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A CRYOPUMP DESIGN WITH TOTAL CHAMBER PUMPING CONCEPT AND PRO-COOLING PROCESS ANALYSIS

Abstract

In recent years,vacuum plume effects of thruster on board have received considerable interest,such as additional forces and moments,excessive heat loads,and contamination.Because of the cost and time requirements associated with space-based experiments,ground-based experiment is necessary to compliment the limited data obtained in space,so the ground facilities must faithfully and consisitantly reproduce the space environment, especially the degree of dynamic interspace vacuum at thruster working.Maximizing the facilitiy's pumping rates,a total chamber pumping(TCP) concept is proposed and the technology is applicated to the typical ground-based facilities,STG in Germany DLR-research center and CHAFF-4 in University of Southern California. At the Beijing University of Aeronautics and Astronautics in China a new vacuum plume effects experiment system (PES) is now under construction.Its main component is a cylindrical liquid helium-driven internal cryopump,which is fixed in a chamber with a length of 12.6m and a diameter of 5.2m.when a thruster is fired at typical mass flow of 2g/sand to maintain vacuum with a pressure 10-3Pa(space quality) means to install a pumping system with speed of several ten million litres per second. In order to realize the requirement of the vacuum degree, the design of the cryopump is guided by the major demand of the steady plume from 5N thruster ,with a total heat load of about 500w.Based on the TCP concept, two kinds of design scheme,separate and integral cryopump configuration,are proposed.Its outstanding advantage is a three-storeys plume adsorption-pump with an area of about 65m2,which mounted in the liquid helium cryopump and increased the cooling-plate area220m2.the similarity of them is that the constructional elements of PES's pumping system are ribbed pipes made of stainless tube and copper fins.The differences of them are structural framework and mounting mechanism. By comparison, the latter has a superiority of save space, material and cooling medium. In this paper the details of the initial numerical calculation investigation of PES's cryopump pre-cooling process is presented.A best proposal,using LN2 to cool down the radiation shield, plume adsorption-pump and liquid helium cryopump to 80k,is recognized.The further cooling of the plume adsorption-pump and cryopump is driven by LHe. Through the analysis and comparison of the cooling time and LHe consumption at the different flow velocities, the best pre-cooling strategy is obtained.