Clean Fuel – Low-Sulfur High-RON FCC Gasoline

GT-BTX PluS®
Method for Low-Sulfur FCC Gasoline without Losing RON
FCC Gasoline Desulfurization – Typical Scheme

Typical Gasoline Desulfurization Process

- FCC Naphtha
- Selective Hydrogenation Unit
- Hydrogen
- LCN
- C5-iC6
- HCN
- Severe HDS
- Hydrogen
- ULS Gasoline
FCC Gasoline Desulfurization

<table>
<thead>
<tr>
<th></th>
<th>Olefin</th>
<th>Thiophenic Sulfur</th>
</tr>
</thead>
<tbody>
<tr>
<td>LCN</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>HCN</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>MCN</td>
<td>Medium</td>
<td>Medium</td>
</tr>
</tbody>
</table>
FCC Gasoline – RON Loss in Typical Scheme

Processing scheme with 2 naphtha cuts will have significant octane loss.
FCC Gasoline Desulfurization

Typical Gasoline Desulfurization Process

Figure 3 – Dependence of the loss of octane number on the level of hydrodesulfurization in HDS section of Prime G based on data by Axens

New regulations require sulfur reduction > 99%.
GT-BTX PluS® - Segregates the Sulfur to Avoid Octane Loss

Simplified Process Scheme

FCC Naphtha → MCN 70-150°C → LCN C5-iC6 → ULS Gasoline

⇒ HCN 150°C-EP → MCN 70-150°C → HDS → Raffinate: Paraffins + Olefins

⇒ Extract: Sulfur + Aromatics

⇒ Severe HDS → H₂, H₂S → ULS Gasoline

GT-BTX PluS®
GT-BTX PluS® - Case Study

Refiner configuration before implementing GT-BTX PluS®
GT-BTX PluS® - Case Study

FCC Gasoline

Heavy Column

EDC

SRC

Hydrogen

Light Gasoline

Raffinate

Hydrotreated Gasoline

Treated FCC gasoline to gasoline blending

New

Existing

Shu

Light Column

LCN

MCN

Extracted Oil

Off-gas

Hydrogen

Sulfur/Aromatics Extraction

GT-BTX PluS® - Case Study
GT-BTX PluS® - Case Study
## Sulfur Balance

<table>
<thead>
<tr>
<th>Stream</th>
<th>Sulfur wppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full-range FCC gasoline feed</td>
<td>498 – 660</td>
</tr>
<tr>
<td>Light gasoline</td>
<td>11 – 15</td>
</tr>
<tr>
<td>GT-BTX PluS raffinate</td>
<td>4 – 5</td>
</tr>
<tr>
<td>Product from HDS</td>
<td>2 – 4</td>
</tr>
<tr>
<td>Full-range desulfurized FCC gasoline product</td>
<td>2 – 7</td>
</tr>
</tbody>
</table>
FCC Gasoline Desulfurization Unit
Performance post-GT-BTX PluS®

• A GT-BTX PluS® unit started up in 1Q 2016 in Dongying, China. The unit was added to an existing FCC gasoline HDS unit.

• Total liquid yield: 99.6%+

• Total sulfur removal rate: 99%+

• $H_2$ unit consumption: Reduced by 60%

• Cost of production: unchanged
  (steam consumption increased but $H_2$ reduced )

• Octane loss: reduced from 4.0 to 0.6
GT-BTX PluS® - Enabling Technology

Technically advanced extraction process enables

- Desulfurized gasoline to < 10 ppm sulfur with near zero octane loss
- Reduced benzene in cracked gasoline to < 0.5% benzene
- FCC olefins preserved for conversion to aromatics or propylene
- GTC has licensed 6 GT-BTX PluS® units.
- To-date, there are over 50 references for GT-BTX® family of technologies.

Patented process – available through GTC Technology
GTC Technology Day