Field Modification of DCU Support Skirt-to-Vessel Attachment Weld Geometry

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Typical DCU Vessel Failure Modes

- Coker Vessels are known to be susceptible to low cycle fatigue damage
- Delayed Coking requires cyclic operation and the cyclic changes in temperature cause significant stress intensities
- Over time, as operating cycles accumulate, vessels start to experience a variety of failure modes
Typical DCU Vessel Failure Modes

- Bulging
- Skirt Attachment Cracking
- Pressure Boundary Cracking
Established Practice For Shell Bulging/Cracking

- Map vessel to collect deformation data
- Evaluate stress/strain intensities with analytical tools
- Characterize highly affected areas
- Design “Structural Overlays” to address critical regions
Established Practice For Shell Bulging/Cracking

- Install structural overlay(s) in accordance with design criteria
- Utilize automated welding processes to provide homogeneous mechanical properties and minimize volumetric and surface imperfections

Engineered Structural Overlays
Issues at the Skirt to Vessel Interface

Cracking At Top of Skirt Attachment Weld

Typical Skirt Attachment Geometries

1 - “Analyses of Alternate Skirt Attachments to Coke Drums” PVP Vol. 315, Leslie Antalffy et. al., ASME 1995
Field Attachment Weld Geometry Modification

Unique Implementation Case Study
Skirt Attachment Weld Stress Model

Fill

Quench
Customer Issues at the Skirt to Vessel Interface

Original Geometry

 Improved Geometry

Step 1 – Original Skirt Removal

- Remove portions of the existing skirt using track mounted torch cutting system
- Remove remaining skirt to vessel connection weld metal and grind flush
- Repair performed in segments around the vessel to avoid need for crane support
Step 2 – Base Metal Inspection

Magnetic Particle Inspection of Coker Vessel Base Material
(Showing Vertically Aligned Crack)
Step 3 – Removal of Damaged Areas

Removal of Flaws Detected with Magnetic Particle and LPAUT
• The 2-1/4 Cr Cone Base material repaired/restored to nominal using NBIC Alternative Welding Method 2 repair (Temper Bead)

• 2-1/4 Cr filler material ER80S-B3L

• After welding, the surface of the cone was ground flush
Step 4 – Base Material Repair Welding

Repair Welding of Cone Base Material
(2 Layers Required to Achieve Tempering)
Step 5 – Initial Knuckle Build-Up

- A build-up/structural overlay was deposited on the restored and unrestored surface of the cone using NBIC Alternative Welding Method 2
- Machine GMAW process and a 1-1/4 Cr filler material ER70S-B2L was used
- Two layers were applied to ensure proper bead placement and overlap
Appearance of ER70S-B2L Deposit
(Two Layers)
• A Casting Insert was installed to create the desired knuckle radius

• A temporary welding shelf was installed to support the Casting Insert and provide a bottom surface for weld tie-in
Step 6 – Installation of Proprietary Insert

Casting Insert (White) and Welding Shelf
Step 6 – Installation of Proprietary Insert

Casting Insert (White) and Welding Shelf
Step 7 – Weld Build Up of Knuckle

• With the Casting Insert the weld build-up was completed with ER70S-B2L

• NBIC Alternative Method 2 was used for this portion of the weld

• The final deposited weld metal was considered a 1-1/4Cr, P4, base metal for the remainder of the repair
Step 7 – Weld Build Up of Knuckle

Machine Applied Knuckle Weld Deposit
Completely Covering Casting Insert
Step 7 – Weld Build Up of Knuckle

Surface Shaping of Deposited Knuckle Weld
Step 7 – Weld Build Up of Knuckle

- After sufficient build-up was deposited:
  - The Welding Shelf Was Removed
  - The Casting Insert was removed
  - The bottom radius was polished by grinding
  - The front of the build-up was blended to the cone and a bevel prep was cut for the skirt attachment weld
Step 7 – Weld Build Up of Knuckle

Machine Torch Cutting of the Weld Bevel
Step 7 – Weld Build Up of Knuckle

Knuckle Radius Bottom of Weld Deposit
Step 7 – Weld Build Up of Knuckle

Front Surface of Knuckle Weld Deposit
(After Blending and Surface Profiling)
Step 8 – Fit-Up of Replacement Skirt Windows

- Replacement skirt windows were installed and fit to achieve proper weld geometry
- The joint to be welded 1-1/4 Cr, P4 to P4
Step 8 – Fit-Up of Replacement Skirt Windows

Section Alignment Fixturing
Step 8 – Fit-Up of Replacement Skirt Windows

Proper Root Opening for Welding
Step 8 – Fit-Up of Replacement Skirt Windows

Final Fit-Up after Tacking
Step 9 – Final Window Tie-In Weld

- Weld out completed using “Controlled Deposition” which is similar to temper bead but per API-510, not NBIC

- A proprietary GTAW HotPulse process was used for this weld
After completing the weld out of the build-up to skirt weld:

- The backside of the joint will be cleaned up and blended with a pencil grinder
- Contour grinding will be performed on the cap to blend with taper of build-up.
Step 9 – Final Window Tie-In Weld

GTAW Hot Pulse Welding System Installed
Step 9 – Final Window Tie-In Weld

Better Photo of GTAW Hot Pulse on Mockup
Step 9 – GTAW HotPulse Welding In Process
Final Appearance after Installation

(Inspection: Liquid Penetrant Inspection and Linear Phased Array)