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AN INTEGRATED TURBOPUMP FEED SYSTEM BASED ON GAS GENERATOR CYCLE FOR RBCC IN MULTIPLE MODES

Abstract

Rocket Based Combined Cycle (RBCC) engine has a broad application prospects and important strategic significance. It enables a flight vehicle to take off by itself, accelerate or cruise, and even return to base site by operating in the ejector-, ramjet- and scramjet mode as necessary. Thereby the requirement of propellants for the inserted rocket and the secondary fuel- burning in the ram-combustor varies greatly in different modes of RBCC. An integrated feed system for both the rocket and the secondary burning brings a compacter structure and a lower weight for RBCC, however a wide regulating capability of the feed system is demanded considering the flow rates and pressure rise varying greatly in a whole wide flight envelop. It is shown by a trajectory analysis that the ratio of mass flow rate of a primary rocket is to regulate as high as 11, while the pressure rise demanded for the rocket is as much as 11 times higher than that for the ram-combustor in a range of Ma 0 8 when RBCC as the first propulsion of two-stage-to-orbit (TSTO). Obviously, the regulating ability of an integrated turbo-pump feed system for the RBCC operating in a wide envelop depends greatly on the configuration of the feed system. The paper aims to study the conceptual design of an integrated propellant feed system for RBCC based on a gas-generator cycle. The system performance are assessed at typical operating conditions based on the system modeling and simulation under Easy5 which is verified through RD-170 and F-1 engine system. Firstly, it is found that a conventional gas-generator cycle with a single shaft for kerosene/liquid oxygen rocket engine is unable to cover the propellant feed requirements of RBCC. Then the feed system configuration improvements were carried out and comparisons of the potential systems have been conducted. An appropriate integrated feed system is finally approached. The system consists of two turbo-pumps for the kerosene and liquid oxygen, but what different from the conventional kerosene/liquid oxygen feed systems is that two turbines, driven by a single gas generator, power the two pumps respectively. The RBCC is regulated according to operation modes by splitting the gas flow exiting the gas generator and throttling four propellant flow valves with pressure compensated. The simulations show that the mass flow adjusting ratios reach as high as to 11 and 5 for the primary rocket and the secondary fuel- burning respectively.