Innovations in Delayed Coking Technology and Operations

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• Current Technology (CB&I)
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  – Skirt Attachments
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• Summary
History

- Delayed Coking was first practiced in the mid-1920s as a one-drum batch operation.

- In the early 1930s, a second coke drum was added, allowing the unit to operate in a continuous mode.

- The biggest units operate with eight or more drums.

Innovations in Delayed Coking

- Major innovations to delayed cokers in the last 30 years have been in the areas of safety, maintenance and operation. Examples:
  - Distillate Recycle
  - Online Spalling
  - Double Fired Heater
  - Bottom/Top Unheading Device
  - Motor Operated Ball Valves
  - Interlock Systems
  - Continuous Coke Drum Level Indication
CB&I INNOVATIONS

With the need to process heavier crudes at higher capacity, Refiners have gone to shorter drum cycles that have had an adverse impact on coke drum life. CB&I has addressed these issues with the introduction of:

- Vertical plate coke drums
- Innovative skirt attachment designs
- Short Cycle Switching System

- Shorter drum cycles increase thermal stresses on coke drums.
- Bulging and eventual cracking in the vicinity of the circumferential weld seams observed.
- Stiffening effect due to differential strength between weld and drum plate material.
**Vertical Plate Coke Drum™**

- Several measures have been taken to reduce the risk of bulging and cracking
  - Decreasing weld metal strength, uniform shell thickness, etc.
- CB&I developed technology to eliminate up to 70% of circumferential weld seams
- Cylindrical shell sections of up to 46 feet

**Vertical Plate Coke Drum™**

- 11 drums in operation
- 6 new drums on order/under construction
- First drums in operation for over 6 years
  - 204C material
  - 7/8" thick
  - 2,200+ cycles
  - No issues reported
Skirt Attachments (1)

- T-Rex design
  - Similar to keyhole design
  - Based on best practices and lessons learned from many years of fabricating and repairing coke drums
  - Proven by FEA to reduce thermal stresses at skirt attachment significantly
  - 8 drums in service
  - 4 drums under construction
  - No issues reported

Skirt Attachments (2)

- Wrapper skirt (patent pending)
  - More flexible connection
  - No load bearing weld attachments
  - Less thermally induced stresses
  - No pre-stresses from weld shrinkage etc.
  - No installation yet
Short Cycle Switching System
(Patent Pending)

- Over time, drum cycle times have been reduced from more than 24 hours to 12 hours and lower.
- Decoking cycle has been seen as series of separate, manually operated steps that are approached individually.
- If time is lost on one step, the next step is used to make up the shortfall.
- Potential consequences include unit downtime, equipment abuse, unwanted by-products, etc.
- CB&I approach uses computer control to integrate all steps and variables for sustainable, reproducible optimum performance.

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### Table

<table>
<thead>
<tr>
<th>Drum Handling Step</th>
<th>Typical Industry Average</th>
<th>Short Cycle Switching System</th>
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<tbody>
<tr>
<td></td>
<td>Hrs</td>
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<tr>
<td>Steam to Fractionator</td>
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<td>Steam to Blowdown</td>
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<tr>
<td><strong>Total</strong></td>
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<td><strong>12.08</strong></td>
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</table>
STEP 1: TOP AND BOTTOM HEADS OF THE EMPTY CORE DRUM (DRUM A) ARE CLOSED MANUALLY.

STEP 2: DCS COMMENCES STEAM PURGE AND PRESSURE TEST.
STEP 3: ADD ANTI-SLUMPING STEAM TO THE FULL DRUM.

STEP 4: RAISE PRESSURE IN FULL DRUM BY CLOSING MOV 1 TO DIVERT VAPORS TO EMPTY DRUM. COKE DRUM CONDENSATE IS USED AS QUENCH THEREBY REPLACING THE HGO REMOVED FROM THE COKE DRUM VAPOR.
STEP 6: Once the coke drum preheat temperature is reached, the DCS or operator initiates the drum switch.

STEP 7: The back pressure on the coke drums is slowly decreased to normal operation and the switch from full to empty drum is controlled to minimize impact to the fractionator tower by metering NGP product.

STEP 8: Once full flow is established to empty drum, full steam out of the full drum to fractionator commences.
STEP 9: THE FULL COKE DRUM IS DEPRESSURIZED FROM OPERATING PRESSURE TO BLOWDOWN PRESSURE BY CLOSING MOV 2 AND OPENING MOV 3 AT A RATE TO AVOID ANY PRESSURE SURGES IN THE FULL DRUM.

STEP 10: STRIPPING STEAM IS CONTINUED AND QUENCH WATER IS INTRODUCED INTO THE FULL DRUM.
STEP 11: THE QUENCH WATER RATE IS ON A TIMED RAMP BASIS RESET BY COKE DRUM PRESSURE, COKE DRUM KNUCKLE TEMPERATURE, BLOWDOWN TOWER PRESSURE, AND BLOWDOWN CONDENSER EFFLUENT TEMPERATURE.

STEP 12: AS THE QUENCH WATER RATE IS INCREASING, THE STEAM RATE IS DECREASING TO ZERO.

STEP 13: WHEN THE COKE DRUM PRESSURE REACHES ATML, THE MOV ON THE VENT TO ATM OPENS AND THE MOV TO THE BLOWDOWN CLOSES.

STEP 14: WATER IS ADDED AT THE MAXIMUM RATE UNTIL THE MAXIMUM LEVEL IS INDICATED BY THE COKE DRUM LEVEL DETECTORS, WHICH THEN SHUTOFF THE QUENCH WATER.
Short Cycle Switching System

(Patent Pending)

• Benefits of the Short Cycle Switching System:
  – Faster warm-up
    • Can decrease overall cycle time or to increase time for other critical steps like quenching
  – Higher warm-up temperature
    • Reduces drum stress and potential cracking
  – Minimization of pressure swings
    • Reduces foamover and antifoam requirements
Short Cycle Switching System
(Patent Pending)

• Benefits of the Short Cycle Switching System:
  – Elimination of utility costs for re-vaporizing warm-up condensate
  – Longer drum life
  – Less chances for drum blow-outs
  – Reduced probability for drum cave-ins
  – Reproducibility through computer control
  – All affected variables are monitored and integrated into the control algorithm

• Delayed coking has been developed into a safe and reliable process.

• It is very often the most economically attractive option for bottom-of-the-barrel upgrading.

• There have been several advances in the areas of safety and reliability over the last 30 years.

• CB&I’s delayed coking technology addresses the new challenges due to short drum cycles.
Thank you for your attention!!

Q&A