General Coke Drum Statistics

- API - 80% of all coke drums in operation are experiencing cracking
- Cracking occurs within 5 to 7 years
- Most are Cracking and Bulging
Typical Failures

- **Bulging**
  - Circumferential Seams
  - Shell Course

- **Cracking (Partial and Through Wall)**
  - Circumferential seam
  - Skirt to Shell welds
  - Shell plate cracks

- **ID Erosion/Corrosion**
  - Delamination/wear of cladding
Case Study

Delayed Coker Unit Karlsruhe Germany

March 2012

• The MiRO refinery, in Karlsruhe, has a capacity of 300,000 BBL/d
• Drum Diameter - 7315 mm
• Base Material 1.25Cr, ½Mo / 13CrMo44
• Wall Thickness - 40.5mm + 2mm SS410
Case study MiRo

- Planned T/A in 2012
- Bulges in delayed coking unit increased rapidly, so emergent repair had to be executed
- Analytical support and “Engineered Repair” developed
- Machine welding used to implement structural improvement repair
- Temperbead process eliminated requirement for PWHT

Shell Bulging Damage
### Repair Options Evaluated

<table>
<thead>
<tr>
<th>Option</th>
<th>Implementation Schedule</th>
<th>Repair Complexity</th>
<th>Repair Integrity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Window Replacement</td>
<td>Long</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Section Replacement</td>
<td>Long</td>
<td>High</td>
<td>Medium-Low</td>
</tr>
<tr>
<td>Structural Overlay</td>
<td>Short</td>
<td>Low</td>
<td>High</td>
</tr>
</tbody>
</table>
Case study MiRo

Engineered repair solution

- Plastic Strain Index Study performed
- 2 bulge repair areas defined
  - #1 23m²
  - #2 27m²
- Design required additional structural thickness:
  - 0.56” (14.3mm)

Contour plot of the Plastic Strain Index (PSI) looking from the outside of the drum

Coke drum D-001 B
## Final repair information

<table>
<thead>
<tr>
<th>Coke Drum D-001B</th>
<th>Coke Drum D-001B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulge repair Area 1 (includes taper zone)</td>
<td>27.7m² per layer</td>
</tr>
<tr>
<td>Bulge repair Area 2 (includes taper zone)</td>
<td>30.6m² per layer</td>
</tr>
<tr>
<td>Filler material</td>
<td>Alloy 625</td>
</tr>
<tr>
<td>Overlay thickness per layer</td>
<td>3/16” (5mm)</td>
</tr>
<tr>
<td>Total Overlay one layer</td>
<td>58.3m²</td>
</tr>
<tr>
<td>Overlay three layers</td>
<td>174.9m²</td>
</tr>
</tbody>
</table>
Temperbead Welding

HAZ created by 1st weld layer

HAZ is tempered by deposition of successive layers
Case study MiRo

Site preparation

Equipment Deck

A lot of activity around the unit
Case study MiRo

Mock-up: process evaluation & training

Removal of bonded cladding

Mock-up

“Skim” gouging with Carbon Electrodes
2-3mm thickness removed
Case study MiRo

Surface preparation and gouging in the field

Surface “prepped” 410 cladding
Cladding removed
Gouging in process 2 – 3 mm material removed
Application of Structural Overlay on ID of The Vessel

Fully Automated Weld Metal Overlay Welding Systems
Application of NiCr625 Alloy on the ID of the vessel
Summary

Results

- Two bulged areas mitigated
- Alloy 625 installed
- Engineered Repair with 3 layers of overlay
- Additional Cladding areas repaired: surface defects
- Over 40 projects of this type have been performed and demonstrated years of successful operation
Contact Information

Pedro Amador
VP & Chief Technology Officer – WSI
PedroAmador@azz.com
+ 1 (678) 728-9100
Norcross, GA, USA

wsi-europe@azz.com

www.azz.com/wsi-europe