Investigation of Throttling with Hybrid Rocket Engines

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Introduction

Hybrid rocket engines (HREs) have seen a boost in popularity in recent years with the surge of start-ups in the space industry. With this surge, many technical issues still plague HREs, namely the implementation of throttling. Little literature exists on the internal ballistics of HREs during transient throttling regions and the specific effects of engine component design on throttling response time.

Objectives

This investigation intends to study the impact of the design of various engine components on the transient throttling region in an HRE. The time between a commanded throttle and response in engine thrust will be the indicator of throttling efficiency.

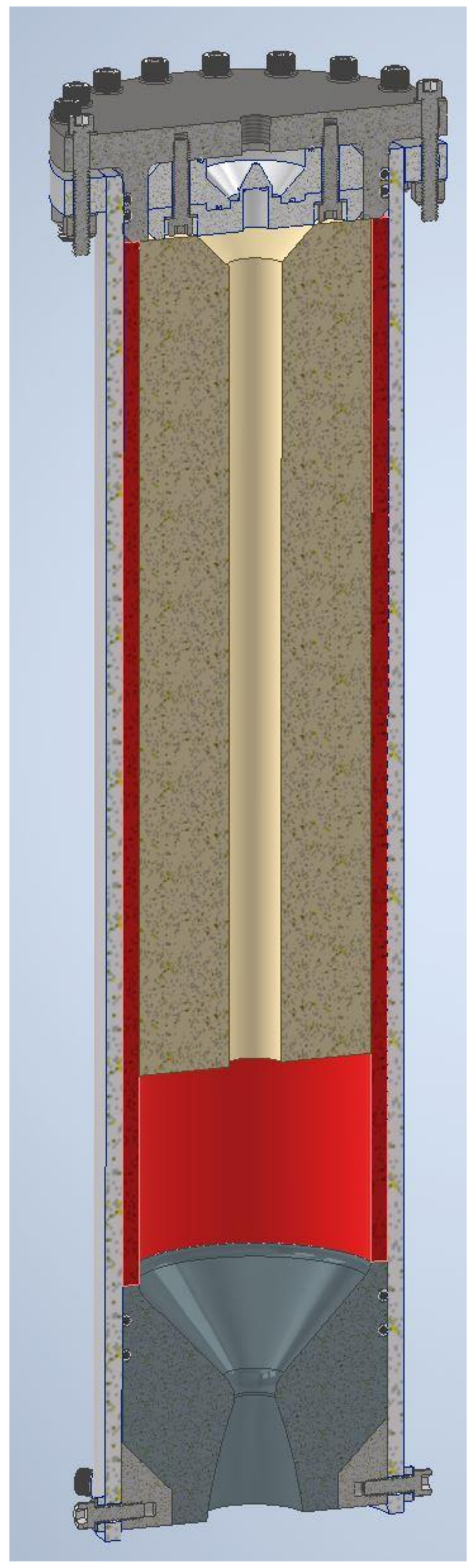
Methods

Phase 1: Upon completion of the engine and propellant feed system, hot fire testing will be conducted without throttling to form a baseline and tune the simulation for future testing.

Phase 2: Hot fire testing will be conducted, introducing throttling commands. Proceeding hot fire testing will implement various throttling patterns to capture all possible flight environments.

Phase 3: New engine components will be designed and manufactured and implemented on proceeding hot fires to form a study into engine component design and the effect on throttling in HREs.

Hybrid Rocket Engine Design



Combustion Chamber (Left) Odyssey Engine Assembly CAD (Right)

Timeline

Spring 2022

- Finish manufacturing of hybrid engine
- Experiment with HTPB fuel grain samples
- Procure oxidizer feed system components

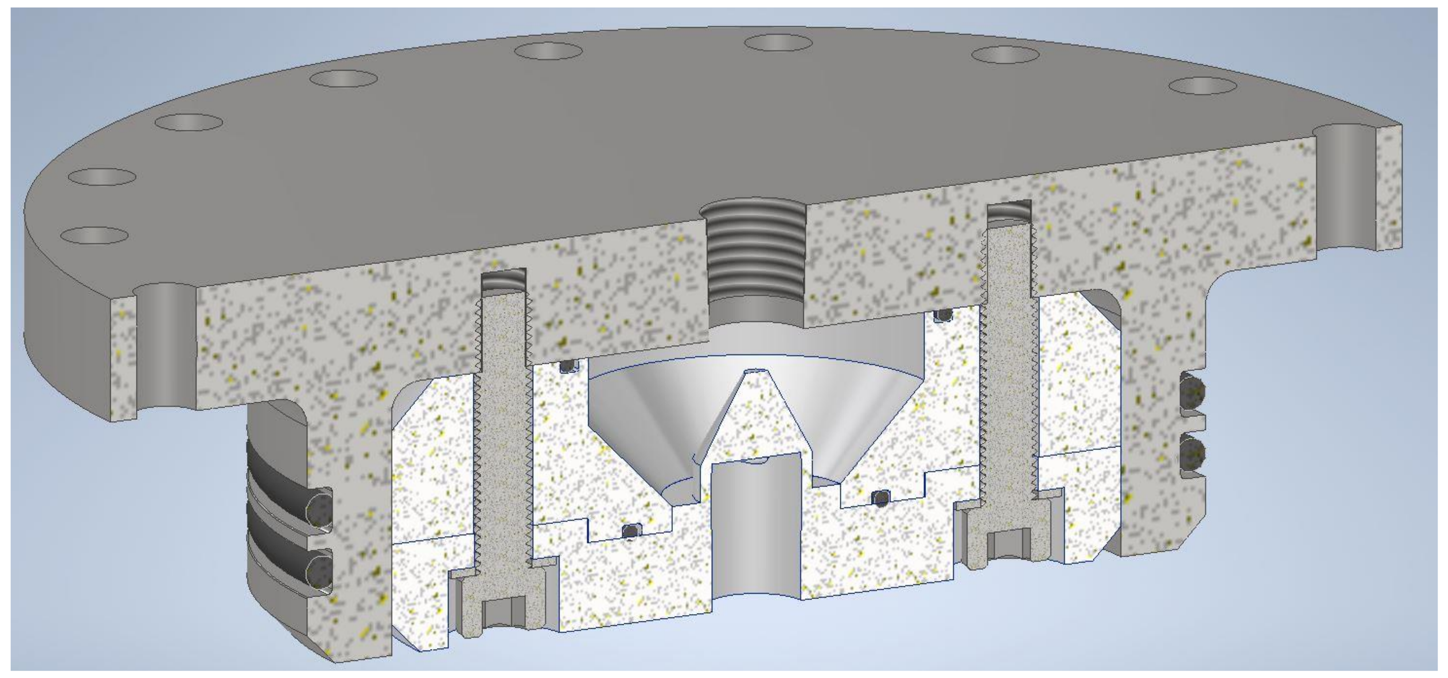
Fall 2022

- Begin hot fire campaign at Cecil Spaceport
- Demonstrate reliability and obtain baseline for engine
- Begin throttling test campaign

Engine Characteristics

Injector Design

The injector plays an important role in the performance of HREs. The initial injector design for baseline testing will be an inward swirl injector due to historical performance enhancement in HREs



Propellant Choice

Liquid nitrous oxide will serve as the oxidizer while hydroxyl-terminated polybutadiene (HTPB) will serve as the fuel. This combination was chosen based on cost and ease of acquisition.

Fuel Grain Casting

Fuel type and consistency are crucial in providing stable and high-performance combustion. Small scale batches of fuel have been prepared using various mixture techniques and ratios to obtain an optimum fuel grain.