Heater-Free, Lowest Power Consumption & Highest Volume Availability Gas-Generator Propulsion System – Most Suitable for Micro to Nano Satellites

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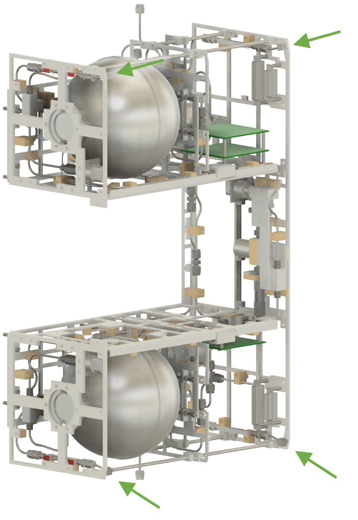


Figure 1: 3D render of ALEx propulsion unit delivered to ALE2 spacecraft.
Green arrows represent forces generated by the 4 thrusters.

Introduction

Patchedconics, LLC of Japan successfully delivered a gas generator propulsion system to a Japanese venture satellite company, ALE, in 2019 (Figure 1). Now it presents the new product featuring Heater-free, Lowest Power Consumption & Ultra High Volume Efficiency Gas-Generator Propulsion System. It is the most suitable low-cost solution for Micro to Nano Satellites.

Features

Patchedconics has come up with key intellectual assets in such vaporization propulsion system especially for micro to nano satellites. This system continuously vaporizes a liquidized gas in space.

Vaporizing systems are not new technology. However, Patchedconics way is different, and allows gas generation without heater, through its proprietary isenthalpic pressure reducer (Figure 3), which enables high quality gas to be provided to thrusters. Another feature of this propulsion system is the utilization of energy harvesting technique, which takes advantage of the heat from the spacecraft structure in the process of gas generation. Those technologies enable the propulsion system to get rid of high-power consumption. The only remaining power consuming components being the electromagnetic valves and PCBs.

Another key technology developed by Patchedconics and featured on this new system is in terms of the volume efficiency with no dead volume. Most of the system is built submerged in the propellant storage. This is one of the intellectual properties that Patchedconics possesses and enables constructing surprisingly concise, high density system with lowered cost. Patchedconics has already **applied for patents for submerged tubing technology** for its 1U and 2U models for Ultra High Volume Efficiency propulsion units.

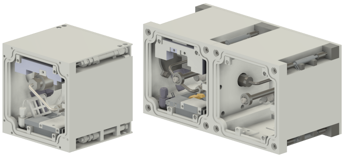


Figure 2: 3D render of Ultra High Volume Efficiency propulsion units. 1U model, 2U model (from left to right)

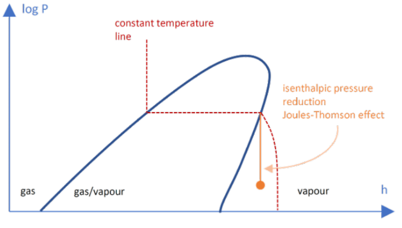


Figure 3: Isenthalpic pressure reduction process in a Pressure x Enthalpy diagram.

Patchedconics' Ultra High Volume Efficiency (Figure 2) design is able to contain any leakage from the gas lines inside the storage tank, and the cubic design is possible by using a propellant with low vapor pressure, which does not require special high pressure tanks. The propellants available for usage in this system do not require special handling license, are not toxic and can be purchased near any launch site. Such propellants can be easily approved by launch provider for usage in their launch vehicle.

Modular Configuration

Patchedconics' Ultra High Volume Efficiency units starts from 1U and can be used in combination for larger spacecraft. On the 2U model, the content inside each of the modules can be different, not requiring two gas generators and same gas lines to be placed in both modules. A larger 4U unit is available, as well as the possibility to have a modular system for larger spacecrafts, with units placed at each corner of the satellite. The modules each have their own gas generator and the propellant tanks can be connected by tubes through which only liquid propellant flows, preventing one of the modules to be left empty (with only gas) due to unbalanced usage of the thrusters on each corner.

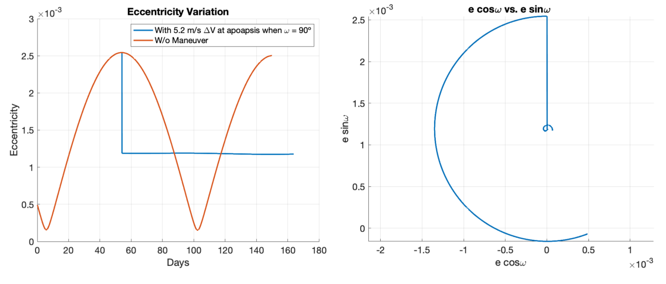
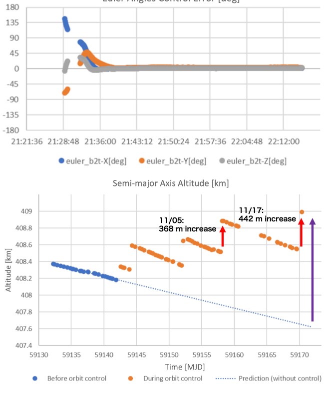


Figure 4: Results from the correction strategy. Left: eccentricity variation after maneuver. Right: *e* cos(w) x *e* sin(w) transitioning to nearly frozen orbit.



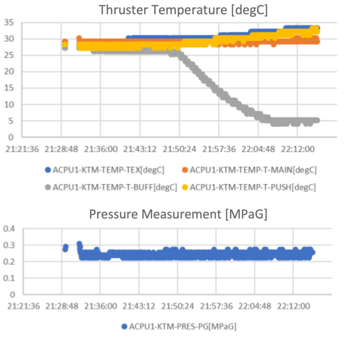


Figure 5: Real data from ALE2 showing behaviour of ALEx engine [1]. Courtesy of Tohoku University.

Correction Strategy

Patchedconics has been working with orbital analysis and strategies for improving lifetime of satellites. Simulations of orbital maneuvers (Figure 4) have been performed using real orbital data from spacecraft and results point that reaching a trajectory with little to no variation of the eccentricity can reduce the decay of an orbit by 6%. Circular orbits are ideal but can't be maintained because of Earth's oblateness. Reaching a stable orbit is the best strategy to reduce decay due to atmospheric drag.

Experience from ALEx Engine

ALE2 spacecraft was launched in late 2019 and there is an example of the operation of the propulsion unit (Figure 5). On the top left we can see the attitude being controlled using the thrusters as preparation for an orbit control maneuver. On the bottom left we can see the semi-major axis being successfully raised also using thrusters, under several half-revolution maneuvers. On the top right, the Joules-Thomson effect can be visualized – the pressure is being reduced isenthalpically and because of this, the temperature decreases. The last figure, on the bottom right, we can see the pressure of the buffer tank successfully controlled by the system.

ALEx propulsion unit, developed by Patchedconics and in use with ALE2 spacecraft have successfully served its purpose for the time being. It is the first unit provided by Patchedconics and shows possibility of extremely low power and low cost propulsion units for small satellites. Our goal is to enable more satellite fabricators to include capability of attitude and orbit control in their spacecraft.

References

[1] SSC21-III-09 Yuji, Sato, et. al. (to be presented at Small Satellite Conference 2021)

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