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ADDRESSING CHALLENGES TO ENGINEERING FEASIBILITY OF THE CENTRIFUGAL NUCLEAR THERMAL ROCKET

Abstract

The Centrifugal Nuclear Thermal Rocket (CNTR) is a Nuclear Thermal Propulsion (NTP) concept designed to heat propellant directly by the reactor fuel. The primary difference between the CNTR concept and traditional NTP systems is that rather than using traditional solid fuel elements, the CNTR uses liquid fuel with the liquid contained in rotating cylinders by centrifugal force. If the concept can be successfully realized, the CNTR would have a high specific impulse (1800 s) at high thrust, which may enable (i) viable near-term human Mars exploration by reducing round-trip times to 420 days and (ii) direct injection orbits for scientific rendezvous missions to the Solar System outer planets and Kuiper Belt objects. The CNTR could also use storable propellants such as ammonia, methane, propane, or hydrazine at an Isp of, enabling long-term in-space storage of a dormant system. Research is presently underway to determine resolutions for the significant engineering challenges that the CNTR concept presents. Papers were presented at the 2021, 2022, and 2023 IACs which described these challenges, the study plan to address them, and progress to date. In particular, the 2023 paper described progress to level the heat generation gradient in the liquid uranium annulus, which allows higher operating temperature and achieves engine performance approaching the target of 1,800 s. This paper provides a follow-on update which summarizes progress of the overall research effort, including strategies and key results to date on establishment of a reference configuration, definition of key parameters which allows integration of the results of various analyses, and reviews strategies to mitigate the problem of Uranium vapor saturating the propellant exhaust and significantly impacting the CNTR's specific impulse. Finally, updated estimates of engine key performance parameters including specific impulse, thrust and thrust to weight ratio will be given along with the identification of selected design margins within the engine itself - all toward the goal of enabling plans for a laboratory demonstration of a single Centrifugal Fuel Element.