SELECTION OF CONDENSERS AND CHILLERS

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4) Selection criteria of Chiller (Evaporators) as per application.
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6) Maintenance of Chiller (Evaporators).
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1. Type of Condensers.

a) Shell and Tube. (S&T)

- MOC of the tube is MS or CS hence corrosion is major threat.
- Can NOT have close design approach for Condensing temp WRT Water outlet temp.
- Performance is linked to cooling water IN temp and cooling water flow.
- Cleaning is done with wire brush.
- Widely used in Industrial application where cost is prime factor.
- Can be located in the plant room.
- It requires skilled engineer for designing.
- Bulky in size.
1. Type of Condensers cont.....

b) PHE.

- MOC of the plates is SS316.
- Can have close design approach for Condensing temp WRT Water outlet temp.
- Performance linked to cooling water IN temp and cooling water flow
- Cleaning done by back flushing.
- Normally Chemical cleaning is done to remove the scaling, if physical cleaning is required then it needs to be dismantled.
- Widely used in Dairy, F&B, Breweries, where hygiene is of prime importance.
- Proprietary design
- Compact size.
1. **Type of Condensers cont.....**

c) **Atmospheric.**

- Combination of S&T condenser and cooling water circuit.
- Performance is linked with the WBT.
- Saves power
- Performance not consistence as it is linked with the natural air flow which varies throughout the day and from season to season.
- Occupies large space, huge wastage of water due to drift losses.
- Formation of algae poses a major hygiene threat.
- To be located in OPEN where free air flow is available.
1. Type of Condensers cont.....

d) Evaporative.

- Scientifically designed Improved version of atmospheric condenser.
- Replaces condenser and cooling tower circuit and saves energy.
- Compact in size.
- Required Air is forced OR induced over the wet coils.
- Small spray pump is used to circulate the water from tank over the coils.
- Energy efficient and saves approx 0.08 to 1.1 KW/TR WRT conventional combination of water cooled condenser and cooling water circuit.
1. Type of Condensers cont.....

e) Air Cooled.

- As the name implies Air is used as medium to de-superheat and condense the refrigerant vapours.

- Performance is linked with DBT hence condensing temp and corresponding operating pr. is on higher side when compared to other type of condensers.

- Bulky in construction and normally not very popular in Ammonia application though off-let its use is increasing due to scarcity of water.

- Should be located in OPEN with sufficient space around.

- NOT energy efficient.
2. Type of Chiller (Evaporators).

a) Shell and Tube Flooded type.

- Most conventional type. Surge Drum is integral part of Chiller.
- Requires more space considering tube cleaning area.
- Refrigerant boils off - shell side & medium flows through tubes.
- Simple control system i.e. Refrigerant level controller, solenoid & Hand Exp. valves.
- Can be designed for any capacity.
2. Type of Chiller (Evaporators) cont.....

b) Shell and Tube ‘DX’ Type

- Not many installations of (AMMONIA) but off-let gaining the popularity.
- Refrigerant through tubes & medium through shell.
- Thermostatic Exp. Valve (TEV) regulates the flow of refrigerant.
- In Economiser Ammonia on shell side is sub-cooled by Ammonia.
- Used as intercooler in two stage system.
- Limitation on capacity due to size of TEV.
2. Type of Chiller (Evaporators).

c) PHE.

- Though PHE is compact it requires Feed Vessel which makes the Skid Bulky.

- MOC of Plates SS316, Titanium.

- Higher Capital Cost but Long Life.

- Other features are similar as mentioned above in condenser.

- Proprietary Design.

A. For S&T and PHE

a) Heat Rejection (Q) calculated & Margin over it.

b) CW Inlet Temperature. (Normally 32°C)

c) CW Outlet Temperature. (Normally 36°C)

d) Flow of water.

e) Fouling Factors (FF).

f) Type of Water.

A. For S&T and PHE

- Sizing of Heat Exchanger
  - Heat Rejection (Q) (Kcal/Hr) =
    \[ m \, (\text{kg/Hr}) \times Cp \, (\text{Kcal/kg}°\text{C}) \times ΔT \, (°\text{C}). \]
  - Heat Rejection (Q) (Kcal/Hr) =
    Heat Transfer Co-eff (U) (Kcal/sq.m Hr °C) \times \text{Effective Area (A) (sq. m)} \times \text{LMTD (°C)}

- Type of Tubes: Plain OR Enhanced Surface

- Diameter and length of tube and available space.

- MOC of tubes and shell.

A. For S&T and PHE

- Fouling Factors (FF).
  - Fouling or scale factor is resistance to the heat flow from refrigerant to medium.
  - Units are Hr.Sq.M.°C/Kcal (MKS). & Hr.Sq.ft°F/Btu (FPS).
  - FF affects ‘U’ factor.
  - Higher the FF lower the ‘U’ factor requires higher surface.
  - Being open circuit FF are on higher side generally 0.002 Hr.Sq.ft°F/Btu / 0.0004 Hr.Sq.M.°C/Kcal
3. **Selection Criteria of Condenser.**

B. **For Evaporative Condenser.**

- Heat Rejection (Q) calculated & Margin over it.
- Wet Bulb Temperature (WBT)
- Air Flow and Water Flow over the tubes.
- Fouling Factor.
- MOC of tubes.
- Proprietary Design
3. **Selection Criteria of Condenser.**

C. Air cooled.

- Dry Bulb Temperature.
- Air Flow.
- Availability of open space.
- Type of Industry. viz. chemical, F&B, Marine, Oil & Gas.
### 3. Comparison between S&T and Evaporative Condenser

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<td>Cooling water in temp.</td>
<td>32</td>
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<td>Cond.temp 40°C</td>
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<td>CW Out Temp. 36°C</td>
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- Water spray
- Air filling Temp. 28°C

- Cond.temp 36°C
- Air stream

a) Temperature of the Medium

- Above 5°C then water is best
- Below 5°C secondary refrigerant viz. NaCl, CaCl2, MEG, Methanol, Propylene Glycol (PG), Kerosene, Methylene dichloride, Caustic soda (Lye) Thermic fluids etc.

b) Process where it is used

- F&B - Generally Propylene Glycol
- Reactions where water contamination is NOT allowed – MDC, Kerosene.
- Common medium for heating and cooling – Thermic fluids.

c) Other Properties of the chilling medium

i. Viscosity
   ▶ (MEG 50% conc. by wt + Water) viscosity is around 50 cP at minus 30°C & hence not user friendly below minus 30°C.
   ▶ (Methanol + Water) higher the conc. Lower the viscosity hence most suitable for temp up to minus 70°C.

ii. Safety
   ▶ Chiller other than Methanol & Kerosene can be located in SAFE area.
   ▶ Methanol & Kerosene being highly inflammable chiller is to be segregated into flame-proof area.

c) Other Properties of the chilling medium cont...

iii. Others

- NaCl & CaCl2 being highly corrosive MOC of tube/plate plays major role in selection.
- For above inhibitors are to be added to maintain the pH above 7
- Addition of CaCl2 in water beyond 29% results into precipitation and hence NOT OK around minus 28°C and below.

d) Fouling Factors.

- Fouling or scale factor is resistance to the heat flow from refrigerant to medium.
- Units are Hr.Sq.M.°C/Kcal (MKS). & Hr.Sq.ft°F/Btu (FPS).
- Higher the FF more heat transfer surface to be provided.
- Higher the Fouling lesser the heat Transfer.
- Being a closed circuit of medium the FF are on lower side as compared to condenser
  - 0.001 Hr.Sq.ft°F/Btu / 0.0002 Hr.Sq.M.°C/Kcal.

e) Available Space.

f) Type of industry
4. **Selection Criteria of Chiller.**

- **Sizing of Heat Exchanger**
  - Heat Rejection (Q) (Kcal/Hr) = \( m \) (kg/Hr) x \( Cp \) (Kcal/kg°C) x \( \Delta T \) (°C).

  - Heat Rejection (Q) (Kcal/Hr) = Heat Transfer Co-eff (U) (Kcal/sq.m Hr °C) x Effective Area (A) (sq. m) x LMTD (°C)

- Type of Tubes: Plain OR Enhanced Surface

- Diameter and length of tube and available space.

- MOC of tubes and shell.
5. **Maintenance of Condenser.**

During following observation maintenance of the condenser is to be taken up:

i. Increase in Discharge pressure.

ii. Frequent tripping of compressor on high discharge pressure.

iii. Popping out of safety valve.

iv. When you observe less temp. diff. across the condenser for the same cooling water flow.

v. Increase in pressure drop on water side.

vi. When you smell ammonia in cooling water.
**Causes**

- Presence of non condensable gases in refrigerant.
- High cooling water inlet temp (water cooled)
- LOW cooling water flow (water cooled)
- Low performance of Evaporative condenser

**Remedies**

- Pump down the system refrigerant in receiver and purge air from condenser.
- Check the performance of cooling tower
- Check whether the valves are partially closed,
- pump suction strainer choked,
- Low level of water in sump.
- Check the water distribution in evaporative condenser.
- Check the air flow.
- Low water level in sump.
<table>
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<th>Causes</th>
<th>Remedies</th>
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<tr>
<td>Scaling of Tubes/Plates.</td>
<td>Physical de-scaling by using wire brush for S&amp;T condenser.</td>
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<tr>
<td>smell ammonia in cooling water.</td>
<td>Chemical cleaning of the tube sides using sulfonic acid or suitable chemicals as specified by the water treatment people.</td>
</tr>
<tr>
<td>Chocked tubes foreign materials</td>
<td>Dismantling of PHE plates and cleaning with brush.</td>
</tr>
<tr>
<td>check whether tubes are punctured.</td>
<td>check whether tubes are punctured.</td>
</tr>
<tr>
<td>Physical cleaning of tubes</td>
<td>Physical cleaning of tubes</td>
</tr>
</tbody>
</table>

During following observation maintenance of the chiller is to be taken up:

i. LOW suction pressure

ii. When you observe less temp. diff. across the chiller for the same cooling medium flow.

iii. Frequent tripping of compressor on LOW suction pressure.

iv. Higher outlet temp of the medium

v. Compressor tripping on high refrigerant level in the chiller.

vi. When you smell ammonia in cooling medium.
Chiller

**Causes**

- For Low suction pressure
  1. Liquid line strainer choked.
  2. Less refrigerant in the system.
  3. Liquid line solenoid valve. partially/completely shut.
  4. Scaling of the tubes.
  5. Partial freezing in tubes.
  6. Oil accumulation.

- Less temp diff across the chiller
  1. Low suction pressure
  2. Higher medium flow

**Remedies**

- For Low suction pressure
  1. Clean the strainer.
  2. Charge refrigerant.
  3. Check the function of the SV and level controller, rectify/replace if found faulty.
  4. Clean the tube
  5. Check the gravity if brine (as medium)
  6. Check flow of medium across the chiller.
  7. Drain the oil from chiller.

- Less temp diff across the chiller
  1. Please refer above
  2. Reduce medium flow to the designed value

- For frequent tripping of compressor on LOW suction pressure
  1. Please refer above
Chiller

**Causes**

- Higher outlet temp of the medium
  - Higher process load.
- Compressor tripping on high refrigerant level in the chiller.
- No sufficient level of refrigerant on shell side.
- Low performance of Compressor
- Less temp. diff. across the chiller
- Smell of ammonia in chilled water brine

**Remedies**

- Higher outlet temp of the medium
  - Reduce the process load
  - Start stand by or increase capacity.
- Check the level controller and solenoid valve coil loop.
- Same as above
- Check compressor.
- Check the chiller flow and in case of brine check the specific gravity (conc.)
- Check oil accumulation and drain to oil drain pot.
- Check for the puncture of tubes
7. **Material Specifications.**

- **For Shell and Tube Condenser.**

1. **Design Criteria**
   - i. Good Engineering Practise
   - ii. TEMA/ASME or any other standard.

2. **MOC of Shell & Tube sheet**
   - i. In special case Low Carbon steel (516 Gr. 60/70 or IS 2002) is used.

3. **Thickness of the shell**
   - i. Operating and design pressures on shell side.

4. **Thickness of the Dish Ends**
   - i. Operating and design pressures on tube side.
7. **Material Specifications.**

- **For Shell and Tube Condenser.**

5. **Thickness of the Body Flange**
   - i. Design pressure on shell and tube side.
   - ii. MOC plate or Forged.

6. **Type of tubes**
   - i. Plain.
   - ii. Enhanced surface.

7. **MOC of Tubes.**
   - i. ERW not recommended
   - ii. Seamless CS ASTM A179
   - iii. SS 304, SS 316.
7. Material Specifications.

For Shell and Tube Condenser.

8. Diameter and Thickness of the tube

i. There are guidelines provided by TEMA where minimum thickness of the tube to be used is specified depending upon its diameter

ii. Generally 3/4 inch 16 BWG, 1 inch 14 BWG and 1 ¼ inch 12 BGW are used. However client and supplier can mutually agree for higher thickness.
7. **Material Specifications.**

▶ *For Shell and Tube Chiller.*

1. **Design Criteria**
   - i. Good Engineering Practise
   - ii. TEMA/ASME or any other standard.

2. **MOC of Shell Tube sheet**
   - i. For evaporating temp. below minus 28C Low Carbon steel (516 Gr. 60/70 or IS 2002) is to be used.

3. **Thickness of the shell**
   - i. Operating and design pressures on shell side.

4. **Thickness of the Dish Ends**
   - i. Operating and design pressures on tube side.
7. Material Specifications.

For Shell and Tube Chiller cont..

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   i. Design pressure on shell and tube side
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I ♥ AMMONIA

THANK YOU