Strategy of Takreer on R&D for Sustainable Future of Refining Industry

31st JCCP International Symposium
30-31 January 2013 - Japan
Takreer Strategic Focus Areas

1. To create and maintain conditions under which Takreer’s refining business and Environment can co-exist in productive harmony to fulfill the socioeconomic requirements of present and future generations of UAE

2. To ensure growth of Takreer’s Oil refining industry in scale and complexity to ensure full utilization of natural resource, while striving for continuous improvement in product quality to sustain Environment

3. To make Takreer’s refining business more competitive while enhancing the risk mitigating capabilities by developing technological edge by mastering crude oil refining technologies with the support of R&D

4. To focus on Refinery emission reductions for sustainability of environment by actively promoting enabling technologies in TAKREER’s R&D initiatives
### Develop Platform for Sustainable Growth

<table>
<thead>
<tr>
<th>Challenges</th>
<th>Initiatives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meeting increasing local demand</td>
<td>Increasing Refining capacity from 22 to 42 MMTPA; Gasoline: 2.5 to 5.4 MMTPA; Gas Oil 4.7 to 12 MMTPA</td>
</tr>
<tr>
<td>Increase Refining Value</td>
<td>Base Oil, Bottom up-gradation: Delayed Coker/ RFCC</td>
</tr>
<tr>
<td>Meet more stringent prod. specifications</td>
<td>Meeting EURO-V Gasoline/ Gas Oil specifications</td>
</tr>
<tr>
<td>Expand Product Basket: Value added products</td>
<td>Base Oils; Propylene</td>
</tr>
</tbody>
</table>

R&D is identified as one of the Key elements in sustaining the change to meet TAKREER’s key objectives
Research & Development at TAKREER

2006 - 2009
TAKREER Research Center: Initiation; Planning; Start-up
Japan Cooperation Center, Petroleum (JCCP) Idemitsu Kosan Co. (IKC)

2010 - 2013
Development: Commissioning testing equipment
Studies related to existing equipment conducted
Work for full integration of existing refinery is in progress

2014 - 2017
Establishment:
Strong support to existing units
Trouble shooting and optimization of integrated refinery
To be a gateway to technology and innovation: Catalyst, Process and Product Development
Vision:
- To become a leading Research Center in the field of refining technology, process and product development.

Mission:
- To support and Develop TAKREER core refining activities as well as assist in technology transfer and Human resource development with local and international institution and Universities

Objectives:
- Ensure stable operation through troubleshooting
- Optimization of Process conditions and selection of most effective catalyst
- Save energy and reduce environmental impact through process integration
- Implement most advanced technology through in-house and collaborative R&D
- Develop workforce through trainings and internships
TRC Support & Collaboration

REFINERIES: Process Licensors/ Catalyst Providers

JCCP / IKC: Support
Japan Petro. Energy Center
Japan Petro. institute
Tech universities Japan

Petroleum Institute: New catalysts/ Modeling

Future OPCOs Research center: Boroge Innovation center; Masdar Institute; UAE University

TRC Support & Collaboration

Large Scale Pilot plants:
Hydro-treating; Hydro-cracking; Reformer

Lab Analysis: to support pilot plants; Refinery special testing needs; Assay analysis

Process Engineering; Modeling and Simulation
TRC Support ….

Pilot Plant Testing

• Designed and Procured pilot plant units to mimic refinery processes

• Started purchasing large scale pilot plant units (more than 100 CC catalyst volume): Used for yield prediction and product quality assessment

• Substantially invested in hydro-treating, hydro-cracking and reformer pilot plant units

• For processes like isomerisation, alkylation and adsorption plans are made to acquire smaller pilot plants
Catalysis

• Analyze and understand root causes of catalyst malfunction, deficit in activity, faster deactivation, lack of selectivity and poor mechanical strength

• Fast screening of various commercial catalysts in order to select the most suitable catalyst for the relevant processes/ application
  
  • Actively involved in RFCC catalyst formulation and improvement to maximise propylene yield

• ACE-MAT (Advance Catalyst Evaluation/ Micro Activity Test) unit is under procurement: this unit is planned to support day to day operation of RFCC unit

• Reaction kinetic modeling: To translate in to mechanisms and models capable of predicting catalyst performance at actual conditions of commercial units
TRC Support …..

Process

• Improve product quality and provide necessary support to meet specifications
• Energy efficiency: target for more efficient energy distribution and minimize energy consumption of units by improving energy integration
• Limit emissions NOx, Sox and other atmospheric pollutants
• Introduce sources of renewable energy
• Close monitoring and trouble shooting of refinery operations
• Building detailed simulation models for all important units of refineries
• Using refinery-wide modeling tools for process studies and developing yield vectors for various feed and process conditions for optimization studies
TRC Support .....

Lab Analysis

• Providing timely analysis of characterization of feed, assessing product qualities etc

• Support pilot plants testing requirement

• Support refinery testing and trouble shooting requirements

• Laboratory features standard and sophisticated testing methods and equipment

• Typical testing instruments:
  • Distillation methods, density, viscosity, cold flow properties, sulfur, trace nitrogen, CHN, high temperature simulated distillation, TBP and vacuum distillation, metals etc

• Involvement in ASTM round-robin tests is planned
Activity Programs at TRC:

- RFCC catalyst testing: initial investigations; selected optimum catalyst to maximize propylene production
- Reducing hydrogen consumption in Gas Oil hydrotreater: 30% reduction in H2 consumption with reactor pressure adjustments
- Crude Assay analysis: development of crude and condensate assay. Full assay report has been generated for Khuff condensate
- Refinery-wide simulations featuring rigorous reactor models are finalised
- Energy conservation in reformer units: Identify and recommend areas of improvement
- Assessing performance of Gas Oil hydrotreating catalyst to produce lowest possible sulfur content with various feed options
- Studying utilisation of idling gas oil hydrotreater to produce 10 ppm S Gas Oil
A case study for extending the life of old Gas Oil Hydrotreater for producing 10 ppm S Gas Oil by using new generation catalysts
Extending the life of an old Gasoil HydroDeSulphirisation unit using new generation catalysts
Constraints

- **Flexibility**: To study the possibility of processing feeds ranging from Kero to heavy Gas oil

- **No investment**: No additional investment in the form of additional reactor or new compressor.

- **Need of a more active, polyvalent and stable catalyst**
Effect of Hydrogen Partial Pressure

- N200: T=354°C, LHSV=5.0 H-1; H2/HC = 150 N/l
- N200: T=345°C, LHSV=3.5 H-1; H2/HC = 150 N/l
- KF737: T=340°C, LHSV=5.0 H-1; H2/HC = 150 N/l
Effect of Hydrogen to Hydrocarbon Ratio

![Graph showing the effect of hydrogen to hydrocarbon ratio on sulfur in product (ppm). The graph includes data points for different temperatures and hydrogen to hydrocarbon ratios, with labels indicating conditions such as T=354°C, LHSV=5.0 H-1, PPH2 = 40 bar, and similar conditions for other data points.]
# Feed - Analysis Results

<table>
<thead>
<tr>
<th>Tests</th>
<th>LGO</th>
<th>HGO</th>
<th>GO 500</th>
<th>LGO + HGO Mixture</th>
<th>Kerosene</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density, kg/l</td>
<td>0.8259</td>
<td>0.8559</td>
<td>0.8384</td>
<td>0.8405</td>
<td>0.7916</td>
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<tr>
<td>Sulphur, mg/kg</td>
<td>3271</td>
<td>9128</td>
<td>374</td>
<td>6294</td>
<td>999</td>
</tr>
<tr>
<td>Distillation (D 86)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IBP</td>
<td>189</td>
<td>230</td>
<td>226</td>
<td>207</td>
<td>154</td>
</tr>
<tr>
<td>5 % Rec.</td>
<td>231</td>
<td>275</td>
<td>251</td>
<td>243</td>
<td>167</td>
</tr>
<tr>
<td>10 % Rec.</td>
<td>242</td>
<td>289</td>
<td>260</td>
<td>254</td>
<td>171</td>
</tr>
<tr>
<td>20 % Rec.</td>
<td>251</td>
<td>302</td>
<td>272</td>
<td>265</td>
<td>177</td>
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<tr>
<td>30 % Rec.</td>
<td>258</td>
<td>311</td>
<td>282</td>
<td>274</td>
<td>183</td>
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<tr>
<td>40 % Rec.</td>
<td>263</td>
<td>318</td>
<td>291</td>
<td>281</td>
<td>188</td>
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<tr>
<td>50 % Rec.</td>
<td>267</td>
<td>324</td>
<td>300</td>
<td>289</td>
<td>194</td>
</tr>
<tr>
<td>60 % Rec.</td>
<td>270</td>
<td>331</td>
<td>311</td>
<td>298</td>
<td>202</td>
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<tr>
<td>70 % Rec.</td>
<td>274</td>
<td>339</td>
<td>324</td>
<td>310</td>
<td>210</td>
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<tr>
<td>80 % Rec.</td>
<td>278</td>
<td>350</td>
<td>339</td>
<td>326</td>
<td>220</td>
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<tr>
<td>90 % Rec.</td>
<td>284</td>
<td>364</td>
<td>360</td>
<td>350</td>
<td>232</td>
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<tr>
<td>95 % Rec.</td>
<td>290</td>
<td>376</td>
<td>375</td>
<td>366</td>
<td>241</td>
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<tr>
<td>FBP</td>
<td>300</td>
<td>387</td>
<td>385</td>
<td>378</td>
<td>249</td>
</tr>
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</table>
## Test Points & Results

<table>
<thead>
<tr>
<th>Feed</th>
<th>Pressure (bar)</th>
<th>LHSV (h⁻¹)</th>
<th>HZ/HC (Nm³/m³)</th>
<th>T (°C)</th>
<th>Sulphur in liquid product (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>(bar)</td>
<td>(h⁻¹)</td>
<td>Nm³/m³</td>
<td>(°C)</td>
<td>(ppm)</td>
</tr>
<tr>
<td>LGO</td>
<td>40</td>
<td>3.5</td>
<td>150</td>
<td>315</td>
<td>202</td>
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<tr>
<td>LGO</td>
<td>40</td>
<td>3.5</td>
<td>150</td>
<td>354</td>
<td>7</td>
</tr>
<tr>
<td>LGO</td>
<td>40</td>
<td>5</td>
<td>150</td>
<td>354</td>
<td>18</td>
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<tr>
<td>LGO</td>
<td>40</td>
<td>5</td>
<td>100</td>
<td>354</td>
<td>21</td>
</tr>
<tr>
<td>LGO</td>
<td>40</td>
<td>5</td>
<td>300</td>
<td>354</td>
<td>9</td>
</tr>
<tr>
<td>LGO</td>
<td>45</td>
<td>5</td>
<td>150</td>
<td>354</td>
<td>15</td>
</tr>
<tr>
<td>LGO</td>
<td>35</td>
<td>5</td>
<td>150</td>
<td>354</td>
<td>16</td>
</tr>
<tr>
<td>LGO</td>
<td>40</td>
<td>3.5</td>
<td>150</td>
<td>350</td>
<td>7.2</td>
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<tr>
<td>LGO</td>
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<td>3.5</td>
<td>150</td>
<td>345</td>
<td>14</td>
</tr>
<tr>
<td>LGO</td>
<td>40</td>
<td>3.5</td>
<td>100</td>
<td>345</td>
<td>16</td>
</tr>
<tr>
<td>LGO</td>
<td>40</td>
<td>3.5</td>
<td>250</td>
<td>345</td>
<td>8.7</td>
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<tr>
<td>LGO</td>
<td>40</td>
<td>3.5</td>
<td>300</td>
<td>345</td>
<td>6.8</td>
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<tr>
<td>LGO</td>
<td>40</td>
<td>3.5</td>
<td>150</td>
<td>354</td>
<td>5.3</td>
</tr>
<tr>
<td>500 ppm GO</td>
<td>40</td>
<td>3.5</td>
<td>150</td>
<td>354</td>
<td>130</td>
</tr>
<tr>
<td>Mix 50-50 (LGO-HGO)</td>
<td>40</td>
<td>3.5</td>
<td>150</td>
<td>354</td>
<td>455</td>
</tr>
<tr>
<td>HGO</td>
<td>40</td>
<td>3.5</td>
<td>150</td>
<td>354</td>
<td>1396</td>
</tr>
<tr>
<td>Kero</td>
<td>40</td>
<td>3.5</td>
<td>150</td>
<td>300</td>
<td>9</td>
</tr>
</tbody>
</table>
Process considerations

• **With or without amine scrubbing**
  – Acceptable level of H2S in the recycle gas

• **Stripping**
  – Reboiler vs Steam

• **Heat Requirement**
  – Exchanger on/off

• **Distribution Tray**
  – Adequacy: different feeds and flowrates
Final Assessment

- Unit can produce 10 ppm Sulphur content
- Unit can process different feeds
- Unit can absorb extra capacity
- No capital investment with the new generation catalyst
Path Forward: 2013 - 2015

• Further Development of Catalyst Evaluation Technologies
  – Addition of FCC catalyst evaluation

• Enhance Support to Refineries:
  – Upgradation of existing process simulators and building new ones for refinery expansion units
  – Trouble shooting and optimisation of refinery units with real time monitoring
  – Establishment of Material and Corrosion Res. Laboratory

• Developing skills and improving competencies of TRC staff using IKC facilities and expertise

• Collaboration with universities and institutions

• Knowledge sharing: Promoting TRC research activities to scientific and industrial communities
Future Opportunities in R&D Area:

- Carbon Black and Anode Grade Coke quality modeling and assessment.
- Emission Models (Stock, Fugitive and Ambient)
- Electrical / Control Network Modeling and simulation (for Reliability, Resistant of Loss Reduction, Contingency Analysis)
- Naturally Occurring Radio-active Material (NORM) models for decontamination.
- Civil Structure Integrity due to gulf environmental condition
Any Questions?
THANK YOU