Improving Reliability of Coker Heaters

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Why coker heaters?

- Important
- Heavier Crudes
- More products
- Over firing
Typical problems in coker heaters

- Run length
- Tube metal temperatures
- Flame
- Arch pressure
- FD/ID fans
- Oxygen in flue gas
- Stack temperature

Our Objective

- Improving run length of coker heaters
Coker heater

- Heavy residues for the Coker unit
- Charge heated to the desired (app. 900-935 °F)
- Coke formation in drums

Coker Heaters

- Endothermic reaction

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Coker heaters - Design features

- Residence time
- Down flow
- Tube Material
- Tube size
- Number of passes

Coker heaters

- Coking
- Removable plug headers
- Header boxes
- Steam snuffing
Typical coker heater design

- Box heaters
- Horizontal tubes
- Burners
- Bridge wall
- Convection Section
- Stack

Double fired Coker Heater

- Tubes
- Burners
- Number of fire boxes
- Convection section
Terrace Wall Coker Heater

- Foster Wheeler
- Firebox shape
- Firing arrangement
- Number of terraces
- Heat flux

Single fired vs. Double fired

- Single fired
- Double fired
- Differences
  - Coil length
  - Residence time
  - Pressure drop
  - Firing arrangement

Good heater design required
Single fired vs. Double fired

Heat flux

- Average heat flux
- Heat absorbed per unit area
  - radiant heat duty/Radiant surface area
  - units are Btu/hr ft²
- Peak heat flux
- Front of the tubes receive the maximum heat
Limitations on run lengths

- Limiting parameters
- Tube metal temperature
- Pressure drop
- Coke formation

Coke formation

- Two reasons
  - Heater design
  - Heater operation
Coke formation

- Metal thermal conductivity
  - 200 - 300 Btu/hr ft² F /inch
- Coke thermal conductivity
  - 1 - 30 Btu/hr ft² F /inch
- Typically 1/8 inch of coke adds up to 100 F of tube metal temperature rise

Clean tube

- Oil temperature
  - 875 F
- Film temperature
  - 925 F
- Metal temperature
  - 940 F

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Coked tube

- Oil temperature
  - 875 °F
- Film temperature
  - 925 °F
- Coke temperature
  - 1125 °F
- Metal temperature
  - 1140 °F

Coke formation

- High film temperatures
- Cracking of Hydrocarbons
- Laying down of coke
- Coking rate vs. tube metal temperature increases
Coke formation

- Tube metal temperature
- Pressure drop across heater
- Tube rupture
- Tube sagging, bowing

Coking in tubes

- Tube metal temperature
- Pressure drop across the coil
- Firebox temperature
- Firing rate
- Efficiency
- Charge rate
- Shut down the heater and clean the tubes
Monitoring Coking

- Tube skin thermocouples
- Infra-red surveys
- Monitor operation

Good operation vs. run length

- Good Combustion
- Equal flow distribution
Typical operating philosophy

- Firing rates
- Limiting metal temperatures
- Coke formation
- Flames

Uniform firing

- Excess air control
- Provide required draft
### Typical Operating Parameters

<table>
<thead>
<tr>
<th>Heater Number</th>
<th>Flowrate, BPD</th>
<th>Inlet temperature, °F</th>
<th>Outlet temperature, °F</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-1</td>
<td>14,800</td>
<td>756</td>
<td>885</td>
</tr>
<tr>
<td>B-2</td>
<td>15,385</td>
<td>765</td>
<td>894</td>
</tr>
<tr>
<td>B-3</td>
<td>15,200</td>
<td>769</td>
<td>883</td>
</tr>
</tbody>
</table>

### Typical Operating Parameters

<table>
<thead>
<tr>
<th>Heater Number</th>
<th>Inlet pressure, psig</th>
<th>Outlet pressure, psig</th>
<th>Pressure drop, psi</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-1</td>
<td>300</td>
<td>67</td>
<td>233</td>
</tr>
<tr>
<td>B-2</td>
<td>300</td>
<td>59</td>
<td>241</td>
</tr>
<tr>
<td>B-3</td>
<td>350</td>
<td>72</td>
<td>278</td>
</tr>
</tbody>
</table>
Typical Combustion Control

- Oxygen set point - 3%
- Draft set point -?
- Measured O2 in stack - 6-7%
- Draft in the heater -?
- Using stack O2 to control the excess O2
- Using stack damper to control O2.
- Where is the excess O2 coming in the stack?
- How to control the excess O2?

Dampers

- Poor dampers
- Stuck
- Do not operate
- Operators

Furnace Improvements can supply you with very good and reliable dampers which can control draft and excess air
Good operation

- Control draft
- Control excess O2
- Burner register
- Stack damper

Burners

- Burner sizing
- Flame lengths
- Operation

FIS can help you select proper burners and ensure that you get the required flame pattern and correct excess oxygen.
Tube skins before and after tuning

Fuel gas flow and pressure
Before and after tuning

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Training

- Training of operators
- It pays off big time
- Operating cases
- Furnace Improvements can provide classroom and hands on training for your coker heaters

Coking of heater

- Coker heater will be coking
- Design basis
- Extend run length
  - On line spalling
On line spalling

- Alternate heating and cooling with steam to spall of the coke from the tube wall.
  - Extends the heater run lengths
  - Does not require a shutdown
  - Passes are decoked one at a time
  - Feed cut off
  - Steam introduced
  - Coke is thermally stressed until it breaks
  - Goes to coke drums

Tube cleaning during turnaround

- Steam air decoking
- Pigging
Steam air decoking

- Two step process
- Coke spalling
  - Shrinking and cracking the coke loose by heating the outside and blowing steam inside
- Coke burning
  - In this process, air is injected with steam and coke burning takes place inside the tube

Steam air decoking

- Use steam, air and heat to burn out the coke in the tubes.
- Experienced operators are required to perform the decoking.
- Infra-red thermography can help monitor steam air decoking very closely
- Improper procedure can result in overheating of tubes.
- Inexpensive
Pigging

- Abrasive pigs can be used to clean tubes mechanically.
- Propelling a pig with equipped with steel wires through tubes with water.
- The pig is sent back and forth through the tubes and deposits are removed like brushing to clean a surface.

Pigging Process

1: GAUGE PIGG
2: PRIMARY ELEMENT PIGG
3: SECONDARY ELEMENT PIGGS
5: INSPECTION TOOL
4: POLISHING PIGG

CONVECTION/RADIANT TUBE or PIPELINE

Courtesy- Eliminator Pigging Co.
Pigging

- Requires modification in the heater piping to create a location to launch and receive pigs.

- Gaining popularity

- Need to be careful if the tubes are not round

We Hoped You Enjoyed our Presentation

Thank you very much
Visit www.heatflux.com for all your heater needs