| TASK HISTORY | TASK TITLE<br>End of the Summer | TASK NUMBER<br>5 | PROJECT<br>IREC Hybrid |
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| TASK HISTORY AUTHOR<br>Avery Moore | TEAM LEAD<br>Avery Moore | | TASK DOCUMENTATION<br>Valve Problem Solved and Preparing for School Year |
| DATE | MILESTONE | REVIEWER'S INITIALS | |
| 8/11/18 | Valve Problem Solved, More Issues Arise… | CL | |

**Purpose**

To recap the past month of progress for the hybrid rocket engine and the team involved with its construction and development.

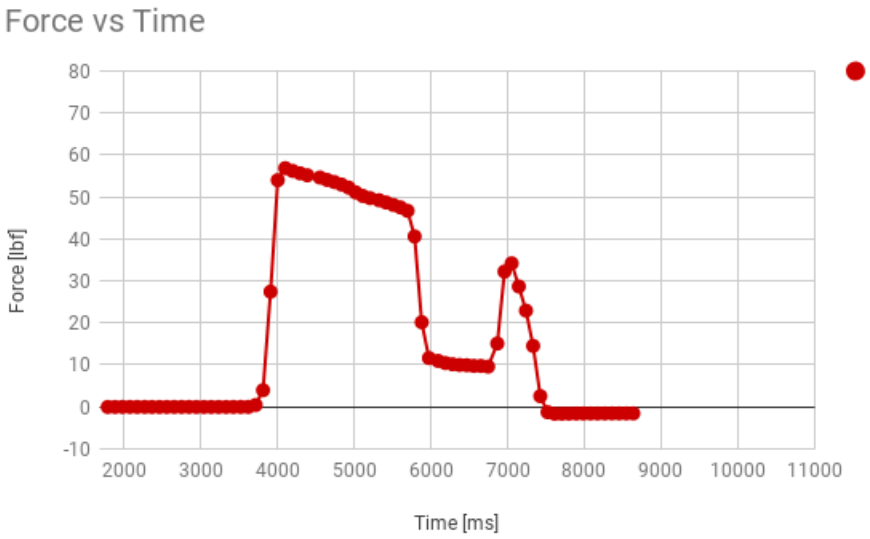
**Background**

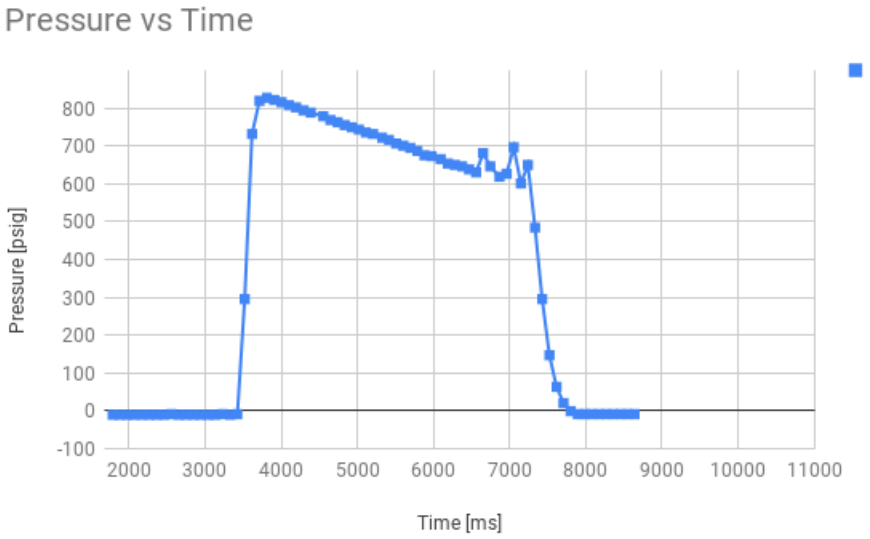
The valve problem was identified and solved with a cheap, but effective solution. There was not enough money to buy electronic ball valves for the Mk. 1 engine, so the team decided to rig up a servo to a hand ball valve by printing a connector piece and pressure fitting it onto a servo so that it could rotate without slipping. This valve would control the flow of NOS into the engine directly from the NOS tank followed by an emergency hand valve with the lever still attached in case the servo system failed, the flow of NOS could still be stopped. This system was tested at two hot fires, July 1$^{st}$ and July 4$^{th}$. The team did not attach the helium tank to the flow system for simplicity during the servo valve test. NOS is self-pressurizing to about 700 psi, so a decent flow rate could still be achieved with the NOS alone. While this still did not give us the desired flow rate, it would test the factor of the solenoid valves choking off our flow rate as the team suspected. The first hot fire tested the system for a short period of time, focusing on the servo valve system rather than ignition and combustion like the second hot fire.

**Results**

Overall, we were very happy with the outcome of the hot fires. The first hot fire proved some issues with the servo valve system connector that was allowing for slipping, so changes were made during a lunch break and the team successfully got the system up and running. For unknown reasons the engine could not get stable ignition, but there was a significant increase in flow rate that looked promising. The team speculates that potentially slipping did occur and not a high enough flow rate was achieve for stable combustion based on the thrust readings. This called for a servo valve connector redesign to get a more consistent opening and closing of the ball valve. The second hot fire was much more successful with shock diamonds appearing in the exhaust of the engine. The engine ignited perfectly and held stable combustion without chugging for about 2 seconds before the exhaust turned to black smoke and a loud bang was heard. This sound was the engine slipping off the nub on the load cell and slamming into the metal backplate. Luckily only a scorch mark of damage occurred to the actual engine, but it was clear that the acrylic piece did not fit well enough in the ID of the engine casing to have an air tight seal during the combustion. There was also slight warping of the engine casing due to the heat at the scorch mark.

**Data**




**Lessons Learned**

The solenoid valves were in fact choking off our oxidizer flow rate. Switching out the solenoid valves for ball valves and naturally pressured NOS provides about have of the thrust that we are hoping for, but we certainly seem to be on the right track. The last month of summer was a little inactive as students were taking their summer class finals, or those with 10 week jobs completed them and were able to go home, so there weren't too many active members working on hybrid. The majority of the work has been on the test stand so that we can have some solid research and design ideas to begin with at the beginning of the year. We also are tackling the problem of the acrylic fuel grain casing, cleaning up the electronics, writing as much of the procedures as possible and preparing a github repository/wiki for the school year. Everything seems to be

going as planned expect for funding. We currently have $750 and need $2000 just to go forward with the project. Avery has two sponsors in the works who have offered to donate but have not specified amounts yet. The team will be traveling to St. Louis on August 17th to meet with Magnesium Elektron about potential sponsorship and donation of parts.

**Impact Statement**

There is still plenty of work to be done:

- Find More Sponsors
- Hot Fire Procedures
- Finalize the Servo Valve Mount & Print
- Fix Acrylic Sealing to Engine
- Organize Electronics/Document/Condense
- Research/Test New Fuel Grain Casting Methods
- Test Stand Research/Preliminary Design
- IREC Wiki and Resources Repository Organization
- Get Ready for the School Year @Avery

But things are looking up for the hybrid engine. Once we get multiple stable combustions with consistent data proving that we are maximizing our efficiency as much as we can with the materials we have provided. Then begin the design and development of the Hybrid Engine Mk. 2 for the actual IREC competition.