IAF SPACE PROPULSION SYMPOSIUM (C4)
Liquid Propulsion (1) (1)

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T(H)RUST: APPLIED RESEARCH ACTIVITIES ON LIQUID ROCKET PROPULSION AT SAPIENZA UNIVERSITY OF ROME

Abstract

As a new space race is upon us, special attention is to be given to continuous development of launchers and their enabling technologies. The present research team faces this challenge addressing at the same time applied research and high education with the aim to support present and future developments in the field of liquid rocket engine (LRE) propulsion. Despite liquid propulsion is usually considered as a mature field, the number of challenges to improve practical design and analysis software is still high. Based on a long-time background in the study of LREs, the present research team is addressing low-order modeling for the study of heat transfer, stability, transient operation, performance and testing of these rocket devices. The research approach is based on the development of suitable methodologies to keep the analysis at the same time as quick and accurate as possible thanks to comparison with literature data and with in-house or literature high-order numerical simulations. This general approach will be

illustrated with examples on the different topics and underlining what is considered a peculiarity of the present research team working at the Department of Mechanical and Aerospace Engineering of Sapienza University of Rome and named T(H)RUST (THermal Rocket propUlsion: a Sapienza university research Team). A list of the main analyses and developments in progress by T(H)RUST follows.

High-frequency combustion instability. It is studied in a low-order fashion by an in-house multi-species Eulerian solver, capable of dealing with both longitudinal and transverse instabilities. The closure of the thermoacoustic feedback loop is enforced through a response function that links pressure fluctuations to the unsteady fuel mass flow rate injected by each element. The implementation of a cubic equation of state for the mixture allows the solver to handle systems fed by propellants under supercritical conditions.

Thrust chamber wall heat flux. Validated RANS approaches based on suitable analysis of the minimum reacting species and mechanism needed to yield a reliable prediction of wall heat flux distribution. They include a radiative heat flux in-house code, which integrates the radiative transfer equations through the discrete transfer method, under the assumptions of gray walls and medium.

Cooling channels analysis. Simulations are carried out by in-house codes: a validated conjugate heat transfer approach relying on a RANS 3D code for real fluids and a Fourier equation solver for the channels walls. Lower fidelity models, i.e. 1D and quasi-2D tools, have been developed to perform massive parametric analyses.