Flow Distribution Effects on the Thermal Efficiency of a Brazed Plate Heat Exchanger

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BUFFALO, New York (CNN) -
- Getting a break from record snowfall that has buried the upstate New York city since Christmas Eve, residents of the Buffalo area began to dig out of their homes and businesses Saturday.

More than 83 inches of snow have fallen......
Snow
The Real Story: The Best Summers in the Northeast

<table>
<thead>
<tr>
<th>Percent of Sunshine</th>
<th>Average Rainfall, Inches</th>
<th>Average Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>June through August</td>
<td>June through August</td>
<td>July afternoon</td>
</tr>
</tbody>
</table>

Source: Weather Service, May 2023
Why?

- Popularity in brazed plate heat exchangers have increased.
- Most applications require accurate performance calculations.
- Understanding the fluid distribution in a brazed plate heat exchanger is necessary to make accurate performance calculations.
Advantages

- One-sixth the size
- One-fifth the weight
- Up to one-fifth the surface is required
- Greater efficiency

200,000 BTU/Hr

BPHE = $500.00

Shell & Tube = $1,200.00

* SS Tubes = $2,500.00
How it Works

- Turbulence
- Counter current flow path
- Less fouling
- High heat transfer coefficients
Flow Maldistribution

• **Maldistribution is any variation in flow distribution effecting a heat exchangers performance.**

\[ m^2 \]

*This flow distribution parameter has been suggested by Bassiouny and Martin [1984]*
Project Objective

• The aim of this study was to extend the analysis of flow maldistribution in plate and frame style heat exchangers to a brazed unit
Parameters Effecting Flow Maldistribution

- Number of channels, $n$
- Port diameter, $D_p$
- Corrugation angle, $\varphi$
- Flow rate
- Fouling
A flow distribution parameter has been suggested by Bassiouny and Martin [1984]

\[ m^2 = \left( \frac{nA_c}{A_p} \right)^2 \frac{1}{\zeta_c}. \]

The Parameters Affecting Port flow Maldistribution

- Area Ratio between channel and port cross-section, \( \frac{A_c}{A_p} \)
- Channel Flow Resistance, \( \zeta_c = f \left( \frac{l}{d_c} \right) + \text{minor losses} \)
- Number of channels, \( n \)
Maldistribution Effects on Performance

Maldistribution can:

• Increase a units pressure drop
• Hinder thermal performance
Testing for Maldistribution

- Pressure Drop Readings
- Visual Evaluation
Pressure Drop Data Collection

ITT Brazed Plate Heat Exchanger consisting of 60 plates
Pressure Drop Data Collection

Diagram:
- Pressure Transducer
- Mobile Static Pressure Probes
- Outlet
- Valves
- Inlet
- Flow Meter
- Test Heat Exchanger
Pressure Drop Data Collection
Pressure Drop Results

Distance Within Inlet Port (in)

Pressure Drop Across Core (psi)

TOP

Inlet

Outlet

6.25
5.5
4.75
4
3.25
2.5
1.75
1
0.25

20 GPM
30 GPM
40 GPM
50 GPM
60 GPM
Pressure Drop Results

50 GPM
### Pressure Drop Results

#### 50 GPM vs Rao, Sunden, and Dos

<table>
<thead>
<tr>
<th>Number of plates</th>
<th>Pressure reading across upper flow channels (psi)</th>
<th>Pressure reading across lower flow channels (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>14</td>
<td>10.8</td>
</tr>
<tr>
<td>60*</td>
<td>15*</td>
<td>10*</td>
</tr>
<tr>
<td>81</td>
<td>9.96</td>
<td>1.13</td>
</tr>
</tbody>
</table>
Pressure Drop Results

- When plotted pressure curves diverge for inlet (P) and outlet (P*) pressure profiles indicate maldistribution, as suggested by Bassiouny and Martin [1984]
Visual Test Setup
Visual Studies
Visual Study Results
Visual Study Results
Project Summary

- Collected data showed that maldistribution is occurring in the tested 60-plate heat exchanger.
- Variation in pressure drops across individual flow channels indicate that flow across individual channels varies.
Project Summary

• Visualization studies reveal a variation in flow velocities across a plates surface.

• Dead spots on the plates surface were easily detected
Recommendations

• Use the largest possible port diameter.

• Keep $n$ to a minimum.

• Operating flow rates should be kept as low as possible.
Recommendations

Lack of Distribution enhancing geometry
**Recommendations**

Redesign port geometry as the number of plates increase.

Redistribute the flow in the inlet to make better use of all the heat exchange surface.

Allowing fluid to distribute to the lower channels