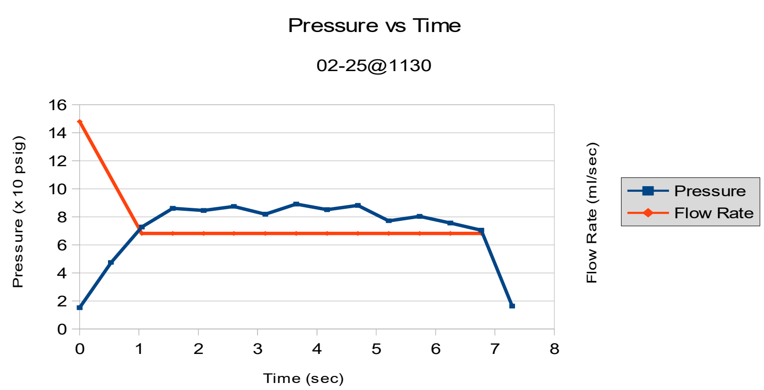
Executive Summary

This month, in an attempt to increase the thrust of the class I engine, I increased the O/F ratio by shortening the fuel grain from 15 cm to 12.5 cm. This reduced the contact surface area of the fuel grain and also, reduced the mass of the rocket engine by about 20 gm. Ignition occurred around 0.9 sec. I observed a net positive thrust of greater than 19.1 N at ignition and a c* efficiency of over 100%.

Technical Stuff

My main objective this month was to increase the thrust from the class I rocket engine. The best results came from increasing the oxidizer to fuel ratio and running the engine oxidizer rich. In my previous experiments, the O/F ratio hovered around 2.2 and 2.3 and the characteristic velocity (c*) was about 85 to 88%. In theory, the O/F ratio should be around 3.0 and c* about 1,485 m/s. As such, in an attempt to increase the O/F ratio, I shortened the fuel grain from 15 cm to 12.5 cm. This reduced the contact surface area of the fuel grain and also, reduced the mass of the rocket engine by about 20 gm. The results were better than expected!

Ignition occurred around 0.9 sec and I observed a net positive thrust at ignition. Burn time was ~ 6.2 sec and total run time was ~ 7.1 sec. The mass of the HTPE (o/f = 25), oxidizer tank, plumbing, 12 V dc solenoid valve, check valve, and fuel core plus a 500 gm mass was ~1.95 kg. There was a net positive thrust of greater than 19.1 N (video of test). Pressure and volume flow rate of the oxidizer are shown below.



The average pressure was 96.2 psia (81.5 psig), average oxidizer flow rate during ignition was 6.82 ml/sec, and average throat area was ~ 0.27 cm^2, resulting in a c* of 1,521 m/sec, a c* efficiency of 102% (ref: the August 2021 end of month report for the procedure I use to calculate the characteristic velocity).

Is this possible? I updated my inputs to the NASA CEA code to bring the theoretical value up some but still it was over 100%. I will be adjusting the fuel core length to find the optimum length and running more test next month to verify these results. Also, I'll continue to adjust the CEA code to bring the theoretical values closer to my experiment. Some may think this is fudging the code, that's okay. I intend to use the code to scale up my research and the closer it is to experiment the better.

Also this month, as suggested by colbourne (ref colbourne), I printed a 15 cm PLA/Al fuel core using off the shelf aluminized PLA with an aluminum content of ~ 13%. I infused the PLA/Al fuel core with $KMnO_4$ and assembled a rocket engine based on the PLA/Al/$KMnO_4$ fuel core. All other parameters were the same. Ignition occurred in ~ 1.3 sec and burn time was ~ 5.8 sec. The c* was 1,477 m/s with a c* efficiency of 96%. This too looks promising (video). If ignition time is reduced by running the engine oxidizer rich as noted above, it may be worth pursuing. Also, using a finer grain of Al with the PLA may improve performance.

Next month, I'm upgrading my rocket engine test stand and adding a 5 kg load cell. I should get more accurate test results with a load cell, pressure probe, and mass of fuel grain before and after the burn. I'll continue to run my engines oxidizer rich and pin down the optimum length. Also, I'll continue to work on the Mk I Viper flight system.

<u>Reference</u>

colbourne, Reply #14, NASASpaceflight.com Forums>>General Discussion>>Advanced Concepts>>
HTP/PLA/KMnO4 Hybrid Rocket Engine, 10/10/2021