FEATURE: Identify Hydrotreating Process Variables

ART Engineers Elaborate on Innovations & Operational Issues Affecting Hydrotreater Performance

The recent Grace Davison and Advanced Refining Technologies (ART) FCC/Hydrotreating Symposium in Houston provided a forum for in-depth discussions of important developments and operational issues affecting FCCUs and hydrotreaters.

The need to provide technically advanced solutions and cost effective options when refining margin pressures are high is why this organization invested over $70 million in R&D in 2009 for refining catalyst and related technical support. These include FCC catalysts, as well as hydroprocessing catalyst systems developed through ART (Advanced Refining Technologies), a joint venture with Chevron Products Company. Through ART, a comprehensive line of catalysts are supplied for distillate hydrotreating, fixed bed and ebullating bed resid hydrprocessing applications as illustrated in the accompanying figure shown on page 2.

There have been quite a lot of recent changes in the $4.4 trillion global energy and refining industry segment affecting processing and operations. Many of today's refineries require unit-specific technical solutions that in many cases directly affect hydrotreating profitability and efficiency. Against this backdrop of operational concerns, ART engineers started off the hydrotreating session of the symposium with a detailed overview of key process variables affecting hydrotreating operations, including:

- Weighted average bed temperature (WABT)
- Liquid hourly space velocity (LHSV)
- Hydrogen
- H2S effects
- Feed effects
- Determination of H2 consumption and heat release
- Pressure drop.

Importance of Temperature

Achievement of a higher WABT will result in higher removal of sulfur and nitrogen via hydrodesulfurization (HDS) and hydrodenitrification (HDN) conversion, respectively. Higher WABT will also result in higher aromatic or poly-nuclear aromatic (PNA) saturation until the thermodynamic limit is reached.

Hydrotreating reactions are exothermic, making certain temperatures important to specific reactions, which is why a weighted average temperature for each reactor is calculated as follows:

$$WABT = \sum_{x=i}^{n} x_i \left(T_{INi} + \tfrac{2}{3}[\Delta T_i]\right) - EIT$$

Where:
WABT = weighted average bed temperature
x_i = fraction of catalyst in a given bed (i) or reactor
EIT = equivalent isothermal temperature.

WABT determines the level of sulfur and nitrogen removal for HDS and HDN reactions, while the outlet temperature determines the conversion for aromatic or PNA saturation. The inlet temperature (T_{IN}) is the control variable, but is not very meaningful when discussing catalyst activity due to the exothermic nature of hydroprocessing reactions, while ΔT is an indication of a given feed's reactivity (at given conditions) on a given catalyst. However, this is not a good way to compare catalysts, unless the feed and conditions are identical.
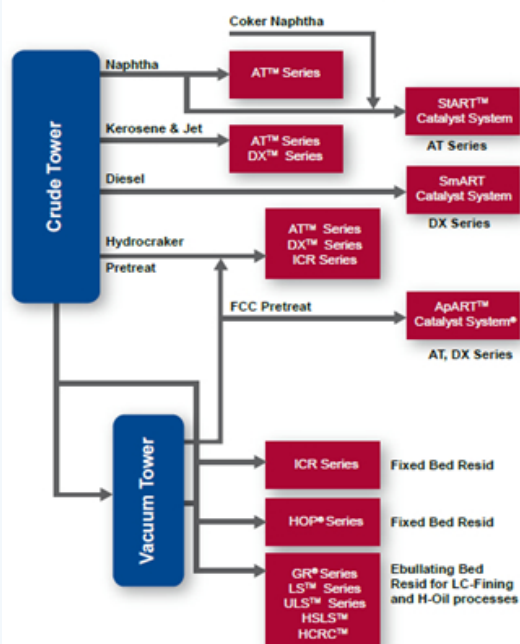
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ART Product Portfolio

ART supplies a comprehensive line of catalysts for distillate hydrotreating, fixed bed and ebullating bed resid hydroprocessing applications

Hydrotreating catalysts for

Naphtha treating

Jet and Diesel desulfurization

Hydrocracker and FCC pretreatment

ART Catalyst Systems for Distillate Hydrotreating

SmART: **S**ulfur **m**inimization by **ART**

Efficient use of hydrogen for ULSD

ApART: **A**dvanced **p**retreat by **ART**

Improve FCC economics

StART: **S**ilicon **t**olerance by **ART**

Treating of Si-contaminated coker stocks

Resid catalysts for

Fixed bed and up flow Online Catalyst Replacement (OCR) systems

Ebullating bed for H-Oil and LC-Fining processes

Grace Davison Refining Technologies 2010 Houston Seminar

As reactor WABT increases, product sulfur decreases. For example, when processing a 1.1 wt% sulfur LCO blend at 1.0 LHSV (where LHSV = volumetric charge rate/catalyst volume) at 1000 psig and 2100 scfb H2/Oil, product sulfur drops to approximately 50 ppm at WABT of 629°F, and drops down to approximately 5 ppm sulfur at a WABT of 670°F.

As a rough approximation, 1/LHSV is approximately equal to the residence time. Higher feed rates correspond to higher LHSVs and higher product production rates, but require higher WABTs to maintain product specifications. As residence time is reduced (i.e., higher LHSV as per 1/LHSV approximation), the required temperature required to maintain the same product sulfur is also increased.

However, higher WABTs come with costs. This is because higher temperatures reduce run length ($T_{EOR} - T_{SOR}$) and increase coking (fouling). The net result is that higher LHSVs result in shorter cycle lengths. As a "rule of thumb," fouling rate is proportional to $(LHSV)^{2-3}$.

In estimating EOR, determination of end-of-run (EOR) is highly dependent on the process feedstock. For example, for naphtha hydrotreating, mercaptan recombination, catalyst poisoning (e.g., silicon [Si], arsenic [As], etc.) and pressure drop determine EOR. Catalyst poisoning (e.g., nickel [Ni], vanadium [V], Iron [Fe] and As), yield losses, furnace and metallurgical limits determine EOR when hydrotreating VGO.

Importance of hydrogen partial pressure

Hydrogen partial pressure (H2PP) plays a significant role in hydroprocessing operations. As a rule-of-thumb, catalyst deactivation rate is proportional to the reciprocal of the hydrogen partial pressure factored by an exponential ranging from 2 to 3:

Catalyst deactivation rate α $(1/H2PP)^{2-3}$

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The H2PP has a large impact on fouling rate, aromatics and PNA saturation (i.e., large effect on product properties related to aromatics like product density, diesel, color and cetane). H2PP also has a significant impact on required WABT for HDN and a moderate impact on required WABT for HDS (but large in ULSD). H2PP is determined by:

- Reactor design pressure
- Make-up hydrogen purity
- Recycle gas rate and purity (important for H2PP at the reactor outlet)
- Bleed or purge rate
- Hydrogen consumption
- Degree of feed vaporization.

The effect of H2PP on HDS and HDN in VGO service was discussed in detail and graphically illustrated by ART experts, as well as H2PP on HDS in ULSD service. A 20°F improvement in HDS is observed with increased H2PP when processing 19.6 API gravity and 1.81 wt% sulfur feed at 1.0 LHSV and 2500 scfb H2/oil reactor conditions. However, a loss of 20°F could occur if the unit operation is allowed to change with less or lower quality hydrogen or lower separator pressures. In addition, a 70°F improvement in HDN is observed with increased H2PP. However, a loss of 70°F could occur if the unit operation is allowed to change with less or lower quality hydrogen or lower separator pressures. It is important to note that for improved HDS in ULSD service, the required WABT delta declines with increasing H2PP. For example, with a 33.0 °API feedstock and 1.66 wt% sulfur, the required WABT delta approaches 0 at 800 psig H2PP (0.75 LHSV, 3000 scfb H2/oil).

The effects of increasing gas-to-oil ratio (scfb H2/oil) raises H2PP, reduces reactor outlet H2S concentration, increases unit activity and stability and increases reactor pressure drop (ΔP). The following gas rate definitions include H2 availability:

Total treat gas rate = Make-up gas rate + Recycle gas rate - ½ Quench gas rate.

Hydrogen gas rate = (Recycle gas - ½ Quench) × (mol% H2 + make-up gas × mol% H2).

H2/Oil = Hydrogen gas rate/Barrels of oil (all in same units, hour or day).

H2 availability = (H2/Oil) / (Chemical H2 Consumption).

Minimum H2 availability recommendations include:
- ≥ 3.0 for straight-run
- ≥ 4.0 for cracked stocks
- ≥ 5.0 for straight-run (ULSD hydrotreating)
- ≥ 6.0 for cracked stocks (ULSD hydrotreating).

Impact of cracked stocks

Cracked stocks are typically more difficult to hydrotreat and require higher WABT compared to straight-run (SR) material at similar product targets. Coker distillates and gas oils have higher sulfur, nitrogen and olefins (Bromine number) with a higher heat release from olefin saturation and higher feed sulfur. Their aromatic content is similar to SR. However, FCC LCO has a higher total aromatics and PNA content (i.e., much lower °API vs. SR or coker) and more olefins that SR, but less than coker material. FCC LCO also has a higher heat release due to high levels of olefin and PNA saturation. FCC LCO also has a significant impact on reactor WABT. For example, an increase in %LCO from 20 to 40 corresponds to a required temperature increase from 50°F to 90°F, respectively. A summary of the process variable effects are summarized in Table 1 on page 4.

As the feed end-point (EP) or final boiling (FBP) increases, this results in an increase in sulfur, nitrogen, % hard sulfur species, aromatics and PNAs. Directionally, this increases feed difficulty, which must be compensated for by increasing reactor temperature.

Causes of pressure drop

There are a variety of reasons for pressure drop in hydrotreaters, including feed quality, void fraction in the catalyst bed, liquid and vapor properties (i.e., density and viscosity) at reaction conditions, vapor and liquid superficial velocities, coke buildup and reactor internal problems.

In terms of feed quality affecting pressure drop, this is based on the amount and variety of particulates and contaminants in the feed. They can include iron sulfide, rust/scales, salts, coke fines, FCC catalyst fines and phosphorous. Poor equipment and line clean-up can further exacerbate problems from these particulates. Iron naphthenate formed from corrosion due naphthenic acids can cause iron to precipitate when heated and/or reacted with H2S. Other contaminant problems can include carbon and stainless steel sulfides from piping and furnace/exchanger tubes loosened during shutdown. Cracked stocks can form oxidation polymers when exposed to air. These deposit on the catalyst bed. In addition, diolefins/olefins can polymerize forming a gum on the catalyst bed.

Void fraction in the catalyst bed depends on catalyst size (diameter and length), catalyst shape and loading method (sock vs. dense method) and handling. The catalyst or support material breaks up during loading or operation. Careless handling and loading and rapid heating of "wet" catalyst can also increase catalyst bed void fraction.

Pressure drop problems also develop due to coke buildup result from excessive

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Table 1. Process variable effects on catalyst life.

An Increase in the Following Conditions (e.g., WABT) will Cause Product S, N or Aromatics to increase or decrease, depending on the Specific Condition

Specific Condition (other conditions constant)	Sulfur	Nitrogen	Aromatics	Catalyst life will ↑ or ↓, depending on specific condition
% Cracked Feeds	↑	↑	↑	↓
WABT	↓	↓	↓	↓
Feed Rate (LHSV)	↑	↑	↑	↓
Hydrogen Pressure	↓	↓	↓	↑
%H2S in Treat Gas	↑	↑	↑	↓

temperatures during operations or upsets that can cause coke lay down between (and on) catalyst pellets, as well as from heavy ends carry-over in feed.

Pressure drop from reactor internal problems may be traced back to torn support screens allowing catalyst into internals and plugging of support screens by corrosion products or fines. Plugging of the reactor outlet collector can be another reason for pressure drop.

Pressure drop buildup can be mitigated by feed filtration to remove particulates (at least 25 microns). It is important to ensure internals are assembled properly and remain clean during loading. Exposure of feedstocks (especially cracked stocks) to air in tankage should be minimized. Size-graded catalyst loading should be used for the top bed.

General Rules of Thumb Concerning Hydrotreater Reactors
- Hydrogen Consumption:
  - Each increase in Cetane number (1.0) leads to approximately 100 scfb H2 consumption in diesel
- Unless the feed is very high in sulfur, most H2 consumption comes from either PNA saturation or olefins
- Removal of contaminants (Si, Fe, Na, Ni, V, etc.) that deposits at 1.0 LHSV for one year will deposit on average across all the catalyst, about 1.0% of the catalyst weight. In addition, the top of the catalyst bed can easily collect 3-to-5 times the average for more reactive deposited materials and lead to plugging
- Most efficient systems exhibit SOR ΔPs of 0.5 to 1.0 psi/ft of catalyst bed in trickle flow. Good gas-liquid distribution is a must, and top bed size, void fraction and activity grading is a requirement.

Note: *Refinery Operations* extends its appreciation to the Grace Davison/ART organization for providing this beneficial information for the refining industry. ∎

GRACE Davison

ART Advanced Refining Technologies

PROCESS OPERATIONS

Realistic Propylene Production Objectives

High severity fluid catalytic cracking for the conversion of heavy oils into light products and olefins, especially propylene, is resulting in one unit in Asia producing at least 16 wt% propylene on a consistent basis.

Propylene prices leapt higher in Asia in early September. Gains were triggered by a visible lift in downstream polypropylene (PP) buying sentiments coupled with supply worries on account of recent plant outages. This is partially because an explosion at the propylene pipeline of China's Nanjing Jin-gling has given cause for concern to many in the markets. Exacerbating these fears are reports that the recent power outage at the Daesan cracker of Samsung Total will result in a loss of about 10,000 mt of propylene. As a result of these triggers, propylene prices bolstered up in early September with FOB Korea prices assessed up at the USD 1085/mt levels.

In India meanwhile, petrochemical major Reliance Industries Ltd (RIL) recently announced an increase in PP prices of Re 1/kg basic. The increase was in

>> Realistic Cont.

keeping with gains recorded recently in PP prices in the rest of Asia coupled with improved demand and firmer upstream propylene rates.

While several major licensors of FCC-based propylene technology have verified propylene yields of 25 wt%, such as with a paraffinic VGO feedstock, a more realistic target is closer to 19.5 wt% at reduced dry gas production.

In addition to the high cracking temperatures seen in propylene producing FCC units, increasing propylene production typically requires a dedicated FCC catalyst formulation and ZSM-5 based additives.

The higher severity cracking temperatures increases thermal cracking for the formation of lighter products. However, depending on riser residence times, thermal cracking leads to undesirable secondary reactions such as hydrogen-transfer reactions, which consume olefins.

A few refiners are obtaining more than 9 wt% propylene using ZSM-5 based additives added to conventional cracking catalyst to increase LPG olefins by cracking C6+ gasoline olefins to smaller olefins, such as propylene. Of course, higher wt% propylene yields depend on the paraffinic content of feedstock as opposed to those refiners needing to process higher volumes of resid-type feedstock.

Hydrotreated FCC feeds also tend to produce higher percentages of propylene. Changes in process strategy, such as recycling a certain percentage of FCC naphtha through a separate riser, or through feed injectors located below the gas oil injection zone where it may be cracked at higher temperature and catalyst-to-oil ratio increased propylene yield. According to one independent FCC consultant, Warren Letzsch, "several FCC units currently in operation are employing the proprietary Shaw DCC technology. One of these units in Asia is consistently producing 16 to 19 wt% propylene." ∎

Maximizing Visbreaker Conversion

Increasing visbreaker cracking temperature maximizes conversion of atmospheric or vacuum resid to valuable distillate. However, fouling in the furnace and downstream equipment limits conversion, in addition to the instability with produced heavy fuel (tar). The chemical treatment programs that have been developed in the industry to deal with this problem typically include unique monitoring tools.

The asphaltenes and coke formed from the thermal cracking of resid streams precipitate in several different areas of the unit that reduce run length and heat transfer efficiency. However, chemical treatment programs to control fouling rate and improve tar stability have improved with the use of monitoring systems.

According to technical literature available from GE Infrastructure Water & Process Technologies, their proprietary Visbreaker Fouling Monitor (VFM) device is capable of quantifying changes in feedstock and visbroken tar quality that impact the fouling tendency in the unit and can give a very early warning when the operating conditions would lead to off-spec heavy fuel due to instability.[1]

1. Vanhove, Andre and D. Owen, "Visbreaker Fouling Control & Maximizing Conversion: V-STAR Program," GE Infrastrucutre Water & Process Technologies. ∎

Adding Value to Regenerator Flue Gas

Power recovery trains (PRTs) downstream from the FCCU regenerator are currently being considered for refineries with FCCUs operating at 40,000 bpd or higher. Additional investment in particulate emissions reduction systems is imperative for those FCCUs operating with a PRT downstream from the regenerator. Protection of the PRT's turbine blades from erosive particulate matter is becoming more cost-effective.

While many PRTs are employed to power the unit's main air blower (MAB) and provide steam, a few PRTs have been designed to support refinery cogeneration objectives. In any event, the emergence of lower cost alternatives to expensive particulate removal technologies, such as wet gas scrubbers (WGS) and electrostatic precipitators (ESPs), may increase the expansion of PRT capacity. ∎

Increasing Hydrogen Production Options

Producing hydrogen from the lowest cost feedstock for hydrogen units originally designed to run on feedstocks such as natural gas can have a significant impact on refinery operations once the decision is made to use lower cost feedstocks. For example, switching to a lower sulfur naphtha will impact crude unit operations as operators would be compelled to run sweeter crudes at reduced rates in order to produce naphtha to hydrogen plant specifications.

As many hydrogen units contain "add-on" process systems upstream and downstream from the steam reformer, any changes to the hydrogen plant feedstock must therefore be given serious consideration. For example, a pre-reformer may have been added upstream from the steam reformer to increase feedstock diversity and a

post-reformer system may have also been added at a later date to increase hydrogen production capacity.

Depending on the complexity of the hydrogen plant (e.g., vaporizing and pre-heat section, HDS unit, pre-reformer, reformer, PSA unit, etc.), a lot of parameters need to be taken into consideration including metallurgy, catalyst, DCS and operating procedures, etc. ■

INDUSTRY NEWS

Energy Efficiency Imperatives

Long-term trends in oil prices and feedstock quality are giving refiners even greater incentives to reduce energy usage. For one, the processing of more refractory feedstock compels most refining facilities to find ways to increase hydrogen production as hydrotreating and hydrocracking severity generally increases. In the medium-to-long term, competitiveness of refineries will depend on their abilities to be prudent in managing their costs while complying with environmental regulations. Furthermore, the EU Climate and Energy package compels plants to achieve a 20% reduction of energy use by 2020. Similar energy efficiency imperatives are also seen in North America.

At the upcoming ERTC Energy Efficiency Conference in Amsterdam (October 19), various ways plants can achieve higher profitability through better energy management will be explored. According to the www.gtforum.com outlining the scope of the conference, some of the issues that will be covered at the conference include:
- Integration of clean energy and refining
- How to plan for most efficient plant cycles
- In-depth analysis on how much energy plants use
- Power, steam and fuel system optimization
- Technical issues in energy conservation within refinery processing
- Technologies that aid energy efficiency for capex and non-capex projects
- What are the constraints and how do they vary by location, refinery configuration and product demand profile?

Many of the current Best Practices energy efficiency programs target a facility's, thermal and fractionation systems. For example, normal refinery operation allows significant quantities of light hydrocarbons to enter the refinery fuel gas system. These hydrocarbons can reduce operating efficiencies for fired heaters and boilers by increasing plugging and fouling of the gas burner tips. It is possible, however, to recover the hydrocarbons from the fuel gas system. Related to this, one North American refiner used process simulation models of its light ends distillation columns and associated reboilers and condensers to predict the performance of potential equipment configuration changes and process modifications. ■

Butane Used as Petrochemical Feedstock

Spot prices for delivered cargoes of North Sea butane have started to strengthen recently on the back of increased demand, according to industry sources. Throughout this summer, North Sea butane has been sold as a petrochemical feedstock substitute for naphtha. CIF prices for North Sea cargoes of mixed butane are usually at a discount to the CIF naphtha price, but in early July a combination of tight availability and healthy buying interest pushed spot butane prices up to parity with naphtha, based on Platts data. This is due in part because butane is also widely used as a refinery feedstock (e.g., alkylate production).

Butane demand, particularly from the petrochemical sector, then began to weaken with the CIF naphtha/mixed butane price ratio dipping down to less than 94% at the beginning of September. However, some traders say they expect to see increased demand in certain regions going into the fourth quarter of 2010. ■

Global Hydrocracking Capacity Approaching 6.0 Million bpd

Close to 100 hydrocracking units are currently in operation throughout the world at a total capacity of 5.0 million bpd with close to 40% of those units currently operating in Asia. Total hydrocracking capacity is expected to exceed 6.0 million bpd by 2015. However, this projected capacity could be higher if efforts to increase hydrogen availability in refinery operations become more economical and CAPEX becomes more available. For example, Egyptian Refining Company's planned 80,000 bpd refinery facility near Cairo has been on hold as financing is put together. Although this planned facility is small by global standards, it will include a vacuum resid hydrocracker employing the latest

>> Capacity Cont.

technology from Axens.

Closer integration of hydrocracking, hydrotreating and FCC operations could also lead to demand for additional hydrocracking capacity. Changes in market conditions could also drive up hydrocracking demand such as with higher diesel production in the gasoline centric North American market and low sulfur specifications legislated for certain heavy distillates and fuels such as heating oil.

However, because of the previously noted high CAPEX requirement for new hydrocrackers, especially the higher pressure hydrocrackers (i.e., increased demand for saturating PNAs, etc.) , most hydrocracking capacity over the next few years will involve improvements to existing units with the addition of reactor beds, or entirely new reactors designed with better heat integration and quench capabilities, distributors and control systems. ∎

Operating FCCUs at Reduced Throughput

Record breaking attendance at the NPRA Cat Cracking Conference held in Houston at the end of August reflected the profitability and compliance concerns by many refiners operating in a margins leveraged market.

A primary focus for many of the delegates concerned running an FCCU at throughput significantly below design for prolonged periods. As mentioned in one of the conference presentations by Shaw's Eric Henning and FCC consultant Ken Pecatiello, "prolonged periods of operation at lower throughput affects safety, reliability, environmental concerns and operations in general."

Targeted reductions in NOx, SOx and particulate matter in full burn and partial burn units are being achieved with catalyst and additive systems along with mechanical improvements to feed injectors, reactor and regenerator cyclones. ∎

Improving Amine Unit Reliability

Many refinery amine systems and sulfur plants are pushing the envelope processing increased acid gas loads from low sulfur fuel production. In this effort, filtration and separation technology to remove particulate and liquid contaminants from entering the amine circuits will improve unit reliability. With these increased sulfur loads, corrosion products, liquid hydrocarbons and organic acid are making their way into amine units.

According to industry "rules-of-thumb," total suspended solids in an amine circuit should be

kept below 1 ppmw, and liquid hydrocarbons and organic acids must be reduced to near-zero levels. In general, particulate matter found in amine solutions are usually corrosion byproducts.

Field test data from Pall's databases has shown that the particle size distribution (PSD) of suspended solids is generally finer than 20 μm with the majority of particles being found in the sub-10 μm category. This observation has been generally consistent even when total suspended solids have varied from site to site.

In complex refineries where there are multiple contactors, the best option is to deploy central filtration and separation as a means to eliminate free liquid hydrocarbons from the amine. High performance liquid/liquid coalescers can break the stable, rich-amine/hydrocarbon emulsion that can have adverse effects on the amine unit and sulfur plant operations, which can impact overall refinery SO2 emissions. ∎

AUTOMATION

Emerson's Neil Peterson Discusses Cyber Security Strategies

The importance of cyber security and strategies for dealing with wireless security threats in process operations has escalated over the past few years and has been discussed at refining industry seminars such as the NPRA. At the most recent NPRA Q&A and Technology Forum, a presentation titled "Cyber Security for Wireless Field and Plant Networks (PD-09-121), wireless network security in process facilities was discussed by Emerson Process Management's Senior Marketing Manager - Wireless, Neil Peterson. The following summary is based on Peterson's discussion on strategies for dealing with wireless security threats.

The main reasons for wireless security failures can be attributed to: human factors, lack of wireless security policy, poor configuration, and lack of understanding about security vulnerabilities and the defenses available to mitigate them. The good news is that secure wireless is not an oxymoron.

To prevent wireless attacks and protect the facility's network, "end-to-end" wireless security is needed to control access to the network. Attacks on a wireless network can take on many different forms, including stolen user's credentials, users connecting to malicious access

points (APs), stolen media access control (MAC) addresses, virus or worm infections from mobile devices, service disruption and eavesdropping. These security gaps can lead to operational problems and leakage of confidential information.

To address these security gaps, users must: 1. Control access to the network, 2. Protect the network, and 3. Ensure client integrity. To control access to the network, the 802.1x Extensible Authentication Protocol (EAP) protocol can be used to identify the individual (authentication), determine what the individual is allowed to do (authorization). Additionally one must monitor what the individual did in the plant and when he/she did it (accounting). More importantly, this form of accounting monitors attempts by unauthorized users to gain access to the network and legitimate users attempting to perform unauthorized actions. If you aren't monitoring your network, you may already have intruders.

Effective end-to-end network protection requires a wireless control system (WCS) to automatically manage and encrypt communications within the mesh AP network, a network firewall to ensure communications are properly limited to the wired network, as well as a wireless intrusion prevention system (wIPS) to monitor the wireless airwaves for hackers.

For example, the wIPS monitors the wireless network and RF signals in the "open air," and detects suspicious APs. The WCS ensures that only authenticated APs participate in the mesh network and prevent eavesdropping on communications. Anti-virus software installed on client devices that connect to the network ensure that (regardless of where the handhelds have been) no viruses can bypass the typical peripheral defenses and attack the network.

Above all, encrypted communications in a reliable wireless process plant means that data integrity can be assured when it is transferred from a trusted source to a trusted recipient without an unintended party being able to intercept or change the data.

More detailed elaboration on the end-to-end wireless security architecture is discussed in NPRA paper PD-09-121, including: verification; encryption (e.g., rotating of encryption keys); anti-jamming and coexistence (e.g., prevention of jamming between device and gateway); and WirelessHART field device communications including gateway-to-host security.

It is the integration of all these security components that will protect and control access to the network and ensure integrity of the wireless process facility, thereby avoiding operational problems and leakage of confidential information. ∎

Hydrocracker Optimization

In hydrocracker optimization projects commissioned since the fourth quarter of 2008, benefits are expected to be about $0.30 per barrel of hydrocracker feed when an optimizer is implemented along with proper multivariable advanced control.

With over 100 hydrocracking units throughout the world producing over 4.5 million bpd of product, hydrocracking capacity is expected to continue expanding due to the need to process relatively high refractory feedstocks that resist catalytic cracking , such as with the more aromatic cycle oils and coker distillates.

The hydrocracking process is often carried out in multiple stages at hydrogen partial pressures ranging from approximately 35-100 bar. For the purpose of mitigating CAPEX requirements, it is preferable to design a one reactor unit with multiple beds, each with its own specially formulated catalysts (e.g., demtallization/denitrification/desulfurization beds followed by additional beds of hydrocracking catalysts).

The feedstocks processed in today's refineries contain a wide spread of feed components in measurable quantities. Each of these components reacts in a complicated reaction pathway leading to a very large network of reactions. In kinetic modeling, the actual reaction network is reduced to a small number of reactions among a smaller number of lumped species. The lumps are normally defined based on the boiling point description.

It is almost impossible to characterize the chemical species present in the lumps. Therefore, since the composition of the lump is not rigorously defined, it is possible to have many different possible components with the same boiling point representation. Also, as the number of lumps increase, the number of rate parameters also increase. Thus, making the parameter estimation problem more difficult from a computing perspective.

In contrast to this traditional approach, the novel concept called Single Event Kinetics (SEK) has been developed to model the hydrocracking kinetics. The single event concept was originally developed by Froment and co-workers (Vynckier and Froment, 1991). The essential features of this approach are:

1. Single event kinetics considers individual molecules
2. Full details of the reaction pathways are retained
3. Reaction network is generated in terms of fundamental elementary reactions

>> **Hydrocracker Cont.**

4. Rate parameters are invariant with respect to the feed composition and they are tractable (<30) in number.

The first step in developing a hydrocracker model is to understand the carbenium ion chemistry, which forms the backbone of the hydrocracking kinetics. The elementary steps are generated using a computer algorithm. The reaction network generation requires high-speed computers and a considerable amount of computer memory. However, since the elementary step network generation is completed, the SEK concept can be used to identify the independent set of rate coefficients. It is worth noting that unlike other lumping approaches, in the SEK approach, the number of rate parameters does not increase with the number of components or lumps. ∎

EDITORIALLY SPEAKING

The BACT Myth

Rene Gonzalez, Editor,
Refinery Operations

Under the leadership of Obama's EPA chief, Lisa Jackson, the EPA is preparing to issue guidance this fall to refiners and power plants on what is known as "best available control technology" (BACT) to limit greenhouse gas (GHG) emissions that the anthropogenic global warming crowd claims is harming the environment.

To be sure, the earth is in a period of temperature change for whatever reason. After all, warming trends have also been detected on other planets, such as Mars and Jupiter. However, there are no SUVs, oil refineries or human beings on those planets to cause global warming. Back here on earth though, the EPA and Global Warming Czar, Carol Browner, and other global warming enthusiasts are planning on slapping some BACT on refiners just in case they are the culprits.

After all, early in his Presidency, Obama made it clear that if Congress failed to limit carbon emissions, he would use his authority under the Clean Air Act to control GHGs. For example, rules requiring automakers to boost fuel economy 5% per year and average 35.5 miles per gallon by 2016 take effect January 2, 2011.

Refiners currently undergoing major expansions, of which there are only a few, are caught in the crosshairs of proposed GHG regulations. The EPA stipulates that newly built industrial facilities, or existing ones that undergo "major modification," must use "best available control technology" to reduce their emissions if they are responsible for more than 25,000 tons of GHGs per year.

It is still too early to project what impact BACT requirements will have on refining margins.

The regulations have been undergoing a period of public comment and further agency review before they are final, as Congress debates whether to create a "cap-and-trade" system of exchangeable pollution rights.

The proposed regulation for industry doesn't define "best available" control technology for refineries. Rather, a "case-by-case analysis" will be conducted for newly built and modified facilities because "the best available technology can change over time," EPA Administrator Lisa Jackson told reporters back in October of 2009.

Of course, refiners already have to install BACT for other pollutants, such as "scrubbers" that remove the sulfur dioxide that causes acid rain. Going into the fourth quarter of 2010, there is still no cost-effective technology to scrub carbon dioxide from refinery smokestacks, so these EPA requirements may result in more domestic refining capacity going overseas where the environmental standards don't apply. This is because the best way to cut CO_2 emissions from US refineries is to close the facility and instead rely on imports, to the obvious benefit of the tax-subsidized ethanol industry and green energy elites. ∎

CALENDAR OF EVENTS

September
20-21 NPRA Environmental Conference, San Antonio, (202) 457-0480,
www.npra.org.

23-24 Russia & CIS Refining Technology Conference & Exhibition, Moscow, +7 495 517 77 09, +7 495 662 33 87 (fax), Moscow@europetro.com,
www.europetro.com.

October
10-13 NPRA Q&A and Technology Forum, Baltimore, (202) 457-0480,
www.npra.org.

12-13 Central & Eastern European Refining & Petrochemicals, 13th Annual Meeting, Budapest, Hungary, +44 (0) 207 067 1800,
www.wraconferences.com.

19 ERTC Energy Efficiency Conference, Amsterdam, +31 (0) 20 62 34 255; (fax) +31 (0) 20 62 52 997,
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