Team 514: Hydrogen Pre-Heater in the Nuclear Thermal Rocket Simulation

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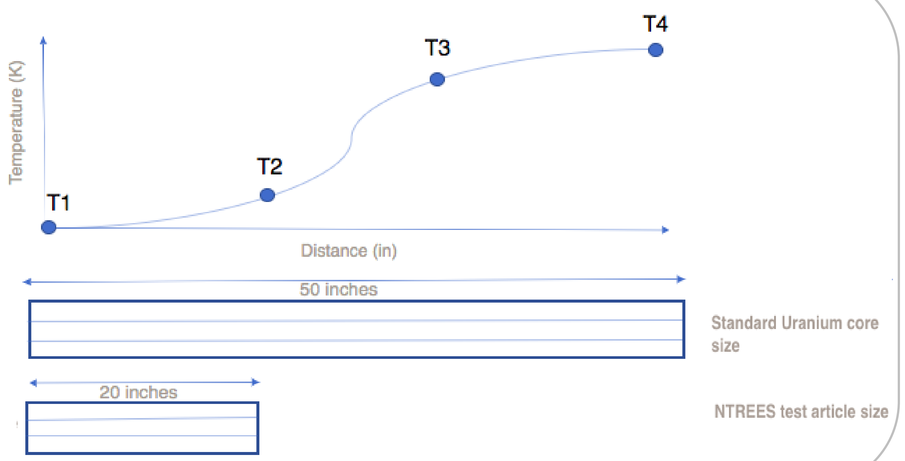
Project Description

The objective of this project is to provide a tool that allows customers to choose heating components to achieve desired outlet temperatures of hydrogen flow and to design a heat exchanger that meets fixed operating requirements

Background/Motivation

NASA's NTREES (Nuclear Thermal Rocket Element Environment Simulator) currently simulates the conditions found in a nuclear fuel element of a nuclear thermal rocket with a 20-inch test article and induction coils wrapped around the test article to heat hydrogen flowing inside. The true size on the nuclear fuel element is 50 inches, so in order to properly simulate varying temperatures across the true length, a pre-heater must be used. The images below show what a temperature profile might look like and a comparison of the true length to simulation length.



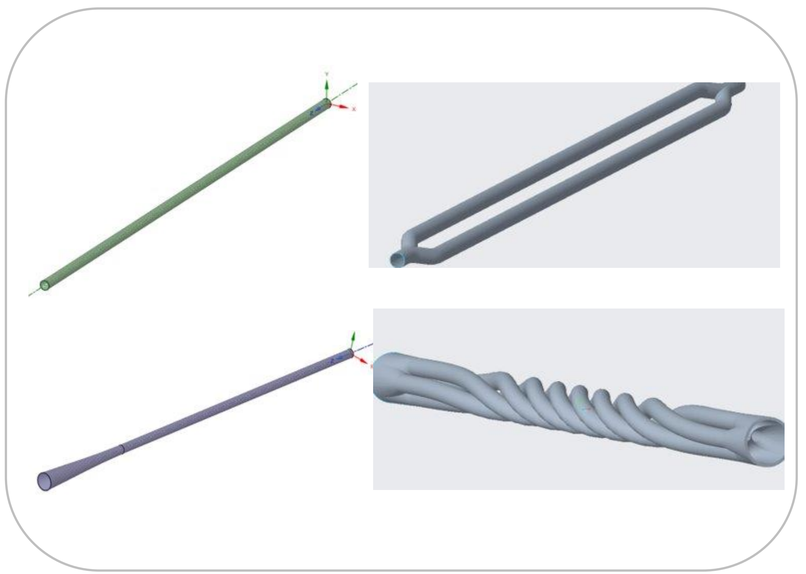
Selected Designs

Operating Requirements & Design Constraints

- 10 g/s mass flow rate
- 1000 psi incoming hydrogen pressure
- 900 K outlet temperature
- 2-inch diameter, 20-inch-long cylindrical design space

Optimization Parameters

- Cross-sectional temperature distribution because heating occurs on surface and conducts into the colder fluid
- Pre-heating (outlet temperature)

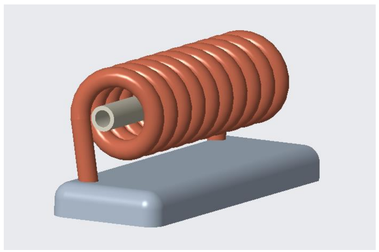


CAD renderings of designs

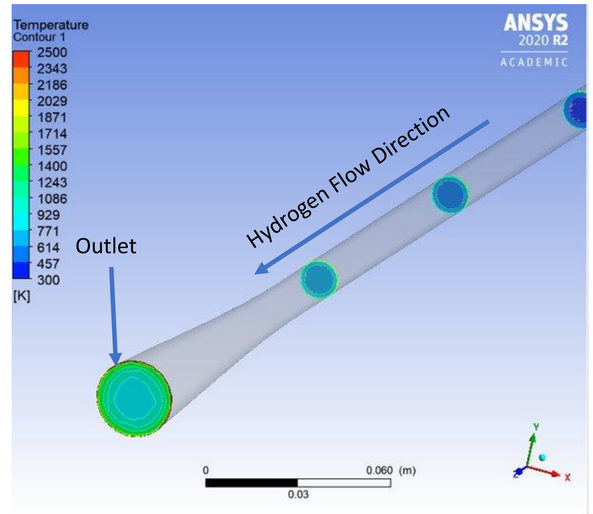
Analysis Results

Assumptions

- No radiation heat transfer
- Constant heat flux boundary condition
- Ideal gas
- All heat transfer on surface of heat exchanger enters fluid



Induction coils and test article



Temperature distribution for best design