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RAPID DESIGN OF A SMALL SCALE KEROLOX FLIGHT VEHICLE PROPULSION SYSTEM

Abstract

In recent years, there has been a push by collegiate rocketry groups to develop methods for the rapid design of small scale, affordable, and liquid based flight vehicles. The Liquid Propulsion Lab (LPL) is a graduate level research laboratory at the University of Southern California (USC), chartered on the premise of creating such a system that has been under development the past four months. Aimed at reaching an altitude of 40,000 feet, this will be LPL's first flight vehicle, dubbed the Gruntman I, and is intended to break the altitude record for any student built, liquid powered flight vehicle. In addition, the design was centered on being affordable, easily manufactured, and taken from design to flight rapidly. This project was developed as a framework for a liquid-liquid flight system that can be used by other groups to rapidly design KeroLOx based systems.

The presentation is aimed to further explore the design process of two key systems, the flight engine and flight feed system. The engine is entirely additively manufactured for affordability and rapid iteration, it has a chamber pressure of 350 psi and a mixture ratio of 1.3, producing 650 lbf. The engine leverages the work of previous LPL designs of a like-like doublet spray showerhead injector that was 3D printed. Additionally, regenerative and face film cooling are used to maintain the thermal loads experienced during firings with a 38% margin on wall temperature and 15% margin on the fuel boiling within the regenerative cooling channels. All designs were analyzed with Computational Fluid Dynamic (CFD) simulations on a range of wall roughnesses, ensuring that the feed system could handle any pressure drop resulting from printing uncertainties.

The liquid feed system was designed such that the standard layout would only need to accommodate an increase in components and line sizes. The design process utilized systems engineering concepts aimed at simulating industry standards to make an aggressive schedule achievable. Standardization of components and processes along with substantial risk mitigation was essential in order to arrive at a static-fire attempt.

During the development cycle, many issues were faced and overcame. This paper will evaluate the lessons learned in the design and testing process, as well as identify where improvements can be made. Finally, it will document the static-fire results and data analysis to determine if the design process was successful and can be used in the future.