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Author: Mr. Varun Reddy Nandyala
FOTEC Forschungs- und Technologietransfer GmbH, Austria, nandyala@fotec.at

Dr. Robert-Jan Koopmans
Austria, koopmans@fotec.at
Dr. Tijen Seyidoglu
FOTEC Forschungs- und Technologietransfer GmbH, Austria, seyidoglu@fotec.at
Mr. Emmeric Vitztum
FOTEC Forschungs- und Technologietransfer GmbH, Austria, vitztum@fotec.at
Dr. Markus Hatzenbichler
FOTEC Forschungs- und Technologietransfer GmbH, Austria, hatzenbichler@fotec.at
Mr. Florin Plesescu
FOTEC Forschungs- und Technologietransfer GmbH, Austria, plesescu@fotec.at
Mr. Christian Matkovits
FOTEC Forschungs- und Technologietransfer GmbH, Austria, matkovits@fotec.at
Mr. Michael Happl
FOTEC Forschungs- und Technologietransfer GmbH, Austria, happl@fotec.at
Dr. Bernhard Seifert
FOTEC Forschungs- und Technologietransfer GmbH, Austria, seifert@fotec.at
Mr. Ferran Valencia Bel
ESTEC, The Netherlands, ferran.valencia.bel@esa.int
Dr. Martin Schwentenwein
Austria, mschwentenwein@lithoz.com
Mr. Altan Alpay Altun
Austria, aaltun@lithoz.com
Dr. Romain Beauchet
Université de Poitiers, France, romain.beauchet@univ-poitiers.fr
Dr. Yann Batonneau
France, yann.batonneau@univ-poitiers.fr

VACUUM TESTING OF 3D PRINTED 1N HYDROGEN PEROXIDE THRUSTER AND A NOVEL PLATINUM CATALYST

Abstract

A critical part of almost all monopropellant thrusters is the catalyst which is responsible for decomposition of propellants and there by generating thrust from the exhaust gases. Typical requirements for catalysts are that the decomposition reaction is fast enough to reach steady state thrust under 50 milliseconds, that they operate over extended periods and the pressure drop over the catalyst is minimal. But perhaps the most severe conditions for the catalysts are when the thruster is operated in pulse mode. The thruster performance is determined by a complex interaction by, amongst others, injector, chamber and nozzle design, the chemical energy that is liberated during decomposition, the flow field inside catalyst.

From a testing facility perspective, this requires two aspects to be taken care about. First of all, the propellant feed system should be such that repeatable short pulses can be delivered and recorded. A particular difficulty here is that conventional mass flow meters are not suitable for determining the mass flow rate for short pulses of 10-20 milliseconds.

Over the past years, many catalyst designs were tested at FOTEC. The catalyst designs were primarily made up of a ceramic substrate coated with platinum as active phase. The previous tests were conducted at atmospheric pressure and were focused on steady state firing mode. To increase the development status beyond TRL4 and with recent advancements in technology, FOTEC developed a novel Pt catalyst and a process to completely 3D print a 1-10 N level thruster in one piece. A vacuum facility was commissioned to perform the thruster firing tests at a vacuum level of up to 5 mbar. The feed system was designed such that thruster can be tested in pulse mode operation as well. Pulse mode operation and mass flow measurements can be performed down to a duration of 10 milliseconds and the facility can collect real time data on all the sensors up to 20 kHz for further analysis.

A series of tests were performed to verify the performance of the 3D printed thruster and the newly developed platinum catalyst compared to previous ceramic catalysts. To this end, different catalyst designs, both traditional ceramic catalyst and the newly developed catalysts were exposed to 98 hydrogen peroxide with a bed loading of 20 kg/sq.m. The thruster is tested at vacuum conditions of approximately 5 mbar.

This paper discusses the new facility that was designed and built. It also presents the results of additive layer manufactured (ALM) thruster and catalyst tested in vacuum conditions.