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Author: Dr. Alessandro Lazzari
AVIO S.p.A., Italy

Mr. Nicolò Maria Frisone
AVIO S.p.A., Italy

NOZZLE EXTENSION CONCEPT DESIGN OF AVIO'S LIQUID ROCKET ENGINE

Abstract

In cryogenic liquid rocket engines, the use of a nozzle extension allows improving thrust performance by increasing the expansion area ratio. With the main objective of saving weight while increasing the rocket efficiency, the use of light materials able to withstand harsh temperature and environment conditions represents a challenging requirement to be met.

Modern designs investigate the use of carbon-matrix composite (CMC) nozzle extension [1]. Compared to metallic nozzle extension, CMC materials guarantee high thermo-mechanical performance as well as light weight. Nevertheless, such materials can be strongly affected by chemical erosion and the effect of oxidation must be thoroughly investigated. Moreover, interface compatibility issues between the CMC nozzle extension and the metallic counterpart of the nozzle must be tackled. As a result, development and qualification of such product involves meaningful efforts in order to overcome demanding requirements and constrains.

Within this framework, the main objective of this work is to present a concept design of the M10 VEGA-E Upper-stage nozzle extension. Particular attention is given to the design of the interface between the CMC nozzle extension and the metallic nozzle. While the latter benefits from an active cooling system, the nozzle extension is instead subjected to a significant heat flux without cooling, thus making more complex the accommodation of strains between the components of the interface. A concept of such dedicated interface, as well as the main technological achievement for implementing a CMC nozzle extension, is presented.

Overall, the present work provides a glimpse into a new promising design aimed to improve the performance of M10 VEGA-E rocket engine while saving significant weight.

[1] Gradl, Paul R., and Peter Valentine. "Carbon-carbon nozzle extension development in support of in-space and upper-stage liquid rocket engines." 53rd AIAA/SAE/ASEE Joint Propulsion Conference. 2017.