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Author: Mr. Spencer Christian
The Ohio State University College of Engineering, United States

Dr. John M. Horack
The Ohio State University College of Engineering, United States

THERMIONIC CONVERTERS: POWER GENERATION FROM WASTE HEAT

Abstract

Power is the most valuable component of every spacecraft. Nonexistent or insufficient power leads to diminished operability of the spacecraft, reduction of scientific experimentation, and challenges in communication, all of which threaten the success of a mission. Because of its high energy density, nuclear power is being actively investigated for extended space missions, specifically crewed and uncrewed travel to - and stays on the surface of - the Moon and Mars. Nuclear thermal propulsion (NTP), nuclear electric propulsion (NEP), and fission surface power (FSP) are all examples of nuclear systems under consideration and evaluation. While legacy NTP designs such as the NERVA engine built and tested by the US in the 1960's and 1970's did not explicitly generate electric power, such capability is inherent to the system. All three nuclear systems (NTP, NEP, FSP) must reject waste heat in order to maintain reactor temperature to prevent meltdown and/or to remove energy from the coolant loop. In this work we investigate recent developments in thermionic converters to generate electricity from this "waste" heat. Although legacy thermionic converters ranged from 5% to 10% efficiency, recent improvements have attained 10% to 20% efficiency. Despite the relatively low efficiency of converters, without conversion to electricity, the power generated needs to be radiated out to deep-space, essentially a "0% usage factor" for the mission. Incorporating thermionic converters into space nuclear power systems therefore can generate additional electric power in environments where every watt of power is critical.