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LARGE EDDY SIMULATION OF THE INFLUENCE OF PRIMARY ROCKET JET ON LOW FREQUENCY COMBUSTION INSTABILITY IN A ROCKET-BASED COMBINED-CYCLE ENGINE

Abstract

This paper describes effects of primary rocket jet parameters, which are among the most probable sources of combustion instability in a Rocket-Based Combined-Cycle (RBCC) engine, on the combustion characteristics of a three-dimensional RBCC numerically. Though the self-excited and sustained pressure oscillations in the cavities mounted in primary and secondary combustor, the large scale vortices shedding at the sudden expansion structures created by the main strut and secondary injection struts, the uncertainties of location of the thermal throat and fluctuations of fuel mass flow rate are all possible sources of combustion oscillations, they are not studied in detail in this paper. Compressible Large Eddy Simulation (LES) with kerosene sprayed and vaporized is performed on an experimental RBCC. Couples with reduced three-step chemical kinetics of kerosene, the LES are used to investigate the large amplitude and low frequency longitudinal oscillations in the engine. LES results are compared with experimental observations in pressure oscillation amplitude and frequency in the low components, all show good agreement. Influence of the primary rocket jet on pressure oscillations of the main combustor is analyzed and the relation of its high speed jet oscillation characteristics with that of the combustor is recognized. Results reveal that the unsteady high temperature jet comes out of the rocket, which is always rich in fuel, has a significant influence on the vaporization and combustion features of the fuel downstream of the secondary struts, and consequently on the combustion features of the main chamber. The LES solver is validated with experimental data for a scramjet located in the Institute for Chemical Propulsion of the German Aerospace Center (DLR) and shows good predictions.