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Understanding the risks and economic impact of cyber-attacks

KYLE KORNEGAY, *Hydrocarbon Processing*

Focusing on cybersecurity has never been more necessary. Today's political cycle has highlighted the threat that criminals and nation states present to governments and industry. The keynote speaker for AFPM's Cybersecurity Day opening session, Eric Cornelius, presented his views of cybersecurity in its present form, a glimpse of the cyber-threats of the future, and a pragmatic path to reducing the threat and impact of cyber-attacks.

ERIC CORNELIUS is the director of Critical Infrastructure and Industrial Control Systems for Cylance.

As the director of Critical Infrastructure and Industrial Control Systems for Cylance, Mr. Cornelius has worked in many aspects of the cyber defense world, and has intimate knowledge of threat levels and industry trends.

Mr. Cornelius opened his presentation with the statement, "The industrial control system environment is one of the most inherently defensible within any plant or facility due to the fact that it is static in nature, easily segmented and purpose-driven."

Unfortunately, cybersecurity technology far outpaces the adoption of the technology in the industry, which has led to widespread vulnerabilities. "One of the biggest factors in this slow rate of adoption," according to Mr. Cornelius, "is the lack of understanding in the business sector of the economic impact of a cyber-attack.

A pervasive industry trend when considering cybersecurity is the belief that certain businesses are not considered worthy targets for cyber criminals. Even the US government has stated that certain industry segments are unlikely targets for cyber-attacks. It is this false sense of security that stalls the adoption of the latest technologies and personnel training that could prevent such an attack in the first place.

"One of the most insidious aspects of cyber-attacks," Mr. Cornelius stated, "is that cyber weapons are not like conventional weapons, in that we cannot count how many of them exist on the planet. Unlike a nuclear missile, a cyber weapon is almost invisible until it is in use. When you couple this with the fact that, compared with a missile, a cyber weapon is extremely low-tech and highly accessible to the public, they become even more dangerous. It is extremely difficult to build a conventional weapon because the materials are restricted. Cyber weapons are within the scope of technologies that can be obtained and utilized by anybody. All it takes is money."

Defense begins with detailed analysis. So, how does our industry effectively

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Actionable information sharing through mutual trust

KYLE KORNEGAY, *Hydrocarbon Processing*

Continuing with Tuesday's Cybersecurity Day theme and its in-depth examination of the many challenges associated with overcoming organizational vulnerabilities, the CISA Panel focused on the sharing of actionable information related to potential cyber-threats.

Kimberly Denbow, the Director of Security, Operations & Engineering Services for the American Gas Association (AGA), provided a brief synopsis of the evolution of information sharing over the past 10 years. "A decade ago, the largest gap in the security world was the lack of timely sharing of actionable information from the intelligence community, and vice-versa," she said.

Ms. Denbow recalled that the business community was receiving more information via CNN and other mainstream news sources than through government agencies. Businesses were interested in learning which sites and systems needed the most protection, but this information was often considered "classified" and difficult to access in time for it to be pertinent and actionable.

A decade ago, a significant portion of her efforts were geared solely toward convincing legislatures and the government that the information and technological capabilities needed to protect the country's business interests did not conflict with the government's efforts to capture criminals and terrorists. As always, this proved challenging.

Similarly, the government wanted businesses to share the information learned from outside forces attempting to infiltrate their systems. Businesses, however, felt that sharing this information might be detrimental to their interests, and an uncertain impasse was the result.

Thankfully, since that time both governments and businesses have improved their understanding of the benefits

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The AGA's **KIMBERLY DENBOW** was part of Tuesday morning's CISA panel that addressed the challenges of information sharing.

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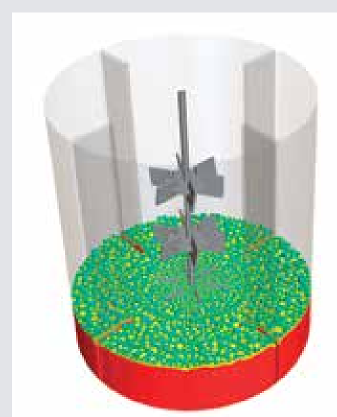

Modeling software by CD-adapco can achieve optimum designs

Pepperl + Fuchs details the consolidation of systems into a central, virtual machine

CYBER-ATTACKS, continued from page 1

defend itself against a cyber-attack? "There is no cure, but businesses can significantly reduce risk for a relatively low investment," he said.

The installation of the latest technology is not enough, however. Businesses must undergo a thorough analysis of their systems to determine their needs. Once these needs are determined, cybersecurity technology can be installed where it is needed most. This includes internal technologies, operational details and intellectual property.

"Determining exactly the level of security required by any business is particularly difficult," Mr. Cornelius said. "This is also true and relevant following an attack, because cyber criminals do only what is necessary to infiltrate systems. If a system is easy to infiltrate, they will not use complex methodologies when a simple one will do. So, it is difficult to determine how sophisticated a criminal is by analyzing methods of infiltration, especially if defense systems were poor at the time of the attack."

Another difficulty in persuading businesses to increase their security prior to an attack is the relative ease with which a minor attack can be remedied. "Even in a (relatively) minor attack, many of the economic costs are not readily apparent to the victims. The cost of hiring consultants to clean up and recover from an attack may seem comparatively cheap, but there may be hidden costs in terms of lost labor, production, and operational technologies and data that businesses do not factor into their estimates."

Achieving personnel buy-in. Employee behavior is one of the major vulnerabilities that most companies face. Every organization has policies in place to regulate the behavior of its employees, but employees often find a way around these policies. This is not done out of malice or intent. Employees are always encouraged to seek efficiencies in their work processes, and they simply may not be aware of the importance of maintaining a closed environment in the pursuit of those goals.

"You cannot solve a behavioral problem with a technological solution," said Mr. Cornelius. "Employees must become invested in the processes and procedures that supplement the technology. Proper training for all employees and an understanding of why the procedures are necessary is critical to maintaining a secure system."

Mr. Cornelius focused on several economic factors that prevent businesses from investing in cybersecurity. The first is the up-front cost of the technology involved. "I won't tell you that cybersecurity technology is inexpensive. However, the technology does not have to be replaced frequently. If viewed as a cost over a period of time rather than an up-front payment, the expense per year is much more reasonable," he said.

Another economic factor that might prevent a cybersecurity investment is the relatively cheap cost of cleanup after an attack. Repairing systems following an incident, though, does nothing to increase security in the future.

Large businesses with several subsidiaries or multiple different businesses are especially vulnerable, Mr. Cornelius stated. Often, these companies will spend large amounts of money on cyber defense for what they consider their most important divisions, but will overlook a portion of their business that seems less likely to be attacked. Because of the interdependence of the different divisions of a company, they are all still susceptible to an attack. "If the site is a 'choke point' through which much of the business operates, it is vitally important to keep it secure. Shutting down a seemingly unimportant portion of the company might have far-reaching effects and high economic costs."

Mr. Cornelius concluded by stressing the importance of preventative cybersecurity. "Cyber-attacks are often like a cancer. Once they have begun, it is far more difficult to keep them from spreading."

An effective defense against such attacks is achievable, but early detection and preventative action is always the best, most economical policy. ●

INFORMATION SHARING, continued from page 1

of information sharing that is both timely and actionable, and they have taken steps to close the communication gap.

Michael Echols, Executive Director and CEO of the International Association of Certified Information and Sharing and Analysis Organizations (ISAOs), previously worked for the Department of Homeland Security (DHS). One of his most significant contributions in the area of information sharing was his role in the establishment of ISAOs.

ISAOs are an evolution of an earlier form of information sharing, Information Sharing and Analysis Centers (ISACs). "Although ISAOs and ISACs are similar, they are meant to be complementary, as opposed to competitive," Mr. Echols said.

ISACs were first implemented in the late 1990s to allow companies to "share information for critical infrastructure protection" without the fear of anti-trust lawsuits. This process, however, was sector-based, meaning that information was only shared between companies within a particular sector of the economy (energy, manufacturing, etc.). It became necessary to explore new and increasingly effective means of collaboration. Cyber-threats have evolved over time, and the needs of companies seeking to prevent attacks have grown to keep pace. A new organization was needed to deal with new trends in cybersecurity.

"Information sharing is one of the greatest opportunities to reduce risk," Mr. Echols said. "A critical issue facing the hydrocarbon processing and petrochemical industries is how the information is shared."

President Obama laid the groundwork for the formation of ISAOs, which allow any community of interest to form an information sharing network. For example, companies in different industries that use the same control systems could share information in ways that were previously not permitted in an ISAC. This also encompasses information that could potentially be shared with the government, at the company's discretion.

Mr. Echols emphasized that government has recognized that it cannot protect every business from cyber threats. "When it comes to cybersecurity, you bear sole responsibility for the protection of your own environment."

Evan Wolff, Partner at Crowell & Moring LLC, spoke about the legal issues facing information sharing networks, such as an ISAC or ISAO, in their early development.

In 2014, the Department of Justice released a letter stating that if businesses shared information that wasn't classified as "market information," but was instead utilized to prevent cyber-attacks, anti-trust liability was not applicable.

Another issue that companies faced was the possibility of liability for an infected network being used to invade another company network. Companies in the same sector were often targeted by hackers who could gain a foothold in one system, and then use that system to access similar companies within the same sector. Again, this accentuated the fear of violating regulatory statutes and inhibited the growth of cooperative exchange between organizations.

Fortunately, these issues have been (and continue to be) resolved.

The panel stressed that the most important issue facing information sharing is the continued development of a mutual confidence between parties. The three panelists agreed that they are seeing the consistent growth of interdependent information exchange and shared connectivity against a common enemy.

"For ISAOs to be effective, it all comes down to trust," said Ms. Denbow. "I think it is quite impressive that we have progressed from ISACs, which are very sector-based, and are advancing toward ISAOs, which are much more collaborative, interest-based and reliant on trust." ●

AROUND THE MEETING

Left: Pete Sharpe from Emerson Process Management, Merrick & Company's Jay Steiner and Bruce Wright from Baker Hughes were part of a panel that led the Crude/Vacuum Distillation & Coking Q&A.

Right: Sal Torissi from Criterion Catalysts & Technologies LP presented *Yesterday, Today and Tomorrow in Hydroprocessing* in the Tuesday's Principles & Practices track.

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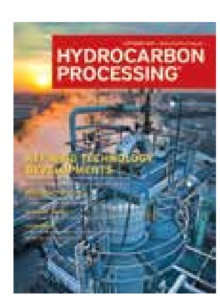

The new wave of alkylation activity in the US

GEOFF STEPHENSON and **DOMINIC VARRAVETO,** Burns & McDonnell

Octane deficiencies in US refineries are being driven by light naphtha surplus from tight oil and reduced diluent demand, increased fuel efficiency standards, and octane loss from Tier 3 sulfur reductions. These factors are spurring renewed interest in alkylation.

Light naphtha from tight oil is a suitable gasoline blend stock, but it has a poor blending octane. The octane of light naphtha can be improved through isomerization, but the resulting isomerized naphtha has a high vapor pressure. Higher vapor pressure blending components limit the amount of butane that can be blended. The increase in domestic oil production has also weakened the demand for heavy Canadian crude, reducing the demand for light naphtha diluents.

Tighter Corporate Average Fuel Economy (CAFÉ) standards have pushed engines to operate at higher efficiencies, which requires higher operating temperatures and higher octane fuels. In turn, the higher octane required by the newer high-efficiency engines will lead to the phase out of 85-octane gasoline sold in the Mountain West.

Finding the balance. An ideal solution is alkylate, which is prized for its high octane and low vapor pressure. Alkylate is produced by the reaction of isobutane with light olefins, primarily propylene and butylenes, using a strong acid catalyst.

Isobutane feed originates in the refinery crude oil feed and is recovered as mixed butanes in a saturates gas plant and other process units, such as a naphtha reformer debutanizer and a hydrocracker stabilizer. Depending on location and availability, additional isobutane can be imported to the refinery from natural gas liquids processing. When internal production is insufficient to balance with alkylate demand, the conversion of normal butane to isobutane in an isomerization unit is an alternative to importing.

Butene-2 is the preferred olefin and produces the highest octane alkylate, but propylene and amylene (C_5) can also be alkylated to form high-octane fuel. TABLE 1 provides the general performance of sulfuric acid (H_2SO_4) and hydrofluoric (HF) acid catalyzed alkylation based on different olefin feed stocks.

The primary source of olefins for most alkylation units is the fluid catalytic cracking unit (FCCU), where light olefins are formed and recovered. The yield of FCC light olefins can be adjusted by making operational changes that include varying severity, catalyst formulations/additives and operating pressure. Typical light olefin yield from an FCCU operating in traditional gasoline mode can range from 8% to 15%. Through design changes, the FCCU can be converted to operate in petrochemical mode, producing 20% to > 35% light olefin.

Balancing isobutane availability and FCC light olefin yield with existing alkylation capacity is challenging. Developing and implementing a strategy for increasing alkylate capacity requires addressing current feedstock, process configuration and equipment limitations to meet growing alkylate demand.

Key process variables. Burns & McDonnell can provide additional information on emerging trends in FCC and alkylation units, including production and recovery of light olefins, high-purity propylene for the petrochemical market, increased use of amylene as incremental alkylation feed, and olefin feed segregation and staging.

In addition to traditional sulfuric and hydrofluoric acid catalyzed alkylation processes, solid catalyst and ionic fluids provide alternative technologies.

The key process variables that impact the alkylation process are:

- **Reaction temperature.** The alkylation process is operated at a low temperature, which favors higher octane. Higher operating temperatures cause higher acid consumption and increase polymerization reactions.
- **Acid strength.** Higher acid strength favors higher alkylate quality, but operating at a lower spent acid strength reduces acid consumption, which is a major operating cost factor for the process.
- **Isobutane concentration.** In the alkylation process, a higher ratio of isobutane to olefin (I/O ratio) in the reaction section reduces polymer formation and acid consumption, but increases the amount of isobutane being recycled in the process, again increasing operating costs.

The two predominant technologies to produce alkylate are sulfuric acid alkylation and hydrofluoric acid alkylation. Key differences between the two technologies include:

- Sulfuric acid is generally considered safer than hydrofluoric acid. Hydrofluoric acid will vaporize when released and form a dangerous acid cloud, although there are additives that can be added to the acid to reduce volatility. Sulfuric acid is a burn hazard, but will not vaporize when released.
- The hydrofluoric acid process regenerates the acid in the process with only a small acid make-up required. This is possible because the contaminants in the process readily separate from the acid. In the sulfuric acid process, the acid soluble oils (ASO) do not easily separate from the acid and work to weaken it. The acid must be continuously replaced, resulting in significant acid replacement and shipping costs.
- The hydrofluoric process can operate at higher temperatures, which allows for reaction heat to be removed using cooling water. The lower operating temperature requirements of the sulfuric acid process requires that refrigeration be used to cool the reaction. This can be supplied directly through auto-refrigeration or indirectly by effluent refrigeration. Both systems require mechanical compression.
- Both the hydrofluoric and sulfuric acid processes require about the same I/O ratio in the reaction section. In the sulfuric acid process, approximately

► See ALKYLATION, page 13

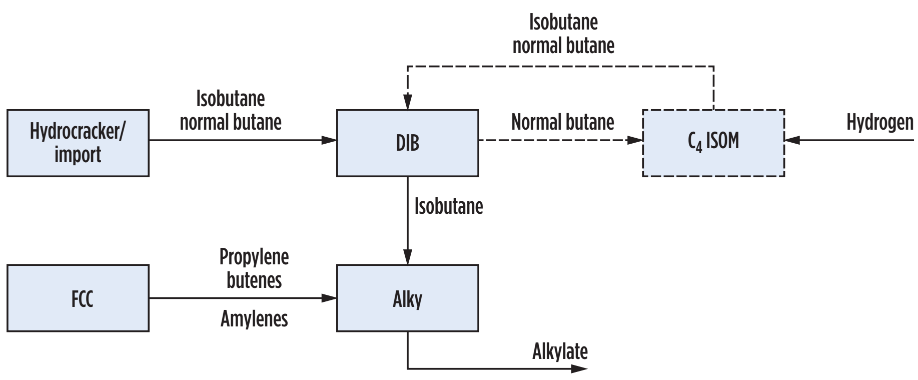

FIG. 1. A typical configuration to link the alkylation unit and a C_4 isomerization unit, with a shared deisobutanizer column.

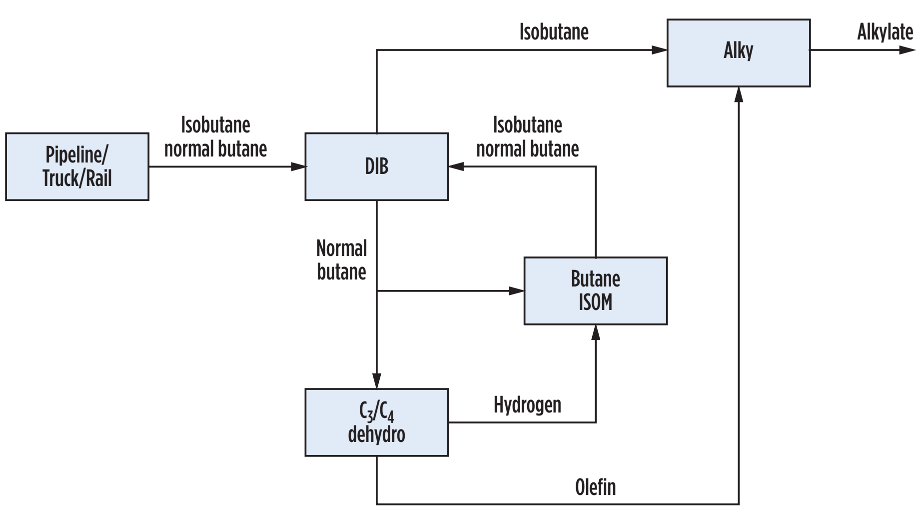

FIG. 2. Dehydrogenation plants can provide the hydrogen required for the process in butane isomerization units.

TABLE 1. General performance of sulfuric acid and hydrofluoric acid catalyzed alkylation

	RON	RON	MON	MON
	HF	H_2SO_4	HF	H_2SO_4
Propene	91–93	89–92	89–91	88–90
Butene-1	90–91	97–98	88–89	93–94
Butene-2	96–97	97–98	92–93	93–94
Isobutene	94–95	90–91	91–92	88–89
Amylene	90–92	90–92	88–89	88–90

TABLE 2. A list of recent Burns & McDonnell alkylation experience

Customer	Project	Location/Year
Refiner	Technology evaluation	Midwest, ongoing project
Refiner	Grassroots sulfuric acid unit	Gulf Coast, ongoing project
Refiner	Sulfuric acid debottleneck	Texas, ongoing project
Chemicals producer	Sulfuric acid alkylation plant	Confidential, ongoing project
Chemicals producer	Sulfuric acid technology evaluation	Confidential, ongoing project
Refiner	HF fractionation	Midwest, 2010
Refiner	Coker/VDU OSBL with HF revamp	Texas, 2005
Refiner	HF acid leak detection and mitigation	Midwest, 2015
Refiner	HF water curtain	Midwest, 2015
Refiner	HF acid detection and leak mitigation	Midwest, 2015

The politicalization of the SEC

CHET THOMPSON, President, American Fuel & Petrochemical Manufacturers

The benefits of fossil fuels are undeniable. However, a political movement is underway, all in the name of climate change, demonizes the oil and natural gas industries with the intent of gradually reducing and eventually eliminating their use. Consider what has happened to the coal industry within the last 10 years, and understand that radical environmental activists have a plan to destroy the oil and natural gas industries.

A recent tactic in their campaign is the Securities and Exchange Commission's (SEC) consideration to mandate disclosure of non-material environmental and social policy information, including how a company might be impacted by a changing climate. This regulatory effort, driven by climate activists with the support of some politicians, must be stopped.

In a concept release, which is comparable to a Notice of Proposed Rulemaking (ANPRM), the SEC seeks to explore if and how corporate financial disclosures can be modernized. SEC Commissioner Kara Stein has said that "many believe the era of sustainability or impact investing has arrived. Sustainability disclosure differentiates companies, and it may foster investor confidence, trust and employee loyalty…companies that adopt certain environmental, social and corporate governance measures may perform better than those that do not."

Her statement is a clear indication that eight decades of legal precedent establishing "materiality" as the cornerstone of SEC reporting is at serious risk of being uprooted, and is subjected to the political whims and special interests of whichever party controls the White House.

Requiring a company to disclose social and environmental matters that are not materially relevant or sufficiently certain would effectively force companies to support social and environmental policy agendas that lie outside the SEC's authority. Additionally, this requirement is an attempt to stifle freedom of speech by forcing entities to accept and amplify the social message du jour.

In late July, AFPM filed comments to the SEC's Concept Release on Business and Financial Disclosure required by Regulation S-K. In our comments, we made it clear that it is vitally important to maintain the integrity of the nation's longstanding corporate disclosure laws. Non-material information should be kept separate from what is material and relevant to a company's financial profile. We also pointed out that the SEC lacks legal authority to force disclosure of non-material information, including climate change-related information.

AFPM's members support the SEC's goal of maintaining fair, orderly and efficient markets through transparent and timely disclosure of material information. We support what is best for capital formation, economic growth and, above all, what is best for investors.

This concept release is a slippery slope with the potential to cause significant harm. Today, it is about climate change; tomorrow, it could be about whatever the latest social cause may be at the moment. This is a dangerous precedent to set.

The SEC should stick to its core mission of protecting investors and the integrity of markets, and not be vulnerable to political pressure. The longstanding definition of "materiality," which has been supported for decades by both Democratic and Republican administrations, should not be changed to reflect the latest social or political causes. ●

CHET THOMPSON is president of American Fuel & Petrochemical Manufacturers (AFPM), the trade association representing over 400 companies that encompass virtually all US refining and petrochemical manufacturing capacity. He became president of AFPM in May 2015, and leads a staff that advocates for petroleum refiners and petrochemical manufacturers before Congress and the executive branch on a broad range of public policy issues.

Before coming to AFPM, Mr. Thompson had a successful legal career in Washington, D.C. for over two decades. Most recently, he was a partner at Crowell & Moring LLP, where he was chairman of the Environment & Natural Resources Group, one of the country's premier environmental practices. He previously served as deputy general counsel at the Environmental Protection Agency (EPA) during the George W. Bush administration, where he provided legal advice to the agency's administrator, general counsel and program offices.

Before joining the EPA in 2004, he spent 10 years at Collier Shannon Scott PLLC. Since joining AFPM, Chet has been named to the US Chamber's Association Committee of 100 and The Economic Club of Washington, D.C.

Thompson holds a BA degree in political science from Boston College, and a JD degree from the Catholic University Columbus School of Law.

S&SE VAPOR RECOVERY AND DESTRUCTION SOLUTION

Ship and Shore Environmental (S&SE) has released its latest vapor recovery and destruction technology, known as S&SE VRU&D Systems. Typical products used in the loading of high-vapor pressure compounds utilize carbon elements, requiring frequent replacement of spent carbon.

S&SE's method bypasses carbon using a unique vapor recovery solution in applications including tank breathing; marine, truck and rail loading; and solvent recovery (FIG. 1).

S&SE's VRU&D Systems enable compliance with US Environmental Protection Agency (EPA) rules, local air quality rules, US Coast Guard regulations, and other industry standard practices. Volatile organic compound (VOC) recovery and destruction is managed by incorporating oxidizers directly in the vapor recovery system (VRU) system. S&SE VRU Systems feature:

FIG. 1. S&SE's VRU&D Systems manages VOC recovery and destruction by incorporating oxidizers directly in the VRU system.

- VOC destruction efficiencies of 96%–99%
- Varying VOC mixtures and/or varying exhaust
- User-friendly design for rapid installation and ease of maintenance
- Programmable control systems with LOG-IC (PLC) with data recorder and remote access
- Variable frequency drive (VFD) for reduced electrical consumption
- Integrated VPN for remote troubleshooting and view of real-time operations
- Low NO_x burners and/or multiple burners.

THE RISK MANAGEMENT OF DOWNSTREAM CYBER THREATS

A successful cyber-attack on a plant's industrial control systems (ICS) can be catastrophic. Unlike traditional data attacks, a compromised ICS can impact a plant's physical operations, causing significant financial and reputational risk, and potentially even threatening lives. Pöyry is drawing on a deep knowledge of industrial plant automation, process engineering and IT security to advise businesses on the most resilient cyber security programs.

Low oil prices put the downstream oil and gas sector under heavy pressure to reduce production costs. This may negatively affect the plant's security budget and consequently increase a risk-taking appetite, despite the oil and gas sector generally being ahead of the cyber security curve compared to other industries.

With the Internet of Things (IoT) driving greater connection between hardware and software, plants are becoming more vulnerable. Scenarios such as the cyber-attack on Ukrainian sub-stations in December 2015, during which 200,000 people lost their electricity supply, demonstrate that while data can be restored or replaced, the impact of physical damage is far more difficult to repair.

It remains the responsibility of individual companies to take ownership of their plant cyber security and provide protection. However, many companies are failing to embrace the holistic approach that is required, and are instead relying on traditional IT solutions and standards.

Pöyry is advocating a full security audit service that covers all engineering disciplines, instead of a mere IT/software-based focus. The audit provides plant owners with risk-based planning services for security and specifies the required emergency response from the plant's processes and systems. It is only through this bespoke and holistic approach that plants have a chance of staying one step ahead.

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The FFC Plus technology from Merichem delivers increased capacity and more efficient sulfur extraction treating of hydrocarbons. This technology enables higher through-put within smaller equipment and better turndown at no additional cost. Process changes and upsets are also handled more effectively without affecting product quality.

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Merichem's advanced FIBER FILM technology provides enhanced coalescing of both liquid phases that improves separation efficiency and reduces contaminant carryover. These features protect downstream equipment and catalysts.

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The higher capacity and efficiency of FFC Plus translates into reduced equipment sizes and plot space. This reduces project capital and lowers plant operating costs.

Existing Merichem or other treating units can be easily retrofitted with FFC Plus, providing up to 150% additional capacity. This capacity increase will not affect the existing turndown range of Merichem units and will improve the turndown of other units. The new contactor is a direct "drop-in" replacement that can be added or switched with minimal modifications within a short shutdown period.

MERICHEM COMPANY

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Training combats increased automation complexity

DONALD GLASER and **MATTHEW GARVEY,** Simulation Solutions Inc.

Plant automation and advanced control systems in global refineries continue to grow in complexity, allowing plants to operate in a safer and more efficient manner, but also keeping operators further from the process. With limited "flying-time," or time in direct control of the process, it is difficult for operators to gain the confidence to directly operate the processes they control. Operators have assumed more of a management position as they spend most of their time on "auto pilot."

While equipment such as sensors, transmitters and control valves become more reliable, their failure rates are far from negligible and create problems for human operators.

FIG. 1. Simulation Solutions' distillation simulator paired with ExplainMedia's virtual reality outside operator.

Based on our five-step INSTO™ approach, Simulation Solutions developed an operator training course designed to build operator competence and overcome the challenges of increasing automation. More than 200 incumbent refinery operators have participated in the two-day training throughout the US and Europe. Participants have included outside operators, outside operators transitioning to a console operator position, incumbent console operators and young engineers.

During the training course, trainees have access to their own process simulator (**FIG. 1**) to validate predictions as to how the plant and controls are designed to function in different scenarios, such as normal operations, a variety of plant upsets, safe startups and shutdowns, and exercises in increasing plant profitability.

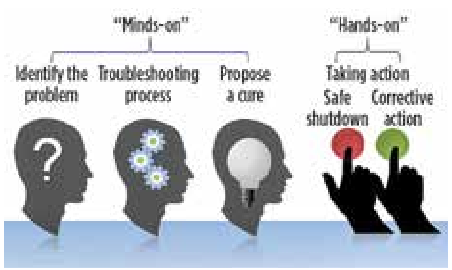


FIG. 2. The training course encourages operators to identify and detail the effects of an upset, match instrument responses to specific upsets and unscramble recovery procedures.

These highly interactive courses provide operators with transferable learning techniques that can be brought back to their control room or physical plant. Trainees are encouraged to ask questions regarding their process units and to use the techniques throughout their careers to become lifelong learners.

During the course, trainees predict how multi-loop controls actually work. The removal of operators from these control schemes shines through as trainees often struggle to relate process variables, setpoints and outputs in a simple cascade loop. Asking trainees how process variables and controller outputs will respond to abnormal conditions also reveals this degradation of controls knowledge, as trainees often can predict process variable responses yet struggle with controller outputs.

In another exercise designed to take operators out of their comfort zone, trainees are presented with a "scrambled" list of the key steps of a startup procedure for a distillation column. While operators can follow their own plant procedures to bring their specific units online, when asked about general concepts of any distillation column, trainees begin to make errors.

Without a "cookbook" sequence to follow, trainees err by suggesting starting steam before they have any level in the column, admitting steam to the column before commissioning the overhead condenser, or generating overhead vapors without a proper pressure control system in place.

Simulation Solutions' course removes trainees out of their specific unit and instills generic distillation principles from a conceptual level that can be taken to any column. Once they are through this "startup scramble" exercise, trainees then go through the detailed step-by-step procedures.

Identifying and solving problems. Specific training focuses on identifying and solving unusual problems (**FIG. 2**) and imparts troubleshooting tools and techniques, rather than practicing sparing a pump for the hundredth time.

Some operators are better than others using trends to analyze events and troubleshoot back to the root cause. Trend-matching exercises challenge operators to come in "cold" to a control room, such as after a shift change, and use the trending data to understand where their unit is and if any aspect needs specific attention.

Exercises are broken into small steps:

- Identifying the effects of an upset in detail
- Matching instrument responses to specific upsets
- Unscrambling recovery procedures to a known upset.

Another cold startup serves as a final troubleshooting exercise, with hidden faults and malfunctions that must be identified. To build confidence, operators are given full control of a unit that they will not see in their control room. During an optimization exercise, trainees compete against each other in teams to increase throughput into the distillation column while maintaining product qualities in a safe and profitable manner.

Operator feedback on the course has been overwhelmingly positive, and includes comments such as, "I am going to be more proactive,"; "I am going to look at the big picture first before making any moves,"; "I am going to use trends more effectively,"; and "I am going to communicate better with my outside operator."

Simulation Solutions' two-day operator course empowers operators to stay ahead of the curve instead of constantly trying to play catch up, and creates an attitude of lifelong learning in an increasingly automated control room. ●

ALKYCLEAN TECHNOLOGY RECEIVES TOP HONOR

CB&I and Albemarle were awarded the 2016 Presidential Green Chemistry Challenge (PGCC) award in the Greener Pathways Category by the US Environmental Protection Agency (EPA) for their AlkyClean process technology. The EPA's PGCC Challenge program recognizes organizations for successfully researching, developing and implementing novel green chemistry technologies.

Alkylate, the product of the reaction of isobutane with light olefins (C_3–C_5), is valued as an ideal "clean fuels" blending component for motor gasoline. It consists of clean combusting isoparaffins, which have a low vapor pressure and a high octane value. Furthermore, it contains no environmentally unfriendly components, such as aromatics, olefins or sulfur compounds.

The AlkyClean technology employs a solid alkylation catalyst, which is inherently safer and more environmentally friendly than conventional technologies that use toxic, corrosive liquid acid catalysts.

Global alkylate production capacity is now more than 2 MMbpd, nearly 60% of which is located in North America. These facilities require the use of liquid acid catalyzed processes, either HF or H_2SO_4. HF, in particular, is extremely toxic and, upon release, forms clouds that can be lethal for up to five miles. Albemarle and CB&I offer a catalyst/process combination that addresses these drawbacks. ●

Back to basics: Maximizing octane barrels from the FCCU

ALEXIS SHACKLEFORD, BASF

The fluidized catalytic cracker unit (FCCU) is a very flexible machine. Refiners are pushing its limits on distillate and light olefins generation, both of which will be needed in higher amounts. However, there is still a place for the FCCU to produce gasoline. US demand for distillate has dipped and refiners' production of gasoline continues to grow, as seen in **FIG. 1.** The value of an octane barrel rose significantly from \$2.10 in 2010 to \$3.99 in 2015. The FCCU should get back to what it does best: producing high-octane gasoline.

An FCCU contributes to the gasoline pool through both cracked gasoline production and C_4 production, which is used to generate high-octane alkylate for blending. Today, iC_4s and C_4 olefins are the highest valued product from most FCCUs in North America, often valued at \$20/bbl higher than gasoline.

How does a refinery optimize the production of gasoline and alkylate feed to maximize octane barrels? Unfortunately, like most things in FCC, the answer is, "It depends," due to individual units' various constraints and needs. There are four main controls on an FCCU to increase gasoline, gasoline octane and lighter products: reactor temperature (ROT), catalyst activity, catalyst selectivity and using a light olefins additive (ZSM-5).

Optimizing the available options. Maximum gasoline octane barrels are produced by optimizing these variables up to the unit's constraints. First, catalyst activity should be targeted at a high level to generate maximum gasoline while limiting overcracking. To determine this number, it is best to use laboratory data to plot activity vs. gasoline yield, and find the inflection point where gasoline yield starts to decrease with higher activity. If laboratory data is unavailable, unit data can be used.

While ROT is the least effective way to increase gasoline yield, it is the most effective way to increase gasoline octane. Increasing ROT also has the benefit of a higher cat:oil ratio, which will further increase conversion. Operating at the highest ROT up to the wet and/or dry gas production limit will produce maximum octane. Several refineries have increased ROT and decreased activity to improve octane.

A longer term option to increase octane barrels includes selecting the proper catalyst with low hydrogen-transfer activity. Often, this is accomplished by lowering the catalyst rare earth (RE) to zeolite ratio. The use of a ZSM-5 additive is another way to increase C_4s and octane. Both options will be at the expense of gasoline yield. When comparing the two methods, lowering the fresh catalyst rare earth is more selective to C_4s, while ZSM-5 is more selective to propylene.

In **FIGS. 2–5,** the four operating variables—ROT, catalyst activity, catalyst selectivity (low RE) and ZSM-5—are compared to show their effect on yields and gasoline RON. All four cases give a 1 vol% increase in butylenes for an unconstrained base case. For example, while increasing ROT will provide the largest surge in gasoline RON, it also gives the largest increase in dry gas. For unit optimization, the correct route depends on the FCCU's constraints. A good practice is to use a kinetic model such as FCC-SIM to determine the best operating variables and catalyst properties for the refiner's unit.

Refiners will continue to utilize the flexibility of the FCCU to maximize profits. BASF has the expertise in FCC modeling to help refiners achieve successful and profitable operation.

To learn more about BASF products and capabilities, meet the team at booths 1/2 or visit the hospitality suite on Tuesday evening. ●

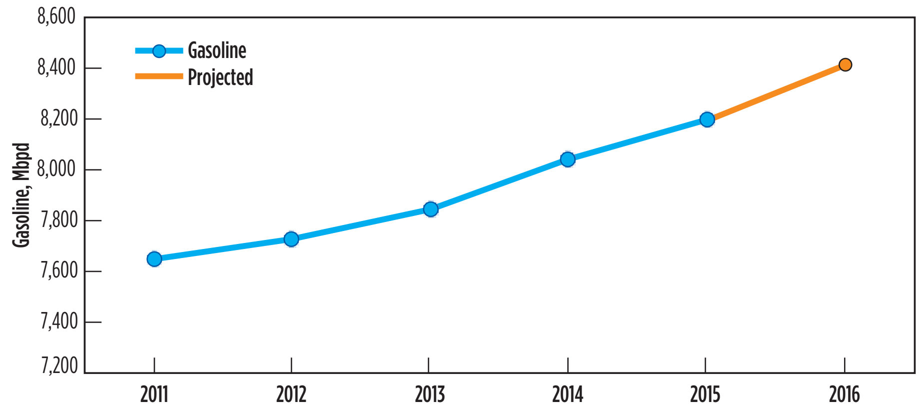
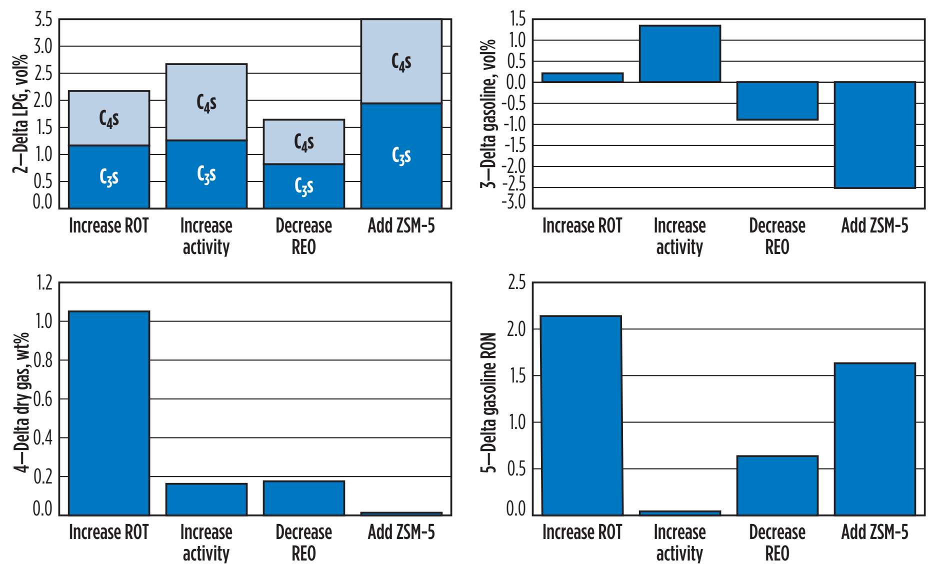


FIG. 1. US refinery gasoline output continues to rise, and 2016 is projected to outpace 2015. Source: IHS Inc. 2016.



FIGS. 2-5. Comparison of ROT, catalyst activity, catalyst RE, and ZSM-5 vs. the effect on LPG (liquefied petroleum gas), gasoline, dry gas and gasoline RON. All four cases give a 1 vol% increase in butylenes.

Accelerate supply chain profitability in a dynamic environment

ALLISON MCNULTY, AspenTech

Fluctuating crude oil markets and general industry volatility are spurring oil and gas companies to adapt and manage their businesses more scrupulously than ever before. Optimizing supply chains and better managing feedstock prices allows owner-operators to respond more quickly to disruptions, capitalize on trading opportunities, and optimize inventory and transportation assets. Agility can only be achieved if managers maintain easy access to business information and data.

To gain a lasting competitive edge in the petroleum supply chain, companies must deploy the latest technologies.

Large distribution networks operate in a dynamic environment and require accurate information to make fast decisions. Without an optimized tool set, companies can face late deliveries, too little or too much product, or even idle transportation due to sub-optimal logistics planning.

Many leading oil and gas companies rely on advanced fleet optimization software solutions to manage the complexities of secondary supply distribution and various demand patterns.

These solutions (**FIG. 1**) provide users with forecast technology and active guidance to address challenges related to order management, demand forecasting, fuels inventory management, replenishment planning, transportation scheduling and execution management.

Users have access to proportional replenishment algorithms functionalities that factor constraints into a robust replenishment plan, including terminal, tank, truck or cargo constraints, and seasonal fluctuations.

New interactive web-based mapping applications provides dispatchers with an accurate view of the schedule as it is being executed. Users can filter groups by date, time period, product and geography. Color coding enables the user to view which stations have received their product and track deliveries.

Changes to the supply chain can be anticipated. Dispatchers can also better anticipate unplanned runouts and proactively solve the issue.

In the constant global battle for profits, integrated software solutions offer the necessary continuous innovation to help oil and gas companies adapt quickly to energy price changes and market fluctuations. ●

FIG. 1. With advanced tools, such as AspenTech's Map Monitor, users can visualize the schedule as it is being executed.

Mixing in the process industry: Saving through design exploration

THOMAS EPPINGER and **RAVINDRA AGLAVE,** CD-adapco

The process industry is about converting raw materials into value-added products in three steps: Mix, react and separate. This is an oversimplification, but high cost penalties associated with poor mixing are a reality.

Computer simulation and optimization using mathematical modeling software to achieve the best design can shorten or avoid conventional trial and error method. Once mixing performance parameters are identified, hundreds of design points can be quickly analyzed to arrive at optimum designs within given constraints and satisfy process requirements.

Within a stirred tank design optimization study, the design objectives are minimizing mixing time, improving mixing quality and minimizing power consumption. From a geometrical design perspective, parameters include impeller configuration, vessel size and type, number of baffles, etc. A complex, nonlinear relationship between design parameters and design objectives exists. Scaling up the process to production capacity can also be costly and time-consuming. Numerical design optimization adds value by allowing design improvements to a stirred reactor before physical prototypes are even built.

In many cases, objectives are competitive in nature (e.g., minimizing mixing time and minimizing power consumption), so there is no single optimum design. Improving mixing time is only possible by sacrificing power consumption. In such scenarios, a non-dominated sorting algorithm can determine the best design in terms of one objective for a given value of the counteracting objective.

For this study, a series of tuning parameters and two competitive objectives for a stirred tank design were identified: power number vs. mixing time.

The goal was to find an optimal tradeoff between the competitive objectives for each case. A multi-objective mixing study using MO-SHERPA from the HEEDS software, and computational fluid dynamics analysis using STAR-CCM+ was carried out.

Mixing criteria. Mixing time can be defined as the time it takes to achieve a pre-defined level of homogeneity, and mixing quality can be evaluated using die decolorization, electrical conductivity and pH measurements, among others. STAR-CCM+ from CD-adapco can define a variety of desired mathematical formulations for measuring the mixing quality through field functions.

A statistical analysis method was used on the mixing quality of every cell inside the numerical domain using the relative standard deviation (RSD) method, which is the ratio of standard deviation of the tracer's mass fraction over the entire domain to its corresponding average concentration. RSD can be formulated as follows (Eq.1):

$$RSD = \frac{\sigma}{\bar{C}} \qquad \sigma = \sqrt{\frac{\sum_{i=1}^{n}\left(C_i - \bar{C}\right)^2}{n-1}} \qquad (1)$$

where C_i is the mass fraction of the tracer at the ith cell, C is the volume-averaged value of mass fraction of the tracer in the entire domain, and n

▶ See **MIXING INDUSTRY,** page 13

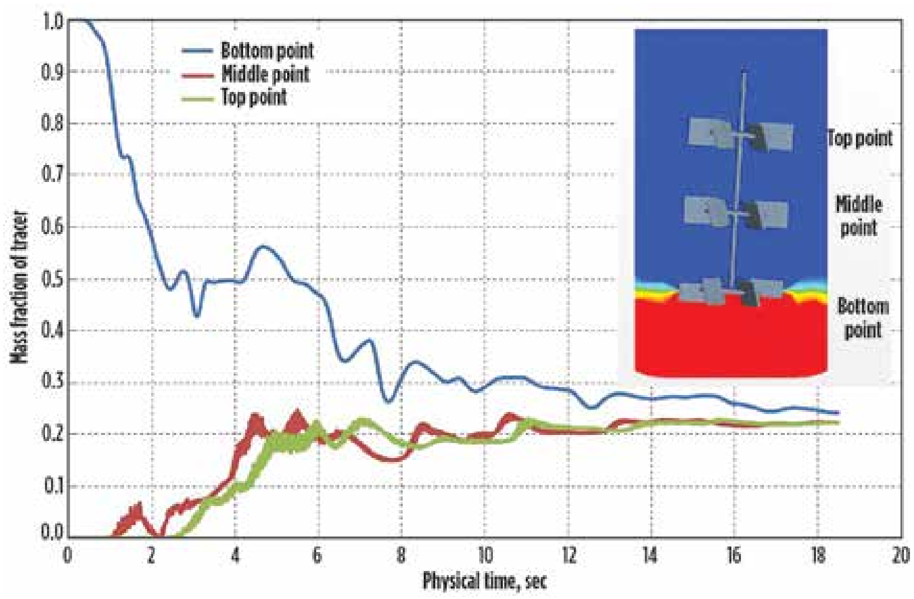


FIG. 1. A 3D-CAD model of a parametric mixing tank geometry.

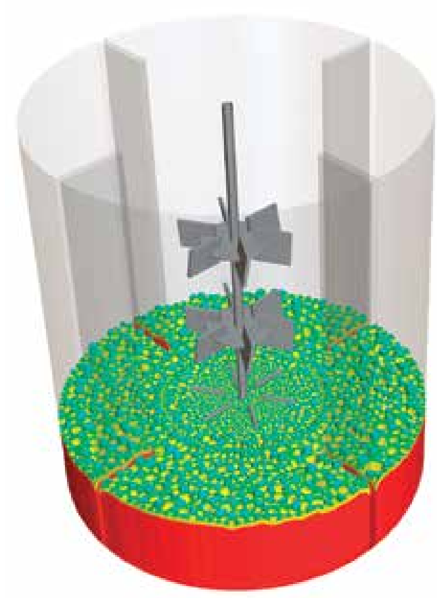


FIG. 2. In the stirred tank optimization study, mixed liquid was tracked as a passive scalar that is initially at rest at the bottom of the tank.

TABLE 1. Seven design variables chosen for the optimization study

	Minimum	Maximum	Intervals
Number of impellers	2	4	3
Number of blades per impeller	3	9	7
Impeller blade angle	0	45°	16°
Impeller blade height	0.01	0.06	11
Impeller radius fraction	0.2	0.5	21
Number of baffles	2	6	5
Baffle height fraction	0.6	1	21

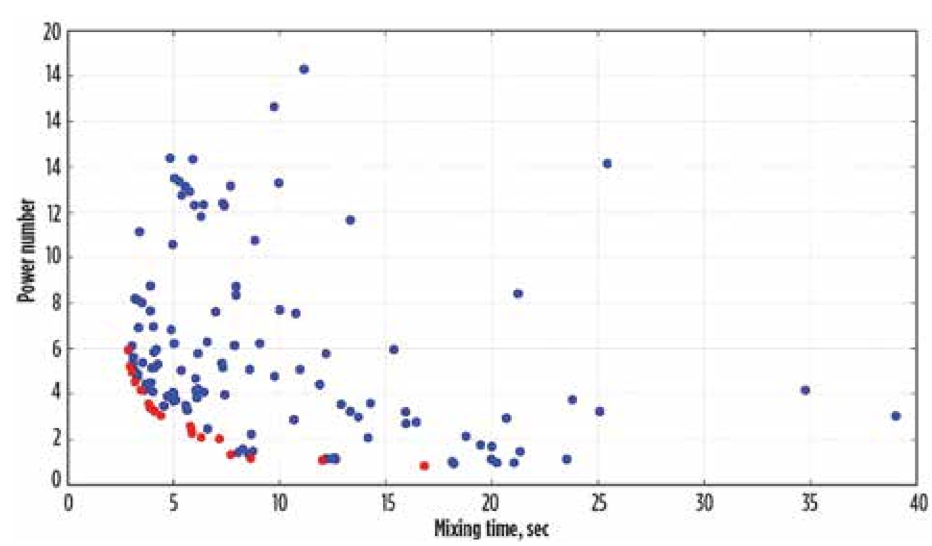


FIG. 3. The clustering of dots illustrates how the optimizer is forcing the designs toward the optimal corner, corresponding to lower values of mixing time and power number.

The virtues of virtualization—An emerging role for HMI in process automation

Traditional process automation includes multiple PCs deployed across an operation, each with its own dedicated operating system, software and hardware. Every PC operates independently, controlling specific applications, alarms, historic data, asset management and MES software, among other tasks.

If one workstation fails, the entire operation could fail. Separate software and hardware upgrades become expensive and time consuming, and workstations in the process area are restricted from changes without violating compliance certificates.

FIG. 1. While the user operates the dedicated workstation as usual, the host server generates the user interface, compresses it and sends it through an Ethernet-based remote protocol to the thin client.

Virtualization, where a variety of operating systems, software and hardware functions (PCs) are consolidated onto one or more central server(s) as virtual machines, has changed all that. Each workstation is replaced by a remote monitor and an embedded thin client, which communicates work being performed behind the scenes in a central server. The host server is capable of simultaneously operating multiple virtual machines in different environments. To a field operator, the virtual human machine interface (MHI) looks, acts and feels like a dedicated PC.

The concept of virtualization has been around for decades, but has only recently found practical and cost-effective applications in process automation.

Thin clients and remote monitors. A thin client is a basic HMI that runs only necessary drivers for input and output devices, such as a mouse, keyboard or touchscreen. Thin clients are the first-choice technology for virtualized automation systems as they transfer data efficiently over an Ethernet network.

The host server generates the user interface, compresses it and sends it through an Ethernet-based remote protocol to the thin client. User inputs are sent in the opposite direction. For the user, operating an application is no different than running a dedicated workstation (FIG. 1).

Conventional technologies such as keyboard-video-mouse extenders are ill-suited for virtualized systems because one or many machines usually run on host server hardware with no dedicated physical interface to connect HMIs.

Thin clients are a high-performance and low-cost solution for accessing applications and information in process automation (FIG. 2). Some remote monitors, such as those offered by Pepperl + Fuchs, are engineered to withstand the harshest conditions and hazardous areas in process automation applications.

One of the key benefits of a thin client is that no data or applications are installed locally or need to be maintained. Because thin clients use Ethernet and remote protocols to access applications and data from a host server, the system configuration is simplified and computing hardware is minimized. Upgrades are all performed from the host.

A "remote monitor" is often an interchangeable term for a "thin client," but the label remote monitor is frequently used for robust machines that are based on industrial-grade hardware without any moving parts. These machines are commonly rated to withstand wide temperature ranges, shock and vibrations, and are sometimes rated for hazardous locations with explosive atmospheres.

A remote monitor offers several features that optimize the remote connection with automatic logins, connection loss detection and backup connections. By removing critical hardware from hazardous, harsh or even sterile environments, far fewer resources are spent on protecting HMI equipment.

Another key benefit is the long lifecycle of industrial thin clients. For example, Pepperl+Fuchs' first-generation thin clients have been available for nearly a decade, and the second generation have just been recently launched. Most consumer-based thin clients have a short lifespan of less than three years before obsolescence.

Benefits to virtualization. Centralized management and a lower dependence on hardware devices are just a few of the appealing aspects for the process automation industry.

On the hardware side, only a limited set of components need to be maintained. For software, powerful tools are available that allow easy management of multiple virtual machines. Features include duplication of virtual machines based on master images that easily allow simultaneous software updates among multiple virtual machines.

Consolidating numerous physical computers into a virtual network with only one or a few physical host servers can substantially reduce hardware expenses.

The centralized management of virtual automation also simplifies the rollout of new applications. Software updates can be installed on a single server and then duplicated across the entire network. New applications can be tested offline in machines that run independently from the virtual machines used in production.

Increased uptime. Virtual systems make it easy to set up redundant servers and increase a system's reliability. For example, multiple host servers can be configured as a pool of resources, with virtual machines deployed throughout the pool. If one of the physical host servers fails, virtual machines can be automatically switched to an alternative host server.

Administrators can also balance server loads in the same way, either locally or remotely, and equipment can be freed up for repair without shutting down the whole system. This equates to virtually no downtime due to IT issues, which is not possible with a traditional server infrastructure, where the operating systems are closely coupled to their physical servers. •

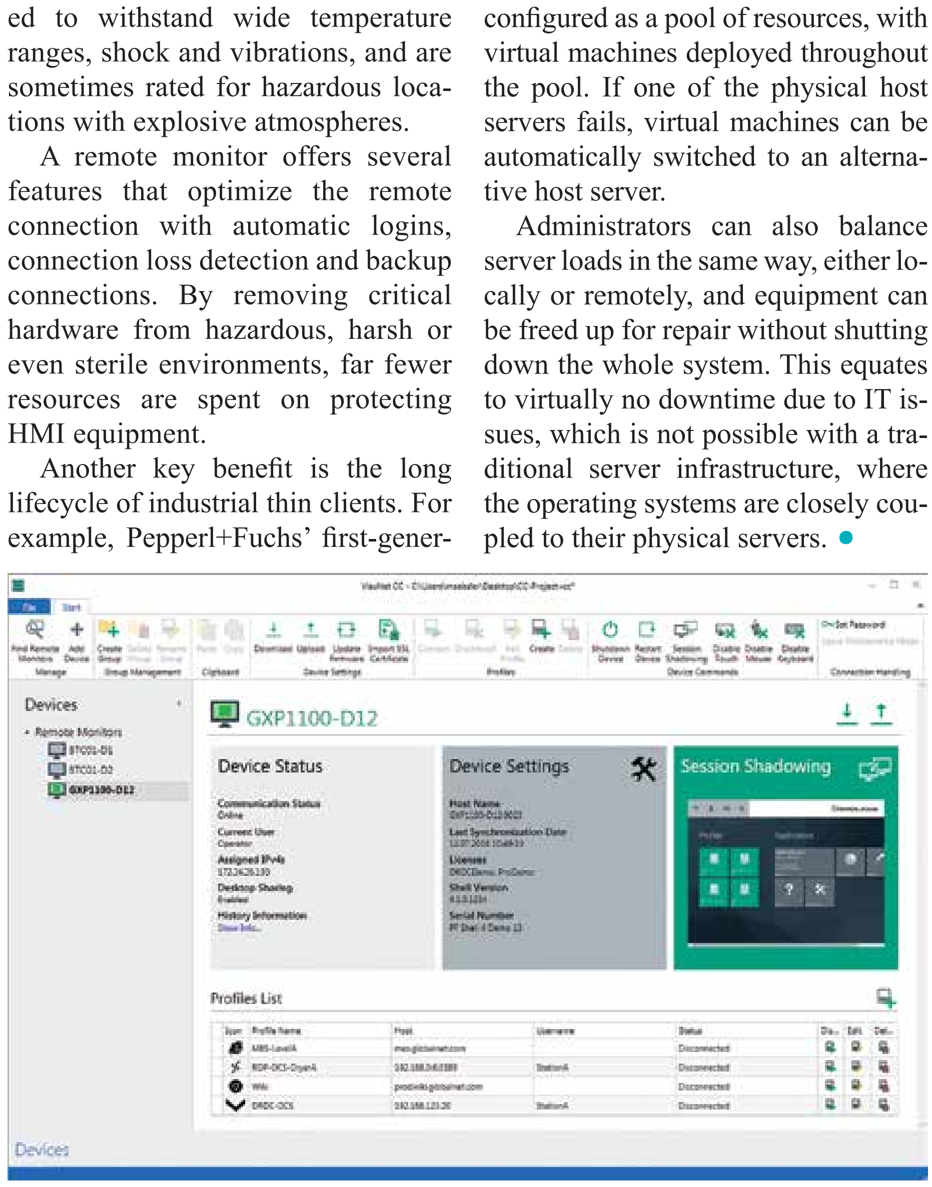


FIG. 2. Remote monitors are easily administered using thin client management tools.

ALKYLATION, continued from page 4

half of the isobutane recycle is achieved through the refrigeration system and the rest through distillation. In the hydrofluoric process, all isobutane recycle is achieved through distillation, which increases distillation equipment size and operating cost.

FIG. 1 shows a typical configuration to link the alkylation unit and a C_4 isomerization unit into a single processing unit with a shared deisobutanizer column.

Partnering to explore opportunities. Other novel configuration options for alkylate production include non-refinery-based units that import the olefin and isobutane and export alkylate product. There is negligible byproduct production in the alkylation process, which reduces the need to integrate the unit into a refinery. On-purpose olefin can be produced from natural gas liquids through dehydrogenation processes to supply stand-alone alkylation plants. Butane isomerization units can also be incorporated into stand-alone plants, but require a source of hydrogen for the isomerization process. Dehydrogenation plants can provide the required hydrogen (FIG. 2).

The abundance of natural gas liquids from shale gas production, as well as increasing demand for alkylate, have presented many opportunities. These opportunities range from FCC reconfiguration and alkylation unit revamps for incremental capacity, to fully integrated stand-alone alkylation plants.

An experienced refinery process engineering company like Burns & McDonnell (TABLE 2) provides start-to-finish conceptual, front-end planning, and detailed engineering and construction capabilities to bridge any gaps between technology licensor, engineering execution and implementation. We are technology neutral and will work with a preferred alkylation technology licensor to develop and optimize your overall alkylation project, including utilities and offsites. ●

MIXING INDUSTRY, continued from page 10

is the number of cells. Good mixing corresponds to a low RSD value. In this study, the mixing time is defined as the time it takes to reach an RSD value of 0.3, which does not denote ideal mixing, but serves as a common value for "good" mixing.

Numerical approach and competitive objectives. A parametric mixing tank geometry was created in STAR-CCM+ using the 3D-CAD modeler (FIG. 1). Mixed liquid was tracked as a passive scalar that is initially at rest at the bottom of the tank (FIG. 2). A transient simulation was performed and the two competitive objectives were power number vs. mixing time.

TABLE 1 shows seven design variables and defines the range within which the variables can be fine-tuned tuned using Optimate, a mathematics based rigourous optimization plugin. In this study, this number corresponds to 8,149,680 variations. Covering this design space manually would be nearly impossible, so Optimate uses the SHERPA optimization algorithm to reduce the number of evaluations to a time-efficient number of runs per design variable and modifies its search-ing strategy as it progresses. Optimate took only a few days to search the design space and complete 150 evaluations for the best results.

The set of outcomes resulting from the optimization is called the Pareto front (FIG. 3). The clustering of dots close to the Pareto front illustrates how the optimizer is forcing the designs towards the optimal corner, which corresponds to lower values of mixing time and power number. This plot answers questions such as, "What is the minimum possible power number for a specific mixing time?" or "For a specified power number, what is the minimum possible mixing time?" These questions are worth millions of dollars in the mixing industry.

Key learnings. Process engineers are driven by the desire to reach the highest mixing efficiency, which is influenced by competitive objectives such as mixing time vs. power consumption, or moment on the impeller assembly vs. turbulent kinetic energy. Because these objectives depend significantly on the geometry of the tank and the impeller, a multi-objective parametric study is required to identify the best design to achieve both objectives. Using the design space exploration/optimization approach, process engineers can arrive at final designs faster. ●

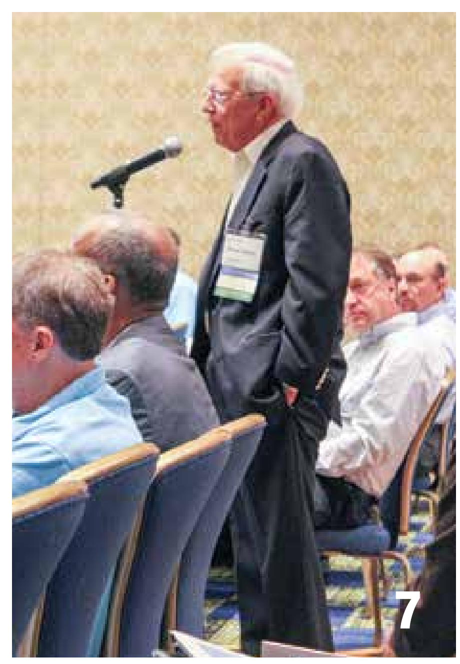
CALIFORNIA FURTHER RESTRICTS POLLUTANTS

California has moved to restrict air pollutants from sources as diverse as diesel trucks and cow flatulence, the latest of several efforts to reduce state-wide emissions.

Under a bill signed by Governor Jerry Brown, the state will cut emissions of methane from dairy cows and other animals by 40%, and black carbon from diesel trucks and other sources by 50%. The bill also mandates that the state reduce emissions of fluorinated gases, or hydrofluorocarbons, used in refrigeration.

The measure follows several climate change bills signed in recent weeks, including one that will, by 2030, mandate an overall reduction of greenhouse gas emissions to 40% below the 1990 levels. ●

SCENES FROM THE 2016 AFPM Q&A AND TECHNOLOGY FORUM



1 **Paul Clewis** from Axens North America sat for a portrait by a talented digital artist in the company's hospitality suite Monday night.

2 High-rollers share a victory laugh as they test each other's nerves in **Athlon's** casino-themed hospitality suite Monday evening.

3 Gulf Publishing Company's **Josh Mayer, Susan Yashinskie** from AFPM and **Kirk Novak** from Merichem Co. connected at Monday night's reception.

4 **Steve Williams, Arvids Judzis, Tim McGuirk, Joan McGuirk** and **Carl Bochow** from CB&I discussed their latest technologies and products with attendees.

5 A fortune teller read the palms of an AFPM attendee. A sharp business sense, a passion for the industry and a bright future were some of the key findings.

6 Even during breaks, AFPM attendees were actively networking and discussing the latest industry trends.

7 Industry veterans like **Warren Letzsch** contributed their expertise to the Q&A sessions.

8 Not even a thorough shoeshine could distract those who visited **Johnson Matthey's** lively event from the presidential debate.

9 The team from **Technip** gathered with colleagues to celebrate a successful AFPM conference.