Keys To A Successful
Delayed Coking Unit Revamp

By

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Coking.com®
MORE PRODUCTION - LESS RISK!

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IOCL Introduction

• Indian Oil Corporation Limited, or IOCL is an Indian state-owned oil and gas corporation

• World's 88th largest corporation, according to the Fortune Global 500 list

• The Indian Oil Group of Companies owns and operates 10 of India's 22 refineries with a combined refining capacity of 65.7 million metric tonnes per year

• Currently operates eight delayed coker units (DCUs) with combined capacity of 9.3 million metric tonnes per year
CB&I DCUs in India and Abroad
Why Revamp Your DCU?

R - Reliability
E - Environmental
V - Versatility
A - Advancement
M - Metallurgy
P - Profitability
S - Safety

RE VAMS
So What Revisions are Needed?

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Key Input to Revamp Study

- Complete feed characterization
- Maximum demonstrated capacity
- Existing facilities limitations
- Equipment reliability history
- Plant testing with *close coordination between owner/operator and process licensor*
• Current knowledge of the unit is essential
  - to define the revamp scope,
  - to project schedule and planning, and
  - to budget, by minimizing scope

• Communications with licensor
  - to insure consistent expectations
  - to insure successful deliverables
Impact of DCU Revamp

- **Operational Differences**
  - Higher coke drum pressure
  - Lower unit recycle
  - Higher preheat temperature
  - Reduced cycle times

- **Performance Differences**
  - Product yield shift from liquid distillates to coke
  - Heavier HCGO end point
  - Shorter heater run lengths
Pre/Post Revamp Operations

- Operating basis for both the original DCU and revamp DCU were essentially satisfied

- The VR feed temperature was the most significant discrepancy

- The coke drum pressure ran high in the original DCU, but only rose slightly in the revamp design
• The DCU liquid product yields exceeded the original design basis.
• In the revamp DCU, coke yields have increased and C$_5^+$ liquid yields have fallen slightly.

• Similarly, the HCGO product quality was well within the original design basis during stable operations
• However, this critical product quality has increased considerably in the revamp operations
Revamp Process Considerations

- VDU cut point
- Coke drum cycle time reduction
- Coking heater capacity
- Blowdown/CCD loading/reliability
- Coke handling and dewatering
- Gas processing and cooling
- Product recovery and hydraulics
- Product treating
- Safety and PSV/flaring facilities
- OSBL considerations
- Increasing the VDU cut point reduces the net DCU feed.
- Higher cut point typically achieved by modifications to the flash zone (i.e. higher efficiency packing, revised feed/vapor horn) and/or vacuum system upgrades.

![Graph of Heavy & Light Crude Oil Distillations](image)
Cycle Time Reduction

Which step times can be safely trimmed?
### Cycle Time Reduction

Must address – if not avoid – overlapping activities.

| Hour | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 |
|------|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| Drum 1 |   |   |   |   |   |   |   |   |   |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Drum 2 |   |   |   |   |   |   |   |   |   |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Drum 3 |   |   |   |   |   |   |   |   |   |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Drum 4 |   |   |   |   |   |   |   |   |   |    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |

<table>
<thead>
<tr>
<th>Color Code</th>
<th>Coking</th>
<th>18</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Switch Drums</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>Steamout to Fractionator</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>Steamout to Blowdown</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Slow water cooling</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>Fast water cooling</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Drain coke drum</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Remove top and bottom heads</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>Hydraulic boring/cutting</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Reheading/Pressure Testing</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Drum Heat-up</td>
<td>5</td>
</tr>
</tbody>
</table>

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Cycle Time Reduction

• Some Common Cycle Time Reductions
  - Coke cutting (up to 2 hrs+)
  - Drum draining (~1 hr)
  - Unheading/reheading (1.5 hrs+ with replacement of semi-enclosed heads)
  - Step sequential efficiency (0.5 hrs+ in steam-out transitions, heating transitions)
Cycle Time Reduction

- Decoking Activities to Preserve
  - Steam-outs to fractionator and blowdown
  - Slow and fast water quenching
  - Steam purge/pressure test
  - Hydrocarbon preheating
Coking Heater Capacity

• Key Challenges
  - Sensitivity to coking rate and heater run lengths
  - Limited practical revisions to firebox dimensions
  - Panipat coker heater run length (typical):

<table>
<thead>
<tr>
<th>Capacity (MMTPA)</th>
<th>Online Spalling Frequency</th>
<th>Steam Air Decoking Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.4</td>
<td>every 6 months</td>
<td>After 2-3 online spalling</td>
</tr>
<tr>
<td>3.0</td>
<td>every 3 months</td>
<td>After 2-3 online spalling</td>
</tr>
</tbody>
</table>
# Coking Heater Capacity

<table>
<thead>
<tr>
<th>Heater Revision</th>
<th>+Cap @ Same TST</th>
<th>Coil Pressure Drop</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational – Increase Excess Air</td>
<td>Up to 10%</td>
<td>10-15% higher due to increased flow</td>
<td>Heater efficiency will decrease up to 4%</td>
</tr>
<tr>
<td>Preheat – Higher Feed Temperature</td>
<td>Up to 15%</td>
<td>Up to 20% higher due to increased flow</td>
<td>Crossover temperature increases due to reduced LMTD</td>
</tr>
<tr>
<td>Addition -- Roof Tubes</td>
<td>Up to 20%</td>
<td>Up to 40% due to increased coil length and flow</td>
<td></td>
</tr>
<tr>
<td>Retrofit -- Replace Coil with Larger Tubes, Same Spacing and Wall Thickness</td>
<td>Up to 5%</td>
<td>50% reduction</td>
<td>Added surface reduces heat flux but larger diameter increased film temperature.</td>
</tr>
<tr>
<td>Retrofit -- Replace Coil with Larger Tubes, Increased Wall Thickness</td>
<td>Up to 20%</td>
<td>25% reduction</td>
<td>Tube wall temperature will be higher, but thicker schedule allows for much higher temperature rating</td>
</tr>
</tbody>
</table>
Blowdown System Loading

- Vapor loading → hydraulic enhancements
- Heating limitation → exchanger revision
- Pump reliability → filter/piping revisions
- Pump capacity → add/revise pumps
- Cooling limitation → revise fin fan coolers
• Review crane duty cycles
• Check crusher load rating
• Confirm OSBL facilities are sufficient
• Check pad drainage and fines settling
• Potential revisions to hydrocyclones and/or maze
Gas Processing and Cooling

- Rerating the wet gas compressor facilities
  - Possible rotor replacement
  - Possible driver revisions
  - Potential increase in driver rpm

- Ensure sufficient cooling in gas circuit
  - Possible addition of shells
  - Possible air cooler revisions
Product Recovery and Hydraulics

- Highest capacity test run to find the bottlenecks
- Debottleneck existing limitations
- Choose most practical options to alleviate limit (larger pump impellers, new pump, piping modifications)
- Expect minimal revisions up to 125% of capacity
Product Treating

- Often overlooked, but can undermine revamp success
- Accurate feed characterization is crucial
- Current treating performance and utilities limitations also crucial
Safety and PSV/Flaring Facilities

- Coke drum interlocks
- Coke cutting system safeguards
- Fired heater ESD upgrades
- Expanded PSV/flaring loads review and potential modifications (i.e. SISs e.g. HIPPS)
OSBL Considerations

- Is steam supply sufficient?
- Can sour water strippers handle increased production?
- Are higher B/L pressures needed to reach tankage/downstream dispositions?
- Power distribution?
Project Planning Considerations

• *Safety must be foremost consideration*
  
• Determine environmental/permitting requirements well in advance of procurement/construction phase
  
• Long lead items coordination with shutdown schedule
  
• Constructability review for major equipment revisions
  
• Possibility of taking necessary hook-ups/pipe laying while unit onstream
  
• Pre and post shutdown work well defined
Benchmarking Metrics

- Vacuum residue feed: 566 °C+ (1050°F) cut point
- 3-4 months+ heater run-lengths depending on feed quality/throughputs
- Low recycle: < 1.05 TPR
- Lower cycle time: < 16 hours
- Drum pressure: < 1.3 kg/cm² for low pressure operations
Key Issues in Next Revamp

- Product quality issues w.r.t HCGO
- Drum vapor velocity
- Fractionator Flashzone C-factor
- More Capacity
Who Else Needs A Revamp?

Thank You for Listening

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