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PREDICTION OF HYBRID ROCKET NOZZLE BEHAVIOUR UNDER HIGH TEMPERATURE OXYGEN RICH ENVIRONMENT

Abstract

Chemical rockets can be separated into three categories such as solid, liquid and hybrid. The hybrid rockets are a combination of the liquid and solid fuelled rockets. Hybrid rockets convenience of benefit solid propellants by their low technological cost and convenience of use in solid phase, usually fuel, and benefits the advantage of throttling, shut-off and restart abilities by carrying the other propellant, usually the oxidizer, in liquid phase. In this paper, theoretical analysis, numerical simulation, and experimental testing methods will be used to study the thermal boundary conditions of the hybrid rocket nozzle. Phenolic-graphite felt, phenolic-silica, phenolic-carbon, novolac type phenolic-silica and graphite materials are used as nozzle. The rocket nozzle is simulated with Computational Fluid Dynamics (CFD method, and the results are investigated experimentally on a gas-oxygen – paraffin-based lab scale hybrid rocket motor. A three-dimensional study of internal fluxes has been conducted in Ansys Fluent. A reaction regime has been set and the Eddy Dissipation Model (EDM) has been selected as the reacting species transport model. To predict the fluid field and wall temperature distribution, numerical models have been developed considering both solid and fluid regions. Solid and fluid regions work together, each one providing a boundary condition for the other, and the solution to the coupled problem has been attained. Theoretically the conjugate gradient method with adjoin problem for function estimation iterative technique is used to solve the Inverse Heat Conduction Problem (IHCP) to estimate heat flux and internal wall temperature of the nozzle. The convective heat transfer coefficient is calculated using Bartz equation. Thermal properties of composite nozzles have calculated by using the rule of mixture. In order to find nozzles that maximize thrust performance in terms of thermal and strength, the results are compared.