4th Quarter 2004

DRIVING Competitive Advantage

Helping Clients Improve Profits
and Achieve Pacesetter Performance

KBC provides independent consulting services and implemented solutions to improve the sustainable profitability of our clients worldwide in the process industries.

Our Services Include:

Process Improvement

Linnhoff March® Energy Services

Reliability, Availability and Maintenance (RAM)

Planning Services

PEL Market Services

Profimatics™ Simulation Software

Petrochemicals

Training Services

IN NEXT ISSUE

How a Five-Star Energy Efficient Refinery Further Reduced its Energy Consumption and CO2 Emissions.

The article will focus on BP's Scholven refinery and highlight the main project details and the resulting RoadMap. The outcome justifies BP's conviction that even a pacesetter's performance could be further improved.

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FEATURE STORY

ULSD problems and solutions

Scott Sayles, Jim Bailor, and Robert Ohmes of KBC.

The production of ultra low sulfur diesel (ULSD) is scheduled to begin in June of 2006 in the USA. Refiners have many plans to produce ULSD, which vary in complexity from plant to plant. However, some refiners are still concerned with their ability to deliver the product. These concerns range from the method of production to the pipeline transportation system. Other refiners are struggling with routinely optimizing these new assets once the project is complete and the first shipment of ULSD is produced.

Kinetic models such as KBC's Profimatics® HTR-SIM® can provide accurate ULSD predictions, which are useful for ULSD design, operation, and monitoring. In addition, the HTR-SIM model predictions are suited for developing accurate ULSD LP vectors, which can help the refinery anticipate production variations due to changes in feedstock rates and qualities for improved ULSD operational control.

Clean fuels production is a worldwide initiative. The refining industry has successfully faced many such challenges by delivering continually cleaner, low-cost transportation fuels to the consuming public. The "clean fuels" title is used to cover a wide range of fuel characterizations for different initiatives: reduce sulfur levels, reduce aromatics, increase cetane, and meet additive package requirements. Selected from this wide-ranging criterion are the specific issues and factors surrounding the refinery requirements to produce 100% highway ULSD according to USA regulations.

Technology selection and implementation

Several options exist for the refiner to produce ULSD. Selecting the best option involves carefully weighing many important issues:

- Can an existing hydrotreater be revamped to make ULSD or should a grassroots unit be built?
- Which option gives the best flexibility for meeting current and future ULSD quality specifications other than sulfur?
- Which option gives the most flexibility for upgrading heavier and/or cracked feedstocks to ULSD?
- How to ensure the ULSD product still meets specifications when it is delivered to the customer?

Many refiners have existing diesel hydrotreating units. However, most of these units require major modifications to make ULSD, and some of these units are totally not suitable for upgrading diesel to ULSD.

The difficulties in producing 15 wppm sulfur are well documented as a function of hindered sulfur species conversion in various feedstocks. An additional concern is the ability to commercially measure sulfur levels of 15 wppm or less.

ULSD situations

KBC provided strategic planning services to review and evaluate the use of existing low-pressure hydrotreaters to produce ULSD. The main design changes required to produce ULSD in this particular low-pressure unit were increased catalyst volume, increased hydrogen circulation rate, and increased heater firing. Two key results of these changes are significantly shorter run lengths due to higher temperature requirements and a production limitation of lower aromatic fuels in the future.

Areas of concern identified when conducting this revamp study were pressure ratings of exchangers and upstream vessels, which received feed pump spill-back flow that must be carefully reviewed. Heat integration must be reviewed to ensure that the higher average reactor pressure and temperatures can be accommodated within the design limits of the existing or expanded feed/effluent exchanger train. In addition, operational viability to achieve 10 ppm sulfur on a daily basis must be built into the design.

An example of a vessel pressure ratings evaluation is in the spill-back of the reactor feed pumps to the charge drum. Modifications to this system are often required to raise the system pressure to the design maximum. The design modifications being considered must ensure that the spill-back will not bypass the motor-operated isolation valves to prevent potential overpressure of the feed drum.

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FACTOIDS

• The earth receives more energy from the sun in just one hour than the world uses in a whole year.

• World energy consumption is projected to increase by 59% from 1999 to 2020. Much of the growth in worldwide energy use is expected in the developing world. (International Energy Outlook 2001, EIA)

• Though accounting for only 5 percent of the world's population, Americans consume 26 percent of the world's energy. (American Almanac)

• Worldwide, some two billion people are currently without electricity. (U.S. Department of Energy)

• Among industrialized and developing countries, Canada consumes per capita the most energy in the world, the United Sates ranks second, and Italy consumes the least among industrialized countries.

• On average, 16 million tons of carbon dioxide are emitted into the atmosphere every 24 hours by human use worldwide. (U.S. Department of Energy)

• The United States is the world's largest single emitter of carbon dioxide, accounting for 23 percent of energy-related carbon emissions worldwide. (U.S. Department of Energy)

• Fossil fuels are depleted at a rate that is 100,000 times faster than they are formed.

• Wind power is the fastest-growing energy source in the world. (Worldwatch Institute)

• Germany currently leads the world in wind power generation, with 8,000 MW. The United States follows with 4,250 MW. Spain is in third place with 3,300 MW, followed by Denmark with 2,500 MW, which is now getting 18 percent of its electricity from wind. (Deutsche Stiftung Fur Internationale Entwicklung (DSE), Sept.-Oct. 2003)

• Using biodiesel in a conventional diesel engine substantially reduces emissions of unburned hydrocarbons, carbon monoxide, sulfates, polycyclic aromatic hydrocarbons, nitrated polycyclic aromatic hydrocarbons, and particulate matter. (Biodiesel is typically produced by a reaction of a vegetable oil or animal fat with an alcohol such as methanol or ethanol in the presence of a catalyst to yield mono-alkyl esters and glycerin, which is removed.)

• Replacing one incandescent lightbulb with an energy-saving compact fluorescent bulb means 1,000 pounds less carbon dioxide is emitted to the atmosphere and $67 dollars is saved on energy costs over the bulb's lifetime. (U.S. Environmental Protection Agency and Alliance to Save Energy)

• A decrease of only 1% in industrial energy use would save the equivalent of about 55 million barrels of oil per year, worth about $1 billion.

Source: Solar Energy International, http://www.solarenergy.org/resources/energyfacts.html, 2004.

FEATURE STORY

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Other critical areas that KBC recommends refiners pay close attention to include recombination reactions at the effluent of the hydrotreating reactor, catalyst sulfiding, and coker gas oil silicon traps.

The reaction of H_2S at the effluent of the hydrotreating reactor is called recombination. The products are mercaptans and these can cause the ULSD product to fail specification. Recombination reactions are between olefinic hydrocarbons and the H_2S in the reactor effluent stream. These reactions occurred in existing diesel units, but at the 500 ppm product sulfur level, the 1 to 20 ppm produced by recombination was not significant. However, at the 10 ppm level, these reactions must be controlled.

In one documented KBC engagement, a unit could not make 15 wppm sulfur product immediately after start-up with a new high-activity catalyst. The product was analyzed to determine sulfur types and mercaptans were found to be the predominant sulfur species. Since mercaptans are the easiest sulfur species to remove from the feed in the reactor, the conclusion was the mercaptans were probably made in the reactor effluent train by recombination. A sample from the reactor outlet confirmed the sulfur level was lower than the sulfur level in the product rundown line. A review of operating data taken during the catalyst sulfiding indicated less-than-ideal procedures were used.

Amine scrubbing of the recycle gas to reduce reactor effluent H_2S levels will directionally help reduce mercaptan formation from recombination. However, the key to reducing recombination is minimizing olefins at the reactor outlet. The most important action in this regard is to design the unit for low temperatures and high H_2 partial pressures at the reactor outlet during the entire run. While operating the unit, maximize reactor pressure and H_2/oil ratio to maximize reactor outlet H_2 partial pressure. Hot spots in the catalyst bed can increase olefins in the reactor, so they must be prevented. Improperly sulfided high-activity catalyst and flow maldistribution are the two main causes of local hot spots in reactor catalyst beds. Good catalyst sulfiding procedures are essential for ULSD units. The result of sulfiding with a spiking agent can be a four to six percent gain in the HDS activity over the course of the run. Excellent catalyst loading methods and proper installation of a clean, well-designed reactor distributor tray are critical to prevent channeling in the ULSD catalyst beds. Therefore, close monitoring of the reactor loading by refinery operations and technical personnel is critical. Adequate thermocouple coverage in the catalyst beds can help detect major catalyst hot spots. If channeling is suspected, radioactive tracer testing can be used to check for channeling a reactor beds.

Silicon containing coker gas oil can poison hydrotreating catalyst, but at a rate such that other factors typically limit run length for a conventional diesel hydrotreater. As a result, the concern over strictly monitoring and controlling the silicon in a conventional diesel hydrotreater's feed is reduced. However, at the 10 ppm product sulfur level, the ULSD hydrotreater catalyst activity must be maximized over the cycle. Therefore, the use of a silicon trap catalyst in the first bed of the ULSD hydrotreater can vastly improve the cycle catalyst activity. These silica trap catalysts can hold between three to four times the silicon of a typical hydrotreating catalyst.

Email tvalach@kbcat.com to receive the unedited version of this article that was published in the autumn issue of Petroleum Technology Quarterly (PTQ).

NEWS & INNOVATION

KBC NEWS

In our last issue of Driving Competitive Advantage we announced Petro-SIM, our new refining simulation software. Now, you can view the Petro-SIM demonstration online at www.kbcat.com, under the Profimatics Simulation Software section.

FCC-SIM Version Release: KBC will launch its latest version of FCC-SIM, which supports a feed hydrotreating configuration as a standard option, as well as online documentation.

Picture of the Producer's Panel at the 4th Russian Refining Technology Conference (RRTC) in Moscow.

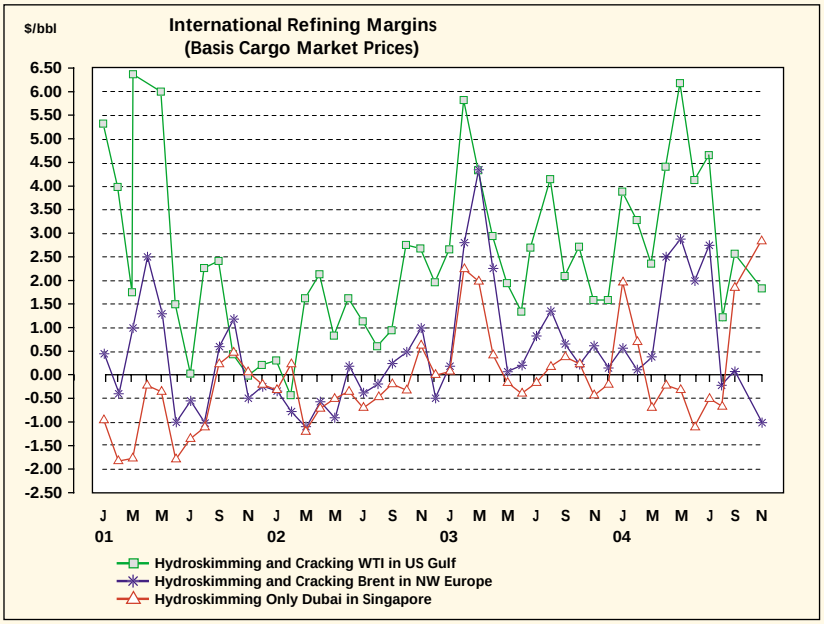
Refining Margins

by Olan O'Sullivan

Atlantic Basin refining margins came under downward pressure against benchmark crude oils during October with NW European margins on a hydroskimming and cracking basis recorded their lowest monthly average, US$1/bbl below breakeven since March 2002. US refining margins also averaged only US$1.75/bbl for the month. This contrasted sharply with the position in the Far East where margins against Dubai on a hydroskimming-only basis went above US$5/bbl and averaged US$3/bbl in October.

However, these results were hugely influenced by the dramatic widening in the price differentials between light and heavy crude oils. The margin in NW Europe based on Urals crude, for instance, increased in October by over a US$1/bbl and averaged around US$3.50/bbl. In Singapore, the margin on Tapis was much lower than Dubai and averaged US$2.68/bbl below breakeven in the month.

It appears that the world has effectively run out of cracking capacity. As a result light crudes are trading at a premium, while heavy crudes are in clear oversupply and are trading at a massive discount to light grades. This is clearly seen in the Brent/Dubai spread which averaged US$11.65/bbl in October compared to an average of US$2.75/bbl in the first nine months of the year.



EVENTS

PetroMin's Reliability, Availability, Maintainability & Safety Conference, November 29-30, Kuala Lumpur

Maka Khajarern, Senior Staff Consultant of KBC, will present a paper on routine maintenance optimization. Khajarern's paper will focus on two sites, a European refinery/olefins complex and a North American refinery where maintenance change programs were conducted to enhance operational reliability and reduce annual maintenance costs.

6th Annual European Fuels Conference, March 14-16, 2005, Paris

KBC will present a special pre-conference seminar "Delivering Competitive Advantage" at the 6th Annual European Fuels Conference on Monday, March 14th, at the Arc de Triomphe Hotel. Join us as we present strategies to maximize your ROCE. The seminar begins at 12:00 and is free to all registered guests. Visit our Web site frequently to get the latest information. For specific information or questions kindly contact Claudia Matthews at cmatthews@kbcat.com.

COMPLETED PROJECTS

PetroChina Daqing Petrochemical Refinery Achieved Over US$ 0.40 per bbl in Implemented Benefits

Asia

KBC consultants implemented a Profit Improvement Program (PIP) at PetroChina Daqing Petrochemical Company. The client had three objectives for the PIP: (i) to improve refinery gross margins by US$ 0.40 per bbl; (ii) to apply best practice management methodology and technology; (iii) to learn from KBC its PIP methodology, in particular, how to sustain and continue profit improvement for long-term cost reduction and higher margins. The total identified opportunities for the entire PIP project was US$ 0.75 per bbl in crude.

Phase One of the eleven-month long PIP concentrated on identifying yield and energy improvement opportunities that required no capital investment. Phase One resulted in a 4.5% increase in diesel and 10% increase in wax yields, plus efficiency improvements in the utilities system. Phase One implemented opportunities equaled to US$ 0.13 per bbl, which enabled the program to pay for itself in the first year of the project.

Phase Two focused on further implementation and debottlenecking of major conversion units including the residue catalytic cracking and delayed coking units by optimizing operating conditions without investment on additional equipment, as well as finished product blending optimization. By the end of Phase Two, thirteen months after completion of Phase One we were able to test, implement, and sustain benefits of over US$ 0.40 per bbl of crude.

The success of this project was due to a positive partnership between PetroChina and KBC and the active participation by the PetroChina management and operating staffs in every step of the Profit Improvement Program.

Refinery and Petrochemical Asset Evaluations

Europe

N M Rothschild and Sons appointed KBC to perform a preliminary due diligence study on the potential purchase of downstream assets. It involved generating ten-year cash flow forecasts for EBITDA and capital costs for two European refineries and their associated retail, wholesale, and LPG businesses. Net Present Values were calculated and the gross margin risk was highlighted by generating two crude and product price scenarios. Refinery unit yield modeling was based on KBC's proprietary simulation model and price forecasts reflected our latest views on world oil supply and

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COMPLETED PROJECTS

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demand. Capital cost forecasts were based *inter alia* on the need to accommodate tighter product quality specifications. A special feature of this analysis included steps needed to maximize synergies with an adjacent petrochemical plant. Potential upgrading investments for residue and naphtha streams were also critiqued.

Another due diligence project with Rothschild involved the evaluation of a potential sale of specific chemical assets of the Jose de Mello group in Portugal. The fertilizer and industrial chemical businesses were modeled by sector, and a contribution was forecasted for each sector and EBITDA for each business. This involved price forecasting of the key streams, such as ammonia, caustic soda, and benzene. The study revealed the most critical exposures to international market price changes. Models were left with the client for further planning work.

Both of these contracts enabled Rothschild to advise a commercial strategy to its clients. The government was also apprised of KBC's work.

Identified 51 Energy Projects Valued at $US 34M/YR in Savings

North American

KBC Energy Services consultants recently performed an Energy Project Identification program for a North American 290KBPD hydrocracking refinery. The outcome of the program identified 51 defined projects with energy savings of $US 34M per year ($US 0.27 per bbl), as well as some associated yield benefits through process debottlenecking.

The program combined KBC Energy Services' leading-edge pinch analysis software, SuperTarget, along with strong operations experience to produce a variety of practical projects in a short eleven-week period. The program commenced with a site visit to review the current process operation, data collection, and a review of the utility system to identify the marginal mechanisms and key constraints. Heat & mass balances were completed for each of the process units using KBC's simulation software, Petro-SIM. The completed heat & mass balances were used as the starting point for the pinch analysis software. SuperTarget is a powerful tool that can easily and quickly identify the minimum heating and cooling requirements for any process unit. Once the minimum targets have been defined, projects can be identified using a combination of process expertise and pinch techniques.

The types of projects identified ranged from using low-level heat to preheat deaerator feed water; switching steam pressure levels for column reboilers; generating additional steam and improving preheat train recovery; and hence, reducing furnace firing. At the end of the eleven-week program a review was taken of the 51 identified projects of which 21 were rejected due to unacceptable economic returns. These are summarized in the table below:

Projects	No of Projects	MUS $/year	MBTU/h
High Potential	8	10.8	292
Medium to High Potential	3	3.1	76
Medium Potential	15	7.8	354
Low Potential	4	0.6	14
Rejected	21	11.8	337
Total	**51**	**34.1**	**1073**

KBC is now working with the refinery to produce the project definition documentation of the selected projects.

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Lead Story: ULSD Problems and Solutions

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