AXENS’ IRAN SEMINAR
PAVING THE WAY TO A HIGHLY COMPETITIVE IRANIAN REFINING INDUSTRY
TEHRAN - 29/30 TIR 1395 (19/20 JULY 2016)

Symphony™
A New Beat in Reforming

Xavier Decoodt
What the Market is Looking for?

- BETTER Yields
- BETTER Economics with better yields stability
- HIGHER On-stream factor
What the Market is Looking for?

- Increased C$_5$+
- Increased total aromatics
  - More A$_7$+, primarily toluene and xylenes
  - Essentially same benzene
- Increased hydrogen
- Reduced C$_4$-
  - Primarily LPG (C$_3$-C$_4$)
  - Also FG (C$_1$-C$_2$)
- Reduced pentanes
  - Lower RVP
  - Affords incremental C$_4$ blending in gasoline
- Activity maintenance
What the Market is Looking for?

- Long term performances maintenance
  - Higher long term better yields
  - Low chlorine elution
  - Lower chlorine downstream side-effects
  - Higher catalyst surface area maintenance
  - Lower coke make

- Facilitate reactant and product diffusion efficiency
  - Highest catalyst activity
  - Lowest deactivation rate

- Provide requisite crush strength

- Minimize attrition
Existing Formulation: SELECTIVITY versus ACTIVITY selection

- By use of Promotor
  - A CARRIER
  - B CARRIER

Axens’ Iran Seminar – 19-20 July 2016 – Paving the Way to a Highly Competitive Refining Industry
Optimized Acid-Metal Balance Key
The optimized pass way

Transitions on Metal Sites

Transitions on Acid Sites

Cracked Products/
Coke Precursors

Coke
Current General Status: Catalyst Ageing

- Regular performances drop is mainly due to surface area decrease by catalyst carrier hydrothermal degradation phenomena.

- Catalyst chlorine elution is increasing through the time linked to catalyst surface area decline.

![Graph showing performances drop versus time](image)

**Performances drop versus time**

- 1 to 2% C5+ drop
- 0.1 to 0.2% H2 drop
How Much Does Ageing Really Cost? Hypothesis

- Hypothesis
  - Plant located in **Asia**
  - Capacity: 50 000 bpsd
  - Heating with Fuel Gas
  - Catalyst life: 7 years
  - Discount rate: 10%

- Replacement of operating catalyst by a high hydrothermal resistance catalyst
How Much Does Ageing Really Cost? Net Present Value Impact

- Replacement of operating catalyst by a high hydrothermal resistance catalyst

**Graph:**
- **Y-axis:** USD/t
- **X-axis:** Operating Catalyst Life
- **Bars:**
  - 0%: NPV = 1 USD/t
  - 33%: NPV = 4 USD/t
  - 50%: NPV = 5 USD/t
How Much Does Ageing Really Cost?

Catalyst Pay-Out Time

- Replacement of operating catalyst by a high hydrothermal resistance catalyst

Catalyst Pay-Out Time

<table>
<thead>
<tr>
<th>Operating Catalyst Life</th>
<th>Fresh</th>
<th>33%</th>
<th>50%</th>
</tr>
</thead>
<tbody>
<tr>
<td>months</td>
<td>14</td>
<td>6</td>
<td>4</td>
</tr>
</tbody>
</table>
How Much Does Ageing Really Cost?
To sum-up

- Selection of the highest hydrothermal resistance catalyst is a major economical driver:

  • Fresh to fresh increment gain between former generation type catalyst and the new generation is around 2 USD/t

  • Mid life catalyst (SBET ~160 m²/g) is worth to be replaced by the new generation type catalyst with:
    › an additionnal margin of about 4.4 USD/t
    › and a Pay-Out-Time of about 5 months
HOW to Answer: Symphony™

Officially launched in 2013

Symphony™
Reforming Business Acquisition Accelerates Development of New Technology

- Superior alumina support technology
- Game changer catalysts: PS 40, PR 30 & PR 15

- Superior multi-metal formulation technology
- Global leader in metallic active phase catalysts

Over 100 years of cumulative excellence in the production of reforming catalysts
A Wide Portfolio of Reforming Catalysts

Fixed Bed Series:
- Family of products for Semi Regen and Cyclic units
- Mono & Bi-metallic
- Balanced & Skewed
- Multi-promoted
- High activity, selectivity, and longer cycle length

Moving Bed (CCR):
- AR series for high severity Aromatics
- CR high density & PS low density series for Gasoline
- Multi-promoted
- Superior strength and Cl retention, maximum yield selectivity & catalyst life
Axens Fixed Bed Reforming Catalysts Portfolio

### Family of Multi-Promoted Fixed Bed Catalysts

<table>
<thead>
<tr>
<th>Re/Pt</th>
<th>Pt Only</th>
<th>Balanced</th>
<th>Unbalanced</th>
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<tbody>
<tr>
<td>Target Unit</td>
<td>Cyclic</td>
<td>Cyclic/SR</td>
<td>SR</td>
</tr>
<tr>
<td>Stability</td>
<td>+</td>
<td>++</td>
<td>+++</td>
</tr>
<tr>
<td>S tolerance</td>
<td>+++</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>Low density</td>
<td>RG 532</td>
<td>RG 582</td>
<td>RG 682</td>
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<tr>
<td>Standard density</td>
<td>P 15</td>
<td>PR 15</td>
<td>PR 36 PR 30</td>
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<td>P 152</td>
<td>PR 150</td>
<td>PR 156</td>
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</table>
Symphony™ Fixed Bed PR Series

- Higher H₂ yield
- Higher C₅⁺ yield
- Higher Aromatics yield

All this with 10-15% increased cycle length at same activity
Symphony™ Fixed Bed PR Series

- Symphony™ fixed bed catalyst series products provide vs previous products, industrially demonstrated:
  
  • Yields stability
  
  • Better Stability = Extended cycle length
    › Due to lower coke make
  
  • Proven industrial regenerability

Repeated orders from Majors
# Axens CCR Reforming Catalyst Portfolio

## New

<table>
<thead>
<tr>
<th>Application</th>
<th>Gasoline</th>
<th>Aromatics</th>
<th>Gasoline / Aromatics</th>
<th>Sn + Others (Multi-Promoted)</th>
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<tbody>
<tr>
<td>Pt, wt%</td>
<td>0.25</td>
<td>0.30</td>
<td>0.30</td>
<td>0.29</td>
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<tr>
<td>Promoters</td>
<td></td>
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<tr>
<td>Moving bed density, t/m³</td>
<td>0.65</td>
<td>0.65</td>
<td>0.54</td>
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## Main Attributes

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<thead>
<tr>
<th>Activity</th>
<th>Yields</th>
<th>Strength</th>
<th>Activity</th>
<th>Strength</th>
<th>Activity</th>
<th>Strength</th>
<th>Yields</th>
<th>Strength</th>
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<table>
<thead>
<tr>
<th>Density</th>
<th>High density</th>
<th>Low density</th>
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</table>

## Target Unit

- All
- All
- Competitor
Best Performances with PS 100

- Improved $C_5^+$, aromatics and $H_2$ yields
- Improved Hydrothermal Stability
- Same activity

All Commercial units using Symphony™ PS 100 have confirmed these gains
The today’s optimized solution.
Thank you! And see you on Axens’ Blog
axens.net/blog

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