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NUMERICAL ANALYSIS ON RBCC INLETS OF DIFFERENT TYPES IN EJECTOR MODE

Abstract

RBCC engine exploits the synergistic interactions between rocket engine of high thrust-to-weight ratio and air-breathing engine of high specific impulse. It can operate through various modes including ejector, ramjet and scramjet modes in a wide flight range. In general, the RBCC inlet is designed for super/hypersonic speeds and does not have to be tuned only to the sub/trans-sonic regime. Nevertheless, as an essential part of the engine, RBCC inlet must work in the ejector mode, although the flight conditions are far off its design conditions. Two dimensional (2-D) inlet and sidewall compression inlet are mostly employed as the basic configurations of the supersonic inlets. Similarly, RBCC inlets are usually established based on these two types of inlets. In this paper, a 2-D and a sidewall compression RBCC inlet were designed and numerically compared in the ejector mode. Their configurations were kept as identical as possible in several primary parameters, in terms of operational Mach range (0 4.5), capture area, total contraction ratio (2.0), and isolator expansion ratio (1.2), etc.. A fuel-rich GO2/alcohol rocket with a mixture ratio of 1.2 was embedded in the central strut that installed in the isolator. By adopting the same dual mode rectangle combustors and semi-expanded nozzles, integration numerical simulations were carried out on typical flight conditions (Mach 0, 0.3, 0.9, 1.5 and 2.0). Although the different compression types brought significant differences to the two kinds of RBCC inlets in the ramjet and scramjet modes, the distinctions were not so obvious in the ejector mode, especially in the sub/trans-sonic regimes: (1) The operational states of the inlets were extremely sensitive, and the internal flow features were strongly correlated to the flight condition, physical configuration, rocket operation, and secondary combustion, etc.. (2) Based on the basic working characteristics under different flight conditions, the ejector mode operation of both the two RBCC inlets could be generally divided into several typical phases, as “suction”, “spillage”, “bow shock”, “inlet unstart” and “inlet start”. (3) The key parameter of air entraining mass flow rate affected the engine performance significantly. Further, the throat area of the RBCC inlet played the dominating role in the parameter, no matter what type of the inlet was. (4) Specially, the sidewall RBCC inlet exhibited better resistance to the serious flow separations at the static condition, while performed favorable “low-drag” characteristic in the transonic flight regime.