Coke Drum - Engineering & Manufacturing Challenges

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At Galveston Tx

It’s all about imagineering®
## Our Experience – Licenser wise

<table>
<thead>
<tr>
<th>Licenser</th>
<th>Manufactured</th>
<th>Under manufacturing</th>
</tr>
</thead>
<tbody>
<tr>
<td>FW</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>CB&amp;I</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>PB</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>EM</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>***</td>
<td>6</td>
<td>0</td>
</tr>
</tbody>
</table>

Total Count: 48 Nos

*** Under Secrecy agreement

- Manufactured: 32 Nos.
- Under manufacturing: 16 Nos.

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### Coke Drum And L&T

- **Coke Drum Technical Challenges**
  - **Design**
    - Creep – Fatigue Analysis
    - Skirt Optimization - Seismic and Fatigue
    - Banana Movement – Top Dished Nozzle
    - Feed Spool Bolting - Gasket Relaxation
  - **Manufacturing**
    - Automatic Welding & Grinding
    - Latest NDE Techniques – TOFD
    - Distortion Control at Weld Joints
    - Skirt # Cone Junction
    - Expertise in Heat Treatment
    - Welding Capabilities
Design Capabilities

- High cyclic loading at elevated temperature
- Design by Analysis – Not empirical formulas
  - Creep
  - Fatigue
  - Buckling

- L&T’s In-house capabilities for Finite Element Analysis.

Unique FEA capabilities – Creep Fatigue

- Hotbox
- Feed Nozzle
- Banana Analysis
- Feed Bolting
Creep Fatigue Analysis of Skirt Joint (Hot Box)

- Segmental 3-D model: Determining effect of slots in skirt
- Axi-symmetric analysis: Skirt without slots
- In house FORTRAN program: Determining radiation effect in Hotbox

Temperature Plots

- Warm Up (329.2K)
- Oil in (533K)
- Start Coking (727.4K)
- Start Quenching (643.9K)
- End Cutting (414.6K)
**Stress Plots**

- Warm up (99.5 MPa)
- Oil in (212 MPa)
- Start Coking (236 MPa)
- Start Quenching (103 MPa)
- End Cutting (144 MPa)

**Fatigue Life Study - Skirt Joint**

<table>
<thead>
<tr>
<th>Skirt MOC</th>
<th>Skirt thk. (mm)</th>
<th>Inside radius of crotch (mm)</th>
<th>Hotbox Height (mm)</th>
<th>Fatigue life* (Years)</th>
<th>Fatigue life# (Years)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>SA 387 Gr 11 Cl 2</td>
<td>28.5</td>
<td>R12</td>
<td>638</td>
<td>19.2</td>
<td>4.75</td>
<td>Slotted Skirt Creep Range</td>
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<tr>
<td>SA 387 Gr 11 Cl 1</td>
<td>40.0</td>
<td>R12</td>
<td>665</td>
<td>22.2</td>
<td>4.55</td>
<td>Slotted Skirt</td>
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<tr>
<td>SA 387 Gr 11 Cl 1</td>
<td>40.0</td>
<td>R25</td>
<td>665</td>
<td>45.9</td>
<td>2.52</td>
<td>Slotted Skirt</td>
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<tr>
<td>SA 387 Gr 11 Cl 2</td>
<td>32.0</td>
<td>R13</td>
<td>582</td>
<td>6.5</td>
<td>-</td>
<td>Without slot</td>
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<tr>
<td>SA 387 Gr 11 Cl 2</td>
<td>25.4</td>
<td>R25</td>
<td>925</td>
<td>17.3</td>
<td>-</td>
<td>Without slot</td>
</tr>
<tr>
<td>SA 387 Gr 11 Cl 2</td>
<td>40.0</td>
<td>R32</td>
<td>857</td>
<td>44.2</td>
<td>-</td>
<td>Without slot</td>
</tr>
</tbody>
</table>

*Fatigue life at Skirt # Toricone joint; # Fatigue life at slot tip

**Conclusion:**

- Increase in radius and hotbox height improves fatigue life
- Lower skirt thickness gives flexibility & thus improving fatigue life
Creep Buckling of Skirt

Allowable comp. stress for 1 Hr

Allowable comp. stress for 0.1mn Hr

FEA Model

Creep Fatigue Analysis - Nozzle Attachments

FE Model

Temp-Coking

Stress-Coking

Analysis

- Fluctuating piping loads
- pressure and temperature
- Banana Effect - Horizontal moment of drum
Creep Fatigue Analysis - Feed Spool Bolts

- Analysis
  - Fluctuating pressure and temperature
  - Model includes Effect of bolt pre-load
  - Creep relaxation and gasket relaxation

Manufacturing Capabilities - Enhancing Coke Drum Life

- SAW welding
- Automatic grinding
- Distortion control at weld joints
- Latest NDE Techniques
  - TOFD on Less Thickness
- Skirt # Cone Junction
- Expertise in Heat Treatment
- Welding Capabilities
Automatic Grinding

- Chipback Grinding
- Clad stripping
- Cone C-Seam Grinding

Distortion Control

- Welding Fixture
- Set up Fixture
- Cone Rolling
Latest NDE Techniques - TOFD

8 CHANNEL TD POCKET SCAN

On Job TOFD

Skit # Cone Junction

Weld build up

In house machining ≤ 10m Ø
Expertise in Heat Treatment

Temperature Profile  Local PWHT

Vertical Deformation

Welding Capabilities

- More than 6000 qualified welding procedure
- Team of 500 + qualified welders

- Narrow Groove Submerged Arc Welding
- Gas Tungsten Arc Welding
- Shielded Metal Arc Welding
- Submerged arc Strip/ Electro Slag Strip cladding
- Flux Cored Arc welding
- Gas Metal Arc Welding
- Automatic inside overlay

- Carbon-Steels
- Low Alloys Steels (Cr-Mo / Cr-Mo-V)
- Quenched & Tempered Steel
- Low temp Nickel steel
- Inconel Chemistry
L&T Heavy Engineering

Conclusion

L&T has developed all technical capabilities under one roof to meet technical challenges in Coke Drum manufacturing and increase life span of Coke Drum. Some of which mentioned below:

- Skirt optimization considering fatigue and buckling at elevated temperature
- Shape control of coke drum during manufacturing including Out-of-Roundness and peaking
- SAW welding and automated clad stripping operation to increase fatigue life at weld seam
- Alternative weld build up design to increase fatigue life

Contribution to International Society

- “Simulation of Temperature Field of TIG Welding Using FDM”, ASME PVP 2009.
- “Design Of Skirt To Cone Joint In Coke Drum: A Parametric Approach Based On Fatigue Analysis” ASME PVP 2011
World’s Largest Coke Drum

Aug-2011

630 MT
9.8 m ID

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Track Record

Coke Drum: ABB Process – 8.5 m ID, 310 MT Each, 04 Nos

Coke Drum: FW Process – 9.8 m ID, 520 MT Each, 04 Nos
Track Record

Coke Drum: CB&I Process – 8.0 m ID, 240 MT Each, 04 Nos

Coke Drum: Petrobras Process – 8.9 m ID, 245 MT Each, 16 Nos,

Thank you
You Imagine.......We Create

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