Development and testing of a hydrogen peroxide - fed monopropellant thruster[1]

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The interest in the potential of hydrogen peroxide as propellant in space propulsive systems has grown in recent years and its application in a wide range of configurations is the subject of investigation by several research groups worldwide (mainly in Europe, US and China). Highly concentrated solutions of hydrogen peroxide, also known as HTP (High Test Peroxide, usually denoting a peroxide concentration higher than 85% by weight) can be used both as monopropellant in propulsion systems requiring a relatively low thrust level, e.g. satellite attitude control, station keeping, de-orbiting (typical thrust levels in the range 1÷20N), or as oxidizer in bipropellant engines delivering up to 500N, to be used again on satellites, for orbit insertion manoeuvres, or for attitude control of more massive systems, as cargo carrier vehicles.

HTP versatility mostly derives from the possibility to release the energy stored in the H_2O_2 molecule by decomposing it, and then to use the hot gases generated by the decomposition to generate the target thrust (through the expansion in a nozzle, monopropellant engine) or to ignite a liquid/solid fuel (bipropellant/hybrid engine). H_2O_2 decomposition can occur thermally or catalytically: the thermal path becomes significant only at very high temperature, and its application to a propulsive systems would require propellant heating from ambient temperature to the required level, with a significant power demand and mass increase that can be hardly accepted on satellites; the focus is then shifted towards the catalytic path, with the identification and the development of a catalyst configuration able to start H_2O_2 decomposition at low (ambient) temperature.

The present work describes the development and testing activities of a H_2O_2-fed monopropellant thruster, designed to deliver a maximum thrust of 20N (in vacuum conditions). The system is based on an innovative catalytic chamber, with a multiple-catalysts configuration: as schematized in Figure 1, the propellant is distributed on six honeycomb catalyst modules; a single module is shown in Figure 2 (raw ceramic support in Yttria Stabilized Zirconia, active phase and catalyst preparation procedure developed by the University of Napoli). The catalyst exhaust stream passes through a post-chamber, where pressure and temperature taps are located, and then expand through a convergent-divergent un-cooled stainless steel nozzle. A mass flow-meter/control is mounted on the propellant feed-line to measure and control the peroxide flow, while load cells are used to measure the delivered thrust.

The configuration has been proved to achieve high efficiency levels (i.e. high H_2O_2 conversion and decomposition temperatures close to the maximum theoretical value, as can be inferred from Figure 3).

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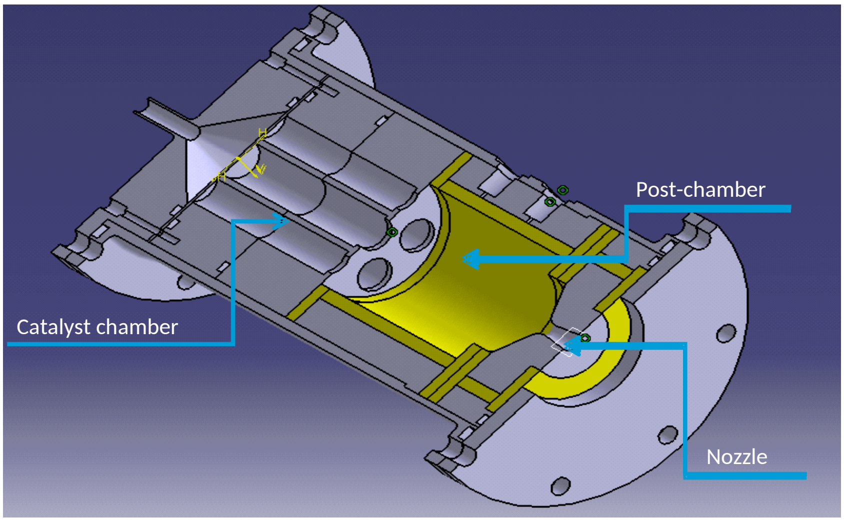

Figure 1. Thruster CAD model

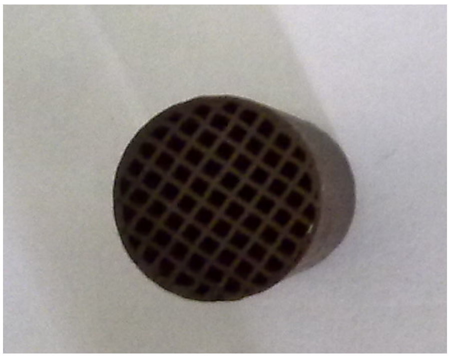
Figure 2. Honeycomb module

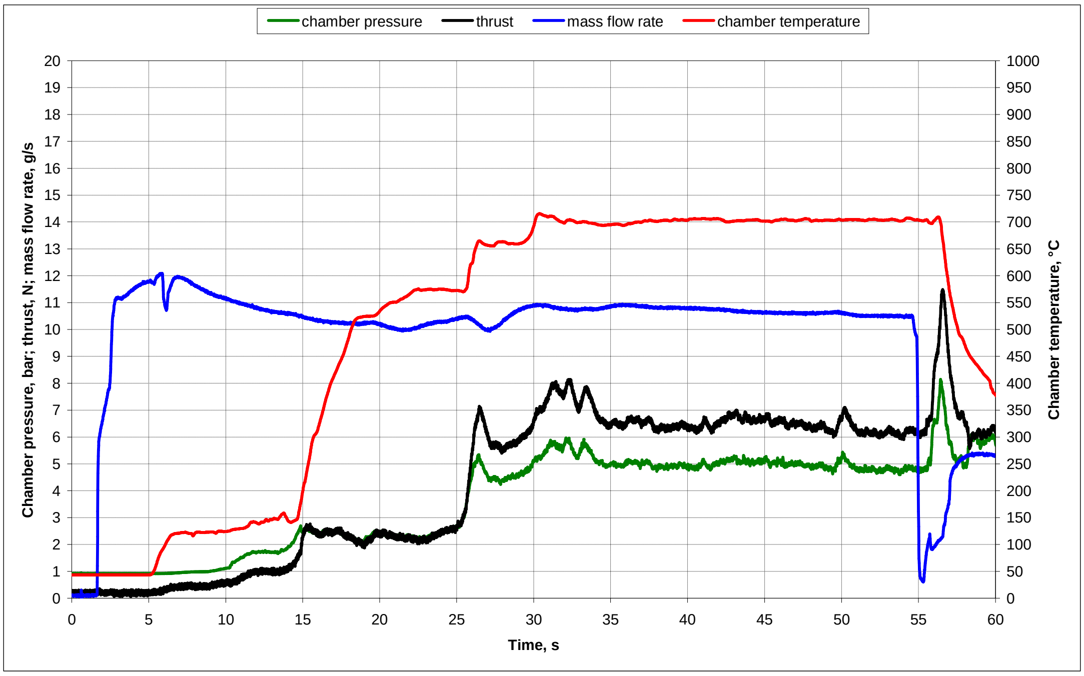

Figure 3. Thruster ground testing: main operating parameters