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

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FREEJET TEST OF A ROCKET BASED COMBINED CYCLE ENGINE AT MACH 3

Abstract

A rocket based combined cycle (RBCC) engine was designed to demonstrate its wide applicability in the ejector and ramjet mode within the flight range from Mach 0 to Mach 4.5 by Northwestern Polytechnical university. A prototype for technology validation was designed and tested as a freejet engine operating at flight Mach number of 3 using hydrocarbon fuel for the first time in China. The heat sink alloy steel constructed ramjet test article was a full scale, reduced width model with fully integrated flowpath that was fully instrumented with pressure sensors and combined with fuel supplying and active control system inside. Additionally, an axial force measurement system measured engine thrust, the primary measure of engine performance. The objectives of this freejet test were to confirm RBCC inlet and combustor operability limits, expose unforeseen component interactions, determine engine performance, and validate computational prediction tools. Tests were conducted to simulate flight conditions at Mach number of 3 and at ambient static pressure of 26 kPa. Twice freejet tests were successfully carried out. Mass capture determination and back pressure capability validation of RBCC inlet was made in the 1st test. For which, a alloy steel constructed rectangular-to-circular shape section was designed and installed instead of 2nd combustor and nozzle of the freejet RBCC engine to obtain a uniform flow field. Rakes for stagnation pressure and static pressure measurement and mass capture calculation were designed and instrumented at the end of the section, meanwhile, a cone driven by a stepper motor for axial movements was positioned at its exit. Formal test was the 2nd test. After the inlet stated, along with high efficient combustion, fuel injection was adjusted for total equivalent ratio variation from 0.55 to 0.85.The primary engine performance goals were either met or exceeded. The RBCC inlet kept starting smoothly through the entire test, and the mass capture coefficient computed from the rake data obtained in a subsonic flow field was 0.944. The pressure distribution along the inlet and its back pressure capability were well validated the computational prediction. Component interactions of the entire engine worked well, and the ignition and aft flameholding and efficient combustion were successfully accomplished, while the thrust gain reached 0.33kN-0.49kN. This paper reviews the test approach, conduct, and experimental results of this effort in detail.