Executive Summary

This month, I did a static engine test of the flight system. The thrust ramped up from ~15 N to around 20 N over a 7 sec burn time. The longer than usual burn time is attributed to ignition occurring in ~0.3 sec and thus leaving more oxidizer to fuel the engine. This was due to a small amount of HTPE leaking into the fuel grain during initialization of the receiver, a preheating event.

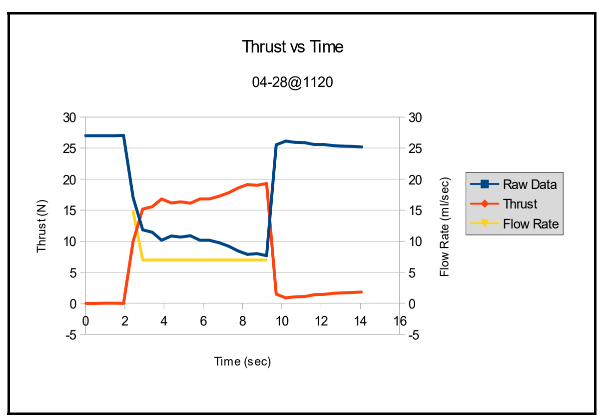
The center of mass (CM) is below the cockpit area and ~ 2 cm off the thrust vector. The off axis thrust will cause the Viper to rotate after leaving the guide rail. Due to the low thrust at ignition, the liftoff velocity will not be enough to correct the rotation of the MkI Viper using the elevators and the vertical stabilizer. I will rearrange the masses inside the fuselage and bring the CM closer to the line of thrust. Also, I believe I can increase the thrust by increasing the initial nozzle throat diameter from 5 to 6 mm.

Technical Stuff

My objective this month was to test different length fuel grains to find the optimum length. However, during my first test (with a 12.5 cm fuel grain) on the static engine test stand, I forgot to put a one kilogram mass on the rocket and it took off. I definitely need a pretest checklist. The liftoff was pretty cool. A video of the test is available at liftoff.

The rocket ran into the load cell, came off the rail guide, and landed on the ground behind the rocket engine test stand. The pressure probe diagnostics mounted on the rocket came off and landed on the concrete pad inside the test stand. Whenever an incident occurs, I follow a three step process; panic, assess the situation, and react. Fortunately, nothing caught fire or was damaged. I re-calibrated the load cell and was ready for the next test.

Before launching a flight system, I wanted do a static engine test. I needed to go through the setup, check out the system, measure the thrust, determine the mass flow rate, and develop a preflight checklist. A video of the test is available at MkI Viper. The test results are shown in the graph below.



Ignition occurred in about 0.3 sec. Ignition usually occurs in 1.0-1.2 seconds. The faster ignition is probably due to a small amount of HTPE being injected into the fuel grain before I opened the 12 VDC solenoid valve, a preheating event. If you watch the video, you can see a small trail of smoke coming out of the nozzle.

The procedure was to turn on the transmitter and then the receiver before pressurizing the tank. By mistake, I pressurized the tank first then turned on the transmitter and receiver. As such, a small amount of HTPE was injected into the fuel grain during the initialization process. This is a good mistake and will be explored. The shorter the ignition time, the more oxidizer there is available for thrust. Ignition burn lasted for ~7.0 seconds.

From the graph, the initial thrust is ~15 N and ramps to about 20 N over the 7.0 sec of burn time. The mass of the MkI Viper is ~1.25 kg. Ignoring fiction, the velocity of the Viper when it leaves the rail guide would be ~3.5 m/s. Prior to the test, I determined the center of mass to be around the cockpit area and ~2 cm below the thrust vector. The off axis CM would cause the Viper to rotate during thrust. After calculating the drag forces on the stabilizers, I don't believe this is enough velocity to correct the trajectory using the elevators and vertical stabilizer. As such, I will delay the launch another month while I rearrange the masses inside the fuselage and try to bring the CM closing to the thrust vector.

For this test, the maximum thrust of 20 N occurred when the throat diameter eroded to ~6 mm. Increasing the initial throat diameter from 5 to 6 mm should give me a thrust of 20 N at ignition, thus increasing takeoff velocity. However, increasing the throat diameter may delay ignition. So, further testing is required.

Finally, the wet mass of the MkI Viper was 1.25 kg, the dry mass was 1.16 kg, the average thrust was 17.3 N, and the average mass flow rate was 12.6 gm/s. As such, the average specific impulse was 1,370 m/s and, using the ideal rocket equation, the ideal burnout velocity is ~102 m/s. With the redesign of the flight system, I believe I can beat this velocity.