SPACE PROPULSION SYMPOSIUM (C4)
Hypersonic and Combined Cycle Propulsion (5)

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RESEARCH ON HYPERSONIC AIRPLANES USING PRE-COOLED TURBOJET ENGINE

Abstract

Systems analysis of Mach 5 class hypersonic airplanes is performed. The airplane can fly across the Pacific Ocean in 2 hours. A multi-disciplinary optimization program with aerodynamic, thermal structure, propulsion and trajectory is used in the analysis. The accuracy of each element model is improved using higher accuracy analysis tools. Aerodynamic performance of the hypersonic airplane is examined by hypersonic wind tunnel test. Thermal management system based on the data of wind tunnel test is proposed. Pre-cooled turbojet engine is assumed as the propulsion system for the hypersonic airplane. The engine can be operated from takeoff to Mach 5, continuously. This engine has adopted pre-cooling cycle using cryogenic liquid hydrogen. The high temperature inlet air at the hypersonic flight will be cooled by liquid hydrogen for fuel. Hypersonic turbojet engine with pre-cooling system is tested under sea level static condition. The engine is installed on a flight test vehicle, which will fly at Mach 2 speed by a free fall experiment from a stratospheric balloon. Liquid hydrogen fuel and gas hydrogen fuel is supplied to the engine from a tank and cylinders installed in the vehicle. Designated operation of major components of the engine is confirmed. Corrected rotation speed, corrected air flow rate and pressure ratio of the compressor is raised by pre-cooling with liquid hydrogen fuel. Corrected air flow rate and pressure ratio at the pre-cooling operation is reduced comparing from that without pre-cooling on the same corrected rotation speed. There is a deep temperature distortion at the inlet of the compressor and it may cause the performance reduction. Large amount of liquid hydrogen is supplied to the pre-cooler in order to obtain enough pre-cooling performance for Mach 5 flight. Then, fuel rich combustion at the after-burner is adopted. Cowl part of variable geometry nozzle is made with C/C composite material and it has no damage after the combustion test. Operation of the core engine by liquid hydrogen is attained by using a control valve with small effective diameter. The experiment is carried out in the condition that the engine is mounted on an experimental airframe with both horizontal and vertical setup. As a result, it is proved that there is little effect of gravity direction to the engine operation.