Exhaust Heat Exchangers and their maturity and related current offerings and success – Renaud Le Pierres
Waste Heat Recovery

• Many different heat sources available:
  • Gas turbine exhaust – 450-600°C
    • Many turbines sizes to choose from (standardisation?)
  • Reciprocating engines – 250-450°C
    • Same challenge as for gas turbine
  • Industrial waste heat (Steel, cement, glass, biomass) with temperatures above 300°C
    • Many different size of plant (standardisation?)
    • Depending on exhaust composition may contain condensable / corrosive materials (life vs. more expensive higher grade alloy)
Echogen EPS 100
sCO2 WHRU Process conditions

- Exhaust gas with large volumetric flow rates (1s – 100s kg/s depending on exhaust source)
- Low pressure with very little allowable pressure drop on exhaust side (down to 1kPa)
- High pressure on the sCO2 side (20-30 MPa)
- Start-up / transient (Peak shaving requires very fast start-up)
- Potential corrosion due to impurities in flue gas (depending on heat source)
- Creep (depending on material vs. exhaust temperature)
sCO2 vs. Steam

• Steam waste heat recovery is established technology (>100 years)
• Existing supply chain for steam waste heat recovery components and HRSG (NEM, Nooter Ericksen, Citech)

• sCO2 is more compact and especially desirable for retrofit, offshore and remote locations installations
• sCO2 can be designed for direct in-stack, single phase (no pinch point limitation as for steam)
• sCO2 is more efficient and can use air cooling option (removing need for water)
• Better heat recovery possible in SCO2 cycles with single phase exchangers
• Two phase boiling at constant temperature (steam cycles) limits close temperature approach (pinching)
Current technology
Current WHRU

• Advantages:
  • Currently available as heat recovery steam generator
  • Proven to work in many applications including CCGT
  • Already used with some systems (EPS-100)

• Disadvantages:
  • Very large units making it a challenge where size is of the essence
  • Relative large thermal mass and associated inertia depending on flue gas
  • Large to very large internal fluid inventory
Current WHRU

• Disadvantages:
  • Price? RoI cannot be longer than 5 years (system cost)

Tim Held
Echogen
New technologies – Compact?

6.5m (H) x 4.4m (W) x 6.3m (L)
40 tonnes each section. 2 sections.

5m (H) x 2.5m (W) x 4.3m (L)
23 tonnes
On-going developments examples

• Thar Energy Sunshot programme (SWRI, GE, Thar Energy)
  • Tubular air to CO2

• Sandia National Laboratories
  • Diffusion bonded Hybrid construction

• Brayton Energy
  • Ingersoll rand based edge welded units
Heatric development

• PCHEs
  • PCHEs typical channels are 1 mm deep (2 mm semi circular)
  • They are well suited for sCO2 but not for exhaust side due to pressure drop constrains
  • PCHEs are already used as Recuperators in sCO2 systems
  • Heatric has developed deep etch technology currently able to achieve 2.5 mm deep channel (5 mm semi circular)
  • TRL 7-8 - may be suitable for small scale WHR units
Heatric development

• FPHEs
  • FPHE fins can achieve taller profiles than PCHEs (4 mm high)
  • Fins are not as well suited for sCO2 as channels but may be more suitable for exhaust side
  • FPHE was designed for ~20 MPa so this product is not ready for most sCO2 pressures
Heatric development

- **H²Xs**
  - H²Xs aim to combine 2 or more different product forms in a single product
  - To date H²X has been considering combining Fins to PCHE channels
  - Work is in progress to validate H²X as part of the Cranfield test loop
  - Further work is on-going to expand channel size on the exhaust side to dH > 5 mm
  - TRL 5
Material of construction

• Material price changes drastically when considering higher operating conditions / corrosive environment (x10 / x20):
• Product form and supply chain must be investigated as some materials are limited in choice
• Above 550C Creep must be considered with Austenitic stainless steel (304, 316) which will reduce plant life
• Operation of WHRU is critical depending on application
Waste Heat Recovery Success?

- sCO2 Bottoming cycle can be achieve with existing technologies
- EPS100 has already demonstrated system performance using ‘conventional’ WHRU
- WHRU units has to answer challenges of size reduction, response time for peak shaving and price
- Compact WHRU technologies for large size units are currently in development