Performance & cost targets for sCO₂ heat exchangers
2015/10/15
Overview

- System concepts
- Operating conditions
- Performance targets
- Cost targets
WHR cycle vs RCBC

- 3 classes of HX
  - Recuperator (LT and HT)
  - Primary (heat source)
  - Heat rejection (water- or air-cooled)
Comparisons

**WHR HX’s**
- Recuperators
  - PCHE
  - T ~ 100-370°C (for 500°C turbine inlet)
  - P ~ 10 / 25 MPa
  - UA ~ 1000 kW/K each (10MW system)
- Primary
  - Finned tube
  - T ~ 550°C
- Heat rejection
  - Water-cooled PCHE or ?
  - Air-cooled fin-fan system

**RCBC HX’s**
- Recuperators
  - PCHE
  - T ~ 100-550°C (for 700°C turbine inlet)
  - P ~ 10 / 25 MPa
  - UA ~ 1000 kW/K each (10MW system)
- Primary
  - Application-dependent
  - T ~ 750°C
- Heat rejection
  - Same as WHR
  - Smaller due to higher cycle η
Performance targets

- Defining performance...
  - Effectiveness
  - UA
- Can’t lose sight of either
  - You pay for UA
  - Design may limit effectiveness
Effectiveness and UA vs cycle efficiency

- Strong non-linearity in UA drives cost/kW
- Assumes pure counter-flow geometry
  - PCHE approximates this
  - Shell & tube, Shell & plate require many shells in series for high effectiveness
- Any new HX technology needs to be able to economically attain high effectiveness
Performance targets

- Cycle optimization drives $C_r \left( \frac{C_{\text{min}}}{C_{\text{max}}} \right)$ toward 1
Details that diverge from counterflow...

For example, cross-flow headers...

...limit maximum effectiveness
S&T just can’t get there

- Need at least 8 shell passes to reach 90% effectiveness
Cost targets

- Current technology, recuperators can be ~ 30-35% of total equipment cost
- Some of the size and much of the weight advantage of sCO₂ turbomachinery is taken back by recuperators
- 30% reduction in HX cost would have meaningful impact on system cost