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DESIGN OF REGENERATIVELY COOLED COMBUSTION CHAMBER A RBCC ENGINE

Abstract

Various types of hypersonic propulsion systems are pursuing high performance and great reusability with limited onboard fuel in hypersonic region, therefore, an efficient regenerative cooling system should be designed to guarantee the structural integrity of the engine after multiple uses. Rocket Based Combined Cycle (RBCC) engine, one of the promising access-to-space technologies, is still facing the problems of long duration and reusability, because the high integration of rocket and scramjet in the same flow path makes much longer length and bigger heat transfer area than each subcomponent. In order to study the thermal protection system of RBCC engine, a regeneratively cooled RBCC engine at Mach 6 is designed in this paper to ensure the structure is not overheated. The design process employs a validated numerical model which considers the combustion process in the inner flow path with 12-steps reactions, the heat conductive processes through the metal wall and YSZ coating, and the heat transfer/pyrolytic reaction in the cooling channels with 3-steps reactions and 17 species. And to simplify the numerical model and speed up the computation process, the inner flow path is simulated separately while the solid/coolant zones are simulated together, and the heat transfer data on the inner walls are transferred through the interface setting. Firstly, after the flow path design to realize high performance of the engine, the characteristics of thermal environment is analyzed in detail with consideration of parameters' variations in the axial and radial directions. Secondly, a regenerative cooling structure consisting of inlet/outlet manifolds, multiple cooling channels, inner/outer metal walls and YSZ coating is numerically investigated to verify the effectiveness of thermal protection system. The combustor is segmented into three sections, each section is composed of four walls including top wall, bottom wall and two side walls. The numerical result of heat transfer shows that the solid walls can be regeneratively cooled with 1.5 times of hydrocarbon fuel. Finally, the strength of each part of regenerative cooling structures is calculated to ensure the reliability of all the components after a satisfied heat transfer result is obtained. Based on the above analysis, the heat transfer result shows that the current regenerative cooling structure can achieve effective regenerative cooling for the RBCC combustion chamber, and the following strength calculation validates the reliability of the cooling structure. The overall result confirms the validity of regenerative cooling system of a RBCC combustion chamber and could be transferred to the experimental process.