SPACE PROPULSION SYMPOSIUM (C4)
Propulsion Technology (3)

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DEVELOPMENT OF A LOX/LCH4 TECHNOLOGY DEMONSTRATOR BASED ON REGENERATIVE COOLING THROUGHOUT VALIDATION OF CRITICAL DESIGN ASPECTS WITH BREADBOARDS IN THE FRAMEWORK OF THE HYPROB PROGRAM

Abstract

Within the HYPROB program activities to increase system design and technology capabilities on liquid oxygen-methane engines are foreseen with the aim to built and operate a system ground demonstrator with a specific interest on the regenerative cycle. Following an incremental approach in terms of system complexity, two different breadboards has been designed and will be used to test critical sub-system components of the demonstrator and to validate design and analysis tools. The first breadboard will be devoted to the analysis of combustion phenomenon in supercritical conditions and heat release at the wall whose prediction inside a LRE is one of the major issues for regenerative thrust chamber design. Despite many works in literature can be found, both from an experimental and numerical point of view, the detailed understanding needed to push further the design of rocket chambers is still somewhat lacking. The main elements of the breadboard are the plate with a single injector element, the combustion chamber and the expansion nozzle. In detail, the chamber is formed by a certain number of interchangeable and removable calorimetric disks, each of them separately cooled by a water circuit in order to derive heat flux profile at the wall by measuring temperature increase of the cooling flow. The same breadboard will be also equipped with an (optional) windowed module to use non intrusive optical diagnostic techniques for the analysis of combustion processes. As a whole, this breadboard will allow for the analysis of basic physical phenomena, as propellants mixing, atomization and combustion, but also will be used to increase system design capabilities and to validate design tools by investigating critical phenomena as wall heating, combustion instabilities, radiation effects. A second breadboard will be focused on the

analysis of methane thermal properties to analyze transition from liquid to gaseous state which takes place, generally, at transcritical or supercritical conditions, in a regenerative thrust chamber. In this breadboard, the methane will be injected into a rectangular channel and heated through an electrical heater. The dimensions of the channel, methane inlet conditions in terms of pressure, temperature and mass flow are fully representative of a typical 3 ton regenerative thrust chamber. The test article will be equipped with thermocouples, flow meters and pressure transducer in order to deeply investigate the thermo-fluid dynamic behavior of the methane into the channel flow. The full paper will report the technical analysis carried out during the design phase.