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Research Project: Modeling Supercritical Brayton Power Conversion for a Direct Cooled Reactor

College of Engineering
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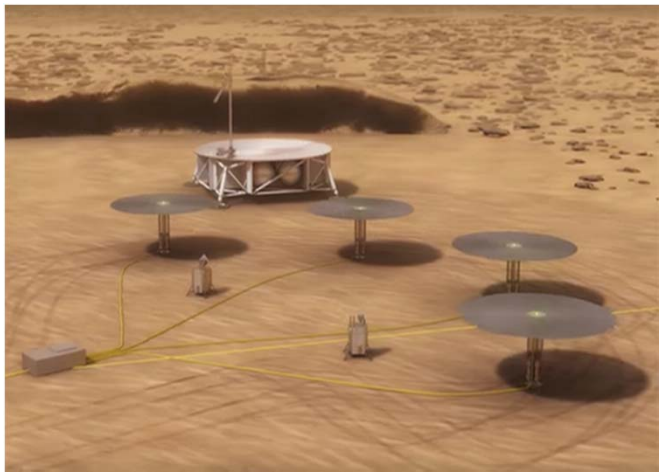
Mars Surface Power for Human Exploration

- Manned missions will require readily available surface power
- Power uses
  - *Astronauts' habitats*
  - *Science equipment*
  - *Oxygen and water*
  - *Propellant for the return trip to Earth*



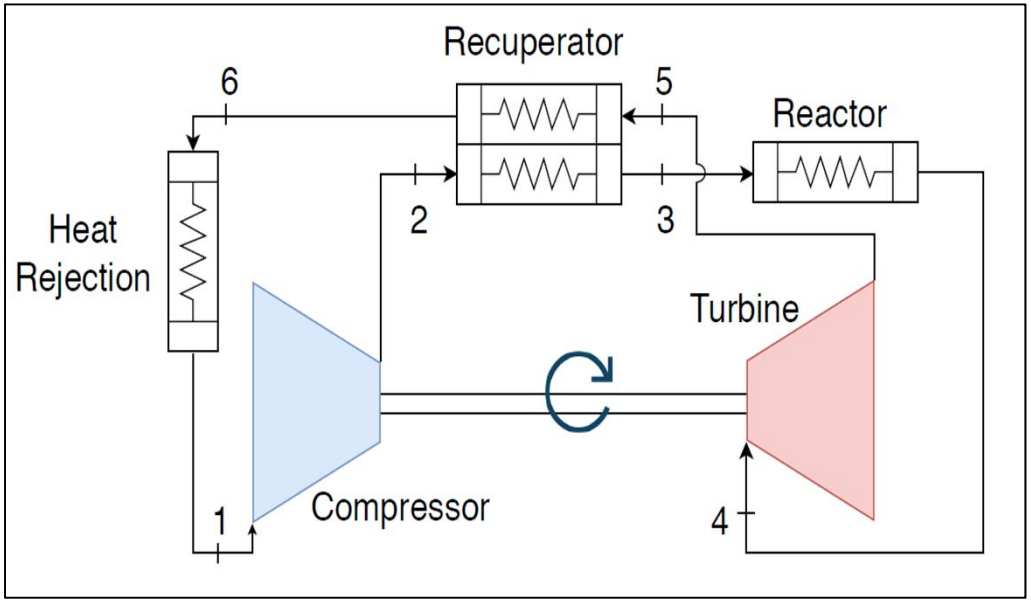
Credit: NASA

- Nuclear heat source was chosen for its high power density
- Previous research was conducted utilizing the Stirling cycle, but the Brayton cycle has shown better energy conversion efficiency
- This project's focus is to explore the potential of Brayton cycle power conversion utilizing a direct cooled nuclear reactor

Brayton Cycle Modeling

- Due to the high cost associated with launching a payload out of Earth's orbit, the main concern is minimizing the system's mass
- To assist in designing an optimum power conversion system, a robust model was developed of the Brayton cycle capable of handling a wide range of parameters

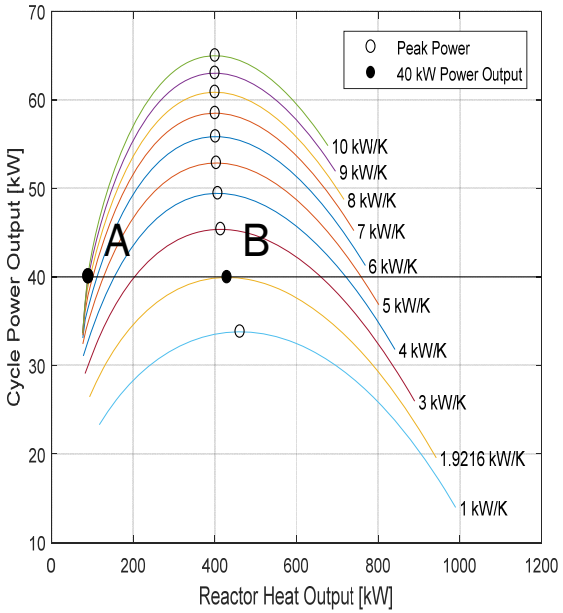
- First, models were developed for each component of the cycle
- Then a model of the full cycle which utilizes all component models was created
- Finally, an optimization routine was written to systematically scan through component options and select the overall least massive cycle



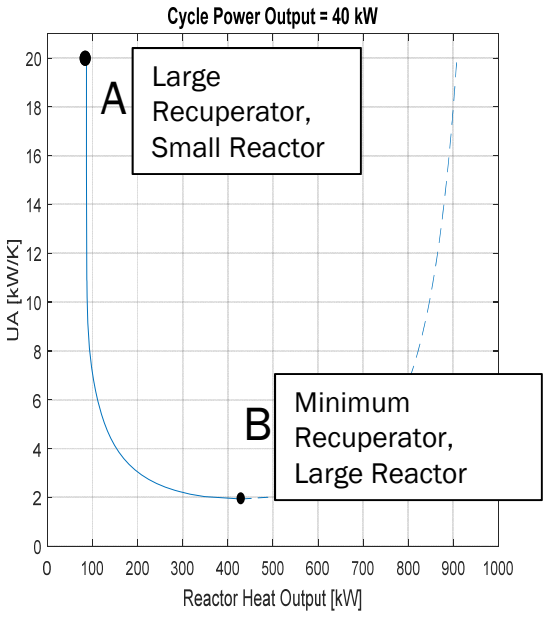
Brayton Cycle Schematic

Optimization Routine

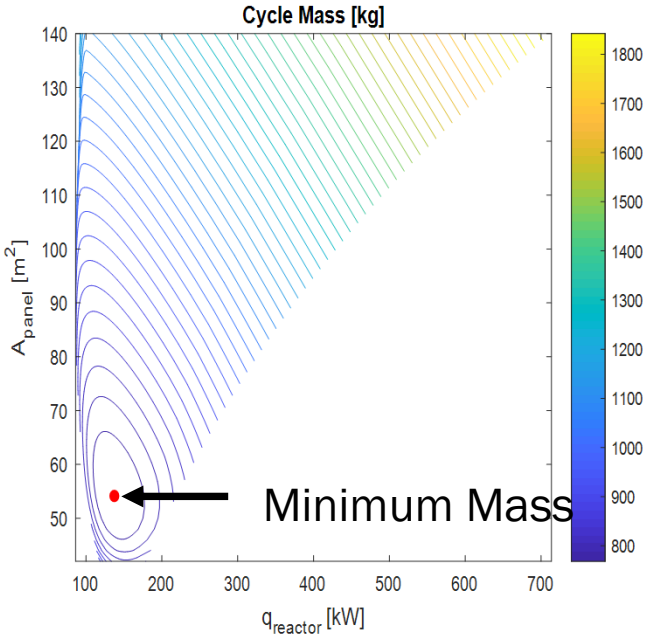
- The reactor, radiator, and recuperator comprise most of the system mass
- The optimization steps
  - *Step 1: with one radiator size, find the minimum recuperation necessary to achieve the desired power level*
  - *Step 2: increase the cycle recuperation while decreasing nuclear reactor heat input, observe the tradeoffs between the two components to find an optimum mass cycle*
  - *Step 3: repeat steps 1 and 2 at several radiator sizes to locate the overall minimum mass cycle*



Step 1



Step 2



Step 3