Presentation outline

- Brief introduction to TIGAS history
- Technical features
- Marked considerations
- Round off
Topsøe’s process for production of gasoline

Natural Gas, Coal, Biomass or Waste to Clean Transportation Fuels

Topsøe is the world’s leading supplier of catalyst and catalytic based technologies

- Supply of thousands of catalyst charges for more than 70 years
- Experience – reliability and combination of catalyst & technology in both refinery and synthesis gas areas
- Design and license of large plants:
  - >300 Ammonia plants and revamps
  - >185 HY/CO plants
  - >65 Methanol plants
  - >35 Chemicals plants (DME, formaldehyde, SNG)
  - >110 Refinery units and revamps
  - >100 Sulfuric Acid plants
Demonstration plants

The choice of technology

Feed
- Natural gas
- Shale gas
- Associated gas
- Coal
- Bio mass

Front-end
- Tubular Reforming
- Two-step Oxygen-fired Reforming
- Autothermal Reforming
- Heat Exchange Reforming
- Gasification

Gasoline Synthesis
- Methanol loop + Gasoline Synthesis (MTG)
- Gasoline Synthesis (STG)

Product Polishing
- Crude gasoline
- Regular gasoline

Gasoline Synthesis (MTG)

Fractionation

Methanol
Steam
Fuel Gas
Raw Gasoline
Water

CO₂, CH₄, C₂H₆
Raw gasoline
De-ethanizer
LPG Splitter

LPG (C₃, C₄)
Gasoline (C₅ – C₁₂)

CW

### GSK – 10 References

**References**
Gasoline Synthesis Catalyst, GSK-10

<table>
<thead>
<tr>
<th>Customer</th>
<th>Capacity</th>
<th>Start-up date</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Qinghua I, Inner Mongolia</td>
<td>100,000 MTPY</td>
<td>February 2012</td>
</tr>
<tr>
<td>Qinghua II, Inner Mongolia</td>
<td>100,000 MTPY</td>
<td>July 2013</td>
</tr>
<tr>
<td>Xinjiang, Zhongji</td>
<td>50,000 MTPY</td>
<td>January 2013</td>
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<td>Xinjiang Xinye Energy, Xinjiang</td>
<td>100,000 MTPY</td>
<td>Exp. 2013</td>
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<tr>
<td>Hebei Kanglida Steel, Hebei</td>
<td>50,000 MTPY</td>
<td>Exp. 2014</td>
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### TIGAS process lay-out

- **Fuel gas**
- **Gasoline reactors**
- **Separator**
- **Process condensate**
- **De-ethaniser**
- **LPG splitter**
- **GUU**
- **Gasoline**
- **LPG**
GUU (Gasoline Upgrade Unit)

SPECIFICATIONS FOR GASOLINE (UNLEADED PETROL)

<table>
<thead>
<tr>
<th>Property</th>
<th>Topsoe TIGAS range</th>
<th>European specifications EN 228:2008 (Euro 5)</th>
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<tbody>
<tr>
<td>Research Octane Number, RON</td>
<td>&gt;91</td>
<td>Min 95</td>
</tr>
<tr>
<td>Motor Octane Number, MON</td>
<td>&gt;99</td>
<td>Min 95</td>
</tr>
<tr>
<td>Lead content mg/l</td>
<td>nil</td>
<td>Max 5</td>
</tr>
<tr>
<td>Density at 15°C (equivalent to SG 60/60°F) kg/m³</td>
<td>750</td>
<td>720–775</td>
</tr>
<tr>
<td>Sulfur content wt ppm</td>
<td>nil</td>
<td>Max 10</td>
</tr>
<tr>
<td>Oxidation stability minutes</td>
<td>nil</td>
<td>Min 360</td>
</tr>
<tr>
<td>Rimanent gum content (solvent washed) mg/100 ml</td>
<td>nil</td>
<td>Max 5</td>
</tr>
<tr>
<td>Copper strip corrosion (3 h at 50°C) rating</td>
<td>5-15</td>
<td>Max 18</td>
</tr>
<tr>
<td>Hydrogenation type content</td>
<td></td>
<td></td>
</tr>
<tr>
<td>aromatics vol%</td>
<td>30-35</td>
<td>Max 35</td>
</tr>
<tr>
<td>Benzene content vol%</td>
<td>Max 1</td>
<td>Max 1</td>
</tr>
<tr>
<td>Oxygen content wt%</td>
<td>3</td>
<td>Max 2.7</td>
</tr>
<tr>
<td>Oxygenates content</td>
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<td></td>
</tr>
<tr>
<td>methanol vol%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ethanol vol%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>isopropyl alcohol vol%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>tert-butyl alcohol vol%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ethers (5 or more C atoms) vol%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>other oxygenates vol%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distillation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% evaporated at 70°C (158°F) vol%</td>
<td>30-35</td>
<td>20-40</td>
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<tr>
<td>% evaporated at 100°C (212°F) vol%</td>
<td>50-52</td>
<td>48-71</td>
</tr>
<tr>
<td>% evaporated at 150°C (302°F) vol%</td>
<td>&gt;80</td>
<td>Min 72</td>
</tr>
<tr>
<td>Final boiling point (FBP) °C, max</td>
<td>210</td>
<td>Max 250</td>
</tr>
<tr>
<td>Distillation residue vol%</td>
<td>0-2</td>
<td>Max 3</td>
</tr>
</tbody>
</table>

GUU (Gasoline Upgrade Unit)

Stabilized gasoline

Light gasoline

Gasoline Splitter

Isomerisation

Heavy gasoline
Market considerations

Price development 2005-2013
Gas monetization

- Incentive for conversion of natural/associated gas to chemicals and transportation fuels;
  - Ammonia
  - Methanol
  - Gasoline
  - Diesel (via Fischer-Tropsch synthesis)

- The market interest for gasoline and diesel covers both
  - Mega scale 15,000 – 150,000 barrels per day
  - Small and large scale 1,000 – 15,000 barrels per day

Ammonia, Methanol & Gasoline

**Ammonia:**
- ~ 150 mill. MTPY
- Growth ~ 3% p.a.
- 80% used for fertilizers

**Methanol:**
- ~ 45 mill. MTPY
- Growth ~ 4-8% p.a.
- Formaldehyde, MTBE, Acetic acid, MTO

**Gasoline:**
- ~ 900 mill. MTPY
- Growth ~ 1-2% p.a.
- Fuel
Common challenges

- Logistics
- Economy of scale
- Market access
- CAPEX vs. OPEX

Market sensitivity of one new plant addition

<table>
<thead>
<tr>
<th>Product</th>
<th>Annual production Million MT</th>
<th>World scale nameplate capacity</th>
<th>Nameplate capacity in % of annual production</th>
<th>Specific NG consumption pr. MT of product (normalised)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gasoline</td>
<td>900</td>
<td>17,500 bbl/d (1,975 MTPD) + 445 MTPD LPG</td>
<td>0.07%</td>
<td>298 244 (gasoline only)</td>
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<tr>
<td>Methanol</td>
<td>45</td>
<td>5000 MTPD</td>
<td>3.7%</td>
<td>106</td>
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<tr>
<td>Ammonia</td>
<td>150</td>
<td>2200 MTPD</td>
<td>0.5%</td>
<td>100</td>
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</table>
TIC (ISBL cost estimate) (US Gulf coast basis)

- NG to gasoline (> 15,000 bbl/d)
  45 - 55,000 USD/bbl

- Gasoline part only! (add-on to existing methanol plant)
  6 - 10,000 USD/bbl

Why choose Topsoe TIGAS process?

- Opportunity to produce fuel – huge market!
- TIGAS is an attractive alternative to FT
  - Investment per barrel lower than FT alternatives
  - Drop in fuel
- Highly successful operation of gasoline catalyst GSK-10
- New feature: GUU = High quality high octane number
- True technology provider – "no strings attached"
- Experience – reliability and combination of catalyst & technology in both refinery and synthesis gas areas
Thank you for your attention

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