Initial Operation of the Nuclear Thermal Rocket Element Environmental Simulator

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Abstract. The Nuclear Thermal Rocket Element Environmental Simulator (NTREES) facility is designed to perform realistic non-nuclear testing of nuclear thermal rocket (NTR) fuel elements and fuel materials. Although the NTREES facility cannot mimic the neutron and gamma environment of an operating NTR, it can simulate the thermal hydraulic environment within an NTR fuel element to provide critical information on material performance and compatibility. The NTREES facility has recently been upgraded such that the power capabilities of the facility have been increased significantly. At its present 1.2 MW power level, more prototypical fuel element temperatures nay now be reached. The new 1.2 MW induction heater consists of three physical units consisting of a transformer, rectifier, and inverter. This multiunit arrangement facilitated increasing the flexibility of the induction heater by more easily allowing variable frequency operation. Frequency ranges between 20 and 60 kHz can accommodated in the new induction heater allowing more representative power distributions to be generated within the test elements. The water cooling system was also upgraded to so as to be capable of removing 100% of the heat generated during testing

In this new higher power configuration, NTREES will be capable of testing fuel elements and fuel materials at near-prototypic power densities. As checkout testing progressed and as higher power levels were achieved, several design deficiencies were discovered and fixed. Most of these design deficiencies were related to stray RF energy causing various components to encounter unexpected heating. Copper shielding around these components largely eliminated these problems. Other problems encountered involved unexpected movement in the coil due to electromagnetic forces and electrical arcing between the coil and a dummy test article. The coil movement and arcing which were encountered during the checkout testing effectively destroyed the induction coil in use at the time and resulted in NTREES being out of commission for a couple of months while a new stronger coil was procured. The new coil includes several additional pieces of support structure to prevent coil movement in the future. In addition, new insulating test article support components have been fabricated to prevent unexpected arcing to the test articles.

Additional activities are also now underway to address ways in which the radial temperature profiles across test articles may be controlled such that they are more prototypical of what they would encounter in an operating nuclear engine. The causes of the temperature distribution problem are twofold. First, the fuel element test article is isolated in NTREES as opposed to being in the midst of many other mostly identical fuel elements in a nuclear engine. As a result, the fuel element heat flux boundary conditions in NTREES are far from adiabatic as would normally be the case in a reactor. Second, induction heating skews the power distribution such that power is preferentially deposited near the outside of the fuel element. Nuclear heating, conversely, deposits its power much more uniformly throughout the fuel element. Current studies are now looking at various schemes to adjust the amount of thermal radiation emitted from the fuel element surface so as to essentially vary the thermal boundary conditions on the test article. It is hoped that by properly adjusting the thermal boundary conditions on the fuel element test article, it may be possible to substantially correct for the inappropriate radial power distributions resulting from the induction heating so as to yield a more nearly correct temperature distribution throughout the fuel element.

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