Paper ID: 64018
student

24th IAA SYMPOSIUM ON HUMAN EXPLORATION OF THE SOLAR SYSTEM (A5)
Human Exploration of Mars (2)

Author: Ms. Emily Wood
University of Alabama in Huntsville, United States

EVALUATION OF MINIMALLY INTRUSIVE POWER GENERATION ALTERNATIVES FOR A NUCLEAR THERMAL PROPULSION ENGINE

Abstract

In a Nuclear Thermal Propulsion engine, after the nuclear reactor is used to provide thrust for the first burn, it cannot be completely shut down or else the fuel elements will cool past their ductile-to-brittle transition temperature and could crack. Instead of shutting the reactor down, control drums will rotate to decrease the power output to idle. In its idle mode, the reactor is estimated to generate 10 MWt. Bimodal nuclear thermal propulsion attempts to convert all of this idle mode heat into electricity for the vehicle. However, bimodal designs call for intrusive changes to the reactor design, such as modification to the number and size of the coolant passages in the fuel elements. Thus, arose the idea for a Minimally-Intrusive Power generation System (MIPS). A MIPS can remove some of the heat generated by the rector in idle mode and removed by the non-propulsive hydrogen coolant loop and convert it to usable power for the vehicle without any changes to the reactor design and only minimal changes to the engine design. The specific application for this MIPS study is for a crewed Mars Transfer Vehicle (MTV) for a round-trip mission to Mars. The power conversion systems considered in this study are a closed-loop Brayton cycle, a Stirling engine, and thermoelectric generators (TEGs). The masses of these systems were compared to the current system for power generation for the MTV – solar arrays. Power requirements for the MTV may range from anywhere between 25 kWe to 100 kWe. Therefore, mass and power data were determined for four increments between those bounds for each of the power generation systems. In order to determine the power output of each system, mathematical models were developed using MATLAB. In order to determine the mass of the Brayton and Stirling engines, CAD models were created using Creo Parametric. It was found that all three of the MIPS alternatives resulted in substantial mass savings for the vehicle. Therefore, MIPS could be a viable candidate for power generations for transport vehicles which use Nuclear Thermal Propulsion.