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DAY THREE | #AFPMSUMMIT

Wednesday, Oct. 16, 2019

# Revamp options for increasing hydrotreater capacity

**ADRIENNE BLUME,** Executive Editor, *Hydrocarbon Processing*

Tuesday morning's Principles & Practices session on Hydroprocessing included a presentation by Simerjeet Singh of Honeywell UOP on revamps for capacity increases in hydrotreaters.

Challenges and drivers for revamps include changes in unit feedstocks (e.g., heavier feeds and changes in refinery feed blends and crude slates) and changes in product slate (e.g., more diesel/less kerosene, less naphtha, or less fuel oil). Changes in product specifications, such as changing markets and the need to meet environmental regulations (e.g., IMO 2020), are another driver. Furthermore, next-generation catalysts/HRI may involve changes in cycle length, a high radial spread, changes in selectivity and reduced unit downtime.

Sometimes equipment reliability is a concern due to higher throughput, or the fractionation constraint results in product downgrade, or catalyst activity is limited by cycle length. UOP Honeywell provides customized solutions for high-level performance of hydrotreaters. Mr. Singh explained how an engineering study can help review unit performance, how equipment solutions can help overcome unit bottlenecks, and how a review of catalyst systems may provide alternative solutions.

Mr. Singh also discussed how frequent (at least one time per week) feedstock changes can result in contaminants getting to the unit, an inability to withdraw distillate or naphtha products, and capacity limitations due to catalysts and fouling. Potential solutions to these problems include conducting an impact assessment on unit performance with different feed blends and increased feed rates, conducting a review of existing unit throughputs and catalyst systems, and compiling ways to maintain or improve unit reliability.

When unit capacity is limited due to catalyst deactivation or HPNA buildup, an HPNA management system can be considered. Next-generation catalyst systems can improve conversion of fuel oil to naphtha or distillate. Also, operators should conduct reviews of optimum conversion levels and options for unconverted oil routing.

The replacement of reactors and/or reactor internals may also help optimize operation and increase efficiency, Mr. Singh explained. With respect to the aging of a reactor, processing objectives can be revisited to increase unit feed rates. A spare reactor can be used, or a new reactor can be designed. Reactor internals can be changed to improve flow distribution and increase catalyst volume.

**SIMERJEET SINGH,** Honeywell UOP.

Operators should also check whether the existing/new reactor design is sufficient and optimized to meet new processing objectives. Reactor internals should be easy to install and maintain, and occupy less space inside the reactor. Also, recommendations for design and installation can help reduce unit downtime. ●

# Energy majors harness power of advanced computing and online sensors

**ADRIENNE BLUME,** Executive Editor, *Hydrocarbon Processing*

Opening Tuesday morning's OPCAT session, Bradley Houk of ExxonMobil Research & Engineering talked about creating value with open process automation to support digital transformation.

**Advanced computing with open process automation.** Today's widely used industrial control systems support stable, safe operations and provide the basis for advanced process control (APC) and real-time optimization operations. The challenges for current control systems, Mr. Houk explained, include proprietary hardware, interfaces and networks; vendor-controlled software access; security gaps; high costs; and limited access to the latest computing power and application platforms.

**BRADLEY HOUK,** ExxonMobil Research & Engineering Company.

ExxonMobil's proposed vision for the optimization of industrial control systems is to create a standards-based, open, secure and interoperable process control architecture that promotes innovation and value creation. "We need open interfaces that allow interoperability. We don't want closed interfaces and networks anymore," Mr. Houk said.

Other characteristics of this vision include interchangeable hardware for edge devices, best-in-class components for both hardware and software, open access to software, designed-in security rather than bolt-on security, and portable end-user software.

Success in implementing this vision would enable application reuse and continuous innovation, create more value, solve system integration issues, empower the workforce and reduce total cost of ownership. Of these, Mr. Houk cited value creation as the most important.

"Engaging the workforce is a key driver for many companies," Mr. Houk explained. "We cannot retain employees if we put them in an environment with 20-year-old technology. They just won't stay. We're competing with the 'Googles' and the 'Amazons'—the high-end technology companies that are attracting young engineers."

Enablers and drivers for these technology changes include demonstrated success in other industries, continued growth in computing power, greater integration of information technology (IT) and operational technology (OT), lower-cost sensors, the Industrial Internet of Things (IIoT), data analytics and big data, cybersecurity innovations, wireless connections and cloud services.

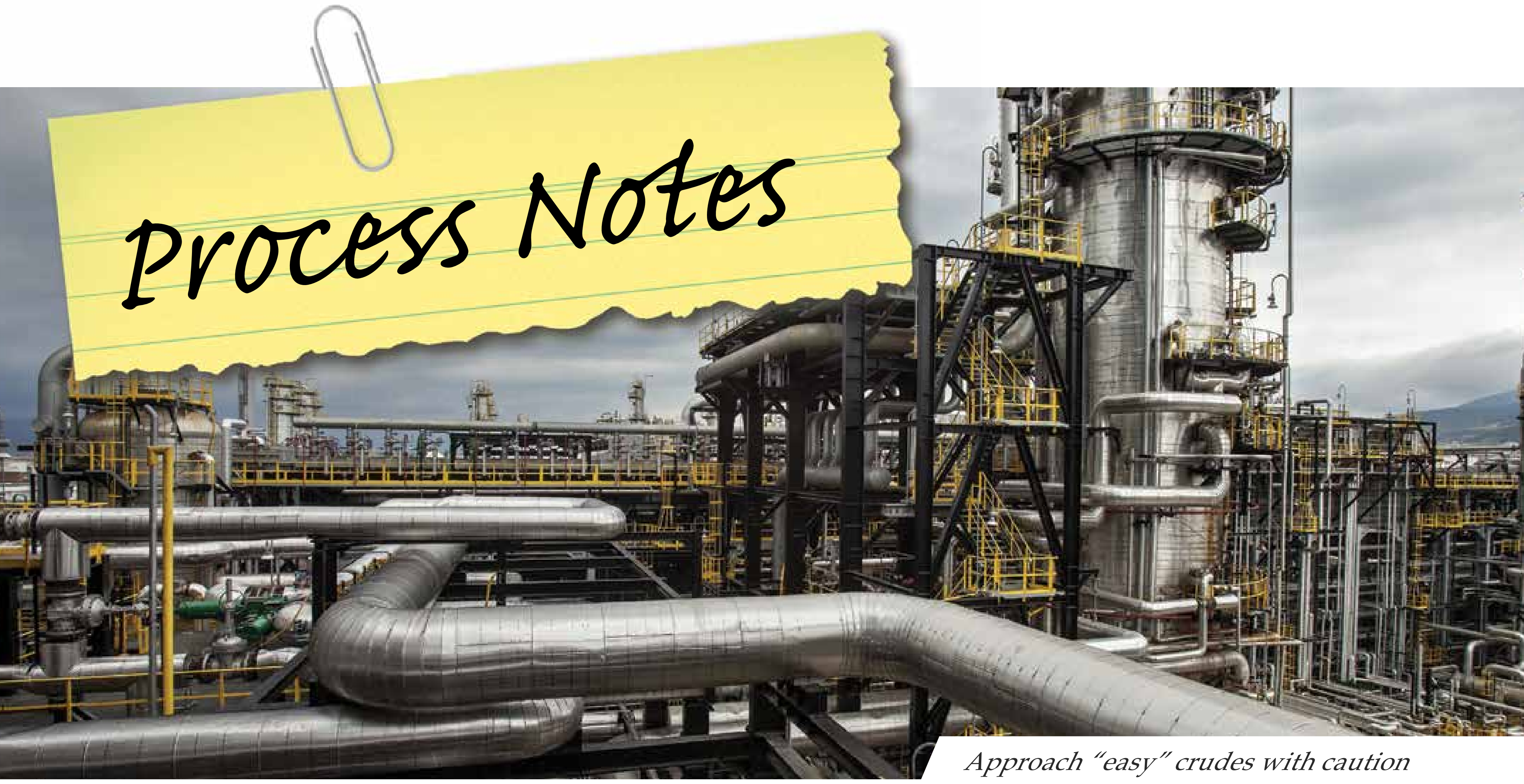
"Any time we can't move on to the next generation of computing power, we're restricting the possibility to derive and add value to our facilities," Mr. Houk said. "Why would we be using ten-year-old technology in our facilities when we don't use them in our cell phones and home computers?"

**Platform structure.** ExxonMobil's Open Process Automation architecture incudes onsite OT data centers, IT data centers at the enterprise level, an external OT data center, and distributed control nodes that encompass I/O processing, regulatory control, logic solvers and application hosting.

The key advantages of this architecture are interchangeable edge devices that can be changed out when needed or desired, as well as the possibility of computing at the edge. It solves the availability and latency problems associated with moving high-end computing to the cloud and back, since the architecture is closely tied into field devices. Improved data access, portable software and high availability are other advantages.

"If we're successful, this will be like running a Level 2 [SIL] device, rather than a Level 3 [SIL] device,"

► See OPCAT, page 3




*Approach "easy" crudes with caution*

# Condensate is Crude

Ultra-light crudes and condensates are here to stay. These streams have flooded the market in recent years, and many of them are deeply discounted against reference crudes. Refiners have been processing increasing percentages of this light material through their Crude Distillation Units (CDUs) up against unit naphtha handling limits. On the surface, processing condensate and other ultra-light crudes with high API gravity and low sulfur should be easy. In reality, many refiners have experienced significant challenges, some of which are unique to ultra-light crudes and condensate.

Although their bulk properties signal that these crudes should be easy to process, new recovery techniques tend to leave undesirable compounds in the crudes that can adversely affect refinery CDUs or Condensate Splitters. Some of the bad actors are:

- High melt point waxes / high paraffin content
- Tramp amines from production $H_2S$ scavengers
- Filterable solids
- Tramp phosphorous compounds

*Severe crude column tray fouling*

These undesirable compounds are the source of operating and reliability problems in CDUs and Condensate Splitters worldwide, and the onset and severity of certain problems can often be traced back to the introduction of new ultra-light crudes and condensates.

These supposedly "easy" crudes have been linked the following problems:

- Fouling in the cold preheat train
- Poor desalter performance
- Fouling in the warm and hot preheat trains
- Crude heater fouling and hot spots
- Accelerated overhead system corrosion
- Salting in the top of the crude column
- Plugging of kerosene section trays and exchangers
- Plugging of stripping trays

Despite the impression that new ultra-light crudes and condensates should all be easy to run, they are not. Condensates and ultra-light crudes are crudes, meaning that many of them can be difficult to process and can present unique refining challenges.

Process Consulting Services, Inc. has experience with these crudes and has addressed all of the problems above through process and equipment design features. Contact us today to maximize profitability and minimize headaches while processing these discounted crudes.

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# The future of real-time monitoring and fault diagnosis

**LEE NICHOLS,** Editor-in-Chief/Associate Publisher, *Hydrocarbon Processing*

The future of processing and equipment failure diagnosis is *now.*

This idea was the subject of a Monday afternoon presentation on cybersecurity and data export for data analytics and machine learning platforms, given by Will Hanlon, Global Marketing Manager—Equipment Sales and Plant Support for Air Products. The presentation focused on Air Products' ProcessMD platform for real-time monitoring and fault diagnosis.

ProcessMD is the next-generation digital platform that applies machine learning to both equipment and industrial gas processes. The Industrial Internet of Things (IIoT) platform began development in 2008 and was first deployed at Air Products' operating plants and assets in 2009—the first being one of Air Products' HyCo (syngas) plants. ProcessMD combines codified knowledge from subject matter expertise, engineering principals and advanced modeling and statistics in a machine learning context to reduce costs, increase margins, improve operating efficiencies and increase the reliability of industrial gas processes. At present, Air Products uses ProcessMD to monitor and maintain more than 400 of the company's industrial gas facilities around the world.

The platform utilizes data-driven, auto-adaptive models to provide users with advance alerts of abnormalities and deviations, based on expected behaviors across an entire plant or individual components. ProcessMD differs from other machine learning platforms by not only recognizing patterns in operations and learning from multiple data sources, but also by diagnosing the root causes of upsets and linking them to solutions in a transparent manner. These actions provide the operations and management teams a concise action plan that can be implemented weeks or months before the upset could occur, thereby preventing a more serious incident that could lead to equipment failure or plant shutdown.

The platform uses adaptive and smart levels based on process models that adjust for variables such as ambient temperature, feed composition, spec power, production rate, etc. The platform uses this data to determine when a key process variable exceeds anticipated variations. Any automated alert is sent to a dedicated team of engineers that diagnose the problem and provide solutions to the site. This data can also be accessed by plant personnel in real time via the cloud.

The platform has provided Air Products with cost avoidance and productivity benefits adding to millions of dollars per year. These benefits include optimizing processes on several of Air Products' steam methane reformers, as well as equipment cost savings—ranging from $10,000–$200,000 per finding—at several of the company's plants. ●

## OPCAT , continued from page 1

Mr. Houk said. "And the advantage is that we'll run it all from one platform."

The four key results of ExxonMobil's proof of concept for its Open Process Architecture were interoperability, interchangeability, configuration portability and application portability. "We demonstrated these four benefits with a heterogeneous system," Mr. Houk said. "Some people thought it wasn't possible."

**Field trials.** ExxonMobil is working on a prototype to demonstrate the Open Process Architecture performance on a small pilot plant. The factory acceptance test is in progress, and site installation is scheduled for November. The platform test will run from December through March.

The test bed will support additional testing to determine the ability to add and remove hardware and software components. It will also reduce the risks of integration of independent components and the security concerns posed by interoperability.

Based on the results and learnings of the test bed runs, ExxonMobil's collaborative partners—Aramco Services Co., BASF, ConocoPhillips, The Dow Chemical Co., Georgia-Pacific, and Linde—will build their own field trials in early 2020, using individually selected system integrators. These field trials will help accelerate the development of the system architecture.

**MARCIO DONNANGELO,** Emerson Automation Solutions

**IIoT optimization of heat exchanger.** Todd Anslinger of Chevron U.S.A. and Marcio Donnangelo of Emerson Automation Solutions next discussed how cloud-based IIoT optimization of a heat exchanger can improve unit performance.

When heat exchangers become fouled, efficiency of temperature transference is lost. In some cases, the heat exchanger becomes so choked that it disables operation. Chevron schedules heat exchanger cleanings every 1–5 years, or during scheduled refinery turnarounds, Mr. Anslinger explained.

Sometimes manual temperature readings are used to run calculations to determine if the heat exchanger is fouled. Gathering these temperature readings requires intensive field installation, recording and analysis. However, a better way exists to monitor temperature and predict fouling. Online monitoring, which Emerson has implemented for Chevron, plots the fouling factor over a timeline.

**Online monitoring.** Mr. Donnangelo discussed how a clamp-on transmitter—Emerson's Rosemount X-well—can be used to gather these online readings from inside the pipe. Thermodynamic sensitivities are installed in the sensor, producing a non-invasive way to accurately measure internal process temperature.

The Rosemount X-well sensor does not require a thermowell, and uses a thermal conductivity algorithm. It requires only three design inputs—pipe diameter, material and thickness—versus the nine design parameters required by other sensors.

**TODD ANSLINGER,** Chevron U.S.A.

Among the requirements for the algorithm, temperatures must be transmitted once per day, the temperature must be accurate within +/– 2°F, and cloud or on-premises calculations must be performed once per day. Added flowrates and wall thicknesses can allow for more accurate predictions and the resolution of targeted heat exchanger issues. ●

## SCHEDULE OF SESSIONS AND SPECIAL EVENTS

### WEDNESDAY, OCTOBER 16, 2019

| | |
|---|---|
| 7:30–10 a.m. | Registration |
| 8–9:30 a.m. | **Concurrent Sessions:**<br>• Principles & Practices: FCC<br>• Principles & Practices: Fostering Profitability |
| 9:30–9:45 a.m. | Coffee Break |
| 9:45–11 a.m. | **Concurrent Sessions cont.** |

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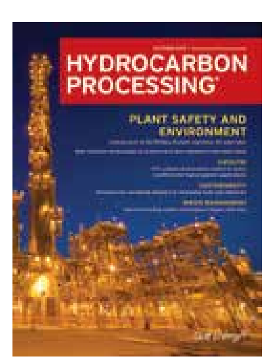

# EIA: Crude oil used by U.S. refineries continues to get lighter in most regions

The API gravity of crude oil input to U.S. refineries has generally increased, or gotten lighter, since 2011 because of changes in domestic production and imports, according to the U.S. Energy Information Administration's Monthly Refinery Report. Regionally, refinery crude slates—or the mix of crude oil grades that a refinery is processing—have become lighter in the East Coast, Gulf Coast, and West Coast regions, and they have become slightly heavier in the Midwest and Rocky Mountain regions.

API gravity is measured as the inverse of the density of a petroleum liquid relative to water. The higher the API gravity, the lower the density of the petroleum liquid, so light oils have high API gravities. Crude oil with an API gravity greater than 38° is generally considered light crude oil; crude oil with an API gravity of 22° or below is considered heavy crude oil.

The crude slate processed in refineries situated along the Gulf Coast has had the largest increase in API gravity, increasing from an average of 30° in 2011 to an average of 32.6° in 2018. The West Coast had the heaviest crude slate in 2018 at 28.2°, and the East Coast had the lightest of the three regions at 34.8°.

Production of increasingly lighter crude oil in the U.S. has contributed to the overall lightening of the crude oil slate for U.S. refiners. The fastest-growing category of domestic production has been crude oil with an API gravity greater than 40°, according to data in the EIA's Monthly Crude Oil and Natural Gas Production Report.

Since 2015, when the EIA began collecting crude oil production data by API gravity, light crude oil production in the Lower 48 states has grown from an annual average of 4.6 MMbpd to 6.4 MMbpd in the first seven months of 2019.

When setting crude oil slates, refiners consider logistical constraints and the cost of transportation, as well as their unique refinery configuration. For example, nearly all (more than 99% in 2018) crude oil imports to the Midwest and the Rocky Mountain regions come from Canada due to geographic proximity and existing pipeline and rail infrastructure.

Crude oil imports from Canada, which consist of mostly heavy crude oil, have increased by 67% since 2011 due to increased Canadian production. Crude oil imports from Canada have accounted for a greater share of refinery inputs in the Midwest and Rocky Mountain regions, leading to heavier refinery crude slates in these regions.

By comparison, crude oil production in Texas tends to be lighter: Texas accounted for half of crude oil production above 40° API in the U.S. in 2018. The share of domestic crude oil in the Gulf Coast refinery crude oil slate increased from 36% in 2011 to 70% in 2018. As a result, the change in the average API gravity of crude oil processed in refineries in the Gulf Coast region was the largest increase among all regions in the U.S. during that period.

East Coast refineries have three ways to receive crude oil shipments, depending on which are more economical: by rail from the Midwest, by coastwise-compliant (Jones Act) tankers from the Gulf Coast, or by importing. From 2011–2018, the share of imported crude oil in the East Coast region decreased from 95% to 81% as the share of domestic crude oil inputs increased. Conversely, the share of imported crude oil at West Coast refineries increased from 46% in 2011 to 51% in 2018. •

## WOOD MACKENZIE CHEMICALS: U.S. PETROCHEMICALS INDUSTRY TO SEE $200 B IN INVESTMENTS

The U.S. petrochemicals industry is experiencing an investment renaissance, Steve Zinger, Wood Mackenzie Chemicals Senior Vice President, said during his appearance at the AFPM 2019 International Petrochemical Conference.

"Since 2010, we have seen more than 300 planned chemical projects linked to shale gas, which some argue will generate almost 500,000 temporary and permanent jobs," said Zinger. "In capital expenditure terms, this equates to more than $200 B, signaling a huge increase in optimism within the industry. Most of these chemical investments have utilized gas-based chemistries and feedstocks, such as methane, ethane, propane and butane."

According to Wood Mackenzie Chemicals, most of these U.S. investments are expected to export to Latin America, Europe, Africa and China. "Initially, most of the U.S. volumes were planned to end up in China, as the country accounts for more than 30% of the consumption of global polyethylene. However, due to the tariffs put in place during 2018's China-U.S. trade war, U.S. producers are expediting their search for higher netbacks and increasingly moving the new resin supply into domestic markets, Europe, Latin America and Africa.

"China's manufacturing industry has experienced growth over the past two decades, and the country has become the largest producer and consumer of most chemicals, including olefins. Going forward, at least for the next decade, China will retain this dominant share of the petrochemicals industry," commented Zinger.

A new wave of refining capacity in China is expected to take place in 2020, driven by several crude-to-chemicals mega-projects. On top of the Hengli and Zhejiang PC projects, at least three other proposed mega-refinery and chemical projects are being planned by private companies in the seven designated chemical bases in China.

According to Wood Mackenzie Chemicals, petrochemical feedstocks accounted for 13% of oil demand in 2018, with this figure expected to rise to almost 20% by 2035. "With the likely longer-term trend of declining oil demand into the all-important transportation sector, energy companies have re-evaluated their chemicals strategies. We are seeing oil players aggressively expand their current chemicals portfolio, form alliances with chemical companies or step into the chemicals space for the first time," added Zinger.

**Plastics initiatives.** As highlighted at the conference, there are growing number of initiatives around plastics recycling and plastic bans. "These could reduce or cause peak petrochemical demand growth in the future, especially considering that a significant number of aromatics and olefins are used within the plastics industry (e.g., paraxylene for PET bottles and ethylene for polyethylene trash bags). These items are targeted for increased levels of recycling and even, in some cases, replacement with non-plastics.

"Plastics producers will ultimately need to make their products more recyclable, support waste collection improvements—particularly in developing countries—and look for ways to become part of, or inject, recycling into their business or production processes," said Zinger.

In its "Q1 2019 Flexible Packaging Global Market Overview," Wood Mackenzie Chemicals highlighted Amazon's decision to move to lightweight, flexible plastic mailers over its traditional cardboard boxes. Should other companies within the industry follow suit, this would signal a departure from a traditionally conservative packaging industry in North America.

"Despite these recycling initiatives and bans, the demand outlook for olefins is very robust due to increasing standards of living in developing countries. In fact, ethylene and propylene have been consistently growing at or above global GDP growth rates. As such, we expect long-term demand growth for olefins to continue to be strong for the foreseeable future."

## JOINT VENTURE: SHELL & AMG RECYCLING B.V.

AMG Advanced Metallurgical Group N.V. and Shell Catalysts & Technologies have signed an agreement to form a joint venture (JV): Shell & AMG Recycling B.V. The JV will provide a long-term sustainable solution for catalyst reclamation and recycling.

Refineries will benefit from the combined technical capabilities and integrated resources by reducing the risk and cost of transporting and disposing of spent catalyst and eliminating the need to landfill. In addition, they will benefit from the monetization of the valuable metals contained in their waste.

The process used by Shell & AMG Recycling B.V. extracts critical materials, including vanadium, in the form of ferrovanadium from spent catalysts. Ferrovanadium is an alloy that increases the strength of steel and is primarily used in infrastructure applications, such as rebar or girders. Through the reclamation of ferrovanadium from spent catalysts, steel manufacturers benefit from a low-$CO_2$ alternative compared to sourcing the vanadium through mining. With the implementation of the IMO 2020 fuel sulfur regulation, significant spent catalyst volume growth is expected. The end-to-end option that will be available to oil refineries will represent an outstanding $CO_2$ reduction opportunity.

## NEW CITGO REFINERY WORX™ APP

Augmented reality brings the refining process to life in the newly launched CITGO Refinery Worx app, introduced by CITGO Petroleum Corp. While designed to teach young people about the refining process and the scores of everyday products derived from it, the app has an even bigger purpose in mind: inspiring students to pursue Science, Technology, Engineering and Math (STEM)-related career paths as part of the Company's STEM Talent Pipeline program.

Refinery Worx not only creates an interactive outlet for students to explore their interest in STEM-related activities, but it also demonstrates the numerous innovative approaches to STEM support.

Working with students and observing how they absorb information was the inspiration for a fresh approach that can be easily shared using a mobile device. Through the app, users can discover how crude oil provides the fundamental ingredients for common household items like toys, cellphones and makeup. As users navigate through the refinery, they can discover how products as diverse as jet fuel and road asphalt come from the same sources.

Although CITGO has worked to provide STEM opportunities for students for years, CITGO Refinery Worx is the first augmented reality app the company has created for students to step inside the refinery processes. The app can be easily downloaded for free to any mobile device or tablet. •

# Enclosed combustion equipment and technology

**ANU D. VIJ,** Ship & Shore Environmental

Selection of an enclosed combustion solution is a complex process that involves various environmental and operational requirements that are unique for each application. Great benefits come from selecting the correct equipment, which translates into decreased capital and operational costs by preventing over-designing or under-designing the equipment. Different technologies offer tradeoffs between initial cost, operating expense and complexity, emissions, fuel efficiency and destruction efficiency. The main categories of enclosed combustion devices are discussed here, and the advantages and tradeoffs are presented to aid in selecting the proper equipment for a particular case.

**Enclosed flares.** The simplest enclosed combustion device is an enclosed flare, which is designed only to hide the flame rather than to increase combustion efficiency or reduce emissions. Enclosed flares provide cooling and combustion air through natural draft. The enclosed flare burner is simple and can be an anti-flashback type, a high-pressure type or a forced-draft type. A forced-draft type of device is used when the process gas tends to produce smoke. It utilizes a blower to provide 20%–40% of the stoichiometric air to the fuel gas near the burner tip. Enclosed flares typically operate at around 98% destruction efficiency.

**Thermal oxidizers.** To reach higher levels of destruction efficiency and lower emissions, thermal oxidizers employ a wide variety of designs, but can be generally split into three main categories: direct-fired thermal oxidizers, regenerative thermal oxidizers and catalytic thermal oxidizers. The main difference between a thermal oxidizer system and a combustor is that a thermal oxidizer does not rely on directly igniting the process gas for oxidation.

**FIG. 1.** To reach higher levels of destruction efficiency and lower emissions, a direct-fired thermal oxidizer uses a burner to heat the chamber to proper oxidation temperatures.

**FIG. 2.** A regenerative thermal oxidizer employs ceramic media to capture heat from oxidation to reach thermal efficiencies of up to 98%.

A direct-fired thermal oxidizer (**FIG. 1**) uses a burner to heat the chamber to proper oxidation temperatures for the required destruction efficiency. The chamber must be designed to maintain an adequate residence time and provide sufficient velocity for turbulent mixing. If the process gas has sufficient heat content, it can be used as the fuel gas for the burner. Otherwise, supplemental fuel is required to maintain the combustion temperature.

A recuperative thermal oxidizer is a variation of a direct thermal oxidizer that incorporates heat recovery into the design. Heat recovery may be achieved through a heat exchanger on a hot oil heater, boiler or steam superheater, or may be used to preheat the process gas to increase fuel efficiency. Direct-fired thermal oxidizers offer high destruction efficiencies of up to 99.99% and can provide lower nitrogen oxide ($NO_x$) and carbon monoxide (CO) emissions.

A regenerative thermal oxidizer, shown in **FIG. 2,** operates on slightly different principles. This type of system is used for applications where the combustible concentration is below 3% of the lower explosivity limit. A regenerative thermal oxidizer employs ceramic media to capture heat from oxidation to reach thermal efficiencies of up to 98%. Thermal energy is retained by the ceramic media and is then used to heat and oxidize the process gas as it enters the thermal oxidizer. To accomplish this, the system uses multiple beds and alternates the inlet and outlet of the oxidation chamber. A two-bed system would cycle approximately every 2 min., allowing heat to be captured by the ceramic media on the outlet and heating the process gas from residual heat in the inlet bed. Once the system cycles, the direction of flow is reversed, allowing the temperature to be regenerated on the beds.

Selection of an enclosed combustion solution is a complex process that involves various environmental and operational requirements that are unique for each application. Selecting the correct equipment translates into decreased capital and operational costs by preventing over-designing or under-designing the equipment.

**Selection guidance.** When selecting a combustion system, emissions and destruction efficiency have become the primary criteria. Across the industry, there are pressures and economic incentives to reduce $NO_x$ and CO emissions, as well as emissions of volatile organic compounds (VOCs). With this in mind, the first step should be to determine what local emissions guidelines apply to the specific device, and to evaluate the benefits in reducing emissions. Several cutoff points exist. A simple enclosed combustor will achieve approximately 98% destruction efficiency. This can be achieved by almost any diffuse flame burner without additional effort. Up to 99.5% destruction efficiency can be achieved with a temperature-controlled combustor, a regenerative thermal oxidizer or a catalytic thermal oxidizer.

**$NO_x$ emissions.** $NO_x$ emissions have traditionally been especially difficult to control. $NO_x$ is formed through various mechanisms during combustion, which, if not addressed, can create large amounts of this pollutant. A diffuse flame burner will generate the largest amount of $NO_x$, so typically any enclosed combustor, even temperature-controlled models, will produce relatively large amounts of $NO_x$. This includes direct-fired thermal oxidizers; even though they offer great destruction efficiency, they do not greatly improve upon simpler combustors in $NO_x$ generation.

**Fuel efficiency.** Fuel efficiency is another important, yet frequently overlooked, consideration for selecting an enclosed combustion system. While a fuel source, such as natural gas, is inexpensive, it may not always be feasible to invest in a higher-cost system to increase fuel efficiency. However, many products are still worth considering. Regenerative thermal oxidizers offer the greatest fuel efficiencies, recovering up to 98% of thermal energy. These systems are ideal for low-concentration and high-flowrate applications.

Given the different factors that can influence the selection of an enclosed combustion system, it can be difficult to determine where to start. In general, the decision factors should prioritize process gas composition, followed by emissions, and finally fuel efficiency and capital costs. Following these priorities ensures that the equipment selected provides the required performance at the lowest capital and operational costs. Proper selection requires that these factors be researched and determined in advance to ensure that the expectations for the equipment are in line with the operational requirements. ●

# Sustainability: Adapting and prospering in the energy transition

**KENJI HASEGAWA,** Yokogawa, and **TIM SHIRE,** KBC, a Yokogawa Company

Pressure from society is leading policy-makers and investors to demand faster and deeper cuts to carbon dioxide ($CO_2$) emissions from all industrial sectors. Simultaneously, technology is facilitating change, with falling costs of renewable energy resulting in cheaper and greener power, and digitalization allowing energy suppliers and consumers to act in a connected, nimble way. Despite this, world demand for energy has increased, and will continue to increase, for the foreseeable future.

One change in the balance between energy production and consumption will occur as the demand side is poised to make substantial geographical shifts over the coming decades. North America, Europe and Japan are projected to experience decreasing demand—while the rest of the world, especially developing regions, will see increasing demand, led by China and India. This increasing demand will often be led by heavy industry energy consumption, particularly in the petrochemical industries.

As new power generation assets and industrial users are brought online, they are built with the latest technologies to increase efficiency and reduce emissions. However, it is imperative to consider the massive installed base of production and consumption equipment, which represents a huge optimization opportunity. This includes considering both technology advances and human decision-making processes augmented by better data analysis.

Energy efficiency is the most economically attractive means of carbon mitigation. Optimization efforts are equally applicable to both the supply side and the demand side across the energy, chemical and process industries.

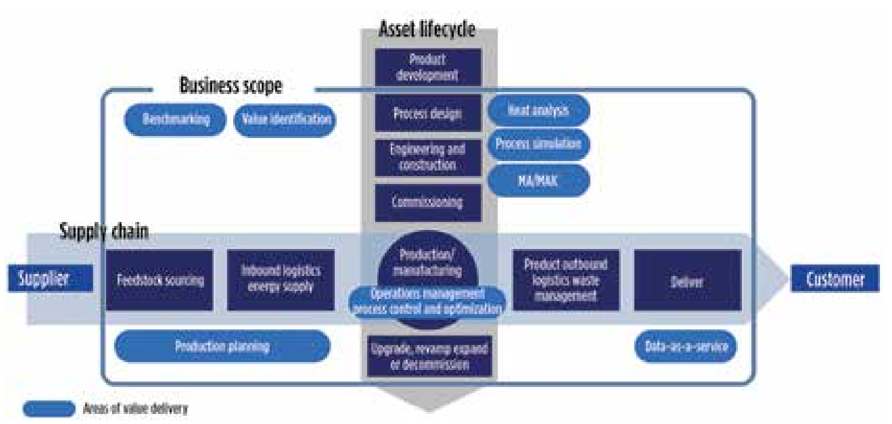


**FIG. 1.** Optimization opportunities exist within the lifecycles of plants' physical assets, as well as through production planning and the supply chain.

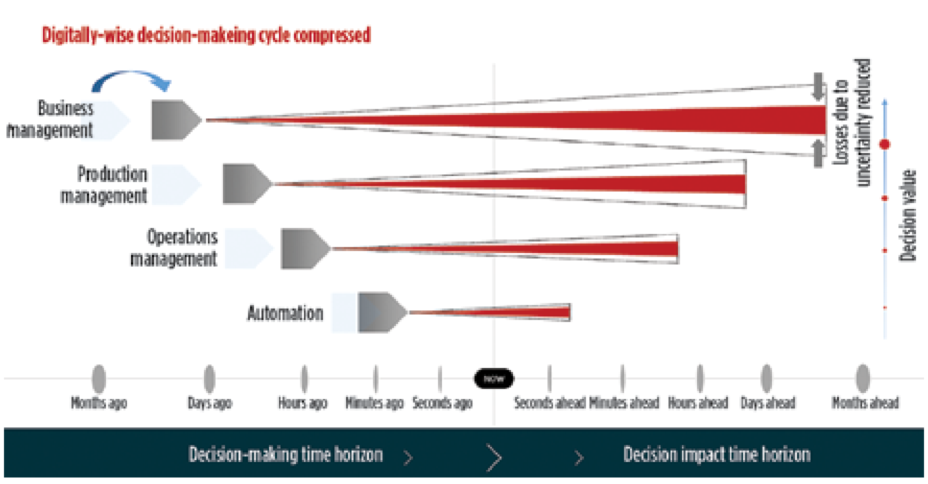


**FIG. 2.** Digital analysis provides better information in a timely manner, helping an organization make impactful decisions with more certainty.

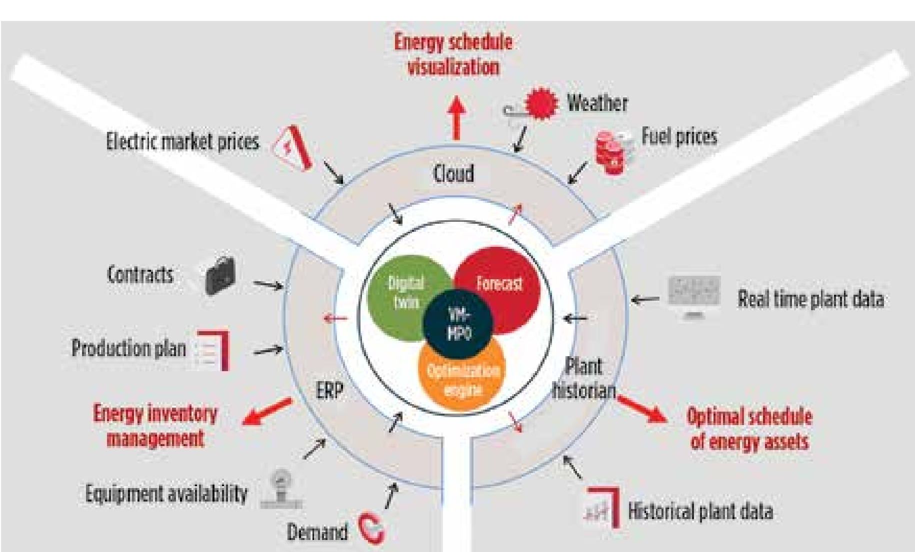


**FIG. 3.** Multi-period optimization establishes a comprehensive system model, and then integrates many variables and forecasts by using an optimization engine to determine optimal operation parameters.

**Power generation and use trends.** Approximately 20% of total energy demand is satisfied by renewable sources, and that percentage will continue to grow. This leaves the remaining 80% of energy sources already in service as candidates for emissions reduction if demands can be optimized. Analysis by the World Business Council for Sustainable Development (WBCSD) indicates that, in 2016, 30% (118 exajoules) of world energy consumption was by industry consumers, of which refineries and petrochemical plants constitute a significant portion. Only a minute portion of this energy demand is supplied by sources other than coal, oil and natural gas.

For many industrial processes, energy represents the largest controllable operating cost—typically 30%–70%—of non-feedstock costs in a plant, so even small efficiency improvements can provide substantial cost savings and reduced emissions.

**Get the carbon out.** The WBCSD finds that 60% of $CO_2$ emissions are associated with the power generation and industrial sectors. Industrial consumers include all sorts of manufacturing, process plant, refinery and petrochemical operations. These sectors produce price-sensitive commodities that will be needed in greater quantities as the world develops. These production facilities are long-term investments. While new capacity will continue to be added, significant assets will remain in service for decades, making them prime targets for optimization and ongoing savings.

These mechanisms for reducing $CO_2$ emissions (e.g., substitution with bio-derived feedstocks and fuels, carbon capture and storage, carbon offsetting) add operating cost. In contrast, energy efficiency cuts variable costs while reducing emissions.

**An end-to-end approach.** Energy optimization is best achieved using a continuous lifecycle approach, which is valid for both the supply and demand sides and is equally applicable across any process industry sector.

The initial step involves identifying an opportunity, followed by engineering, design and construction, to evaluate and implement the improvement. These steps require deep domain knowledge of the production process and energy efficiency technologies, including analytical capabilities to fully understand existing conditions, and leading-edge simulation technology to explore potential solutions. Dozens to hundreds of energy improvement opportunities exist on a large industrial asset; a highly systematic approach is required to identify all opportunities and evaluate the synergies, conflicts and priorities among the options.

Two distinct but intersecting paths are available for optimizing business processes (FIG. 1). Approximately 50% of potential savings can be realized by performing optimization of physical assets over their lifecycle, including process design improvements. The other 50% is obtained through optimal production planning related to the supply chain, associated energy usage and resulting products.

**Asset lifecycle and supply chain.** For physical assets, two mechanisms are fundamental to saving energy: improving the physical asset and optimizing the business practices (operations, maintenance and planning) to extract the maximum performance from the physical hardware.

Asset value can be maximized through overall process simulation and optimizations, which must balance energy consumption, equipment life, product quality and overall productivity.

Fired equipment, to a lesser extent than heat exchangers and other process equipment, can also be investigated using online analyzers and other techniques to ensure peak performance, and minimize energy costs and emissions.

From a supply chain standpoint, optimization efforts address a wide range of activities, such as choosing the lowest-cost energy sources, assigning operational assets and selecting optimal feedstocks for processing into the desired product.

Energy costs must be addressed on several fronts. A total amount of energy is required to produce a product, depending on the raw and finished values, and the equipment needed for processing. An important factor is the timing of when the energy is needed in relation to the cost, involving strategic adjustments to scheduling and asset allocation. Opportunities may exist to select from among different energy inputs. Finally, in certain regions and seasons, such as the southern US in summer, daily demand experiences wide swings from peak to trough that feed through into variable pricing and tariffs to industrial energy consumers.

Asset lifecycle and supply chain optimizations typically cross paths during production or manufacturing, so they must interact to determine the best overall course of action. The optimization tools, methodologies and expertise deployed address all aspects simultaneously.

Automation upgrades may be necessary to provide a suitable platform for energy optimization, including best-in-class process technologies like distributed control systems (DCSs), data historians, advanced process instrumentation, Industrial Internet of Things (IIoT) sensors and digital data-gathering techniques.

Functional and scheduling improvements must be operated and sus-

▶ See SUSTAINABILITY, page 15

# The RCF alternative reshaping the petrochemical industry

**GARY JUBB,** Morgan Advanced Materials

Refractory ceramic fiber (RCF) has long been the first-choice material for lining fired heaters in the petrochemical industry. Its excellent handleability, low thermal conductivity and heat capacity, superior thermal shock resistance, resistance to pollutants and ability to withstand extreme temperatures makes it ideal for extending the life of fired heaters.

However, some in the industry are looking for RCF alternatives. EU regulations designed to address the health concerns of RCF and crystalline silica have required materials manufacturers to develop innovative furnace linings fit for the future.

Under the EU Carcinogen Directive, businesses are required to use RCF substitutes where technically and economically feasible. Unfortunately, these requirements are open to interpretation and, until recently, no material can match the insulating performance and high melting point of RCF.

**Replacing RCF: A balancing act.** Replacing RCF can negatively affect furnace operations, so it is an unpopular option. A typical furnace can generate $120,000–$1.2 MM worth of product each day, forcing many operators to weigh the pros and cons between their bottom line and complying with regulations.

By contrast, many operators value their ethical approach. Some are maintaining the fired heater's lining to extend its lifespan rather than replacing it, in the hope that a viable RCF alternative will become available. However, this decision may be made at the expense of efficiency.

Beginning in 2020, producers and users of RCF in Europe will need to keep the amount of RCF fibers in the workplace < 0.3 fibers/ml. Other countries have imposed similar controls, making RCF's use difficult and expensive.

This is compounded by the increasing commitment of industrial companies to improve "green" standards and places the onus on the fiber industry to find viable alternatives. For example, RCF has been more resistant to attack by alkali-based pollutants than the existing low-biopersistent fiber compositions, which has limited the replacement of RCF in many applications.

**FIG. 1.** Morgan Advanced Materials recently launched Superwool **XT***RA*, which performs similarly or better than RCF in fired heaters without the associated environmental, health and safety risks.

**An alternative to RCF.** In recent years, Morgan's Thermal Ceramics' Fiber Centre of Excellence in Bromborough, UK has been conducting research into RCF alternatives. The aim has been to produce a low-biopersistent fiber with the performance of RCF that does not form crystalline silica. As a result, the company has recently launched a material that performs similarly or better than RCF without the associated environmental, health and safety risks.

Superwool® ***XT****RA* is unique in that it does not form crystalline silica—a major revolution for the industry. Morgan's breakthrough material is also exonerated from any carcinogenic classification under Nota Q of Directive 97/69EC.

**Tried and tested.** Crucially, petrochemical operators are guided by the American Petroleum Institute standards. The API's classification temperature for insulation outlines an obligatory 150°C overtemperature capability on the fiber within furnaces.

Critical furnaces (**FIG. 1**) within the industry run between 2,192°F and 2,282°F (1,200°C and 1,250°C) and, therefore, require materials with a 2,552°F (1,400°C) minimum classification rating. With a classification rating of 2,642°F (1450°C), Superwool ***XT****RA* offers a performance superior to RCF.

**Making the switch.** Identifying the need for a new furnace lining is not easy, as testing new materials can cost upwards of $37,000 per trial and increase furnace downtime. However, ensuring lining quality is essential for protecting personnel, minimizing heat loss and maintaining operational reliability.

**Carefully consider engineering design.** To achieve maximum efficiency for the materials specified during the furnace relining process, it is critical to ensure that the engineering design is appropriate.

Not only must the materials have enough studs to hold them in place, but they also require enough joints for expansion or shrinkage. If a brick lining is installed without adequate expansion joints, the brick can grow so large that it pushes the entire lining off the furnace wall, requiring the process to be repeated.

Over long periods at temperature, fiber modules develop shrinkage gaps that need filling with more fiber during scheduled maintenance shutdown periods. Superwool ***XT****RA* is innovative in that it expands when heated to high temperatures, closing any shrinkage gaps. This expansion is reversible; when it cools down, the shrinkage gaps become visible. Unlike other fibers, there is no need to fill the gaps, saving on labor costs, material and loss on downtime.

A correctly installed furnace lining can last up to 20 years and must perform efficiently and reliably. Each furnace lining product also requires unique installation methods, so it is important that the personnel employed to carry out the work are highly skilled and experienced to avoid costly complications and downtime.

Superwool ***XT****RA* provides a low-biopersistent option for refineries and petrochemical plants. Through considerable testing, it has proven to be a viable alternative to RCF and, in addition to its thermal efficiency credentials, the product's improved EHS performance has alleviated concerns within the industry. It is available in various forms and can provide low-biopersistent thermal insulation to the iron and steel, glass and ceramics sectors. ●

## DRONE IN A BOX

Percepto, a global market leader for autonomous industrial drone solutions, has released information to the upstream, midstream and downstream segments of how its artificial intelligence-powered drone-in-a-box (DIB) solution (**FIG. 1**) is able to automate inspection, operations, security and safety for organizations operating oil and gas refineries.

The oil and gas sector has been one of the earliest to recognize the potential of autonomous drones. Earlier this year, the American Petroleum Institute (API) published its "Guide to developing an unmanned aircraft systems program," in which it suggests "These systems have the potential to significantly reduce safety risks to personnel, cut operational costs and increase efficiencies across a variety of tasks."

**FIG. 1.** Percepto's DIB solution.

These benefits mirror the experience of Percepto's Chief Commercial Officer, Ariel Avitan, who explained, "Our DIB solution is in use by refineries and energy sites around the world and we are seeing benefits across the board. At one site, our drones fly as many as 15 multi-missions per day, all without the need for any human involvement." Ariel added, "A drone can take off and conduct a detailed inspection of a stack or a section of pipeline, before returning to its base station to recharge and then flying a perimeter surveillance patrol. In an emergency situation, a drone can be rapidly diverted from its current mission and dispatched to the scene."

**Automating routine inspections.** With on-board, high-definition and thermal cameras, a Percepto drone is able to detect crucial maintenance needs before they become costly repair emergencies (e.g., temperature variations that could lead to overheating, fires and/or anomalies in sensitive locations that could be indicative of gas leaks and oil spills). The drone can also assist in making planned maintenance shutdowns more efficient by providing data that enables issues to be prioritized, as well as monitoring the works in progress to ensure minimal downtime.

**Onsite safety.** Should an incident occur, refinery operators no longer require the incident response team to place themselves in harm's way by being the first on the scene. Percepto drones can be rapidly deployed to gather information and provide the team with information that will help them to respond effectively and safely.

**Detecting, tracking unauthorized personnel and intruders.** Drones flying pre-defined patrol routes and reporting back in real time can achieve maximum intruder deterrence at minimal cost and decrease the need for supervision within restricted and dangerous areas. Percepto drones automatically detect intruders, alert security teams, provide visual updates and track fleeing intruders until they are apprehended. ●


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TRANSFORMING ENERGY TOGETHER

# SUEZ desalter program successfully extracts 70% iron from crude

**SYLVAIN FONTAINE** and **MIKE DION,** SUEZ - Water Technologies & Solutions

Iron present in crude oil can pose significant downstream processing concerns for refiners. Metals, such as iron, can accelerate fouling, poison catalysts and may engender out-of-spec finished products. The costs associated with this include:

- Increased cleaning frequency of heat exchangers and pumps
- Increased catalyst replacement frequency
- More frequent furnace decoking to maintain throughput
- Reprocessing or blending costs associated with out-of-spec products.

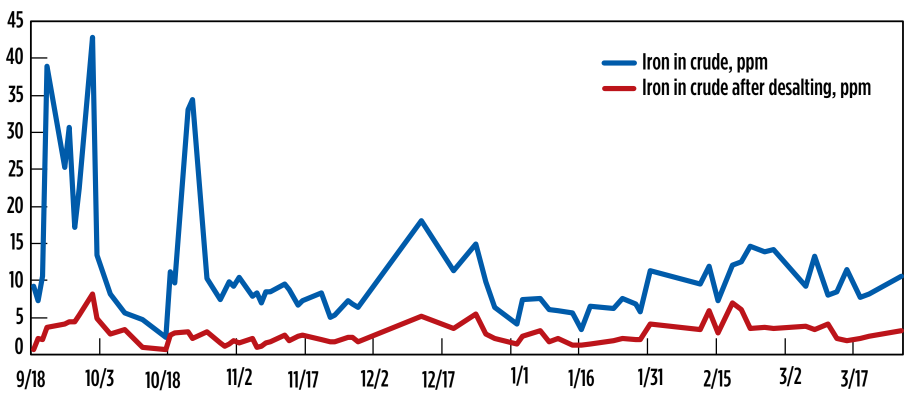
These factors contribute to increased operational costs and reduced profitability. SUEZ - Water Technologies & Solutions has developed proprietary iron removal strategies based on the specific nature of the iron and the configuration of the system to be protected. Iron can be present as a particulate (corrosion byproduct), associated with asphaltenes in the crude, or as a soluble complex (iron naphthenate), each requiring different approaches for effective removal.

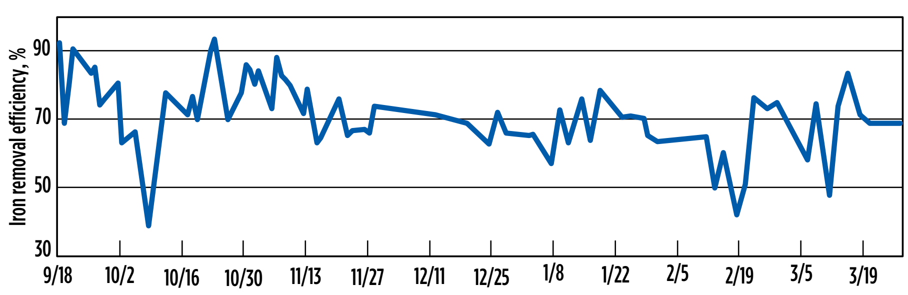
**Case study.** A refinery, processing bottoms streams through a resid desulfurization (RDS) unit and then a fluid catalytic cracking unit (FCCU), was experiencing fouling of the RDS catalyst and poisoning of the FCC catalyst when processing crude slates containing shale oil crudes. The shale oils traded at a discount to other crudes with similar yield structures. To reduce the impact of iron concentration on RDS and FCC catalysts, the refinery granted SUEZ an opportunity to evaluate SUEZ's iron removal extraction program.

After detailed lab tests, SUEZ recommended a complex iron removal solution to the refinery. The program employed a three-product approach at the crude unit desalters: an Embreak demulsifier product injected into the crude oil, a Predator product for metal naphthenates and a proprietary Embreak solid extraction product injected into the wash water. Since program implementation by the SUEZ and refinery team, the iron removal has been maintained at a high level.

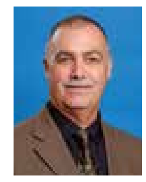
Although the iron content in the raw crude changed during the program execution, the iron content in the desalted crude averaged 2.8 ppm with a standard deviation of 1.5 ppm. The removal efficiency has averaged 70.8% with a standard deviation of 10.8 (**FIGS. 1** and **2**).

**Takeaway.** SUEZ's desalter iron removal program successfully decreased the iron in the reduced crude (atmospheric bottoms) consistently below 10 ppm. The lower iron content has reduced metal poisoning of catalysts at the RDS and FCC units. It is anticipated that the reduced iron will prolong unit operation between turnarounds by 30%, considerably reducing plant operational costs and increasing profitability—a great success and an example of SUEZ's process-solving capability and solutions.




**FIGS. 1** and **2.** Since program implementation by the SUEZ and refinery team, the iron removal has been maintained at a high level.



For 31 years, **SYLVAIN FONTAINE** has held various research, technical, sales and sales management positions, where his responsibilities included servicing, product line management, new product development, marketing, and field sales support for cooling and boiler water, wastewater, emulsion breakers, antifoulants and corrosion control chemistries to the refining processing industry. He provides global technical support to the refining and processing industries, with a principal focus on desalting, phase separation, antifoam and solid settling best practices, knowledge management and technology development. Fontaine holds a BSc degree in biology from Sherbrooke University, Québec, Canada.

**MIKE DION** is the Global Refinery Process Separations Center of Excellence Leader for SUEZ. He is responsible for strategic planning, technical support and marketing of SUEZ's refinery separations product line. He has process experience with chemical applications in refinery crude/vacuum units, FCCUs, hydrocrackers, cokers, oil movements and slop oil, as well as oil field chemical application experience in degassing, free-water knockout and dehydration units. He has seven years of oil field experience and 28 years of refining experience, is the co-author of three patents and has published six articles for organizations and publications that include AIChE, AFPM and *Hydrocarbon Processing*. Dion holds a BS degree in chemical engineering from Michigan Technological University and an MBA from Our Lady of the Lake University in San Antonio, Texas.

## ALE PRECISE LIFTING ENABLES SMOOTH U.S. REFINERY EXPANSION

The installation of three large pressure vessels (**FIG. 1**) was required at a refinery in the Texas panhandle. This work required minimal disruption to the plant's six-figure throughput, while taking up as little space as possible.

The three vessels, each with different dimensions, were received onsite by ALE. The first was approximately 16 m in length with a 3.65-m diameter (52 ft 9 in. × 12 ft); the second was 35 m in length with a 4-m diameter (116 ft × 13 ft); and the final vessel was 56 m in length with a 4.2-m diameter (184 ft × 14 ft).

**FIG. 1.** The installation of three large pressure vessels at a refinery in the Texas panhandle required minimal disruption to the plant's six-figure throughput, while taking up as little space as possible.

The smallest vessel was delivered under hook and tandem-lifted by two hydraulic cranes with 110-ton and 440-ton capacities, respectively. This operation tailed up the vessel from its delivery trailer and set it on its foundations.

The mid-sized vessel was received by ALE in a laydown yard onsite. From there, it was loaded onto SPTs fitted with bolsters and transported to its dress-out location, adjacent to where it would be lifted and set in place.

Once dress-out was completed, the vessel was weighed, establishing its center of gravity. It was attached by its skirt ring to an SPMT with a 496-tons capacity tailing frame, then tailed to a vertical position and set on its foundations.

Due to its size and weight, the largest vessel was transloaded onto SPMTs using ALE's 700-ton capacity gantry lifting system. It was then transported to the dress-out location, where it was rotated 60°, having been shipped out of orientation. This rotation was performed using chain hoists in combination with the ALE gantry lifting system.

The final vessel was then tailed up in similar fashion, using a tailing frame mounted to an SPMT and a 1,488-ton capacity crawler crane, with an 84-m (275-ft) main boom configuration and a 617-ton counterweight. The radius of all tailing lifts was 38 m (125 ft).

Equipment used during these lifts included 40 axle lines of SPMT, ALE's Lift 'N' Lock gantry lifting system, 330-tons capacity weightors, plus various pieces of staging equipment. The project also utilized LTM 1100 and 1400 mobile cranes and an LR11350 mobile crane.

The project allowed refinery activity to continue during installation. ALE's custom transportation methodology for the largest of the three vessels ensured that installation could take place without shutdown or rerouting of a large pipe rack onsite.

The methodology used for all vessels also minimized working at height, as dressing-out could take place at ground level prior to lifting. All three vessels will be used to increase petroleum desulfurization capability at the plant.

ALE's specialized engineering teams, large fleet of innovative equipment and global network of operating centers allow the company to bring an intelligent and flexible approach to projects across a wide breadth of industry sectors. Developed by ALE's R&D team, the Innovation Series features world-leading lifting and jacking capabilities that have helped reduce schedule and risk for a range of major projects. This is coupled with an extensive fleet of heavy cranes, specialist transport and installation equipment that allows ALE to work smarter, safer and stronger, regardless of project size or scope.

# Reducing risk to operations: The need for robust industrial cybersecurity

**JON LAVENDAR,** Dragos

With the rise of increased network connectivity and the Internet of Things (IoT) in industrial environments, risks are now manifesting in through the very foundation of businesses. The operational technology that drives our everyday lives—a continuous power supply, water filtration, gas pipelines, supply chain, manufacturing, etc.—can become threatened by those looking to disrupt it.

Industrial environments have a large number of devices and systems producing a vast volume of data. These environments have wide-ranging characteristics: some are controlled environments, while others are highly variable, remote locations with extreme environmental conditions. At the same time, numerous options exist for industrial cybersecurity connectivity internal to the OT network and external to the IT network.

When looking to secure an industrial environment, remember the critical objective of maximizing risk visibility and minimizing downtime. This can be accomplished by proactively monitoring assets and managing the balance of risk between output and potential disruption.

**Monitor and assess.** To ensure an informed risk assessment, monitor the fairly large expanse of both OT and IT networks, detecting not just vulnerabilities, but also indicators of compromise, anomalies, signs of intrusions, and often-hidden threats, which typically only surface via advanced analytics of OT network data. Additionally, because the typical industrial control system (ICS) adversary takes a year or more to achieve its goal, historical data is needed to enable accurate analysis. This compounds the need for a highly scalable industrial cybersecurity solution with scalability reaching gigabytes and, quite possibly, terabytes of data storage.

As part of minimizing downtime, asset owners must take measures to reduce dwell time—the time a threat is present but undetected within a network. Beyond monitoring, the ability to surface undetected threats (and in a short timeframe) is important, as well. To achieve this, an industrial cybersecurity solution requires a high rate of data processing and analytics to detect and enable quick and efficient threat investigation.

When considering an industrial cybersecurity solution, it is important to assess:

- How quickly can you detect a threat in your OT network, and what risk level does that generate?
- Is reducing that detection time impactful to your risk as a continuous business operation? If so, how can you quantify the impact?
- Does the solution assist you with response or mitigation once a threat is detected?
- Does the solution scale to the parameters of your environment? Consider:
  - What kind of systems (historians, devices) can be monitored?
  - What types of data can be collected and analyzed?
  - Will they be connected to or via the cloud?
  - What are the environmental requirements?
- Are there limitations by vendor? (e.g., control-system vendor specifications or warranty requirements).

When determining the appropriate industrial cybersecurity solution for your organization, there are many capabilities to measure for value and effectiveness. Create a checklist based on your organization's specific cybersecurity needs so you can comprehensively examine your environment, determine budget limitations and identify priorities to ensure that your process results in a decision-making framework that enables your business to maximize risk visibility and minimize downtime. ●

JON LAVENDAR is the Chief Technology Officer and Founder of the critical infrastructure cybersecurity company Dragos Inc.

# RIVE® FCC catalyst powered by Molecular Highway® zeolite technology

**TONY TAVARES,** W. R. Grace & Co.

RIVE® FCC catalysts powered by Molecular Highway® Y-zeolite (MHY®) technology enhances feed molecules' access to and from active catalytic sites in the zeolite. As a result, MHY zeolites crack larger fluid catalytic cracking (FCC) feed molecules more selectively than conventional active matrix materials. This allows refiners to make more primary cracking products, including liquefied petroleum gas (LPG) olefins, and less coke per unit of conversion—both of which are highly valued by many refiners. This improves operational flexibility, allowing refineries to increase LPG olefinicity, pursue heavier feedstocks via delta coke reduction, reduce FCC dry gas without LPG loss, increase volume swell in delta coke limited operations, increase gasoline octane and alleviate existing unit constraints such as main air blower rate, wet gas compressor rate,and regenerator temperature.

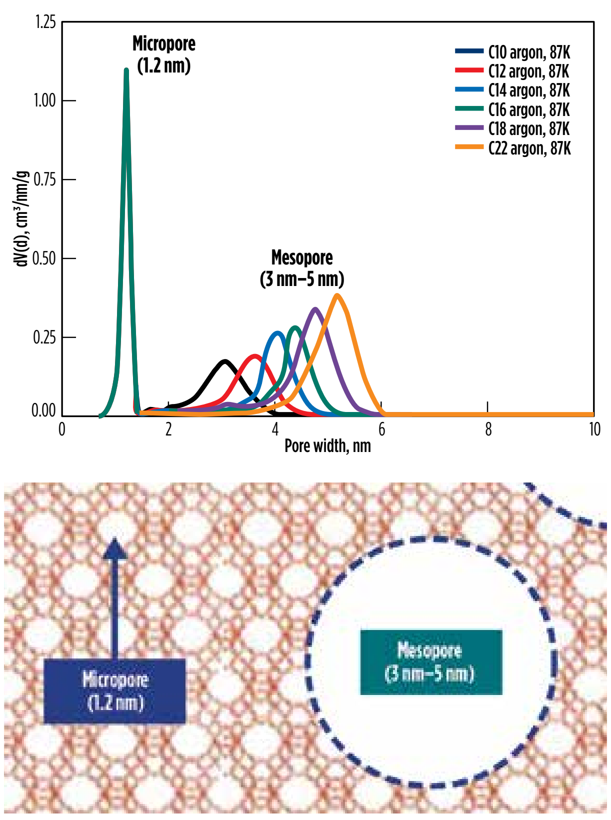



**FIG. 1.** Controlled and ordered mesophores formation.

**The Molecular Highway advantage.** MHY technology is a surfactant-templated, post-synthesis zeolite meso-structuring process that introduces ordered, well-controlled and hydrothermally stable mesoporosity into zeolite crystals. The Molecular Highway process is engineered to allow a high degree of control in the size and amount of ordered mesopores created inside the zeolite crystal, resulting in homogeneously distributed and interconnected pores (**FIG. 1**).

The RIVE FCC catalyst represents the first and only use of ordered mesoporosity in FCC zeolites or catalysts, providing a step change in value for many FCC operations, resulting in enhanced diffusion of hydrocarbons into and out of the catalyst particle

With conventional Y-zeolites, molecules with kinetic diameters up to roughly 1 nm (10 Å) can directly enter the Y-zeolite structure. This corresponds to hydrocarbons that boil up to around 950°F (510°C). Larger hydrocarbons boiling above this temperature are traditionally cracked in the FCCU by mesoporous aluminas. These materials have less selective acid sites and the goal is to cleave off hydrogen-rich side chains, which can subsequently enter the zeolite cage.

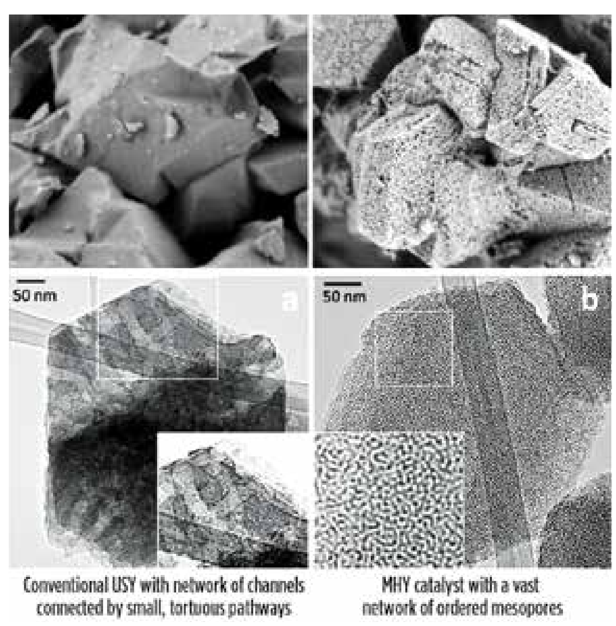



**FIG. 2.** Mesopores are integral to the MHY zeolite crystal.

With the vast network of interconnected ordered mesopores (3 nm–5 nm; 30 Å–50 Å) in the MHY zeolites, larger feed molecules that boil at temperatures in the 950°F–1,100°F (510°C–593°C) range are now able to directly access the strong acid sites in the zeolite. MHY zeolites can crack these larger feed molecules more selectively than conventional active matrix materials. This translates into coke-selective bottoms cracking. Also, MHY zeolite technology rapidly channels the valuable cracked products out of the zeolite before they succumb to potentially undesirable reactions, such as over-cracking, hydrogen transfer or condensation reactions to form coke within the catalyst pores.

Among primary and secondary "cracked products," LPG olefins are very reactive, particularly at the high temperatures present within the FCCU riser and reactor. If these valuable, reactive molecules spend too much time inside the catalyst, they can become saturated through hydrogen transfer reactions into less-valuable LPG paraffins. MHY zeolite's ordered mesopores allow rapid transport of valuable LPG olefins out of the zeolite. Preservation of primary products in conjunction with reduced hydrogen transfer also leads to a boost in research octane number (RON).

SEM, HR-TEM, electron tomography and rotational electron diffraction all show co-existence of mesoporosity and crystallinity/microporosity within the same zeolite crystal. It is this proximity of micro and mesoporosity in the same zeolite crystal that provides Molecular Highway Y-zeolite (MHY) with its enhanced catalytic performance characteristics (**FIG. 2**).

**Commercial success.** RIVE FCC catalysts powered by Molecular Highway Y-zeolite (MHY) technology have been used successfully in numerous commercial operations. There has been no increase in catalyst losses or stack opacity at any of these loca-

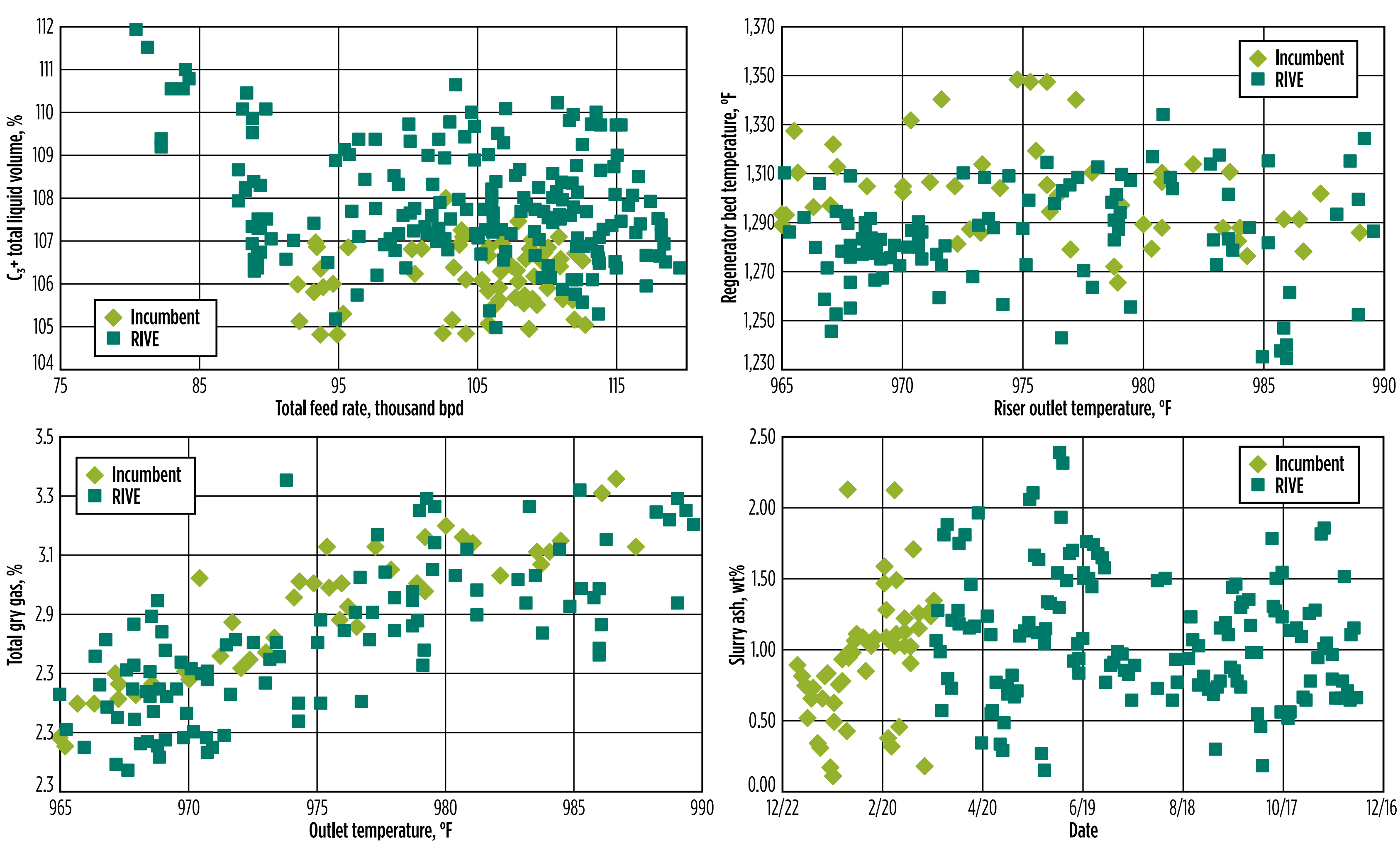



**FIG. 3.** Case study: Operational data on the new Y-zeolite catalyst.

tions, confirming the excellent physical properties of the RIVE catalysts supplied. Several sets of commercial results (including stack opacity comments) have been published through AFPM (www.grace.com/value).

An example is the ongoing operation at a former Motiva (now Shell) refinery in the U.S. where this commercial operation has demonstrated notable improvements in coke selectivity, dry gas selectivity, LPG olefinicity, bottoms reduction and $C_3$+ total liquid volume. During and since the trial, Motiva has been able to realize uplift in the range of $0.40 to $1.20 /BBLFF (within the boundary of the FCC unit) depending on the market economics (**FIG. 3**).

In addition to deploying MHY technology in some of Grace's global FCC catalyst products and new development pipeline, this technology has broad applicability to different types of zeolites. Many refiners are considering shifting FCC objectives to produce light olefins for petrochemical feedstocks to best utilize existing FCC assets. As demand for petrochemicals grows, the addition of Molecular Highway zeolite technology offers customers additional solutions and greater flexibility in converting crude oil to petrochemical feedstocks. Grace is already working on new ways to deploy Molecular Highway zeolite technology in a wide range of chemical applications.

For more information, visit www.grace.com/RIVE ●

**SUSTAINABILITY,** continued from page 8

tained to deliver value, and OT and IT services deliver the technology implementation. Functional business units (production planning, operations and engineering) must own and define the overall solution to support the tasks and decisions made by those teams.

**The decision-making cycle.** Optimization requires the collection and interpretation of good data, whether from within the facility or externally, such as raw material costs and energy prices.

Within an organization, optimization can occur at several different levels (**FIG. 2**):

- Business management—concerned with overall costs and profitability
- Production management—coordinates raw materials and inventories
- Operations management—organizes day-to-day plant operations
- Automation—automated process and manufacturing systems produce the actual goods.

The higher the decision level, the longer the time "horizon." Ideally, the lead time in making decisions and implementing the actions at all levels should be compressed as much as possible so that results are realized earlier and uncertainty is reduced.

Tools such as digital twins and big data analytics can compress the decision-making cycle. Procedural and industrial automation, as well as work process management, can speed up the transfer of information and the effectiveness of decision implementation.

**An optimization environment.** It is crucial to obtain useful data for offline detailed analysis and simulation, as this will drive improved process parameter selection and business decisions. Traditionally, scheduling of energy assets has relied on experienced personnel that are focused on sub-areas within an organization. However, optimizing energy generation and consumption is a wide-ranging and complex problem with many time-sensitive variables.

This time sensitivity involves changing values and future projections for those values. A detailed analysis must include projections of costs into future time periods.

Therefore, a complete scheduling and optimization environment must handle all these concerns over multiple time periods. To do so, such a system requires at least (**FIG. 3**):

- Digital twin
- Forecasting capability
- Optimization engine.

Digital twins are software models built to represent the physical behavior of the real-world system under various operating conditions. Actual process data from plant assets, obtained via historians in real time, are used to automatically create accurate models.

Forecasting information can come from a variety of sources. Cloud-based information can supply energy costs and weather conditions. Enterprise resource planning (ERP) systems can be accessed for data concerning raw materials and production availability.

The optimization environment provides an upper decision layer to unite all levels of variable elements, resulting in faster and better energy management choices. Rather than only short-term thinking, organizations can move to a longer-term strategic approach.

**Takeaway.** Energy is one of the largest costs for process plants, so even slight improvements can enhance the bottom line for these operations, especially over the long term. Energy optimization is best pursued using a lifecycle approach. Some improvements directly involve production assets and their operation, while others take advantage of alternate operational, scheduling or asset allocation approaches.

For best success, a digitalized optimization environment is essential, which must accurately model the system and use connections to live and forecast data to operate an optimization engine and determine best results. Fully automated digital twins combined with cloud-based support services are an ideal way to achieve this. These types of implementations can address both the asset lifecycle and supply chain aspects of optimization. This approach minimizes uncertainty and helps end users transition from a short-range tactical approach to a long-range strategic approach for energy management. ●

# Meeting the global challenge of clean air while improving refinery performance

**CARL KEELEY, MARTIN EVANS** and **PAUL DIDDAMS,** Johnson Matthey

Sulfur oxides ($SO_x$) are harming the environment and the people you care about. Worldwide, many government agencies are imposing stringent legislations to reduce $SO_x$ emissions from oil refining. Oil refineries have risen to this challenge, and since the fluid catalytic cracking unit (FCCU) is the major source of $SO_x$ in most refineries, many solutions have been employed to reduce FCC $SO_x$ emissions (e.g., feed sulfur restrictions, hydrotreating, $SO_x$ additives, flue gas scrubbers) (**FIG. 1**). However, some solutions reduce refinery flexibility or are costly to implement. Ultimately, these are not sustainable. Good science and experience have proven that FCC $SO_x$ reduction additives enhance life and are often the best solution.

**$SO_x$ emissions.** In the FCC process, the feed cracks and releases sulfur. Coke and metals sulfides (e.g., iron sulfide) transfer sulfur to the regenerator where the sulfur is converted to reduced sulfur species [hydrogen sulfide ($H_2S$) and carbonyl sulfide (COS)] and $SO_x$. The sulfur species formed depends on regenerator operation and the availability of oxygen. In full-burn operation, sulfur oxides are favoured. However, in partial-burn regenerators, reduced sulfur compounds are also formed. Downstream, in the CO boiler, these reduced sulfur species are converted to $SO_x$. Eventually, the $SO_x$ leaves the FCCU with the flue gas. In the environment, $SO_x$ reacts with moisture in the air to form acid rain, which harms plants and the soil. In addition, $SO_x$ binds particles and promotes the formation of harmful PM10 particulates, which are linked to breathing difficulty.

## $SO_x$ REDUCTION ADDITIVES

The good news is that the right tools exist, and FCCU $SO_x$ emissions can be reduced by adding $SO_x$ reduction additives directly to the FCCU catalyst inventory. They absorb sulfur oxides in the regenerator and then release the sulfur as $H_2S$ in the reactor. Three basic steps are detailed here.

Stringent legislations are being imposed to reduce $SO_x$ emissions. Since the FCCU is the major source of $SO_x$ in most refineries, the focus has been to reduce these emissions. Some solutions reduce refinery flexibility, but FCC $SO_x$ reduction additives are often the best remedy.

1. **Sulfur oxidation.** As the coke burns in the regenerator, $SO_x$ is formed. Vanadium and cerium oxides promote the conversion of sulfur dioxide ($SO_2$) to sulfur trioxide ($SO_3$). A special oxidation package is needed for partial-burn regenerators, where oxygen availability is much more limited (Eq. 1).

$$SO_{2\,(g)} + \tfrac{1}{2}O_{2\,(g)} \rightarrow SO_3\,(g) \quad (1)$$

2. **Sulfur trioxide capture.** $SO_3$ is captured by Mg/Al-hydrotalcite or Mg/Al-spinel, shown in Eq. 2 as a simple representation (*MO*). Sorption effectiveness is improved by maximizing the amount of *MO* in the additive.

$$SO_{3\,(g)} + [MO]_{(s)} \rightarrow [M]SO_{4\,(s)} \quad (2)$$

In full-burn regenerators, > 95% $SO_x$ reduction is typically achievable. However, in partial-burn regenerators, the potential to reduce $SO_x$ emissions depends on the availability of oxygen, which depends on the regenerator % of CO. Theoretical calculations and practical experience suggest that 30%–50% $SO_x$ reduction is more typical for most partial-burn regenerators.

Rule of thumb: % $SO_x$ reduction = 100 – 10 × % of CO

3. **Sulfur release.** In the reactor, sulfur release is assisted by hydrocarbons (nascent hydrogen) in the riser, catalyzed by vanadium present in the additive. $H_2S$ is formed (Eq. 3).

$$[M]SO_{4\,(s)} + 8[H]_{(g)} \rightarrow [MO]_{(s)} + H_2S_{(g)}\; 3H_2O_{(g)} \quad (3)$$

**Sulfur recovery.** The incremental $H_2S$ production is relatively low (typically a < 10% relative increase in $H_2S$) and can usually be handled by existing sulfur recovery facilities. The recovered sulfur can generate a small income for the refinery.

**FCC feed sulfur.** High-sulfur (sour) FCC feed is usually lower cost than sweet feed and, therefore, economically more attractive. $SO_x$ reduction additives unlock the potential to process this feed without exceeding $SO_x$ emissions limits, which increases FCC profitability.

**Flue gas scrubbers and additives.** If a refinery has an FCC scrubber, $SO_x$ reduction additives are still relevant. Operators increasingly use $SO_x$ reduction additives to reduce the scrubber load. This reduces scrubber chemical consumption and effluent production; effluent treatment is expensive. Even when the scrubber is performing well and its operating costs are under control, $SO_x$ reduction additives improve flexibility (FCC + additive + scrubber).

**Performance predictions.** Significant FCC $SO_x$ reduction is within reach. The percentage of $SO_x$ reduction depends on many factors. Feed sulfur, riser conditions, regenerator conditions, additive factors, and practical experience for different FCCU designs and operating conditions are important, too. Ask your $SO_x$ additive supplier, which should have experience with different FCCU configurations.

**$SO_x$ reduction additive experience.** $SO_x$ reduction additive research began in the 1980s. First-generation additives performed well in full burn regenerators, but their effectiveness was too low to allow most refiners to meet ultra-low $SO_x$ emissions targets now applied in the U.S. It was found that the effectiveness of the additive depended on several factors, especially high Mg/Al ratio (higher Mg leads to higher $SO_x$ capturing capacity). In the 2000s, $SO_x$ reduction additive use increased, and it became apparent that there were large differences in $SO_x$ additive performance from unit to unit. Further investigation revealed why, and some of these differences were exploited to improve additive formulation. More recently, dedicated additives for different types of FCC operation have been introduced.

**Supplier quality and reliability.** Control of $SO_x$ emissions is vital, so your supplier must be able to deliver on-time, on-spec, high-quality $SO_x$ additives whenever you need them. The additive should be tuned for your requirements. Furthermore, to capture maximum advantage from lower-cost, sour feeds, while minimizing your working capital, you need a reliable SOx additive partner who is always ready to deliver to you at short notice.

To complete the picture, good additive loaders are essential to provide accurate, precise and reliable additions that enable FCCU operators to optimise $SO_x$ additive use.

**Takeaway.** In full-burn operation where oxygen availability is not an issue, the primary variable determining $SO_x$ additive efficiency is the Mg/Al ratio of the additive. Johnson Matthey's **INTERCAT™ SUPER SOXGETTER™** family of FCC additives have the highest Mg/Al ratio in the market and are also the most active $SO_x$ reduction additives available.

In partial-burn operation, oxygen availability is extremely limited, so the additive oxidation package becomes the most important variable in determining $SO_x$ reduction. The **INTERCAT LO-SOX™PB** family of additives were developed with this limitation in mind and have been shown to outperform all current-generation $SO_x$ reduction additives operating in partial-burn.

Johnson Matthey $SO_x$ reduction additives are enabling FCCU operators to target lower FCCU $SO_x$ emissions, reduce scrubber chemical consumption and process economically attractive, high-sulfur feed without exceeding FCCU flue gas $SO_x$ emissions limits. ●

**FIG. 1.** Oil refineries are rising to the challenges imposed by stringent government legislation to reduce $SO_x$ emissions.

# Data is the new oil, and why that is not necessarily a good thing

**MICHAEL KANELLOS,** OSIsoft

I would love to be a consultant.

You throw on the blue blazer, hop a flight to London, burst into the executive boardroom and blurt, "Don't think about the total cost of ownership; think about the *total cost of failure,*" or something equally ludicrous.

Then, they give you a check for $500,000 and you are on your way to the next gig.

If the dot.com era taught us anything, it is that you can go a long way by serving up well-honed clichés with great conviction. Give away the razor and sell the blade. It is like Moore's Law for breakfast cereals. Green is the new black.

The latest favorite? Data is the new oil.

The data-is-like-oil line, of course, underscores something that is actually true. We are on the verge of another technological era where industry will save money, increase safety and improve their return on capital by taking increased advantage of the trend lines on their screen.

However, an ugly underside to the analogy exists, particularly in the Internet of Things (IoT).

**There is a lot more data than you think.** We are nowhere near "peak data." BP is in the midst of digitizing its offshore assets. It tracks more than 1 MM data streams, and harvests more than 100 B data points from its digital twins. These efforts have helped the company detect equipment problems and solve other issues, but the sheer volume of data can be daunting. Another oil company performs more than 10 T (trillion) read/writes per month on its operational data. That means building more internal expertise and reaching out to third parties.

**More data will originate from remote, challenging environments.** Scraping data from a website to determine a shopper's demographic profile and capturing thousands of signals each second from trucks driving in subzero temperatures are difficult. So is trying to wire chemical reactors and other various pieces of equipment that predate the invention of the ethernet, yet still perform admirably. Once a company begins to take data seriously, it will discover all of the things that are not wired yet.

**Value will range all over the map.** BRK Ambiental, a water utility in Brazil, has discovered a way to prevent overflows in its sewage lagoons by tracking a few parameters, such as water level and fill rate. "This is a simple solution. It is not crazy with a lot of calculations," explained Marcia Cintra, an IT analyst for BRK. "We can achieve huge results; you do not need to make magic."

At the other end of the spectrum, situations arise where an analysis on 10 years of performance data yields what you already knew. Ultimately, this means that most companies must collect and store more than they would like until they can figure out (1) the problem they want to solve, and (2) the relevant data set that goes with it.

**Refine data before you use it.** Data needs context: 87°C can be an ideal temperature or the first sign of a looming disaster. Digital twins, which can combine different data streams from an asset into a cohesive whole, will play a big role in contextualization. They will make it easier to understand the relationship between flow (in liters) and power consumption in kWh that otherwise may not jump out at you.

**Everyone will want data.** Back in 2001, Intel commissioned a survey that found people would abandon a web site if it didn't load in eight seconds. Today, you'd be climbing the wall. Digital transformation will evolve in the same manner. It will start with engineers and percolate to plant manager, executives, R&D, sales and even partners. Forget monthly production reports: people across an organization will want real time value cross-checked against geographic maps and pricing forecasts.

**It will dominate the economy for at least a century.** OK, this is one the consultants get right. Maybe that's why they make the big bucks. ●

MICHAEL KANELLOS is a Technology Analyst at OSIsoft, where he helps customers understand how data is changing some of the world's biggest businesses. He has worked as an attorney, travel writer, reporter, analyst and marketing exec in Silicon Valley for more than 20 years. His work has appeared in *The New York Times, CNET, Forbes, Newsweek, Newsday, The Chicago Tribune* and *National Geographic.* Kanellos holds a BA degree in history from Cornell University and a JD degree from the University of California Hastings College of the Law.

# Alkylation technology update

**DOMINIC M. VARRAVETO,** Burns & McDonnell Oil Gas & Chemical

Most U.S. refiners have alkylation units that combine light olefins—propylene ($C_3^=$), butylene ($C_4^=$) and amylene ($C_5^=$) with isobutane ($iC_4$) to produce alkylate, a low-vapor pressure, high-octane gasoline blend stock. The installed capacity and number of operating units are split roughly between two different homogenous catalyst systems, sulfuric acid ($H_2SO_4$) and hydrofluoric acid (HF). Both catalysts operate at similar $iC_4$-to-olefin recycle ratio and require similar associated equipment for feed pretreatment, effluent separation, distillation and product treatment (**FIG. 1**).

Unlike most other refinery processes that operate at relatively high temperatures to achieve desired results, alkylation reactions are exothermic and proceed more favorably at relatively low temperature. Alkylation reactors using HF, which is a stronger acid than $H_2SO_4$, can be operated close to ambient temperature. When using $H_2SO_4$ as the alkylation catalyst system, the desired reaction temperature is approximately 50°F below ambient. This difference in operating temperature attributable to acid strength results in a significant difference in reactor section equipment. $H_2SO_4$ catalyst requires a refrigeration compressor to maintain reactor temperature and remove the heat of reaction. Cooling water is used to remove heat and maintain HF reactor temperature.

**Enhancements to traditional systems.** To mitigate risk, several enhancements to traditional catalyst systems have been developed and implemented. Much of the focus has been on improving safety and reducing the health risk to those inside and outside refineries from loss of containment of HF acid. A list of possible modifications to existing HF alkylation process units include:

- Reduction in high-potential leak points, including acid circulation pump
- Reactor section acid inventory minimization
- Upgraded acid detection systems using cameras, lasers, etc.
- Automated emergency shutdown and unit isolation
- Water sprays and curtains, acid sewer and segregated acid flare
- Rapid acid transfer system
- HF acid volatility suppression additive (MHF).

Not all operators have deployed all of these modifications. In fact, many have stopped short of introducing an additive into the circulating acid, generically referred to as converting to MHF, to lower vapor pressure and reduce volatility if containment is lost.

Instead, refineries—especially those with HF units—are seeking alternative catalysts. One offered solution involves replacing HF acid with $H_2SO_4$ acid and revamping or replacing the existing reactor section. An additional advantage, besides the improved safety and reduced risk from relatively lower acid strength and vapor pressure of $H_2SO_4$ acid, is a potential increase in alkylation throughput without replacing the distillation equipment.

Design improvements for $H_2SO_4$ alkylation reactors have been introduced, including next-generation, higher-capacity, horizontal, motorized contactors that mix and emulsify reactants with acid and reactor inserts to suppress tube inlet vaporization. A downflow reactor, using proprietary internals for mixing and reacting, has also been commercialized. The flow regime and mixing energy in this design is set to avoid emulsifying the reaction mixture, reducing or eliminating the processing requirements for removing acid from the product and recovering product from acid. Olefin feed segregation and acid cascade are two other ways to improve $H_2SO_4$ alkylation efficiency and performance.

**Solid alkylation catalyst.** In the 1980s and 1990s, the focus was on finding a heterogenous (solid) catalyst replacement for HF. Such a catalyst system, which is more typical of most other refinery processes, would go a long way toward addressing the safety and risk concerns from loss of containment. Due to rapid deactivation of solid catalyst from alkylation reactions, none of those efforts—including continuous catalyst regeneration systems to burn off coke and recondition the catalyst—proved commercially viable. More recently, a new wave of replacement catalyst formulations, both liquid and solid, have been introduced to address HF risk mitigation *and* improve alkylation unit performance. None of these catalysts have been commercialized in the U.S. yet; however, there are international locations (primarily in China) where alkylation units have started up and are in service using either new solid or liquid catalyst.

There are at least two technology licensors now offering a process based on solid alkylation catalysts to refiners. The catalysts are zeolite-based with noble metal additives. A key claim from one licensor is the ability to tune the catalyst formulation, including physical characteristics like particle size, pore size and pore distribution, and chemical characteristics like acid site type, density and strength. The result is the ability to improve performance by increasing selectivity for high-octane alkylate, reducing undesirable polymer formation and eliminating acid-soluble byproducts.

The solid catalyst reactor system, which operates at pressure high enough to prevent vaporization and temperature low enough to remove heat using cooling water, consists of multiple reactor vessels with multiple catalyst beds in each reactor. Mixed feed is introduced at the inlet and between beds. Heat of reaction is removed by external liquid recycle. Net effluent flows directly from the reactor outlet to the distillation section, eliminating the need for a separator/settler.

The solid catalyst is regenerated by sequentially changing each reactor from reaction mode to regeneration mode and back to reaction mode using switching valves. In regeneration mode, hot recirculating hydrogen is used to reverse catalyst deactivation by stripping polymer and carbon accumulation from the catalyst and is vented to the refinery fuel gas system before returning the reactor to reaction mode (**FIG. 2**).

**Ionic liquid catalyst.** There are also at least two licensors now offering ionic liquid catalyst to refiners for new and replacement alkylation applications. The first commercial U.S. application of ionic liquid alkylation technology is being constructed and scheduled for startup in 2020. The other licensor of ionic liquid technology claims several commercial applications in China, the earliest of which was started up more than 10 years ago.

Ionic liquid catalyst is a liquid salt with zero vapor pressure, making it easy to store and contain and much safer compared to liquid acid catalysts. Both licensors describe a catalyst that uses a chloro-alumina base with a trace HCl co-catalyst formed in the reactor by injecting organic chloride into the feed. Ionic liquid catalyst has higher relative catalytic activity requiring smaller reactor volume and is nearly insoluble in hydrocarbon. Reactions take place at the hydrocarbon-catalyst interface and separation of the reaction products from the catalyst is easily achieved. Integrated, online regeneration of ionic liquid catalyst is a unique process using a slipstream of circulating catalyst and hydrogen and does not require polymer incineration or caustic neutralization. Re-use of existing pretreatment and distillation equipment by replacing the reactor section, including separation and adding regeneration equipment, is possible for revamp applications (**FIG. 3**).

If solid and ionic liquid replacement alkylation catalysts perform as promised, both will address safety and risk mitigation concerns from potential loss of containment, corrosivity and volatility of HF acid without a loss in performance. ●

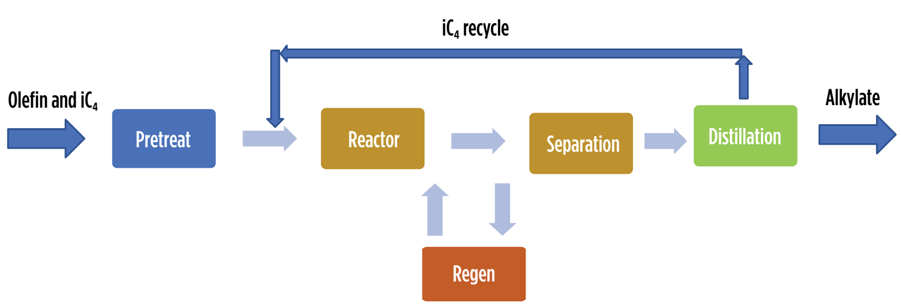



**FIG. 1.** Alkylation block flow.

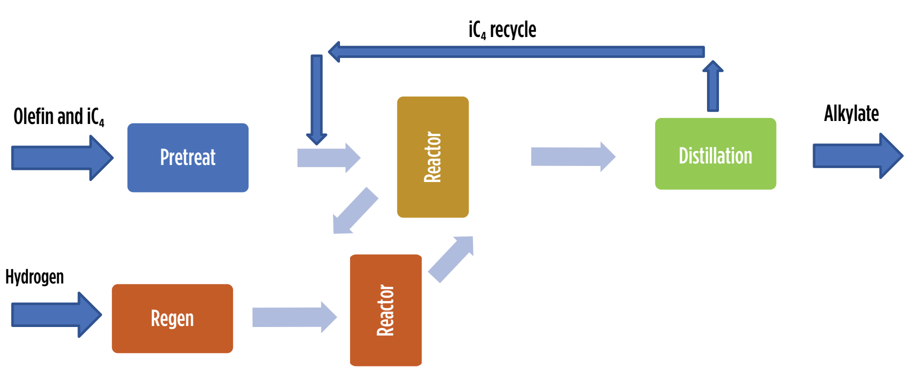



**FIG. 2.** Solid alkylation catalyst.

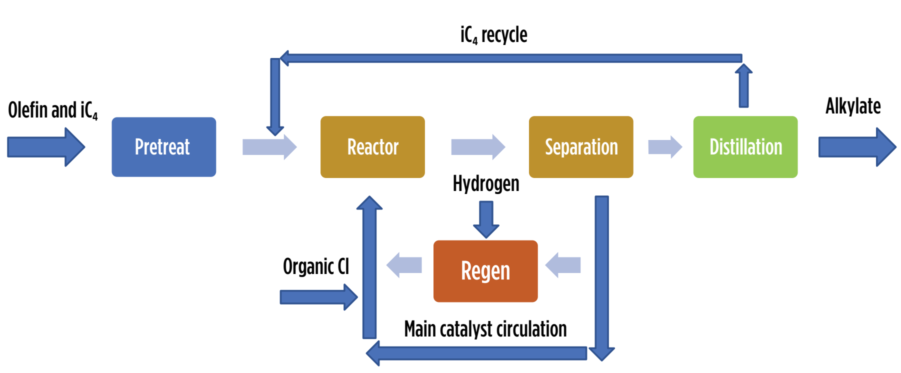



**FIG. 3.** Ionic liquid alkylation catalyst.

**TABLE.** 1. Comparison of alkylation technology

| Catalyst | HF | $H_2SO_4$ | Solid | Ionic liquid |
|---|---|---|---|---|
| Yield, vol/vol olefin | 1.78 | 1.77 | 1.88 | ? |
| Octane, RON $iC_4$= free feed | 95–96 | 98 | 99 | 95–96 |
| Acid-soluble oil | Yes | Yes | Eliminated | Eliminated |
| Regeneration cycle time, hr | In-situ/onsite | Ex-situ/offsite | 24 | In-situ/onsite |
| Reactor heat removal | Cooling water | Refrigeration | Cooling water | Cooling water |
| Product treatment | Required | Required | Not required | Not required |

# Where foresight replaces hindsight: AI is impacting the future of oil and gas safety

**HEATHER STEWART,** Advisian Digital, and **CHRIS AITKEN,** SaltGrid

According to the International Association of Oil and Gas Producers (IOGP), there were 31 fatal incidents across the industry in 2018. This result was down only slightly from 33 the year before. A startlingly small improvement, given that preventing major accidents, injuries to people and hydrocarbon releases are top priorities across the energy industry.

Thanks to enhancements in technology, safety management in the sector is undoubtedly and steadily improving. Traditional methods of capturing and handling safety information have become incrementally more efficient, helping to keep people and assets increasingly safer.

What if the future allows us to take the entire industry a step further? Widespread adoption of artificial intelligence (AI) promises to transform safety management in oil and gas. The sector has the chance to shift safety management from a backwards-looking discipline to predicting likely events (**FIG. 1**).


**FIG. 1.** Each gain in safety management brings the industry closer to an operating environment with less risk.

What does that mean, not only for the industry, but for the role of tomorrow's safety manager?

**Safety management today.** Safety management has always been a discipline of continuous improvement, from seeing the redesign of infrastructure to account for human factors, to reformed processes that integrate productivity with safe execution. Each gain brings the industry closer to an operating environment with less risk.

Safety management can also be a discipline of creativity and detective work. After all, identifying repeat patterns associated with incidents in the face of colleagues' indecipherable handwritten or weather-beaten reports is no easy feat. Digitalization has improved data capture systems, but the analysis is still predominantly a time-consuming task fraught with human bias.

**Enter AI.** The next generation of digital safety systems promises to deliver more than just information about past incidents. Instead, it is now possible to analyze historical patterns to identify the nature and timing of future events.

SaltGrid, a predictive analytics platform created in partnership between SaltGrid, a leading data science company based in Silicon Valley, and Advisian Digital, Worley's data science, software and technology business, has been built to do just this. A cloud-based platform, it applies AI to health, safety and environmental (HSE) data to predict the number, types and timing of incidents likely to occur in the future.

Using safety data, the system is also designed to quickly (and without bias) recognize patterns and relationships that standard business intelligence does not. Predictive platforms like SaltGrid have the potential to shift safety professionals' time and efforts from administrative tasks—such as manipulating and analyzing incidents, near misses and leading indicator data—to building programs based on what is likely to happen next.

This opens the role of safety management to a whole new future.

**Foresight in safety management.** Far from reducing or diminishing jobs, AI has the potential to widen the scope of a safety manager, adding an opportunity to focus on creativity and problem-solving.

There is no doubt that AI-driven platforms can free up considerable time for safety professionals by automating the gathering, cleansing, manipulation and analysis of data. That time could be spent looking at the specifics of a project, asset or facility, and considering: "How do I apply my safety expertise, based on what these machine-generated insights are telling me? What can I do to change the predicted outcome?"

AI can put these decision-making pinch points front and center, moving the focus toward proactive, specific action at a project, asset or facility level. This focus means that future mitigating measures can be highly targeted and efficient.

For example, the impact of weather conditions on a day-to-day basis is one area for data-driven improvement. Teams can be alerted to changes in the safety environment created by changes in temperature, wind or precipitation, by cross-matching this with incidents experienced across historical combinations of asset, activity and conditions.

By using historical data around incident patterns, mitigation measures can be put in place early, further the reducing risk.

**A lesson learned is a lesson shared.** With less focus on administration and more time to focus on pre-emption, the safety manager of the future must be prepared to take a truly collaborative and transparent approach to safety. Continuously drawing on lessons learned and actively sharing experiences with industry peers will become the norm, benefiting everyone working in the sector.

One of the visions, and even requirements, of predictive AI platforms, is increased industry collaboration around data sharing. Anonymized data offers the opportunity to truly automate the lesson-learning process between companies and across multiple verticals.

While energy companies remain competitive with one another, safety is one area of ongoing cooperation. To a large degree, this reflects inherent, shared risk, and the recognition that everyone has a part to play in reducing the risk to people, assets and the environment.

**Creating a safer world.** Driven by advances in data processing capabilities, significant progress has been made in managing risk across the energy industry. With the introduction of AI into the process, the future promises to be more data-driven, more creative and, most importantly, safer than ever before. ●

## CLOUD-BASED ENTERPRISE RESOURCE MANAGEMENT SOLUTION FOR EPC MARKET

Worley has selected AVEVA's Enterprise Resource Management solution as its preferred materials management platform. The partnership combines Worley's engineering, procurement and construction (EPC) knowledge with AVEVA's industrial software expertise to deliver a cloud-based enterprise resource management solution (ERM) optimized for the EPC market.

Today's EPCs are challenged with reducing project costs while keeping pace with changing IT environments. However, as EPC projects operate as mini-enterprises, on-premises configuration and hosting of enterprise projects within private networks is not only costly, but restrictive and unsustainable in an industry undergoing mass consolidation. For global EPCs to remain competitive, the move from an on-premises infrastructure to a cloud-based ERM is necessary.

By embedding Worley's subject matter expertise in EPC supply chain management, major updates to the AVEVA Enterprise Resource Management solution for EPCs include:

- Project-specific functionality: Enabling EPCs to view and work on projects in AVEVA Enterprise Resource Management as standalone entities
- Updated catalogs and specifications module: Migration of Worley's legacy corporate catalog and specifications to create a robust, easy-to-use model for EPCs
- Training solution: Allowing EPCs to streamline internal training on the new solution.

In April 2019, Worley and AVEVA began the final stage of a four-phase program to develop the AVEVA Enterprise Resource Management solution for EPCs. Phase one included design, while phase two incorporated the solution build, moving onto phase three integrations and catalog readiness, and now into phase four—project go-live and decommissioning of Worley's legacy solution.

As part of the program, AVEVA Enterprise Resource Management reduced training time across engineering, procurement and project controls by 23%. Participants noted the solution was easy to use, provided quality training materials and the right functionality for EPC projects. ●

# Will your plant be running tomorrow? Real-life predictive operations

**CRICK WATERS,** Falkonry

Chemical manufacturing processes can be extremely complex because they include hundreds of vessels pumps, thousands of valves and miles of process piping. However, these processes can be generalized into six common steps, shown in **FIG. 1.**

Product separation (Stage 4 in **FIG. 1**) is important in chemical processes, as this is when products and byproducts are separated from any unreacted materials. Poor product separation can make the final product unusable.

One method is centrifugal separation, which uses centrifugal force to separate products, byproducts and unreacted materials of different mass, especially in liquid-solid separation. Following the reaction stage, heterogeneous solutions are separated by industrial centrifuges. These complex mechanical devices (**FIG. 2**) are used in chemical processing to produce raw products, such as oil refinery byproducts, polymers, oil-water-solids, acids and salts.

A chemical manufacturing plant may have many of these mechanically complex centrifuges, each prone to imbalances and vibrations. These machines have parts that spin at high rates of speed, which makes reliability a big issue. Furthermore, these machines operate in harsh industrial environments, leading to frequent breakdowns. One characteristic leading indicator of failure of centrifuges is plugging of the centrifuge discharge line. Plugging can be observed as "high vibration" of the centrifuge. Unfortunately, by this time, it is too late. Detecting early warnings of plugging events is needed before they cause damaging high-vibration conditions.

**Chemical manufacturing lessons.** At one U.S. chemical manufacturing plant, the unanticipated failure of a centrifuge severely impacted production throughput, causing losses in the $300,000–$500,000 range for a single production line. However, by using predictive operations machine-learning software, the chemical manufacturing plant can now predict centrifuge failures in time to take corrective action and prevent production losses. Falkonry Inc., a leading enabler of predictive operations for Global 2000 companies, helped this chemical manufacturer tackle this specific problem.

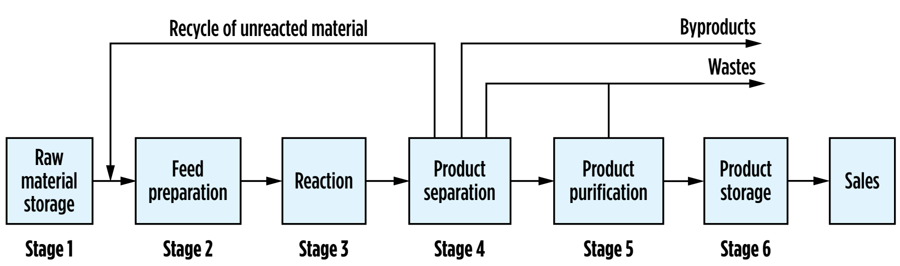



**FIG. 1.** Anatomy of a chemical process. Source: Chemical Engineering Projects.

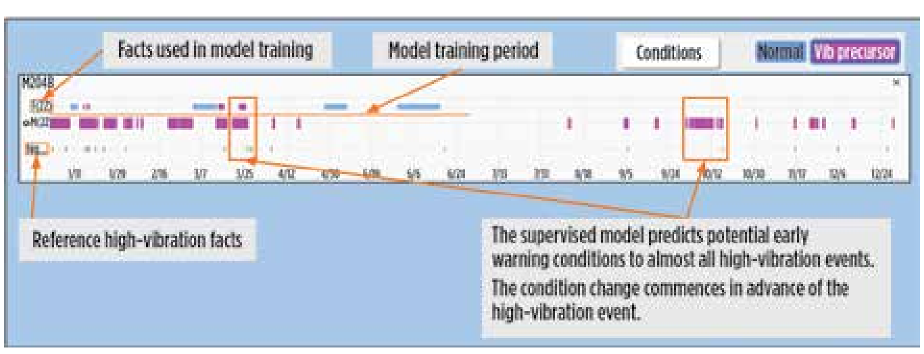



**FIG. 3.** A Falkonry LRS user can label a few periods of time during which the normal conditions are known, and just before known high-vibration conditions occurred, thereby marking periods of time during which early warning conditions should be detected.

Falkonry LRS is a pre-packaged machine-learning system for predictive operations. It applies automated feature learning, an explanation of its results and predictive analytics to discover patterns, recognize conditions and provide insights. These insights are then used to create alerts that warn of centrifuge failure.

In addition to the technical challenge of reliably discovering and recognizing complex patterns in the process operations data from the separation stage, the Falkonry LRS system was further challenged with the constraints of:

- No new sensors
- Using historical data only
- No data scientists or data engineers.

These constraints eliminated approaching the problem with traditional third-party data science or in-house data engineering options. Though these approaches may have worked, they are expensive, time-consuming and difficult to deploy and maintain. Instead, this chemical manufacturer turned to Falkonry's automated machine-learning system, which the manufacturer's own process and improvement team members could use without the need for, or knowledge of, data science.

In this use case, the manufacturer collected historical data from 14 existing process measurements, including:

- Pump amps
- Pressure
- Temperature
- Three-axis accelerometer (three variables)
- Valve position
- Centrifuge motor amps
- Vent head pressure
- Tank level
- Feed pump amps
- Feed pump pressure
- Feed pump temperature
- Recirculation flow to tank.

**FIG. 2.** Rousselet-Robatel horizontal peeler centrifuge with screw conveyor discharge.

Using Falkonry LRS, a model of the centrifuge operation was automatically developed using a small set of historical signal data. Within the data range were periods of known "normal" and known historical periods of high-mechanical vibration indicating plugging or mechanical breakdown events. With the click of a computer mouse, the Falkonry LRS user labeled a few periods of time during which the normal conditions were known, and just before known high-vibration conditions occurred, thereby marking periods of time during which early warning conditions should be detected.

Models were automatically created and applied to both the training range and validation range of data showing periods of time before known high-vibration events clearly marked as vibration precursor periods (**FIG. 3**).

A complete solution for centrifuge monitoring, and detection and prediction of early warning failure conditions will include:

- The existing data historian
- Falkonry LRS
- Output to the historian for display and notification
- Output to the computerized maintenance management system (CMMS) for maintenance scheduling.

**Takeaway.** For companies embracing Industry 4.0 digital transformation, predictive operations systems that perform automated machine-learning without the need for data scientists empower and enable existing plant process and maintenance improvement teams, which can take their companies from reactive to predictive operations, saving millions of dollars in recovered production throughput. ●

## HYTORC PARTNERS WITH CUMULUS DIGITAL SYSTEMS

HYTORC has entered into a partnership with Cummulus Digital Systems Inc., whose "Internet of Tools" platform collects data from digitally enabled tools to provide real-time quality assurance and progress tracking. The partnership will couple HYTORC's advanced powered bolting equipment with Cumulus' Smart Torque™ System (STS), to create fully connected and data-driven solutions that significantly improve safety, quality and productivity in bolting maintenance and construction.

Paired with HYTORC bolting solutions, the fully Bluetooth®-enabled technology allows users to program bolting patterns on a tablet and transmit that information directly to a HYTORC pump. The pump then activates the rest of the connected HYTORC bolting solution—hydraulic or battery-powered torque tools—to automatically tighten bolts uniformly, substantially increasing joint integrity by achieving a verifiable, even circumferential, and targeted bolt load. The integrated system is easily applied to the ASME PCC-1 recommended "Simultaneous Multi-bolt Tightening Pattern." HYTORC refers to this enhanced method as the "Parallel Joint Closure Method," which uses multiple tools (usually four) on each bolting application. The result is substantially reduced torque increments and bolting time while further increasing joint integrity, thereby significantly reducing or eliminating leaks.

By applying STS, users can realize up to 60% reductions in quality assurance and control costs, and reductions in bolting time of 50% or more. STS has also been proven to reduce dangerous, and potentially costly, bolting safety incidents. With more than 150,000 flanges under management, STS has delivered 60% decreases in quality control and assurance costs, and eliminated leaks.

Among the key features of the integrated HYTORC and Cumulus system is its digital documentation functionality. In line with the industry's push to go paperless, STS logs all activity for effective record-keeping, planning and overall accountability and traceability.

HYTORC and Cumulus will provide customers with data transparency to improve work quality, prevent accidents and injuries, and minimize unplanned downtime. The partnership will ensure seamless integration of HYTORC's bolting equipment with Cumulus' software. HYTORC personnel will be certified to provide STS training and support, and Cumulus' customers will have access to HYTORC's global field service network. ●

# Gas chromatography in the downstream analysis of petroleum hydrocarbons

**ANDREW JAMES,** Ellutia Chromatography Solutions

Gas chromatography (GC) has been used in the process and quality control of downstream petroleum hydrocarbons since the late 1960s. GC has since become a vital tool as it allows producers to analyze the main process stream components in fuel production, and to detect trace impurities that can impact the production process and final product.

Since its early use, GC technology has developed to offer better separation and higher sensitivity so that a greater number of chemical components can be detected within a sample. This is invaluable when it comes to analyzing downstream petroleum, where contaminants can seriously compromise a site's production output. Multiple detectors can be combined for the analysis of complex mixtures, resulting in instruments with multifaceted and highly involved configurations.

**GC methods for petrochemical hydrocarbons.** Petrochemical hydrocarbons are usually made of the following groups: linear alkanes (paraffins), branched alkanes (paraffins), cyclic alkanes or cycloparaffins (naphthenes), and aromatic alkanes (aromatics). Analyzing alkanes using GC is performed with a non-polar column with separation based on the sample's boiling point. Normal alkanes boil a few degrees higher than their respective branched ones. The chromatogram in **FIG. 1** shows how the branched alkanes are closer together, whereas the corresponding normal alkanes boil at a higher temperature.

Using GC analysis shows how branched alkanes elute first, followed by the normal alkanes. This allows quality control and inspection to take place in downstream petrochemical hydrocarbons, as users can rapidly identify different compounds that offer different alkane characteristics, providing assurances that the product is consistent and of a high quality.

**Ultra-fast GC.** One of the key innovations in GC in recent years is the development of ultra-fast GC (UFGC). This technique offers analysis cycle times of anywhere from 5–20 times faster than conventional GC, making it a valuable tool in downstream analysis, for example, when determining the presence of branched and normal alkanes, as shown in **FIG. 1.** As the name suggests, UFGC can perform fuel oil separations with cycle times measured in seconds, where previous analysis would take minutes or even hours.

UFGC uses direct heating, rather than a hot air-blown oven to heat the column. This can be achieved with a heating element close to a fused silica column, or by using a metal column and resistively heating it by passing an electrical current directly through it. This allows for significantly faster temperature ramping. As only the column has been heated rather than an entire oven, the cool down time is also greatly decreased. This also means that upper temperature limits are not restricted by the upper temperature of the GC oven, but by that of the column used.

UFGC typically uses much shorter columns than conventional GC. The much faster temperature ramping is then used to rapidly drive compounds through to sharpen peak shapes and maintain resolution.

The optimum ramp rate for achieving results using UFGC is typically between 60°C/min. and 200°C/min., although rates of up to 1,000°C/min can be achieved. Run times can be as short as 1 min., with UFGC rarely taking longer than a few minutes to deliver highly accurate results. This is of value in the downstream analysis of petrochemicals that produce heavier hydrocarbons, requiring higher temperatures than conventional GC. The speed of accurate results for fuel oil separation can be seen in **FIG. 2.**

Industry standard organizations, such as ASTM, are now adopting UFGC in methods as alternatives to conventional GC. One example of this is ASTM D-7798 (Standard Test Method for Boiling Range Distribution of Petroleum Distillates with Final Boiling Points up to 538°C by UFGC). The use of instruments such as the Ellutia 500 Series GC means this method can be run in around 2.5 min., where with the previous method (ASTM-D2887), it would have taken 20 min.–30 min.

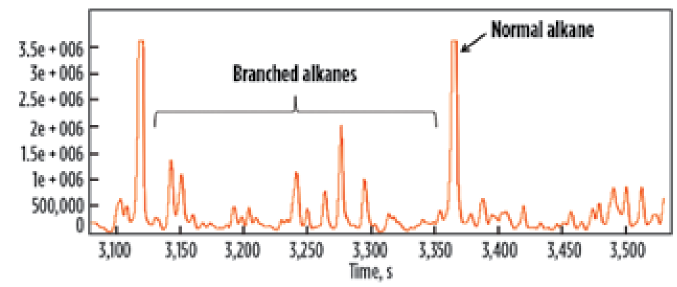



**FIG. 1.** The integration of branched and linear alkanes.

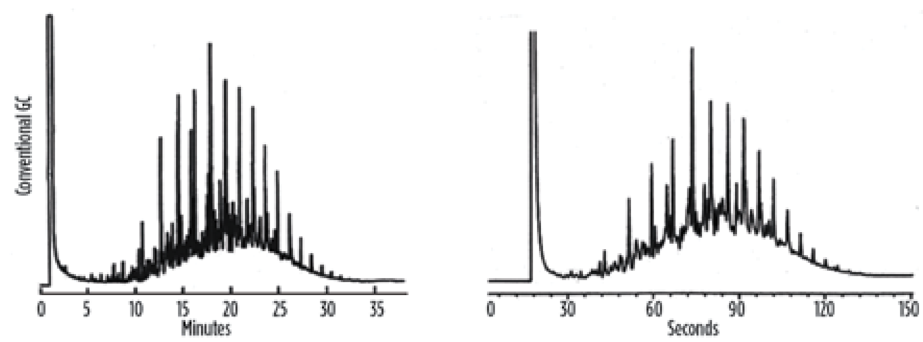



**FIG. 2.** The comparative results in fuel oil separation between a conventional GC analysis at 35 min. with a very similar analysis by UFGC in just 150 sec using the Ellutia 500 series GC.

These industry standards mean producers are under pressure to identify and fix problems quickly. UFGC provides a vital tool in ensuring quality control in this process by allowing users to carry out simulated distillation to achieve rapid results and ensure product quality and safety.

**Future use of UFGC.** The latest advances in detection and fully integrated systems have helped to move UFGC into common use. The next step for UFGC is the continued development of optimized columns, which will allow even greater scope for the petrochemical hydrocarbons industry to implement rigorous quality controls. The industry has also seen the development of faster multichannel detectors that have improved detection capabilities, including time-of-flight GC-MS, infrared absorption spectroscopy, atomic emissions detection, and far-UV absorption spectroscopy.

Technology leaders are creating more robust instruments that can be transported into very isolated locations and used in the field where previously samples would have to be sent away before results could be measured. New instruments give users the option to switch between standard, fast and UFGC within the same benchtop instrument. This is vital for companies that operate at remote sites and do not have the space to accommodate multiple instruments in one location, or those that are concerned about committing to an instrument that can only perform one type of GC.

The ramp rate and cool-down speed of UFGC means that instruments can provide accurate data several times an hour, enabling users to effectively analyze more data before confirming results.

More widespread use of UFGC in petrochemical hydrocarbons can have a significant impact on ensuring the industry continues to improve upon safety standards and quality control.

For more information, visit www.ellutia.com. ●

**ANDREW JAMES** is Marketing Director at Ellutia, where he has worked for more than 20 years. During this time, he has been involved with many aspects of the business from product development to strategic planning. This wide range of involvement has developed an extensive wealth of knowledge and experience in the chromatography industry. James has led the company's marketing for the last eight years, working to continually grow both the Ellutia brand and company.

## ALFA LAVAL INTRODUCES U.S. EXPANSION

Alfa Laval, a leading global provider of specialized products and engineering solutions based on its key technologies of heat transfer, separation and fluid handling, has strengthened its operations in the U.S. with three new facilities.

These investments better position Alfa Laval as a key partner for its customers throughout the U.S., providing greater accessibility to the products, services, capabilities and industry-leading expertise needed to improve their processes and enhance business sustainability and profitability.

The $50-MM investment continues to increase the company's pace of innovation. The state-of-the-art facilities provide Alfa Laval customers access to the company's expert engineers and service centers designed to make it easier for customers to optimize their equipment and processes.

The company has expanded its facility in Richmond, Virginia with a new brazed heat exchanger production unit. This will provide customers in the U.S. with an enhanced and streamlined supply chain for this range of compact heat exchangers. As a result of this expansion, 90% of the most popular brazed heat exchanger models will be produced in the U.S.

Alfa Laval has also expanded its facility in Greenwood, Indiana to house a new, automated distribution center that, combined with a centralized transportation hub outside of Indianapolis, will shorten order lead times. The facility features state-of-the-art service center upgrades for reconditioning and repair of plate heat exchangers, decanters and high-speed separators. Plus, an all-new high-speed separation center of competence has been developed, offering factory acceptance, media testing, and hands-on customer training from expert Alfa Laval engineers.

The company has expanded its facility in Broken Arrow, Oklahoma with a new spiral heat exchanger manufacturing facility adjoining its existing air-cooled heat exchanger facility. Together, these facilities offer a Welded Competence Center for customers in these demanding market applications. ●

# SCENES FROM THE 2019 AFPM SUMMIT











**1** Shine 'em up! Johnson Matthey provided visitors to their hospitality suite the chance to kick up their feet and meet the company's team.

**2** Tuesday morning's Q&A panel, "Crude/Vacuum Distillation & Coking" featured (pictured left to right) **Steve Williams,** Marathon Petroleum Company; **Tim Sawyer,** CHS Inc.; **Raul Romero,** Nalco Champion; **Xiomara Price,** SUEZ – Water Technologies & Solutions; and **Maria Aldescu,** KBC Advanced Technologies.

**3** On Tuesday night, DuPont's "Jazz Night" featured a cool combo with The Voice contestant Lex Land out front.

**4** Calling all Superheroes! Axens had possibly the safest hospitality suite, and visitors were in good hands as they learned about the company's technologies.

**5** **Tom Berry** (left) and **Alejandro Vasquez** from Shell Catalysts & Technologies spoke during Tuesday morning's Principles & Practices session, "Digital Medicine for Living a Long Healthy Life: Refinery of the Future."

**6** **Rudy Torres** from Lion Oil Company and **Steve Treese** (pictured, right) of Becht Engineering led Tuesday morning's "High Salt Diet: Chloride Management—Sources and Effects" session.

**7** **Ralph Navarrete, Andrew Daily** and **Randy Rechtien** (left to right) introduced their refining customers to the new Baker Hughes: an energy technology company like no other.

**8** The Exhibition Hall provides the chance for companies to highlight their products and interact with potential clients.

**9** In Tuesday morning's Principles & Practices session, **Wendy Wildenberg** from Flint Hills Resources fielded questions and comments from a capacity crowd.

TANGO