Challenges for proper implementation of residue upgrading processes within oil refineries

February 15, 2016 | A. Blumenstock (Speaker), W. Hamschmidt, T. Streich
Agenda

1. thyssenkrupp Industrial Solutions - Process Technologies
2. Oil refining and petrochemicals
3. Measures and market - Bottom upgrading project
4. Implementation of a residue conversion plant
5. Increasing flexibility of the distillation plants
6. Summary
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## Industrial Solutions
**The new dimension in Plant Engineering**

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<thead>
<tr>
<th>Business Area</th>
<th>Industrial Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business Unit</td>
<td>Marine Systems</td>
</tr>
<tr>
<td></td>
<td>Submarines</td>
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<tr>
<td></td>
<td>Surface Vessels</td>
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<td>Services</td>
</tr>
<tr>
<td></td>
<td>Process Technologies (former Uhde)</td>
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<tr>
<td></td>
<td>Fertilizer/ Coke Plant Technologies</td>
</tr>
<tr>
<td></td>
<td>Chemicals/Oil &amp; Gas Services</td>
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<tr>
<td></td>
<td>Resource Technologies (former Polysius and Fördertechnik)</td>
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<tr>
<td></td>
<td>Mining</td>
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<td>Cement</td>
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<td>Services</td>
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<tr>
<td></td>
<td>System Engineering</td>
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<td>Assembly Systems</td>
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<td>Car Body Technology</td>
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<td>Lightweight Solutions</td>
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<td></td>
<td>Forming Dies</td>
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<tr>
<td></td>
<td>Testing Solutions</td>
</tr>
<tr>
<td></td>
<td>Services</td>
</tr>
</tbody>
</table>

### Regional Organizations
- Americas
- Europe
- CIS
- MENA
- India
- Sub-Saharan Africa
- Asia Pacific
Delivering true efficiency!

Industrial Solutions

develops reliable, long-term solutions together with its clients,

to enable global industrial development while protecting scarce resources,

by means of the combined power of 200 years of engineering excellence with German roots.
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# Field of activities

## Overall value chain

<table>
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<tr>
<th>Upstream</th>
<th>Midstream</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1</strong> Exploration</td>
<td><strong>3</strong> Crude Transportation</td>
</tr>
<tr>
<td><strong>2</strong> Production</td>
<td></td>
</tr>
</tbody>
</table>

### Upstream
- Survey
- Exploratory Drilling
- Field Level

### Midstream
- Conventional Oil Processing (Drilling)
- Unconventional Oil Processing (Hydraulic Fracturing, Oil Shale, Oil sands, etc.)
- Crude oil / LPG transportation
  - Pipeline
  - Railcars
  - Trucks
  - Barges

### Downstream

<table>
<thead>
<tr>
<th>Downstream</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>4</strong> Crude Storage</td>
</tr>
<tr>
<td><strong>6</strong> Prod. Storage</td>
</tr>
<tr>
<td><strong>8</strong> Distribution</td>
</tr>
</tbody>
</table>

- Feed and product storage
- Broad range of Refinery processing
- Sale to costumer (petrol stations, petrochemical companies)
- Pipeline
- Tankers
- Trucks
- Railcars

**Main field of TKUES activities**
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Strategic search for new trends
Refinery investment drivers

- Total investments of refining industry (avg. Annual CAPEX): 4 – 5 bn €
- Expected long-term trend:
  - Decreasing overall fuel consumption
  - Constant investments
Strategic search for new trends
Opportunities

Global Heavy Crude Proc.\(^1\)

<table>
<thead>
<tr>
<th>Year</th>
<th>2010</th>
<th>2015</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>mio. b/d</td>
<td>12</td>
<td>16</td>
<td>20</td>
</tr>
</tbody>
</table>

LNG Demand Marine Sector\(^2\)

<table>
<thead>
<tr>
<th>Year</th>
<th>2015</th>
<th>2020</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>bil. m³/a</td>
<td>100</td>
<td>150</td>
<td>200</td>
</tr>
</tbody>
</table>

Global Sulphur Limit.\(^3\)

<table>
<thead>
<tr>
<th>Year</th>
<th>2010</th>
<th>2012</th>
<th>2025</th>
</tr>
</thead>
<tbody>
<tr>
<td>[% w/w]</td>
<td>5</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

Worldwide shift to heavier crudes
Replacement of heavy fuels by LNG
More stringent regulations to heavy fuel oils

Focus on bottom upgrading processes

Strategic search for new trends
Opportunities

Distribution by Bottom Upgrading Processes

Distribution by Coking Technologies

Source: Hydrocarbone Publishing 3Q, 2010

thyssenkrupp Industrial Solutions
13 | February 15, 2016 | Egypt Downstream 2016 – Challenges for proper implementation of residue upgrading processes within oil refineries | A. Blumenstock
Focus on Residue Upgrading Processes

Vacuum Gas Oil

Atm. Residue

Vacuum Residue

FLUID CATALYTIC CRACKER (FCC)

HYDROTREATER / HYDROCRACKER

THERMAL GASOIL UNIT

DELAYED COKER

SOLVENT DEASPHALTING

VISBREAKER

PARTIAL OXIDATION

Intermediate Product to further Processing in Refinery

Syngas

Hydrogen

Steam

Power

Heavy Fuel Oil

Petroleum Coke

Bitumen

Licensed by TK

Licensed by Others; TK References
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Delayed Coker Unit (DCU) Project
Up- and Downstream Plants

Crude Oil Distillation

Vacuum Distillation

Atmospheric Residue

Crude Oil

Vacuum Residue

Delayed Coker Unit (DCU)

Coker gas

Power and Heat Generation; LPG Recovery

DC Naphta

Naphtha Hydrotreater

Light Coker Gas Oil

Middle Distillate Desulphurization

Heavy Coker Gas Oil

Hydrogen Desulphurization

Coke

Power Station

Power Station

Crude Oil Distillation

Distillation

Crude Oil

Distillation

Vacuum Distillation
Challenges for DCU integration
Many pieces must fit together to form a coherent whole

Revamp, modification or installation of complete new processing units like HDS/HDA/HT

Implementation of ThruPlus® Delayed Coker Unit (ISBL process plant)

Revamp, modification or installation of associated utilities, offsite and auxiliary facilities
Considerations for Coker Implementation

Diagram of refinery processes including:
- Crude Oil
- Atmospheric Distillation
- Desalter
- Vacuum Distillation
- Cracking
- HDS (Hydrogenation Desulfurization)
- FCC (Fluid Catalytic Cracking)
- Steam Reformer
- Hydrogenation
- Isomerization
- Vacuum Gas Oil
- Fuel Gas
- Heavy Fuel Oil
- Gasoline
- Diesel
- Aviation Fuel
- Kerosene
- Heating Oil
- Boiler Feed Water
- Coolant Water
- Electrical Power
- Flare
- Sour Water Treatment

Thyssenkrupp Industrial Solutions
Considerations for Coker Implementation
Considerations for Coker Implementation
Additional units and expansion of existing units

ISBL:
• Delayed Coker (CDU) – new
• Marine Diesel Desulphurization (MDD) – new
• Cracked Naphtha Hydrotreater (CNHT) – new
• LPG Recovery including Caustic Wash/Water Wash or Merox – new
• Crude and Reformer Naphtha Fractionation (CPL) – revamp, modifications
• Naphtha Hydro Desulphurization (NHD) – revamp, modifications
• Diesel Hydro Desulphurization / Dearomatization (HDS / HDA) – revamp, modifications
### Considerations for Coker Implementation

**Additional units and expansion of existing units**

#### OSBL

- **PSA (H₂) unit** – expansion of existing PSA unit
- **MEA (amine) absorbers** – new absorbers and modifications of existing absorbers
- **MEA regeneration** – 1 new regeneration unit
- **Sour water/process water** – revamp and 1 new sour water stripper
- **Wet Sulphuric Acid Plant (WSA)** – new (alternatively revamp of Claus Plant)
- **Coke Handling Unit** – new
- **Coke Loading (ship / rail)** – new
- **LPG Loading (rail)** – revamp depending on logistics

#### Utilities

- **BFW / Steam / Condensate** – revamp and 1 new demin water unit
- **Cooling water** – 1 new circulation system with air cooler or cooling tower
- **Instrument Air / Plant Air** – revamp, 1 new compressor (existing drying unit is sufficient)
- **Flare** – new flare for new plants (DCU, MDD,) etc. and study of existing flare/flare system
- **Slop system** – extension
- **Flushing oil system** – extension (new vessel and new pump)
- **Biological waste water plant** – revamp
Consideration of Coker Implementation

Total cost evaluation

Implementation of residue upgrading processes within oil refineries

ISBL - new Coker
Invest Cost: ~40% – 50%

OSBL – all existing units reflecting the Integration
Invest Cost: ~ 50% – 60%

Challenge for modifying of crude oil processing (CDU and VDU)
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Increasing flexibility of the distillation plants

<table>
<thead>
<tr>
<th>Economic driven considerations for increasing crude oil processing flexibility</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Heavy Crude Oil</strong></td>
</tr>
<tr>
<td>The continuous rise of heavy crude oils production in the upstream industry requires modification of CDU/VDU sections</td>
</tr>
<tr>
<td><strong>Changes of feedstock quality</strong></td>
</tr>
<tr>
<td>The need of higher sulphur-rich and higher corrosive feedstock processing requires a specific material selection for long-term operation</td>
</tr>
<tr>
<td><strong>Demand of middle distillate</strong></td>
</tr>
<tr>
<td>Increasing of flexibility of Naphtha Cut point reduction reflects the higher demand of Diesel towards Gasoline / Naphtha</td>
</tr>
<tr>
<td><strong>Bitumen production</strong></td>
</tr>
<tr>
<td>Increasing of flexibility of VDU matching Bitumen product quality for high range of crude slates</td>
</tr>
</tbody>
</table>
# Increasing flexibility of the distillation plants

**Example: Top1 / Vak1 Project for a client in Europe**

<table>
<thead>
<tr>
<th>Units</th>
<th>Objectives</th>
<th>Modifications of existing plants or new design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude oil Distillation Unit (CDU)</td>
<td>• Increasing of middle distillate yield by means of Naphtha Cut Point reduction</td>
<td>• Replacement of the column top (new design and material selection)</td>
</tr>
<tr>
<td></td>
<td>• Processing crude oils currently not applicable</td>
<td>• Replacement of column trays (middle section of column)</td>
</tr>
<tr>
<td></td>
<td>• Decreasing of Maintenance Cost</td>
<td>• Additional new UCR System</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Modifications regarding the LGO withdrawal route (new LGO pump, new LGO cooler, etc.)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Optimization of material selection</td>
</tr>
<tr>
<td>Vacuum Distillation Unit (VDU)</td>
<td>• Increasing the range of crude slates for Bitumen production in order to allow:</td>
<td>• New vacuum column,</td>
</tr>
<tr>
<td></td>
<td>• Processing crude oils currently not applicable for Bitumen production</td>
<td>• Replacement of relevant hot pumps (Vacuum Residue, VGO, etc.)</td>
</tr>
<tr>
<td></td>
<td>• Increasing of VGO yields</td>
<td>• Replacement of heat exchangers and air coolers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• new vacuum system (2 stages ejectors and liquid ring pump)</td>
</tr>
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- The worldwide crude slate has shifted to heavy and extra heavy feeds with high sulphur content.
- New maritime bunker fuel specifications with stringent emission norms for SOx and NOx increase the switch over from heavy fuel oil to clean combustion natural gas (LNG).
- Decreasing of the use of residue fuel oils in power production requires a further processing of Residues by producing more valuable distillate products. There is a growing drive to cost effectively maximize production from every barrel of crude oil processed.
- By integrating a Residue Upgrading Process there is a advantage of being able to process heavier and sulphur-rich feedstock and therefore reasonable priced crude oil. This requires a high flexibility of the distillation plants.
Thank you!

engineering tomorrow together.