Thermal-Hydraulic Testing of a Compact, Diffusion Bonded Heat Exchanger for a Supercritical CO$_2$ Brayton Power Cycle

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Heat Exchanger Development

- Heat exchangers are an enabling technology for efficient power generation with a closed, recuperated Brayton cycle using supercritical CO$_2$ as the working fluid.
- The heat exchangers impact the overall system efficiency (operating cost) and size (installation cost).
- The heat exchanger designs must balance between heat exchanger effectiveness and pressure drop to achieve the desired tradeoff between system efficiency and system size.
Water-to-CO2 Heat Exchanger

- ASME Certified, Section VIII, Division 1 (‘U’)
- Maximum Allowable Work Pressure: 2,500psig (H₂O side); 3,175psig (CO₂ side) up to 732°F
- SA240 TY316/316L
- Block 30 x 6 x 11 inches
- Duty: 180-185kW for design conditions.
Test Configuration

Recuperator allowed flexibility in regulating inlet temperature of the CO₂ – yet maintain the CO₂ pumping capacity.
Thermal Performance

![Graph showing heat transfer rate vs maximum possible heat transfer rate]

- **Heat Transfer Rate (kW)**
- **Maximum Possible Heat Transfer Rate (kW)**

Legend:
- □ < 3.0 lbm/sec, CO2
- △ > 3.0 lbm/sec, CO2
- ● Design Point

Lines:
- ε = 1.0
- ε = 0.9

**Source:** Naval Nuclear Laboratory
Hydraulic Performance

(expanded uncertainty ±0.003psid)
Conclusion

- The compact heat transfer surface in the form of a water-to-CO$_2$ heat exchanger performed well in the thermal-hydraulic testing.
- The testing of the first-of-a-kind heat exchanger confirms the fabrication and design knowledge for the heat transfer surface consisting of a diffusion bonded stack of chemically etched thin plates.