Heat Exchanger Selection
AUGUST 1, 2017
Heat Exchanger Types

Type of Heat Exchangers

- **Plate $** - fluid products, small to no particulates
- **Tubular $$** - thin to semi-viscous products with/without particles
- **Shell & Tube $$$** - thin to semi-viscous products, high pressure, smaller foot print than tubular
- **Spiral Tube $$$$** - high pressure & velocity where fouling is critical
- **Scrape Surface $$$$$** - viscous, difficult to process, or when needing flexibility
Product Viscosity Range

- Heavy Duty Applications
  - Peanut butter
  - Sandwich creams
  - Marshmallow
  - Sugar slurries / syrups
  - Frostings & Icings

- Medium Duty Applications
  - Pudding
  - Cheese sauce
  - Cream cheese
  - Sour cream
  - Fruit & vegetable purees

- Light & Ultra Light Duty Applications
  - Milk
  - Sports drinks
  - Dairy creams
  - Beer
  - Juices
Heat Exchanger Selection - PHE

**Plate Heat Exchanger**

- Good price level
- Limited viscosity range
- Numerous contact points are an issue with parts
- Large surface area capacity
- Small overall footprint
- Capable of heat recovery (regeneration)
- Lower operating pressures
Heat Exchanger Selection - PHE

<table>
<thead>
<tr>
<th>Tie-Bar Frame</th>
<th>Automated Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Low cost solution</td>
<td>• Fast recovery for daily/wkly teardown</td>
</tr>
<tr>
<td>• More labor intensive style</td>
<td>• Consistent tightening extending the life of plates &amp; gaskets</td>
</tr>
<tr>
<td>• Subject to over-tightening, damaged plates and gaskets</td>
<td>• Less labor intensive for frequent opening/closing</td>
</tr>
<tr>
<td>• Removable parts (tie-bars)</td>
<td>• PLC tracking capabilities</td>
</tr>
</tbody>
</table>

Plate Heat Exchanger
## Heat Exchanger Selection - Tubular

<table>
<thead>
<tr>
<th>Smooth &amp; Corrugated Heat Exchangers</th>
<th>Coiled Heat Exchangers</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Excellent for particle laden products</td>
<td>- Expensive tubular solution</td>
</tr>
<tr>
<td>- No moving parts</td>
<td>- Excellent UHT processes</td>
</tr>
<tr>
<td>- Large hold up volumes and considerable losses can occur</td>
<td>- Long runtimes due to high velocity</td>
</tr>
<tr>
<td>- Less maintenance than other heat exchangers</td>
<td>- Small footprint</td>
</tr>
<tr>
<td>- Large product range</td>
<td>- High pressure limits</td>
</tr>
<tr>
<td><img src="image1" alt="Smooth &amp; Corrugated Heat Exchanger Image" /></td>
<td><img src="image2" alt="Coiled Heat Exchanger Image" /></td>
</tr>
<tr>
<td><img src="image3" alt="Turbulent Flow Diagram" /></td>
<td></td>
</tr>
</tbody>
</table>

- High pressure limits
- Turbulent flow
Double Tube Heat Exchanger

- Suitable for particle laden products
- Good product recovery with pigging system
- Large product range
- Potential for heat recovery
- Least expensive tubular option
Heat Exchanger Selection - Tubular

- Lower viscosity range option
- Large surface area per section
- Turbulent flow – High heat transfer
- Capable of small particles
- Indirect heat recovery potential
- Capable of high flow capacities
Heat Exchanger Selection - Tubular

**Triple Tube Heat Exchanger**

- Higher viscosity range option
- Laminar flow conditions
- Product to product heat recovery
- Inner/Outer surfaces for product contact
Heat Exchanger Selection - Tubular

Coiled Heat Exchanger

- Lower viscosity range option
- Large surface area per section
- Capable of small particles
- Indirect heat recovery potential
- Turbulent flow = Long runtimes
- Responds to CIP (high velocity)
Scraped Surface Heat Exchanger

- Most expensive heat exchanger option
- Excellent for products changing state (crystallizing, etc.)
- Wide range of utilities (steam, refrigeration, etc.)
- High viscosity, abrasive, sticky products are candidates
- Incorporates mixing for homogenous products
- No heat recovery capabilities
- Requires regular maintenance of wear parts
- Multiple configurations available (conc, ecc, oval)
# Heat Exchanger Comparisons

## Sanitary Applications

<table>
<thead>
<tr>
<th>Attribute</th>
<th>PHE</th>
<th>Tubular</th>
<th>S.S.H.E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital Cost</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Heat Transfer Coefficient</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laminar</td>
<td>Low</td>
<td>Low</td>
<td>Medium</td>
</tr>
<tr>
<td>Turbulent</td>
<td>High</td>
<td>High</td>
<td>Medium</td>
</tr>
<tr>
<td>% Regeneration</td>
<td>Excellent</td>
<td>Good</td>
<td>None</td>
</tr>
<tr>
<td>Operating Pressure</td>
<td>Low</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Particulates</td>
<td>Poor</td>
<td>Excellent</td>
<td>Excellent</td>
</tr>
<tr>
<td>Materials of Construction</td>
<td>Excellent</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>Residence Time</td>
<td>Low</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Length of Run</td>
<td>Medium / Good</td>
<td>Medium / Good</td>
<td>Good / Excellent</td>
</tr>
<tr>
<td>Flexibility of Process</td>
<td>Fair</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>CIP Ability</td>
<td>Fair / Good</td>
<td>Excellent</td>
<td>Good</td>
</tr>
<tr>
<td>Maintenance Expenses</td>
<td>Medium</td>
<td>Low</td>
<td>High</td>
</tr>
</tbody>
</table>
Sizing Data Input Requirements

Heat Exchanger Selection

- Process Info
- Product Info
- Customer Expectations
Product Information

**Product Description** (What is it? Compared to what?)

**Product Qualities**
- Heat Sensitive (Discoloration or fouling)
- Shear Sensitive (Separation or viscosity reduction)
- Sticky
- Abrasive (fiberous, undissolved granules, etc.)
- Lubricating (fatty or oily)

**Product Specifications**
- Viscosity information
- Composition (Total solids, % moisture, % fat, % sugar, etc.)
- Specific Gravity
- Specific Heat
- Thermal Conductivity
- Particles (Size, shape, % to carrier fluid, expected integrity, etc.)
- pH value
Product Characteristics

Shear Thinning Products

Waukesha Cherry-Burrell Process Equipment Division
Proving Center Viscosity Plot

Customer Name

\[ \eta = 1.89E+7 \cdot T^{-1.232} \cdot \gamma^{-0.756} \]

- Temp = 75°F - \( \eta = 88994 \cdot \gamma^{-0.756} \)
- Temp = 135°F - \( \eta = 49579 \cdot \gamma^{-0.756} \)
- Temp = 195°F - \( \eta = 26788 \cdot \gamma^{-0.756} \)

Solids = 38.0% (OHAUS)
Sp.Gr. = 1.04
pH = 5.03
Cp = 0.81 (EST)
k = 0.26 (EST)
Filename = ATW5CH98.XLS

Shear Rate (\( \gamma \)) (Sec. \(^{-1} \))

Apparent Viscosity (\( \eta \)) (Centipoise)
Process Information

**Process Description** (What process?)
- Heat/Cool/Crystallize/Cook/Pasteurize/Sterilize/Freeze?
- Heat Recovery? Amount?
- Batch/Semi-continuous/Continuous

**Process Conditions**

**Product parameters**
- Flow rate
- Inlet/Outlet temperatures

**Utility parameters**
- Description of source (Chilled, tower, glycol, ammonia, etc..)
- BTU/Tonnage/Concentration limits
- Inlet/Outlet temperatures

**Process Considerations**

- Pump type & pressure limits
- Product quality (time vs temperature relationships, applied shear, etc...)
- Process efficiency
- Heat recovery
- Maintenance costs (Labor and parts)
- Product losses (Loss of expensive ingredients)
Other Requirements

- Potential requirements could include:
  - Cost effective solution
  - Project timing
  - Product quality (Taste/Appearance/etc...)
  - Process control & responsiveness
  - Ease of maintenance
  - Space limitations (Horizontal/Vertical)
  - Technical/Local support
  - Aftermarket support
  - Reduced downtime
  - Energy reduction
  - Maintenance costs
  - Product losses (expensive ingredients)
  - Cleanable (Sanitary design & CIP)
  - Meets regulatory standards
  - Safety
Media Selections – How it affects sizing

Steam Supply

- Can be run at elevated temperatures (up to 400°F (204°C)) to decrease the surface area required
  - The media temperature is the same across the entire unit – Increases the LMTD – Allows for less surface area

- Dry steam supply yields the best heat transfer

- Minimum recommended steam pressure is 15 PSI (1 bar) → 250°F (121°C)
  - Below this pressure the steam is difficult to control

- Condensate removal from a heat exchanger is critical to optimize the thermal performance
  - Steam trap sized for the application

BWS – Bleed and Feed Loop

Figure 8: Suggested Media Piping, Steam

1. Steam IN
2. Strainer
3. By-Pass Line
4. Steam Pressure Regulator
5. Steam Solenoid
6. Temperature Regulator
7. I/P
8. Temperature Control
9. Product OUT
10. Product IN
11. Drain Valve
12. Condensate Trap
Media Selections – How it affects sizing

Bleed and Feed Loop

- Generally a customer does not have liquid media at the exact temperature and flow rate specified on a quote.

- A bleed and feed loop is recommended to achieve the necessary media conditions needed for the application requirements.

- Requirements to Implement
  - Liquid media either hotter or colder than what listed on the quote
  - A recirculation pump
  - Valves
  - Gauges (Startup and Troubleshooting)

Figure 5 – Suggested Media Piping, Water or Liquid

Table 2: Call Outs For Figure 5

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Media IN</td>
</tr>
<tr>
<td>2</td>
<td>Product OUT</td>
</tr>
<tr>
<td>3</td>
<td>Product IN</td>
</tr>
<tr>
<td>4</td>
<td>Temperature Regulator</td>
</tr>
<tr>
<td>5</td>
<td>Media OUT</td>
</tr>
<tr>
<td>6</td>
<td>FP</td>
</tr>
<tr>
<td>7</td>
<td>Temperature Control</td>
</tr>
</tbody>
</table>
Types of Refrigeration Setup

- **Gravity**
  - Performs liquid/gas separation at the point of use
  - More expensive equipment at usage point
  - Less expensive compressor – easier to expand in future

- **Liquid Over Feed (LOF)**
  - Performs liquid/gas separation at the compressor
  - Less expensive equipment at usage point
  - More expensive compressor – more complex to expand in future
Thank You!