Managing Weld Stresses for Advantage in Coker Engineered Repairs
Pedro Amador (VP&Chief Technology Officer WSI)

Coking and Cat Cracking Conference
New Delhi, India - October 2013
Topics

Industry experience
• Managed stress repair history
• Machine welding enablers
• Temperbead welding
• Refinery example

Case study MiRo
Bulge repair example
• Bulge repair design
• Defining a repair strategy
• Executing in the field

Summary

Contact
Initial uses of managed stress weld repairs in the nuclear industry

- Highly stressed nozzle to pipe connections
- Corrosive environment created SCC conditions
- Common in BWR and PWR designs
Industry experience

Residual stress model: pressurizer spray nozzle

- Structural WOL process patented
- Residual stresses from welding used to generate compressive stresses
- Added strength of deposit provides a redundant repair
- Over 1,000 nuclear applications performed
Industry experience

Small nozzle structural overlay in pressurizer vessel
Industry experience

Welding beneficial stresses

Welding stresses
• Inevitable with full fusion bond
• Accurately be managed through parameter control
• Homogeneous

Basis / key contributors
• Accurate heat input
• High dimensional quality

Results
• Predictable mechanical properties

Machine-applied predictability
• Allows accurate modeling and repair design
Industry experience

Temperbead Welding

HAZ created by 1st weld layer

HAZ is tempered by deposition of successive layers
Predictive analysis drives FCCU repair plan

Pressure Vessel Example
- FCCU stripper/reactor
- High temperature creep failure
- 5 Year life extension required

Anticipated Design Repair
- Model existing failure condition
- Develop “Engineered Design Repair” to manage stress levels below creep failure limits
- Perform level 3 FFS analysis

Engineered Design Repair
- Reduced scope of work
- Reduced cost for repair
- Validation of repair lifetime

FCCU Stripper/Reactor failure area
Industry experience

Engineered repair cycle using NPA

Estimated life of repair
Well in excess of 5 years

Areas exceeding creep stress limit

Regions below temperature threshold for creep

Post overlay stress gradients

Engineered structural overlay

www.azz.com/wsi-europe
Case study MiRo

Mineraloelraffinerie GmbH&Co (MiRo)

Bulge Repair of Delayed Coker Unit
Karlsruhe Germany, March 2012
Predictive analysis drives FCCU repair plan

- The MiRO refinery, in Karlsruhe, has a capacity of 300,000 BBL/d
- 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 by Stress Engineering
- Machine welding used to implement structural improvement repair
- Temperbead process eliminates requirement for PWHT
**Case study MiRo**

**Coke Drum dimensions**

<table>
<thead>
<tr>
<th>Coke Drum D-001B</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Base Material</td>
<td>1.25Cr, ½Mo / 13CrMo44</td>
</tr>
<tr>
<td>Estimated remaining thickness of existing clad</td>
<td>2mm</td>
</tr>
<tr>
<td>Nominal thickness</td>
<td>40.5mm + 2mm SS410</td>
</tr>
<tr>
<td>Diameter</td>
<td>7315mm ID</td>
</tr>
</tbody>
</table>

Entrance level @ 15m

Total height 35m
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
# Final repair information

<table>
<thead>
<tr>
<th>Coke Drum D-001B</th>
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</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><strong>Total Overlay one layer</strong></td>
<td><strong>58.3m²</strong></td>
</tr>
<tr>
<td><strong>Overlay three layers</strong></td>
<td><strong>174.9m²</strong></td>
</tr>
</tbody>
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### Case study MiRo

<p>| | |</p>
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Coke drum D-001 B
## Case study MiRo

### Repair schedule

<table>
<thead>
<tr>
<th>Task name</th>
<th>Duration in days</th>
<th>Start</th>
<th>Finish</th>
<th>Resource names</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total duration on site</td>
<td>21</td>
<td>Mon 3/5/12</td>
<td>Fri 4/6/12</td>
<td>WSI</td>
</tr>
<tr>
<td>SS &amp; QC onsite prep</td>
<td>2</td>
<td>Mon 3/5/12</td>
<td>Wed 3/7/12</td>
<td>WSI/MiRo</td>
</tr>
<tr>
<td>Safety Induction</td>
<td>1</td>
<td>Wed 3/7/12</td>
<td>Thu 3/8/12</td>
<td>WSI/MiRo</td>
</tr>
<tr>
<td>Unload qquipment and site set-up</td>
<td>2</td>
<td>Thu 3/8/12</td>
<td>Sat 3/10/12</td>
<td>WSI/MiRo</td>
</tr>
<tr>
<td><strong>Total Duration inside Coke Drum</strong></td>
<td><strong>26</strong></td>
<td>Sat 3/10/12</td>
<td>Thu 4/5/12</td>
<td>WSI</td>
</tr>
<tr>
<td>Set-up inside vessel &amp; inspection</td>
<td>1</td>
<td>Sat 3/10/12</td>
<td>Sun 3/11/12</td>
<td>WSI/MiRo</td>
</tr>
<tr>
<td>Removal of existing liner</td>
<td>5</td>
<td>Sun 3/11/12</td>
<td>Fri 3/16/12</td>
<td>WSI</td>
</tr>
<tr>
<td>Dewwatering bin activity</td>
<td>1</td>
<td>Fri 3/16/12</td>
<td>Sat 3/17/12</td>
<td>MiRo</td>
</tr>
<tr>
<td>Grid blasting</td>
<td>0,5</td>
<td>Sat 3/17/12</td>
<td>Sat 3/17/12</td>
<td>MiRo</td>
</tr>
<tr>
<td>Inspection (base materials)</td>
<td>0,5</td>
<td>Sat 3/17/12</td>
<td>Mon 3/18/12</td>
<td>WSI/MiRo</td>
</tr>
<tr>
<td>Bulge repair area 1&amp;2 (overlay)</td>
<td>15</td>
<td>Sun 3/18/12</td>
<td>Mon 4/2/12</td>
<td>WSI</td>
</tr>
<tr>
<td>Taper repair</td>
<td>2</td>
<td>Mon 4/12/12</td>
<td>Wed 4/4/12</td>
<td>WSI</td>
</tr>
<tr>
<td>Final inspection</td>
<td>1</td>
<td>Wed 4/4/12</td>
<td>Thu 4/5/12</td>
<td>WSI/MiRo</td>
</tr>
<tr>
<td>Demob from site</td>
<td>1</td>
<td>Thu 4/5/12</td>
<td>Fri 4/6/12</td>
<td>WSI/MiRo</td>
</tr>
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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
Case study MiRo

Application of structural overlay

External preheat in place

Close-up of 1st layer
Case study MiRo

Repair execution

Areas 1 & 2
4 machines each; total 8 machines
Case study MiRo

Repair execution

Welding 3 layers of Inconel 625
Total thickness 15mm
Case study MiRo

Deposit edge transition

Inspection by QC MiRO, TuV and WSI

- Hardness / layer
- Liquid penetrant inspection
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

wdi-europe@azz.com

www.azz.com/wsi-europe