Challenges in Commissioning & Operation of Delayed Coker at IOCL Gujarat Refinery
DELAYED COKER AT IOCL GUJARAT REFINERY

- 3.7 MMTPA (70,000 BPD)
- Licensor & Heater design: M/s Foster Wheeler
- World’s largest Coke Drums (4 nos., 32 ft)
- M/s Z & J fully Automatic Top and Bottom Heading/Un-Heading device
- Ultra Low Pressure & Ultra Low Recycle operation
- Spray Chamber Design
- HCGO - last side draw
- Total Water Re-use & Complete Blow-Down recovery
- Commissioned in April’ 11
CHALLENGES IN COMMISSIONING & OPERATION OF A DELAYED COKER

- Operator & Plant Safety Hazards
- Health Monitoring of major equipment
- Synchronized start-up/ operation of all the auxiliary facilities associated with the Unit
STRATEGIES EMPLOYED TO MEET CHALLENGES

- Safer plant design philosophies & Equipment features preferred over conventional ones
- Time tested operational practices ‘picked’ from Operating Cokers
- Plant & Operator Safety accorded ‘highest’ priority
- Emphasis on ‘Hands-On’ training of Operating Crew in addition to theoretical inputs
- Focused Equipment/ Process monitoring during & Post Commissioning phase in consultation with Licensor/ Equipment vendors
- Innovative approach to ‘start-up’ for minimizing ‘gap’ between Mechanical completion & Commissioning
ASPECTS OF PLANT & OPERATOR SAFETY

- Standard Operating Procedures
- Coke Drum Switch Safety Interlock System (CDSSIS)
- Coke Cutting System Safety Interlock System (CCSSIS)
- Innovative shop floor Ideas
- Physical Barriers at Coke Drum Top & Bottom Levels
- Operator Training & Awareness
- Remote Unheading
- Fire Safety System on the Coke Drum Structure
- Reliable Coke Drum Level Indication
- Coke Cutting Tool Auto Switch
COKE DRUM SWITCH SAFETY INTERLOCK SYSTEM (CDSSIS)

<table>
<thead>
<tr>
<th>Permissive for Coke Drum ‘Feed Isolation Valve’ operation</th>
<th>Permissive for ‘Switch Valve’ operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>The ‘Feed Isolation valve’ of a particular Coke Drum will operate only when</td>
<td>The ‘Switch Valve’ will not move towards a particular Coke Drum until</td>
</tr>
<tr>
<td>1. Coke Drum top cover is closed</td>
<td>1. Its’ ‘Feed Isolation valve’ is open</td>
</tr>
<tr>
<td>2. Coke Drum bottom cover is closed</td>
<td>2. Both its’ ‘Vapor valves’ are open</td>
</tr>
<tr>
<td>3. ‘Switch valve’ is in ‘BYPASS’ or ‘OTHER COKE DRUM’ mode</td>
<td>3. Its’ ‘Drain valve’ is closed</td>
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</table>

<table>
<thead>
<tr>
<th>Permissive for Coke Drum ‘Drain Valve’ operation</th>
<th>Permissive for Coke Drum ‘Heading/ un-head ing’</th>
</tr>
</thead>
<tbody>
<tr>
<td>The ‘Drain valve’ of a particular Coke Drum will operate only when</td>
<td>Heading &amp; un-heading operation of the Coke drum will be allowed only when</td>
</tr>
<tr>
<td>1. Coke Drum top cover closed</td>
<td>1. ‘Feed Isolation valve’ closed</td>
</tr>
<tr>
<td>2. Coke Drum bottom cover closed</td>
<td>2. ‘Vapor valves’ closed</td>
</tr>
<tr>
<td>3. Coke Drum feed isolation valve closed</td>
<td>3. ‘Blow down isolation valves closed</td>
</tr>
<tr>
<td>4. Switch valve in ‘BYPASS’ or ‘OTHER COKE DRUM’ mode</td>
<td>4. Switch valve in ‘BYPASS’ or ‘OTHER COKE DRUM’ mode</td>
</tr>
<tr>
<td>5. Vapor temperature is ‘safe’</td>
<td>5. Vapor temperature is ‘safe’</td>
</tr>
<tr>
<td>6. Coke Drum pressure is ‘safe’</td>
<td></td>
</tr>
</tbody>
</table>
Operating personnel are prone to exposure to steam, hot vapors, H₂S & Coke fines.

Physical Barriers along the length of Top & Bottom Cover platforms enable the Operator to Head/ Un-Head Coke Drum & carry out Coke Cutting from a safe location shielded by a ‘see-through’ wall.
SAFETY FEATURES ASSOCIATED WITH SHOT COKE

- Rounded pieces of various sizes/ spherical shaped chunks
- Do not bond with each other and have low porosity
- Reasons for shot Coke formation
  - Ratio of Micro Carbon content & Asphaltenes in the feed
  - Low pressure, low recycle operation favors
  - Heavy feeds processed for maximum liquid yields
- Operational/ Safety Issues
  - Bottom Nozzle plugging
  - Uneven cooling/ quenching - hot spots - eruption
  - Unstable coke bed/ Dump
  - Coke in ‘flowable’ condition
SAFETY FEATURES ASSOCIATED WITH SHOT COKE

A Fully Automated, Remote Operated Top & Bottom Heading/ Un-Heading Device

A Centering device for the Drill Stem – eliminating the requirement of Operator to ‘manually’ guide the Drill Stem into the Coke Drum Top Cover

Enclosed and Ventilated Operator Cabin
OPERATOR COMPETENCE, SKILL DEVELOPMENT, AWARENESS & SOPs

- Human Intervention
- Operator Competence & Proficiency/ Skill Development
- Experienced Operation Team essential
- On the Job Training for New Recruits
- Training/ Re-Training commensurate to the Operating Experience
- Communication
- Awareness of
  - Safety Procedures
  - Down-time losses
  - Maintenance procedures
  - Equipment health monitoring plan
- Standard Operating procedures (SOPs)
INNOVATIVE SHOP FLOOR IDEAS

• Glowing warning lights/ barricades for restricting the personnel movement on the platforms while top and bottom covers un-heading is in progress
• Electronic display in the elevator regarding Critical activities on each floor
• Operators to work in ‘Pairs’ – for all critical operations in Coke Drum
• At least two approaches/ escape routes for the operator carrying out bottom cover un-heading operation
• Prominent fluorescent display of SOPs / Checklists in Coke Drum area
• Operating consoles for the bottom cover heading/ un-heading device for two coke drums to be ‘crossed’
• Operating consoles for the top and bottom heading/ un-heading device to be enclosed with a clear view of the top and bottom flanges
EQUIPMENT MONITORING PROGRAMME

COKE DRUMS

- Severe Thermal & Physical stresses - vulnerable to damage (Cracks/ Bulges)
- Temperature variations from 450 deg C to 70 deg C within a span of few hours - Repeated cyclic operations
- ‘Rate of Change’ of Coke Drum walls is identified as ‘Critical’ monitoring parameter

Equipment Monitoring Plan involves

- Regular analysis of Skin thermocouple trends specially during Vapor heating & water cooling (quenching) steps
  - Adjustments in Heating & Cooling rates
  - Switching Duration & Pre-Switch temperature

Single – Side Feed entry is a Challenge
EQUIPMENT MONITORING PROGRAMME

COKE DRUMS

- Vibrations
  - Must not be ignored
  - Source
    - Process - Cutting, Vapor heating, Quenching, Coking
    - Mechanical - Foundation Bolts, Rubbing/ Fouling

- Banana Effect
  - Caused due to uneven cooling of Coke Drum Walls and cyclic thermal expansion in vertical as well as horizontal plane
  - Monitoring for Abnormal behavior is a challenge
  - ‘Marked’ Reference points on the Top deck help in quick detection

- ‘Clearances’ in Coke Drum O/H lines & small bore pipes
  - Thermal expansion & Contraction may result in Rubbing/ Fouling of Process/ Utility lines with Structures etc.
  - Monitoring is a Challenge
EQUIPMENT MONITORING PROGRAMME

HEATERS

Monitoring involves

- Remote (On the panel)
  - Tube Skin temperatures
  - Pressure drop across tubes
  - Inlet pressure
  - Turbulising water injection rate
  - Box temperatures
  - Fuel consumption
  - Draft
  - Cross-Over temperatures
  - Run Length
  - Combustion air/ flue gas temperatures
  - MOC

- Physical (In the Field)
  - Tube texture
  - Burner flame pattern
  - Flame impingement
  - Hotspots
  - Tubes bulging/ Bowing
  - Color of Tube Supports
  - Box appearance
  - Overall health of the Heater

- On Line Spalling
- Velocity steam/ Condensate Injection
- Feed Quality
EQUIPMENT MONITORING PROGRAMME

VAPOR LINES

Reasons for Coke Lay Down

• Inadequate quench oil flow/ pressure
• Spray Nozzle poor health
• Misleading ‘After Quench’ temperature Indication
• Interruption in Quench Oil supply

Monitor

• Delta P between Coke Drum Top & MF Flash Zone
• Periodic Inspection/ Cleaning
REAL CHALLENGES FACED

Heat shield in MF Column

• For ensuring an effective control on Recycle Ratio, ‘heat shield’ is envisaged below the vapor entry nozzles.

• Heat Shield serves the purpose of thermally isolating the pool of liquid in the bottom of the Fractionator from the hot coke drum vapors.

• Donut shaped baffle segregates the hot coke drum overhead vapor and liquid holdup while allowing the recycle material to mix with the fresh feed.

• The open area of the donut baffle was envisaged to be ~ 50%.

• Heat shield installed in the column was having an ‘open’ area of 80% and instead of the intended round opening; it was having a square opening in the middle.
REAL CHALLENGES FACED

Heat shield in MF Column

• Additional plates were welded to the existing four plates to meet the ‘required’ cross-sectional coverage while maintaining the ‘slope on the plates.

• The supports already installed for the ‘original plates’ were further strengthened.

• By employing this solution, direct welding to the column shell and consequent hydro-test could be avoided.
REAL CHALLENGES FACED

Erosion in Heater Pass flow C/Vs

- Severe erosion observed in the heater pass flow Control Valves BODY within 6 months of operation
- 4” Rotary Control valve
- Deep Grooving observed at the C/V outlet side
- PMI of the internal valve body conformed to ASTM A 217 Gr.C12 - the design material
- Thickness of the valve body reduced from original 16.7 mm to 8.7 mm

Failure location. Flange and the control valve body outlet are damaged.
REAL CHALLENGES FACED

Erosion in Heater Pass flow C/Vs

- Detailed Analysis indicates ‘Cavitation’ as the immediate reason for severe erosion
- As per OEM, at lower C/V openings Rotary valves are prone to Cavitation

- As per Process requirement, Delta P across the C/V varies significantly

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<tr>
<th></th>
<th>Min</th>
<th>Norm</th>
<th>Max</th>
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<td>7</td>
<td></td>
<td>280.00</td>
<td>280.00</td>
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<tr>
<td>8</td>
<td>kg/cm² (g)</td>
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<td>10</td>
<td>(m³/hr)</td>
<td>20183.000</td>
<td>40367.000</td>
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<td>11</td>
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<td>12</td>
<td>(CP)</td>
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<td>15</td>
<td>Max Shutoff / Shutoff Class</td>
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<td>Available Air Supply</td>
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<td>17</td>
<td>Valve Function</td>
<td>Throttling</td>
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<td>19</td>
<td>Flow Coeff. (Cv)</td>
<td>4.048</td>
<td>15.493</td>
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<td>20</td>
<td>Est Stroke (Percent)</td>
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<tr>
<td>21</td>
<td>Pressure Drop (kg/cm²)</td>
<td>41.410</td>
<td>11.310</td>
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<td>22</td>
<td>Choke Drop (kg/cm²)</td>
<td>44.450</td>
<td>38.901</td>
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<tr>
<td>23</td>
<td>Noise (IEC) (dBA)</td>
<td>&lt;70</td>
<td>&lt;70</td>
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<tr>
<td>24</td>
<td>Valve Vel (m/s)</td>
<td>0.846</td>
<td>1.089</td>
</tr>
<tr>
<td>25</td>
<td>Pipe Vel (m/s)</td>
<td>1.072</td>
<td></td>
</tr>
</tbody>
</table>

Control Valve Selection was Incorrect

Anti Cavitation Type Globe control valve
REAL CHALLENGES FACED

O/H Crane Rail

The most important activities in successful erection & smooth ‘run-in’ of this Crane are:

- ‘Impeccable’ fixing & alignment of ‘rails’.
- Proper ‘thermite’ welding of the rail joints
- ‘Perfect’ alignment of the SPAN between the two legs of the Crane
- Readiness check of Electrical and PLC Circuits
- Vendor Tuning
- Operator Training
REAL CHALLENGES FACED
O/H Crane Rail

- Started facing the problem of ‘Cracked’ rail joints very early in to the Operation of Crane
- Reasons attributed to
  - Improper ‘Thermite’ welding
  - ‘Less than Perfect’ alignment of Rails as these were laid in 3 phases
REAL CHALLENGES FACED

Under sized Coke Chute

• Chute is a hollow passage at the bottom of the Coke Drum for safe disposal of coke to pit during cutting
• Coke Chutes installed were not adequately sized; possible Blockage
• Detected prior to start of the commissioning activity

Incorrect Assumptions in Design

• Cutting Rate assumed as Constant – *which is Incorrect*
• Total time allocated for Cutting (5 hrs) shall be available for Cutting – *Which Is Incorrect*
REAL CHALLENGES FACED

Under sized Coke Chute

- ‘Critical’ bottleneck in Plant operation eliminated
- Chutes had to be re-fabricated to meet the requirement
REAL CHALLENGES FACED

HCGO Backwash

- Automatic backwash filters provided in HCGO product line
- Backwash frequency of these filters envisaged as 4-6 times a day
- Design Flux : 1 gpm/ft²; 20 micron
- Backwash material - routed to Blow-Down system for re-processing in Coker itself
- Frequency of backwash is extremely high - Overloading the Blow-Down system & restricting the Plant thru' put
- HCGO & Steam - the two backwash ‘media’ considered have been used
- Duration of each backwash manipulated (in consultation with OEM)
- Problem persists
- Critical Observation: Unfiltered HCGO admixed with SRVGO gives better performance w.r.t. Backwash frequency
REAL CHALLENGES FACED
DCV (De-Coking Valve) - Partial Operation

• DCV is a Motorized 3-Way valve
• Located in the Discharge of High Pressure Jet Pump
• Diverts water to
  • Tank (bypass)
  • Part Tank/ Part Coke Cutting Ckt. (Pre-Fill)
  • Coke Cutting Ckt. (Full Flow)
• Challenge faced
  • Single piece of Equipment
  • Actuator unable to ‘close’ the valve against Full pump Discharge pressure
  • ‘Auto’ shift function of Coke Cutting Tool – defunct
  • Leads to unwarranted ‘stop/ start’ of 5 MW jet pump
Thank You