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

Author: Dr. Wei Zhao
Chinese Academy of Sciences, China

Dr. Qingjun Zhao
China
Prof. Jianzhong Xu
Institute of Engineering Thermophysics, Chinese Academy of Sciences, China

A PRE-COOLED AND FUEL-RICH PRE-BURNED MIXED-FLOW TURBOFAN CYCLE FOR GROUND-TO-MA5 ENGINES

Abstract

A Pre-cooled and Fuel-rich Pre-burned Mixed-flow Turbofan (PFPMT) Cycle is presented for reusable Ma 5 vehicles based on practical technologies to reduce the travelling time of long distance flights. The PFPMT concept is derived from Air Turbo Rocket (ATR), which is a high-supersonic engine that offers a high thrust-to-weight ratio and specific thrust within a wide flight envelop. However, the oxidizer ATR consumes to generate fuel-rich gas for driving a turbine reduces the engine's specific impulse significantly and limits it to be an accelerator engine. If the oxidizer for ATR comes from atmosphere, so that the specific impulse could be improved, and a cruise engine for high-supersonic flight might be obtained. In ATR the oxidizer pumped to the fuel-rich gas generator upstream of a turbine is at a high pressure to ensure the total pressure at the exit of the turbine equal to that of the compressor. If the turbine expansion ratio is decreased, the pressure of the oxidizer can be reduced and the pump can be replaced with a compressor. PTRC uses an inlet hydrogen precooler to reduce the inlet temperature for a core flow compressor and thus reduces the compression work for a given pressure ratio. The core flow compressor provides pressurized air for a fuel-rich gas generator to burn with the warmed hydrogen from the precoolers. The gas from the gas generator is introduced to a turbine to drive the core flow compressor and a bypass flow fan. The exhaust of the turbine is mixed with the bypass flow in a combustor at an equal total pressure, and is ignited. The high temperature combustion products are expanded in a nozzle to generate thrust. The emphasis in this work is on the analysis of the design parameters for feasible PTRC. Parametric studies are performed with the following parameters: 1) the bypass ratio; 2) the core flow fuel ratio, which is defined as the core flow mass over the fuel mass; 3) the core compressor pressure ratio; and 4) the bypass fan pressure ratio. The cycle simulation results for a PFPMT engine show that on the ground the specific impulse and specific thrust are 4965s and 944N/(kg/s) respectively with a bypass ratio of 7.3, the core compressor pressure ratio of 5, and the bypass fan pressure ratio 2.4. At the flight Mach number of 5.0 the specific impulse and specific thrust become 3860s and 1129N/(kg/s) respectively.