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DEVELOPMENT OF A WATER PROPULSION SYSTEM FOR SMALL SATELLITES

Abstract

A propulsion system based on water electrolysis is developed which uses non-toxic, low pressure water as main propellant. Water is decomposed via electrolysis on orbit to generate the gases hydrogen and oxygen which can be used in a thruster to propel a spacecraft.
Water propulsion offers high performance with low toxicity and therefore low handling and manufacturing costs. Another significant advantage is its easy handling on ground. Compared to other chemical propellants, which store their energy chemically and therefore have a high risk while handling, with a water based system it is possible to work on an already fueled spacecraft, because the energy addition to the propellants happens on orbit electrically.
Other propulsion systems like cold gas thrusters usually need highly pressurized gases, which are primarily extensive in handling, but also require heavy storage tanks to withstand high pressures. Whereas the pressurization of the combustion gases in the water propulsion system happens on orbit and therefore is without any risk for the ground crew.
The propulsion system consists of a water storage, an electrolyzer, gas storage and thrusters[1].
Special effort is put into the development of a zero-g electrolyzer to generate the combustion gases without water droplets and to compress the gases up to a certain pressure. First promising experiments have been conducted.
In cooperation with Airbus Safran Launchers, IRS develops a one Newton thruster to combust the gases generated by electrolysis and stored under pressure. Main objective of the thruster is to be propelled by a stoichiometric mixture ratio. The performance of hydrogen and oxygen combustion is the highest possible with chemical propellants, with a specific impulse (Isp) of over 350 s.
Due to its modularity, the propulsion system can be adapted to the particular mission, by increasing the number of thrusters or modifying the storage capacity for water or gases, for varying thrust, Δv or impulse, respectively.
Synergetic effects can be used when combined with a fuel cell to use the system as a battery or in combination with life support subsystem to generate oxygen breathing gas to save additional mass.
A breadboard model consisting of thruster, electrolyzer and storage tanks is currently under development in order to reach TRL 6 by the end of 2017. It will be tested and characterized at the electric propulsion vacuum facilities at IRS Stuttgart.

[1] Harmansa, N., Design of a Low-Cost Propulsion System based on Water Electrolysis, Masters Thesis, IRS-15-S-04, Stuttgart, 2015