Aerospace Europe Conference 2023
Joint 10th EUCASS – 9th CEAS Conference

Abstract #XXX *(to be filled by the organizers)*
Preferred Topics: PROPHY
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Type: Oral
Status of corresponding author: Student
For student corresponding author: student member of one of the following:
AIDAA

Title

Cold-Flow Testing of various injector designs for a novel hypergolic and green propellant combination developed at DLR Lampoldshausen

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Abstract

In the field of Space Propulsion, the Green Propellants topic is a recurrent trend, experiencing an exponential growth in the last few years with the excitement connected to the unfolding of the New Space. The current leading compounds used as propellants for in-space operations are well-known to be toxic and hard to manage. Many entities around the world are moving to ban or reduce the use of these compounds for general use, including the space sector, hence it becomes everyday more important investigating and researching new alternatives to reduce health and safety risks together with lowering the compound management costs.
Many new alternatives have arisen in decades of research, nonetheless only a few show some crucial characteristics that made them stand out against the toxic leading propellants.
Between the many alternatives, a combination recently developed at DLR Lampoldshausen appears particularly promising. The combination has all the correct features to lead the change: storability, reduced toxicity, good performance and especially hypergolicity. The propellant combination is an energetic ionic liquid fuel, called HIP_11, coupled with highly concentrated hydrogen peroxide as oxidizer.
The propellant itself is promising but there is a need for development and testing in relevant conditions to mature this technology. In this framework the current study analyses the application of this propellant combination to small-thrust engines and the deriving sets of challenges. In particular, this study focuses on the analysis of different injection strategies in the combustion chamber. The fuel, although promising from a performance point of view, is a fluid with higher viscosity than common propellants and hence requires particular attention during the design to obtain the ideal and desired spray pattern. Being a hypergolic combination, the atomization and spray pattern of the propellants in the combustion chamber is crucial for a correct and reliable behaviour of the thruster.
The analysis describes the different approaches of various injector designs, describing the multifaceted challenge of injecting the low mass flow rates required. The study is completed by a test campaign performed at the testbench M11 at DLR Lampoldshausen. The test campaign, based on cold-flow conditions using water and simulant fluids, investigates the spray behaviour and pattern of the various injector designs by using high-speed camera, mass flow meters and pressure transducers.
The test campaign allowed to explore the physics of the injectors before utilizing them with the real compounds in a combustion chamber.