Thermal Propulsion Capture System Heat Exchanger Design

National Aeronautics and Space Administration

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One of the biggest challenges of manned spaceflight beyond low earth orbit and the moon is harmful radiation that astronauts would be exposed to on their long journey to Mars and further destinations. Using nuclear energy has the potential to be a more effective means of propulsion compared to traditional chemical engines (higher specific impulse). An upper stage nuclear engine would allow astronauts to reach their destination faster and more fuel efficiently. Testing these engines poses engineering challenges due to the need to totally capture the engine exhaust. The Thermal Propulsion Capture System is a concept for cost effectively and safely testing Nuclear Thermal Engines. Nominally, hydrogen exhausted from the engine is not radioactive, but is treated as such in case of fuel element failure. The Thermal Propulsion Capture System involves injecting liquid oxygen to convert the hydrogen exhaust into steam. The steam is then cooled and condensed into liquid water to allow for storage.

- Introduction -

The Thermal Propulsion Capture System concept for ground testing of a nuclear powered engine involves capturing the engine exhaust to be cooled and condensed before being stored. The hydrogen exhaust is injected with liquid oxygen and burned to form steam. That steam must be cooled to saturation temperatures before being condensed into liquid water. A crossflow heat exchanger using water as a working fluid will be designed to accomplish this goal.

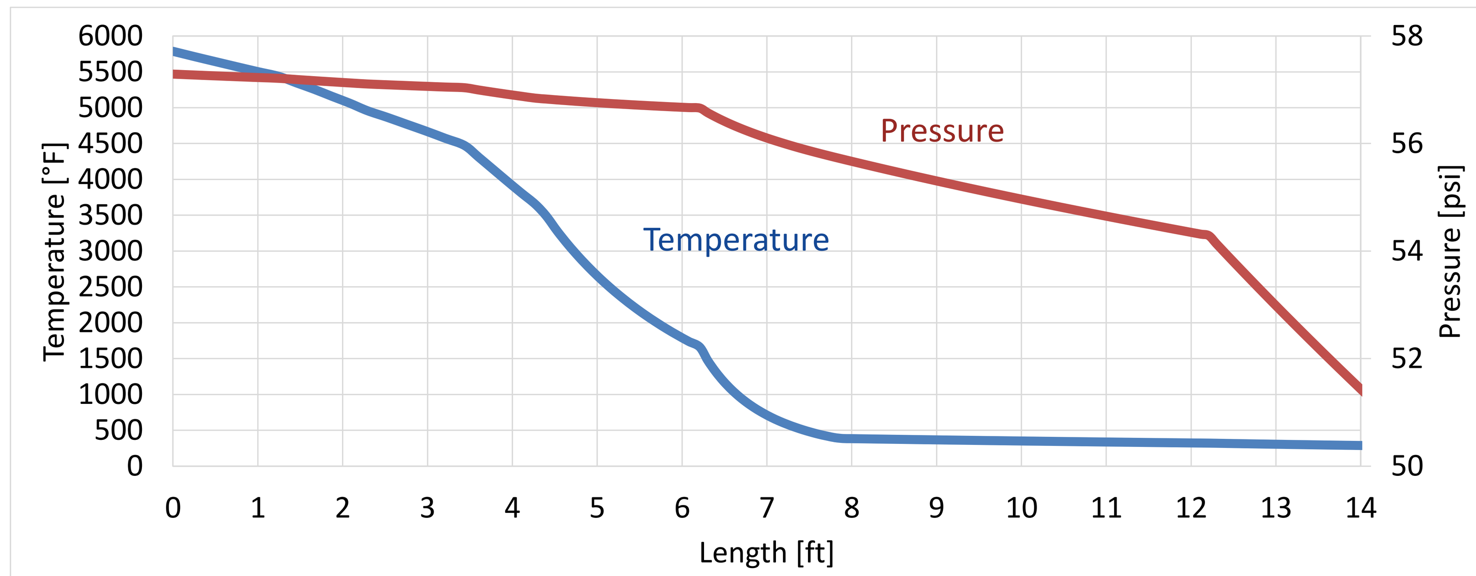
- Objectives -

Design a cross flow heat exchanger for the Thermal Propulsion Capture System testing which:

- Eliminates the need for water injection cooling
- Cools steam from 5800°F to saturation temperature
- Is efficient and minimizes water requirement

- Outcomes -

- Cross section: 15.0 ft. x 15.0 ft.
- Length: 14.0 ft.
- Tube Size: 1.0 in.
- Total Flow Rate: 150,000 gpm



- Nuclear Engine Concept -

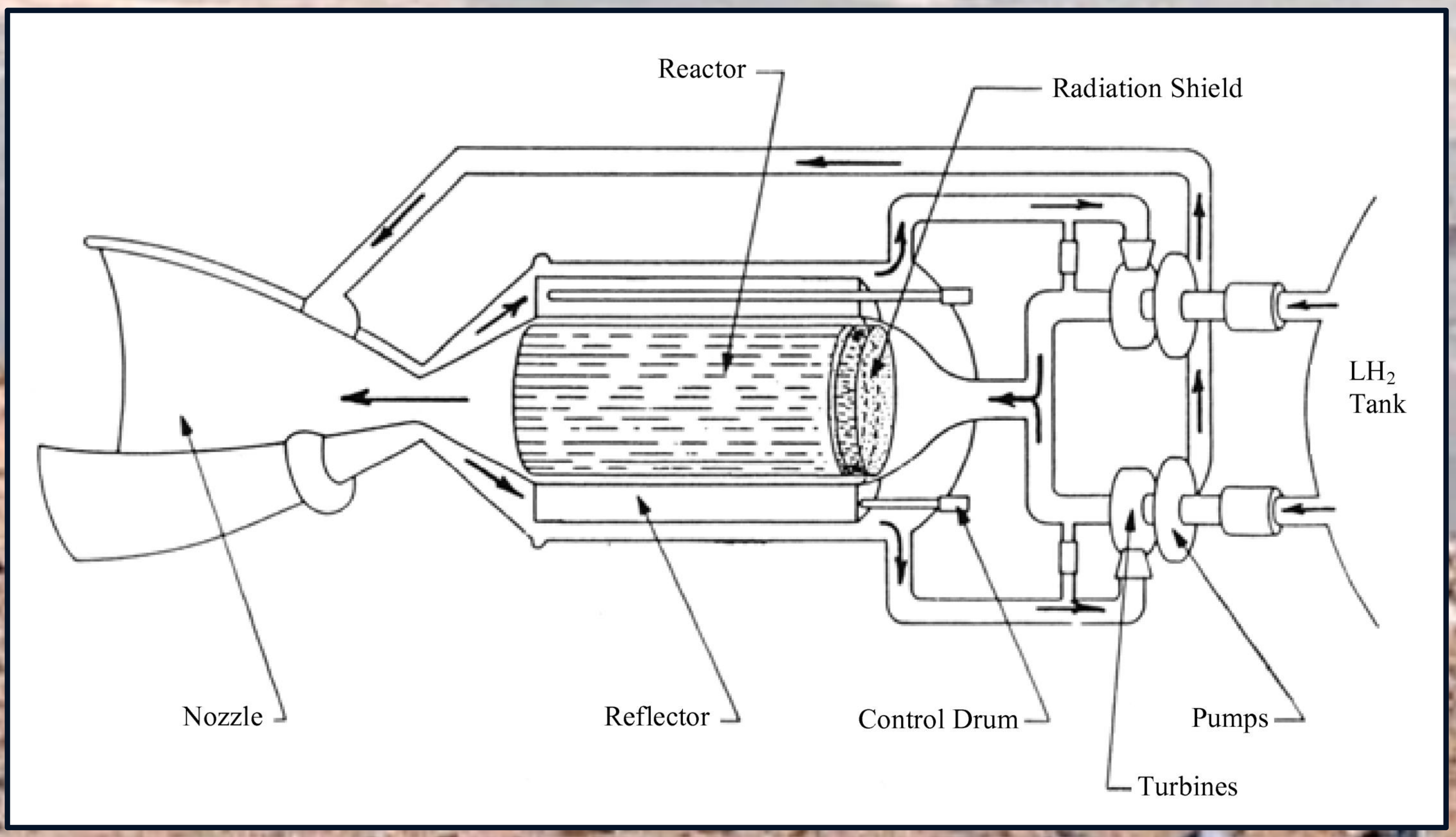
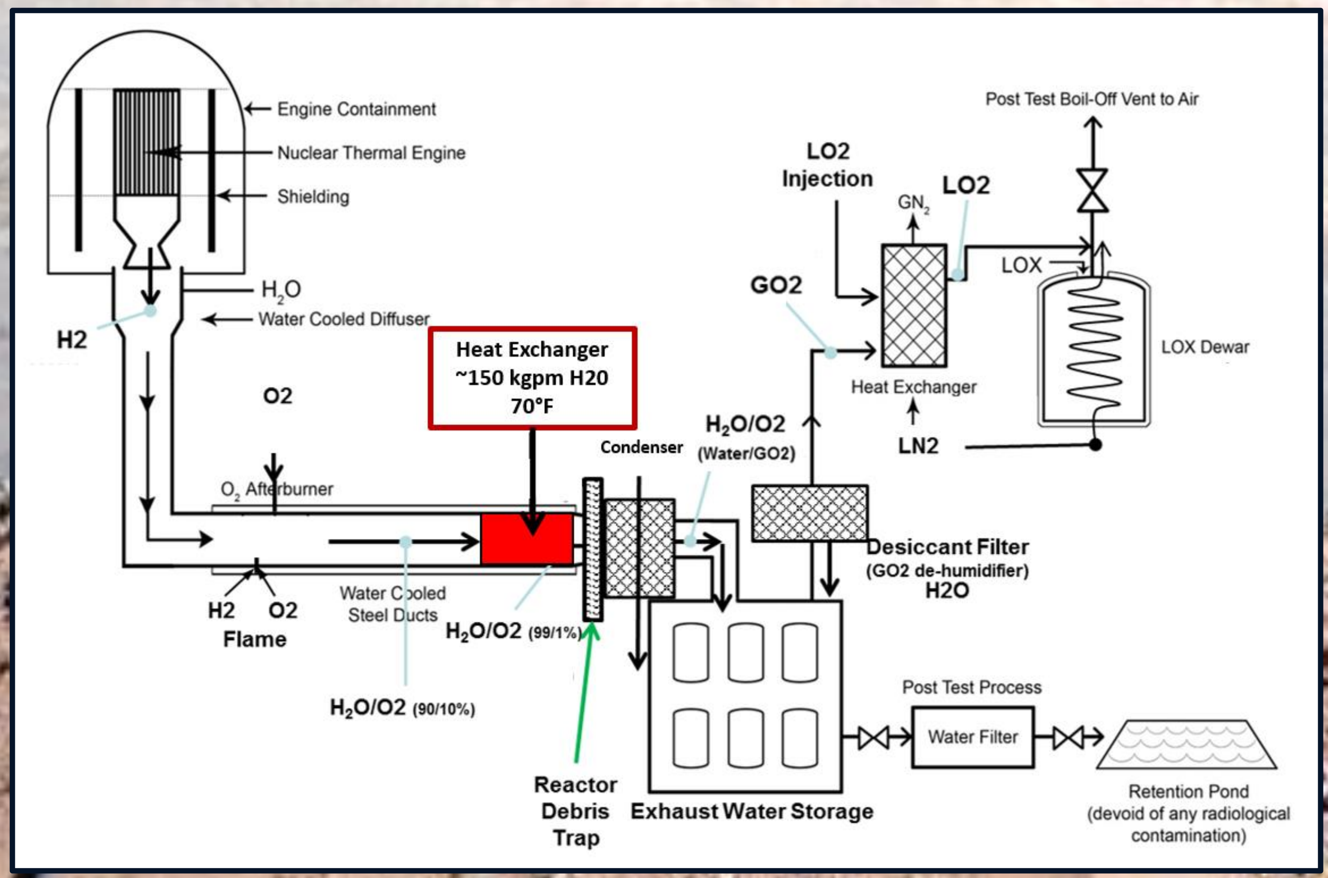


Image source: large.stanford.edu

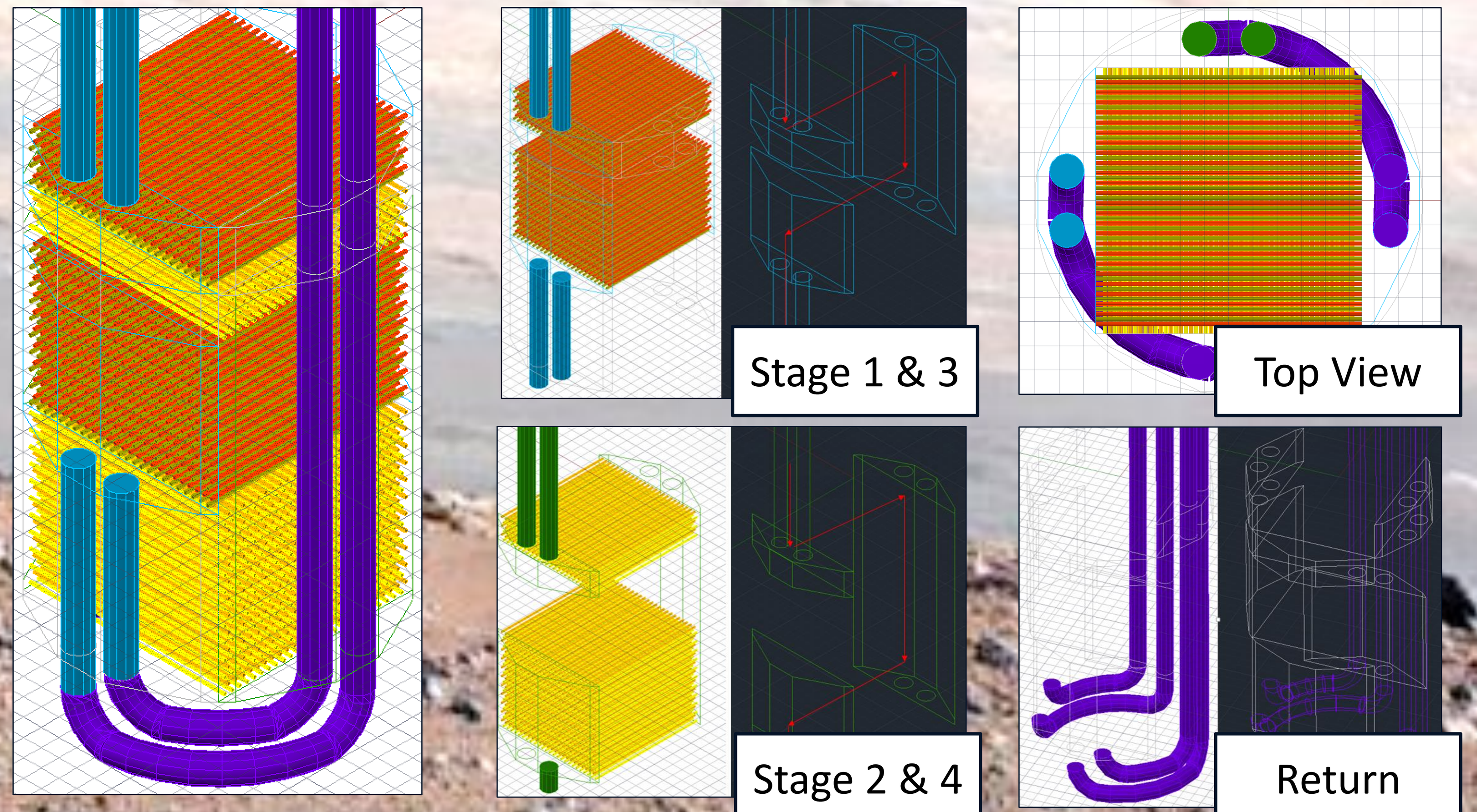
Concept Schematic of a mono-propellant, regenerativly cooled nuclear thermal engine

- Thermal Propulsion Capture System -



Schematic of the Thermal Propulsion Capture System shows where heat exchanger would replace water injection

- Heat Exchanger Model -



Representative AutoCAD® model of a crossflow, 4 stage heat exchanger done by Richard Wear

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