Heat Exchangers

Reportout II

Materials, Installation, Scalabilty, Performance

HX Type	**Shell and tube**	**Plate frame**	**Aluminum Plate Fin**
Material	Aluminum, Titanium, Stainless steel, Copper-nickel	Stainless steel, titanium	Brazed aluminum
Installation/ Deployment	Simple; size important in terms of configuration/manifold	Difficult; complex piping system, expensive valving, less flexible for OTEC	Easy to manifold in modular system, easy handling
Scalability	Easy; Modular design- 100 MWe -- 10 MWe modules	Limited; Size and number of plates	Easy to scale up
Performance data and design	Lots of performance data; need enhanced tube	Lots of data High pressure drop HX	Lots of data DOE test data

Operability

- Repair
  - Shell and tube: plugging
  - Plate-frame: replace individual plates
  - Plate-fin: cannot repair on-site
- Replacement
  - Shell and tube: degrades past service life (major operation)
  - Plate-frame: replace individual HX
  - Plate-fin: replace module
- Decommissioning
  - Key: handling ammonia
  - Platform designed so that HX can be decommissioned without destroying whole system
  - Materials are resalable including NH3
  - Use industry standards for clean NH3 out of HX
- Personnel Safety
  - PPE/confined space entry for dry HXs
  - Divers for submerged HXs
  - Ammonia handling

Manufacturability (MRL)	modular Process: manually intensive **MRL: 7**	Easy: automated welding Plate size is an issue **MRL: 8**	Modular; **MRL: 6**
Relative Cost	High: labor intensive; integration: low cost	HX cheaper but add pipes/manifolding; ammonia side esp.	Potential lower cost (R&D in progress) lower in cost for integration
Logistics	**Issues with transportation** **Build on shore-float to plant**	**ship individual HXs and plumb in**	**modular brazed units shipped and assembled on site**
TRL	8	8	5

What risks are associated with failure?

- Ammonia safety- leaks
  - Codes and standards for refrig. industry are applicable to OTEC
  - Leak in piping system- need sensors (refrig. Standards)
  - Sensors needed for air and water leakage
  - Ammonia pump could fail – need standby (redundancy)
  - No clear codes for water-NH3 systems
  - Periodically change/calibrate sensors
- Low temp and pressure make for safer system than other industries
- Risk of failure: lower performance - cost issue
  - Biofouling
  - Corrosion

What are the cost drivers?

- Low deltaT drives cost (large size required)
  - Materials
  - Assembly/integration
  - Manufacturing
  - Logistics
  - O&M

What are possible cost-savings?

- Performance enhancements (reduce size of HX)
  - Surfaces (increasing SA, turbulence, mixing)
  - Configuration
  - Surface treatments
  - Optimization
- Cost Reduction
  - Materials (e.g. plastics, different alloys)

What are the hurdles?

- HX industry not motivated to provide optimized units to meet OTEC needs
- Time to test and evaluate different designs
- Qualifying aluminum manufacturing processes
- Chlorination acceptable

What is the development time frame for the technologies associated with HXs?

- 5 MWe (12-18 month)
- Commercial Design: 1 year
- Commercial Manufacturing: 2-3 years