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

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PROGRESS OF ROCKET BASED COMBINED CYCLE IN NORTHWESTERN POLYTECHNICAL UNIVERSITY

Abstract

A review of studies in rocket based combined cycle (RBCC) in Northwestern Polytechnical university (NPU) is presented. RBCC engines take advantages of the synergistic interactions between the rocket and the airbreathing engine, effectively integrating high thrust-to-weight ratio with high specific impulse, and providing a higher mission-averaged specific impulse than all-rocket technology. RBCC propulsion is recognized as a promising technology for reusable space launch, orbital rendezvous and hybrid global strike. As one of the pioneers in the field of this advanced propulsion technology in China, NPU has conducted associated studies since 2001. An overview of progress of RBCC in NPU in the past nearly two decade is given, along with propulsion research methods, laboratory constructions and the develop program in future. Selected achievements in different technical issues are enumerated, these include: RBCC engine/vehicle design and airframe/propulsion system integration: different launch trajectories were designed for two-stage-to-orbit (TSTO) vehicles; multidisciplinary design optimization methods were established, and relevant design software was developed; Integrated numerical simulations were conducted for aerodynamic force/heat analysis. Flowpath design and optimization for multimode operation: variable-geometry RBCC inlets and nozzles of different types for Mach 0-7 were designed and experimental investigated; dual-mode scramjet combustors for wide operation range of Mach 2.5-6 that consist of struts and cavities were developed and well validated by direct-connect tests. Fuel injection and combustion organization: excellent combustion adopted for wide range fight Mach numbers from 2.5 to 6 was obtained under different operation modes by adjusting fuel injection and rocket operation; a new kind of strut for higher efficient mixing and combustion was developed. Component interaction validation of entire engine: a RBCC prototype of fully integrated flowpath was designed, and tested in ejector mode under static condition on the ground and in ramjet mode at Mach 3 in the freejet tunnel, through which good compatibility of RBCC engine for multimode operation were well validated. Engine control system design: precise fuel supplying system and control system were established, which can adjust mass flow

rate of fuel injection according to active feedback of pressure variation in RBCC combustor. Fundamental investigations: mechanism of fuel injection by different physical/chemic state, spread process of flame, flameholding by strut and cavities were investigated through numerical and optical methods, such as LES, PLIF, PIV, CCD, schlieren photography, and high-speed photography, etc.