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STUDY, DEVELOPMENT, IMPLEMENTATION AND TESTING OF A WATER RESISTOJET PROPULSION SYSTEM FOR CUBESATS

Abstract

With the exponential increase of interest in nano/micro satellites, which accounted to a total of 633 launches in 2022, the interest in finding a way to ensure the longest possible operational life has grown. This study is focused on the development of a prototype of a modular 1U propulsion system based on a water resistojet that can be installed on board CubeSats from 3U. The aims are to provide a cost-effective, simple and scalable system that can extend the operational life of the satellite by controlling its orbit. The study and prototyping was performed at Sapienza University of Rome, with the S5Lab research group. A typical resistojet engine consists of a heat exchanger where a working fluid can be heated or boiled by an electrical resistor and a conventional nozzle through which the hot gases can be expanded and expelled to provide thrust. The simplicity, the sturdy design of the system and its moderate thrust-to-weight ratio are attractive for the use onboard small spacecraft. During the study and development, various technical choices have been investigated: working fluids, geometries for the heat exchanger, the final temperature of the hot gases, operating pressures, layouts and architectures for the complete propulsion module. The final selection opted for an engine working at low pressures, temperature and power consumption and two different engine designs have been made. Various CFD analyses have been carried out to investigate the flow inside the water supply pipes, heat exchanger and inside the nozzle in such way as to predict some operating parameters and heat transfer. Three prototypes have been produced, each with different features to evaluate the two heat exchanger geometries, the general well-behavior and the capability of the engine to produce a sufficiently high thrust in different operating conditions. The testing of the models has been carried out inside a vacuum chamber and have provided important informations for the validation of the engine designs and for the development of a complete final prototype of the engine module. For this project COTS components have been extensively used, by also considering the use of advanced technologies such as 3D printing, nowadays increasingly useful in aerospace applications. The following paper will describe the process of design, numerical analysis, construction and testing of the resistojet prototypes made with the S5Lab research laboratory at the Sapienza University of Rome. Besides the achievements and results, the future perspectives will be extensively described.