Flight Testing of a Prototype LOX/propylene Upper Stage Engine

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Abstract

The objective of this paper is to present testing of an early prototype upper stage engine which could be evolved into a second stage engine for a Nanosat Launch Vehicle (NLV). The NLV is designed to deliver a nominal 10 kg payload to LEO and is being developed by the California Launch Vehicle Education Initiative (CALVEIN), a partnership program between Garvey Spacecraft Corporation and California State University, Long Beach[i].

The engine is pressure fed and uses LOX/propylene as propellants. It is designed to operate at a chamber pressure of 1 MPa (approx. 150 psi) and provide a vacuum thrust of 2000 N (approx. 450 lbf). Propylene was chosen as a propellant because it provides a higher specific impulse than RP-1 with comparable density at cryogenic temperatures[ii].

This paper presents a first iteration of the preliminary design intended for space operations with an expansion ratio of 70 as well as the testing of its sea-level version with an expansion ratio of 4. The space engine is designed with targeted combustion efficiency of 95% and nozzle efficiency of 98%, corresponding to a specific impulse of 347 s.

The combustion chamber assembly is built using an ablative liner and a carbon fiber overwrap, while a flat head injector provides additional film cooling to minimize ablation rates. A pyrotechnic igniter mounted in the center of the injector face is used for the SFT instead of what will likely be a direct-spark or torch igniter on the space engine. Also, this first version of the engine uses propylene at room temperatures instead of densifying it.

A Static Fire Test of the engine with expansion ratio of 4 has been conducted at sea level. Recorded data will be used to assess previous assumed efficiencies and refine, if necessary, the shape of the nozzle. Furthermore, the configuration of the thermocouple is subject to change. The engine was tested twice with a burn time of 15 s and 5 s, respectively. Pressure data of the second test is shown in Figure 1 along with the picture of the test in Figure 2.

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The next steps include a flight test in the near future, which will provide a better understanding of the performance of the engine in flight. The paper will also address ways to improve ignition reliability and reduce overall engine weight to improve performance.

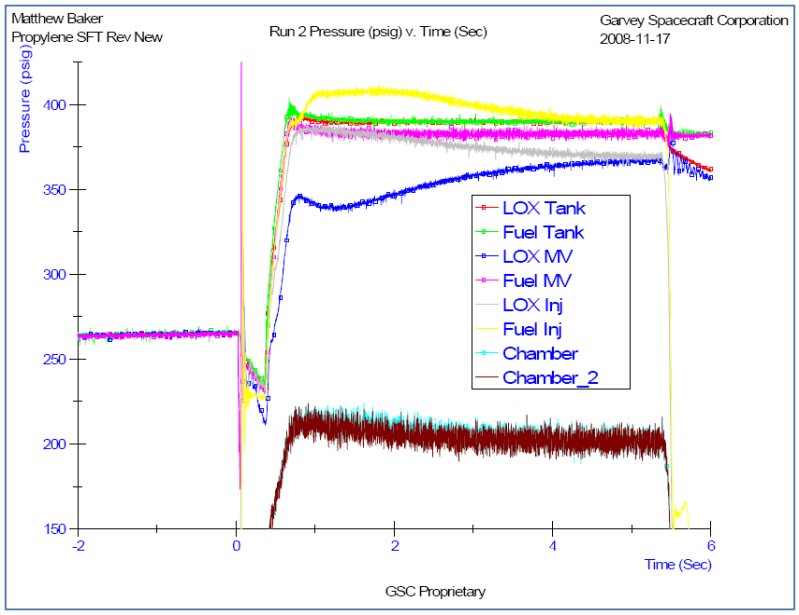

Figure 1. Pressure data for LOX/Propylene Engine Static Fire Test 11/2008

Figure 2. LOX/Propylene Engine Static Fire Test 11/2008

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[i] J. Garvey and E. Besnard, "A Status Report on the Development of a Nanosat Launch Vehicle and Associated Launch Vehicle Technologies," AIAA Paper No. 04-7003, presented at the 2nd Responsive Space Conference, Los Angeles, CA, April 2004.

[ii] Pioneer Astronautics, "LOX Olefin Rocket Propulsion for Deep Space," proposal abstract, NASA SBIR 02-1 Solicitation, proposal no. 02- S1.02-7918, 05 September 2002