IAF SPACE PROPULSION SYMPOSIUM (C4)
Electric Propulsion (2) (6)

Author: Mr. Beifei Sheng
China Academy of Space Technology (CAST), China, feixiangniao8388@sina.com

Mr. Siqiao Ge
China Academy of Space Technology (CAST), China, gesiqiao2008@163.com
Mr. Shuo Jiang
China Academy of Space Technology (CAST), China, 454782907@qq.com
Ms. Xuan Zhang
China Academy of Space Technology (CAST), China, zhang_xuan53@163.com
Mr. Fengping He
China Academy of Space Technology (CAST), China, 251924944@qq.com
Mr. Kang Li
China Academy of Space Technology (CAST), China, likang15210582641@163.com

UNEXPECTED ELECTRICAL BREAKDOWN CHARACTERISTICS AND PROTECTION OF PPU IN SPACE ELECTRIC PROPULSION SYSTEM.

Abstract

In order to improve the load ratio, more and more GEO communication satellites begin to use electric propulsion for orbit change, which makes the working environment of electric propulsion devices shift from the vacuum state in GEO orbit to the low atmospheric pressure environment near the ground, which will lead to serious low atmospheric pressure discharge risk of space electric propulsion devices. Especially for ion thrusters, their unexpected electric breakdown will directly affect the reliability of satellite engineering applications. The existing on-orbit cases show that the unexpected breakdown occurred in the power processing unit (PPU) of the ion thruster during the orbit change, which led to the failure of the thruster. Therefore, this paper analyzes the high-voltage components inside the PPU of the miniaturized electric propulsion device, and comprehensively and systematically discusses the PPU and its working environment, the control and protection technology of unexpected electrical breakdown of the electric propulsion system and its aerospace engineering. In this paper, we mainly discuss the electric field strength and discharge margin of high-voltage circuit components, high-voltage shield-grid transformers, high-voltage conductors and other components in the PPU under the conditions of different potting materials or insulation defects, and further propose a method for fault monitoring and evaluation of electric propulsion system based on partial discharge detection. Firstly, the highest transient voltage distribution of each high-voltage device is analyzed by means of transient circuit simulation, and then the electric field distribution of different high-voltage devices is analyzed based on finite element electric field simulation, and its discharge margin is analyzed. The research results show that the discharge margin of high-voltage components in the PPU of the ion thruster is close to the lowest discharge voltage level of uniform electric field under low pressure, so reasonable insulation protection measures should be taken against discharge in high voltage components. The robustness of the PPU is further improved and the fault monitoring and response speed of the electric propulsion system is improved from the perspectives of potting process, insulation shield setting, shield-grid structure adjustment, etc.