

2nd International Conference and Exhibition on **Mechanical & Aerospace Engineering** September 08-10, 2014 Hilton Philadelphia Airport, USA

Experimental investigation and numerical simulation of combustion processes in hybrid rocket engines

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The renewed international attention to hybrid rocket engines (HRE) points out the need of a deeper understanding of physico-chemical phenomena controlling combustion process and fluid dynamics in the motor. Combined experimental and numerical research activities can improve the knowledge of phenomena such as complex interactions among fluid dynamics, solid fuel pyrolysis, oxidizer atomization and vaporization, mixing and combustion in the gas phase, particle formation, and radiative characteristics of gas and flame. Re-ignition, throttability and thrust modulation represent important features of HRE. They are peculiar factors for vehicle maneuvering and impulse management to extend hybrid technology to new missions, not yet affordable. 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 the identification of the physical-chemical phenomena affecting the transient behavior of the system. Tests were performed in two different lab-scale combustion chambers. The average regression rate was measured for different (polymeric- and paraffin-based) fuel formulations. Original strategies were applied to overcome the problems of paraffin poor mechanical properties. A new test rig was developed for the investigation of typical transient phenomena occurring during HRE operation. Ad hoc probes were developed for local and instantaneous regression rate measurement. A numerical simulation of the phenomena involved in HRE combustion was performed, using OpenFOAM. A new solver was implemented for the simulation of the different phenomena involved, including solid fuel regression, pyrolysis, spray formation and combustion.

Biography

L Merotto has completed her PhD at Politecnico di Milano in 2011. Her research activity focuses on both experimental investigation and numerical simulation of combustion processes in hybrid rocket engines. She has been involved in several international research programs, such as PF7 ORPHEE (Operative Research Program on Hybrid Engine in Europe) and SPARTAN (SPace exploration Research for Throatable Advanced eNgine), and has more than 20 publications. Her work has received some important awards, such as the AIAA Best Paper 2011 and the ITWIIN award 2012 for Best Woman in Innovation. She was candidate to the EUWIIN 2013 Award.

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