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KEYNOTE: DIELECTROPHORESIS AS A MEANS FOR RECYCLING ENTRAINED URANIUM FOR IMPROVED SPECIFIC IMPULSE IN LIQUID CORE NUCLEAR ROCKETS

Abstract

Nuclear Thermal Propulsion (NTP) systems offer increases in performance compared with chemical propulsion for in-space missions. The so-called bubble-through nuclear reactor design features a reactor fuel which is rotated at high speed to maintain a layer of molten fuel around the hydrogen-permeable inner cylindrical surface, and this concept is referred to at the Centrifugal Nuclear Thermal Propulsion (CNTP) system. CNTP systems may reach Isp values from 1100 to 1800 seconds, a marked improvement over solid core NTP systems with 850 to 900 s. One of the concerns with CNTP is vaporization of the uranium and entrainment into the hydrogen propellant stream. Just a 1Motivated by potentially significant reduction in CNTR rocket performance due to molten uranium vaporization, we propose electrodynamics for recycling the uranium, preventing both reactor fuel loss and reduction in specific impulse. Specifically, we will investigate dielectrophoresis for selectively removing the evaporated uranium from the hydrogen propellant. Dielectrophoresis (DEP) is a force exerted on any material when subject to a non-uniform electric field. Compared with electrostatic forces, materials (solid, liquid, gas, particles) do not need to be charged. Because of material-based frequency dependence, DEP can manipulate material with great selectivity, including metal droplets. In this paper, we will present a notional concept for dielectrophoresis recovery of uranium vapor, including electrode geometry, voltage requirements, modeling, and power requirements. The power requirements per CFE fuel element will be characterized as a function of geometry, and it is shown that theoretically, only 100 W is required per centrifugal fuel element (CFE). A 3D method of moments simulation will provide the electric field, and the volumetric force will be used to model the uranium vapor 'current' and trajectory against the CFE hydrogen flow. A design of subscale experiments will be given to provide early feasibility of the concept.