

Nuclear Thermal Rocket Element Environmental Simulator (NTREES) Upgrade Activities

Joint Propulsion Conference

July 14 - 17, 2013



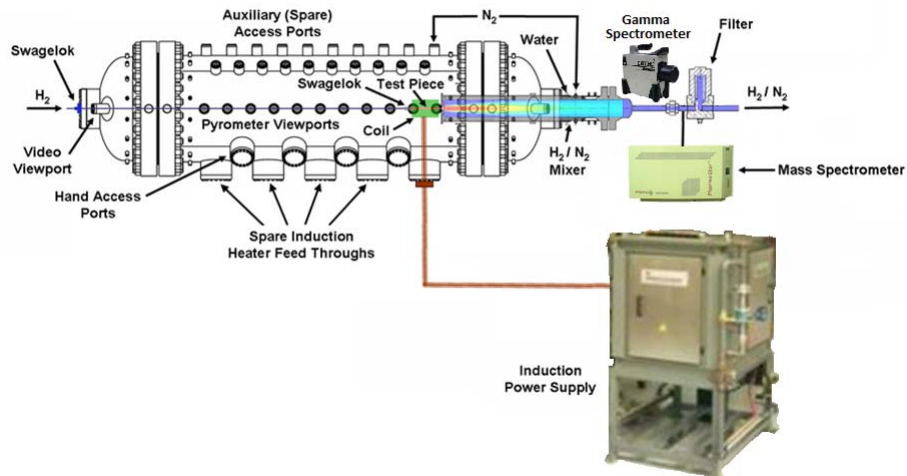
Nuclear Thermal Rocket Element Environmental Simulator (NTREES)

A key technology element in Nuclear Thermal Propulsion is the development of fuel materials and components which can withstand extremely high temperatures while being exposed to flowing hydrogen. NTREES provides a cost effective method for rapidly screening of candidate fuel components with regard to their viability for use in NTR systems

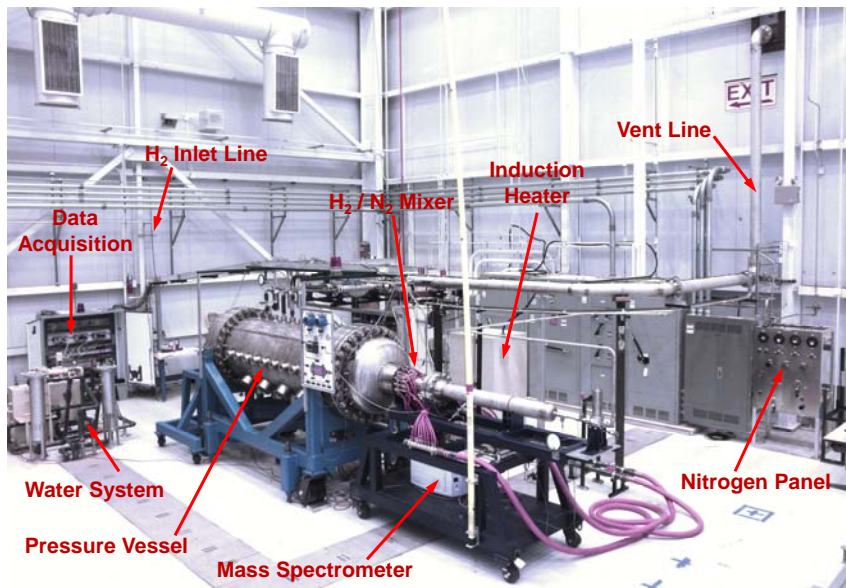
- The NTREES is designed to mimic the conditions (minus the radiation) to which nuclear rocket fuel elements and other components would be subjected to during reactor operation.
- The NTREES consists of a water cooled ASME code stamped pressure vessel and its associated control hardware and instrumentation coupled with inductive heaters to simulate the heat provided by the fission process.
- The NTREES has been designed to safely allow hydrogen gas to be injected into internal flow passages of an inductively heated test article mounted in the chamber.



NTREES Hardware Test Chamber and Induction System



Initial NTREES Configuration in 4205/101





NTREES Power Upgrade Activities

- NTREES induction power supply will be upgraded to 1.2 MW
- Water cooling system will be upgraded to remove 100% of the heat generated during testing
- Nitrogen system will be upgraded to increase the nitrogen flow rate to at least 4.5 lb/sec
- New piping will be put in at strategic locations to handle the increased flow rates
- The H₂ / N₂ mixer will be upgraded to handle the increased heat loads



NTREES GN₂ System

- Inerts and dilutes the hydrogen flow
- Cools the exhaust gases
- Flow rates up to 1.5 lb/sec. Limited by the currently installed building piping
- Building supplies nitrogen at 4500 psi





NTREES GH₂ Test Configuration

- GH₂ panel and associated components have been relocated to a position 50 feet away from the exterior of the building
- Hydrogen supply from trailer is only hooked up during tests
- H₂ detectors strategically located inside the building to detect potential leaks at fittings



NTREES Data Acquisition and Control



- *Labview* based
- Real time embedded controllers
- Ethernet connection to control computer
- Many extra channels for future expandability
- Backup power unit in case of building power loss



Upgraded NTREES Configuration

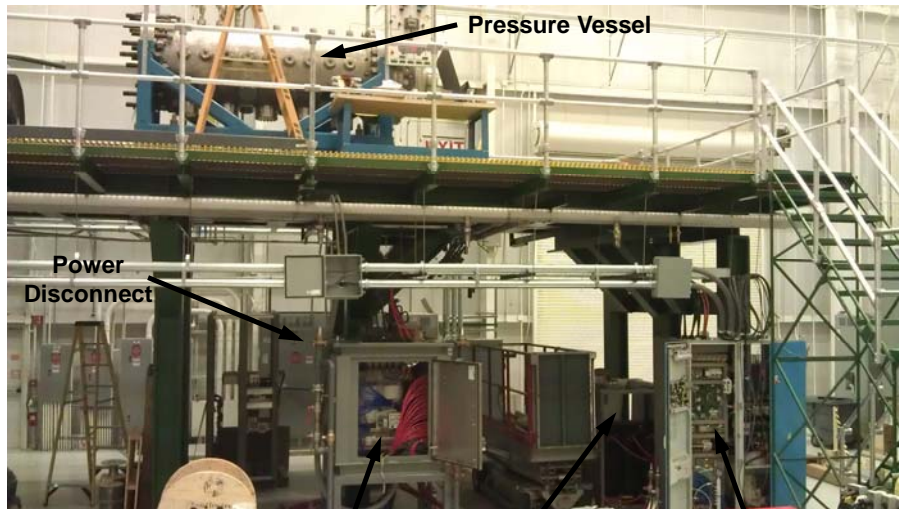
Chamber Lifted into Place



Chamber in Place on Platform



Upgraded NTREES Configuration



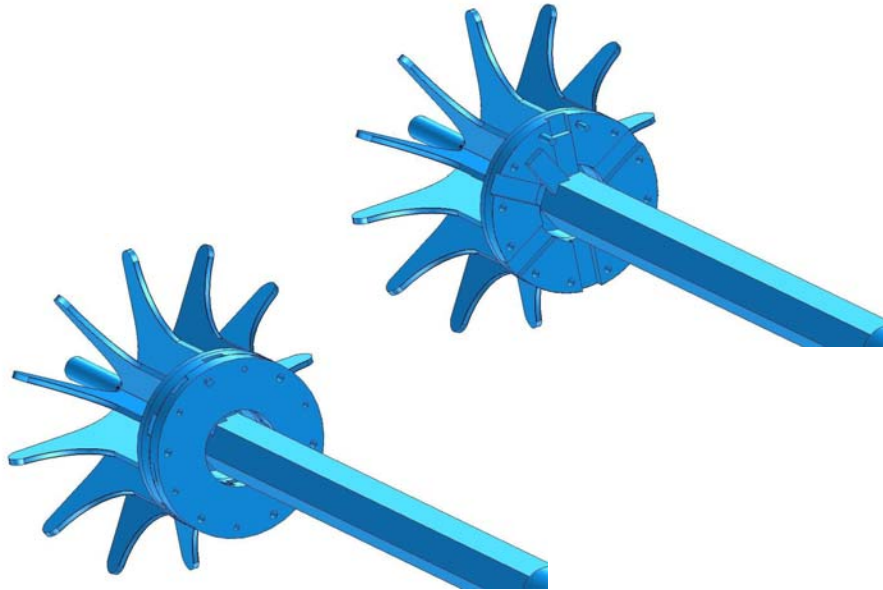
Inverter

Transformer

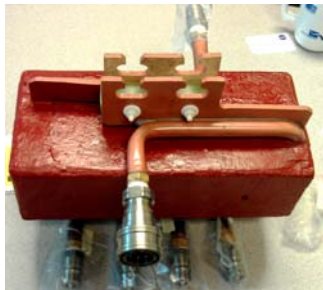
Rectifier



Fuel Element Clamp (Cold End)



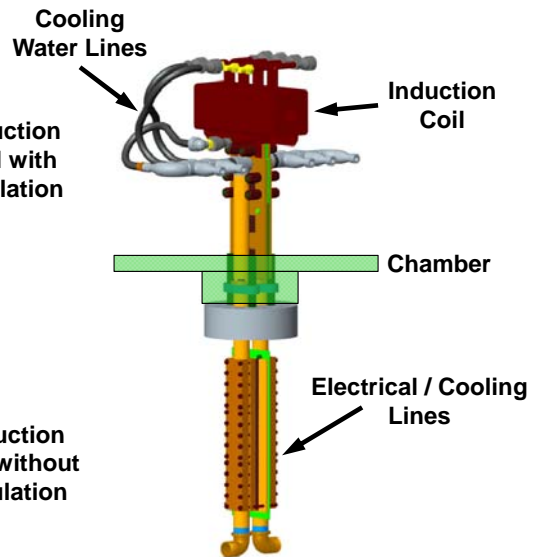
Induction Coil & Feedthrough Assembly



Induction Coil with Insulation

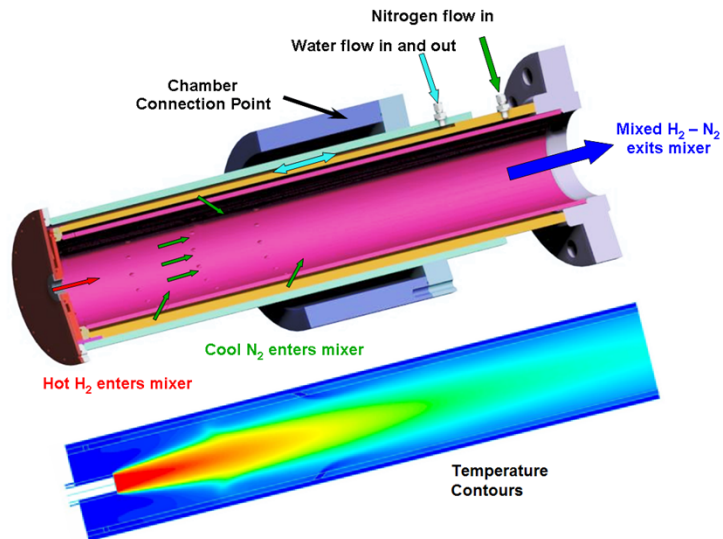


Induction Coil without Insulation

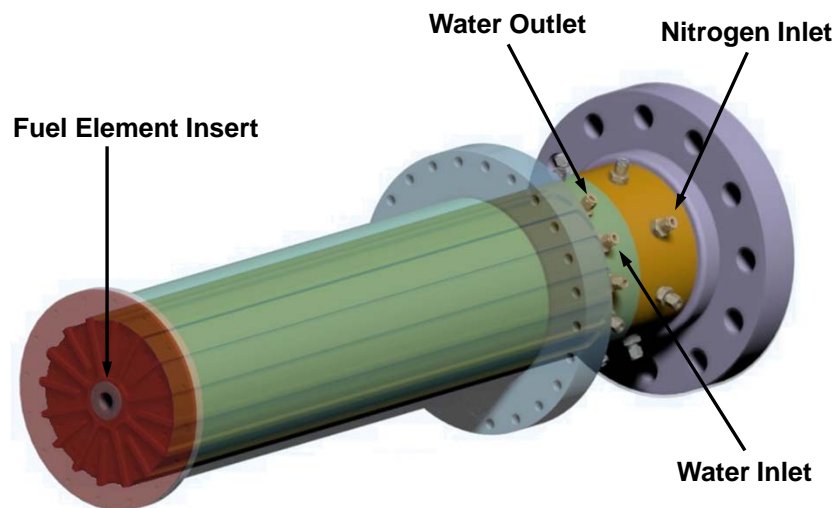




H₂ / N₂ Mixer Assembly



H₂ / N₂ Mixer Assembly





H₂ / N₂ Mixer Assembly

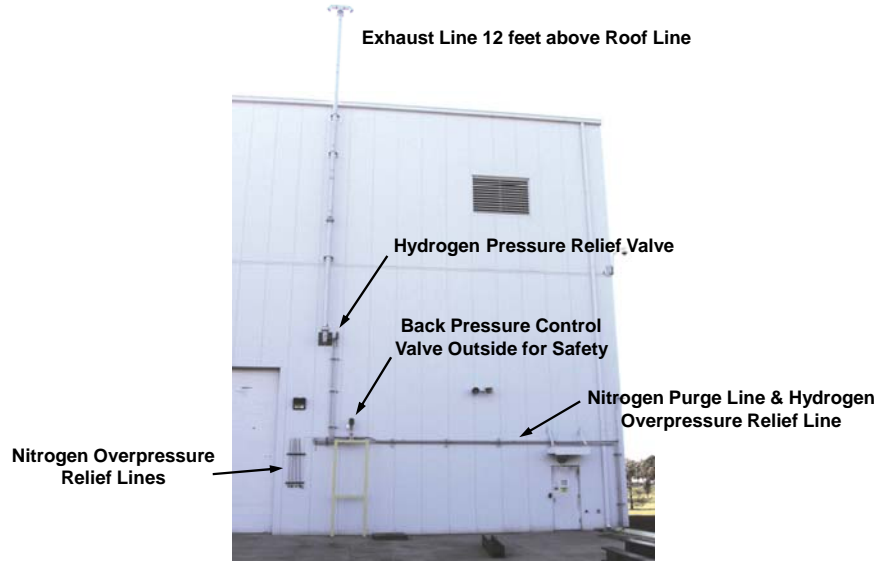


H₂ / N₂ Mixer Assembly





NTREES Exhaust System



Fuel Element Test in NTREES





Fuel Element after Testing in NTREES



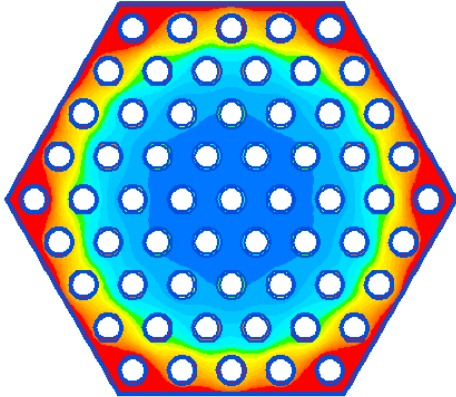
Induction Heating versus Fission Heating

- Fission heating will yield fairly flat power and temperature profiles across the fuel element
- Induction heating can yield fairly skewed power and temperature profiles across the fuel element
- Varying the frequency of induction heating can greatly help in this regard
- External wall cooling of fuel elements heated inductively can also help flatten the temperature profiles.

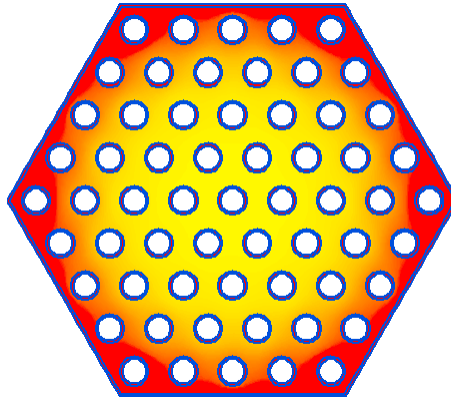


Induction Heating Profiles in an ANL-200 Fuel Element

Induction Frequency = 60 kHz

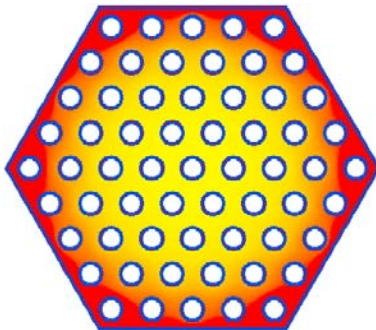


Induction Frequency = 20 kHz

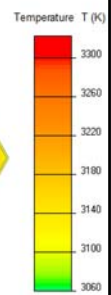
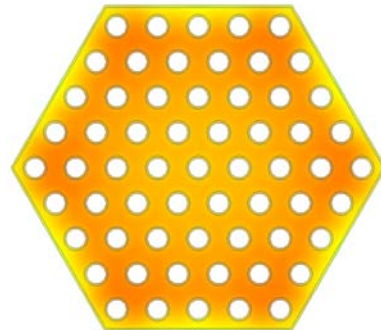


Power & Temperature Profiles in an ANL-200 Fuel Element

Power Profile



Temperature Profile with Wall Cooling





Summary and Status

- All big ticket items have been purchased. Only small dollar purchases will be required to finish NTREES assembly. Sequestration should minimally affect schedule
- Nitrogen system upgrade will be delayed until next year due to funds limitations. Power will probably be limited to several hundred kilowatts
- H₂ / N₂ mixer assembly is complete
- Water system is essentially completed
- Sound proof control room has been purchased and will be assembled in the next couple of months
- NTREES is on schedule to be completely assembled by late fall
- First fuel element tests should occur in late spring 2014