

OPCAT: Using refinery-wide simulation models for optimization

ASHLEY SMITH, *Hydrocarbon Processing*

Organizations use simulation tools for unit optimization and as an overall refinery model. The question that Prachi Chapman from KBC Advanced Technologies Inc. wanted to answer at one of Tuesday morning's OPCAT sessions was simple: What are the capabilities of using a complex refinery-wide model, and then optimizing the model?

Ms. Chapman pointed out that recent advances in simulation technology have made it possible to investigate refinery-wide optimization.

"These refinery-wide simulation models have historically been used for setting economic points or process



Prachi Chapman, Senior Reactor Model Development Engineer at KBC Advanced Technologies Inc., explains how to take advantage of refinery-wide simulation models for optimization.

changes, such as re-routings, conversion changes, cut-point changes, introducing new units, or other process improvement studies," Ms. Chapman said.

Exploring the idea of using models for refinery-wide optimization is an alternative to how linear programming (LP) is developed today. Schematic models are used to develop LP vectors, most commonly with rigorous kinetic reactor models. This information is then used in the development of the LP.

"While a lot of time and resources go into making sure an LP is valid and reasonable within a limited range," Ms. Chapman said, "ultimately, LP is optimizing simplified representations of detailed kinetic reactor models."

These same companies also have a set of simulation tools, and uses for these models include localizing unit optimization and utilizing refinery-wide simulation models for CAPEX and "what if" studies.

"Can we put an optimizer around an entire rigorous refinery-wide simulation model to potentially assist in crude selection, or set the operational targets for an entire refinery?" Ms. Chapman asked the audience.

To test the theory and conduct a proof of concept test, Ms. Chapman explained that a hypothetical, 150-Mbpd conversion refinery was developed. It was then provided with five crudes of varying levels of density, sulfur and varying volume fractions.

Two case studies were presented: the first study varied the crude composition, while the second case study varied operating conditions.

▶ See **OPCAT**, page 3

Separating fact from fiction in ICS cyber attacks

ASHLEY SMITH, *Hydrocarbon Processing*

Industrial control system (ICS) cyber attacks seem to be more prevalent, and an increasing number of news stories are being published about them, increasing both awareness and concern. However, Robert Lee, CEO and founder of Dragos Inc., separated what is fact and what is hype during the Cyber security session Tuesday morning.

"ICS and cyber security are a little bit hyped-up at times," Mr. Lee said. "We are either never going to go down, and everything's perfect, and we can go back to manual operations for everything we do, and we do not need the Internet, or we are all going to die."

Before delving into a specific cyber attack, CRASHOVERRIDE, Mr. Lee began setting the stage by explaining what the real concern is (especially from an ICS standpoint), illuminating just how these attacks

occur and offering takeaways that companies can use when implementing their own defenses.

While the industry is and will continue to be bombarded by numerous technologies, the basics are the best place to begin, he explained.

"It is always the basics that present the most challenges," Mr. Lee said, "and the basics that we are able to master and utilize will make our industrial environments awesome."

Before tackling the issue of cyber security, one of the most significant challenges to overcome, particularly with national security, is bias. "Everything about our livelihoods, backgrounds and experiences shape our biases, and we see the world differently because of that," he said. "I find it interesting to hear people say, 'Well, China is going to do this, or Iran will do this.' I am a

white guy from Alabama who served in the national security community and now has a startup. All of those things have shaped my bias."

▶ See **CYBER ATTACKS**, page 3



Robert Lee, CEO and founder of Dragos Inc., dissects the major concerns surrounding ICS cyber attacks.

INSIDE THIS ISSUE

4 IHS Markit: Refiners and shippers scramble for low-sulfur requirements

The consultancy discusses the necessary investments to achieve compliance to the upcoming 2020 IMO regulations

6 Digital transformation: Field operations meet terminal management



The Implico Group's software solution for handhelds that makes mineral oil loading faster, simpler and safer

7 DSG system pilot test addresses operational, equipment issues

Pentair partners to enhance the performance and reliability of a chemical plant's DSG system

9 Industry collaboration delivers recommended practice to fight cyber threats



DNV GL launches globally applicable recommended practice to manage emerging cyber threats

12 The benefits of going wireless

WirelessHART by Emerson Process Management enables the consideration of applications without wired instruments

14 High-quality fuel and feedstock in the new crude price reality

Clariant catalysts to convert surplus FCC olefins into high RON gasoline

18 Scenes from the 2017 AFPM Summit

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OPCAT, continued from page 1

In the context of these case studies, the process models included rigorous, first-principle based calculations for conversion units and detailed tray-to-tray calculations for distillation columns. Because of the rigorous models, they were able to capture nonlinear responses, such as the impact of feed and operational severity on catalyst deactivation, the impact of distillation overlap on product specifications, and pumparound duty or condenser duty constraints.

“Modeling is always a trade-off between how much rigor, robustness and speed you want to put into the model, particularly when you start looking at optimization,” she said.

For the test, they created a balance between more rigorous tray-to-tray columns, semi-rigorous distillation and component splitters. The two blenders used in this test were local, non-linear optimizations themselves, where the refinery was trying to maximize profit by picking the select blend component.

Optimization cases in increasing levels of complexity were run. In the first case study, they varied the crude composition but kept the rate and all unit operating conditions fixed. The second case study had the crude composition fixed, and opened up several operating conditions, as well as the crude rate.

Ms. Chapman explained how they determined the validity of the results by running the exact same optimization more than 30 times from different starting points. This showed that, depending on where a refinery’s operations started, the same optimum consistency was achieved.

For the purposes of the case studies, the constraints were kept simple, similar to LP constraints, but more detailed constraints are possible with a refinery-wide simulation model. The constraints used for testing are representative of column flooding limit, feed or product pump limits, heater limits, etc.

The tests were run on multiple standard desktops, each with similar results. A nonlinear algorithm was also used. Runtime for the first case study was around half an hour, while the second case study had a runtime of 4.8 hours.

Several takeaways were revealed from the case studies. The practical application is in planning. After the crude slate is set by the LP, the refinery-wide simulation model can then optimize the operations of the process units.

“This takes advantage of the detailed nonlinear reactor models and the more differentiating hydrocarbon stream characterization detail,” Ms. Chapman said.

Another practical application is that, rather than LP directionality, a refinery can potentially make a more precise operational plan, depending on how confident the user is with the results.

Refinery-wide optimization is showing promise, but its development might still be too slow to completely replace LP for crude selection. Refinery-wide optimization is more rigorous, and it can augment LP as well as double-check crude selection results.

At KBC Advanced Technologies Inc., Ms. Chapman specializes in kinetic reactor model development for FCC, delayed coker and furnace units. ●

CYBER ATTACKS, continued from page 1

As Mr. Lee explained, bias shapes the way we perceive the industry, and it can create an atmosphere—or an outlook of where the industry will go—that drives companies to security investments that may not always match what the industry needs or dictates.

“Ultimately, our threat landscape is mostly unknown,” Mr. Lee said, “and until we can plot a course to solve that, copying and pasting best practices of IT and ICS simply will not cut it.”

The environment created by hype is what leads to bias and over-spending on security investments. Hype is created and perpetuated by the shortage of personnel within ICS security who really understand their industrial operations.

Hype is also created when metrics and numbers are misconstrued, Mr. Lee explained, especially when analytics are left out altogether. “One of the things ICS-CERT always highlights is specifying and tracking how much manufacturing was hit, and how much oil and gas was hit.”

Misconceptions. Mr. Lee explained the two most relevant misconceptions people have about those metrics. The first is, “What counts as an attack?” For example, when someone contacts ICS-CERT to report that they have received a phishing email, a trouble ticket is opened. If that same person comes back to say, “Never mind, it was a mistake,” it is still counted as an attack.

“This is not an accurate incident counter,” Mr. Lee said. “It is a trouble ticket counter.”

The second misconception in the industry is not about the number of people who have been attacked, but rather the number of people that are reporting it. The one metric that never gets highlighted, he adds, are the attack factors.

In 2015, there were a total of 295 incidents, and the majority (the same every year, according to Mr. Lee) are unknown. “If we even detect the threats, the metrics might say that it is because IT caught it going into the ICS. If we caught it only in the ICS, we have no idea how it got there,” Mr. Lee said.

To break down how security is viewed, Mr. Lee has developed a slid-

ing scale of cyber security. Moving from left to right, the scale includes:

- Architecture
- Passive defense
- Active defense
- Intelligence
- Offense.

“A lot of the value ends up on the left side of the scale,” Mr. Lee said. “Architecture is getting it right from the first stance, keeping things patched and maintained, understanding assets and serving as the core foundation.”

Where cyber security should go, and has yet to reach, is toward the right side of the scale, beginning with active defense. This is more of a human focus, rather than relying on tools.

“As someone who has been on the offense before, I can get copies of your tools and I can run circles around them,” Mr. Lee said. “On the other hand, I cannot run circles around your people because I have never met them. Your people will always present the most difficult barrier for any adversary to cross.”

Knowledge is power. Information sharing is also important to becoming more proactive with cyber security, and not just against an adversary, but also against the techniques and methodologies used.

“Real information sharing says, ‘Here is the adversary and attribution does not matter; here is their tradecraft and what is novel about it; here is how we were challenged when responding to it; here is where we failed as an organization, or did really well; and here are the lessons we have learned,’” Mr. Lee said.

The major takeaways from the CRASHOVERRIDE cyber attack, he explained, include the fact that it was a framework rather than a single piece of malware that installs and exports, and there were no vulnerabilities. What it was doing is effectively using operational knowledge against the equipment.

“That matters for other industries because companies are probably prioritizing patching and firewall tuning,” Mr. Lee said. “The problem is, of course, that if they are using the equipment against you, you may not

actually see that. You must be very proactive, and that human element needs to be added into the environment to maintain vigilance.”

In addition to being the CEO and founder of the industrial cyber security company Dragos, Mr. Lee is also a non-resident National Cyber Security Fellow at New America, which focuses on policy issues relating to

cyber security of critical infrastructure. He has authored several courses on ICS, with accompanying certification. Previously, Mr. Lee served in the US Air Force as a cyber warfare operations officer and worked in various government organizations, including establishing the first ICS/SCADA cyber threat intelligence and intrusion analysis mission. ●

SCHEDULE OF SESSIONS AND SPECIAL EVENTS

WEDNESDAY, OCTOBER 4, 2017

7:30–10 a.m.	Registration
8–9:30 am	Concurrent Sessions: <ul style="list-style-type: none"> • Cybersecurity • Principles & Practices—FCC • Principles & Practices—Fostering Profitability
9:30–9:45 a.m.	Coffee Break
9:45–11 a.m.	Concurrent Sessions cont.



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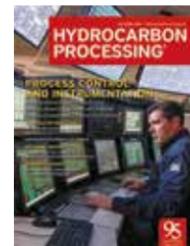
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IHS Markit: Refiners and shippers scramble to meet low-sulfur requirements

The International Maritime Organization (IMO) recently confirmed that global refiners and shippers must comply with new regulations to reduce the sulfur content in marine bunker fuels by January 2020—five years earlier than widely expected. As a result, both the global refining and shipping industries will experience rapid change and significant cost and operational impacts, according to new analysis from IHS Markit, a leading global source of critical information and insight.

“While the IMO is taking positive action to address the environmental impacts of air pollution from ships, the rapid change creates significant disruption for both the refining and shipping industries,” said Kurt Barrow, Vice President of downstream research at IHS Markit. Mr. Barrow, along with Sandeep Sayal, Senior Director of refining and marketing research at IHS Markit, are two authors of an IHS Markit report, “Refining and shipping industries will scramble to meet the 2020 IMO bunker fuel rules.”

The report asserts that both the shipping and refining industries are “vastly unprepared,” and that neither have

made the necessary investments to achieve compliance. “The 2020 implementation date will result in a scramble,” said Mr. Sayal. “Both industries are taking a wait-and-see approach until firm signals are in place by the IMO for compliance with the regulation.”

Both industries will face significant costs. Shippers will have to upgrade equipment or switch to more expensive fuels, and refiners will experience significant price impacts as they shift production to deliver more lower-sulfur fuels to the market and, at the same time, find a market for the higher-sulfur fuels they produce. Mr. Barrow said, “Refineries, like ships, do not turn on a dime, so it takes significant investment and market demand to re-tool a refinery to deliver new supply.”

Compliance options. According to IHS Markit, shippers will have numerous options to meet the new IMO regulations, including low-sulfur bunker fuels—primarily for smaller vessels—and liquefied natural gas (LNG)—primarily for newbuilds. However, it is expected that onboard ship scrubbers, which clear harmful pollutants from exhaust gas, will be the primary compliance path for

ships, which could continue to burn higher-sulfur fuels.

IHS Markit estimates that approximately 20,000 ships account for around 80% of heavy fuel oil bunker fuel use (FIG. 1). As there is presently no economic incentive for the ships to add scrubbers, only about 360 ships have installed scrubbers. However, based on the price spreads between low-sulfur bunker fuel and high-sulfur fuel oil during the scramble period, it will be economic for many of them to install scrubbers. According to Krispen Atkinson, Senior Consultant, IHS Markit Maritime & Trade research, “The payback period for installing a scrubber on the largest vessels would be two to four years in 2022–2025, and less than one year based on peak price spreads in 2020.”

A key uncertainty also lies in the actual level of compliance to the IMO regulation in 2020. “Not only is it hard to enforce compliance in the open seas, but it is still uncertain if sufficient supplies of compliant bunker fuels will be broadly available in all ports,” Mr. Sayal said.

Disrupting the refined products market. Overall, the installations of scrubbers and some level of noncompliance will not be in time to halt the disruption on refined products markets, IHS Markit said. The primary challenge with the bunker fuel quality change (which requires sulfur content to be reduced from 3.5 wt% to 0.5 wt%) is the disposal of high-sulfur residual fuel, and not the production of low-sulfur bunker fuel (FIG. 2).

“When we account for all the supply and demand factors for the sour residual balance, including new conversion projects, capacity creep, scrubber and LNG capacity, as well as quality compliance, our bottom line is that a sizable portion of today’s fuel oil will be pushed into lower-price tiers, notably oil-fired power-generation plants,” Mr. Barrow said. “Refining capacity will most likely exist in 2020 to produce the low-sulfur bunker fuel, but higher overall crude runs will be required.”

The largest refinery margin disruption will be significant but fleeting, according to the IHS Markit report, with impacts felt most notably in

2020 and 2021. IHS Markit expects an unprecedented light-heavy price spread during 2020–2021, when pricing for high-sulfur fuel oil (HSFO) will have to be near thermal parity with coal to clear into the power market—a very low price relative even to today’s fuel oil price.

As ship owners respond to the large-scrubber investment incentives, high-sulfur bunker fuel demand will rebound, although not to prior 2020 levels. Due to increasing demand and the addition of debottlenecking capacity for residue conversion, IHS Markit estimates that price spreads will moderate within a few years, depending on a number of variables.

Refiners to benefit. Refiners will produce more distillates (higher-value components derived from crude) as new demand arises for these products during the disrupted years, IHS Markit said. With HSFO priced at coal-thermal parity and demand for middle distillates (kerosene, jet fuel, diesel) increasing to blend to low-sulfur bunker fuel, refining margins will benefit, but in different ways.

“Refiners of sour crude will be negatively impacted by the nearly valueless sour crude residue, while refiners of sweet crude conversion will experience moderately higher margins, but sweet crude prices will reflect the low-sulfur residue value,” Mr. Barrow said. “It is the high-conversion refiners of sour crude that are expected to have extraordinary margins.”

According to the report, highly complex refineries benefit the most from the IMO specification change, as these refineries will produce the least amount of residual fuel oil and the highest amount of distillate and gasoline compared to lower-complexity refineries.

Crude price relationships, specifically between light-sweet and heavy-sour crude, will widen around the compliance timeframe, IHS Markit said. Assuming the specification change implements as announced on a global and instantaneous basis with no phase-in timing or quality transition allowances, the margin uplift will be acute in the compliance period from 2020–2021. ●

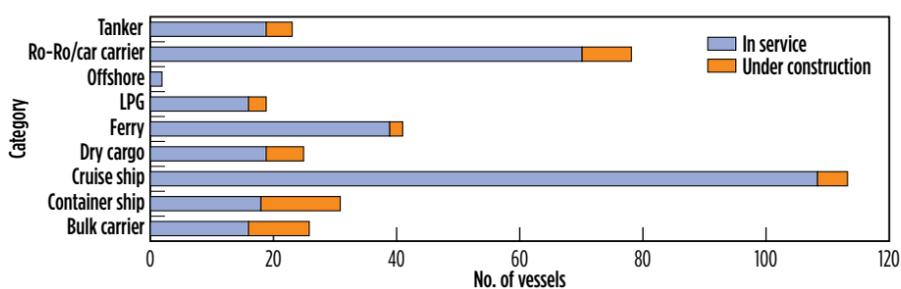


FIG. 1. The number of vessels fitted with scrubbers, by vessel type. Source: IHS Markit.

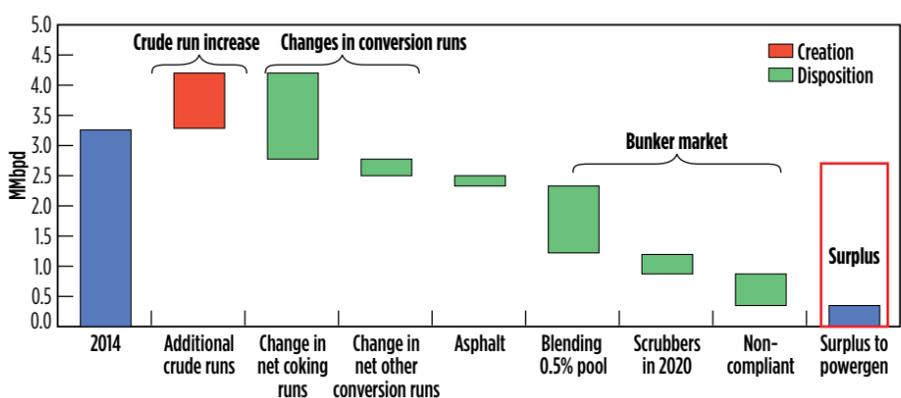


FIG. 2. Global residue in bunker sector, 2014 vs. 2020. Source: IHS Markit.

INNOVATING ALARM MANAGEMENT

PAS Global LLC, a leading solution provider of ICS cybersecurity, process safety and asset reliability in the energy, power and process industries, has released PlantState Suite™ (PSS) 8.3 featuring Alarm Mechanic. This new feature helps improve process plant safety and console operator performance, minimizing nuisance alarms through automated analytics and recommendations.

PlantState Suite makes power and process plant operators more effective at identifying, evaluating and managing alarms. The company says that PSS is the industry’s most comprehensive, integrated abnormal situation management software platform

designed to optimize independent protection layers (IPL), such as process control loops, alarms, safety instrumented systems (SISs) and pressure relief systems. With PSS, companies gain:

- Improved operator situation awareness and effectiveness
- Greater speed and accuracy in detection and response to abnormal situations
- Reduced severity of process upsets
- Safer, more profitable plant operations.

With the addition of Alarm Mechanic, PSS 8.3 fully automates complex analyses that determine alarm delay time settings. Delay time is a critical

method for solving nuisance alarm problems. Leveraging decades of PAS project experience and a proprietary master alarm database, Alarm Mechanic replaces manual calculations and guesswork with automated, deterministic recommendations that ensure consistent and optimal settings.

PSS 8.3 also enhances support for corporate operational excellence programs and risk-tracking dashboards. The new release also eases integration and enables custom alarm analytics.

PAS technologies are deployed throughout 13 of the top 15 chemical companies and 10 of the top 15 refining companies in the world. ●

OPCAT: Advanced predictive analytics for column flooding events

In Monday morning's OPCAT session, Dr. Jose Bird, Director of Advanced Analytics for Valero, and Jill Brown Burns, Director of Process Technology for Valero, presented their paper, "Use of Advanced Predictive Analytics for Early Detection and Warning of Column Flooding Events."

In this paper, they implemented a methodology to predict crude distillation tower flooding events based on key process variables, including product yields, column pumparound flowrates, column temperatures and overhead reflux flowrate. A logistic regression model was selected as the predictive tool due to its ability to differentiate flooding events from non-event data, as well as the ease of implementation.

As column flooding events occurred

very infrequently with an incidence rate of about 0.25% for the distillation tower considered, an over-sampling technique was used to improve the model sensitivity to flooding events. Several models were constructed using different time lags of the predictor variables and compared using receiver operating characteristic (ROC) curves, which provide the relationship between the model event detection rate and the model false alarm rate. The final model selected was validated against a stationary monitoring study and radioisotope scans of the column. The model was then implemented in the data historian system to provide early warning to engineering and operations of potential flooding events for corrective action. ●



In Monday morning's OPCAT session, Valero's **Dr. Jose Bird** (pictured) and **Jill Brown Burns** presented their technical paper.

THE ALKYLATION SEESAW



At DuPont's well-attended and informative pre-conference workshop on Sunday, Samantha Presley, Business Development Manager for alkylation technology, provided the details and technological benefits of DuPont's STRATCO® alkylation technology.

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Digital transformation: Field operations meet terminal management

The digital transformation of business continues to progress, and the downstream segment is no exception as demand increases for solutions that can replace the remaining paper-based processes.

The Implico Group has developed a software solution for handhelds that makes mineral oil loading faster, simpler and safer, enabling tank terminal operators to take the next step toward embracing the Internet of Things (IoT). The new, mobile solution connects employees in the field directly to the OpenTAS terminal management system to ensure that important information is immediately available everywhere. It also supports staff in the visual inspection of tank trucks and railcars.

With its new software solution for handhelds, the Implico Group is now enabling digitalization in an area that was previously almost inaccessible: product loading in relation to railcars, ships and pipelines.

Easy recording of incoming railcar and tank truck data. Operations staff at refineries or tank terminals can digitally record incoming railcar and tank truck data using handheld devices and the new software, eliminating the need for subsequent entry of manual notes into the terminal management system. The solution is faster, more cost-efficient and avoids typical errors associated with manual data entry.

The application uses a predefined checklist to guide employees step by

step through the handling process, increasing process safety by preventing staff from forgetting steps.

System-based visual inspection. The checklist also supports the visual inspection of vehicles and loading, as prescribed by hazardous materials legislation for the transportation of dangerous goods. A history function in the application permits the entry of details such as earlier damage to a vehicle, enabling personnel to carry out targeted inspections of such areas.

In many countries, vehicle compartments are sealed with special steel seals once loading is complete. Instead of painstakingly writing down complex seal ID numbers, employees need only a few seconds to scan in the numbers with the handheld application. This data is then stored immediately in the terminal management system.

Transparency and quick access. The new handheld application closes the previously existing digital gap between operations (FIG. 1) and the terminal management system. Refinery or tank terminal personnel can access the OpenTAS terminal management system during their work in the field, which results in substantial efficiency gains. For example, if the vehicle data is already stored in OpenTAS, then it is shown to the employees as the default entry, so they do not need to enter the data again. Conversely, all data input by the operator is relayed back in real time, which means that the latest process information is visible immediately to the other team members.

The system can also be used to confirm which operator performed which tasks, and when.

Preventing product contamination. The solution's unique real-time transparency and the soon-to-be-available background checking feature can also be used to prevent product contamination. Since the system is always up to date, it can report immediately if processes running in parallel may result in product contamination.

This kind of integration into process planning and monitoring, in particular, is innovative in the context of terminal and refinery logistics. The only alternative to achieving the levels of transparency and safety that are now available with Implico's standard solution would involve major investment in connected automation in all areas of logistics.

Close cooperation. Development work performed by Implico involved close collaboration with hardware makers Honeywell and ECOM, as well as with several petroleum companies. Future implementations will also require close collaboration with the companies that will adopt the solution.

The solution is compatible with any make of device, including those intended for use in explosion hazard areas. Back-end functionality is provided by the OpenTAS Web Application Server. The handheld clients are connected in real time and access the solution via a browser. This enables true real-time transparency for logistics processes. ●



FIG. 1. The new handheld solution connects employees in the field directly to the OpenTAS terminal management system to ensure that important information is immediately available everywhere.

IFS: 84% OF INDUSTRIAL COMPANIES FACE GAP BETWEEN IOT AND ERP

IFS, the global enterprise applications company, has released a primary research study on how the Internet of Things (IoT) affects readiness for digital transformation in industrial companies. According to a survey of 200 IoT decision-makers at industrial companies in North America, only 16% of respondents consume IoT data in enterprise resource planning (ERP) software. That means 84% of industrial companies face a disconnect between data from connected devices and strategic decision-making and operations, limiting the digital transformation potential of the IoT.

The study posed questions about degrees of IoT sophistication, and explores how well companies' ERP, enterprise asset management (EAM) or field service management (FSM) software prepares them for digital transformation and to consume IoT data within enterprise software.

Respondents were divided into groups, including IoT "leaders" and IoT "laggards," depending on how well their enterprise software prepared them to consume IoT data—as well as digital transformation "leaders" and digital transformation "laggards," depending on how well their enterprise software prepared them for digital transformation.

- The two leaders groups overlapped, with 88% of digital transformation leaders also qualifying as IoT leaders, suggesting that the IoT is a technology that underpins the loose concept of digital transformation.

- Digital transformation leaders made more complete use of IoT data than digital transformation laggards; leaders are almost three times as likely to use IoT data for corporate business intelligence or to monitor performance against service level agreements.
- Digital transformation leaders were more likely than digital transformation laggards to be able to access IoT data in applications used beyond the plant floor. They were more than four times as likely to have access to IoT data in EAM software, twice as likely than digital transformation laggards to be able to access IoT data in high-value asset performance management software, and almost twice as likely to be able to use IoT data in ERP.
- The data suggests a real need for more IoT-enabled enterprise applications designed to put data from networks of connected devices into the context of the business.

In reviewing the findings, IFS Chief Technology Officer for North America, Rick Veague, commented, "Are your planning and maintenance systems robust enough to make real-time decisions using IoT-sourced data? Many are facing the reality of having to answer 'no.' We have seen examples of companies coming to us because their incumbent software is not able to administer and use IoT data to achieve the gains they want to realize."

Steve Andrew, IFS Vice President of Marketing for North America added, "Long before the term IoT was coined, IFS was committed to introducing machine data into enterprise applications. With the release of the IFS IoT Business Connector, we are

in a better position than ever to help our customers operationalize their IoT data. This study data shows that this technology is required to connect the IoT with strategic data from around their organization. In turn, this allows businesses to use the IoT not just for cost avoidance strategies like condition-based maintenance, but to add new or enhanced product or service lines, increase enterprise agility and realize the growth and revenue benefits of digital transformation."

OLIN LIFTS FORCE MAJEURE FOR PRODUCT SHIPMENTS FROM FREEPORT, TEXAS

Olin Corp. is lifting the force majeure declared on August 31 for all product shipments—except phenol, acetone, methyl chloride, methylene chloride and chloroform—from its Freeport, Texas facility.

Olin was forced to reduce production at the facility due to supply and logistic constraints from truck, railroad and marine transportation caused by severe flooding resulting from Hurricane Harvey. Olin's 3Q 2017 adjusted EBITDA will be reduced by approximately \$40 MM, representing incremental costs to continue operations, unabsorbed fixed manufacturing costs and reduced profit from lost sales.

Isolated transportation, raw material and customers' issues will continue to be experienced in both the Chlor Alkali Products and Vinyls and Epoxy segments into 4Q 2017. The impact on 4Q 2017 adjusted EBITDA is expected to be significantly less than the 3Q 2017 impact. ●

DSG system pilot test addresses operational, equipment issues

Critical to ethylene production in chemical plants, dilution steam helps reduce the partial pressure of hydrogen (H_2) and shifts the equilibrium of the chemical reaction toward an increased cracked gas yield. Dilution steam generators (DSG) are large columns filled with trays or packings and act as saturators. Smooth operation of the DSG is one of the most important process objectives in chemical plants, as it can have a huge impact on the cracker furnace yield. Challenges to this operation arise from the quality of feed water that is recycled from the quench towers after pretreatment, which consists of conventional filtration and coalescers, but is typically ineffective in removing the highly emulsified hydrocarbons and coke fines from feed water.

The reboilers, which are part of the DSG and provide the source of heat, must be taken offline frequently for cleaning before being put back into service. This results in higher costs and reduced profitability due to downtime and lost production. Some plants measure the HP steam flowrate to the reboilers as an indication of progressive fouling to predict the next cleaning cycle. In the chemical plant in this case study, this cycle had never exceeded two to three weeks.

Pentair partnered with a chemical plant to enhance the performance and reliability of its DSG system. This partnership came on the heels of the past performance of another Pentair system, Hydrocarbon Recovery Technology, for its highly emulsified quench water stream.

Test and validation. The first step began with an inline pilot test at the facility that involved a pre-filter and coalescer. The test results doubled the run length and online life by 100%, despite operational issues concerning level control in the coalescer vessel. It was also discovered that the technology held a constant HP steam flowrate through manual control.

The results of this pilot test are represented in **FIG. 1**. Prior to conducting the pilot test, the plant had never seen any dP buildup on the pre-filters or any hydrocarbons in the top drain of the coalescer. Both the top and bottom drains of the coalescer vessel were completely blocked and had to be dismantled to enable free flow of recovered hydrocarbons. Pentair's work at the customer's facility included helping with the resolution of these operational issues and optimizing the drainage of hydrocarbons from the top of the coalescer vessel.

The success of this pilot test validated that Pentair separators and filter elements are protecting critical equipment and dramatically save operational costs and resources. Due to the success of this pilot test, the customer chose Pentair to upgrade the entire existing DSG system with highly efficient separation equipment. These technologies are used to help facilitate balanced systems that are highly stable, reliable and robust, increasing throughput, reducing operating cost and minimizing waste. The company's technologies help solve the most critical separation and extraction issues for the gas, refining, chemical and power generation industries. ●

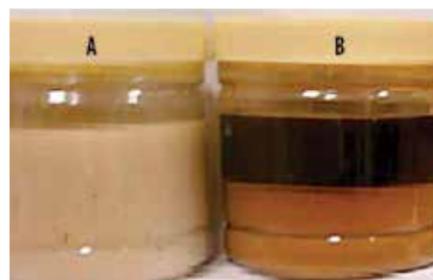


FIG. 1. During the pilot test, the top and bottom drains of the coalescer vessel were found to be completely blocked and had to be dismantled to enable free flow of recovered hydrocarbons. Here are shown the inlet to prefilter (A) and the hydrocarbon recovered from the coalescer top drain (B).

TAKING THE TIME



One of the most important benefits of the AFPM Summit is the opportunity to meet new contacts, establish relationships and connect with friends. During a networking break on Tuesday, associates discuss industry news and exchange knowledge.

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Operational excellence: The path to world-class performance

PHIL MURRAY, Petrotechnics

Why is operational excellence (OE) increasingly being recognized as the path to world-class performance? A recent, industry-wide survey across health, safety and environment (HSE), maintenance and operations professionals has provided a real insight into the industry's thinking on the opportunities and challenges associated with OE.

The respondents overwhelmingly agreed that OE is "the unrelenting pursuit of world-class operational performance." Pressure to improve productivity and efficiency, along with increasing scrutiny from regulators and the public, is higher than ever. As a result, organizations are moving toward an enhanced operating model, one driven by the pursuit of OE.

Broad consensus exists that the successful implementation of OE is essential to the future success of the hydrocarbon processing business, with over 95% of respondents saying that it is "important" to their organizations (FIG. 1).

The overwhelming majority of those surveyed recognized that OE success means that everyone in their organization is able to make better-informed decisions that reduce risk, improve productivity and reduce costs. OE starts with a more integrated approach to operations management.

Productivity, risk and cost are inextricably linked, and the key to OE is to enable everyone, from the boardroom to the frontline, to better understand how their decisions impact their part of the business. The challenge is that company personnel are struggling to get a view of operational reality through what can be a blizzard of complexity.

Senior executives are learning the same painful lessons as NASA—that the myriad of key performance indicators (KPIs) provide little insight into the reality of their operations. The NASA Space Shuttle program was collecting 600 metrics per month (right before the loss of the Columbia

space shuttle), none of which turned out to be helpful in predicting the loss or identifying the clear migration of the program to states of increasing risk. The author found a similar story in Texas City, when he worked on the team brought in to provide operational stability immediately after the refinery explosion incident.

If OE is about better decisions, then a simpler approach is required that connects disparate processes and people in a way that allows everyone to visualize and manage risk and operations in a new way.

The survey recognized the role of digital technology in OE, with over 92% agreeing that it is a key enabler. What is required is a shared view of operational reality where everyone knows what is happening, where it is happening and when it is happening.

A recent whitepaper detailed that companies that implement best-practice OE programs see an average increase in production by 29%, are able to reduce costs by up to 43%, and improve asset uptime/availability by 29%. Additional benefits that can be gained by leveraging OE are shown in TABLE 1. The author's company's survey and the industry whitepaper present a strong argument that OE has never been more necessary; and with technology, it has never been more achievable. As the whitepaper points out, "With new technological advancements, we have the potential to improve business functions across the industry ... technology has caught up with the industry's needs."

The value of technology is seen when it connects people and processes with data-derived insight. This idea is not just about spending billions more on integrating maintenance management systems and planning systems, while wrench-time and plan attainment remain stubbornly resistant to improvement. The right technology does not replace skilled, knowledgeable or experienced people. Instead, it enables everyone in an organization to manage activity in a practical, joined and routine way. It empowers people to consistently make the best possible operational decisions.

Top-performing companies arm everyone, from the CEO to the per-

sonnel working in the plant, with the right information to understand the wider impact of their actions. This is the foundation for delivering on the true potential of OE. Only a connected enterprise can achieve OE. If the industry is to achieve the performance that current conditions demand, organizations must be more connected.

By replacing silos with an enterprise platform and by connecting data horizontally across the organization, every person can be given the information required to make better, safer, smarter operating decisions.

OE in practice. This approach to OE offers context for key operational decisions at various levels, in support of strategic objectives for oil and gas operators around the world. As an example, in preparation for running a large onshore operation in the Middle East, one hydrocarbon operator is using an OE platform as a risk advisory and activity management tool. The platform is integrated with the operator's maintenance management system (MMS) and equipment status historian. For short-term schedule optimization, the platform displays high-risk areas in future shifts (14 d ahead) based on deviations captured from the historian and planned activities based on the maintenance schedule. This schedule is optimized based on resource utilization.

Within the OE platform, the execution of maintenance, and those activities associated with the maintenance schedule, are managed, such as removing equipment from service, depressuring, draining and purging, and installing energy isolations. Also included are ancillary activities, such as scaffolding erection and crane utilization.

Once built, the full schedule of work can be checked, and where necessary, optimized based on expected risk levels. The revised schedule is then synchronized with the MMS.

The OE platform helps manage operations activities, permitted and non-permitted work, while providing real-time visualization based on time, space and risk—to help identify what is happening on the plant, when and where—in terms of all activity and risk. ●

In 1989, PHIL MURRAY recognized the need to provide technology-based solutions to hazardous industries to reduce operational risk, and to help them move beyond compliance to optimize operational performance and drive continuous improvement. In response to this need, he founded Petrotechnics, and is now responsible for managing and driving global teams to support Petrotechnics' customers in more than 22 countries. For more than 25 yr, Mr. Murray has been instrumental in changing the way people work, giving them the tools to manage the relationship between operational performance and risk. Prior to founding Petrotechnics, he spent 10 yr with BP in a variety of technical, operational and managerial roles.



FIG. 1. OE survey infographic shows importance of OE to energy industry professionals. Source: Petrotechnics.

TABLE 1. Potential benefits of leveraging OE programs

Reduce emergency and reactive work by 90%
Add up to 30% of value to the production asset base
Reduce total operating costs by 43%
Improve HSE metrics and reduced incidents by 43%
Increase asset uptime/availability by 29%
Increase oil and gas production by 29%
Achieve schedule compliance of more than 80%

Industry collaboration delivers recommended practice to fight cyber threats

While the benefits of digitalization in the oil and gas industry are profound, they are also causing cyber risks to increase. Almost 68% of oil and gas companies were affected by at least one significant cyber incident in 2016, and many attacks are assumed to have remained undetected or unpublished. Based on a joint industry project, DNV GL is now launching a globally applicable recommended practice (RP), DNVGL-RP-G108, addressing how oil and gas operators, system integrators and vendors can manage emerging cyber threats.

Critical network segments in production sites (FIG. 1), which used to be kept isolated, are now connected to networks, making operational technology (OT) more vulnerable. According to recent research, 59% of oil and gas companies surveyed believe that the risk is greater in the OT segment than in the IT environment. Managing threats toward OT requires knowledge beyond general information security, such as oil and gas operational domain competence, in particular related to automated, unmanned, integrated and remote operations that are accessible online.

The new DNV GL recommended practice, “Cyber security in the

oil and gas industry based on IEC 62443,” is the result of a nearly two-year joint industry project (JIP) with partners Shell Norge AS, Statoil, Woodside, Lundin Norway, Siemens, Honeywell, ABB, Emerson and Kongsberg Maritime. The Norwegian Petroleum Safety Authority has observed the work and exchanged experiences with the JIP group from a regulatory perspective. The RP is based on the IEC 62443 standard, international practice and professional experience, and takes into account HSE requirements and the IEC 61511 functional safety standard. It outlines a tailored approach for the oil and gas industry on how to build security, with the emphasis on OT.

The scope of the RP encompasses guidance on how to use the IEC 62443 series of standards for projects and operational phases, including good practices and a reusable approach, and is tailored for oil and gas onshore and offshore operations. The IEC standards define what to do, while the RP describes how to do it. Implementation will result in:

- A reduced risk of cyber security incidents
- Cost savings for operators by reducing the resources

needed to define requirements and follow up

- Cost savings for contractors and vendors based on standardized design requirements from operators
- Simplified audits for authorities and auditors due to common requirements and common conformance claims.

A joint statement from the vendors involved in the RP states, “Our customers in the oil and gas industry are, to a large extent, facing the same types of cyber threats found in information technology systems. Being able to standardize what we deliver to our customers is important in reducing cyber risks and lowering costs. The RP will increase the safety, availability and reliability of operational technology systems. The organizations operating the systems can also manage cyber risks by following and implementing the identification, protection, detection, response and recovery steps defined in the standards to withstand cyber attacks. In the process of defining this RP, we have collaborated with both our competitors and our customers on guidance to the IEC 62443 series of standards.”

Pål Børre Kristoffersen, JIP Project Manager for DNV GL–Oil & Gas,

says, “Industry players need confidence that security countermeasures can deal with more frequent and sophisticated cyber attacks, which are becoming increasingly costly and harder for companies to recover from. While the awareness of cyber security requirements that must be in place is growing, there has, until now, been a lack of guidance for the oil and gas industry on how to implement these requirements. The new RP, developed in collaboration with key players, puts OT and IT in the limelight, so that the oil and gas industry can protect their operations.”

DNV GL is a technical advisor to the oil and gas industry, bringing a broader view to complex business and technology risks, and setting standards for technology development and implementation. ●



FIG. 1. Managing cyber threats toward OT requires knowledge beyond general information security.

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IFP Group Technologies

A new dimension in pipeline safety

HARTMUT LEISTNER, HIMA

Leak detection and localization systems monitor critical parameters in pipeline operations and allow leaks to be detected and located as quickly as possible. Operators have traditionally used conventional monitoring systems without safety orientation for this purpose. The world's first hybrid solution from HIMA, composed of an SIL3 safety controller and a leak detection and localization system, significantly boosts pipeline safety and profitability within refineries and petrochemical facilities.

Pipelines must fulfill strict requirements for safety, availability and environmental protection, and leaks pose considerable risks (FIG. 1) to personnel, the environment and the potential loss of reputation. In many cases, the losses from cleanup tasks and fines are much greater than the actual loss of resources.

Pipeline operators should utilize a leak detection system for their fa-

cilities. In many countries, the implementation of best business practices for plant operation is prescribed. If an incident occurs, the operator is always jointly responsible and, depending on the legal scenario, management can even be held liable if they operate a pipeline without a modern leak detection system. Insurance companies can amend their policies according to the leak detection technology, reduce premiums or refuse coverage if a suitable system is lacking.

Growing statutory requirements. Pipeline operators are also confronted by growing statutory requirements of the safety integrity level (SIL) and cyber security. A variety of international standards for pipeline integrity management must be taken into account: the two main standards are the US standards API 1160, which provides general guidance on overall pipeline integrity management, and

API 1130, which focuses specifically on leak monitoring.

New compliance topics arise from legislation, such as California Assembly Bill 864, which requires pipeline operators to deploy the best available technologies in environmentally sensitive areas to limit the amount of escaping oil in the event of a leak.

Shortcomings of conventional leak detection systems. The four biggest challenges facing pipeline operators with regard to leak detection systems are excessive false alarms, failure to detect leaks, the lack of leak localization and costly or complicated maintenance.

A horizontal pipeline has a steady flow with a constant volumetric flowrate and a linear pressure drop along its length (FIG. 2). A leak changes the hydraulic behavior of the pipeline: the flowrate is greater before the leak than after the leak, resulting in a pressure drop ahead of the leak location that is steeper than after the leak. The pressure also declines slightly at both ends of the pipeline. A leak detection system attempts to recognize these features and determine whether an unplanned outflow is present and where it is located.

In practice, conventional leak detection systems using only pressure sensors often generate false alarms, as a detected pressure drop in the pipeline does not always mean that a leak is present—it can also result from operational factors. These systems are generally prone to measurement errors and are dependent on sensor positioning.

A new hybrid solution for reliable leak detection. The new FlexSILon PMC pipeline management solution, the first to combine leak management with emergency shutdown, not only protects the facilities concerned but also controls and manages safety-relevant processes (FIG. 3). The key components of the integrated hybrid solution are the SIL3 safety system and the leak detection and localization system.

Flowrate monitoring runs directly in the SIL3-capable HIMax safety hardware, with pressure and tem-

perature data transmitted to the control center for visualization via the SafeEthernet protocol developed by HIMA. The HIMax systems are also connected to each other over SafeEthernet, so each system knows the state of the overall pipeline. If a leak occurs, the HIMax controller automatically adjusts the flow and, in an emergency, shuts down the pipeline immediately, enabling the system to prevent or significantly reduce damage. The safety controller is based on HIMA's XMR technology, which combines SIL3 safety hardware and software with a scalable, fault-tolerant architecture to avoid nuisance trips.

An important part of FlexSILon PMC is the FLOWorX software for leak detection and localization, which enables operators to constantly monitor flowrates, pressures and temperatures in their pipelines. Anomalies are reliably recognized. The system also supports pressure and temperature correction calculations. In addition, the FLOWorX software can detect pipeline rupture and ensure that the damaged pipeline section is automatically shut down in the event of rupture.

Operators can flexibly adapt the detection algorithms to their specific needs. Unlimited changes and even prescribed verification tests during ongoing system operation according to the SIL3 standard are possible. Thanks to open interfaces, the system can be integrated into virtually every automation environment. Along with the automation components necessary for management, control and monitoring of gas and liquid pipelines, the package includes customer support and service.

Precise leak localization. The SIL3-capable leak localization system conforms to the relevant standards, including API 1130. To ensure continuous system availability, leaks are analyzed and localized by several methods: the enhanced pressure wave method, the volume/mass balance method and the pressure drop method are used either individually or in combination, depending on the nature of the damage and the operating state of the pipeline.

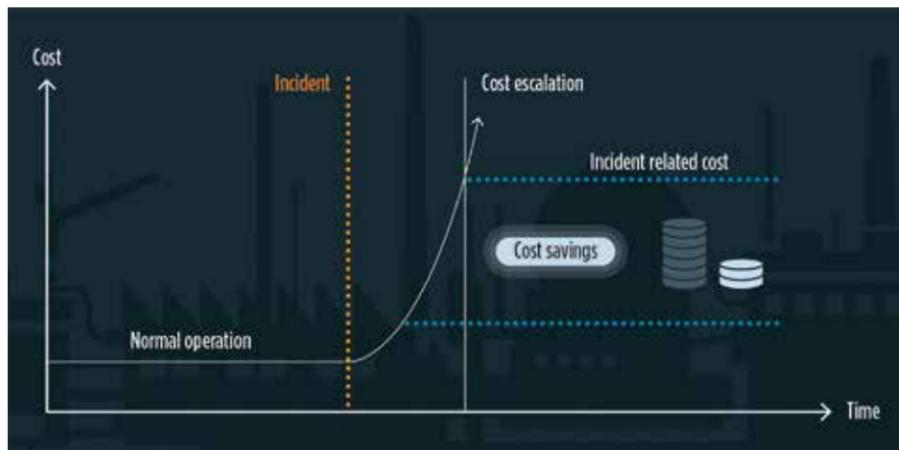


FIG. 1. Quick leak detection can significantly reduce incurred costs.

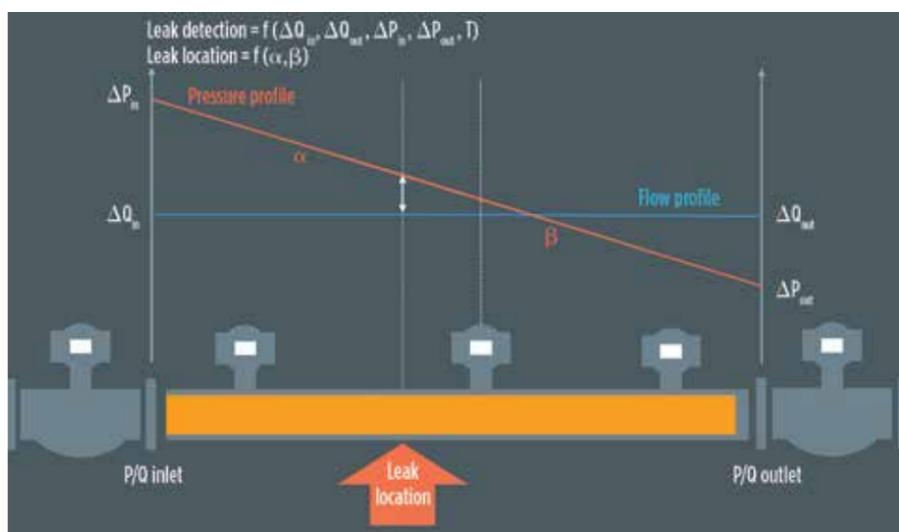


FIG. 2. Basic hydraulic principle of pipeline leak detection.

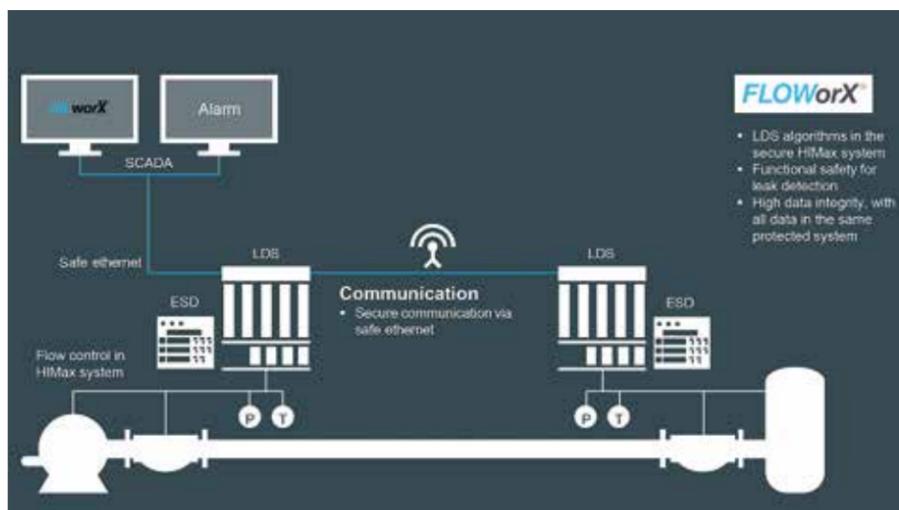


FIG. 3. HIMA FlexSILon PMC combines all safety-related pipeline functions in a single solution

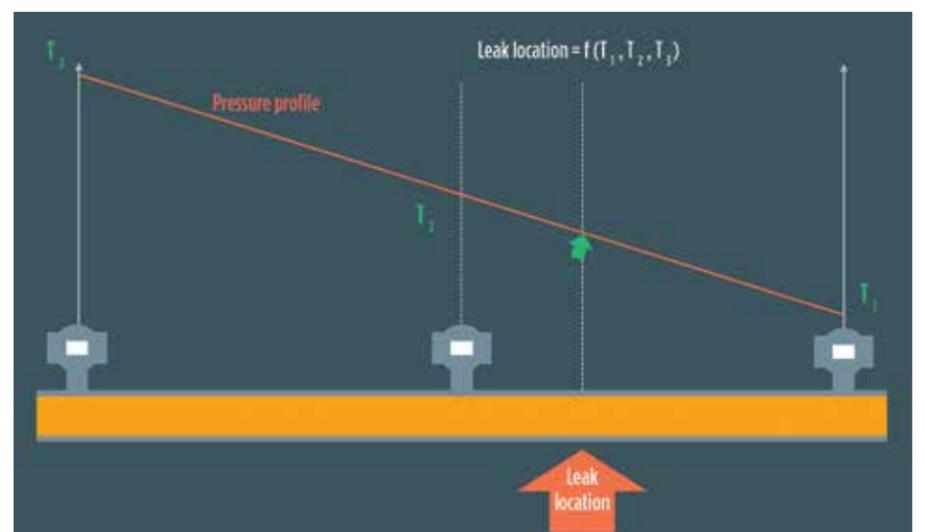


FIG. 4. The enhanced pressure wave method improves leak detection and localization.

These methodologies ensure reliable detection of even the smallest leaks and minimize false alarms. For example, the enhanced pressure wave method increases the detection sensitivity of the system, allowing the detection of leaks with a pressure change as low as 0.35% (FIG. 4) and eliminating more than 80% of false alarms.

Safety systems also address security. Pipelines are increasingly being targeted by hackers, and very few safety systems are prepared for this. By contrast, FlexSILon PMC hybrid solution meets all relevant requirements for cyber security. The safety controller offers several protection options for secure communication. For example, CPU and communication tasks are structurally partitioned. Using HIMA's own hardware and software with the proprietary operat-

ing system makes access considerably more difficult for hackers. In addition, there is no need for the time-consuming patches commonly required with standard software.

The FlexSILon PMC hybrid solution allows pipeline operators to implement both safety and critical control applications in compliance with all essential standards, while significantly increasing the safety and profitability of pipelines by quickly and accurately detecting and localizing leaks. This also reduces false alarms and downtime. Operators benefit from higher availability over the entire pipeline lifecycle, as well as a lower liability exposure and risk of consequential costs; and avoid environmental damage and loss of reputation. The combination of functional safety and information security increases the overall safety and security of the facility. ●



HIMA's hybrid leak detection and localization system monitors critical parameters in pipeline operations and allows leaks to be detected and located as quickly as possible.

MODERNIZING INDUSTRIAL CONTROL ROOMS

Honeywell Process Solutions (HPS) has introduced its Experion® Local Control Network (LCN) solution. This new offering enables the incremental upgrade of the company's legacy TotalPlant™ Solution (TPS) control system to allow for a secure, seamless integration with Experion® PKS. With Experion LCN, industrial facilities can gradually move their legacy control system forward while leveraging existing automation assets.



Today, users of TPS are dealing with compliance issues related to new safety regulations, as well as with increasing system support challenges. As every industrial organization is under pressure to reduce costs while improving performance, plants running outdated control systems must avoid obsolescence by employing the latest automation technology. The Experion LCN solution provides users with standards-based functionality, regulatory support capabilities, and integrated operations from the field through the plant to the business level.

Honeywell's on-process incremental upgrade to Experion LCN modernizes the control system infrastructure and enables deployment of the Industrial Internet of Things (IIoT). Existing control strategies, field terminations, applications, history and graphics can be retained, allowing users to focus on high-value improvements.

Using Honeywell's proven Experion Fault Tolerant Ethernet (FTE) infrastructure, the new Experion LCN bridge connects Experion to Classic Coax LCN. Once this connection is established, the LCN coax connection can be removed one LCN node at a time. Instead of a hardware connection for every Experion TPS node, only one redundant Experion LCN bridge pair is needed to enable virtualization.

Honeywell's TPS modernization solution minimizes operating disruptions and maintains overall consistency, delivering significant lifecycle advantages. After modernization, the control system can have a common human-machine interface (HMI) and unified physical control network, enabling control devices to easily integrate/expand with the latest generation of Experion PKS controllers and safety systems. The advanced control solutions and new functions within Experion PKS controllers can additionally improve the effectiveness of plant operations. ●

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The benefits of going wireless

MOAZZAM SHAMSI, Emerson Process Management

Installing new instruments in an existing process plant can provide information and improve the performance of steam traps, heat exchangers, pumps and other equipment. However, it can be difficult to justify these projects

with conventional wired instrumentation due to high cost, lengthy installation time and required downtime.

Traditional wired control networks using 4-20 mA, HART, Foundation Fieldbus, Profibus PA or other solu-

tions require power and signal wiring. The conduit, cable tray and other infrastructure needed for this wiring are a major cost component.

This wiring infrastructure is not needed for battery-powered *WirelessHART*[™] installations, as it is replaced by a wireless mesh network consisting of a gateway base station and repeaters. Including wireless can help justify a project as the incremental solutions and applications that can be added to the wireless network can demonstrate benefit beyond the original project scope.

The *WirelessHART* communications protocol is officially designated by the IEC 62591 standard. Ensure that the existing or proposed new process control system is able to support native integration of *WirelessHART* on its network. If not, the *WirelessHART* gateway will have to connect to the process control system via some other method, typically a protocol converter.



FIG. 1. A *WirelessHART* project typically involves the end user, the wireless equipment vendor and perhaps a systems integrator.



FIG. 2. A battery-powered *WirelessHART* instrument requires no signal or power wiring, and no wiring support infrastructure.

similar process equipment—*WirelessHART* makes it possible to consider applications previously too expensive to implement with wired instruments. These include measurements in remote places, or those previously considered uneconomical for monitoring, such as:

- Pressure relief valves with an environmental impact can employ a wireless acoustic device to monitor venting
- Steam traps can be prioritized, with high-value traps monitored with a wireless acoustic device
- Heat exchangers can be instrumented with wireless pressure and temperature devices
- All pumps and motors requiring routine assessment can be equipped with wireless diagnostic sensors.

Infrastructure and equipment. After the functional requirement specification is completed, equipment must be selected. Wireless field instrumentation can be used for all non-critical process measurements, and for control loops that are not fast acting.

WirelessHART devices can also be used in hazardous locations. The devices that are certified to the relevant protection level for the hazardous area reduce or eliminate the amount of supporting wired infrastructure installed in the hazardous area.

All non-SIL independent protection functions can be implemented with wireless. These will form part of any layers of protection analysis (LOPA) assessment. Consider the need for redundant gateway devices for applications requiring high availability, such as process control loops.

Many wired process measurements requiring redundancy may be better served by providing this functionality with wireless instruments, as this provides a second and completely independent source of measurement. This determination should be made during the HAZOP study.

Ensure that security best practices are used in the design of the wireless network and gateways. If a separate Wi-Fi infrastructure is not part of the project specification, then the installation contractor may benefit from temporary Wi-Fi access points to aid field commissioning using mobile worker client applications, such as Emerson's AMS Device Manager. ●

Project design. A *WirelessHART* project typically involves two or three parties: the end user, the systems integrator designing the system and installing the equipment, and the equipment vendor supplying the wireless instruments and communications infrastructure. The systems integrator and wireless equipment vendor may be the same company (FIG. 1).

The end user typically produces a functional requirement specification that describes applications, wireless instrumentation and the necessary infrastructure for the wireless network. The end user must determine what points are to be measured, and then work with the wireless instrument vendor to ensure that appropriate devices are selected for both process and diagnostic measurement functions.

Because each *WirelessHART* instrument does not require wires for signals or communication, and often neither for power (FIG. 2), the financial calculations determining whether a measurement should be made are very different than with wired instruments. The significantly reduced cost for a wireless measurement should be taken into account when deciding whether or not a particular parameter should be monitored.

In addition to flow, pressure, level and temperature measurements in conventional applications—such as on tanks, vessels, reactors, pipes and

API: US PETROLEUM DEMAND HIGHEST FOR AUGUST SINCE 2007

Total petroleum deliveries in August increased by 1.3% from August 2016 to average 20.5 MMbpd, according to an America Petroleum Institute (API) report. Compared with July, total domestic petroleum deliveries (a measure of US petroleum demand) decreased 0.6%. For year-to-date, total domestic petroleum deliveries rose 1.3% compared to the same period last year.

Gasoline deliveries in August were down from the prior month, the prior year, and the prior year-to-date. Total motor gasoline deliveries, a measure of consumer gasoline demand, decreased 1.5% from August 2016, to average 9.5 MMbpd, but remained the fourth highest deliveries to date. For year-to-date, total motor gasoline deliveries decreased 0.3% compared with year-to-date

2016 to the second highest year-to-date level at 9.3 MMbpd. Distillate deliveries in August were up from the prior month, the prior year, and the prior year-to-date to reach the highest August deliveries in 10 years and the highest deliveries since March. Distillate deliveries averaged 4.1 MMbpd, up 6.5% compared with August 2016, and were up 0.7% compared with July. For year-to-date, distillate deliveries increased 3.2% compared to year-to-date 2016.

US crude oil production remained above 9.0 MMbpd for the seventh consecutive month. Domestic crude oil production in August decreased from the prior month, but was up from the prior year and the prior year-to-date to reach the second highest August output since 1972. ●

Fired heater performance improvements

RYAN MCSHERRY, Yokogawa Corporation of America

Fired heaters are installed in a huge range of industries: any manufacturing process needing heat is likely to have one. Refineries account for thousands of fired heaters, and they tend to be particularly large, so performance improvements in this context deliver the biggest return on investment.

Three areas tend to dominate discussion involving fired heater design and operation:

- Safety and operational practices
- Efficiency and minimizing the amount of fuel required
- Emissions.

Safety and operational practices. Users must ensure that their installations are in compliance with the latest National Fire Protection Association (NFPA) standards—including NFPA 85, 86 and 87—and others that may apply, such as FM 7605, API-556, OSHA 1910.110 PHA and ISA-TR84.00.05. Additional industry-specific or local requirements may be applicable, so consultation with an expert is important to ensure safety and compliance, particularly as less experienced workers are moving into many plants.

Efficiency and emissions. Efficiency and emissions must be treated together because one is dependent on the other. While secondary influences on efficiency exist, such as a coating of soot on the tubes, combustion management has the greatest direct determination on both efficiency and emissions.

The most efficient and cleanest combustion occurs when the amount of air and fuel are in ideal stoichiometric proportions. For a natural gas-fired unit, ideally one molecule of methane (CH_4) and two oxygen (O_2) molecules react to form one carbon dioxide (CO_2) and two water (H_2O) molecules. Unfortunately, this is not always the case, and without adequate control, the mixture can become too fuel-rich.

In extreme cases, unburned fuel can simply be blown out the stack. However, the effect is usually subtler, with insufficient O_2 causing incomplete combustion. As a result, carbon monoxide (CO) and hydrogen (H_2) go to atmosphere, or worse, mix with tramp air outside the combustion chamber and burn where it is not desirable. In either case, fuel is wasted and emissions increase.

Most users run fired heaters with a fuel-lean mixture, allowing an overabundance of air. This generally ensures more complete combustion, but also has undesirable effects. Not only does excess air cause a loss of efficiency, it also promotes the formation of nitrogen oxide (NO_x) compounds and, in severe situations, may cause a flame-out. Low- NO_x burners stage the combustion by spreading out the mixture of fuel and air, but this tends to reduce peak flame temperature and efficiency.

Controlling combustion. Controlling the amount of fuel is not a problem, but since most units use natural draft

rather than forced air, controlling the amount of air is more challenging. For many designs, the function is supposed to be largely self-regulating, depending on the buoyancy created by the fire itself to pull an appropriate amount of air through the combustion chamber. A flue damper combined with air registers may allow some degree of regulation, but without instrumentation determining the actual mix, adjustments are largely guesswork.

Ideally, a fired heater would have instrumentation capable of working with the combustion control system to monitor the flue gas so that the controller could optimize airflow to match the fuel rate. Unfortunately, most fired heaters suffer from a lack of instrumentation, and the combustion control system is too rudimentary to perform such a calculation. To make matters worse, it is doubtful that any mechanism can control airflow with any degree of precision.

Many installations will have some sort of oxygen sensor. This is typically a zirconium oxide probe mounted in the stack, which must be heated to 500°C to operate. The probe provides a spot reading, which can at least warn of a serious imbalance, but this technology can be fooled in a fuel-rich environment because high levels of H_2 and CO can mask the true oxygen concentration.

Better instrumentation improves operation. The most effective place to gauge combustion performance is in the radiant section, but the temperature is too high for most technologies. However, it is possible to get a very accurate picture with a tunable diode laser spectroscopy (TDLS) instrument (FIG. 1), which sends a beam across the radiant section of the unit.

The TDLS can be configured to measure O_2 , CO, CH_4 or other specific gases. In most cases, two units are used in combination and provide a complete picture of the combustion. The O_2 sensor detects fuel-lean conditions, while the CH_4 and CO sensor detects fuel-rich conditions. Moreover, when the instruments are mounted in a cross-stack arrangement, both sensors read across the full width, so uneven gas distribution can be averaged out of the calculation.

TDLS technology is non-contacting and has no moving parts, so it is very durable and reliable. Many installations dating back 15 years continue to perform without incidents. Measurements are also unaffected by other gasses in the stream, so odd process conditions will not mask the critical measurement.

Taking control of the process. As mentioned earlier, a fired heater is governed by two systems: the burner management system (BMS) and the combustion control system. The TDLS system provides critical information to both systems.

The basic process control system (BPCS) can analyze data from the TDLS instruments and utilize it to close the loop for fuel and air flow. When the process calls for a specific temperature and flow for the process fluid, the BPCS can adjust the fuel flow to reach that point. Data from the TDLS instruments can verify air flow for complete and efficient combustion.

With TDLS, the degree of control precision is typically limited by the

mechanism to control air flow. Data from the TDLS instruments can be very precise, but often the mechanisms to control air flow in a natural draft design may be limited to manually operated controls, such as a damper and air registers. The efficiency improvement and reduced emissions can be significant when an accurate picture of the combustion process is available through properly utilized TDLS instrument measurements. ●



FIG. 1. Properly utilized TDLS instrument measurements provide an accurate picture of the combustion process.

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As the global leader in catalysis, we see it as our task to unite apparent opposites and to create true and tangible benefits, both for our customers and the environment. With our comprehensive experience and pioneering spirit, we develop products, services and solutions for the petroleum refining industry that enhance both performance and sustainability. When catalyst innovations empower our customers' success it's because at BASF, we create chemistry

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A hand holding a vial of brown liquid with a blue heart overlay, with a refinery in the background.

High-quality fuel and feedstock in the new crude price reality

Oil and gas companies have endured several challenging years since the collapse of crude oil prices, and they have made the necessary aggressive cost adjustments to their businesses to remain profitable and competitive. However, with low oil prices predicted to (potentially) remain that way in the foreseeable future, the continuous drive for further efficiencies and the need to utilize every drop of product has become the new reality. It is accepted that refineries must continue to pursue more cost-effective and environmentally sustainable ways to produce high-

quality fuels, as well as feedstocks for essential plastics production.

One such fuel—polygasoline—can be produced through the use of catalysts to convert surplus fluid catalytic cracking (FCC) olefins into high research octane number (RON) gasoline. With approximately 45 refineries around the globe applying this long-established technology in such a low-cost environment, it is vital to now utilize the latest catalysts to deliver those critically important efficiencies.

Additionally, the processing of propylene and butylenes derived from the

same FCC process can be commercially leveraged to produce a broad range of products. These products can be used either as building blocks in the production of intermediate materials, or as end products, such as base materials for many consumer-oriented products (e.g., PVC and synthetic leather in cars or laundry detergents).

Profitable, sustainable and compliant.

Catalysts are among the most powerful tools to create value for refinery owners by leveraging compounds produced in their processes. Catalysts leverage short-chain olefins derived from FCC—such as propylene and butenes—in polygasoline units, where they are converted into gasoline.

A new generation of phosphoric acid catalysts are now leading to not only increasingly profitable polygasoline production, but also more sustain-

able fuel upgrading in FCC refineries. Sustainability and environmental compliance are another pressure on producers. Innovative, high-performance phosphoric acid catalysts, such as Clariant's PolyMax® 850, can increase gasoline—as well as nonene and tetramer—yields at lower operating temperatures, reducing energy costs. The new catalysts have a high level of activity and selectivity, increasing the rate of reaction and optimizing both productivity and product quality compared to other existing catalysts.

PolyMax® 850 has also been designed to minimize environmental impact across its lifecycle. From the outset, the catalyst is produced from diatomaceous earth and phosphoric acid in a process that does not even generate wastewater. After a long service life at a refinery, the catalysts can be completely recycled into fertilizers or other useful phosphorous compounds. Almost 65% of spent PolyMax® catalysts are recycled, helping reduce the consumption of phosphate rock in the production of phosphorus. Clariant is actively working with international partners to further increase recycling rates.

To learn more and to meet members of the Clariant team, visit booth #46 in the exhibition hall. ●



To minimize environmental impact across its lifecycle, Clariant's PolyMax® 850 is produced from diatomaceous earth and phosphoric acid in a process that does not even generate wastewater.

While oil and gas companies make the necessary aggressive cost adjustments to their businesses to remain profitable and competitive, refiners must continue to pursue cost-effective and environmentally sustainable ways to produce high-quality fuels and feedstocks for essential plastics production.



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A tale of two refineries

DAVID WILLIAMS and TOM BREWER, VEGA Americas

Alberta, Canada and northern Texas are not known for their similarities. Separated by thousands of miles, the two geographies experience different climates, have dissimilar population sizes and support varying cultures. However, one thing they do have in common is a robust refining industry, and two refineries share a common desire for maximum process efficiency.

One refinery processes heavy crude and the other light, and still operators had identical lists of challenges in their desalter vessels. Each plant reported sampling errors, costly process upsets due to grid shortages, water and salts in the downstream process, and underutilized process equipment. However, the worst of times quickly became the best of times as the refineries overcame their difficulties with the same technology: the Multi-point Density Array (MDA) system from VEGA.

Multi-point density array: How it works. The MDA system (FIG. 1) provides continuous density data at individual measurement points on a vessel, and each measurement is specific to a horizontal plane of elevation. With a source and a detector at each individual elevation, operators can see exactly what is happening in real time and can make advanced control decisions, as necessary. For example, as the output from each detector changes, the operator can determine the height of the water level and the movement of the rag layer, allowing the operator to adjust on the

fly to prevent the liquid from shorting the desalter's electric grid.

The system is low-maintenance because all detectors mount externally and have no direct contact with the process, eliminating the possibility of corrosion or detector damage due to temperature. Additionally, external mounting frees refineries from purchasing a cooling system and/or using exotic materials. Calibrating the MDA is relatively simple, requiring the collection of only two data points. The first point is collected while the vessel is empty, and the second point can be collected when the vessel is filled with a fluid of a known density, which can be either water or some type of hydrocarbon.

The detectors are easily accessible for maintenance; with multiple independent measurement points, one offline detector does not shut down operation of the entire system. This arrangement ensures high reliability and that detectors do not influence each other's accuracy.

The low-activity Cesium sources used in the system allow VEGA to create process paths up to 26 in., minimizing the influence of buildup on the measurement. A distributed control system (DCS) algorithm implements level and density control without requiring a separate computer that represents a single point of failure. The system provides water level control with no extra equipment or risk.

Taken together, these features create a reliable system that delivers real results for refineries around the

world, including our two plants in Texas and Alberta.

Desalter efficiency improves entire refining process. The overarching impact of the MDA on desalters inside the two refineries is optimizing all process equipment, beginning with the desalters themselves, where greater water level control has several benefits. The MDA measurements allowed users to keep the emulsion below the electric grids, eliminating the risk of expensive and process-crippling grid shortages. Additionally, enhanced water control reduced corrosive salts out of the desalters, which aids in preserving the life of downstream equipment. Greater water level control also reduced undercarry, which can harm the environment and lead to hefty regulatory fines. Both refineries report a near elimination of crude unit upsets and rate reductions since installing the MDA system.

Receiving a consistent interface measurement from the MDA also uncovered sampling errors that neither refinery knew about. Each facility used this discovery as an opportunity to retrain operators in the art of sampling. A panel operator in the Canadian refinery stated that the VEGA MDA system made sampling easier, and he felt it was more accurate than operating a desalter based on sample

spins and grid amps because VEGA's solution makes it easier to distinguish water, oil and rag layers inside the desalter. The operator expressed that he would not want to be without the MDA system. After retraining, operators take samples once per month rather than once per shift, representing a paradigm shift in terms of time, effort and money saved.

Refinery operators in Texas also experienced significant process improvements as a result of installing the MDA system on its desalters. Most notably, they increased throughput by 17% without making any changes to the desalter. Without new configurations and/or recalibrations, the info collected from the MDA allowed the refinery to run consistently. Operators in the Texas refinery estimate that the VEGA MDA system paid for itself in approximately one year due to the elimination of product upsets and reduced maintenance costs.

VEGA's Multi-point Density Array delivers independent measurements to create a density profile that allows refinery operators to exercise real-time control over the product level inside desalters. This unparalleled control is helping preserve the life of equipment in refineries in Canada and Texas, as well as improving both refineries' production. ●

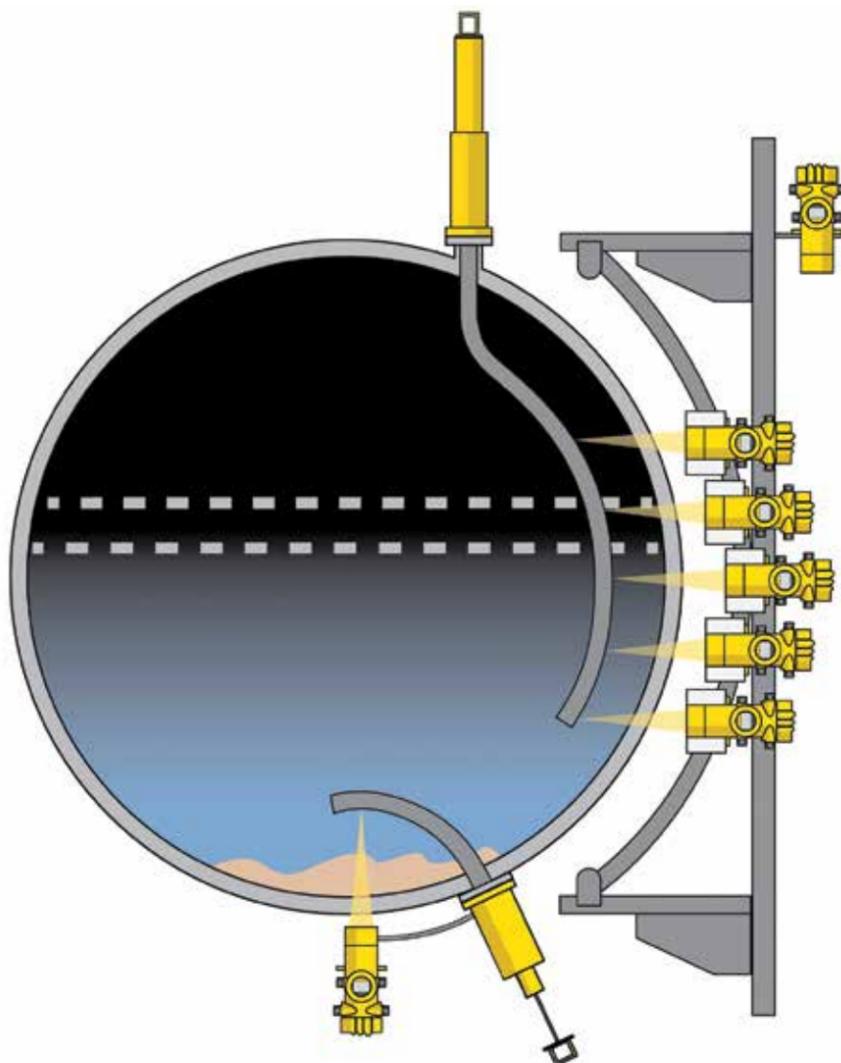
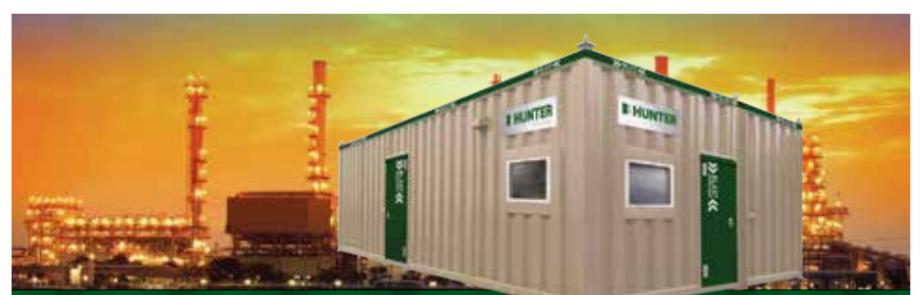


FIG. 1. The VEGA Multi-point Density Array system provides continuous density data at individual measurement points on a vessel, allowing operators to see exactly what is happening in real time and enabling advanced control decisions



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New generation of dewaxing catalysts

HENRIK W. RASMUSSEN, Haldor Topsoe Inc.

The refining industry has been considering incorporating dewaxing in ultra-low sulfur diesel (ULSD) and hydrocracking services to increase the flexibility of hydroprocessing units and process more barrels by increasing the endpoint of the feed when diesel margins are favorable. Processing higher endpoint feed makes it more difficult to meet product specifications for cold flow properties and the T90. Dewaxing is one solution, but because today's dewaxing catalysts also have a significant cracking functionality, some of the extra diesel barrels will be lost to naphtha and light ends, making dewaxing less attractive in many cases.

The key is to use a dewaxing catalyst that is very selective toward isomerization and, consequently,

will result in a minimal reduction of the diesel yield. Topsoe has recently launched a series of dewaxing catalysts that are true isomerization catalysts and have very little activity toward cracking of the diesel molecules. These catalysts are called TK-910 D-wax™, TK-920 D-wax™, TK-930 D-wax™ and TK-940 D-wax™, and their application areas are shown in **TABLE 1**.

Cold flow properties. These catalysts will enable true molecule management while minimizing the economic penalty of losing valuable diesel yield. In other words, refiners can increase the endpoint of the diesel feed, even during the winter months, to produce extra diesel barrels and still meet the cold flow property specs, easily justifying the cost of the dewaxing catalyst.

The ULSD cold flow properties are defined as cold filter plugging (CFPP) and cloud point (CP), or pour point (PP). These properties are negatively affected by the presence of waxy molecules, such as normal paraffins, in the diesel feed. The high melting point of the paraffins in the higher boiling range of the ULSD feed is what determines the cold flow properties.

Without the use of a dewaxing catalyst, only a few remedies can get the cold flow properties on spec during the winter months:

1. Feed management: Endpoint reduction and, consequently, a loss of barrels
2. Kerosine blending: Diluting the wax molecules
3. Use of additives: An increased operating cost to the refinery.

These options are often not commercially attractive. The case study here will show that the use of Haldor Topsoe's new TK-930 D-wax catalyst

in ULSD service provided the refiner with a substantial increase in profitability during both the winter and summer periods, easily justifying the cost of the dewaxing catalyst.

Topsoe's new dewaxing catalysts are based on a proprietary zeolite structure promoted with nickel and tungsten, or noble metals, to provide an unmatched selectivity toward isomerization and an exceptional yield structure of the product.

Another key feature of the new TK-930 D-wax and TK-940 D-wax catalysts is that they exhibit good desulfurization (HDS) and denitration (HDN) activity in their sulfided state, which means that they work well in a sour environment. Therefore, the volume occupied by these catalysts will help meet product sulfur specs and saturate aromatics for additional volume swell. Since the catalysts work in a sour environment, they may be installed in the same reactor as the hydrotreating catalyst.

FIG. 1 shows that the new D-wax series catalysts generate only one-eighth of the yield loss per degree of CP improvement, compared to Topsoe's previous-generation dewaxing catalyst. Furthermore, 90% of the diesel yield loss experienced with the D-wax series is lost to naphtha—which still provides value for the refiner—and 10% is lost to light ends (C₁-C₄).

Case study. A US refinery operating a 25-Mbpd ULSD unit selected a load of Topsoe new NiMo catalyst TK-611 HyBRIM™ on top of a layer of TK-930 D-wax for use in the higher pressure ULSD unit. This was based on a detailed pilot plant study confirming the high activity of TK-611 HyBRIM and the selectivity of the dewaxing catalyst. The feed properties of this unit are listed in **TABLE 2**.

Using the TK-930 D-wax cata-

lyst enables the refinery to increase the feed rate during the five winter months by more than 600 bpd while still meeting the cold flow property specifications. In addition, the catalyst system reduces the T90 point of the product by 12–15 degrees, depending on the level of dewaxing. Most refineries are limited on the feed endpoint because they are up against the T90 spec in the product. The reduction in the T90 enabled the refinery to process an additional 1.5 Mbpd during the summer months and still meet all ULSD specifications.

The additional profit from the enhanced winter and summer modes of operation correspond to approximately \$6 MM/year–\$8 MM/year or ~\$30 MM over the catalyst cycle. The additional cost of the dewaxing catalyst compared to using all NiMo catalyst is paid back in a matter of weeks.

Renewable fuels dewaxing with TK-920 D-wax. Renewable diesel generated by the hydrotreating of triglycerides are mainly n-paraffins and will have very poor cold flow properties. Unless the renewable diesel is used in a very warm climate or as blendstock, it is necessary to dewax the product significantly. Since the renewable feedstocks are typically very sweet, the use of Topsoe's noble metal-based TK-920 D-wax is recommended. This catalyst is already installed in several renewable fuels reactors and provides the required cloud point reduction with a very low diesel yield loss.

Topsoe's new dewaxing catalysts are proven to provide one-eighth of the yield loss experienced with a traditional dewaxing catalyst per degree of cloud point improvement. The outstanding selectivity allows refiners to maintain high feed endpoint during the winter months and, due to a reduction in the T90 point of the product, it is also possible to process more barrels in the summer months. The use of the D-wax series of catalyst enables a much higher degree of molecule management to significantly increase the profitability of existing assets. ●

TABLE 2. Feedstock properties and operating conditions

Distillation	
Distillation curve, IBP	221
Distillation curve, 10 wt%	392
Distillation curve, 30 wt%	466
Distillation curve, 50 wt%	529
Distillation curve, 70 wt%	591
Distillation curve, 90 wt%	663
Distillation curve, FBP	752
Sulfur	1.0 wt%
Nitrogen	350 wtppm
Aromatics	41 wt%
Pressure	1,200 psig
LHSV	1.2 hr ⁻¹

TABLE 1. Topsoe new generation dewaxing catalyst, TK-900 D-wax

	Sweet mode	Sour mode
Diesel/renewable	TK-920	TK-930
Lube/VGO	TK-910	TK-940
Metal type	Noble metal	Base metal
Yield loss	Very low	Very low
H ₂ consumption	Very low	Very low

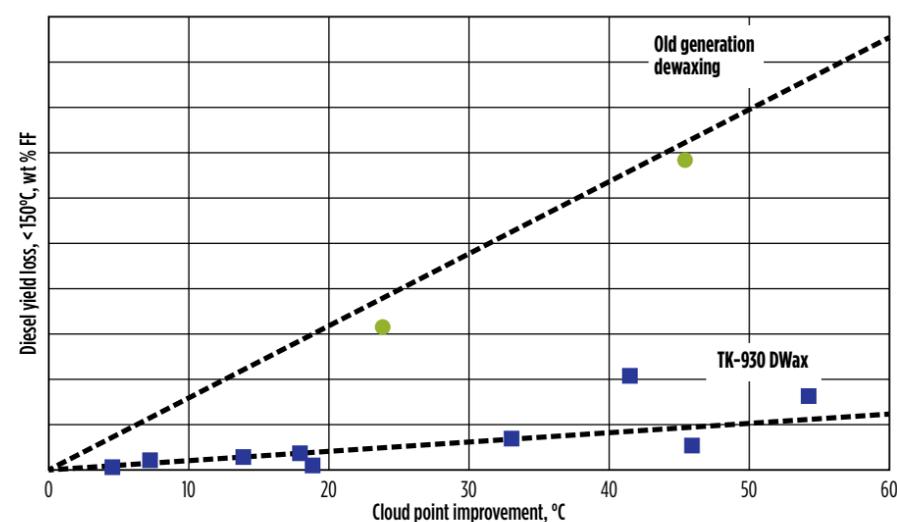


FIG. 1. Yield loss as a function of dewaxing.

ROCKWELL AUTOMATION EXPANDS ITS PARTNER NETWORK

Industrial operators focused on improving production through enterprise-wide integration must rely on multiple suppliers and partners. To support and simplify this process, Rockwell Automation has added six companies as members of its PartnerNetwork program.

The PartnerNetwork program helps industrial companies better solve their production and automation challenges by providing access to an expansive network of leading suppliers, distributors, system integrators, and machine and equipment builders.

In North America and Europe, the Encompass Partner program, a product reference program that helps customers quickly locate products that solve their application challenges, welcomed four new members:

- CBS ArcSafe
- Emulate3D
- Point Eight Power
- Woodward Inc.

Two new companies have joined the OEM Partner program in North America. OEM Partners are machine and equipment builders that help provide flexible and efficient equipment leveraging Rockwell Automation solutions. The new OEM Partners are:

- Case Engineering Inc.
- Cloud Packaging Equipment

The Rockwell Automation PartnerNetwork program offers global manufacturers access to a collaborative network of companies mutually focused on developing, implementing and supporting best-in-breed solutions to achieve plant-wide optimization, improve machine performance and meet sustainability objectives. ●

NEWS IN BRIEF

US FUEL EXPORTS RECOVER AFTER HARVEY, OFFERING BUYERS RESPITE

Fuel exports from the US Gulf Coast have surged as refineries recover from weeks of disruptions due to Hurricane Harvey, offering respite to buyers in Latin America and Europe.

The gradual resumption of regional operations has prompted a drop on both sides of the Atlantic in benchmark gasoline and diesel refining margins.

Mexico's state-run oil company Pemex bought gasoline from US Gulf Coast suppliers this week, according to shipping data, after sourcing dozens of cargos from Europe, the Middle East, the Caribbean, the US East Coast and Asia through September.

Mexico, which imports half of its gasoline, typically buys two cargos of the fuel per day, mostly from the US Gulf Coast.

US outages came at a difficult time for Mexico, as one of its refineries, the 190-Mbpd Ciudad Madero, was undergoing maintenance. Pemex's largest refinery, the 330-Mbpd Salina Cruz, was also halted after an earthquake damaged its electric system. Salina Cruz is expected to restart by the third week of October, Pemex said, adding that it has sufficient inventories of gasoline and diesel for the domestic market.

Shipping data shows that 10 tankers carrying US diesel have also been booked to sail to Europe this week, following approximately three weeks of almost no activity on the transatlantic route.

US refineries increased crude runs at the end of September by 1 MMbpd to 88.6% of total capacity, the highest rate since Harvey hit on Aug. 25, according to weekly data from the Energy Information Administration (EIA).

Harvey knocked out more than 4 MMbpd of US refining, nearly a quarter of its total capacity.

While product refining margins come under pressure, strong overseas demand is expected to support Gulf Coast refining profits.

The discount of US crude prices to the global Brent benchmark widened in the wake of the storm, meaning US refiners currently enjoy higher profit margins than those in Europe.

The sharp drop in US exports disrupted many established trade routes, forcing traders around the world to source supplies from different markets, particularly Europe, which relies heavily on diesel imports.

As a result, European diesel stocks are expected to slide in the coming weeks. Brazil and Mexico imported unprecedented volumes of diesel and gasoline from Europe and Asia in recent weeks.

SURVEY REVEALS RISK IN THE GLOBAL HYDROCARBON INDUSTRY

Petrotechnics has released its 2017 Operational Risk and Process Safety Management survey results. Insights from more than 200 senior industry leaders reveal that only 6% believe that their companies are fully up to date with their scheduled safety-critical maintenance.

"The low percentage of companies achieving their scheduled safety-critical maintenance is startling," says Simon Jones, head of professional services at Petrotechnics. "Safety is a top priority in hazardous industries, but these results demonstrate that operators may be exposing themselves to increased major accident hazard risk."

Operational excellence was highlighted as a main driver for improving safety performance (61%), but 59% believed PSM was not always fully incorporated within operational excellence strategies or programs. The top driver for improving safety performance cited, at 71%, was reducing operational and major accident hazard (MAH) risk. However, 57% said that companies do not always have a defined roadmap in place for advancing safety performance, and 77% of survey respondents believe that companies do not always maintain a sense of vulnerability about their exposure to risk.

The survey also highlighted industry progress. 80% believe that regulations and technology have made the industry safer, but there is still some way to go. For example, 70% of companies believe that there is a measurable change in the level of risk exposure on the plant between planned PSM hazard review periods. Additionally, 74% of companies do not employ effective solutions for monitoring and managing the risk arising from operational activities, the impaired health of process safety barriers and other management system deficiencies.

Ninety percent believe risk awareness and safety would be improved if the workforce and management had access to real-time process safety risk indicators on the plant—a significant increase from 73% in 2016.

"Process safety, operational risk and asset integrity professionals understand the complex nature of the challenges they face. The goal now is to deploy systems that enable organizations to bring PSM into the fold of operational excellence," Mr. Jones said.

The Petrotechnics PSM survey was conducted online between June 14 and July 27, 2017. More than 200 individuals took part, and two thirds of respondents have management responsibilities at the corporate level, with the remaining third having single-site or regional responsibilities. ●



EASTERN MEDITERRANEAN GAS CONFERENCE

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- 1 At the popular Principles & Practices: Emerging Leaders Town Hall, industry veterans and younger, up-and-coming professionals discussed the future of the industry.
- 2 The stakes were high at the casino-themed **Athlon Solutions** hospitality suite, and it was a good thing that the money wasn't real.
- 3 **Michael Volk** from the University of Tulsa sits patiently while a digital artist creates his portrait during a visit to the Criterion Catalysts & Technologies team.
- 4 During a Tuesday morning OPCAT session, **Steve Bitar** from ExxonMobil Research and Engineering presented, "Open Process Automation: A Standards-Based, Interoperable and Secure Control System Architecture."
- 5 Shine 'em up! **Johnson Matthey** welcomed its visitors with a complimentary shoe shine.
- 6 Golf Skills with **Reactor Resources** was a popular suite, as a steady stream of golf enthusiasts practiced their swing.
- 7,8 It's all in the follow through. **Chris Steves** (left) and **James Norton** from Norton Engineering (bottom) face off during Haldor Topsoe's carnival-themed hospitality suite Monday night. Next to them, **Raj Singh** from TechnipFMC impressed the crowd by improving his score with each round, no small feat considering that this was the first time he had ever played Skeeball.
- 9 The crowded exhibition hall provided a perfect venue for companies to showcase their latest technologies.

POWERING AHEAD IN 2018



AFPM 2018 Meetings

Annual Meeting

March 11 – 13
New Orleans Hilton
New Orleans, LA

International Petrochemical Conference

March 25 – 27
Grand Hyatt
San Antonio, TX

International Base Oils and Waxes Conference

March 25 – 27
Grand Hyatt
San Antonio, TX

Security Conference

April 23 – 25
Omni Royal Orleans
New Orleans, LA

Labor Relations/ Human Resources Conference

April 26, 27
Omni Royal Orleans
New Orleans, LA

National Occupational & Process Safety Conference

May 15, 16
Grand Hyatt
San Antonio, TX

Reliability & Maintenance Conference

May 22 – 25
Henry B. Gonzalez Convention Center
San Antonio, TX

Cat Cracker Seminar

August 21, 22
Royal Sonesta
Houston, TX

Operations & Process Technology Summit

October 1 – 3
Atlanta Marriott Marquis
Atlanta, GA

Environmental Conference

October 14 – 16
Marriott Rivercenter
San Antonio, TX



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Tighter fuel specifications and the processing of heavier crudes continue to increase the demand for hydrogen around the world adding more pressure than ever on refiners.

Globally over 14 billion SCFs of hydrogen are produced daily across Johnson Matthey **KATALCO** hydrogen production catalysts. Every day hydrogen is sold to refinery operations from Industrial Gas companies around the world and over 5 billion SCFD of this hydrogen are made over Johnson Matthey **KATALCO** hydrogen production catalysts. Our **KATALCO** range of products and services have been proven to be the industry solution for hydrogen production using a range of feedstocks, from natural gas and refinery off-gas, to LPG and naphthas providing reliable, efficient hydrogen to put refiners at ease in meeting new fuel specifications and processing of heavier crudes.

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