Paper ID: 9848
student

15th SYMPOSIUM ON SMALL SATELLITE MISSIONS (B4)
Access to Space for Small Satellite Missions (5)

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REDUCTION TO PRACTICE OF A MICRO ROCKET ENGINE FOR SMALL LAUNCHER PROPULSION

Abstract

PURPOSE

One solution to the challenge of reducing launch costs for small satellites is the use of dedicated launchers. Compared to large vehicles that deliver small satellites as secondary payloads, small launchers require less propellant, drive down insurance costs, and increase mission accuracy. However, the propulsion required for small launchers brings about its own challenges when conventional rocket engine components such as turbopumps are introduced into micro-scale designs. This paper presents the reduction to practice of a simple micro rocket engine for propelling small launchers.

METHODOLOGY

The micro rocket engine presented here attempts to leverage the weight-savings of onboard pumping systems and avoid complications due to micro-scale machinery by implementing a novel pumping system that requires no moving parts. The engine uses a working fluid to pump the fuel and oxidizer—ethanol and hydrogen peroxide, respectively—, producing pressure ratios comparable to designs that use complex rotating parts. The elimination of moving parts allows the engine to be mass-produced efficiently and precisely, and operation is lower risk than existing micro engine designs. Detailed modeling of the cooling, combustion, and decomposition processes is presented here. A regenerative cooling cycle removes heat from the structure to maintain acceptable wall temperatures and to produce vapor to drive the pumps. High heat loss throughout the system requires staged combustion and decomposition to maintain temperatures necessary for autoignition of the fuel. Several fabrication techniques are compared to determine which produce the lowest final costs per pound of payload. Lastly, intricate plumbing networks required for the propellant feeds are discussed that minimize the total engine volume as well as internal pipe losses.

RESULTS AND CONCLUSION

Based on results from the studies discussed above, the design is reduced to practice and is currently being fabricated. Micro-machining techniques are used to drill features into 17 316SS plates, which will be stacked together along the main axis of the 1 cm x 1 cm x 2 cm engine. At a chamber pressure of 30 atm, the engine is expected to produce 10 N of thrust for a 2.5 mm nozzle throat. To initiate startup, a pressurized supply of oxidizer fed into the decomposition chamber is required; heat generated from decomposition will gradually increase the pressure in the boiler until a check valve is opened prompting pumping and normal operation. It is estimated that the engine's simple design could lower launch costs to roughly $500 per pound of payload.