Innovative Coke Drum Repairs

Coking.Com Conference
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
  – Skirt to Shell Weld Repair On-line
  – Bulge Repair with Temperbead
  – Coker Pipe Welding using Orbital Welding
• Conclusion
Coke Drums

• Why are they cracking and/or bulging
  – Operating on shorter cycles
  – Running different feedstocks
  – 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 cladding

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

<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>
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<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

Creating Mechanical Integrity.
WSI Technical Leadership
Technology and Engineering

**Tooling Engineering**
- Mechanical Systems
- High Definition Video
- Controls
- OEM Modifications

**Materials & Welding**
- Codes & Standards
- Welding Processes
- Corrosion Coatings
- Metallurgy

**Project Engineering**
- Solution Design
- Application Eng.
- Field Engineering
- Process Procedures

**Operations Support**
- Fleet Maintenance
- Mobilization Staging
- Site Technicians
- System Testing

**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, 1” thick

- Perform repairs to existing 410 explosion bonded cladding by applying over 1200Ft2 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

WSI Proprietary
Project Planning

• Provided T/A Planner to evaluate other contractors schedule and coordinate activities and scopes
• 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
- 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: .875
- Diameter: Ranging from 26 to 32 Ft.
- Size: Ranging from 66 to 94 Ft.
- 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 examine other coke drums, to the bulges on Suncor’s coke drum.

<table>
<thead>
<tr>
<th>BIF</th>
<th>Internal Cracking Likelihood</th>
</tr>
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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>
</tbody>
</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
• Calculated expected life on the bulge was 8,277 cycles (before repair)
• 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
  – The calculated expected life on bulge is 29,259 cycles (after overlay)
  – The calculated expected life at the overlay taper is 16,463 cycles (conservative calculation)
• Increased Life Expectancy of Coke Drum by over 3X
Bulge Overlay

- Bulged area overlaid: 21’ x 6’

- Applied Alloy 625, .375” thick (2 layers), overlay utilizing temperbead utilizing (2) PLC controlled Unifuse Weld Systems

- Temperbead eliminated the need for PWHT

- Post Soak of 450º 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
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
  - 103 foot tall
  - 26 foot ID
  - Original wall thickness 1.25”
- Turnaround inspection:
  - 2003 T/A repaired weld seams in Coker # 2
  - May 2006 found indications approximately 0.190” deep, 1” long, encompassing entire circumference of 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
Coker Skirt to Shell Circumferential Seam Weld Repair

Refinery in India
Customer’s Challenge

• 8 - Coke Drums (4 Trains)
• Tower details:
  – Material – SA 387 Grade 11
  – Height: 87 feet
  – Diameter: 21.7 feet
  – Original W.T.: 1.37”
• Customer was experiencing extensive cracking at skirt to shell circ seams 360 degrees all 8 drums
Circ Seam
Crack Assessment

R08

Crack >1mm wide
Crack <1mm wide
Faint Crack indication
No Crack indication

Max offset

0.0 mm
11.5 m
6.5 mm
5.2 mm
1.2 mm
4.5 mm
12 mm
3.5 mm
2m
4.5 m
3m
5m
2m
3m
1.5m
4.5 m
3m
5m
2m
1.5m
0.5m

North

South

East

West

Welding Services Inc.
Evaluation

• Cracks did not penetrate into the base material (shell wall), and customer wanted to perform the repairs to cracks with little to no separation while on-line

• Safety and Risk Evaluation
  –Reviewed Refinery’s Past Safety Performance
    • H2S Monitoring
      –Customers existing permanent plant monitors
      –Addition of temporary monitors strategically located
  –Structural Stability Evaluation
    • including wind load
Safety Plan

- Generation of Detailed written Safety Plan
- Focused Training of the team on the specifics on the job and the hazards to watch out for
- Generation of work traveler that incorporates the safety aspects of this evolution
- Heightened Site Safety Presence and monitoring
  - Tented cool down stations for personnel
- Vacated area during emptying of cokers
Repair Plan

- Review Crack Mapping, Structural Stability, and Work Environment
- Crack Excavation
- Pre-Heat: 250 Degrees Utilizing Resistance Heaters
- Root – GTAW Semi-Auto
- Fill – GMAW Semi-Auto
- NDE -Dye Penetrant
- Post Soak (de-gas) – 450 degrees
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
Coker Piping Project

Refinery in Northern California
Project Overview

• T/A to connect new piping from capital project to existing unit
  – Installed Distillation Column and Fractionator Tower
  – Knockouts for processing heavy crudes
• Welds ranging in size from 1.5” to 36”
• Schedule: 50 days
• Goal: Zero manhour lost time.
Customer Challenge

- Reducing Schedule
- Reducing Cost
- Improving Quality
- Reducing Safety Instances
  - Lowering Headcount
WSI Solution

- Provided T/A Planner to evaluate all welding work scopes
- Developed detailed plan to weld all 5 Cr and SS piping 8”-30” 274 weld count
- Provided crew of 18 weld operators and 9 pipefitter support personnel per shift
- All work performed under WSI “R” stamp and QA program
WSI Solution

• Performed 300+ welds with only 3 minor rejects in cap pass

• Reduced schedule 5 days

• Reduced Headcount by 45 Pipefitters compared to GC

• Safety: Zero lost time accidents
Conclusion

• Integrating WSI’s automated welding process customers were able to:
  
  – Reduce downtime
  – Lower Cost
  – Lower Headcount
  – Increase longevity