Development and Testing of a Liquid Oxygen/RP-1 Liquid Rocket Engine

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Extended Abstract

Small-lift launch vehicles have come into industry focus over the past decade with the goal of sending missions to space dedicated to small satellites and CubeSats. [1]. To address this need at an affordable price for university projects, the University of Alabama's ARES Initiative plans to develop a family of small-lift launch vehicles. This endeavor is in its first year, beginning with the design and demonstration of its first liquid rocket engine. This engine will use a pressure-fed liquid oxygen and RP-1 system to achieve an average thrust of 5000 N for an 8 s burn. Through the second half of 2017, the ARES team completed preliminary designs associated with the 5000 N engine. This engine will be manufactured February 2018 with the goal of completing a hot-fire test by mid-April.

The first student-designed liquid rocket engine developed at the University of Alabama will focus on demonstrating complete combustion and validating design methods, rather than maximizing efficiency, as would be appropriate for implementation into a launch vehicle. The design features several choices that exemplify this approach, such as its pressure-fed feed system, modular injector design, and ablative cooling techniques. Designing and testing conservatively, the ARES Team will produce a copper heat sink thrust chamber for rapid startup transient characterization before producing the final stainless steel version.

The process for refining design and validating component, sub-assembly, and full assembly performance will be a phased approach of developmental and qualification tests. Each component will be fully characterized by developmental testing that will validate the design. Performance under extreme conditions during qualification tests will demonstrate that the component is reliable and ready for implementation into the next level of the design. The same process will be followed for all sub-assemblies until all components of the engine are characterized and qualified for final, full assembly testing. The copper test article will undergo developmental tests for short duration burns to characterize ignition and startup transients for the design without requiring ablative cooling. The stainless steel engine will go through developmental tests comparing the ignition and startup to the copper as well as full 8 s duration burns to characterize nominal engine performance. Once the stainless steel engine has successfully completed developmental testing, it will be pushed to perform beyond design conditions to qualify it for integration into a flight vehicle by the end of the next academic year.

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