Life Cycle of Delayed Coker Heater Tubes – An Experience

Reliance Industries

Growth is Life

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India’s Most Profitable Company Today

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)

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US$1 = INR 69.155
Forty Years of Phenomenal Growth

Market Cap CAGR of 32%
Earnings CAGR of 25.5%

$ 0.5 Mn
$ 204 Mn
$ 1,841 Mn
$ 3,090 Mn
$ 5,725 Mn

- IPO
- Polyester @ Patalganga
- Cracker and Polymers @ Hazira
- Fiber Intermediates @ Hazira
- Upstream – PMT
- GDR Issue
- 50/100 Years Yankee Bond
- Jamnagar Integrated refinery and petrochemical complex
- KG-D6 discovery
- IPCL acquisition
- Foray into organized retail
- Recron Malaysia
- Fortune Global 500
- 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
- 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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| Present Affiliation | General Manager  
Section Head - Corrosion & Inspection,  
Reliance Industries Limited, Gujarat-India  
13 years of Experience in Oil & Gas Industry.  
Responsible for ensuring Reliability and Integrity of Static equipment & Piping at Jamnagar Refinery. |
|---------------------|------------------------------------------------|
| Academic Qualification | Bachelor in Mechanical Engineering  
API certified inspector for Pressure vessel, Piping, Risk Based Inspection & Tankages (API 510, 570, 571, 580 and 653)  
Level II in RT, MT, LT & UT. |
| Area of Specialization and external presentations | Inspection of Static equipment  
Risk Based Inspection (RBI) Management  
Corrosion Management in Refinery  
Advanced Non-destructive Testing  
Root Cause Analysis of critical failures  
Coke Drum Reliability |
| Paper Title | Life Cycle of Delayed Coker Heater Tubes – An Experience |
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• CONCLUSION
• Coker unit of Reliance Industries Limited, Jamnagar-Gujarat DTA Refinery was commissioned in Year 1999.

• Gradual thickness loss from inner wall has been observed in radiant section tubes of the heater coils.

• Scrapper pigging is being carried out periodically for removal of adhered coke deposit inside the coils in radiant section tubes.

• NDE & Inspection revealed a significant thickness loss in alloy steel tubes over a period of time.

• The thickness loss was mainly attributed removal of the protective sulphide layer (formed due to high temperature sulphidation) by scrapper pigging and exposing fresh surface for sulphidation and corrosion.

• An in-house strategy has been developed to ensure reliability of heater tubes in DTA refinery coker.

• This paper discusses the cause of heater tube thickness deterioration, Inspection strategy for heater coils, systematic approach for procurement of spare tubes and replacement methodology of tubes.
HEATER CONFIGURATION

• Single Fired, Twin cell and Four pass heater
• Alloy Steel tubes – 9Cr and 1 Mo
• 20 years of operation
• Higher tube ID for bottom tubes
• One heater feeds two drums (called one block)
COKER FURNACE DETAILS

• Behaviour of coker furnace tubes are different from other conventional fired heaters due to severe coking in tubes.

• Frequent decoking is required based on following two reasons:
  a. Coke layer build up in ID of tubes leading to pressure drop.
  b. Increase in Tube metal skin temperature
VARIOUS METHODS OF DECOKING OF TUBES:

Steam Air Decoking

- Option available, but discontinued.

Online Spalling

- **Merits:**
  - a) Individual passes can be spalled if construction of furnace permits.
  - b) Helps in extending run length between two pigging cycles.

- **Demerits:**
  - a) Spalling can be non uniform
  - b) TMT does not return to clean tube levels
  - c) Depends on quality of coke.

Scrapper Pigging

- **Merits:** Helps in achieving longer run length after pigging
- **Demerits:** Heater needs to be taken out of operation
PROBLEM STATEMENT

- Thickness loss observed in tube – detected during periodic ultrasonic thickness mapping
- Max wall loss observed in tube with change in ID
- Trend shows less wall loss as we move towards inlet side.
- Accelerated wall loss observed in newly replaced tubes.
- Cast plug headers have inherently high original thickness as compared to straight tubes and were safe for operation.
THICKNESS VARIATION ACROSS TUBES

Min Thickness Reading for Heater A - Mar, 14

- Pass 1
- Pass 2
- Pass 3
- Pass 4
- Nominal Thickness
- Min Thickness without CA

Tube Number From Bottom

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THICKNESS PROFILE FOR BOTTOM TUBES IN TWO PASSES

Heater X - Pass A

Month for Inspection


Thickness in mm

Tube 1 (min)
Tube 2 (min)
Tube 3 (min)
Tube 4 (min)
Tube 5 (min)
Tube 1 (avg)
Tube 2 (avg)
Tube 3 (avg)
Tube 4 (avg)
Tube 5 (avg)
Nominal thick
THICKNESS PROFILE FOR BOTTOM TUBES IN TWO PASSES

Heater Y - Pass C

Thickness in mm

Month for Inspection

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WHY ACCELERATED WALL LOSS?

Hot Sulfidation

- Corrosion of alloy steel by sulfur compounds in high temperature environments.
- Coke deposit is expected to reduce corrosion rate.

Wall loss due to pigging

- Grooves observed on tube ID. Scraper Pigging removed sulfide scales exposing fresh metal again for corrosion again.
- **Major contributor for wall loss.**
WHY ACCELERATED WALL LOSS?
INSPECTION OF FURNACE TUBES-PRESENT PRACTICE

• Periodic thickness monitoring during Pigging slowdown:
  a. Scaffolding erection for full height thickness
  b. Power tool cleaning for spot thickness

• Intelligent pigging:
  Limitation due to mule ear (cast) plugs on both ends, which makes navigation of tool difficult. Discussion is under progress with various vendors.
STRATEGY FOR TUBE REPLACEMENT

- Minimum thickness calculated as per API 530

- Tubes reliability to be maintained till next planned/opportunity shutdown.

- Thickness mapping carried out for radiation tubes showing accelerated rate during every decoking cycle.

- Tube replacement priority planned based on the thickness trends.
EXPERIENCE DURING TUBE REPLACEMENT

- Prefabrication of full length tube carried (two tubes welded together) as pre fabrication activity.

- Hydrotest of assembly carried out using non-welded plugs.

- Final field weld minimized to one i.e. tube to mule ear weld for each tube

- Though mule ear plug replacement was not planned, ID of same was found enlarged by 3 to 4 mm and same considered for replacement during next outage.

- Stage inspection and controlled PWHT for good quality fabrication of alloy steel tubes.
CONCLUSION

• Pigging should be done and controlled properly to prevent scrapping of parent metal.

• Periodic thickness mapping/NDT inspection is useful for trending the thickness loss. This can help to decide the tube procurement and replacement well in advance.

• Videoscopy of tubes can indicate metal loss on tube ID due to scrapper pigging.

• Prefabrication (preparation of full length tube) can help to minimize field work and also reduce shutdown time.
THANK YOU !