Refining Catalysts for Future Challenges – Clean fuels

Matthias Scherer
Marketing Director, EMEA

Silviu Serban,
Technical Sales & Service Manager, MEA

ARA Week 2018
Cape Town, 14th March
A Global Trend to Lower Gasoline Sulfur

North America
- Tier 3 legislation for 10 ppm sulfur coming into effect in 2017.
- Previously 50 ppm sulfur limit from Tier 2.
- Some refiners already using Grace’s GSR® technology, many refiners evaluating potential for GSR® to help with Tier 3 compliance.

Europe
- 10 ppm gasoline sulfur imposed in EU member states since 2010

Russia + FSU
- Initial plan to meet 10 ppm gasoline sulfur by 2015
- Many refineries producing 10 ppm gasoline sulfur, but delays in imposing the limit nationwide due to concerns of meeting domestic demand.
- Variety of gasoline sulfur specs ranging from 10-500 ppm

Middle East
- Despite a rapid increase in vehicle numbers use of high sulfur gasoline continues to be the norm
- However, many refiners produce 10 ppm gasoline sulfur for export markets.

Asia Pacific
- Japan first country to adopt 10 ppm gasoline sulfur in 2005.
- South Korea followed in 2009
- 10 ppm gasoline sulfur specification in place in some major Chinese cities, 2018 targeted for nationwide implementation
- Other countries generally between 50 to 150 ppm gasoline sulfur

Africa
- Afri 4 by 2020
- 150 ppm Gasoline
- 50 ppm Gasoil

Latin America
- Very much country specific.
- 15 ppm gasoline sulfur implemented in Chile, Argentina taking a stepwise approach to achieve 10 ppm limits in the coming years

Euro 5, 10 mg/kg sulphur content in Diesel/Gasoline Directive 2009/30/EC
Built on talent, technology, and trust, Grace is a leading global supplier of specialty chemicals.

Our two industry-leading business segments—Catalysts Technologies and Materials Technologies—provide innovative products, technologies, and services that enhance the products and processes of our customer partners around the world.

A $2 Billion Technology Leader

Global Public Company

- 3,700 employees in 30 countries
- Customers in 60 countries
- New York Stock Exchange (GRA)
- Holding more than 800 active U.S. patents
- 23 acquisitions since 2003
- Headquarters: Columbia, Maryland USA
- Founded in 1854

Market Leading Positions

- #1 in FCC catalysts
- #1 in resid hydroprocessing catalysts
- #2 in hydrocracking catalysts
- #1 in polyolefin catalysts
- #1 in third-party polypropylene process technology licensing
- #1 in specialty silica gel, pioneer in multiple segments
Delivering Value

- Customer-focused, solutions-oriented approach
- Broad, highly-differentiated portfolio of products
- Industry-leading technical service
- Flexible manufacturing system
- Research leadership and innovation centered on customers’ current and future needs

Key Customers

- Global, public oil companies
- National (state-owned) oil companies
- Independent refining companies

Meeting refiners’ needs and ensuring success

- Achieving maximum yields of most valuable refining products
- Providing optimal catalyst selection for refinery crude slates

FCC Catalysts

- Improving specific yields
- Enhancing product quality
- Reducing emissions

ART Hydroprocessing Catalysts

- Fixed and ebulating bed resid
- Hydrocracking
- Distillates

FCC Additives

- Improving specific yields
- Enhancing product quality
- Reducing emissions

Catalysts Technologies  |  Refining Technologies
About ART – FCC feed pre-treat / fuels post treat

**Who we are**
- Grace-Chevron joint venture leveraging CLG’s hydrocracking catalyst technology and CB&I’s process technology

**What we have**
- A complete portfolio of hydroprocessing catalysts
- Substantial resources dedicated to customer support and product development

**What we do**
- Improve the operation and profitability of our customers in the petroleum refining industry

**How we do it**
- Exceptional design of catalyst systems
- Fully integrated technical support teams

*To provide a single point of contact for refiners hydroprocessing catalyst needs*
FCC unit profitability

Profit drivers in the FCC Operation

Increase Capacity
- processing and equipment capabilities

Lower-cost heavier feed
- crude selection

Changing Product Yields
- local market product values

Improving Unit reliability
- to be able to produce good results time after time

The most profitable refineries are the ones that leverage their flexibility to capture market opportunities
The Only Constant in Refining Is Change

- Shift in demand and production from mature markets to rapidly growing markets
- New crudes and alternative feedstocks
- Changing product demands and what refiners can manufacture
- Complex regulatory environments
- Margin pressures

### Global Petroleum Product Demand Increase 2010-2030

(million barrels per day % growth)

- Latin America: 2.5%
- CIS: 2.0%
- Asia-Pacific: 2.5%
- Middle East: 3.5%
- Africa: 2.0%
- North America: -0.5%
- Europe: 0.5%

Source: Hart Energy
Growing environmental legislations

**Clean Fuels Regulations**

- Clean fuels regulatory demands have brought a focus on the importance of optimized FCC feed pretreating in efforts to facilitate compliance.
- The proper selection of FCC Pretreater catalyst and severity integrated with the selection of the appropriate FCC catalyst design and operating conditions offer a refiner the opportunity for an optimized refining operation.
- **FCC Catalyst Hydrogen Transfer / Matrix / GSR additives**
Selecting the Right FCC Catalyst

Catalyst selection is key to improving FCC profitability

- **Maximum formulation flexibility**
- **Surface area RE (H-Transfer) Attrition resistance**
- **Best in class physical properties**
- **Unit retention**
- **Best-in-class strippability**
- **High efficiency, active surface area**
- **Synthetic – not natural pores**
- **No sacrificial surface area, Tailored ZSA/MSA**
Following market needs, the EnhanceR 4G platform launched:

- **NEKTOR 4G**
  - Coke selectivity for resid feeds

- **ResidCrackerR 4G**
  - Bottoms upgrading for resid feeds

- **NADIUS 4G**
  - High activity for low metals feeds

- **ProtAgon 4G**
  - Propylene Maximisation

Combination with highly porous & active matrix technology

Min. Slurry To FO Pool, Lower S Gasoline

FCC

Gasoline → GSR

LCO

Min. Slurry to FO pool
Gasoline Sulfur Reduction (GSR®) Technology

Grace is the market leader for gasoline sulfur reduction

- Grace’s patented GSR® portfolio is the culmination of over 20 years of product development and commercialization
  - Over 70 applications globally

**GSR® 5/SuRCA®**
- More effective for lower metal applications in full-burn.
- Additive and catalyst solutions
- Typically provides gasoline sulfur reduction of 20-35% reduction across full range gasoline

**D-PrISM®**
- Can be used across wide range of feedstocks, and for both partial- and full-burn operations.
- Typically added at 10% addition rate
- Particularly effective for reduction of light-intermediate gasoline sulfur (20-35% reduction)
Low Sulfur Fuels

Ultralow Sulfur Diesel

- Chevron and Grace joined together in 2001 to form Advanced Refining Technologies (ART).
- Technology expertise, world-class research and development, global manufacturing and technical support footprint, and a complete portfolio of hydroprocessing catalysts designed to meet the challenges of today's refiners.

Low Sulfur Gasoline

- Grace and ExxonMobil initiated a joint development program in 1998, which resulted in the GSR® 5 and SuRCA® technologies for FCC gasoline sulfur reduction.
- 7 patent families, jointly owned.
- GSR® 5 and SuRCA® used by more than 35 refineries worldwide.

Innovation through collaboration to satisfy regulations and meet demand
Case Study - Helping refineries to increase the profitability via the FCC operation
Commercial FCCU

- FCCU: EXXON Flexicracker
- Operation: FB
- Feed: VGO/UCO/HT CGO / 20% AtRes
- ConCarbon =1.8 wt.%

FCCU achievements

- With MIDAS® bottoms upgrading was substantially further improved, resulting in ca. 0.6 $/bbl
- Additional profitability increase, plus significantly reduced OPEX resulted.

3Q 2017, PTQ:

„FCCU Profitability Improvement using MIDAS and OlefinsUltra® MZ“
Commercial FCCU

- FCCU: UOP SBS
- Feed: 90% AtRes
- Metals: 10000 ppm V + Ni
- ConCarbon = 3.5 - 4 wt.%

FCCU achievements

- Uplift of (~1.0 wt%) from slurry to LCO by including MIDAS®
- Similar delta coke for both catalysts
- Profitability improved by min.
  
  **1.4 M USD /yr. over NEKTOR** (w/o delta OPEX).
III Case study - Refinery in RSA

- FCCU: UOP SBS
- Feed: ARDS resid/HVGO/HCK bleed/wax
- Operation: PB
- ConCarbon = 3.5 - 7 wt.%
- ACE data

FCCU benefits (80% changeover)

- More resid feed processing
- Higher LPG Olefins
- Boost Gasoline RON

Switching to a new catalyst technology, Grace helped the Refinery to increase profitability.
Conclusion

• GRACE offers solutions to help refiners processing their residue to **min. slurry to FO**, to cope with the new lower bunker fuels S as of 2020.

• Proper selection of FCC Pretreater catalyst in combination with the **selection of the appropriate FCC catalyst design** and operating conditions.

• Tailored FCC Catalyst H-Transfer & selective Matrix (NEKTOR/MIDAS®).

• **GSR** additives help to further reduce Gasoline S – new Afri 4 Spec.