



## The Development of Rare-Earth Free FCC Catalysts

### Rapid Escalation of Rare-Earth Metal Prices Has Accelerated Formulation of Rare-Earth Free Fluid Catalytic Cracking Catalysts

Colin Baillie and Rosann K. Schiller, Grace Davison Refining Technologies

Rare-earth (RE) metals are important for stabilization of the Y zeolite component of FCC catalysts. Rather ironically, RE metals are not so rare. However, they tend to be concentrated in hard-to-extract ore deposits. As a result, the world's supply comes from only a few sources. China alone accounts for 95% of the world's RE metal output. Recent export quota restrictions on RE metals from China have caused the price of these metals to rapidly rise, accelerating development of RE-free FCC catalysts.\*

Grace has a successful history of developing innovative FCC catalysts, including RE metals catalysts.<sup>1</sup> Grace later developed RE-free FCC catalysts and zeolite components that enhanced gasoline octane in the 1980s and 1990s delivering activity and stability without using RE metals. Over 85% of Grace catalysts used at the time consisted of RE-free zeolites. Later in the 1990s,

Grace developed the Z-21 RE-free stabilized Y zeolite. Based on this developed technology the NEXUS® catalyst family was commercialized in 1997, as a RE-free catalyst family for low-metal feed applications. NEXUS® catalyst has since been used in 10 applications.<sup>2,3</sup>

In 2008, a refiner conducted back-to-back catalyst evaluations comparing NEXUS® catalyst to a competitive RE-based FCC catalyst. Feed properties and operating parameters for both periods were similar. The E-cat gas and hydrogen factors during the back-to-back testing showed how NEXUS® catalyst is more selective at constant nickel equivalents than the competitive offering.

FCC product yields obtained during back-to-back testing are shown in Table 1. NEXUS® catalyst is more selective at constant nickel equivalents than the competitive offering. NEXUS® catalyst provided higher

[Cont. page 2](#)

### In This Issue...

#### FEATURE

The Development of Rare-Earth Free FCC Catalysts

#### PROCESS OPERATIONS

Debottlenecking HCGO Filtration  
FCC Ecat Contaminant Levels Maintain Upward Trend

#### INDUSTRY NEWS

- Cameroon on Track to Modernize its 30-yr Old Refinery
- China's two Largest Refiners Raising Crude Processing Capacity
- Sinopec Takes 37.5% Stake in Saudi Aramco Yanbu Project
- Sinopec and KPC Refinery Startup Planned for 2013
- Shell Sells Stanlow Refinery to India's Essar Energy
- Sohar Refinery Expanding Capacity to 187,000 bpd
- BP Whiting Modernization Deferred until Mid-2013
- Total Adding New G0 Hydrotreater at Gonfreville Refinery
- Jurong Refinery Diesel Hydrotreater Startup Expected in 2014
- PDVSA Project Includes 85,000 bpd Hydrotreater
- TNK-BP Investments Include Increasing Hydrotreating and Hydrocracking Capacity
- China Sets Limits on Rare Earth Output
- Grace - Chevron Joint Venture Celebrates Tenth Anniversary

#### EDITORIALLY SPEAKING

Crude Costs and Higher Operating Expenses Cut Into Refinery Profits

#### CALENDAR

**Table 1. FCC Product Yields Comparing NEXUS® Catalyst with a Competitor's Rare-Earth Based Catalyst.**

Product Yields	NEXUS®-346	Competitor	Delta
H2	0.03	0.07	-0.04
Dry Gas (H2S)	3.6	4.12	-0.52
LPG	16.25	18.19	-1.94
Gasoline C5-210°C	50.16	45.2	4.96
LCO 210-360°C	15.62	18.72	-3.1
MCB 360+ °C	7.98	7.68	0.3
Coke	4.72	4.56	0.16
Conversion	76.39	73.6	2.79

conversion (2.8 wt%), lower hydrogen yield (0.04 wt%), a lower dry gas yield (0.5 wt%) and a higher gasoline yield (5.0 wt%). To summarize, the refiner considered the NEXUS® catalyst trial to be a complete success, realizing a benefit of approximately 1.0 million Euros per year, remaining on NEXUS® catalyst to this day.

## Low Metal Feed Applications

Combining the RE-free Z-21 with new matrices has resulted in the new families of REsolution™ catalysts and REBEL™ catalysts. RE-free REsolution™ catalysts are intended for low metal feed applications, and represent a further improvement on NEXUS® catalyst performance. Within each family of REsolution™ catalysts, the ability to independently adjust activity and selectivities of zeolite and matrix, as well as the ratio of zeolite/matrix activity allow for a tremendous degree of formulation flexibility.

For low metal applications REsolution™ will match/improve the performance of standard RE-based catalysts. Table 2 shows ACE pilot plant testing (CPS-3 deactivation, no metals) comparing REsolution™ and NEXUS catalysts. It can be seen that REsolution™ provides higher conversion and LPG olefins yield, as well as similar gasoline yield, bottoms upgrading and coke. Several trials of REsolution™ catalysts are currently taking place in Europe.

Further R&D work has provided a new RE-free high matrix catalyst system for FCC applications. REBEL™ catalyst, formulated with Z-21, demonstrates similar activity and selectivity as Midas 100® catalyst, and is now under development (Table 3).

Most recently, a breakthrough proprietary stabilization process has been achieved in combination with a unique treatment step to boost acidity, resulting in the RE-free Z-22 zeolite. Relative to REUSY, Z-22 provides equivalent activity, higher LPG olefins and gasoline octane, at constant bottoms and coke make, as shown in Table 4.

**Table 2. ACE Pilot Plant Testing Comparing REsolution™ Catalyst with NEXUS® Catalyst.**

ACE Yields at Constant Conversion (CPS-3 deactivation, metals-free)		
	NEXUS® Catalyst	REsolution™ Catalyst
Cat-to-oil	4.9	4.5
LPG olefins, wt%	13.7	14.2
Gasoline, wt%	49.4	49.4
HCO, wt%	10	9.8
Coke, wt%	2.3	2.2

**Table 3. REBEL™ Catalyst Delivers the Same Activity and Selectivity Over Resid Feedstock.**

ACE Yields at Constant Conversion (CPS-3 deactivation, 3000 ppm Ni + V)		
	REBEL™ Catalyst	MIDAS®-100
Cat-to-oil	5.8	5.5
Dry Gas, wt%	1.8	1.8
Propylene, wt%	3.5	3.5
Butylenes, wt%	5.2	5.4
Gasoline, wt%	46.6	46.8
Bottoms, wt%	9.6	9.5
Coke, wt%	4.2	4.3

**Table 4. Z-22 Delivers the Same Equivalent Activity and Selectivity Without Rare Earth.**

ACE Yields at Constant Conversion		
	Z-22	REUSY
Cat-to-oil	6.6	6.8
Dry Gas, wt%	1.5	1.4
Propylene, wt%	4.6	4.3
Butylenes, wt%	11	10.4
Gasoline, wt%	52	53
Bottoms, wt%	6.7	6.8
Coke, wt%	2.3	2.2

Z-22 zeolite has been successfully produced. Several new catalyst families utilizing Z-22 are now being introduced for hydrotreated or low-to-moderate feed-metal applications, with one commercial trial currently underway in North America.

Introduction of RE-free catalysts utilizing the Z-22 zeolite is also being planned in Europe. For example,

REactor™ catalyst utilizes the Z-22 zeolite, but also incorporates the processing technologies used in NADIUS™ catalyst (an RE-based catalyst for low-metal feed applications). ACE pilot plant testing (CPS-3 deactivation, metals free) demonstrates that both catalysts show similar selectivities in terms of dry gas, coke and bottoms upgrading,

**Cont. page 3**

whilst REactoR™ catalyst provides higher yields of LPG olefins at the expense of some gasoline yield (Table 5).

REplaceR™ catalyst is another new RE-free catalyst family that is based on the Z-22 zeolite, but this catalyst incorporates the processing technologies used in NaceR™ catalyst (another RE-based catalyst for low-metal feed applications). ACE pilot plant testing (CPS-3 deactivation, metals free) comparing REplaceR™ with NaceR™ show that REplaceR™ provides similarly high activity, slightly higher LPG olefin yields and similar bottoms upgrading and coke yield.

These ACE pilot plant results demonstrate that for low-metal applications REactoR™ and REplaceR™ catalyst are suitable RE-free alternatives to established rare-earth based catalysts. Within these catalyst families the matrix type as well as the zeolite/matrix ratio can be varied. Additional formulation flexibility is possible, enabling fine tuning of the catalyst to suit FCCU-specific requirements regarding activity and selectivity. REactoR™ and REplaceR™ catalysts are also manufactured with the proprietary Grace Davison alumina-sol binder system, which ensures low particulate emissions due to its excellent attrition resistance.

## RE-Free Catalyst for Resid Feed Applications

Due to the additional demands placed on zeolite stability, the development of RE-free catalysts for the resid feed sector is much more challenging than for the low-metal feed sector. Rare-earth metals remain the most effective vanadium trap. However, processing technology involving metals resistance functionality has now been successfully applied to catalyst systems containing the Z-21 and Z-22 zeolites, resulting in the REduceR™ catalyst family. Although not fully equivalent to the performance of benchmark pure RE-based resid catalysts, REduceR™ catalyst can be used as a blending component with a RE-based resid catalyst, thus reducing the overall RE requirement. ACE pilot plant testing (CPS-3 deactivation, 5,000 ppm Ni+V) comparing an RE-based NEKTOR™ resid catalyst and the same catalyst containing 30% of

**Table 5. ACE Testing Comparing NADIUS™ with ReactoR™ Catalyst.**

CPS-3 Deactivation, Metals-Free		
	NADIUS™ Catalyst	ReactoR™ Catalyst
Conversion, wt%	75	75
LPG Olefins, wt%	14.6	15.3
Gasoline, wt%	51	50.3
Bottoms, wt%	10.3	10.3
Coke, wt%	1.7	1.6

**Table 6. ACE Testing Comparing NEKTOR™ Catalyst with NEKTOR™/ReduceR™ Catalysts (70/30).**

ACE Yields at Constant Conversion (CPS-3 deactivation, 2500/4500 ppm V/Ni)		
	NEKTOR™ Catalyst	70% NEKTOR™/30% ReduceR™
Cat-to-oil	4.5	5.3
LPG olefins, wt%	13.8	13.9
Gasoline, wt%	51	50.9
Bottoms, wt%	7.2	7
Coke, wt%	5.5	5.3

REduceR™ catalyst are shown in Table 6. To summarize, REduceR™ catalyst, a RE-free resid catalyst can be blended with a RE-based resid catalyst to provide similar performance in the key areas of activity, bottoms upgrading and coke yield. Grace is continuing R&D work to develop a RE-free catalyst with the stability and performance to allow the complete elimination of RE-based grades in resid applications.

## Summary

In the 1980s and 1990s, a large proportion of Grace's customers in North America utilized RE-free zeolite in their catalyst formulations to maximize FCC gasoline octane. In 1997, NEXUS® catalyst, formulated with Z-21, a RE-free zeolite, was introduced for low-metal feeds. In 2008, R&D activities were intensified to develop new RE-free catalysts. This has resulted in several new catalyst families for the low-metal feed sector as well as several promising leads for resid cracking:

- REsolution™ catalyst: Contains RE-free Z-21 zeolite in combination with a new matrix

- REactoR™ catalyst: Contains the newly developed RE-free Z-22 zeolite with the application of the processing technologies used in NADIUS™ catalyst
- REplaceR™ catalyst: Contains the newly developed RE-free Z-22 zeolite with the application of the processing technologies used in NaceR™
- REduceR™ catalyst, a RE-free resid catalyst, which can be blended at a 30% level into RE-based resid catalysts without significant performance deterioration in resid applications
- REBEL™ catalyst, a high matrix catalyst formulated with Z-21, yields similar performance as Midas® 100 catalyst after deactivation with metals.

Grace Davison Refining Technologies has responded quickly to the issues of rare-earth price and availability by developing these new RE-free catalysts, in order to relieve the cost pressure on customers without incurring performance penalties. The developments involving the new Z-22 zeolite

**Cont. page 4**



Editor, Rene Gonzalez,  
**Refinery Operations**

PO Box 11283  
Spring, TX, 77391 USA  
Mobile: +1 713-449-5817  
Office: +1 281-257-0582  
Fax: +1 281-686-5846  
[editor@refineryoperations.com](mailto:editor@refineryoperations.com)

Published biweekly by  
**NEMESIS MEDIA GROUP, LLC**  
PO BOX 5416  
Kingwood TX 77325. USA  
Phone: (713) 344-1379  
[inquiry@nemesismediagroup.com](mailto:inquiry@nemesismediagroup.com)

### Support

**Client Support**  
[support@nemesismediagroup.com](mailto:support@nemesismediagroup.com)

### Advertising

**Advertising & Marketing Dept.**  
[advertising@nemesismediagroup.com](mailto:advertising@nemesismediagroup.com)

### Group Subscriptions

**Client Services**  
[services@nemesismediagroup.com](mailto:services@nemesismediagroup.com)

### Copies & Reprints

**Circulation Dept.**  
[circulation@nemesismediagroup.com](mailto:circulation@nemesismediagroup.com)

### Subscription / Renewal

I want to subscribe to *Refinery Operations* for \$739/yr or \$1,378/2 yr, and receive biweekly issues plus unlimited access to the online premium content and archives.

Name: \_\_\_\_\_  
Title: \_\_\_\_\_  
Organization: \_\_\_\_\_  
Address: \_\_\_\_\_  
City: \_\_\_\_\_ State: \_\_\_\_\_ ZIP: \_\_\_\_\_  
Phone: \_\_\_\_\_ Fax: \_\_\_\_\_  
Email: \_\_\_\_\_

I want to renew my \$739 or \$1,378 subscription to *Refinery Operations*.

My account number is: \_\_\_\_\_  
Charge my Card No. \_\_\_\_\_  
Exp. \_\_\_\_\_ Signature: \_\_\_\_\_

Check enclosed (Payable to *Refinery Operations, LLC*) Postage and processing add/yr: \$25 within U.S., \$100 outside U.S.

will require modifications to our manufacturing plants, which will limit the short-term availability of some RE-free catalyst families. ■

### Literature Cited

1. Wormsbecher, R. et al. "The Role of Rare Earths in Fluid Catalytic Cracking," *Catalagarn* 108
2. Grace Davison *Catalagarn*, European Edition 1999
3. Grace Davison *Catalagarn*, European Edition 2010
4. Maher, P.K. and McDaniel, C. V., "Zeolite Z-I4US and Method of Preparation Thereof," Patent 3,293,192. 20 December 1966

**Editor's Note:** China, the world's largest rare-earths producer and exporter, supplying 90% of the global demand has

set its total output of rare-earth at 93,800 tonnes this year, 4,600 tonnes more or 5.16% higher compared to last year's, the Ministry of Land and Resources announced on March 31, 2011.

### The Authors

**Colin Baillie** is marketing manager with Grace Davison Refining Technologies in Worms, Germany ([colin.baillie@grace.com](mailto:colin.baillie@grace.com)).

**Rosann K. Schiller** is senior marketing manager with Grace Davison Refining Technologies in Columbia, Maryland ([rosann.schiller@grace.com](mailto:rosann.schiller@grace.com)).



## PROCESS OPERATIONS

# Debottlenecking HCGO Filtration

Dahlman based in The Netherlands has demonstrated the feasibility of using gas assisted backflush technology in combination with a special type of filter element to reduce heavy coker gas oil (HCGO) filtration costs. In one specific case, Dahlman engineers noted that a refiner was using a common backwash filter for HCGO filtration, which operates with short cycles and thus consumes too much backwash liquid – a cost factor for the refiner. Additionally, the filter needed to be cleaned ex situ driving up the cost even further. After consultation with the refiner, a basic design was made by Dahlman for a gas assisted backflush filter. The project was approved by the refiner to be designed and fabricated provided a pilot test would be done on site to demonstrate the process performance of the industrial design. The test demonstrated that the selected filter media worked.

The newly designed filter was field proven, demonstrating six hour filter cycle times versus 30-60 minutes on the original backwash filter. According to Dahlman engineers, it can be



Niels van der Horst

concluded that the new design can solve many operational problems at refineries with delayed coker units and other feed filtration processes.

Coking is one of the most important conversion techniques being used to convert the heavy residue oils to transportation fuels. Reduced-crude or vacuum residue is

**Cont. page 5**

used as a feedstock for coking. One of the main products of the coking process is heavy coker gas oil (HCGO), which is often processed in a downstream catalytic unit. As HCGO product often contains fine coke particles pre-filtration is required to prevent fouling of the catalyst beds.

From literature it is obvious that this liquid consists of heavy (polyaromatic) hydrocarbons, predominantly in the range of C13 to C60. Sometimes these asphaltenes can form larger hydrocarbon structures, which can precipitate on the surface of the filter elements. The coke particles, which have to be filtered out, are amorphous. If these particles get inside the filter elements plugging is a big threat. The refiner used a common backwash filter for HCGO, consisting of several small filter banks, which operated with short cycles.

The refiner wanted to cut deep in the operational costs of this filter. Dahlman was very interested in the process as it has experience in several heavy oil processes. Dahlman wanted to demonstrate the possibility of process improvement by using gas assisted backwash technology in combination with a special type of filter element. The photo in Figure 1 shows the industrial scale pilot test filter in place at the refinery for online testing. The unit is designed to perform tests in refinery applications under the most severe operating conditions.

Refiners considering improved filtration technology in order to reduce product losses or to get a grip on their maintenance cost will be able to upgrade feeds and residues economically or to modify the product slate to meet current market requirements. Robust and proven filtration technologies are essential for meeting capacity and quality targets for processes such as thermal conversion, hydrocracking and fluidized catalytic cracking.

Feedstock filtration upstream from hydrotreating and hydrocracking processes can effectively protect the catalyst beds from fouling, and consequently increase the catalyst cycle length and prevent premature shutdowns. However, it is frequently seen that over time filtration systems fail to perform.



**Figure 1.** Industrial Scale Test Filter at a Refining Facility for Online Testing.

Catalyst beds, being well protected by proper designed filtration units are a must for the profitable refinery. Those filter systems will thus be able to deal with the most suitable feeds for the various processes and its requirements towards the desired performances. Implementing them successfully can be challenging, and refiners in today's market are aware of the need to select a filter technology that will secure the best returns. Filtration experience is the key to successful technology implementation.

Installation of reliable filtration units upstream from the catalyst beds allow

for installation of more catalyst, less topping and overall better protection and reliability. This will result in more profitability for the refiner. The solution to achieving this goal is to choose proven experience when selecting the appropriate filtration technology. For refineries that make sound investments, there can be opportunities for enhancing business results. The refinery production management will highlight how important it is for them to retain their license to operate. They must manufacture products that meet ever-tightening specifications. To do this they need

**Cont. page 6**

to be careful about the filtration technologies they select. In the desire to use cheaper feedstocks, which are generally more difficult to process, the right feed filtration technology choice is a critical issue.

Refiners need to look at several factors when choosing filtration technology,

for example, does the selected filter unit give the best performance in all conditions with the product and at the right quality, and is it a filter technology that is reliable? On-stream availability is very important because the refiner can only be productive when his plant is available for use. Unexpected or long

shutdowns due to malfunctioning of filters are to be avoided, and the technology should be simple to maintain. Further information can be obtained by contacting Niels van der Horst, senior sales executive at Dahlman in The Netherlands (n.vanderhorst@dahlman.nl). ■

## FCC Ecat Contaminant Levels Maintain Upward Trend

A detailed assessment published by Olivia A. Topete in the Spring 2011 issue of *Catalagram* (Issue No. 9, pp.s 27-32) emphasizes the increasing levels of contaminants in FCC equilibrium catalyst (Ecat) samples received by the Analytical Services Center (ASC) Tech Service group at Grace Davison. The ASC receives on average over 200 Ecat samples per week from the world's FCCUs. The samples include a variety of competitive FCC catalysts and additives. The Topete assessment noted the growing trend towards resid processing and the corresponding higher severity FCC operations. Rare-earth remains the most effective means to maintain activity and selectivity in FCC catalysts employed in severe operations. Nonetheless, Topete (Figure 1) reaffirms the efforts being made to reduce the expensive rare-earth content in FCC catalyst while still maintaining performance.

Against this backdrop, Topete discussed the average FCC world contaminant levels, including:

**Vanadium:** Approximately 2,000 wppm V, with highest levels in Asia Pacific market and lowest levels in North American market

**Nickel:** The Asia Pacific market growth in resid processing has resulted in average Ni content of 3500 wppm and above recorded from Asian Ecat samples between 2000 and 2010, significantly higher than any other market (by at least 1,600 wppm Ni), with the North American market maintaining the lowest average Ni levels (about 1,363 ppm)

**Iron:** The North American market

maintains the highest average levels currently at about 0.6 wt% Fe. However, the worldwide average indicates a downward overall trend over the last three years with the lowest level at 0.46 wt% Fe contaminant in Ecat samples collected from European FCCUs

**Calcium:** Topete noted that worldwide trends Ca contaminant have tilted downward in the past year and will likely continue in that direction, with Asia Pacific Ecat samples currently containing the highest Ca content at 0.20 wt% in 2010

**Sodium:** Na levels have been steadily trending downward in the last ten years, with Latin America Ecat samples containing a median value of 0.35 wt% over the past three years.

Furthermore, the study points out that average vanadium (V) and nickel (Ni) levels characterizing the Asia Pacific market indicate the region continues to process feeds that are vastly different from other refining regions. Other important trends noted by Topete include:

**Activity:** Consistent upward trend in catalyst activity. Advanced metals trapping technologies have enabled many refiners to retain catalyst activity despite increasing contaminant levels such as V and Ni

**Rare-Earth (Re<sub>2</sub>O<sub>3</sub>):** After the price of rare-earth increased nearly 20 times in eight months, the topic of rare-earth has quickly become the focal point of many reformulation and new technology efforts. Worldwide averages are characterized by a steady upward slope from 1.9 wt% to 2.9 wt% Re<sub>2</sub>O<sub>3</sub> over



Olivia Topete

the 2000 to 2010 time period, reaching a high of 3.0 wt% in 2008

**Unit Cell Size:** During the latter part of the decade, market unit cell size began to converge to an average 24.31 Angstroms (Å) with the exception being Latin American FCC catalysts, remaining slightly lower at 24.30 Å

**Particle Distribution (0 to 40 microns):** The worldwide average for 0-40 particle size is 6%.

The historical results for any FCCU can provide an invaluable reference point for troubleshooting activities for assessment of performance deltas after major turnarounds. Further information can be obtained at [www.e-catalysts.com](http://www.e-catalysts.com) or by contacting the author (Olivia.topete@grace.com). ■

## INDUSTRY NEWS

### Cameroon on Track to Modernize its 30-yr Old Refinery

Cameroon is on track to expand and modernise its Limbe refinery, with all funding for the first phase of the project in place, a senior official at state-owned refiner SONARA has told *Reuters* in early April.

SONARA, which has been operational since 1981, has so far only refined light crude oil imported from Nigeria, Equatorial Guinea and Angola. Cameroon has pumped oil since the mid-1970s but it produces heavy crude that it has

been unable to refine. Around one million tons of SONARA's production is consumed locally, with the rest exported to other African nations, the United States and Europe.

Various African refining projects have been delayed or scrapped altogether, as governments failed to source the necessary funds. But Godfrey Yenwo Molo, in charge of projects at SONARA, said this was not the case for Cameroon. "The financing package is in place," he told

Reuters on the sidelines of an African Refiners Association meeting.

Molo said SONARA's operational and financial track record, fast rising demand for products in the region and the fact that many other projects on the continent had failed to take off, had helped it source funds from local and international banks. He said the first phase, due to be completed in 2013, was financed using pre-payments from future off-takers, including commodity traders. ■

### China's two Largest Refiners Raising Crude Processing Capacity

China's two main oil refiners plan to raise crude processing this year by 7.5% to meet rising demand, and a second fuel price hike this year is expected to be imposed by the government soon.

Sinopec Corp plans to process 228 million tons of crude this year, up 8% from 211 million tons in 2010, as it boosted refining capacity, *Caijing* magazine reported on its website in March citing an unidentified person.

PetroChina Co aims to raise crude throughput by 6.6% to 130 million

tons this year from 122 million tons in 2010, according to Chief Financial Officer Zhou Mingchun.

As China's economy may rise at a slower pace this year, both refiners' plans represented a slowdown in throughput growth - Sinopec processed 13% more and PetroChina refined 9.1% more in 2010.

Their plans could also be affected by domestic fuel prices, which are set by the government under a cost pass-through mechanism. Zhou said PetroChina's

refining break-even point is US\$90 a barrel under current fuel rates.

The 22-day moving average price of Brent, Dubai and Cinto crude, on which China's fuel pricing is based, has gained more than 11% since February 20 when the government last raised gasoline and diesel prices by up to 4.5%, according to C1 Energy.

Analysts said the next fuel price increase is likely to occur around the Qingming Festival, which falls on April 5, when transport demand is set to rise. ■

### Sinopec Takes 37.5% Stake in Saudi Aramco Yanbu Project

China Petrochemical Corp. struck a deal at the end of February to invest in a Saudi Arabian refinery, in a move likely to strengthen China's overseas energy ties but that also carries risks amid rising volatility in the Middle East.

Sinopec will take a 37.5% stake in the Red Sea Refining Company joint

venture that will build the Yanbu refinery once its agreement with Saudi Arabian Oil Co., known as Saudi Aramco, becomes binding.

Aramco will hold the remaining interest, the companies said. The deal marks the first move by Sinopec—Asia's largest refiner by capacity—to become a global player in oil processing

after focusing its overseas expansion up to now in acquiring stakes in producing crude oil and natural-gas fields.

"It will advance Sinopec's overseas operations, enhance its strategic planning of refining, and further guarantee China's energy supply security," Su Shulin, the company's general manager, said.

Cont. page 8

Despite China's efforts to diversify its energy sources, much of the imported crude it needs to fuel growth comes from Saudi Arabia, according to the U.S. Energy Information Administration. Chinese officials say they want to boost trade with Saudi Arabia by about 50% to \$60 billion by 2015, further increasing Beijing's dependence on the kingdom.

The risk for Sinopec, a state-run entity, lies largely in economic implications of possible disruptions to energy supplies coming through the Persian Gulf, and Beijing's unease that the calls for democratic change sweeping across the Middle East and North Africa will set an unwelcome precedent at home.

Sinopec is playing catch-up with domestic peer PetroChina Co., which has

plowed billions of dollars into building up a refining and distribution network that includes hubs in North America, the Caribbean and Europe. In a major deal in January, PetroChina offered around \$1 billion to British petrochemicals firm Ineos Group Holdings PLC for shares in two proposed joint ventures that would conduct crude-oil refining and trading at Scotland's Grangemouth refinery and France's Lavera refinery.

But given the regional turmoil in the Middle East and North Africa, Sinopec's move appears to be much riskier than the PetroChina-Ineos deal.

Up to now, the business relationship has centered on crude trading and Aramco's investment in a Sinopec-run, 240,000 bpd refinery in China's

Fujian province. Saudi Arabia is China's biggest supplier of crude oil, shipping nearly 900,000 barrels a day last year, according to data from China's General Administration of Customs. Although neither Aramco nor Sinopec have disclosed the cost of the Yanbu plant on the Red Sea coast, it will run into billions of dollars. The Yanbu refinery will process 400,000 bpd of Arabian Heavy crude oil, and is expected to begin operations in 2014. The refinery will produce 90,000 bpd of gasoline, 263,000 bpd of ULSD, 6,300 metric tpd of petroleum coke and 1,200 tpd of sulfur, and will supply these products to both the international and domestic markets. ■

## Sinopec and KPC Refinery Startup Planned for 2013

China's top economic planner has recently approved the Sinopec and Kuwait Petroleum Corp.'s \$9.0 billion refinery development in the southern province of Guangdong. The companies will build a refinery with the capacity to process 15 million tons a year, or 300,000 bpd, and a 1.0 million tpy ethylene plant in the

city of Zhanjiang, according to a statement on the National Development and Reform Commission's website.

Kuwait has been in talks to build the refinery project since at least 2004. The complex, scheduled to start operations by 2013, will overtake Exxon Mobil Corp.'s \$5 billion Fujian project to

become China's biggest refining venture with an overseas partner.

Kuwait plans to choose a third partner within six months to develop the refinery, Al-Rai that was reported in the media on March 13. ■

## Shell Sells Stanlow Refinery to India's Essar Energy

According to a March 22 Dow Jones Newswire, the sale of the Shell Stanlow refinery to Essar Energy PLC ([www.essarenergy.com](http://www.essarenergy.com)) is expected to be concluded this month, said Essar Chief Executive Officer Naresh Nayyar. Shell agreed last month to sell Stanlow, the

U.K.'s second-largest refinery, to Essar for \$350 million, including crude and refined product inventories, total consideration of the deal is expected to be between \$1.1 billion and \$1.3 billion.

Mr. Nayyar said that Essar would look to expand Stanlow's capacity when

it takes control of the facility. "The refinery currently has a capacity of 14 million (metric) tons but is running at 75% of capacity," he said. "We are looking at various options for improvement both in terms of capacity utilization and to change its crude slate." ■

## Sohar Refinery Expanding Capacity to 187,000 bpd

CB&I recently announced today that it has been awarded a contract valued in excess of \$40 million by the Oman Refineries and Petrochemical Company for the front end engineering and design

(FEED) and project management services for the Sohar Refinery Expansion Project in the Sultanate of Oman.

The project will increase the capacity of the existing Sohar Refinery from

116,000 to 187,000 bpd by installing various clean fuels units, as well as increasing capacity and debottlenecking existing units in the refinery. ■

## BP Whiting Modernization Deferred until Mid-2013

A BP company executive announced deferring the start of part of its \$3.8 billion modernization project at its Whiting refinery until mid-2013. The project was expected to be completed in late 2012. Iain Conn, chief executive of BP's refining and marketing division, did not provide a reason for the delay during the company's conference call after releasing its fourth-quarter and full-year financial performance. BP posted a full year loss in 2010 of \$3.7 billion, compared to a \$16.6 billion profit in 2009.

Nonetheless, Conn said the Whiting refinery modernization project was 60% complete and making "good progress." Conn said the upgrades at Whiting will allow it to run heavier crude

oils and improve its product yields. He said the company also benefits from the refinery's proximity to Canadian crude sources and pipelines. "Even at relatively low margins, this project is expected to deliver approximately a three-fold improvement in profitability and will contribute materially to improvement in our U.S. fuel value chain position overall," Conn said.

BP spokesman Brad Etlin said some components of the modernization will operate on the earlier schedule. He said the reconfigured distillation unit -- also called the 12 Pipe Still -- is scheduled to operate in the second quarter of 2012. The reconfigured unit will be better designed to process oils including heavy

Canadian crude containing more impurities such as sulfur and nitrogen.

However, operation of the new gas oil hydrotreater and petroleum coker will be delayed until mid-2013.

Elsewhere, BP officials said the company would put its Texas City, Texas, and Carson, Calif., refineries and related marketing businesses up for sale. Despite plans to cut half its refining capacity, Conn said the portfolio after 2013 will provide enough advantages for BP to be competitive in the United States. The Whiting refinery is the nation's sixth-largest, with its 405,000-bpd refining capacity. ■

## Total Adding New GO Hydrotreater at Gonfreville Refinery

According to information gathered by Industrial Info Resources based in Sugar Land, Texas, Total SA plans to add a new gas oil hydrotreater at the 364,000 bpd Gonfreville refinery in the Haute Normandie region of France. The refinery is the largest in France.

The new gas oil unit, known as DGO5, is scheduled to be completed by the third quarter of 2013. With a processing capacity of 27,700 bpd, this unit will replace DGO2, which

will be permanently shut down once DGO5 starts operating.

The construction is part of a 730 million-euro (\$950 million) refinery reconfiguration project to increase diesel production by 10%. This project also includes upgrading the existing 205,000 bpd crude distillation unit, known as D11, and the expansion of the existing 48,000 bpd deep hydrocracker.

Work on the two units will be carried out during a 60-day turnaround

scheduled to take place in September and October 2012.

The engineering, construction and procurement contracts have been awarded to different companies that are currently performing detailed engineering phases: the D11 unit upgrade has been awarded to Foster Wheeler Italiana (Corsico, Italy), while the hydrocracker's expansion and the new unit addition have been assigned to Technip. ■

## Jurong Refinery Diesel Hydrotreater Startup Expected in 2014

ExxonMobils 605,000 bpd Singapore refinery in Jurong will produce mainly low sulfur diesel from 2014 when its diesel hydrotreater is expected to be ready, according to industry sources. Once the hydrotreater is ready, the refinery will move away from producing high sulfur gas oil, which it mainly produces and exports now, to production of

low sulfur diesel, including 50 ppm and 10 ppm sulfur gas oil.

With the addition of the hydrotreater, the 605,000 bpd refinery's total low sulfur diesel capacity will increase to about 25 million liters per day, or about 157,233 bpd, by 2014, a company spokeswoman told Platts earlier this month. Of this quantity, 9.0 million liters per day or

56,604 bpd will be 10 ppm sulfur diesel, with the rest to be 50 ppm sulfur diesel. The exact production of gas oil yield currently from the refinery is not known, but sources based in Singapore estimate that about 30% of total output from the refinery is gas oil. This works out to about 180,000 bpd currently. ■

## PDVSA Project Includes 85,000 bpd Hydrotreater

Petróleos de Venezuela, S.A. (PDVSA) and Haldor Topsøe A/S have signed a contract for the Centro de Refinación Paraguaná Project. The contract includes an 85,000 bpd hydrotreating unit, which will be the biggest ever designed by Topsøe, and the capacity will correspond to about half of Denmark's daily consumption of oil.

Due to the large capacity of the hydrotreater, the project will include two trains with four hydrotreating reactors in

total, which will produce ULSD containing less than 10 ppmw sulfur. The diesel hydrotreater is part of an optimization project in PDVSA's largest petroleum-refining complex in Paraguaná, Falcon state. With the new diesel hydrotreater PDVSA will be able to fulfill new restrictions on sulfur content in diesel both on the local market as well as on the export markets. The diesel product requirements correspond to the strict Euro V specifications.

Topsøe will supply an engineering design package for the hydrotreaters. The scope of supply includes design of the reactors, basic engineering, catalysts and detailed design of the proprietary reactor internals. Erection of the unit is expected to commence in 2014 and PDVSA expects to begin production by the end of 2015. ■

## TNK-BP Investments Include Increasing Hydrotreating and Hydrocracking Capacity

TNK-BP, a venture between BP Plc and Russian investors, plans to invest about \$2.9 billion to expand and improve efficiency at refineries in Russia through 2015, according to a company presentation.

"That is the expectation," Didier Baudrand, executive vice president for downstream, said at a recent conference in Dubai when asked about the investment program.

Russian refiners are investing domestically to produce better quality fuels as the country changes its tax regime on

exports. The Russian government plans to raise the tax rate on exports of heavy oil products, a step that is encouraging refiners to invest in lighter fuels like gasoline and diesel. Expanding the capacity of its facilities and the amount of light products produced will help TNK-BP improve competitiveness and efficiency, according to Baudrand's presentation.

While not yet confirmed, TNK-BP earmarked about \$1.5 billion in capital expenditure on improvements at plants including its Ryazan and Saratov refineries. Work includes

isomerization and diesel hydrotreater upgrades at both plants. Another \$1.4 billion is earmarked for the addition of units like a hydrocracker at Ryazan and expansion of the facility's FCC unit. TNK-BP plans to expand the crude unit at the Saratov refinery and add a visbreaker.

TNK-BP is considering a \$600 million project to install a hydrocracker at the Ryazan refinery, Chief Operating Officer Bill Schrader told reporters back in mid-December in Tyumen, Siberia. ■

## China Sets Limits on Rare Earth Output

China, the world's largest rare earths producer and exporter, supplying 90% of the global demand has set its total output of rare earth at 93,800 tonnes this year, 4,600 tonnes more or 5.16% higher compared to last year's, the Ministry of Land and Resources announced on March 31.

China will not grant any new licenses for rare earths prospecting and mining before June 30, 2012, said a statement on the ministry's website. According to the statement, total output of light rare earths is set at 80,400 tonnes and that of medium and heavy rare earths at 13,400 tonnes this year.

China has announced a series of policies for the rare earth industry since the latter half of last year, including export quota cuts, higher taxes and tighter regulation on mining companies.

Rare earth metals, a collection of 17 chemical elements in the periodic table, are incorporated into various FCC catalysts. ■

## Grace - Chevron Joint Venture Celebrates Tenth Anniversary

Advanced Refining Technologies LLC (ART), a joint venture between W. R. Grace & Co. and Chevron Products Company (Chevron), is celebrating

ten years of successful business activity. The venture was created in 2001 to develop, market and sell a comprehensive line of hydroprocessing catalysts

that help refiners convert heavy crudes and bitumens into lighter products, and remove sulfur and other contaminants from petroleum to

**Cont. page 11**

produce more environmentally-friendly transportation fuels. Today, the organization employs 200+ people around the world and is generating in excess of \$300 million in annual revenue.

The relationship between Grace and Chevron dates back to 1965, when Grace began manufacturing hydrocracking catalysts for Chevron-designed units. "Forming the joint venture was a natural extension of the prior relationship between our two companies," said Scott K. Purnell, General Manager and Managing Director, Advanced Refining Technologies LLC. "Combining Grace's material science, manufacturing, marketing and sales strength with Chevron's extensive experience operating its own refineries and leadership in design and process licensing proved to be a formula for tremendous business success."

Through new product innovation and business development, ART has grown significantly since it began operations

on March 1, 2001. In 2002, ART acquired Orient Catalyst Company's hydroprocessing catalyst technologies and the HOP<sup>(R)</sup> catalyst product line. In 2007, ART obtained an ownership position in Kuwait Catalyst Company, which had been manufacturing HOP<sup>(R)</sup> resid hydroprocessing catalysts under license since 2001. Over the past decade, ART also acquired and effectively integrated new catalyst technologies from several companies, including Crosfield and Japan Energy.

Between 2006 and 2010, to keep pace with the demand for ART<sup>(R)</sup> catalysts, driven in part by more stringent clean fuels standards and increased residue processing, ART expanded manufacturing capacity at its North American plants in Chicago, Illinois; Baltimore (Curtis Bay), Maryland and Lake Charles, Louisiana.

"We look to the future with enthusiasm and optimism," said Woody

Shiflett, Deputy Managing Director, Advanced Refining Technologies LLC. "Our foundation--a customer commitment to proven industry-leading catalysts and technical service--is backed by the research and development power of both the Chevron and Grace organizations."

Today, ART is a leading global supplier of hydroprocessing catalysts, including fixed-bed, onstream catalyst replacement (OCR) and ebullating bed products, designed for processing resid feedstocks.

ART also offers a full line of distillate catalysts used in processing ultra-low sulfur content gasoline and diesel fuel, including the SmART Catalyst System<sup>(R)</sup> and ApART<sup>(R)</sup> catalyst systems, which are customized for individual refiners. Most recently, ART has introduced DX<sup>(R)</sup> 420 catalyst, a next-generation offering for the production of ultra-low sulfur diesel. ■

## EDITORIALLY SPEAKING

### Crude Costs and Higher Operating Expenses Cut Into Refinery Profits

Net income for many refiners has fallen below many analysts' estimates due to 50% or more gains in crude costs. Refiners need to find new ways to counter the negative impact of high crude oil costs as well as higher operating costs. Even though crude prices have escalated, their quality has generally declined, thereby increasing operating expenses. These operating expenses are spread out throughout the refinery, affecting everything from metallurgy, hydrogen and catalyst consumption, and many other facets, including run lengths, reliability, corrosion and fouling control.

In some cases, shutting down facilities can be the best strategy for controlling operating expenses. For example, Zhang Dafu, an inspector of Sinopec Group was quoted as saying on March 7 outside China's annual parliament meeting, "We will remove some small

old facilities and add some new facilities in order to raise the quality of our oil products and improve the environment."

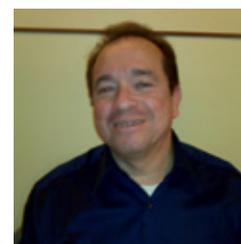
While most in the global refining industry expected the Chinese to shut down smaller and less efficient "teapot" refineries, it is also expected that major refiners in China will focus on maximizing efficiencies at new and recently completed refining facilities by running at close to 100% utilization rates. While shutting down older, less efficient facilities, Sinopec also plans to add a 160,000 bpd crude oil unit and a sulfur recycling unit with a capacity of 100,000 tpy at the Jinling refinery before the end of 2011 and a 3.5 million tpy (about 70,000 bpd) FCCU in 2012.

At the recent NPRA Annual Meeting in San Antonio, one executive from Egyptian Refining Company expressed his surprise to *Refinery Operations* at the

number of new FCCU projects that have recently been announced in the Middle East

and Asia in spite of surplus gasoline capacity in many of these countries. However, it goes without saying that many of these FCCUs are configured for propylene production as well as resid processing. Gasoline surpluses? Nonetheless, global demand for energy is expected to increase 47% by 2035 as economies pull out of the global recession and human populations in Africa, East Asia and Latin America easily begin to exceed 1.0 billion in each of these regions.

More efficient use of energy consumption within the refinery will be required to reduce fuel costs and meet lower NOx and CO<sub>2</sub> emissions targets for the near future. **Cont. page 12**



Rene Gonzalez, Editor  
*Refinery Operations*

More importantly, there appears to be a strong emphasis on unit-by-unit process and energy efficiency improvements throughout the refinery, such as with the development of less expensive and equally effective rare-earth free zeolites used in fluid catalytic cracking. Catalysts suppliers are working diligently at improving the performance of these rare-earth free catalyst systems for resid processing.

Another unit-specific example where efficiency improvements target reduction in hydrogen consumption is with hydrotreating operations operating in

PNA (polynuclear aromatic) mode vs. HDS mode, as the PNA mode requires higher severity operations (i.e., higher H<sub>2</sub> consumption, higher levels of catalyst contamination, etc.) to yield high quality LCO (and ultimately high quality diesel), thus requiring a multi-faceted approach at improving hydrotreating unit operations in order to reduce or at least “mitigate” operating costs.

There are a lot of reasons why refiners will continue to operate in spite of having to deal with feedstocks currently in the \$106/barrel range and operating costs expected to escalate as many

refiners introduce higher amounts of heavy crudes, such as from the Canadian sources oil sands. According to the Canadian Energy Research Institute (CERI), oil sands development is expected to contribute over \$1.7 trillion (USD) to the Canadian economy over the next 25 years, that’s about \$68 billion per year. Feedstock suppliers throughout the world no doubt have a vested interest in helping refiners deal with the higher costs of feedstocks and the cost incurred when converting these crudes into quality products. ■

## CALENDAR OF EVENTS

### APRIL

11-12, *Process Safety Management of Chemical, Petrochemical & Refineries Conference*, Houston, +1 312 540 6625, [www.marcusenvansch.com](http://www.marcusenvansch.com).

13-16, *6<sup>th</sup> Russia & CIS Bottom of the Barrel Technology Conference & Exhibition*, Euro Petroleum Consultants, Moscow, +44 (0) 20 7357 8394, [www.europetro.com](http://www.europetro.com).

### MAY

2-6, *Coking Safety Seminar*, Coking.com, Galveston, Texas, +1 360 966 7251, [www.coking.com](http://www.coking.com).

11, *ERTC Energy Efficiency Conference*, Amsterdam, The Netherlands, +44 (0) 207 484 9700, [conf@gtforum.com](mailto:conf@gtforum.com), [www.gtforum.com](http://www.gtforum.com).

17-18, *China Downstream Technology & Markets Conference & Exhibition*, Euro Petroleum Consultants, Tianjin, +44 (0) 20 7357 8394, [www.europetro.com](http://www.europetro.com).

24-27, *NPRA Reliability & Maintenance Conference & Exhibition*, NPRA, Denver, Colorado, +1 202 457 0480, [www.npra.org](http://www.npra.org).

### JUNE

13-14, *The Global Catalyst Technology Forum*, Euro Petroleum Consultants, Dubrovnik, Croatia, +44 (0) 20 7357 8394, [www.europetro.com](http://www.europetro.com).

15-16, *9<sup>th</sup> International Bottom of the Barrel Technology Conference*, Euro Petroleum Consultants, Dubrovnik, Croatia, +44 (0) 20 7357 8394, [www.europetro.com](http://www.europetro.com).

### OCTOBER

9-12, *NPRA Q&A and Technology Forum*, San Antonio, Texas, +1 292 457 0480, [www.npra.org](http://www.npra.org).

### NOVEMBER

Nov. 29 – Dec. 1, *ERTC 16<sup>th</sup> Annual Meeting*, Barcelona, Spain, +44 (0) 207 484 9700, [conf@gtforum.com](mailto:conf@gtforum.com), [www.gtforum.com](http://www.gtforum.com).

Copyright 2011 by *Refinery Operations*. Reproduction prohibited except for further use by the purchaser and expressly prohibited for resale. This information is obtained from the public domain and the intelligence of the staff of *Refinery Operations*. While every effort is taken to ensure accuracy, it cannot be guaranteed that this information has not been superseded. *Refinery Operations* cannot be held liable for the results of actions taken based upon this information.