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PROGRESS ON LOX-LNG PROPULSION TECHNOLOGY AT ISRO

Abstract

Liquid propulsion systems operations in the Indian launch vehicles have been limited to storable propellant combinations and high-performance Cryogenics. The LOX-Methane cryogenic propellant combination is touted as a promising candidate for future rocket propulsion systems and it is being actively pursued by all major rocket propulsion agencies across the world. In India, a novel method is conceived to fast track the LOX-Methane propulsion system development using the existing high-performance cryogenic rocket engine CE20 powering the upper stage of the GSLV-MkIII launcher.

The CE20 engine which works on LOX/LH2 propellant combination is modified for the purpose of technology demonstration with maximal utilization of the existing hardware. A detailed evaluation of the sub-systems revealed that major components of the engine such as the Thrust chamber, Gas generator, and Turbopumps can be utilized without further modifications. However, the functional fluid circuit is reconfigured for the necessary power balancing.

A series of experiments were conducted on the demonstrator to evaluate critical technologies in LOX-Methane propulsion development for the future. Initial trials were concentrated on the evaluation of the chill down the performance of the facility systems and the engine. Subsequently, the propellant flow trial is conducted for the verification of pre-ignition conditions in the chamber followed by ignition characterization tests. Further, multiple experiments were carried out to evaluate the engine start system performance and subsequent performance of the combustion within thrust chamber and chamber regenerative cooling with LNG. Finally, an experiment is conducted to verify the combustion of propellants in the gas generator.

The experiments successfully demonstrated key technologies such as feed system chill down, pyrogen ignition system, regenerative cooling, combustion performance, and the engine start-up. The usage of

LNG instead of pure Methane has shown significant differences in the transient process compared to LH2. This is attributed to the presence of Ethane in LNG which condenses at high pressure leading to two-phase flow in the regenerative channels. Another criticality observed in the experiments is the combustion instability, wherein the combustion is predicted to be unstable owing to lower stability margins of LOX/LH2 injectors with the new-propellant combination. The experiments provided invaluable insights into the combustion instability with LOX-LNG propellants which will be utilized in configuring future LOX-Methane propulsion systems. This paper discusses the detail of the experimental outcomes.