FCC UNIT FEEDSTOCK FLEXIBILITY IN MOL’S DANUBE REFINERY

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AGENDA

1. INTRODUCING DANUBE REFINERY
2. DCU light naphtha processing in FCCU
3. HSVGO processing in FCCU
DANUBE REFINERY
DUNA REFINERY IN NUMBERS

- Distillation capacity: 8.1 MMT/y
- Storage capacity: 2.0 Mm³
- Nr. of Production unit: 51 pcs.
- White product yield: 80-82%
- Mechanical availability: over 96%
CHALLENGES OF DANUBE REFINERY

Increasing crude and feedstock variability

• Number and amount of tested crudes is increasing - Business opportunity to increase more valuable product ratio in our slate and flexibility.

Increase energy efficiency

Tightening environmental and product quality regulations

Maintaining high equipment reliability
FLOWSHEET OF THE DANUBE REFINERY

AV Dist. Unit 1.2.3 and Vac. Dist. Unit 4

Distillation
Conversion
Oxidation
Addition
Desulphurisation
Solvent refining
Blending
MOL DANUBE REFINERY FCC UNIT

UOP FCC (Side By Side) unit
High efficiency regenerator, complete CO combustion

• Feed: Hydrotreated VGO and DC HCGO
• Design capacity: 4000 MTPD
• Design feed sulfur content up to 2%
• General feed sulphur (2010-2014): 100-400 ppm

Connected units
• ETBE/selective C4 diolefin hydrogenation unit
• Hydrogen Fluoride Alkylation unit
• FCC Naphtha Hydrotreater
  • Design capacity 2500 MTPD
  • Design sulfur content is 70 ppm
DCU LIGHT NAPHTHA PROCESSING

DCU LIGHT NAPHTHA

High sulfur and diene containing light naphtha
Prior processed as chemical naphtha hydrotreatment is a must.

<table>
<thead>
<tr>
<th>Property</th>
<th>UOM</th>
<th>Value</th>
<th>Specification</th>
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<tbody>
<tr>
<td>Reid vapor pressure</td>
<td>kPa</td>
<td>86.3</td>
<td></td>
</tr>
<tr>
<td>Sulphur content</td>
<td>%</td>
<td>0.19</td>
<td></td>
</tr>
<tr>
<td>C4 olefin content</td>
<td>% (V/V)</td>
<td>max. 8</td>
<td></td>
</tr>
<tr>
<td>RON</td>
<td></td>
<td>82</td>
<td></td>
</tr>
<tr>
<td>MON</td>
<td></td>
<td>74</td>
<td></td>
</tr>
<tr>
<td>Bromine number</td>
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<td>109</td>
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</tr>
<tr>
<td>PONA</td>
<td>% (V/V)</td>
<td>48 / 44 / 7 / 1</td>
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</tr>
<tr>
<td>ASTM D86</td>
<td>°C</td>
<td>34</td>
<td></td>
</tr>
<tr>
<td>IBP</td>
<td></td>
<td>41</td>
<td></td>
</tr>
<tr>
<td>10 % (V/V)</td>
<td></td>
<td>46</td>
<td></td>
</tr>
<tr>
<td>30 % (V/V)</td>
<td></td>
<td>52</td>
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</tr>
<tr>
<td>50 % (V/V)</td>
<td></td>
<td>59</td>
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</tr>
<tr>
<td>70 % (V/V)</td>
<td></td>
<td>67</td>
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</tr>
<tr>
<td>90 % (V/V)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>FBP</td>
<td></td>
<td>75</td>
<td>max. 110</td>
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</table>
In case of TA of dedicated hydrotreater (NHT-2) unit it can be switched to slop, then reprocessed.

Disadvantages:
- Additional processing cost
- Corrosive material
- High olefin in LPG product

Alternative processing is desired e.g. processing in FCC
- Sulphur removal partially takes place
- Olefin content is not an issue in LPG product
- Diolefin is partially saturated in ETBE SHU unit
- By cracking of C6 molecules additional propylene is expected
DCU LIGHT NAPHTHA PROCESSING

INVESTMENT AND PREPARATION

About 800 m new pipeline was installed: 0.15 MEUR
New flowmeter installation, DCS and interlock system modification 0.07 MEUR
DCU LIGHT NAPHTHA PROCESSING
TEST RUN FOR IMPROVING C3= YIELD

▶ 5 m³/h OF NAPHTHA WAS PROCESSED (2.5% OF FEED)
▶ NO OPERATIONAL ISSUES
  reactor parameters unchanged
▶ PROPYLENE YIELD LOWER THAN EXPECTED
▶ INCREASE OF GASOLINE POOL INSTEAD OF CHEMICAL NAPHTHA
  ▶ No sulfur issue, mix feed was up to 500 ppm S
▶ THE BENEFIT IS THE FLEXIBILITY

NEXT STEPS
▶ DCU HEAVY NAPHTHA PROCESSING IN FCC IS UNDER INVESTIGATION
HSVGO PROCESSING IN FCCU

Motive:

Lack of feed for FCCU in case of shut-down (catalyst replacement or TA) of FCC feed pretreater unit (MHCK)

- reduced FCC throughput
- or undesired shut-down of FCCU

Alternative:

Heavy sulphur containing VGO co-processing in FCCU
HSVGO PROCESSING

Density (15°C) = 0.94 kg/m³
Sulphur content = 2.0 – 2.6 %
Ni + V content = 0.3 – 1.4 mg/kg
Conradson carbon = 0.5 – 1.2 %

High olefinicity!

Density (15°C) = 0.893 kg/m³
Sulphur content = 150 – 350 mg/kg
Ni + V content = 0.2 – 0.3 mg/kg
Conradson carbon = 0.04 – 0.06 %
HSVGO PROCESSING

BASE CASE:

- FCC UNIT PROCESSING HYDROTREATED FEED FROM MHCK UNIT
- THE AVERAGE SULFUR CONTENT OF FEED IS 200 PPMW%.

ALTERNATIVE:

- IMPROVE REFINERY FLEXIBILITY 5-7% OF MHCK FEED CAN BE MIXED INTO FCC FEED.
- IN CASE OF HSVGO PROCESSING THE SULFUR CONTENT OF FEED JUMP TO ABOVE 1000 PPMW%.
HSVGO PROCESSING

THE HIGHER SULFUR IN FEED THE HIGHER SULFUR IN FCC PRODUCTS

FUEL GAS IS NOT TREATED IN FCC BUT PIPED TO CENTRAL GAS PROCESSING HEADER TO REMOVE SULFUR

AS FEED SULFUR GOT HIGHER THE FUEL GAS SULFUR CONTENT REACHED TO 1 W% !

SPECIFICATION OF TREATED FUEL GAS IS MAXIMUM 250 PPMW.

GAS PROCESSING UNIT WAS ABLE TO MANAGE THE HIGHER FUEL GAS CONTENT FROM FCC.
HSVGO PROCESSING

- **LPG Sulfur Content** was higher during HSVGO processing, but the LPG Merox unit was able to handle it by more energy consumption.

- Sulfur of C4 can be detected in ETBE product (higher than the specification 50 ppmw%)

- Peaks in quality are rather belong to import C4 (DCU C4 to ETBE) than HSVGO processing.
HSVGO PROCESSING

- During normal operation, LCO used to have 50 to 400 PPMW% of sulfur content.

- The more sulfur, the more hydrogen consumption is expected in the GHT unit.
HSVGO PROCESSING

- FCC GASOLINE HYDROTREATER UNIT (NHT-5) FEED SULFUR CONTENT DESIGNED FOR 70 PPM. DURING HSVGO PROCESSING IT WAS ABOVE 70 PPM

- HIGHER REACTOR TEMPERATURE AND MORE H2 HELPED TO SOLVE IT.

- THE REMAINING LIFE TIME OF CATALYST IS SHORTENED.

- SULFUR CONTENT OF HYDROTREATED GASOLINE WAS ACCORDING TO SPECIFICATION (< 10 PPM).
HSVGO PROCESSING

- HIGHER HYDROTREATING SEVERITY
  - H2 consumption has doubled
  - Gasoline RON loss increased up to about 2 unit
SUMMARY

- **TWO TEST RUNS WERE EXECUTED TO IMPROVE FLEXIBILITY AS WELL AS PROFITABILITY.**

- **BENEFIT OF DCU LN PROCESSING IN FCC WAS LOWER THAN EXPECTED. IT CAN BE USED AS OPERATIONAL MODE IN FLEXIBILITY POINT OF VIEW.**

- **BYPASS MHCK UNIT AND PROCESS HSVGO IN FCC CAN ALSO BE A FLEXIBILITY ISSUE OF REFINERY.**

- **SULPHUR CONTENT OF BOTH STREAM DO NOT CAUSED PROBLEM IN PRODUCTS. NEITHER IN CASE DC LN NOR HSVGO.**
THANK YOU FOR ATTENTION