Innovative Coke Drum Repairs

Coking.Com Workshop
Galveston, TX
03/24/2009

Agenda

• Reasons Coke Drums Crack
• Locations of Cracking
• Who is WSI
• Examples of Innovative Repair Methods
  – Repair/Restore Corrosion with Automated Weld Overlay
  – Skirt to Shell Weld Repair utilizing Temperbead
  – Bulge Repair with Temperbead
  – Skirt Replacement and Shell Repair w/Temperbead
• Conclusion
Coke Drums

• Why are they cracking and/or bulging
  – Running different feedstocks
  – Operating on shorter cycles
  – Weren’t designed for low cycle fatigue or compressive strength of coke

• API Survey of 54 Drums
  – 61% Bulging
  – 97% Circumferential Cracking
  – 78% Skirt Cracking

• Cracking occurs within 5 to 7 years

Typical Coke Drum Failures

• Cracking
  – Circumferential seam
  – Skirt to Shell welds
  – Shell cracks

• Bulging
  – Circumferential Seams
  – Shell Course

• ID Corrosion
  – Delamination/wear of I.D.

Many skirts are cracking within 5 years of operation
## WSI: Who We Are

Leading Global Specialty Welding Solution Provider, with …

<table>
<thead>
<tr>
<th>Unique Competency Set</th>
<th>Broad Services Offering</th>
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<tbody>
<tr>
<td>Applied Welding Technology</td>
<td>Erosion/Corrosion Field Services</td>
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<tr>
<td>Mechanical Repair Design</td>
<td>Field Orbital Welding Services</td>
</tr>
<tr>
<td>Global Field Operations</td>
<td>Shop Erosion/Corrosion Services</td>
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<tr>
<td>Project Execution Excellence</td>
<td>Nuclear Repair Services</td>
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### Serving a Broad Global Energy Customer Base

**Safer, Faster, and Better**

WSI Proprietary

## WSI Technical Leadership

Technology and Engineering

### Tooling Engineering
- Mechanical Systems
- High Definition Video
- Controls
- OEM Modifications
- Integrated 3D CAD
- Mockup/Training Center
- Controls Simulation

### Materials & Welding
- Codes & Standards
- Welding Processes
- Corrosion Coatings
- Metallurgy
- 300+ Traveler Library
- FEA Modeling
- 1050+ Welder Certifications

### Project Engineering
- Solution Design
- Application Eng.
- Field Engineering
- Process Procedures
- 600+ Procedures
- Temperbead, E/C, etc.
- Level 3 NDE Capability

### Operations Support
- Fleet Maintenance
- Mobilization Staging
- Site Technicians
- System Testing
- 300+ Automatic Systems
- 75 Semi-Auto Systems
- 40 Remote Vision Sets

**Applied Engineering Excellence**

WSI Proprietary
Coker Weld Overlay Project

Refinery in Southern California

Project Overview

• T/A to Retro fit (4) four Coke Drums to accept new Delta Valves

• Coke Drum Material: SA387, Grade C, 1 ¼ Cr ½ Mo, 25mm thick

• Perform repairs to existing 410 explosion bonded cladding by applying over 115sq.m. of Inconel 82 Overlay in cone section above bottom nozzle

• Schedule: 10 days for all four drums total completion
Customer Challenge

- (2) Large projects occurring in Coker (Installing Delta Valve's and Overlay work)
- Schedule: 10 days
- Reducing Cost
- Improving Quality
- Reducing Safety Instances

Project Planning

- Provided Planner to coordinate schedule and activities with others
- Developed detailed ventilation plan so other contractor personnel can continue to work while WSI performed our scope
- Provided crew of 8 In-direct personnel for entire project and 8 weld operators per coke drum working two shifts
- All work performed under WSI “R” stamp and QA program
WSI Solution

- Utilized 4 Unifuse PLC controlled Automated Weld Systems per drum (16 systems)
- Met customer’s 10 day schedule
- Took on additional scope during the T/A
- Safety: Zero lost time accidents
- Customer stated: “WSI was the best company out 22 on this T/A…First Class Crew”

Bulge Repair of Coke Drum Utilizing Temperbead

Refinery in Canada
Bulging Coke Drum

- 8 Coke Drums
- Material: SA 263 Grade C
- Wall Thickness: 22.3mm
- Diameter: Ranging from 7925mm to 9755mm.
- Size: Ranging from 20m to 29m.
- One of the Cokers was experiencing bulging due to fire in drum.

Bulge Severity and Growth

- Customer used Stress Engineering’s BIF to evaluate bulge severity of the drum surface.
- Result were intended as a guide to rank bulges for inspection priority as a function of their likelihood to encourage cracking.
- BIF factor correlates the geometric bulging patterns of past cracking histories, developed from examining other coke drums, to the bulges on the coke drum.

<table>
<thead>
<tr>
<th>BIF</th>
<th>Internal Cracking Likelihood</th>
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<tbody>
<tr>
<td>≥ +2</td>
<td>Severe</td>
</tr>
<tr>
<td>+1.5 to +2</td>
<td>Very High</td>
</tr>
<tr>
<td>+1 to +1.5</td>
<td>High</td>
</tr>
<tr>
<td>+0.75 to +1</td>
<td>Medium</td>
</tr>
<tr>
<td>0 to +0.75</td>
<td>Low</td>
</tr>
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</table>

- Of the eight drums reviewed, 1 Drum was identified with the most severe bulging at 2 Locations. We name them Bulge A & Bulge B.
Compare 2002 and 2004 Bulges

FEA Performed

- Stress Engineering performed FEA to validate overlay as “fix” for the problem

- Weld overlay reduces the stress on the bulge
  - Bulge peak hoop stress was reduced by 43% and 49% respectively on weld ID and OD
  - Bulge peak axial stress was reduced by 43% and 49% respectively on weld ID and OD

- The life of the repaired bulge is controlled by the hoop stress at the taper

- Increased Life Expectancy of Coke Drum by over 3X
Bulge Overlay

- Bulged area overlaid: 6.5m x 2m
- Applied Alloy 625, 955mm thick (2 layers), overlay utilizing temperbead utilizing (2) PLC controlled Unifuse Weld Systems
- Temperbead eliminated the need for PWHT
- Post Soak of 450º F (233ºC) for 2 hours to eliminate any potential for hydrogen

Temperbead Welding

- HAZ created by 1st weld layer
- HAZ is tempered by deposition of successive layers

WSI Proprietary
Conclusion

• Assessment by Stress Engineering quantified remaining life of bulge, and validated overlay process
• Overlay extended life of drum (bulged area) by 3X
• Unifuse® Overlay controls enabled temperbead application and increased productivity

Skirt to Shell Weld Repair with Temperbead Process

Refinery in Northern California
Skirt Cracking

- 2 - Coke Drums
- Tower details:
  - SA-387-Grade 11 material
  - 31.7m tall
  - 8m ID
  - Original wall thickness 31.75mm
- Turnaround inspection:
  - 2003 T/A repaired weld seams in Coker # 2
  - May 2006 found many indications approximately 5mm deep, 25mm long, throughout the entire circumference of the weld seam in both drums

Customer Challenge

Client options:
- Stick Welding:
  - Already had contracted with local general contractor to gouge and re-weld, and it was going to take 3 outages to complete.
  - 3 Outages x 5 days = 15 Days required
- Automated Welding:
  - Utilize Temper bead technique
  - Work on both Coke Drums simultaneously
  - Eliminate PWHT
WSI Approach

Engineered Repair Design:

- Utilizing 8 Automated Weld Systems
- Machined and Re-Welded Circ Seam using Temperbead WPS
- Post Soak used, eliminated PWHT
- UT Shear Wave acceptable
- 5 day Schedule for the welding of both Coke Drums
- Savings $$$
  - Customer avoided 10 days of Downtime
- Recently inspected after 660 cycles no cracks

Schedule

- Schedule was developed with the integrated team: Operations, Maintenance, Safety, Engineering, and Corporate Executives.
- Project Team reviewed and approved the entire plan…Repair and Safety
- This was an emergent project completely mobilized within 2 weeks notification of need in India
Skirt Replacement and Shell Cracking with Temperbead
In Refinery in Southern CA.

Customer's Challenge

- 12 Drums
- Material: SA 387-12-CL2
- Drum Thickness: 1.377"
- Height: 90’ Tan - Tan
- Diameter: 18’5” ID

- Customer was experiencing cracking below skirt to shell weld. Changed the skirt design (key hole slot) to reduce stress on skirt to shell weld.
Cutting Out the Skirt Windows

- Set up torch to cut out window sections
- Windows were set up to be cut in 3 sections; Total of 9 windows – 3 stages
- The windows were cut approximately 10’ apart from each other.

Cutting Skirt Windows.

- Track guided torch in action.
- The torch cut a slice 90 degree in to the skirt.
- Then the bevels were cut after the window was removed.
Shell Crack Removal

- The crack was excavated with the carbon arc gouge process.
- The cracks ranged in depth from approximately 0.188” to 0.75”
- The cracks were removed to a minimum of 0.380” to ensure that the entire crack was removed.
- If the crack still existed at 0.380” then more excavation was done.
- MT was performed to ensure cracks removed
Shell Crack Repairs

• 1st and 2nd layer of temper bead welded then in process MT performed
• After all of the welding and the 2 hour heat soak was completed a UT shear wave was done to check the area for flaws.
• If no flaws were found the area set for 24 hours to look for delayed cracking. After the 24 hour wait, another UTSW was done.
• If this UTSW was good then the window repairs started in this section of the skirt.

Fitting the windows
Welding Skirt Window

- GMAW and SMAW Temperbead procedure utilized for P4
- Geometry dictated process
- Butter layer applied over 1 ½” backing strap
- Subsequent passes applied
- Post Weld Heat Soak 550 degrees for 2 Hours
- UT Shear Wave performed for Final Inspection

Finish ground window
Conclusion

Keys to Innovative Repair of Coke Drums

• Pre-Planning
• Technology
• Innovation

Value these keys provide:
- Reduced Schedule
- Lower Cost
- Improved Quality/Longevity

Questions……

Thanks…..

Derrick Rogers