Feed Entry Systems For The Modern Delayed Coking Unit
International Refcomm
Budapest, Hungary
Steve Beeston – Vice President, Business Development Technology, Consultancy & Fired Heaters
Amec Foster Wheeler

4 October 2017
Delayed Coking

- Most commonly used residue upgrading process
  - Over 5,500,000 BPSD installed capacity
  - Amec Foster Wheeler is market leader
- Very attractive economics
- Complete residue conversion
  - Gas
  - Naphtha
  - Gas oils
  - Coke (disposal not an issue)
- Specialty coke production
- Maximized diesel yield with Hydrocracker integration
- Wide variety of feedstocks

Photograph courtesy of Petron Corporation
Continuous batch process
- Typical cycle is 18 hour fill and 18 hour empty

Extensive thermal and mechanical stresses on coke drums
Traditional Coke Drum Design

- Utilized central, bottom feed entry
- “Uniform” upward flow in coke drum
- Bottom unheading was a difficult and dangerous task
  - Manpower intensive
  - Time consuming

Photograph courtesy of DeltaValve
Traditional Bottom Unheading

Photographs courtesy of DeltaValve
Semi-Automated Bottom Unheading Systems
Problems with Bottom Unheading

Photographs courtesy of DeltaValve
Slide Valve Bottom Unheading Systems

► Developed by DeltaValve
► Revolutionized DCU operations
  ► Fully automatic
  ► Safe
  ► Cleaner
► However introduced a new problem
  ► How to introduce feed into the coke drum

Photographs courtesy of DeltaValve
Single Side Feed Entry

Photographs courtesy of DeltaValve
Flow Patterns In The Coke Drum

Bottom entry

Single side entry

© Amec Foster Wheeler 2017. All rights reserved.
Issues With Single Side Entry Feed Systems

- Non-uniform flow in the coke drum
- Non-uniform temperature profiles
  - Enhanced banana movement
  - Enhanced thermal fatigue
- Hot spots
- Blow-outs
- Vibration
Dual Feed System

► Claims more uniform flow than in single side entry systems
Dual Feed System

- Claims more uniform flow than in single side entry systems
  - Not necessarily the case due to interactions of streams

- Issues
  - More complicated piping runs around coke drums
  - Equalization of flow
  - Deformation of BUD attachment flange leading to leaks
Introducing the DeltaValve Center Feed Device

- Simulates traditional bottom feed entry
- Based on slide valve unheading technology
Center Feed Device

Photographs courtesy of DeltaValve
Center Feed Device

- Commercially operating (over 5 years successful operation) in 3 locations
- Benefits observed
  - Minimum to zero banana effect
  - Drastic reduction in frequency of hot spots and blowouts
  - Low differential thermal gradients observed during coking and quenching

Photograph courtesy of DeltaValve
Flow Patterns In The Coke Drum

Bottom entry

Center Feed Device
Center Feed Device Installation

Photograph courtesy of DeltaValve
Coke Drum Temperature Profiles
Center Feed Device
Temperature Profile Improvement With Center Feed Device

- Large circumferential temperature gradients
- Non-uniform flow in the drum
- Uniform temperature gradients
- Uniform flow
- Coke insulation layer
- Lower wall cooling rates during quench
Coke Drum Temperature Profiles
Side Entry
Coke Drum Temperature Profiles
Center Feed Device

© Amec Foster Wheeler 2017. All rights reserved.
Temperature Profile Improvement With Center Feed Device

- Large circumferential temperature gradients
- Non-uniform flow in the drum

- Uniform temperature gradients
- Uniform flow
- Coke insulation layer
- Lower wall cooling rates during quench
Coke Drum Movement

- Circumferential temperature gradients result in “Banana Movement” of the drum
- The Banana Movement can be calculated

\[ \text{BM} = 1.2 \times (R + 0.5D) \times (1 - \cos \alpha) \]

where \( \alpha = \frac{57.2956 \times \gamma \times L \times (T_h - T_c) \times (1 + \gamma \times T_c)}{(180 \times D)} \times \pi \)

and \( R = \frac{D}{(\gamma \times (T_h - T_c))} \)

- \( D \) = coke drum diameter
- \( L \) = coke drum length
- \( T_h \) = hot side temperature
- \( T_c \) = cold side temperature
- \( \gamma \) = coefficient of thermal expansion
## Banana Movement

<table>
<thead>
<tr>
<th>Condition</th>
<th>Calculated Banana Movement (in)</th>
<th>Observed Banana Movement (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Side entry</td>
<td>6.7</td>
<td>~ 6</td>
</tr>
<tr>
<td>Center Feed Device</td>
<td>3.1</td>
<td>~ 3</td>
</tr>
</tbody>
</table>

*The Center Feed Device results in a significant reduction in the Banana Movement of the coke drum*
DeltaValve – Amec Foster Wheeler Alliance

► In March 2016 DeltaValve and Amec Foster Wheeler entered into an alliance to promote, sell and install the Center Feed Device
  ► Amec Foster Wheeler fully endorses the Center Feed Device
  ► The Center Feed Device is now Amec Foster Wheeler’s standard feed entry system for all new DCUs
  ► Both DeltaValve and Amec Foster Wheeler can sell the Center Feed Device into existing units
  ► Amec Foster Wheeler can provide the necessary engineering to support a Center Feed Device retrofit
  ► Amec Foster Wheeler can provide installation services for retrofits
Summary

► Traditional and current coke drum feed entry systems have issues
  ► Safety
  ► Environmental
  ► Coke drum life
► The Center Feed Device improves coke drum operation
  ► More uniform temperature gradients
  ► Reduced thermal and mechanical stress on the drums
  ► Reduced Banana Movement of the coke drums
  ► Reduced maintenance and operational costs
  ► Demonstrated performance
► DeltaValve and Amec Foster Wheeler have formed an alliance to promote the Center Feed Device
connected excellence in all we do