Experimental analysis of SiC-based refractory concrete in Hybrid Rocket Nozzles

Raffaele D'Elia [a, b, *]

Gérard Bernhart [a], Jouke Hijlkema [c], Thierry Cutard [a]

Abstract

Hybrid propulsion represents a good alternative to the more widely used liquid and solid systems. This technology combines some important specifications of the latters, as the possibility of re-ignition, thrust modulation, a higher specific impulse than solid systems, a greater simplicity and a lower cost than liquid systems. Nevertheless the highly oxidizing environment represents a major problem as regards the thermo-oxidation and ablative behaviour of nozzle materials. The main goal of this research is to characterize a silicon carbide based micro-concrete with a maximum aggregates size of 800 µm, in a hybrid propulsion environment. The nozzle throat has to resist to a highly oxidizing *polyethylene*/*nitrous oxide* hybrid environment, under temperatures up to 2900 K. Three tests were performed on concrete-based nozzles in HERA Hybrid Rocket Motor (HRM) test bench at ONERA. Pressure chamber evolution and observations before and after tests are used to investigate the ablated surface at nozzle throat. Ablation behaviour and crack generation are discussed and some improvements are proposed.

I. Introduction

Although hybrid propulsion has been introduced since many years, it is only in the last two decades that in view of cheap and reliable access to space has attracted the interest of many researchers and some companies. The environment produced by this kind of propulsion is more oxidizing than that of solid and liquid rockets, inducing a more pronounced ablation of nozzle's throat. This represents an important challenge as regard performances and nozzle's operation time. Usually graphite nozzles are used for hybrid rocket motors, without posing

[a] Université de Toulouse; CNRS, Mines Albi, INSA, UPS, ISAE; ICA (Institut Clément Ader); Campus Jarlard, F-81013 Albi, France

[b] CNES – Direction des Lanceurs, 52 rue Jacques Hillairet, 75612 Paris Cedex, France

[c] ONERA, Centre Fauga-Mauzac, France

[*] Corresponding author at: Université de Toulouse; CNRS, Mines Albi, INSA, UPS, ISAE; ICA (Institut Clément Ader); Campus Jarlard, F-81013 Albi, France, France. Tel.: +33 7 78 20 12 40; fax: +33 5 63 49 32 42. E-mail addresses: raffaele.delia176@gmail.com, (R. D'Elia)