Patrick Spencer

Engineering Portfolio

University of Louisville

Mechanical Engineering

About Me

I am a 3rd year Mechanical Engineering student at the University of Louisville. I have a broad range of experience in many disciplines of engineering including experience in propulsion, additive and subtractive manufacturing, a variety of programming languages, experimental rocketry, fluid systems, and much more. Using my engineering skills, I intend to explore cost-reducing, reliability-increasing innovations in rocket propulsion systems. I am the propulsion lead of my rocketry team and manage a team of 10 developing liquid, solid, and hybrid propulsion systems.

1. Viper Bipropellant Liquid Engine

Description

"Viper" is a 1000lbf, NOx/Ethanol, 1000psi Pc bipropellant liquid engine, and my team's pride and joy. It has completed cold flow tests and the team is aiming for a hot-fire testing program starting this summer. We intend to use this engine in a rocket competing in the Spaceport America Cup collegiate rocketry competition in 2022 or 2023.

My Contribution

I have led this project, as well as the team's solid and hybrid propulsion projects, since early 2021 and have been on the team since 2019. I delegate tasks to and check on progress of all team members. I personally helped with some of the initial design of the system, and have been polishing off all aspects of design since I became project lead. I have personally machined various parts for the engine, ran simulations to verify design, and managed the development of our control program and DAQ system.

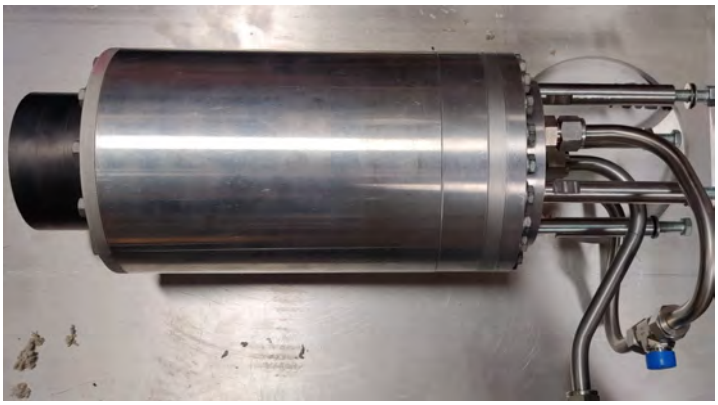
I am also responsible for educating all members of my team about liquid propulsion design and construction. Most team members are initially underclassmen, meaning they have been exposed to little propulsion engineering before joining the team. I change that.

Skills Developed

- Liquid propulsion design and construction
- Fluids systems design and construction
- Precision machining
- Systems integration
- Data acquisition
- Propulsion testing
- Combustion analysis

Programs & Hardware

- CNC mill, lathe
- Solidworks CAD + FEA
- Python
- LabView
- NI DAQ system
- Project time management
- Leadership

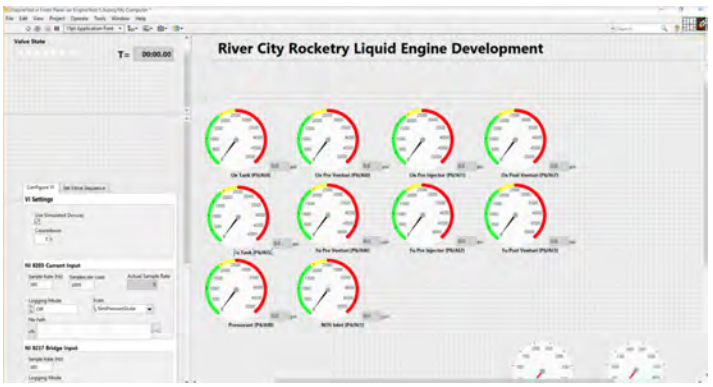


Combustion chamber + nozzle + injector

Test stand

Fluids + electronics stand

Engine control interface (LabView)



2. Level 1 rocket

Skills Developed

- Rocket design
- Trajectory simulation
- Varied manufacturing methods
- CAD
- Amateur rocketry
- Avionics (Altimeters)
- Aerodynamic design (stability, damping)

Programs & Hardware

- OpenRocket simulation program
- Lathe, drill press, bandsaw
- Excel calculators for various aspects of flight

Description

Level 1 rockets are high power rockets intended to get the builder a Level 1 rocketry certification which enables purchase of larger rocket motors. They act as a sort of test to demonstrate execution of high powered rocketry, and the flight needs to be nominal for a cerfication.

My Contribution

Pictured below is my Level 1 rocket, 'Scrapheap' (because it was built wholly from cheap and already available materials). Before building anything, I designed the rocket body and simulated its aerodynamics using CAD to ensure stability and a safe flight. Once I was satisfied, I began building it. Some parts were machined, some 3D printed, and many were made using basic machine tools (drill, bandsaw, laser cutter, etc.) I then successfully flew the rocket and got high power rocketry-certified. Now, I am one of two people (out of ~30 total on the team) who teach and advise other team members building and flying Level 1 rockets. I am in the process of building my Level 2 rocket, the next level of certification, and intend to fly it in June, after that I will go for my Level 3 certification, the highest level.

Visible, top to bottom:
Nosecone
Aft section
Flight electronics (altimeters)
Machined coupler
Parachute
Parachute release (altimeter)
Fin section
Motor casing
Motor retainer

3. Sodium-black phosphorus batteries

Description

This project investigated the novel battery technology of sodium anode-black phosphorus cathode batteries. Sodium batteries are much cheaper and more renewable than current lithium-ion batteries, and may be their successor in the future. Black phosphorus is a material that has not been investigated much for use in batteries but its theoretical battery properties are promising. This project was one of many investigations into novel battery technologies run by the Conn Center for Renewable Energy, part of the University of Louisville.

My Contribution

I was the lead for this project, and coordinated a small group of researchers investigating this type of battery. I prepared the material used as the battery cathode (black phosphorus mixed with a carbon binder), assembled coin-cell batteries using said material as cathode and sodium as anode, tested them for various electrical properties (capacity, voltage, current capacity, efficiency, etc), then disassembled the batteries and inspected the cathode spectroscopically to learn what processes it goes through while charging and discharging, and how to make those processes more efficient and repeatable. This entire process was iterated many, many times over the course of my work on the project, and each time new things were discovered about the underlying chemical processes that necessitated an ever-changing assembly process and testing procedure.

Skills Developed

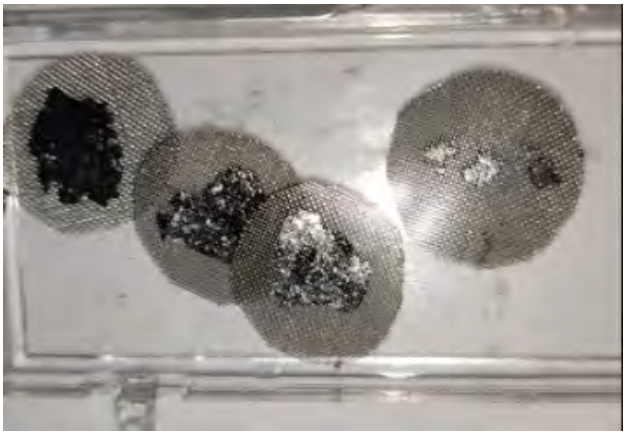
- Chemistry
- Materials science
- Electrical testing methods
- Literature comprehension
- Team management
- Spectroscopy methods
- Data analysis

Programs & Hardware

- Glovebox
- Hydraulic press
- Galvanostats
- Raman spectroscopy instrument
- X-ray diffraction instrument
- Transmission electron microscopy
- Origin graphing program

Many batteries undergoing electrical testing

Single coin cell battery (ruptured)



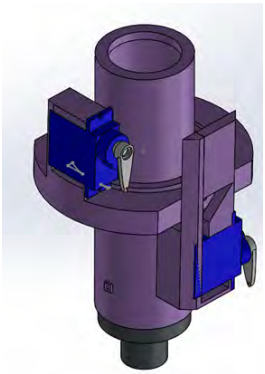
Black phosphorus cathodes

4. Other Projects/Interests

Descriptions of various smaller projects.

Wild Turkey

Large drone for drop-testing rocket payloads and shooting aerial footage. I was one of two main people who designed this large quadcopter (10lb payload capacity), and it is currently being built. I mainly used SolidWorks to design it. Pictured is SolidWorks model.



Thrust Vector Control

I am currently building a small (<1lb) thrust vector controlled rocket using commercial rocket motors. I am using SolidWorks to design it mechanically, SimuLink for modeling the control system and determining PID rates, an Arduino as the flight computer, and 3D printing most other parts of the rocket. Pictured on the right is a TVC mount very similar to mine, developed by another rocket team member.

Composites

River City Rocketry makes its own airframe tubes with carbon fiber blanket layups, and I help with the process. We complete the layup, wrap it with heat shrink tape, then heat up the tape while it cures for a smooth surface and thin tubes. Pictured is me working with a carbon fiber layup in a wing mold, making a CF wing for...

Redbird Robotics

I have assisted with the mechanical design, 3D printing of parts, and composites work for an aerial robot aka drone that is able to switch from a vertical, propeller takeoff into fixed-wing flight and operates completely autonomously using computer vision/image processing. Pictured is the drone.

Machining

I do a lot of machining for various projects, as well as training members of the rocketry team on the machines we have available. Pictured are the two I use most frequently, a manual lathe and a CNC mill.

Long Range RC Planes/Drones

I have a hobby of designing and building long-range, long flight time quadcopters and planes. Electrical design is inherent to the hobby and essential for selecting the correct components for the most range (antennas) and flight time (motors/batteries).