Aerospace Europe Conference 2023
Joint 10th EUCASS – 9th CEAS Conference

Abstract #XXX *(to be filled by the organizers)*
Preferred Topics: PROPHY/CFDMPS *(3 maximum from the list of topics)*
Corresponding author: Marco Fabiani
e-mail of corresponding author: m.fabiani@uniroma1.it
Type: Oral
Status of corresponding author: Student
For student corresponding author: student member of one of the following:

Title

Modeling of swirl injection effects in a H_2O_2-HDPE hybrid rocket

Authors

Marco Fabiani[1], Mario Tindaro Migliorino[2], Daniele Bianchi[3], Francesco Nasuti[4], Massimo Franco[5], Francesco Barato[6], Nicolas Bellomo[7], Daniele Pavarin[8]*
** Corresponding author*
[1] Sapienza University of Rome, 00184 Rome, Italy, m.fabiani@uniroma1.it
[2] Sapienza University of Rome, 00184 Rome, Italy, mariotindaro.migliorino@uniroma1.it
[3] Sapienza University of Rome, 00184 Rome, Italy, daniele.bianchi@uniroma1.it
[4] Sapienza University of Rome, 00184 Rome, Italy, francesco.nasuti@uniroma1.it
[5] Technology for Propulsion and Innovation Srl (T4i), 35121 Padua, Italy, m.franco@t4innovation.com
[6] University of Padua, 35121 Padua, Italy, francesco.barato@unipd.it
[7] Technology for Propulsion and Innovation Srl (T4i), 35121 Padua, Italy, n.bellomo@t4innovation.com
[8] Technology for Propulsion and Innovation Srl (T4i), 35121 Padua, Italy, d.pavarin@t4innovation.com

Abstract

In this paper numerical simulations are carried out to investigate the flow physics and the performance of a 300 N hybrid rocket engine burning high test peroxide (HTP) and high-density polyethylene (HDPE) and employing swirl injection. The engine design and the results of a previous experimental campaign are reported in [1]. The experimental data include tests at three different geometric swirl numbers (SNg = 2, 2.53 and 3.33) and average oxidizers mass fluxes between 30 and 120 kg/(m^2 s).

The numerical approach is based on axisymmetric Reynolds-averaged Navier-Stokes simulations, with sub-models accounting for the effects of turbulence, chemistry, radiation, and fluid/surface interaction, and has already been successfully employed in the simulation of hybrid rockets with axial and swirl injection, burning both HDPE and paraffin-based fuels [2,3,4]. The fuel grain wall boundary condition is based on species, mass, and energy conservation equations coupled with thermal radiation exchange and finite-rate kinetics for fuel pyrolysis modeling. The radiation code is based on the discrete transfer method.

A rebuilding of the experimental data is performed, assessing the capabilities of the model to correctly predict the fuel regression rate and chamber pressure. The effect of the computational setup and of the injection zone modeling is also investigated: simulations with and without the pre-chamber and post-chamber cavities are performed, analyzing their effect on the computed swirl intensity, regression rate, chamber pressure and combustion efficiency.
Additional simulations at SNg<2 are carried out to investigate the effect of swirl on the fuel regression rate and the propellant mixing process.

References

[1] M. Franco et al., Regression Rate Design Tailoring Through Vortex Injection in Hybrid Rocket Motors, JSR 2020
[2] M.T. Migliorino et al., Numerical Analysis of Paraffin-Wax/Oxygen Hybrid Rocket Engines, JPP 2020
[3] D. Bianchi et al., Modeling of High Density Polyethylene Regression Rate in the Simulation of Hybrid Rocket Flowfields, Aerospace 2019
[4] M.T. Migliorino et al., Numerical and Experimental Investigation of a Lab-Scale Paraffin Motor with Swirled Injection of Gaseous Oxygen, Eucass 2022