Get the Most from Your Coker Heaters

By

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Furnace Improvements
Existing Heaters

- Two Identical Units—Each w/Twin Box Horizontal Tubes - Double Fired and Twin Convection Sections
- 4 pass arrangement - 2 passes per Radiant / Convection
- Residual + Natural Recycle Feed
- Design tube skin temperature - 1250 °F
### Existing Radiant Sections

- **Twin Radiant Cells**
- **Total number of Tubes per Cell: 68**
  - Arranged in 2 Rows and 2 Passes
  - Each Pass Separated by FQFB Gravity Wall

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Top 30 tubes</th>
<th>Bottom 4 tubes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tube Size</td>
<td>4” NPS Sch.120</td>
<td>5” NPS Sch. 160</td>
</tr>
<tr>
<td>Tube Material</td>
<td>A335 Gr P9</td>
<td></td>
</tr>
<tr>
<td>Effective tube length</td>
<td>61’-0”</td>
<td>61’-11 ½”</td>
</tr>
<tr>
<td>Tube C-C Spacing</td>
<td>8”</td>
<td>15”</td>
</tr>
<tr>
<td>Heat Transfer Area</td>
<td>5,046 ft²</td>
<td></td>
</tr>
</tbody>
</table>
Existing Burners

- Double Firing with 4 rows of burners in each cell
  - Natural Draft, 15% Excess Air
  - Low NOx, Fuel Gas Fired

- 56 flat flame burners in each radiant cell

- Heat Release
  - Max.: 2.09 MMBtu/hr
  - Normal: 1.67 MMBtu/hr
Existing Heaters – Operational Issues

❖ Flame Impingement on Radiant Tubes
❖ Heat Maldistribution and Excessive Heat Flux Density
❖ High Tube Metal Temperatures
❖ Short Heater Run Length
Proposed Options

- Replace last four radiant 5” NPS Sch.160 coils with six 4” NPS Sch.120
- Upgrade Radiant and Convection coil metallurgy to A312TP347H
- **Option-1**: Two tubes of 4”NPS Sch. 120
- **Option-2**: Six tubes of 4”NPS Sch. 120
- **Option-3**: Addition of new 4” NPS Sch.120 coils installed in convection future rows provision
Benefits of Proposed Options

❖ Increase in Process Fluid Mass Velocity for bottom tubes
❖ Reduction in Inside Film Temperature
❖ Reduction in Tube Metal Temperatures
❖ Reduction in Relative Coking Rate
## Benefits of Proposed Options

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Design</th>
<th>Option-1</th>
<th>Option-2</th>
<th>Option-3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Radiant Heat Flux Density (Btu/hr.ft²)</strong></td>
<td>11,000</td>
<td>5% Reduction (10,450)</td>
<td>19% Reduction (8,910)</td>
<td>25% Reduction (8,250)</td>
</tr>
<tr>
<td><strong>Maximum TMT (°F)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arch Tubes</td>
<td>-</td>
<td>964</td>
<td>908</td>
<td>905</td>
</tr>
<tr>
<td>30th Tube</td>
<td>1,059</td>
<td>1,058</td>
<td>1,051</td>
<td>1,043</td>
</tr>
<tr>
<td>Outlet Tube</td>
<td>1,100</td>
<td>1,075</td>
<td>1,066</td>
<td>1,057</td>
</tr>
<tr>
<td>Reduction in Firing Rate</td>
<td>3%</td>
<td>3%</td>
<td>3%</td>
<td>8%</td>
</tr>
</tbody>
</table>
Pressure Drop Comparison for Proposed Options

- Current Operation, psi: 290 – 310
- Option 1, psi: 342
- Option 2, psi: 365
- Option 3, psi: 383
- Design Pressure Drop, psi: 390

The pressure drop can be reduced if needed by using lower thickness tubes or by increasing OD of the tubes.
Film Temperature Profiles
Relative Coking Rates

![Graph showing relative coking rates for different options: ORIGINAL DESIGN, OPTION 1, OPTION 2, and OPTION 3. The graph compares the coking rate against the heat pass tube count. The coking rate increases as the heat pass tube count increases, with OPTION 3 showing the highest coking rate.](image-url)
Comments

- Significant benefits by adding more tubes in the radiant section and lowering the heat flux, coking rates and film temperatures

- Significant savings are possible by lowering the tube thickness in radiant and convection section

- Huge fuel savings as required firing rate is reduced
Burners

- 112 burners in each heater
- Flat flame, ultra low NOx, Up-fired
- Fuel LHV=1,026 BTU/scf
- 2.09 MMBtu/hr Design Heat Release
- Natural Draft
Methodology
Flowchart of CFD Modeling
## Operating Data for Modeling

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Units</th>
<th>Pass 1</th>
<th>Pass 2</th>
<th>Pass 3</th>
<th>Pass 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charge Rate</td>
<td>BPH</td>
<td>425</td>
<td>420</td>
<td>410</td>
<td>424</td>
</tr>
<tr>
<td>Fuel Gas Flow</td>
<td>scfh</td>
<td>53,038</td>
<td>52,321</td>
<td>44,039</td>
<td>54,490</td>
</tr>
<tr>
<td>Fuel Gas Pressure</td>
<td>psig</td>
<td>12.9</td>
<td>12.8</td>
<td>9.9</td>
<td>14.1</td>
</tr>
<tr>
<td>Excess O\textsubscript{2} in Flue Gas</td>
<td>%</td>
<td>2.44</td>
<td>3.05</td>
<td>2.83</td>
<td>2.49</td>
</tr>
<tr>
<td>Heat Release/Burner</td>
<td>MMBtu/hr</td>
<td>2.27</td>
<td>2.26</td>
<td>1.89</td>
<td>2.33</td>
</tr>
<tr>
<td>Total Fuel Gas Flow</td>
<td>scfh</td>
<td>106,235</td>
<td></td>
<td>99,392</td>
<td></td>
</tr>
</tbody>
</table>
Heater Geometry

Air inlet

Burner Geometry
Planes Used for Results

- Planes along the center of burner
- Planes along the height of heater

Plane B-1, Plane B-2, Plane B-3, Plane B-4

Z-1, height 2’
Z-2, height 6’
Z-3, height 10’
Z-4, height 15’
Z-5, height 20’
Results

❖ The flow pattern of flue gases is shown using
  • Velocity Vectors
  • Path Lines

❖ The temperature profile in the heater is shown using
  • Temperature Contours

❖ The flame profile is shown using
  • CO envelope of 2000 ppm
Velocity Vectors

Plane @ Primary tip

Vertical Firing
Velocity Vectors (by temperature)

Vertical Firing

Plane @ Primary tip

(°F)
Path Lines

Vertical Firing
Temperature Contours

Vertical Firing

(°F)

Plane @ Primary tip

Plane @ Secondary tip
Tube Metal Temperature Contours

Vertical Firing

(°F)
Iso-Surface of CO 2000 ppm

Vertical Firing

<table>
<thead>
<tr>
<th>Minimum Distance From Tubes</th>
<th>Ft</th>
</tr>
</thead>
<tbody>
<tr>
<td>d1</td>
<td>0.65</td>
</tr>
<tr>
<td>d2</td>
<td>0.71</td>
</tr>
<tr>
<td>d3</td>
<td>0.44</td>
</tr>
<tr>
<td>d4</td>
<td>1.5</td>
</tr>
</tbody>
</table>
Inclined Firing

Burners are inclined by 7.5 deg towards the walls.
Velocity Vectors

Colored by Velocity

Colored by Temperature

(ft/s)

(°F)
Temperature Contours

°F

Plane @ Primary tip

°F
Iso-Surface of CO 2000 ppm

Minimum Distance from tubes | ft
---|---
d1 | 2.1

d2 | 2.2

d3 | 2

d4 | 1.9
Vertical vs. Inclined Firing

Inclined Firing

Vertical Firing

(ft/s)
Vertical Up Firing vs. Inclined Firing

Temperature

°F
Comments

- Inclining the burners towards the radiant and fire brick gravity wall helps to direct the flames away from radiant tubes

- Flue gas temperature around radiant tubes is reduced

- Inclined firing in addition to the proposed modifications for radiant coils will enhance the performance of the heater
Thank You Very Much

❖ We hope you will find our presentation helpful and informative.