SPACE PROPULSION SYMPOSIUM (C4)
Hypersonic and Combined Cycle Propulsion (5)

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NUMERICAL AND EXPERIMENT STUDY OF THE DYNAMIC WORK PROCESS OF A NEW TYPE TWO-STAGE SUPERSONIC AIR EJECTOR

Abstract

The research of supersonic air ejector has very important academic value and application prospect in vacuum system for rocket engine altitude test, ground test system for hypersonic breathing propulsion and pressure recovery system for chemical lasers. To establish a stable "super-super" injection between the main flow and the secondary flow, and improve the pressure recovery coefficient and injection efficiency in new ways this paper presents a two-stage supersonic air ejector configuration and studies its dynamic work process by numerical simulations and experiments covering the start process, pressure matching characteristics and flow field oscillation. The first stage of the ejector is composed of an active nozzle, a passive nozzle and a mixing chamber, while the second stage is composed of an active nozzle, a mixing chamber and a diffuser. In the numerical simulations, Navier-Stokes equations for compressible ideal gas are applied, and the SST k- turbulence model is used to solve the turbulent viscosity coefficient. Finally, clear supersonic flow structures within the ejector pipe are captured by coupling algorithm combined with adaptive mesh optimization techniques. Comparative experiments are carried out in a full scale model. Two high-pressure air supply lines are used to provide compressed air for the first and second stages. In the aspects of monitoring and control, pressure scanning system is used for the flow field pressure distribution measurement, and schlieren system is used to observe and recording the structure of shocks. Researches find that the startup sequence, eject pressure and configuration have great influence on the start process; lower total pressure leads to the shock wave structure promoting inward through diffuser; increase the contraction angle or decrease the contraction ratio of the mixing chamber significantly narrowed the range of matching pressure; for a well-designed configuration, after the startup, if fixing one stage at a suitable state, the other stage presents a wide adjustment range that is conducive to enhance the matching range with load flow and improve the efficiency; in the continuous mode, there is shock oscillation in the diffuser and its frequency positively correlates with the total pressure of mainstreams. The results show that two-stage ejector establishes a stable "super-super" injection successfully, and the pressure recovery coefficient and injection efficiency are improved compared to single-stage ejector.