Synthesis of oxygen-methane combustion activities in In-Space Propulsion (ISP-1) Program

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In the frame of the 7th Framework Programme for Research and Technological Development of the European Union (FP7), the In-Space Propulsion (ISP-1) project was initiated in 2009 with the objective of improving the knowledge and the techniques that are necessary for future space missions relying on cryogenic propulsion. It ended in August 2012
The ISP-1 program was structured into five main work packages dealing with various technological issues associated to the development of a Low Thrust Cryogenic Propulsion system based on .liquid oxygen, liquid hydrogen, and liquid methane propellants.

This paper focuses on the issues associated with liquid oxygen/liquid methane combustion. Indeed, Oxygen/methane propulsion is a possible answer to the contradictory requirements of high performance and long duration in space. Before ISP program only preliminary studies have been carried out on methane, mainly in the frame of medium launcher main propulsion for which its overall advantage is not yet clear, especially for what concerns the development effort. Basic researches were required before considering an operational engine development. In addition, in-space propulsion introduces new requirements and possibly the use of new technical solutions that have not yet been explored so far.
Thus, the project has thus aimed at acquiring a basic knowledge on LOX/methane combustion and its in-space propulsion application through research on injection, ignition, combustion, soot formation and engine cooling, involving teams from Astrium, DLR, ONERA, Snecma and University of Roma.

The combustion work package activity combines, (i) experimental work using several measurement techniques to provide with ignition, combustion and cooling data base and first know-how on liquid-liquid injection for oxygen-methane as well, and, on the other hand, (ii) numerical activities for modelling and tool validation, relying on the acquired data bases.

Through theoretical analyses, modelling and experimental work, this project will serve the purpose of improving the maturity of technologies that are key elements of cryogenic space propulsion systems.

This paper deals with the work performed since the last Eucass symposium in 2011 and mainly devoted to the use of data acquired and models developed during the initial period in order to validate these models by CFD computations. Another part of the activity was the test of double swirled liquid injector.

Regarding CFD, firstly a very important work has been done to simulate ignition of DLR M3 combustor. Model comparison, on one hand, between RANS and LES, and on the other hand, between ambient pressure conditions and low pressure conditions, has shown that modelling allows simulating the main phases of the ignition sequence. Areas for improvement were identified during a dedicated workshop: Secondly, simulation of nine test cases obtained on DLR P6 test bench, considering different geometrical features and operating conditions have been achieved considering simplified method and two-way coupling method including heat conduction in the wall.

Regarding liquid injector tests performed at ONERA Mascotte test bench, a lot of data have been acquired for various geometrical features and operating conditions, giving a first view in the double swirled injector technology.