

Induction Heating Model of Cermet Fuel Element Environmental Test (CFEET)

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ABSTRACT

Deep space missions with large payloads require high specific impulse and relatively high thrust to achieve mission goals in reasonable time frames. Nuclear Thermal Rockets (NTR) are capable of producing a high specific impulse by employing heat produced by a fission reactor to heat and therefore accelerate hydrogen through a rocket nozzle providing thrust. Fuel element temperatures are very high (up to 3000 K) and hydrogen is highly reactive with most materials at high temperatures. Data covering the effects of high-temperature hydrogen exposure on fuel elements are limited. The primary concern is the mechanical failure of fuel elements due to large thermal gradients; therefore, high-melting-point ceramics-metallic matrix composites (cermets) are one of the fuels under consideration as part of the Nuclear Cryogenic Propulsion Stage (NCPS) Advance Exploration System (AES) technology project at the Marshall Space Flight Center. The purpose of testing and analytical modeling is to determine their ability to survive and maintain thermal performance in a prototypical NTR reactor environment of exposure to hydrogen at very high temperatures and obtain data to assess the properties of the non-nuclear support materials. The fission process and the resulting heating performance are well known and do not require that active fissile material to be integrated in this testing. A small-scale test bed; Compact Fuel Element Environmental Tester (CFEET), designed to heat fuel element samples via induction heating and expose samples to hydrogen is being developed at MSFC to assist in optimal material and manufacturing process selection without utilizing fissile material. This paper details the analytical approach to help design and optimize the test bed using COMSOL Multiphysics for predicting thermal gradients induced by electromagnetic heating (Induction heating) and Thermal Desktop for radiation calculations.