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EFFECTS OF PRIMARY ROCKET NOZZLE EXPANSION RATIO ON COMBUSTION OSCILLATING CHARACTERISTICS IN A RBCC ENGINE COMBUSTOR

Abstract

This paper reports on effects of primary rocket jet expansion degree, which is regarded as one of the most probable sources of combustion instability in Rocket-Based Combined-Cycle (RBCC) engine, on combustion oscillating characteristics in a RBCC combustor both experimentally and numerically. Two typical Expansion Ratios (ERs) of the primary rocket nozzle, i.e. ER=6 and ER=2 are respectively chosen to achieve different states of the rocket jet, and are studied experimentally on a direct-connect ground test facility operating at scramjet mode. Compressible reactive Large Eddy Simulations (LESs) with liquid kerosene (C12H23) sprayed are accordingly performed on the RBCC combustor. Coupled with a reduced two-step chemical kinetics of kerosene, LES is used to investigate combustion details of the engine. Combustion performances are evaluated in terms of combustion oscillation amplitude and frequency as well as wall pressure distribution along the flow-path, which is thought to be the main source of inner thrust. Effects of primary rocket jet on pressure oscillations of the main combustor are analyzed and the relation of its high speed jet oscillating characteristics with that of the combustor is recognized. Results reveal that the unsteady high temperature jet comes out of the primary rocket, which is designed rich in fuel, has a significant effect on the vaporization features of the fuel injected from the secondary struts, and consequently on the combustion characteristics. LES solver is validated with experimental data of a scramjet located in the Institute for Chemical Propulsion of the German Aerospace Centre (DLR) and shows good predictions.