SPACE PROPULSION SYMPOSIUM (C4)
Hypersonic and Combined Cycle Propulsion (9)

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THE RESEARCH OF AIR-TURBO-ROCKET (ATR) PROPULSION SYSTEM BASED ON DOUBLE SOLID PROPELLANT GAS-GENERATOR

Abstract

In order to meet the wide envelope and high specific impulse requirement of the propulsion system, double solid propellant gas-generator air-turbo-rocket (ATR) is proposed which one gas-generator used to drive the turbine and another one employer to enhance the combustion in the after burner. A design and off design operation simulation program based on components operation matching has been developed. The operation envelope and performance of doubled gas-generateor ATR were studied under the component constraints. Furthermore, the influence on ATR with parameters of compressor-turbine unit is discussed when taking the qualifications of ground test prototype of ATR into consideration; the design selection of compressor-turbine unit is investigated on the basis of the design qualifications.One-dimensional design, two-dimensional meridian flow path design and optimization and three-dimensional design are carried on step by step, then the aerodynamic performance of meridian surface is analysed and the performance map is calculated; in order to investigate the internal flow and working performance of compressor at design point, three-dimensional numerical simulation is carried on; with the demand of compressor power and rotational speed balance, by aerodynamic calculation and empirical formula, the partial inlet impulse turbine including nozzle and rotator blade is designed; and then the numerical simulation is carried on for investigating the performance of impulse turbine at design point.Combustion enhancement technology of ATR has been investigated, and the high efficient combustion scheme has been proposed, and the combustion efficiency has increased significantly. A combustion numerical simulation method is established, and intake mode at the front the afterburner, diffuser scheme, and the intake mode of the afterburning gas is analyzed. The intake scheme, which combined pressurized air jet in an oblique way and driving-turbo gas at high speed rotation, is proposed, and the mixing degree is increased significantly. The afterburner flow field distribution is characterized by fuel-rich region in the center and oxygen-rich region in the outside. Therefore, afterburning gas entering into the afterburner in

transverse jet way is benefits for engine performance and injecting the gas into oxygen-rich region by the speed control that is the key to accomplish efficient combustion. Additionally, multi-stage diffuser scheme is designed to improve useable total pressure and the inlet air quality of afterburner. The optimum value of combustion enhancement scheme is obtained and its applicability during wide operations is verified by simulated calculation results. The ATR principle prototype and the ground experimental system are investigated based on efficient combustion scheme.