On Line Repair of DCU Vessel Skirt Cracks at Reliance SEZ Plant

Anand C Haridas – Head Corrosion & Inspection-Jamnagar Complex, RIL
Pedro E. Amador – VP Business Development & Technology, AZZ WSI
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**Financial Information**

A market leader across energy and materials value chain (E&P, R&M, Petchem) and in consumer businesses (Digital Services and Retail)

- Most profitable company for the year 2018-19. Recorded a net income of US$ 5.7 billion
- Revenue of US$ 90.1 billion, PBDIT of US$ 13.4 billion. Market cap of ~$ 125 billion

### Energy Value Chain

#### Refining and Marketing
- Largest, most complex single site refinery with 1.24 mb/d capacity
- Consistently outperforming regional margins
- ~58% volumes placed in international markets

#### Petrochemicals
- Ranked Top 10 globally in key products
- 2nd largest producer of polyester fibre/yarn globally
- FY19 Production: 37.7 MMT

#### Exploration and Production
- Significant expertise in deep-water operations
- Substantial exposure in US Shale
- R-Cluster first gas expected in 2H FY2021

### Consumer-centric Businesses

#### Reliance Retail
- India’s largest retailer by revenue ($18.9 bn)
- 10,415 stores with 22 MM sq.ft. space
- Presence across 6,600+ cities
- One of the world’s fastest store expansion – added ~10 stores a day in last 2 years

#### Reliance Jio
- All IP-data network with latest 4G LTE technology
- India’s largest wireless data subscriber base : 306.7 Mn with net adds of 120 Mn in FY19
- ~10.9 GB per user per month
- Carrying 71% of the total industry’s 4G data traffic (CY18)
Forty Years of Phenomenal Growth

Market Cap CAGR of 32%

Earnings CAGR of 25.5%

$ 0.5 Mn
• IPO
• Polyester @ Patalganga

$ 204 Mn
• Cracker and Polymers @ Hazira
• Fiber Intermediates @ Hazira
• Upstream – PMT
• GDR Issue
• 50/100 Years Yankee Bond

$ 1,841 Mn
• Jamnagar Integrated refinery and petrochemical complex
• KG-D6 discovery
• IPCL acquisition
• Foray into organized retail
• Recron Malaysia
• Fortune Global 500

$ 3,090 Mn
• Jamnagar refinery & petrochemical complex – 2
• KG-D6 production
• US Shale gas JVs
• Partnership with BP
• BWA spectrum
• Launched biggest ever hydrocarbon capex program
• Innovative financing – perpetual bond, EXIM facilities

$ 5,725 Mn
• Polyester expansion commissioned (PFY, PET, PTA and PX)
• Elastomers (PBR,SBR) commissioned
• Ethane project, ROGC commissioned
• Acquired spectrum in 800/1800 MHz band
• JIO crosses 300 mn subscriber milestone
• CBM production
• Gasification under stabilization

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- Classic skirt attachment failure locations.
- Blend Geometry of upper knuckle to vessel not smooth.
- Multiple conventional repairs at the SC1 location.
Phase 1 (Scope Performed During 2 Week Turnaround Window)

- Pre-Turnaround model knuckle transition geometry to generate a desired transition contour.
- Excavate and Repair knuckle joint cracking using an automated welding temperbead process.
- Using an automated overlay and template grinding process modify the transition contour of this area to meet the requirements of the designed geometry.

Phase 2 (Scope Performed with Units On-Line)

- Repair skirt cracks with a high quality weld deposit while the drums are online to minimize production loss.

Repairs Performed on 8 Drums in Parallel
Phase 1 – Knuckle Transition Repair

- Penetrant Inspection shows cracking at the top of the knuckle to vessel transition.
- Cracking ranged between 9mm to 25mm in depth.
- One location 35mm deep required ID/OD repair.
- Cracking was excavated until a clear PT was obtained.
• Automated temperbead welding was used to re-weld the excavated areas. This deposit was then contoured to remove the last layer and to blend into existing geometry.
Additional weld metal was then applied to add material for template grinding operation to obtain improved transition geometry.
Phase 1 – Knuckle Transition Repair

- Surface Contour after template grinding.
- Model of transitions area
Phase 2 – Skirt to Knuckle Weld Repair

- Initial cracking in this area was experienced after 3 years in operation.
- Over time, several manual repairs were performed using conventional welding methods. Failure frequency of these repairs eventually necessitated a longer life solution.
- The extent of damage in this area was less predictable and presented a larger risk to overall schedule.
- A decision was made to develop procedures to allow the repairs to be performed with the vessels on-line during available safety windows.
- Although the existing damage was significantly more extensive than the original plan, this decision was successful.
Phase 2 – Skirt to Knuckle Weld Repair

- Multiple repairs were made to this weld as needed to continue operation.
- Over time, the skirt and the knuckle became increasingly misaligned.
- This misalignment resulted in a decrease in size of the repair welds and created a location for future crack incubation.
• In some cases the mismatch was large enough to allow the skirt to almost touch the cone.
Phase 2 – Skirt to Knuckle Weld Repair

- The initial plan was to remove the damaged metal and reinstall a weld that provided acceptable root geometry.
- The severe misalignment required that the width of the root opening be increased significantly to allow a proper geometry after welding.

Initial Excavation

Extended Excavation
Phase 2 – Skirt to Knuckle Weld Repair

- Weld build-up was used to reconstruct the excavated weld bevels prior to installation of the root pass.
• After root reconstruction, automated temperbead welding was used to fill and cap the groove.

• Because these repairs were performed on an operating unit, the repairs had to be timed so that enough weld metal was applied during the work window to prevent cracking during the operating cycle.
Phase 2 – Skirt to Knuckle Weld Repair

- Because 8 drums were being repaired in parallel using a temperbead process, careful tracking and monitoring of the status of each drum was required.

- Since repairs were made in operation, each team had to be ready to start work efficiently at the beginning of their work window.

- Effective communication and cooperation between Reliance and AZZ crews was likely the most important contribution to success.
• PAUT was used to inspect all welding upon completion.
• An average of 6 repairs were identified in each circumference with a maximum of 12 repairs on one of the vessels.
Phase 2 – Skirt to Knuckle Weld Repair

- Final Repair area with dye penetrant developer.
- Typical contour and surface finish for each drum.
Phase 2 – Repair summary

- The largest on-line skirt repair was completed with minimal impact to unit production and excellent safety performance.
- Automated temperbead welding was used to perform the majority of welding with excellent PAUT results.
- The knuckle geometry was modified to reduce stress concentration and increase operating life.
- The complexity of working on 8 drums in parallel was managed using update and communication tools.
- Cooperation between Reliance unit personnel and AZZ provided an atmosphere for success.
Thanks for your attention