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PRELIMINARY STUDIES ON PHYSICAL DEFINITION AND DISCRIMINATION OF ROCKET-EJECTOR MODE OF RBCC ENGINE

Abstract

Rocket-Based Combined Cycle(RBCC) engine, which is formed out of rockets and ramjet/scramjet by thermodynamic cycle combination and structural integration, can be adapted to wide-range work requirements from zero speed takeoff to orbit flight. During different speed ranges, different operating modes are needed to achieve best performance, realizing full performance potential of combined rocket and ramjet engine. With flight Mach number increasing, four typical operating modes are successively experienced and smoothly transited, namely the rocket-ejector mode(about Ma0-2), ramjet mode(about Ma2-6), scramjet mode(about Ma6-12) and pure rocket mode(above Ma12). Therein, the rocket-ejector mode, which providing main propulsion force for RBCC-powered vehicle at low speed stage, is extremely crucial for propulsion performance improvement and flight mission realization. Lots of researches about rocket-ejector mode were carried out in the world, however, unified understandings of the physical definition and working range of rocket-ejector mode are not yet formed, which necessary to be studied and specified from the perspective of working process and flow physics. In this paper, the working principles of rocket-ejector during low Mach number range are introduced firstly according to RBCC engine working process. And then numerical simulation studies of full engine flow-path including inlet, combustor and nozzle are carried at low Mach number flight stage. The studies reveal that, the internal flow characteristics are dominated by rocket-ejector effects during subsonic and low supersonic flight speeds, the maximum inflow mass-rate are mainly depended on the rocket-ejector conditions; the freestream ram effects are gradually enhanced with increasing flight speeds, the internal flow characteristics are dominated by ram effects rather than rocket-ejector until a certain flight speed. The rocket-ejector dominated complex flow structures, flow physics details and formation mechanism during low Maher number stage are analyzed from the perspective of intake flow, primary/secondary shear mixing and combustion heat release. The physical definition and working mechanism of RBCC rocket-ejector mode are discussed. Finally, the discrimination principles and methods for RBCC rocket ejector mode and working range are present.