Marshall Problem Statement / Student Design Topic

Problem Title: High Performance Nuclear Thermal Propulsion (NTP)

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Indicate which discipline/s is/are most appropriate to work on this problem, e.g., aerospace, mechanical, electrical, chemical, industrial, civil, computer, physics, materials, test, nuclear, earth science, other

Aerospace, Mechanical, Nuclear

Marshall Problem Statement

Background: The big picture with references to previous work (Why would a student design student be excited about this work?)

Nuclear Thermal Propulsion (NTP) systems could enable numerous advanced space missions. First generation NTP systems could provide high thrust at a specific impulse of ~900 s, roughly twice that of the best chemical rocket engines. Second generation NTP systems could provide an Isp of up to 1800 s if hydrogen is used as propellant, and up to ~900 s if ammonia, methane, or water is used. If successfully developed, second generation NTP systems could help enable the exploration, utilization, and colonization of the solar system.

Recent/on-going research on the problem (What resources, if any, are available to the student design team, such as equipment, software, facility utilization)

There is an ongoing NTP project within NASA, focused on first generation NTP systems. Although this project would focus on second generation systems, the ongoing first generation work would provide an excellent foundation and resource.

Details of the problem; design constraints, requirements (if any), outcome expected (one semester student Design course lasts 15 weeks; two semester course lasts 30 weeks.) (What do you expect the student design team to accomplish?)

This project will investigate engineering challenges associated with one proposed second generation NTP concept. The proposed concept is designed to use only traditional engineering materials and established neutron moderators and reflectors. If available, a solid nuclear fuel (such as a Mo/UN cermet) capable of operating at temperatures above 1200 C may also provide operational and performance benefits.

The unique feature of the concept is that the ~20 individual fuel elements (~10 cm diameter each) rotate to allow centrifugal force to be used to contain uranium fuel and to keep uranium fuel from being entrained in the propellant as it passes through the fuel, even if the fuel is in the liquid or vapor phase.

The specific outcome of the project will be the design and representative non-nuclear demonstration of the rotating fuel cylinder. Key design features will include the propellant distribution system and the ability of the cylinder to providing mixing of the propellant and fuel followed by efficient separation via centrifugal force.

Student Design Project Rules:

1. Weekly telecons will be scheduled to maintain proper progress and prevent dead-end ventures.

2. Deliverable/s required (e.g. one semester course – a written final report; two semester course – written final report and a prototype/model (if practical))