PROCESS OPTIMIZATION IN THE REFINING SECTOR – NRL CASE STUDY

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Current refining scenario is fraught with tough competition, strict Government laws and environmental regulations.

Optimization, ERP, reliability centered maintenance, risk based inspection, corporate sustainability reporting are the challenges for survival and sustainability in the business.

Requires rigorous monitoring and analysis of performances and applying corrective adjustment to the actual operations.

The presentation is focused on process optimization a refinery should follow and methodology followed by NRL.
Several tools and levels of optimization are available to the refiner e.g. Linear programming and advanced process control.

A rigorous optimization approach is being followed in NRL and broadly classified as:

- **Offline Optimization**:
  - Linear Programming (Aspen PIMS)
  - Optimization through process simulator (PRO-II) studies
  - Manual optimization based on heuristic approach.

- **Online Optimization**:
  - Advanced Process Control (Honeywell and Yokogawa) implemented in the process units.
Corporate Targets from SCO
- Market Demands

Planning (Aspen PIMS)

Scheduling (OMS group)

Tankage position
- Operating strategy
- Marketing and logistics

APC (Honeywell/Yokogawa)

Data historian/data analysis

OPTIMIZATION CHAIN
OFFLINE OPTIMIZATION IN NRL USING LP TOOLS

- Linear Programming (LP) model of NRL developed in Aspen PIMS Software and used for long-term production planning.

- It is the corporate level of optimization with targets set by Supply Chain Optimization (SCO) cell of BPCL, which is NRL’s major holding company.

- Also used for doing case studies, what-if scenarios.

- LP is a robust tool for analysing marginal prices and provides a concise picture of the entire value chain.

- Only limitation is that it assumes linearity for most complex processes.
OFFLINE OPTIMIZATION IN NRL USING LP TOOLS

➢ Examples of usage and benefits of LP (Aspen PIMS software) in NRL –

  - **Detailed production plan with marginal value analysis is made every month.**

➢ Beneficial case studies carried out in the LP Model –

  - **MS Maximisation**: 
    - Need to increase MTBE and PYE gas as blending components in E-III/E-IV MS has been found out through marginal value analysis.

    - Through implementation, we could maximise MS production in a month with hardware constraints of tankage & logistics only.
OFFLINE OPTIMIZATION IN NRL USING LP TOOLS

- CD processing maximisation in Hydrocracker Unit:
  - Design maximum CD(coker distillate) in HCU feed is 15 wt% after revamp of the unit in 2009 with revised feed quality but allowed upto 20% with earlier feed quality.
  - PIMS Case carried out to maximise HCU thruput & the run indicated that CD could be further increased in feed.
  - Additional profit of around INR 4.9 lacs per day projected in PIMS by implementation.
  - CD in HCU feed was increased to 20 wt% by adjusting DCU parameters and HCU revamp thruput could be achieved with old feed quality by modulating operating parameters in consultation with licensor.
OFFLINE OPTIMIZATION IN NRL USING PROCESS SIMULATION

An example of optimisation using process simulator at NRL -

- **Crude column optimisation in PRO/II:**

  - CDU furnace COT optimised at 375 degC though the design COT is 382 degC

  - Kero CR 01-EE-10A/B was used as gas oil CR circuit to recover more heat from the column to reduce the gas oil draw off temperature as well as to increase the preheat temperature.
MANUAL OPTIMISATION IN NRL

➢ Continuous innovation on experience / heuristic based approach as follows:
  ▪ Brainstorming session on monthly basis.
  ▪ Review of innovative ideas.
  ▪ Capturing troubleshooting experiences through SOPs.

➢ Implementation of ideas through Management Of Change (MOC) and Standard Operating Procedure (SOP) – Examples:
  ▪ **Optimization in slop reduction in DCU:**
    - Procedural change implemented in post chamber change-over activities
      - After coke-drum changeover, cooling steam which was diverted earlier to the blowdown is now diverted to fractionator column upto an allowable temp.
      - Reduction in flaring and slop generation from DCU was made possible.
MANUAL OPTIMISATION IN NRL

- Hot-well slop-oil diversion (which is around 0.8wt% on crude) to EIII HSD Blend.

- CDU column parameters adjustment to optimize CRU throughput vis-à-vis reformate RON at given cycle length.

- Arresting quality giveaway of products like Kero, ATF, MS, HSD by optimizing products blend.

- Enhancing insulation effectiveness through innovative and optimum approach like telescopic insulation in HGU reformer, Calcium Silicate insulation in HP Steam Network etc.

- Modification of using enriched oxygen from N2 plant in SRU combustion resulting in capacity increase by 25% and reduction of combustion chamber back pressure.
ONLINE OPTIMISATION IN NRL USING APC

- Advanced Process Control (APC) implemented in the process units - CDU/VDU, DCU, HCU and HGU

- Yokogawa System – CDU/VDU – implemented in 2005
  - Remodelling under progress.

- Honeywell – DCU, HCU and HGU – in Nov 2011
  - Real time optimisation of processes using Honeywell’s Robust Multivariable Predictive Control Technology (RMPCT)
    - Involves Honeywell’s Profit Controller and Profit Optimizer technology.
    - Profit Optimizer is a dynamic Optimizer which allows optimization of processes even when not in a steady state.
ONLINE OPTIMISATION IN NRL USING APC

➢ Implementation in DCU:

➢ Strategies adopted for implementation were –

  ▪ FRACTIONATOR AND FURNACE SECTION:

    - Throughput maximization subject to heater and other hardware limitation
    - Maximize the Coker distillate subject to Product draw specs.
    - Minimization of recycle ratio.
    - Unit stabilization during vapor heating and drum changeover
    - Maximization of high quality valuable product as and when required subject to specs
    - Energy minimization in heater
    - Fractionation bottom temperature maximization

  ▪ LPG RECOVERY SECTION:

    - Stabilization of LRU Section
    - Maximization of on-spec LPG subject to Weathering
Two Profit Controllers installed in DCU to meet the strategy –

<table>
<thead>
<tr>
<th>SI No</th>
<th>Profit controllers</th>
<th>Main/Major objectives.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>FRAC</td>
<td>To maximize coker distillate yields subject to product spec. especially HGO colour. Stabilization of the unit during vapour heating and drum switch over.</td>
</tr>
<tr>
<td>2.</td>
<td>LRU</td>
<td>LPG maximization subject to weathering.</td>
</tr>
</tbody>
</table>

Cost benefit was calculated to be around Rs. 57/ MT of feed resulting in annual benefit of about Rs.1.7 Crores with a meager investment of Rs.40 Lacs.
ONLINE OPTIMISATION IN NRL USING APC

Implementation in HCU (Hydrocracker Unit):

Strategies adopted for implementation were –

- **REACTION SECTION**:
  - Feed Maximization
  - Maintaining of Catalyst Average Temperatures.
  - Maximise reactor conversion.
  - Controlling of Reactor Bed Outlet Temperatures
  - Controlling of Reactor Bed Delta Temperatures etc

- **FRACTIONATOR SECTION**:
  - FF-03 COT Management
  - HN Quality control and maximisation w.r.t HN 95% point.
  - Kerosene Quality control and maximisation w.r.t its freezing point (during ATF mode) and FBP.
  - Diesel Maximization w.r.t recovery @ 360 degree C or 95% point.

- **LIGHT ENDS SECTION**:
  - LPG Maximisation and Quality Control (minimize C3 in sour gas)
Online Optimisation in NRL Using APC

Three Profit Controllers installed in HCU -

<table>
<thead>
<tr>
<th>SI No</th>
<th>Profit controller</th>
<th>Main/Major objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>RXR (Reactor Section)</td>
<td>CAT control of HCU reactors &amp; feed maximization</td>
</tr>
<tr>
<td>2.</td>
<td>FRAC (Fractionation)</td>
<td>HN, Kero, HSD maximization.</td>
</tr>
<tr>
<td>3.</td>
<td>LES (Light Ends)</td>
<td>LPG maximization</td>
</tr>
</tbody>
</table>

Cost benefit was calculated to be around Rs. 60/ MT of feed resulting in annual benefit of about Rs. 8.00 Crores with a meager investment of Rs.50 Lacs.
ONLINE OPTIMIZATION IN NRL USING APC

➢ Implementation in HGU (Hydrogen Plant):

  Control objective for HGU APC are –

  - To control H2 rich gas flaring from HCU and accordingly HGU load will be adjusted.
  - To maintain steam to carbon ratio in the reformer and HTER.
  - To maintain H2/HC ration in HDS reactor.
  - To maintain HTER feed to reformer feed ratio in HTER inlet.
  - To control reformer outlet temperature and HTER outlet temperature.
  - To control reformer chamber draft and O2 in flue gas without allowing ID fan from overloading.
  - To control MT & LT reactor inlet temperature.
  - To control CH4 slip in reformer outlet.
  - To control CO slip in MT & LT reactor outlet.

➢ In the month of March, 2012 APC was put in service in HGU and immediate benefit of flat operating parameters achieved facilitating action to reduce energy consumptions. Benefit evaluation is under progress.
ONLINE OPTIMIZATION IN NRL USING APC

- Trends showing stabilization in HGU parameters after APC implementation:

- Reformers steam/carbon ratio

- HGU System pressure
REFINERY PERFORMANCE IMPROVEMENT – AN EFFECT OF DISCUSSED OPTIMIZATION, UTILIZATION OF NG & ENCON REVAMPING OF HGU AND HCU

<table>
<thead>
<tr>
<th>YEAR</th>
<th>Distillate Yld %</th>
<th>SEC (MBN)</th>
<th>F&amp;L (wt%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008-09</td>
<td>84.72</td>
<td>70.68</td>
<td>10.72</td>
</tr>
<tr>
<td>2009-10</td>
<td>85.32</td>
<td>67.55</td>
<td>9.85</td>
</tr>
<tr>
<td>2010-11</td>
<td>84.7</td>
<td>69.02</td>
<td>10.98</td>
</tr>
<tr>
<td>2011-12</td>
<td>91.5</td>
<td>57.5</td>
<td>9.58</td>
</tr>
</tbody>
</table>
THANK YOU!
**OFFLINE OPTIMIZATION IN NRL USING PROCESS SIMULATION**

## Crude column optimisation benefits

<table>
<thead>
<tr>
<th></th>
<th>Before</th>
<th></th>
<th></th>
<th>After</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Kero EE-10A/B in Kero Circuit &amp; CDU furnace COT 372 deg C</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>Kero EE-10A/B in Gas oil Circuit &amp; CDU furnace COT 375 deg C</strong></td>
<td></td>
</tr>
<tr>
<td>Stream Name</td>
<td></td>
<td>GO</td>
<td>HN</td>
<td>KERO</td>
<td></td>
</tr>
<tr>
<td>Flowrate</td>
<td>M3/hr</td>
<td>72.08</td>
<td>11</td>
<td>48</td>
<td></td>
</tr>
<tr>
<td>Sulfur Content</td>
<td>PCT</td>
<td>0.0988</td>
<td>0.01074</td>
<td>0.0206</td>
<td></td>
</tr>
<tr>
<td>Preheat temp, degC</td>
<td></td>
<td></td>
<td></td>
<td>372</td>
<td></td>
</tr>
<tr>
<td>Gas oil draw off temp, deg C</td>
<td></td>
<td></td>
<td></td>
<td>293</td>
<td></td>
</tr>
</tbody>
</table>

- **Preheat temp, degC**: 372
- **Gas oil draw off temp, deg C**: 293
ONLINE OPTIMIZATION IN NRL USING APC

The diagram illustrates the APC (Advanced Process Control) structure, which includes the following components:

- **Model**
- **Optimisation & Control**
- **Predictions**
- **Consistency Check**
- **Setpoint Implementation**

The flow starts with the **Model** feeding into the **Optimisation & Control** block. The outputs are then directed to the **Predictions** block, followed by the **Consistency Check** and **Setpoint Implementation**. The outputs of these processes are then sent to the **Profit Controller**.

The diagram shows the integration with the **DCS Interface Points** and **DCS Controls**. The **Process** is at the bottom, connected to the **DCS Interface Points** and **DCS Controls**. The **CV & DV** (controlled variables and disturbances) and **MV** (manipulated variables) signals are also depicted, indicating the control loop.
ONLINE OPTIMIZATION IN NRL USING APC

- Post APC Yield benefit in DCU is shown as below –

<table>
<thead>
<tr>
<th></th>
<th>LPG yield %</th>
<th>CD yield %</th>
<th>FG yield %</th>
<th>Coke &amp; RFO %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base case (pre-APC)</td>
<td>3.81</td>
<td>52.20</td>
<td>7.95</td>
<td>36.90</td>
</tr>
<tr>
<td>Post APC</td>
<td>3.93</td>
<td>52.49</td>
<td>7.82</td>
<td>35.79</td>
</tr>
</tbody>
</table>
E III MODE of operation: Post APC Yield benefit (in KERO maximized mode) in HCU is shown as below –