Thermal-Hydraulic Testing of a Compact, Diffusion Bonded Heat Exchanger for a Supercritical CO_2 Brayton Power Cycle

Patrick M. Fourspring[1], Joseph P. Nehrbauer[1], and Zhihun Jia[2]

[1] The Naval Nuclear Laboratory is operated for the U.S. Department of Energy by Bechtel Marine Propulsion Corporation, a wholly owned subsidiary of Bechtel National, Inc.

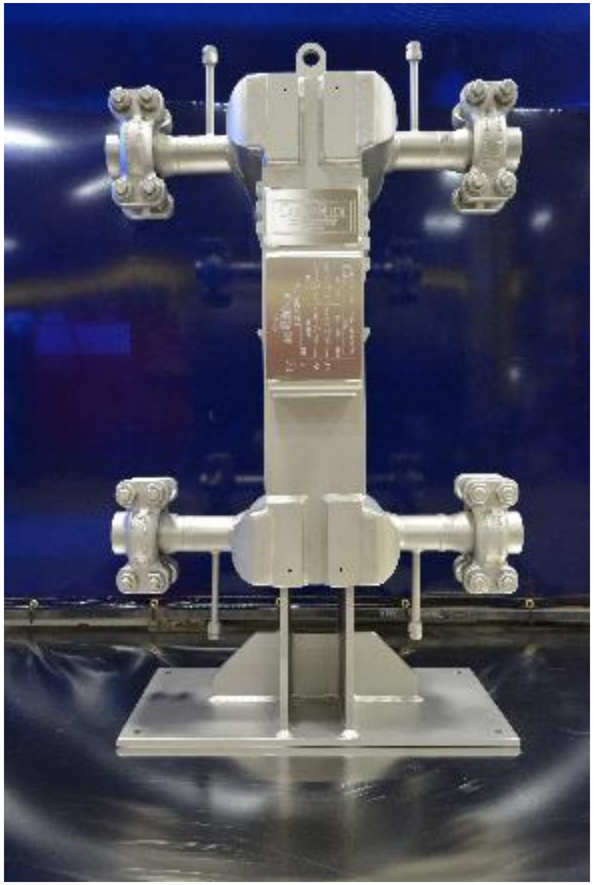
[2] CompRex, LLC

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.

NAVAL NUCLEAR LABORATORY

Water-to-CO2 Heat Exchanger

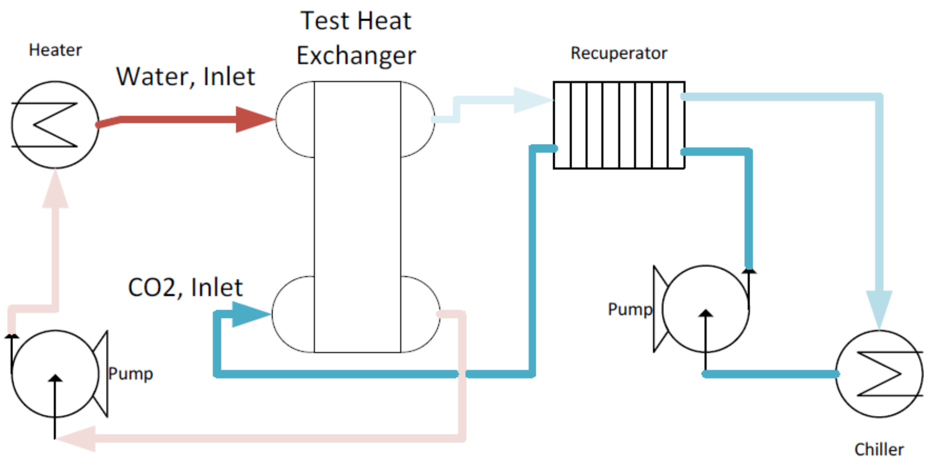


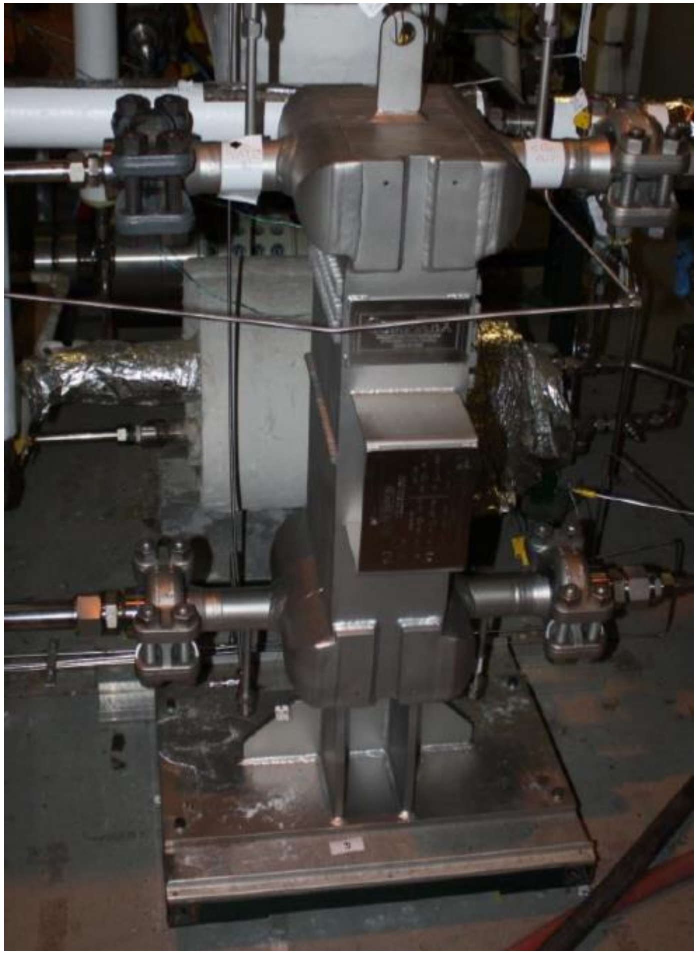
- ASME Certified, Section VIII, Division 1 (‘U’)
- Maximum Allowable Work Pressure: 2,500psig (H_2O side); 3,175psig (CO_2 side) up to 732°F
- SA240 TY316/316L
- Block 30 x 6 x 11 inches
- Duty: 180-185kW for design conditions.

NAVAL NUCLEAR LABORATORY

Test Configuration

Recuperator allowed flexibility in regulating inlet temperature of the CO_2 – yet maintain the CO_2 pumping capacity.

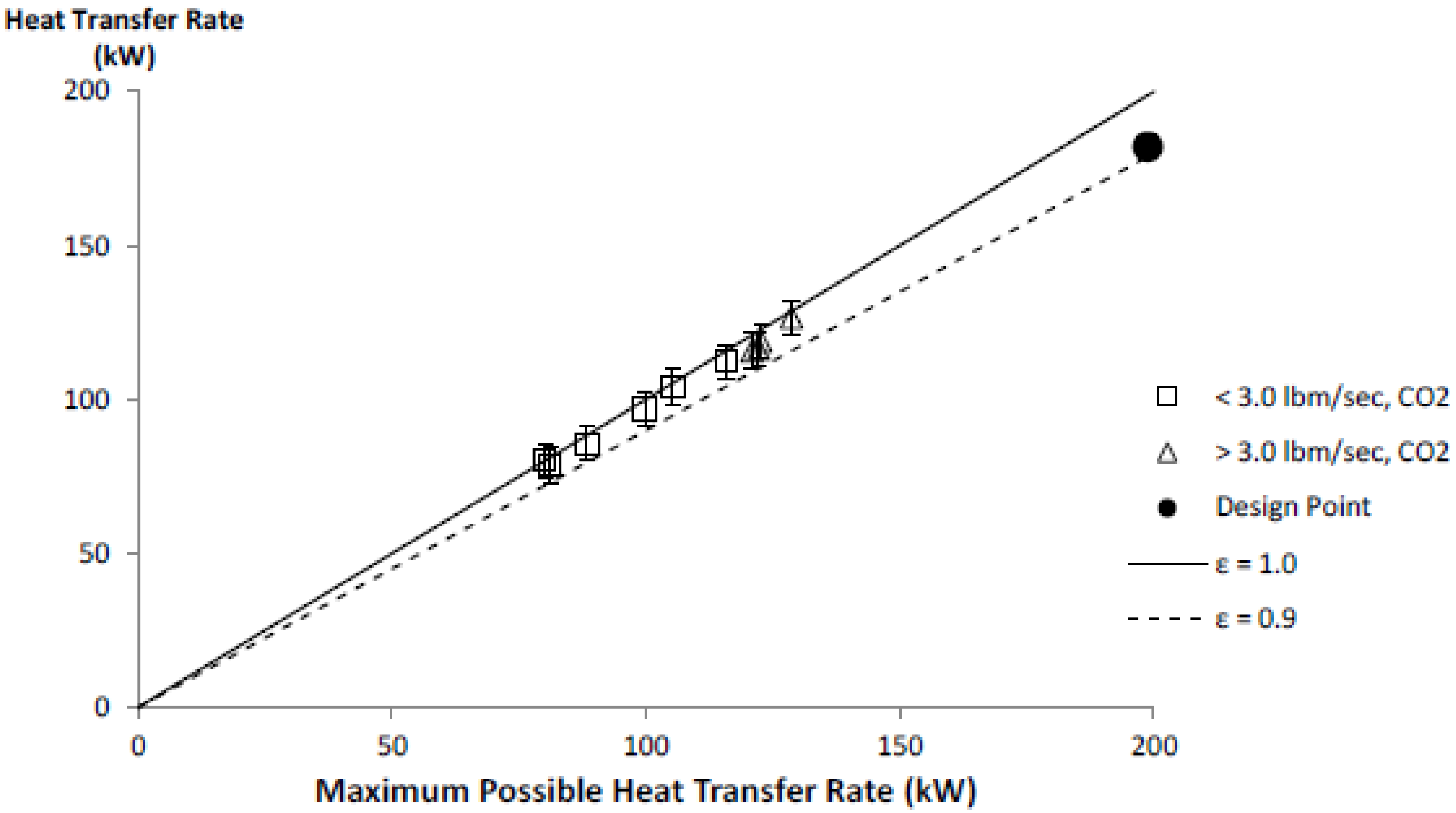




(shown without insulation)

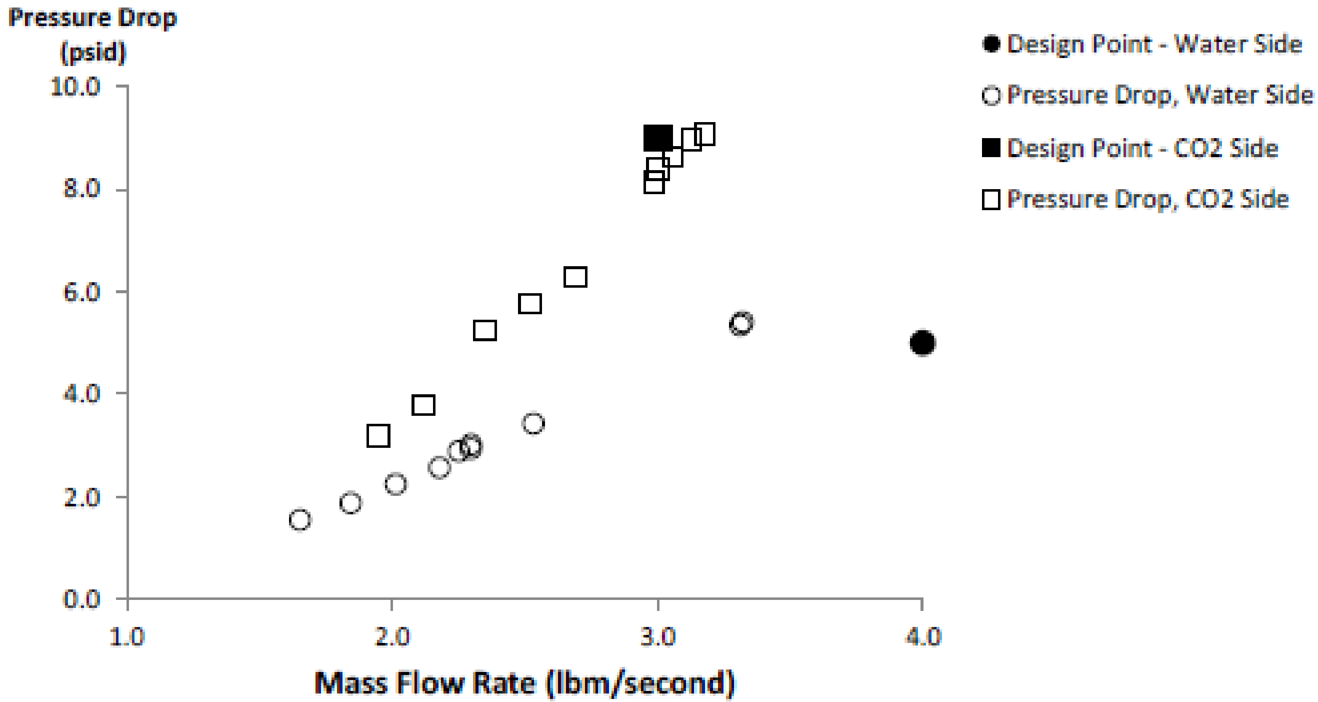
NAVAL NUCLEAR LABORATORY

Thermal Performance



NAVAL NUCLEAR LABORATORY

Hydraulic Performance



(expanded uncertainty ±0.003psid)

NAVAL NUCLEAR LABORATORY

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.

NAVAL NUCLEAR LABORATORY