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Author: Mr. Matthew Cannella
Colorado Center for Astrodynamics Research, University of Colorado, United States

Mr. John Brendel
Iowa State University, United States
Dr. Ryan Starkey
Colorado Center for Astrodynamics Research, University of Colorado, United States
Dr. Steve Harrington
United States
Mr. Jacob Cook
Colorado Center for Astrodynamics Research, University of Colorado, United States

DEVELOPMENT AND TESTING OF A PISTONLESS ROCKET ENGINE PUMP TECHNOLOGY DEMONSTRATOR

Abstract

The Pistonless Pump Technology Demonstrator is a NASA funded project that aims to demonstrate pistonless pump technology for both launch vehicle and in-space applications. Pistonless pumps are a desirable alternative for these vehicles because they feature a simpler design that induces higher reliability. Operating on pneumatic principles, a pistonless pump system features multiple small pumping chambers that draw fluid from a reservoir tank utilizing a pressurant gas. The fluid is then pressurized and ejected at a steady rate by cycling between the pumping chambers. This results in a light-weight fluid pump that does not use any rotating machinery or physical pistons. It offers advantage over liquid rocket pump designs currently in use, which feature fast rotating impellers that, despite the high cost of development and manufacturing, are extremely sensitive to high vibration environments and two-phase fluid flow. While several ground tests have been completed on pistonless pump technology, comprehensive space environment testing is scheduled to increase the technology readiness level of this innovative design.

Through cooperation between academia, industry, and NASA, the team is developing a test bed for the pumping and transfer of a rocket propellant simulant in a relevant operational environment utilizing pistonless pump technology. The project has already begun hardware and design configuration testing. Pending NASA approval, this experiment is slated to fly as a payload on NASA's microgravity parabolic aircraft program for risk reduction flights in July 2013, and will subsequently be manifested on Virgin Galactic's SpaceShipTwo reusable sub-orbital launch vehicle for future testing. As designed, this experiment features a small pistonless pump system, with saturated water at ambient temperature and approximately 25 Torr as the working fluid (cryogenic simulant). Critical measurements for this experiment are fluid pressures entering and exiting the pump, fluid temperature, and a comprehensive video of the pistonless pump in startup, steady state, and power down conditions to observe fluid behavior and any off-gassing of the liquid.

This paper will discuss the design, construction and testing of the experimental payload. Preliminary results from risk reduction flight-testing aboard the Zero-G Corporation's microgravity parabolic aircraft will be examined, and an overview of Virgin Galactic's SpaceShipTwo vehicle flight preparations will be illustrated. Finally, considerations will be given to current understanding of the fluid behavior in a pistionless pump during high-g and micro-g conditions, and the overall viability of such a system for use in future launch vehicle, in-space propulsion, and propellant transfer applications.