Global Space Exploration Conference 2012

Paper ID: 12712
oral
student

Technology Roadmaps for Space Exploration (09)
Advancing Propulsion Technologies (4)

Author: Mr. Lucas Fischhaber
Center for Space Nuclear Research, United States, lucas.fischhaber@live.com

NEXT STEP IN THE EVOLUTION OF THE NUCLEAR THERMAL ROCKET

Abstract

This study investigates the next experimental step to take in the evolution of the Nuclear Thermal Rocket (NTR). A NTR is enabling for manned missions beyond the moon and therefore implies an urgency and importance for further development. Since 1944 when the concept of using fission heat for rocket propulsion began, NTRs have evolved through design, modeling and experimentation. However, despite decades of modeling and design the last time a NTR was experimentally tested was 1973 when the Nuclear Engine for Rocket Vehicle Application (NERVA) program, using a graphite fuel matrix, ended. The NERVA program demonstrated the NTR is fully capable for space application. Furthermore, through several hours of experimentation and design improvements, the NERVA program's success became a new starting point for future research and development focused on experimentation. The NERVA program culminated with the development, fabrication and testing of a 503 MWt reactor called the PEWEE. Even with achieving success, the NERVA-derived PEWEE reached its full potential due to major limiting factors of the graphite fuel. Graphite fuel requires structural support throughout the matrix core that requires cooling by additional propellant, increasing size and weight. It also is susceptible to cracking thereby leaking fission products and allowing corrosion between the propellant, hot hydrogen, and uranium carbide. A different type of fuel first conceptualized in 1955 but never tested in an experimental NTR, tungsten based CERMET fuel, addresses the above issues. A CERMET fuel matrix does not require structural support and therefore the reactor is more compact and complimentary neutronically for the operation of the reactor and also reduces cooling requirements. Additionally, it is capable of reaching fuel centerline exit temperatures of 3,000 K without melting thereby increasing the propellant exit temperature. This study utilizes, as a starting point, the physical dimensions of the NERVA PEWEE NTR exchanging the graphite fuel for a tungsten rhenium uranium dioxide fuel matrix while making few adjustments such as the length of the core. Goals for this study include demonstrating a higher energy per fuel element than the NERVA-derived PEWEE design; a higher thrust to weight ratio of the W-Re-CERMET PEWEE to the NERVA-derived PEWEE through maximizing propellant exit temperature; and achieving a higher performing specific impulse.