Improving Shale Oil Crude Heater Performance

Furnace Improvements

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Objective

- Reduce coking rate in the Crude Heater
- Reduce tube metal temperatures in tubes near arch
- Uniform heat distribution in the heater
Crude Heater

Cabin Type Heater

- Horizontal Tube Radiant & Convection Section
- Gas Fired Low NOx Burners
- Heater Duty = 155.7 MM Btu/hr
- Charge Flow rate = 50,376 BPD
- Temperature (Inlet/Outlet) = 427 / 720 °F
- Pressure (Inlet/Outlet) = 95 / 35 psig
- Avg. Flux Density = 12,000 Btu/hr-ft2
Existing Heater and Radiant Section

- 7'-9" height
- 16'-4" C-C TUBE
- 17'-10" I/S INS.
- 18'-8 3/8" O/S PL.
- No. of Radiant Tubes = 90
Heat Distribution Pattern

- Top portion is receiving maximum heat
- Heat distribution is not uniform
- Pass imbalance
# Existing Burners

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Numbers</td>
<td>Nos.</td>
<td>6</td>
</tr>
<tr>
<td>Maximum Heat Release per Burner</td>
<td>MMBtu/hr</td>
<td>38.9</td>
</tr>
<tr>
<td>Turndown Ratio</td>
<td>-</td>
<td>4:1</td>
</tr>
<tr>
<td>Location</td>
<td>-</td>
<td>Floor Mounted</td>
</tr>
<tr>
<td>Draft Loss Across Burners (at max. firing)</td>
<td>in W.C</td>
<td>3.87</td>
</tr>
</tbody>
</table>

![Diagram of existing burners]
Velocity Vectors at Z-1 Section (ft/s)
Temperature Contours at Z Section (deg F)
Pathlines colored by velocity (ft/s)
Flame Colored by Height (ft)
Flame colored by Temperatures (deg F)
Radiant Tubes Temperature Contours (deg F)
CO Contours at Different Elevations of Heater
Velocity Contours at Different Elevations of Heater
Temperature Contours at Different Elevations of Heater
## Base Case

<table>
<thead>
<tr>
<th></th>
<th>Bottom Zone</th>
<th>Intermediate Zone</th>
<th>Top Zone</th>
<th>Mean Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Radiation Heat Flux</strong></td>
<td>-7429.83</td>
<td>-10071.1</td>
<td>-11350.2</td>
<td>-</td>
</tr>
<tr>
<td>($\frac{BTU}{hr.ft^2}$)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total Heat Flux</strong></td>
<td>-8387.7</td>
<td>-11426.3</td>
<td>-14735.2</td>
<td>-11825</td>
</tr>
<tr>
<td>($\frac{BTU}{hr.ft^2}$)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Heat Flux % Variation</strong></td>
<td>-29.06</td>
<td>-3.36</td>
<td>24.62</td>
<td>-</td>
</tr>
<tr>
<td>from mean</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# Proposed Option

## 18 Ultra Low NOx Burners

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Unit</th>
<th>Existing</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Burners</td>
<td>Nos.</td>
<td>6</td>
</tr>
<tr>
<td>Heat Released/Burner (Max)</td>
<td>MMBtu/hr</td>
<td>12.96</td>
</tr>
<tr>
<td>Flame Length</td>
<td>ft</td>
<td>18-20</td>
</tr>
<tr>
<td>Burner to Burner Distance</td>
<td>ft</td>
<td>3</td>
</tr>
</tbody>
</table>

![Diagram of burner arrangement](image)
Velocity vectors at Y-1 Section (ft/s)
Temperature contours at Y Section (deg F)

Y-1 section

Y-2 section
Pathlines colored by velocity (ft/s)

Pathlines released from burner fuel tip
Flame colored by height (ft)

CO 2000 PPM
Flame colored by Temperatures (deg F)

CO 2000 PPM
Radiant Tubes Temperature Contours (deg F)
Flame colored by height (ft)

Base Case CO 2000 PPM

Proposed Design
Flame colored by Temperatures (deg F)

Base Case  CO 2000 PPM  Proposed Design
Velocity Vectors at Vertical Section (ft/s)

Base Case

Proposed Design

Z-1 section

Y-1 section

Z-2

Y-2
Temperature contours at Z Section (deg F)

Base Case

Z-1 section

Z-2 section

Proposed Design

Y-1 section

Y-2 section
Radiant Tubes Temperature Contours (deg F)

Base Case

Proposed Design
## Mod-18 Burners Case

<table>
<thead>
<tr>
<th></th>
<th>Bottom Zone</th>
<th>Intermediate Zone</th>
<th>Top Zone</th>
<th>Mean Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Radiation Heat Flux</strong></td>
<td>-8283.96</td>
<td>-10029.5</td>
<td>-10824</td>
<td>-</td>
</tr>
<tr>
<td>(BTU/hr*ft²)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total Heat Flux</strong></td>
<td>-9469.57</td>
<td>-11288.8</td>
<td>-13123.9</td>
<td>-11416</td>
</tr>
<tr>
<td>(BTU/hr*ft²)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Heat Flux % Variation from mean</strong></td>
<td>-17.1</td>
<td>-1.1</td>
<td>15</td>
<td>-</td>
</tr>
</tbody>
</table>
Option 3 – 36 Inclined Burners

WELD TO WELD LENGTH

61'-3" O/S PL.

3'-3"3'-2"
TYP.TYP.
Radiant Tubes Temperature Contours (deg F)

Base Case

Proposed Design
Process Parameters

- Low fluid mass velocity in the radiant tubes
  - Existing - 155 lb/sec ft$^2$
  - Recommended- 250-350 lb/sec ft$^2$
- Pressure drop across the crude heater service is low
  - Existing - 53 psi
  - Recommended pressure drop is around 100-150 psi
- Convection tube size is 4 inch and radiant tube is 6 inch.
  - Typically one size difference between the two.
Summary

- The heater was commissioned in January 2014.
- Client is extremely happy with the heater performance.
- They would have preferred to go with 36 burners as an afterthought.
- The run length increased to 1.5 years (estimated based on temperature rise)
- Process modifications have been put off.
Thank You

Questions and Comments are Welcome