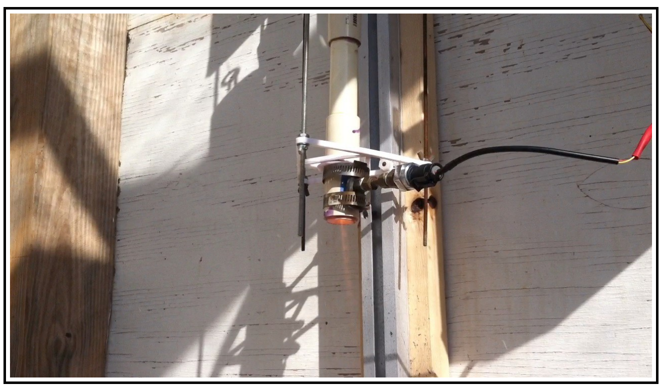
Executive Summary

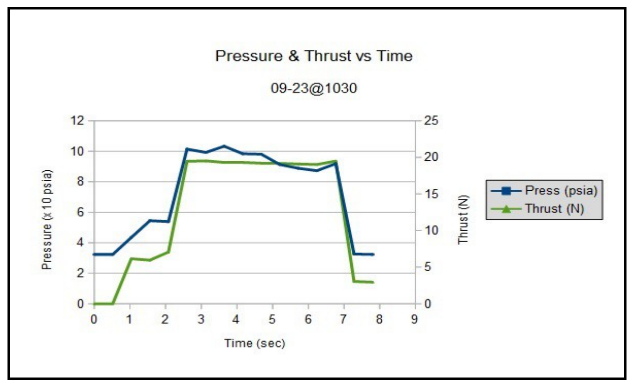
This month I optimized the expansion ratio of the nozzle to 1.8 in an effort to improve the thrust coefficient efficiency. I had a average thrust of ~ 19 N for about 4.4 seconds. However, in my first test, there was no increase in the thrust coefficient efficiency. I plan on keeping the expansion ratio to 1.8 and adjusting the flow rate, fuel core length, and characteristic length. Also, I achieved a 3 to 4 m/sec launch velocity by launching at a 30 degree angle.

Technical Stuff

Recall from last month's EOM report, I had identified several failure modes such as nozzle blow outs, pinhole leaks, and loose connections. This month I repeated many of the test from last month. In one of my best test I used a 1/2" stainless steel mist nozzle with a 1.0 mm orifice, a 12 cm PLA/$KMnO_4$ fuel core, a PLA variable orifice with an initial ID of 10 mm, a 4.6 cm long mixing chamber, a phenolic graphite nozzle with a 6 mm initial throat diameter (L* ~ 58 cm), and I cut off the end of the nozzle to get an expansion ratio of 1.8.

The objective was to examine the effect of an optimum expansion ratio on the coefficient of thrust. Calculations show that the optimum expansion ratio at sea level is ~ 1.7 (ref: Huzel & Huang, Eq. 1-20). By cutting off ~ 4 mm from the end of the nozzle, I get an expansion ratio of ~ 1.8. The results are shown in the video and graph below.





The graph shows a steady average thrust of ~ 19.3 N with a burn time of ~ 4.4 seconds. Ignition occurred in ~ 1.4 seconds. Although I had a really good thrust, my c* and thrust coefficient efficiencies were ~ 75% and ~ 75% respectively. However, my O/F ratio was ~ 5.2, way to high (theoretical at 2.75). Next month I'll work with the expansion ratio of 1.8, increase the flow rate to ~ 23 ml/s and begin increasing the fuel core length. The objective is higher thrust and lower O/F ratio. I'll be shooting for a 30 N thrust for 4 seconds and an O/F ratio of ~ 3.0.

Also this month I worked on my flight system. I made a carbon graphite nose cone, mounted my fins using small screws instead of gluing the fin to the axle, and I launched at a 30 degree angle. Gross liftoff mass was ~ 1.3 kg. Liftoff velocity was between 3 and 4 m/sec. I expected the Mk I Viper nose to pitch up after leaving the rail guide but it pitched down instead. In slow motion, I observed a small amount of rudder control. The Mk I Viper appeared to yaw a little to port (video of launch).

ref: Dieter K. Huzel and David H. Huang, Modern Engineering for Design of Liquid-Propellant Rocket Engines, AIAA, Progess in Astronautics and Aeronautics, Vol 147, p. 9, Eq 1-20.