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DEVELOPMENT OF TUNGSTEN BASED CERAMIC-METALLIC (CERMET) FUELS CONTAINING URANIUM DIOXIDE (UO2) FOR NUCLEAR CRYOGENIC PROPULSION STAGE (NCPS)

Abstract

In majority of independent reviews conducted over the last fifty years, Nuclear Thermal Propulsion (NTP) has been identified as a critical technology need for NASA's deep space human exploration. NASA's Advanced Exploration Systems (AES) Nuclear Cryogenic Propulsion Stage (NCPS) project is focusing on the further development of NTP. Main advantages of NTP include a higher thrust to weight ratio and higher specific impulse compared to current liquid propulsion systems. With the completion of the major NTP programs of the 1950's and 60's, little progress has been made on any sustained fuel development work that appreciably contributed to fuel fabrication data. It is important to revisit fuel fabrication technologies to deploy more advanced processes to develop successful NTP fuels. CERMET fuels, specifically W-UO2, are of particular interest to future NTP development for their advantages: (1) High melting temperatures (2) Ability to accommodate a large fission product inventory during irradiation (3) Compatibility with flowing hot hydrogen when coated. We employ Hot Isostatic Pressing (HIP), Fuel Particle Chemical Vapor Deposition (CVD), and Particle Spheroidization System (PSS) for the fabrication of CERMET fuels. Using the Nuclear Thermal Rocket Element Environmental Simulator (NTREES) for testing and analysis of surrogate materials, we report our thermal cycling studies and data. Then, we report our optimization of the fabrication of CERMET fuel: (1) Investigation of various HIP parameters such as run times and temperatures (1600 C - 1900 C) (2) Test of surrogate materials, Zirconium Dioxide (ZrO2) and Cerium Dioxide (CeO2), for the relationship between particle size and its thermal and tensile properties (3) Relationship between fatigue/fracture properties and thermal cycle of ZrO2 and CeO2 (4) Analysis of specific property benefits between Tungsten coated and uncoated particles. The need for NTP is not specific just for NASA, but for any and all international interplanetary or deep space missions.