SPACE PROPULSION SYMPOSIUM (C4)
Propulsion System (2) (2)

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DEVELOPMENT OF AN EXPERIMENTAL LAB-SCALE SET UP FOR TRANSIENT COMBUSTION INVESTIGATION IN HYBRID ROCKETS

Abstract

Re-ignition, throttability and thrust modulation represent important features of hybrid rocket engines. They are peculiar factors for vehicle maneuvering and impulse management to extend hybrid technology to new missions, not yet affordable. Although theoretically feasible, these features require further investigation in order to achieve a deeper understanding of the transient combustion processes involved and assess the system response to the transient conditions imposed. The diffusion limited turbulent boundary layer configuration involved, requires to identify the physical and chemical phenomena affecting the transient behavior of such a complex system. To contribute to hybrid rocket technology development, a new experimental lab-scale test rig was designed and developed at SPLab of Politecnico di Milano for the investigation of typical transient phenomena (ignition, shut down, throttling) occurring during hybrid rocket engine operation. The test facility includes a mass flow controller, pressure transducers and thermocouples. A careful investigation of the temperature profiles, performed by means of micro-thermocouples inserted in the solid fuel grain, allows correlating the regression rate response and the temperature profile for different throttling ratios; ad hoc probes are developed for the local and instantaneous regression rate measurement. The test rig is designed for fuel sample testing in slab configuration, suitable for high-speed video recording and the analysis of the flame structure behavior during transient conditions. The results show the system dynamic response to imposed oxidizer mass flux variations. Observed overshooting phenomena are presented and discussed for different fuels (conventional, HTPB-, and liquefying, paraffin-based) and correlated to the thermal lags of the system. Important phenomena, establishing the overall transient behavior, are identified.

References

1. L. Galfetti, L.T. DeLuca, C. Paravan, L. Merotto, and M. Boiocchi, “Regression Rate and CCPs Measurement of Metallized Solid Fuels”, 8-ISICP, Cape Town, South Africa, 2-5 Nov 2009.

2. L.T. De Luca, L. Galfetti, F. Maggi, L. Merotto, and M. Boiocchi “Ballistic and Mechanical Characterization of Paraffin-based Fuels for Hybrid Rocket Propulsion”, 47th AIAA/ASME/SAE/ASEE Joint Propulsion Conference Exhibit, 31 Jul - 3 Aug 2011.

3. L. Merotto, M. Boiocchi, A. Mazzetti, L. Galfetti, and L. T. De Luca, “Characterization of a family of paraffin-based solid fuels”, 4th EUCASS, St. Petersburg, Russia, 4-8 July 2011.

4. L. Galfetti, L.T. De Luca, F. Maggi, L. Merotto, and M. Boiocchi, "Characterization of paraffin-based solid fuel for hybrid propulsion filled with metal powders and metal hydrides", CEAS, Venice, Italy, 24-28 Oct. 2011.