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NUMERICAL SIMULATION OF LRE AND HRE REACTING FLOWFIELDS

Abstract

The work described in the present paper shows some applications of the Italian Aerospace Research Center (CIRA) solver NExT in the CFD simulation of combusting flows in both liquid and hybrid rocket engine configurations. A comprehensive numerical model with real-fluid properties and turbulence-chemistry interaction effects was developed in order to predict the combusting flowfield inside a typical rocket combustion chamber. In the first part of the paper, different internal flow problems reproducing mixing and combustion processes have been investigated, with the aim to verify the implemented models and to validate them by comparing available experimental data. Then, typical rocket thrust chamber assemblies are selected and simulated, including all relevant geometrical features such as injectors, the combustion chamber and the nozzle, to evaluate the solver capability in the simulation of both liquid and hybrid rocket engine combusting flowfields. For the simulation of liquid rocket engines, including supercritical mixing, combustion processes and the related thermal environment analysis, the setup of the experiment performed at the Pennsylvania State University's Cryogenic Laboratory has been selected. The tests performed consist in hydrogen/oxygen and methane/oxygen high pressure combustion, for which numerical and experimental wall heat flux are available. For what concerns the evaluation of the solver capability in the simulation of a typical hybrid rocket engine internal flowfield, a lab-scale rocket with a cylindrical grain has been studied. Numerical results have been compared with the experimental results obtained by Grosse. The results show a good agreement with the literature experimental data and are encouraging in order to employ the code in more advanced applications, including the evaluation of hybrid propulsion systems performances in the presence of complex gas-surface interactions phenomena, the analysis of complex geometrical rocket configurations (multi-injectors, swirl injectors, non axial-symmetric fuel port shape, etc..), or the simulation of conjugate heat transfer between fluids and solids structures.