Enhance Refinery Margins by Producing Premium Refinery Products from FCC Slurry Oil

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(Council of Scientific and Industrial Research)
DEHRADUN

CatCracking.com
MORE PRODUCTION - LESS RISK!

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Challenges

• FCC unit in refinery produces Slurry Oil, an aromatics laden residue stream, which is refractory in nature.

• Upgradation of slurry oil into transportation fuels through catalytic route is very difficult

• slurry oil recycling in FCC unit is limited

• Therefore, refiners blend major portion of slurry oil into fuel oil - demand of which is continuously declining or as ‘Delayed Coker’ feed - if such a unit exists in the refinery
General Refining Scheme

FEED → FEED

FCC

GAS → GAS
LPG → LPG
GASOLINE → GASOLINE
LCO → LCO
HCO → HCO

Slurry Oil
(To Fuel Oil Pool/Delayed Coker Feed)

PARTLY SLURRY OIL RECYCLING
Technology for Production of Premium Products from FCC Slurry Oil

• A novel application for upgrading slurry oil into value added premium refinery products

• Innovative concept of integration of two different processes:
  – Solvent Extraction
  – Catalytic Cracking
Innovative Processing Option

FEED

(IMPROVED FCC RECYCLE STREAM)

RAFFINATE

EXTRACT

NMP

LPG

GASOLINE

LCO

HCO

Slurry Oil

Slurry Oil

CBFS / PITCH
This technology is aimed to achieve the following:

- Generation of additional quantity of clean FCC feed and thereby enhanced distillate yields

- Reduction in fuel oil components

- Production of premium quality carbon black feed stock (CBFS)

- Conversion of aromatics present in slurry oil into high value mesophase pitch - precursor for advanced carbon materials
Key Features/Advantages of Technology

• Provides improved quality FCC feed stock, which is as clean as fresh feed (VGO)

• Higher yields of FCC products (gas/distillate) of better quality (reduced sulfur)

• Co-production of high BMCI aromatic extract (premium quality CBFS)

• Reduction in coke lay down on cracking catalyst leading to enhanced catalyst efficacy and cycle life, reduced catalyst consumption and regenerator load

• Reduced CO$_2$ emissions (meeting future carbon emission legislations of the refinery)

• No major investment, high profitability
Technology Development

• Phase I: Basic data generation (single stage and multistage extraction, Cracking Studies in ACE unit) at lab scale

• Phase II: Fine tuning with process parameters of current operation of HPCL refinery

• Phase III: Successful commercial run at HPCL to prove technology concept

The technology is currently operating successfully
Typical Feed Properties

- Technology was developed/fine tuned based on HPCL feed stock (slurry oil) with properties as given below:

<table>
<thead>
<tr>
<th>Properties</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Density gm/ml $d_{4}^{15}$</td>
<td>0.8927</td>
</tr>
<tr>
<td>Kin Viscosity cSt at 100°C</td>
<td>4.18</td>
</tr>
<tr>
<td>Pour Point, °C</td>
<td>+45</td>
</tr>
<tr>
<td>Flash Point, °C</td>
<td>122</td>
</tr>
<tr>
<td>BMCI</td>
<td>36</td>
</tr>
<tr>
<td>IBP, °C</td>
<td>282.9</td>
</tr>
<tr>
<td>FBP, °C</td>
<td>516.9</td>
</tr>
</tbody>
</table>
Slurry Oil Extraction Data

- Typical bench scale lab data & commercial scale test run data obtained and compared
- Bench scale data (yields, BMCI etc.) are well comparable with refinery test run data

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Bench Scale Data</th>
<th>Test Run Data</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Single Stage</td>
<td>Multi Stage</td>
</tr>
<tr>
<td>Extraction Temperature, °C (T/B)</td>
<td>65</td>
<td>65/55</td>
</tr>
<tr>
<td>Solvent to Feed Ratio</td>
<td>0.9</td>
<td>0.9</td>
</tr>
<tr>
<td>Raffinate Yield, wt%</td>
<td>82.7</td>
<td>76.9</td>
</tr>
<tr>
<td>Raffinate Density@ 15°C, gm/ml</td>
<td>0.8637</td>
<td>0.8485</td>
</tr>
<tr>
<td>Extract Yield, wt%</td>
<td>17.3</td>
<td>23.1</td>
</tr>
<tr>
<td>Extract Density @ 15°C, gm/ml</td>
<td>1.0857</td>
<td>1.1208</td>
</tr>
<tr>
<td>Extract BMCI</td>
<td>127</td>
<td>144</td>
</tr>
</tbody>
</table>
Comparison of FCC Yields with Recycling of Slurry Oil & its Raffinate

- This technology increases the yields (wt%) of gas, LPG and gasoline, while reduces coke lay down on catalyst and formation of slurry oil

<table>
<thead>
<tr>
<th>Product</th>
<th>Base Case (FCC Feed : VGO + slurry oil)</th>
<th>Modified Case (FCC Feed : VGO + Raffinate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry Gas</td>
<td>1.7</td>
<td>2.15</td>
</tr>
<tr>
<td>LPG</td>
<td>11.1</td>
<td>15.86</td>
</tr>
<tr>
<td>Gasoline</td>
<td>25.3</td>
<td>42.40</td>
</tr>
<tr>
<td>Distillate</td>
<td>44.1</td>
<td>26.44</td>
</tr>
<tr>
<td>Coke</td>
<td>2.2</td>
<td>2.02</td>
</tr>
<tr>
<td>Bottoms (CLO)</td>
<td>15.6</td>
<td>11.13</td>
</tr>
</tbody>
</table>
**Evaluation of Extract as CBFS**

- Aromatic rich by-product extract exceeds key specifications for premium quality CBFS

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>CBFS Specifications</th>
<th>Extract Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific Gravity @ 15° C</td>
<td>1.07 - 1.12</td>
<td>1.117</td>
</tr>
<tr>
<td>BMCI by viscosity method, min</td>
<td>125</td>
<td>146</td>
</tr>
<tr>
<td>Sulphur, wt%, max</td>
<td>3.7</td>
<td>2.1</td>
</tr>
<tr>
<td>Asphaltene, wt%, max</td>
<td>6.00</td>
<td>1.71</td>
</tr>
</tbody>
</table>
Potential for Further Value Addition of Aromatic Extract Stream

• The extract stream produced is very rich in aromatics and can be converted into high value mesophase pitch – a precursor for a variety of advanced and engineering carbon materials.

• This is a very major value addition to aromatic extract with potential to make huge money.

• Advanced carbon materials produced from mesophase pitch are needed for various strategically important materials.
M/s HPCL carried out ‘commercial run’ for processing of slurry oil in one of their existing solvent extraction units of lube block at Mumbai refinery.

The commercial run was a great success.

Technology is tailor made to HPCL but not limiting to it.
Investment/Economic Impact of Technology

- HPCL invested ~ Rs 50 Lakhs only for implementing this technology
- Gross refinery margin (GRM) of HPCL has increased by ~ US $ 0.14/bbl
- Increase in profit of refinery to the tune of ~US$ 15 million/annum
- Reduction in generation of fuel oil components by ~65 TMT (0.9 wt%) annually/5.45 TMT per month
- Monthly production of 3.85 TMT of premium cat feed (raffinate) and 1.60 TMT of premium CBFS (Extract)
Other potential applications of Technology include:

- Production of paraffinic feed for isodewaxing/isocracking to make new generation high quality group-II and Group-III lube base oils
- Production of low aromatic raffinate from LCO which can be blended for quality upgradation with diesel
- Production of needle coke from premium CBFS (the major demand of needle coke is met through import)
Recognition

This innovative technology begged prestigious ‘CSIR Technology Award’
Conclusions

• A novel technology for production of valuable refinery products from low – value slurry oil such as good quality FCC feed, premium quality CBFS, precursor for advanced carbon materials

• Concept of integration of solvent extraction and FCC is new

• This is a proven technology as it is successfully running at HPCL Mumbai refinery

• Investments are low, enhancement in annual refinery profit is high

• Best suited for refineries having FCC and Solvent extraction units but can be implemented to other refineries also with only small investment
Acknowledgements

• The lab study was financially supported by Centre for High Technology (CHT), New Delhi and Hindustan Petroleum corporation Limited (HPCL), Mumbai

• The contributions of M/s CPCL, EIL and HPCL in the collaborative project leading to development of basic know-how of this technology are gratefully acknowledged

• We compliment M/s HPCL for implementing the technology in its Mahul Refinery for which they are deservedly reaping rich dividends.