SPACE TRANSPORTATION SOLUTIONS AND INNOVATIONS SYMPOSIUM (D2)
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DESIGN AND GROUND TEST OF AN RBCC BASED TWO-STAGE-TO-ORBIT REUSABLE LAUNCH VEHICLE

Abstract

In response to a demand for fast access to near space, a horizontal take-off and horizontal landing TSTO air-breathing reusable launch vehicle (RLV) concept is proposed. The proposed RLV is designed to deliver a maximum 2,000 kg payload to 200km circular orbit with no less than 50 times reuse capability and no more than 48 hours turnaround time. The first stage is powered by Carbon-Hydrogen Rocket Based Combined Cycle (RBCC) engines, and has capability of flying back to the launch site. The second stage is an aircraft-like Hydrogen-Oxygen rocket piggybacked on first stage. In this paper, we put focus on the first stage and introduce the system concept, system design methodologies, and preliminary ground test results for integrated airframe/propulsion technology that is critical to RBCC based RLV. Four sections are included in this paper. In the first section, the system concept and key parameters are defined. Balancing between several alternatives, the configuration of lift-body aerodynamic shape with six-module RBCC engine located under airframe is selected. The optimal separation velocity (2470m/s) and altitude (30km) are chosen by sensitivity analysis. Then, under given mission and selected configuration, the sub-systems of propulsion, thermal protection system, GNC, structure, avionics, separation, undercarriage, and power, are selected and described in detail. In the second section, the Multidisciplinary Design Optimization (MDO) methodology utilized to resolve tight-coupled system design challenge is provided. The methods and tools used include: 1) a weight sizing tool, 2) a multi-point optimizer for aerodynamic shape design over wide-range speeds, 3)a multi-point optimizer for RBCC engine design to meet requirements of all working modes, 4) an integrated aerodynamic/propulsion performance computation tool, 5) a gauss-pseudo spectral based optimizer to find the optimal trajectory, 6) a structural design and sizing method, 7) an thermal protection system concept selection and sizing tool, and 8) a hybrid algorithm and adaptive Response Surface Method based system optimizer. With these methods, the optimal system design found by optimizer is described. In the third section, the recently integrated airframe/propulsion ground test carried out in ϕ2.0m free jet wind tunnel is reported. The test results show that during Mach number 4-7, the performance of aerodynamic and RBCC engine are satisfied. Finally, the next-step arrangement about ground and flight tests to validate performance during Mach number 0-3, especially mode-transition process between ejection and ramjet modes will be reported.