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Sandia National Laboratories

SCO2 Brayton Cycle Mechanical Design and Testing

Brayton Cycle Industrial Engagement Workshop

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U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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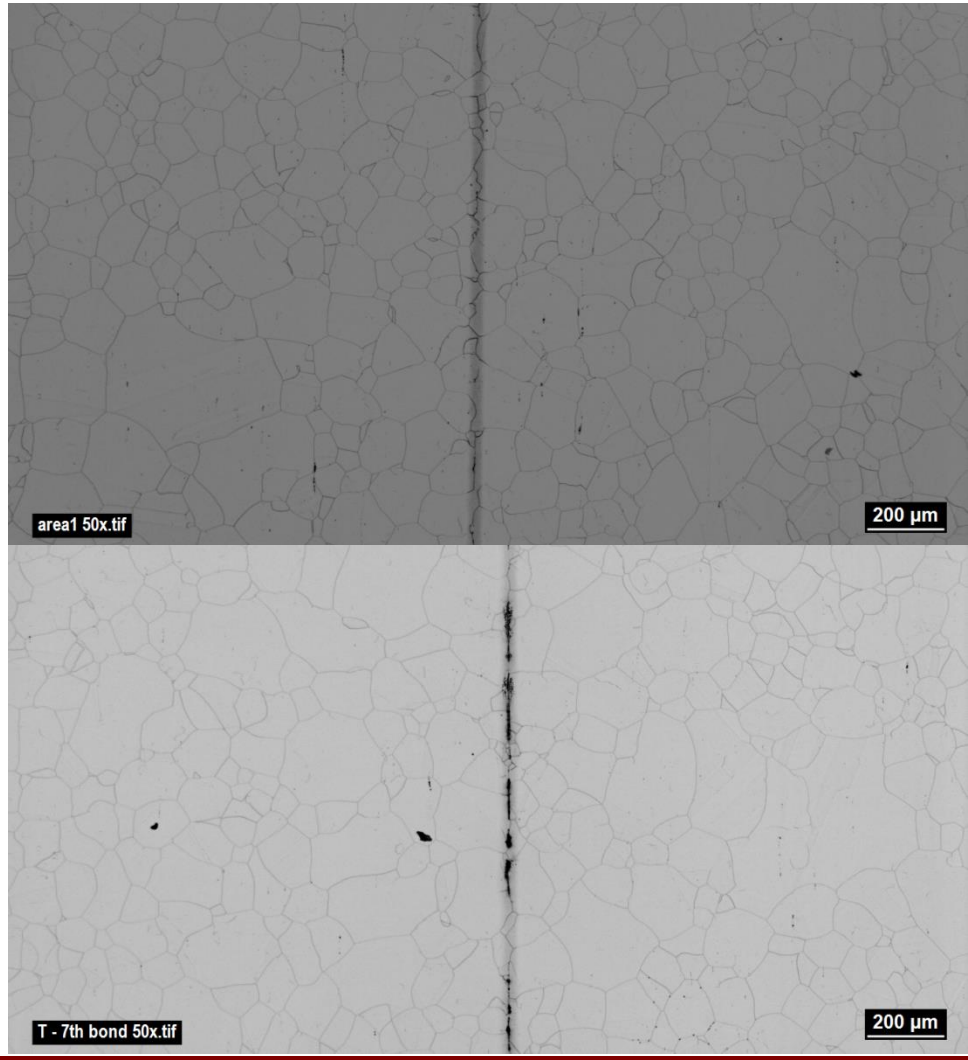
Overview

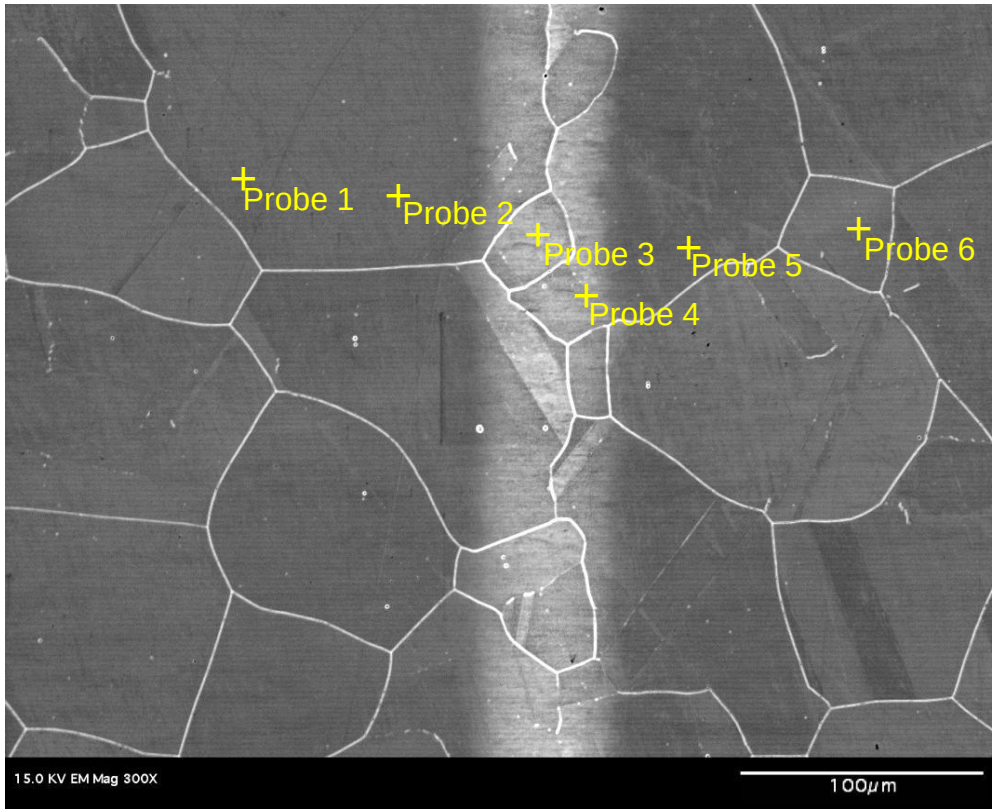
- Diffusion bonding
  - Understanding the diffusion bonding process
  - The bond composition
  - Tensile testing
- Heat exchanger testing facilities
  - Contaminant monitoring and preventive maintenance approaches
  - FY15 heat exchanger development
  - Performance testing of first of the kind heat exchangers

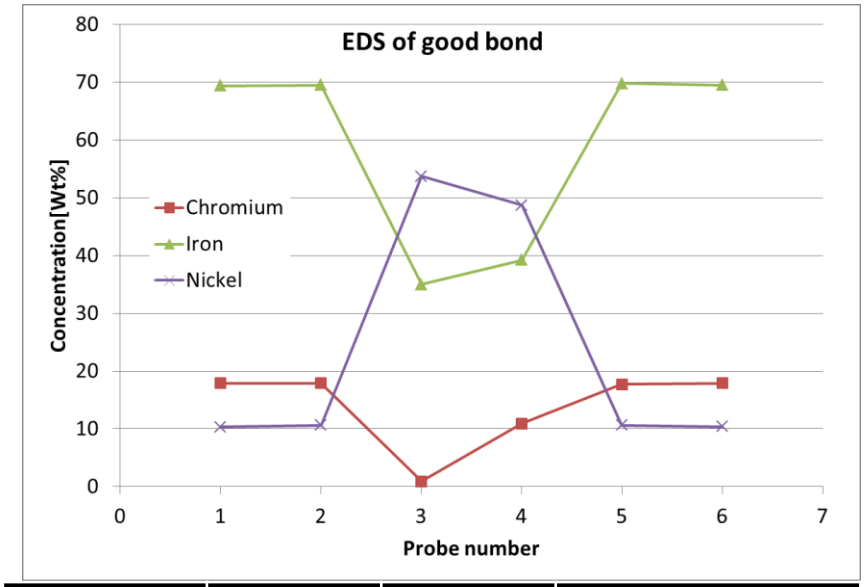
SEM Microstructural Analysis

- Baseline analysis performed on "Sample 0"
- 24/25 joints exhibited diffusion boundary growth across the joint
- Porosity was observed in one bond and subsequent analysis determined this was isolated to the outer edge
- An "ideal" diffusion bond should exhibit no difference from the bulk alloy
  - The apparent bond line is an artifact of the bond process used by the supplier



EDS Microstructural Analysis

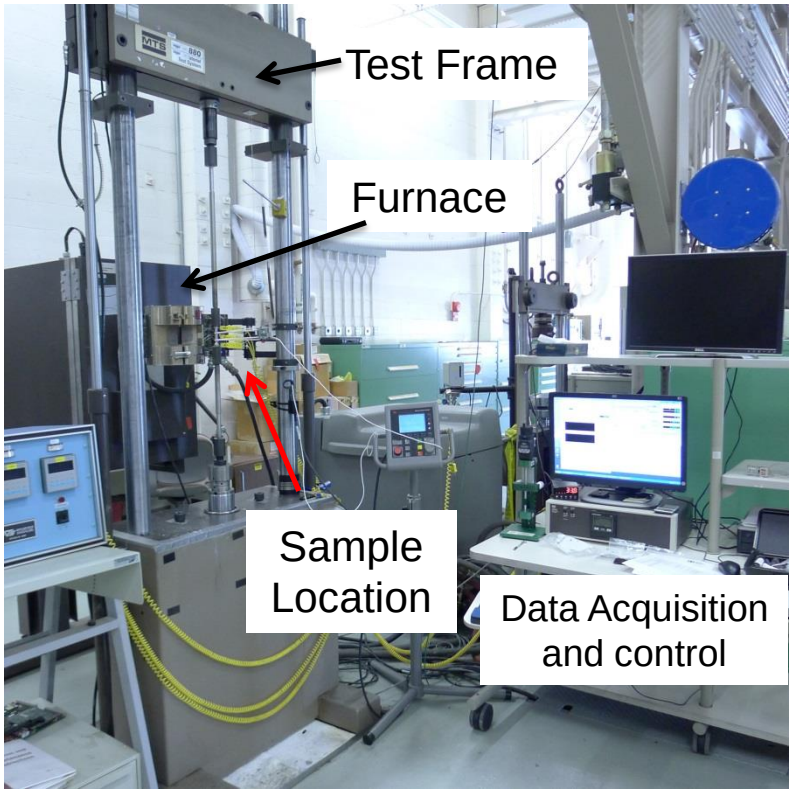


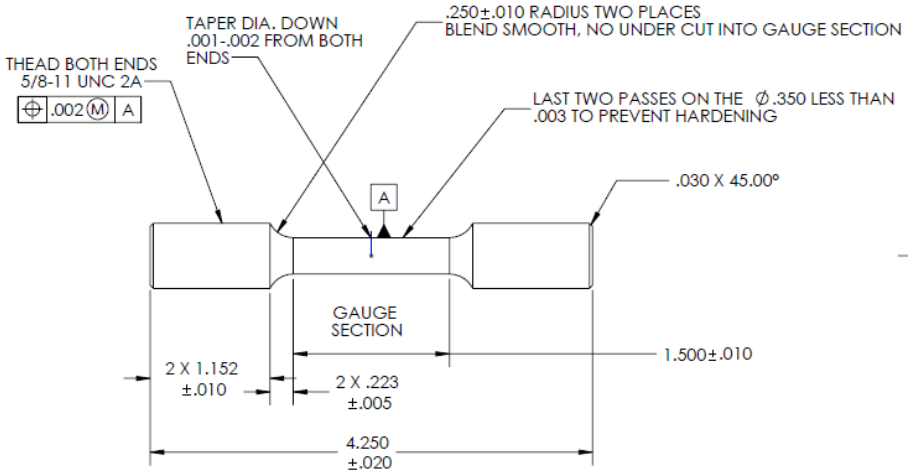


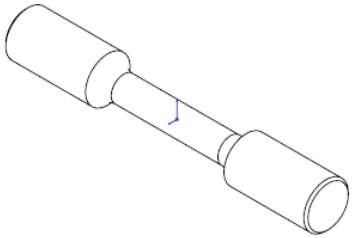
Fe	Cr	Ni	Other (1-3%)
Balance	16-18	10-14	Mo, Mn, Si
For 316L SS, all values in weight %			

- Energy Dispersive Spectroscopy (EDS) indicates that at locations outside of the electrodeposited nickel bulk properties of the steel are preserved.
- Nickel and iron formed an intermetallic, while some places in the bond are chromium deficient.

Tensile Test: Methodology

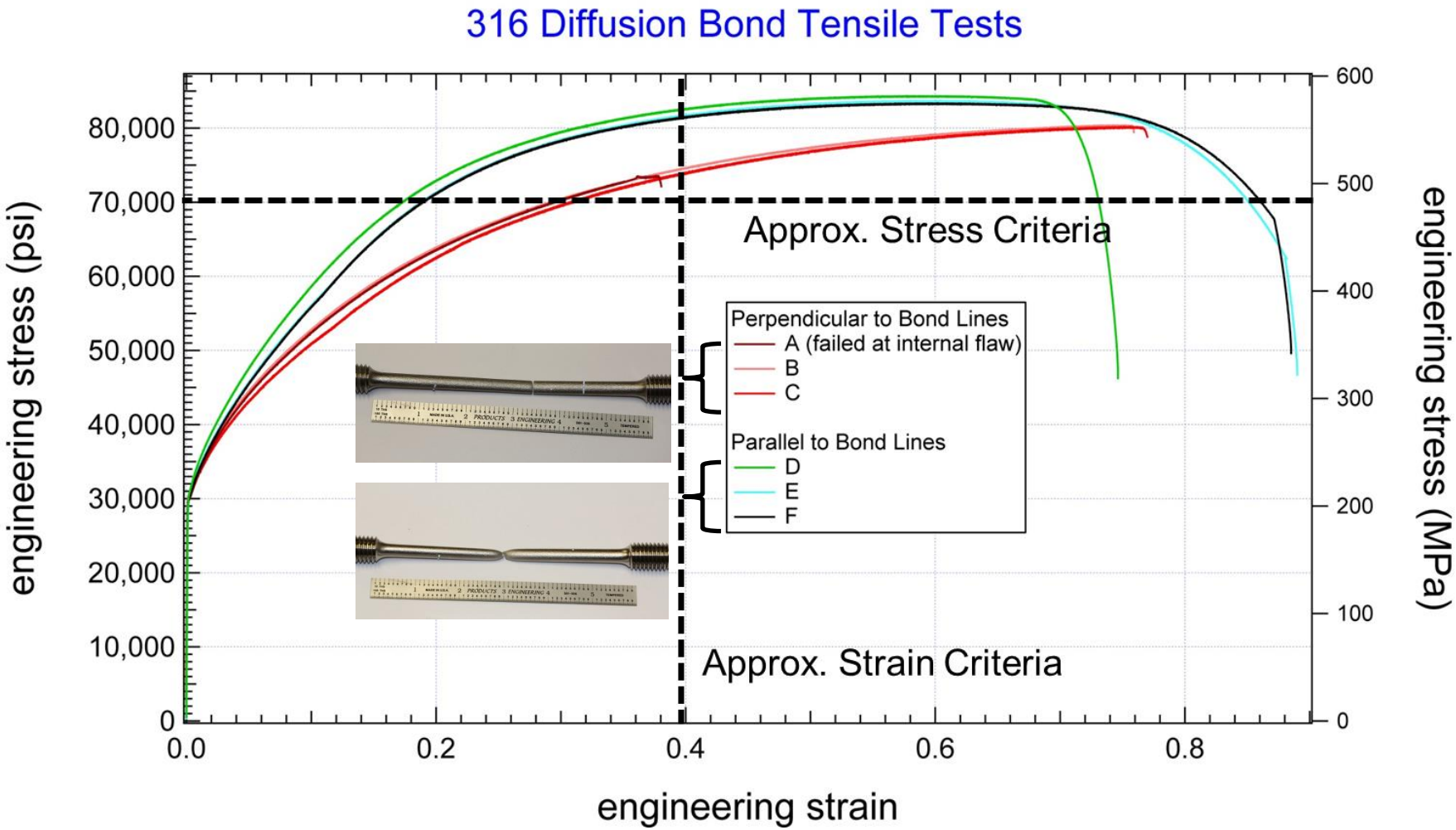




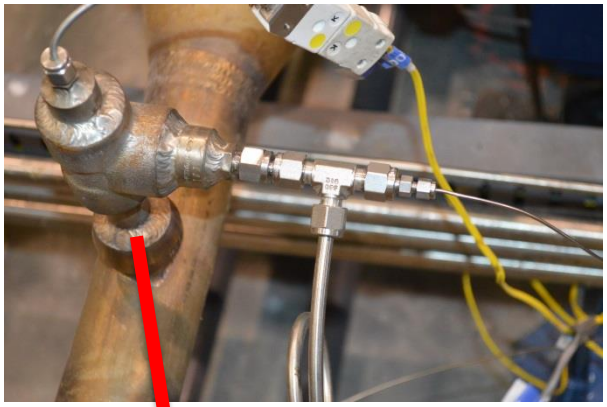


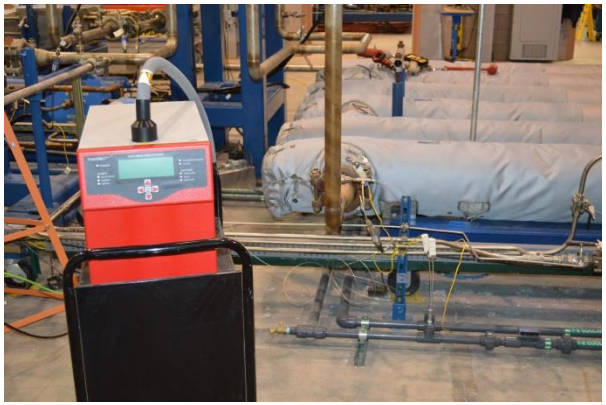
- ASTM standard (E8) used for tension testing guidance, with tests in constant displacement mode
- 2 tests were performed, room temperature (RT) and at 650°C
- Post mortem metallography was performed on both samples

Current Diffusion Bond Testing

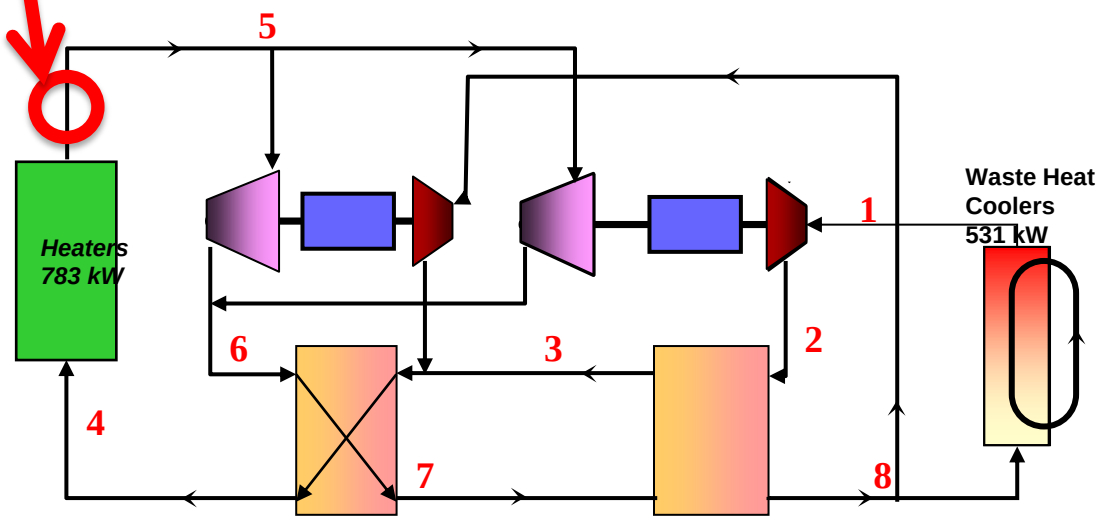


Monitoring for Loop Contaminants



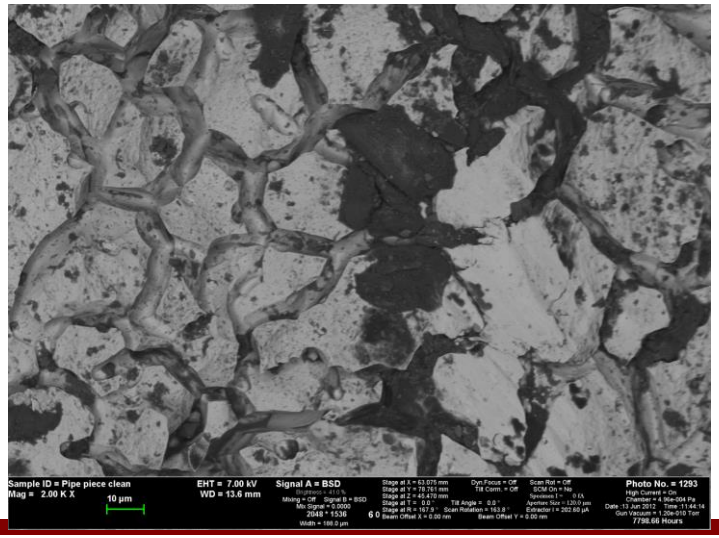


- Thermostar mass Spectrometer installed at highest temperature location
- Capillary tube installed in the Supercritical CO2 hot stream flow path
- In-situ monitoring of CO2 loop contaminants
- Using this to discover the potential of hydrocarbons transport throughout the loop.



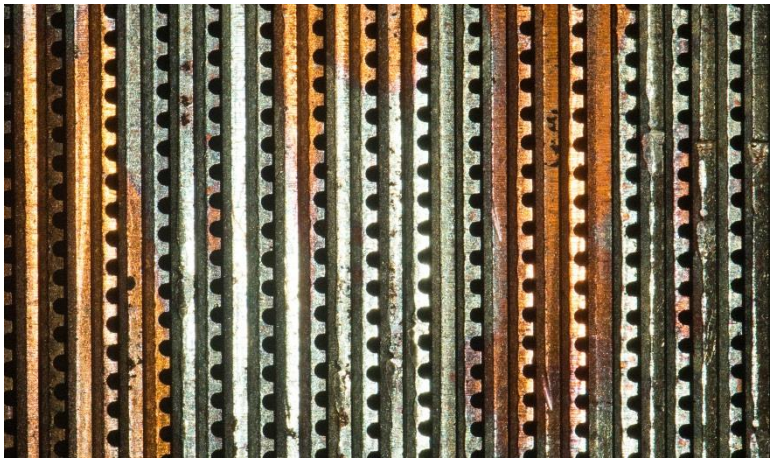
Preventive Maintenance

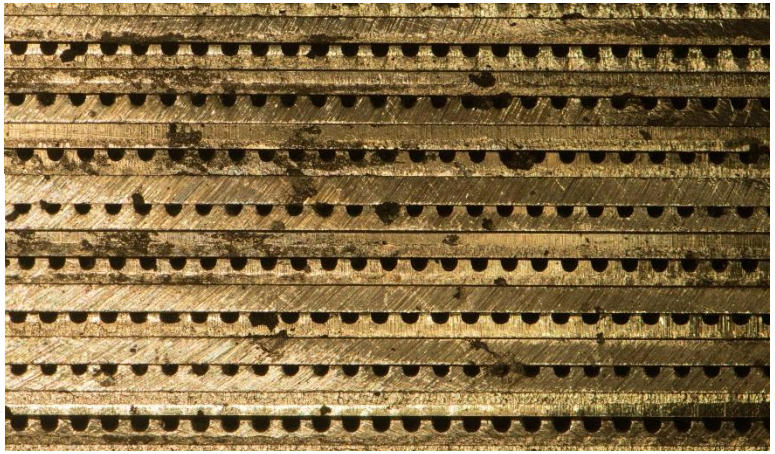
- Visual documenting pipe samples
  - SS 316L pipe samples sent to SNL-Livermore
  - Used for benchmarking
    - Determine surface scale and oxidation
- Heat exchanger samples
  - Pictures taken for benchmarking
  - Physical sampling of the sediment in the heat exchanger

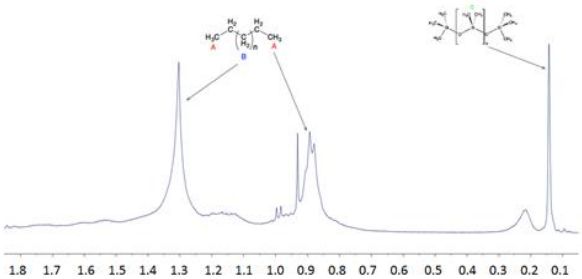


Heat Exchanger Sampling

- Photos taken to benchmark pitting and plugging
- Samples taken of presumed “hydrocarbons” from plugged heat exchanger passages

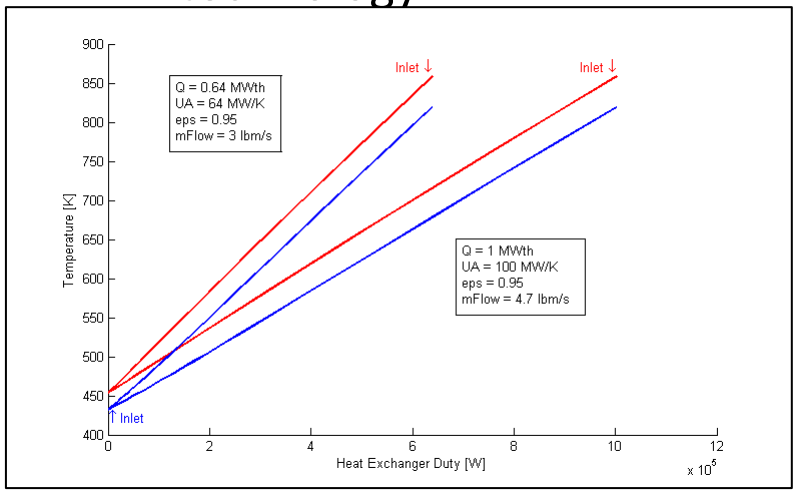


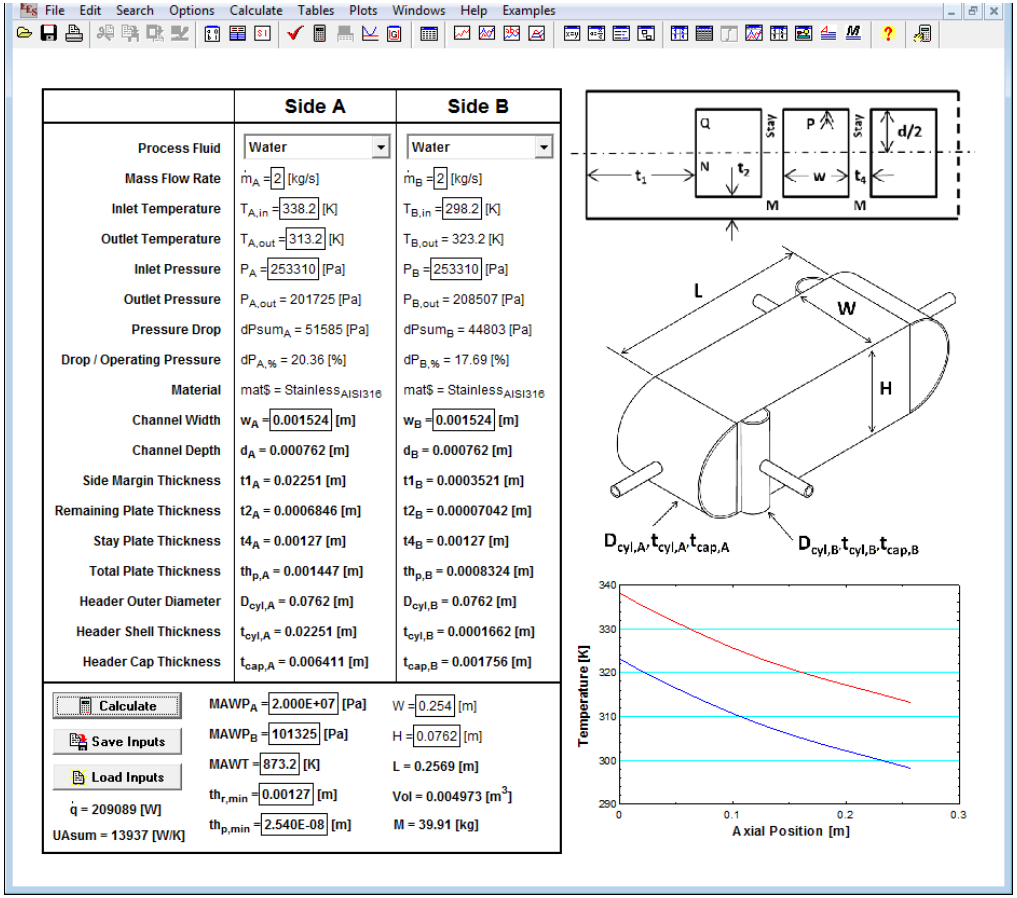




Heat Exchanger Development FY15

- Develop relationships with “alternative” heat exchanger vendors
  - With those vendors we plan to help commercialize their technology

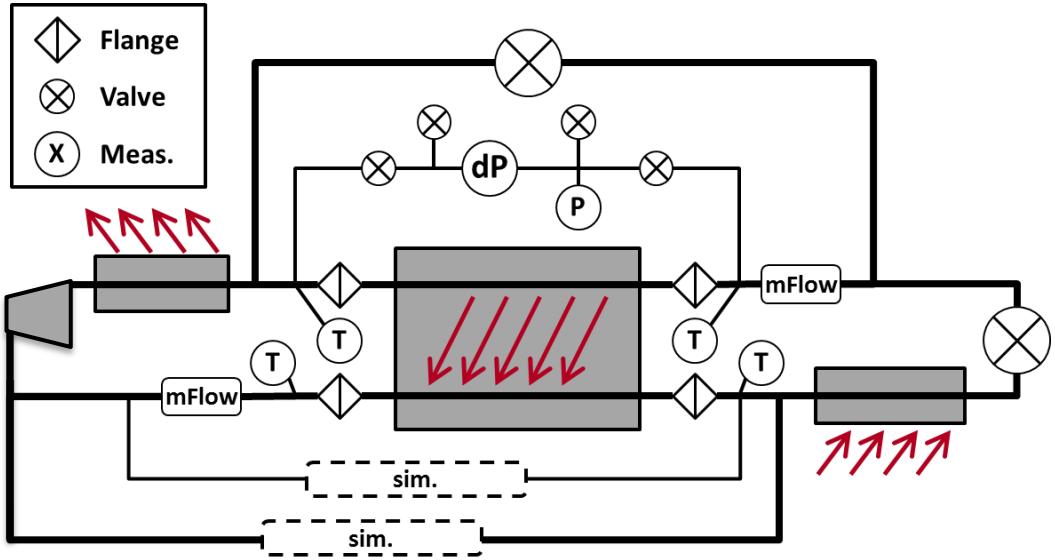




Heat exchanger testing platform

Capabilities

- 100 kW Heaters (Elec)
- 100 kW Cooling Capability
- Water to Water System
- 150 GPM flow rates



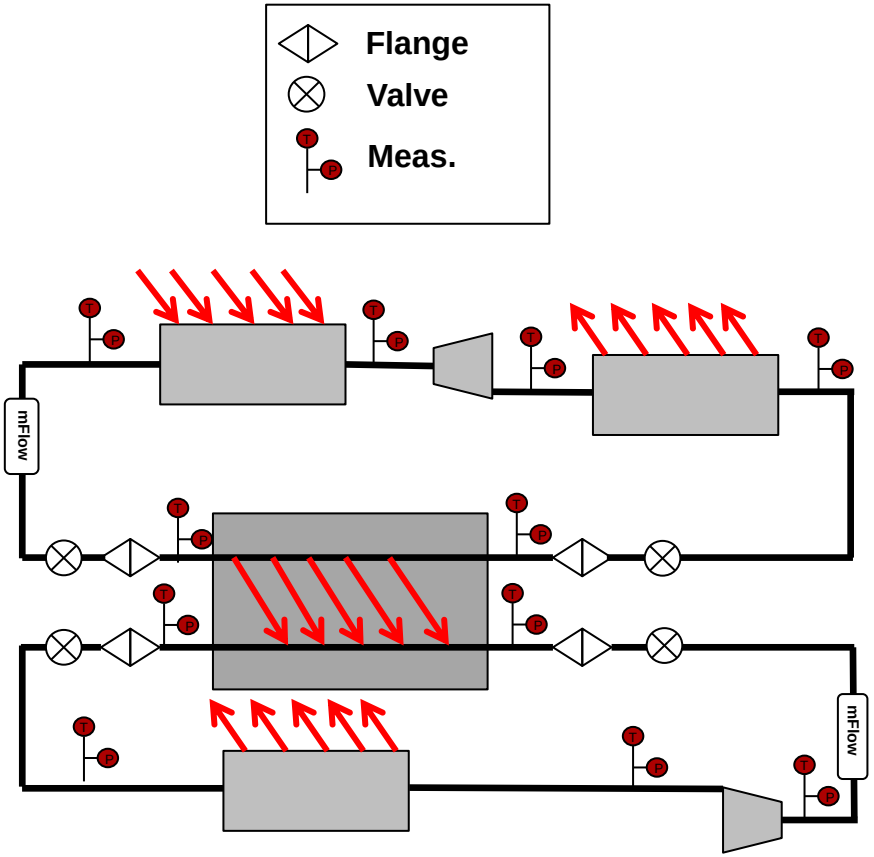
Facility Goal:

- Provide safe testing capability for prototype heat exchangers with low TRL

Heat Exchanger Testing Platform FY15

Capabilities

- 500 kW Heaters (Elec.)
- 500 kW Cooling Capability
- Gas to Gas System
- 5-7 kg/s flow rates



Facility Goal:

- Provide a testing capability for vendors to help with the commercialization of their technology.

Questions??