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Author: Mr. Roger X. Lenard
LPS, United States

RESULTS OF LPS MULTI-PHYSICS MODELING OF A NTR IN A NASA PHASE I SBIR

Abstract

On June 29, 2014, Little Prairie Services was awarded a Phase I NASA SBIR to perform an initial assessment of multi-physics modeling of a nuclear thermal rocket engine. The LPS team comprised of Little Prairie Services, Sandia National Laboratories and the Center for Space Nuclear Research performed sweeping investigations of available multi-physics models. The initial simulation code which optimizes a nuclear rocket engine design, is called IROC for Integrated Rocket Optimization Code which forms the initial executive for the entirety of the design process. When we started the effort, IROC was comprised of two separate analysis codes under control of a Matlab routine. The two parts of the code consistent of MCNP-6X and an internally developed finite-difference thermal hydraulics code. The two codes could be manually coupled. Within the Phase I effort, LPS integrated the two codes so that the neutronics analysis, which produced energy tallies, later converted to power profiles was integrated within Matlab to determine power-to-flow matching and could show hot-spots within the core. This allowed the core to be modified to enhance power flattening and produce a more uniform mixed mean outlet temperature.

In the Phase I effort, we linked the results of a simple concentric circle reactor concept via a .stl file into Sandia's massively parallel hydrocode, PRESTO. This code shows how a reactor will deform during an impact. The code is highly benchmarked and performs well for impact safety analyses. We demonstrated coupling the output of PRESTO via an LPS proprietary translator to Serpent 2, a mesh-based transport code. We performed a criticality calculation based on the high-speed impact of a UO2 penetrator into water. The results were dramatic. In the Phase I effort, we also linked Serpent2 with certain MOOSE (Multi-Physics Object Oriented Simulation Environment) codes, and integrated Serpent 2 with YAKXS cross-section informed by the mesh. Finally RattleSNake, solves the k-eigenvalue problem for transient analyses.

Finally, the LPS team evaluated the ability of fiber optics systems to perform certain nuclear thermal rocket engine operational parameters for the typical operational run time. Parameters such as vibration, temperature and strain were shown to be feasible within certain temperature limits.

This paper presents the results of the project and potential follow-on work.