66th International Astronautical Congress 2015

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

Author: Prof. Shen Chibing
National University of Defense Technology, China, cbshen@nudt.edu.cn

Dr. Xianyu Wu
National University of Defense Technology, China, wxynudt@aliyun.com
Mr. Chen Xuefu
College of Aerospace Science and Engineering, National Univ. of Defense Technology, China,
Chxuefu_2013@163.com

STUDY ON THE TURBO-PUMP PERFORMANCE OF THE SCRAMJET FUEL FEED SYSTEM

Abstract

Scramjet is the ideal power system and the core component of hypersonic vehicle, and the critical technology of scramjet has been developed with a significant progress, but the turbo-pump performances of the scramjet fuel feed system have not caught enough attention. The turbo-pump feed system based on expansion cycle is a competitive scheme for the long-time working scramjet with hydrocarbon-fueled regeneration cooling. The hydrocarbon fuel has transition from cold liquid state to supercritical/cracking state after heated in cooling channels which can be used to drive turbine. The study on the turbo-pump performance of scramjet fuel feed system is performed and the supercritical cracked kerosene turbo-pump performance analysis method is proposed on basis of the expansion cycle scheme for scramjet fuel feed system. Turbo-pump performance analysis model is built, and the supercritical cracked kerosene turbo-pump performance is analyzed. Then the following results are obtained: the variation range of the inlet temperature of the supercritical cracked kerosene turbine with inlet pressure, and the available energy content of the working fluid in the turbine and output horsepower. The analysis results of the pump horsepower characteristics show the pump horsepower requirements should be controlled in the range of the turbine output horsepower, and the turbine driven by the supercritical cracked kerosene can meet the pump horsepower requirements by use of controlling reasonably the kerosene pressure and temperature at the turbine inlet. Moreover, turbo-pump performance test is performed, the acting performance of different state working fluid for turbo-pump with nitrogen gas, fuel-rich gas, and heated kerosene are evaluated. Then the flowrate coefficient of the turbine and the turbo-pump efficiency are obtained. Additionally, the following conclusion about the affinity law of a pump can be drawn: there is a good affinity between the pump pressure head ratio and the square of pump rotating speed ratio. From performance tests of turbine driven by heated kerosene, the state of kerosene is researched and the following data in different temperature ranges can be obtained: the thermal cracking conversion rate, average molecular weight, gas constant and expansion acting capacity of kerosene. This work has a benefit to develop the integration design technology of the scramjet system and to study thoroughly the dynamical and thermal coupling problem.