When you can’t predict what’s in the pipeline

USE GRACE RESID FCC CATALYSTS to capture the value of opportunity crudes

NEKTOR™ SERIES
RESIDCRACKER™
MIDAS®

Case Studies Using Grace Resid FCC Catalysts
Overview

- Grace FCC Catalyst Portfolio
- Case Studies
  - Refinery X
  - Refinery Y
  - Orpic
Grace FCC Catalyst Portfolio

- Grace FCC Catalyst Portfolio
- Case Studies
  - Refinery X
  - Refinery Y
  - Orpic
Grace has a highly differentiated portfolio of catalysts

- **Zero RE HT/VGO**: ProgREss-100
- **RE-based HT/VGO**: ProtAgon-100, DieseliseR-100, NaceR, NADIUS
- **RE-based Resid**: ProtAgon-500, DieseliseR-500, ResidCrackerR, NEKTOR Series
- **Low RE Resid**: ProgREss-500, REduceR, REduceR, REduceR

**Objective**
- Maximum propylene
- Maximum LCO
- Max bottoms cracking
- Min delta coke
Grace is the technology leader for both light and heavy feed sectors.

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<th>Refinery Location</th>
<th>Supplier</th>
<th>ConCarbon (wt.%)</th>
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Grace is the leading catalyst supplier in the Middle East

- Broad, highly differentiated product portfolio
- Flexible manufacturing platforms
- Industry-leading technical service
- Highly responsive equilibrium catalyst analysis (typically 1-2 days)
- Full catalyst life-cycle management
- Investing in the Middle East region
Case Study: Refinery X

- Grace FCC Catalyst Portfolio
- Case Studies
  - Refinery X
  - Refinery Y
  - Orpic
Case Study at Refinery X

- Refinery X is in Western Europe with an FCCU processing resid feedstock
- Conradson carbon > 2wt.%
- E-cat Ni levels ca. 3,000 ppm
- E-cat V levels ca. 7,000 ppm
- Refinery switched from Competitor B to a Grace NEKTOR catalyst in October 2010
- Main unit objectives were:
  - Lower fuel gas
  - Maximisation of C3’s
  - Increased gasoline yield
  - Improved bottoms conversion
  - Improved coke selectivity
Case Study at Refinery X – E-Cat Properties

NEKTOR provided lower Gas Factors and Hydrogen Factors
Case Study at Refinery X – FCCU Yields

NEKTOR provided lower fuel gas yields
NEKTOR provided higher gasoline yields
Case Study at Refinery X – FCCU Yields

NEKTOR provided lower bottoms yields

NEKTOR was more coke selective
Case Study at Refinery X

- NEKTOR provided:
  - Lower fuel gas
  - Higher C3 yields
  - Increased gasoline yield
  - Improved bottoms conversion
  - Improved coke selectivity

- Catalyst switch was considered a complete success, and the refinery calculated an improvement in FCCU profitability of US$ 2-3 million per year.
Case Study – Refinery Y

- Grace FCC Catalyst Portfolio
- Case Studies
  - Refinery X
  - Refinery Y
  - Orpic
Case Study at Refinery Y

- Refinery Y is in Western Europe with an FCCU processing up to 20% resid
- Conradson carbon ca. 2 wt.%
- E-cat Ni + V levels ca. 6,000 ppm
- Refinery switched from Competitor B to a Grace NEKTOR-ULCC catalyst in March 2010
- Main unit objectives were:
  - Increased gasoline yield
  - Improved bottoms conversion
  - Improved coke selectivity
Case Study at Refinery Y – ACE E-Cat Testing

<table>
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<tr>
<th></th>
<th>Competitor B</th>
<th>Grace (NEKTOR-ULCC)</th>
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<tr>
<td>Cat-to-oil</td>
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<td>Coke</td>
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<tr>
<td>Delta Coke</td>
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Catalyst trial was a complete success, and Refinery Y continued to use NEKTOR-ULCC.
Case Study – Orpic

- Grace FCC Catalyst Portfolio
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  - Refinery Y
  - Orpic
Who we are

• Orpic is Oman’s national refining and petrochemicals company and is owned by the Government of the Sultanate of Oman and Oman Oil Company, a government owned company which invests in energy projects both inside and outside Oman.

• Orpic has four plants, employing more than 1,600 people with Omanis representing 73% of the workforce.

• Average Production:
  o 222,000 kbbls/day refining capacity
  o 1,016,000 metric tonnes/year of Para xylene and Benzene production
  o 350,000 metric tonnes/year of Polypropylene production

• Our plants allow us to provide 100% fuel to the nation.
Our Plants

Sohar Refinery

Opened 2006 and produces:
• Gasoline
• Diesel
• Liquid Petroleum Gas
• Jet fuel
• Fuel oil
• Naphtha
• Propylene
Our Plants

Mina Al Fahal Refinery

Opened 1982 and produces:
- Gasoline
- Diesel
- Liquid Petroleum Gas
- Jet fuel
- Fuel oil
Aromatics Plant

Opened 2010 and produces:

- Benzene
- Para xylene
- Light Straight Run Naphtha
- Liquid Petroleum Gas
- Heavy Aromatics
- Raffinate
Our Plants

Polypropylene Plant

Opened 2006 and produces:
• Polypropylene
Our Plants
Low rare earth NEKTOR catalyst

- When rare earth price peaked in 2011 Grace performed a catalyst selection study in their European R&D centre to lower rare earth
- Grace identified a low rare earth version of NEKTOR as the most suitable candidate for Orpic
- Grace commissioned an independent evaluation in a circulating riser pilot plant, which verified the suitability of the low rare earth NEKTOR
Feedstock properties deteriorated somewhat during the trial, whilst rare earth content of catalyst was decreased.
Low rare earth NEKTOR increased conversion despite the slight decline in feedstock quality.
Improving Catalyst Management

- In the original design set up at Orpic Sohar Refinery four hoppers are used for the storage of the FCC fresh catalyst, e-cat and ZSM-5 additive.
- In 2010, a specifically customized addition system from Grace was installed to enable the refinery to operate at maximum flexibility and reliability

Features:
- Can handle up to 4 components from different hoppers and/or flowbins.
- Customized design, tailored to the needs of the refinery
- Total dosage rates up to 30 MT/day achievable
Two D.A.I.S. QUATTRO devices were installed, and operated on a stand-by basis. This allows to constantly maintain an uninterrupted dosage of fresh catalyst into the FCC unit.

An additional flow bin was also included to allow separate injections of Grace’s combustion promoter if required.
Improving Catalyst Management

- In the conventional operation approximately 20-30 super sacks (1000 kg each) of fresh catalyst were unloaded every day into the storage hopper.

- The handling of such a large volume of material had previously been an intensively time consuming and environmentally unfriendly operation.

- There was also safety concerns associated with the forklift truck movements in the area, and the costs associated with it were a permanent issue during the previous operation.

- In addition, during the unloading operation, dust generation was inevitable, causing losses of catalyst and limiting the maintenance activities in the area.
One effective way to avoid the handling of Super Sacks is to deliver larger volumes of catalyst and additives overseas in more suitably designed containers.

A trailer tipper was supplied to allow the refinery to change from the traditional super sacks delivery to the safer and logistically cleaner container system. This solution was successfully installed on site in a simple manner without the need for extra engineering and construction. The frame is adjustable to variable heights of trailers, being able to manage a trailer of maximum 40’ without the front car.
During the unloading operation the trailer is locked with chains and a safety bar over the container. The catalyst is then transported into the storage hopper by the Power Pipe system below.

This easy to use device is operated by vacuum providing the refinery with a noticeable reduction of time during the unloading operation.
Summary

- Large reduction in dust generation while handling the fresh catalyst.
- The reduced dust generation within the process areas could reduce man hours spent on cleaning and housekeeping.
- The reduced dust generation represents a safer and more pleasant working environment for the operations personnel.
- The reduced manual handling of catalyst can be used either to free operator man hours for other duties or to reduce site costs accordingly.
- In conclusion, using the newly implemented D.A.I.S. QUATTRO system and the custom-built container offloading facilities at Orpic improved the operation and allowed the refinery to operate at maximum flexibility and reliability.
E-Cat Reworking Solutions

- Orpic is an RFCCU high in conradson carbon and metals

- For several years spent catalyst has been stored at or near the refinery, while possible re-use options were explored

- Orpic in cooperation with Grace have explored various options for the re-working of spent catalysts. The two companies have a re-working contract, in compliance with local environmental regulations, which granted Orpic a governmental export license for spent catalyst.
A partner of Grace re-works the spent catalyst from Orpic at their facilities in Germany. To do this they operate under Grace’s REACH registration umbrella.

For the subsequent re-work two different patented capabilities have been developed.
E-Cat Reworking Solutions

- Orpic and Grace teams have worked together very closely for the ultimate goal of an optimum operation of the RFCC unit.

- The combined efforts of the Orpic and Grace teams have led to Grace providing Orpic with state-of-the-art catalyst technologies to enable the RFCC unit to surpass targets despite processing an extremely challenging feedstock.

- The close collaboration of Orpic and Grace teams, has led to the implementation of a unique catalyst management solutions at Orpic RFCC unit to optimise the daily operations.

- A task force involving Orpic and Grace specialists was set up to ensure the management of the RFCC spent catalyst in the most efficient and environmentally friendly way.