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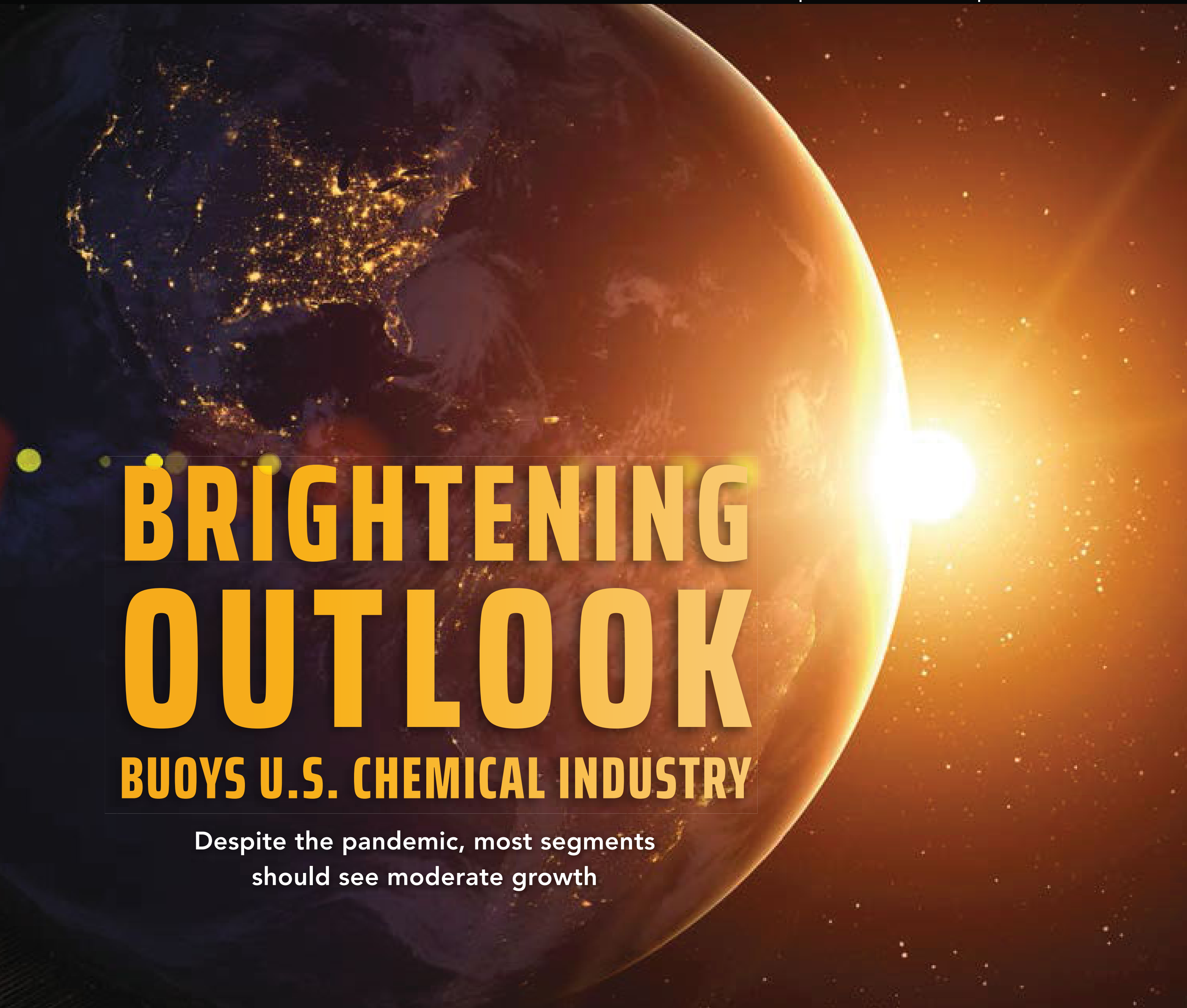

BRIGHTENING OUTLOOK BUOYS U.S. CHEMICAL INDUSTRY

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JANUARY 2021

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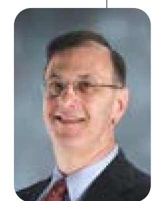
Open Access Reaches a Milestone

Expect easier availability of much research work



Publishers of scholarly journals are responding.

JANUARY MARKS a significant juncture in the advance of open access publishing. It's when a major initiative, cOAlition S, comes into full force. Launched in 2018 by a group of European and international organizations as well as charitable foundations that fund research and with the support of the European Commission and the European Research Council, the initiative aims to eliminate restrictions on access to articles that cover work underwritten by such funding.

"With effect from 2021, all scholarly publications on the results from research funded by public or private grants provided by national, regional or international research councils and funding bodies must be published in Open Access Journals, on Open Access Platforms, or made immediately available through Open Access Repositories without embargo," mandates the group. (For more details on cOAlition S, see: www.coalition-s.org.)

The initiative arose from concerns that, while funding for much of the work covered in papers in academic journals comes from government bodies and charitable foundations whose aim is to make results widely and quickly available, the subscription-fee-based approach traditionally used by these journals thwarts broad access. Indeed, the high subscription prices of many journals have posed a significant burden on libraries and often limited the number of titles to which they can afford to subscribe. This also, of course, undermines ready access by individuals to papers they might find valuable.

Publishers of scholarly journals are responding. For instance, in late November, Springer Nature, New York City, which publishes an immense number of journals, including *Nature*, *Nature Biotechnology*, *Nature Catalysis* and a host of other titles related to chemistry and engineering, announced that authors now have an open access option.

However, open access will come at a steep price at Springer Nature. The publisher will charge authors $11,390 (€9,500) to provide open access to a paper in *Nature* and 32 other journals that rely on subscriptions and now keep most content behind paywalls (i.e., access requires paying a fee).

Interestingly, a news item on Nature.com about the option, https://go.nature.com/33MZm0F, notes that the highest charge elsewhere is under $6,000 (≈€5,000) and cites several people in academia who call the fee too high. That piece also includes a response from the publisher on why it must charge more.

That news item says Springer Nature is exploring an approach that would about halve the open-access fees for some journals. Now in trials with *Nature Physics*, *Nature Genetics* and *Nature Methods*, it involves paying a non-refundable fee of ≈$2,600 (€2,190) to cover editorial assessment and peer review. Then, for any submission found suitable, the author pays an additional fee of ≈$3,100 (€2,600) for publication.

By the way, paywalls certainly don't only afflict scholarly journals. Some trade magazines require an extra subscription fee to access their full content online. Rest assured that *Chemical Processing* never charges to make the complete text and graphics of our content available. However, for some online content such as our free webinars and special reports, we do ask for a bit of information, e.g., your name, email address and job title, which we consider reasonable and not burdensome. ●

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Successfully Change Particle Size

Sometimes you can modify crystals without starting over

Doing process development in a production environment is messy.

MANY PROBLEMS in solids processing aren't traceable to a specific piece of equipment or the procedures used to create the product. The culprits can be very elusive, especially when you're trying to make a specific particle size distribution (PSD). It gets worse when your customers come out with a new specification. You just can't change a temperature to get a new product in one piece of equipment as you can in a distillation column.

Often, the requested alteration is in the PSD. To make that change, you may have from one to four pieces of equipment in the process that you can use. The crystallizer is the most common piece of process equipment that can adjust the PSD. However, just altering the conditions in the crystallizer isn't enough; that change must last through the solid/liquid separation and possibly a dryer, not to mention transport (conveying and packaging).

If your chemists have evaluated the crystallization process as I outlined in a past column "5 Alternatives to Conquer Crystallization Challenges," https://bit.ly/36Fdf2C, you only may need to modify the crystallizer. For example, we made a product in a draft-tube crystallizer that used a fines destruction loop to control PSD. Changing the PSD was fairly straightforward. Luckily, our chemists pretty painlessly could evaluate different conditions and parameters. They did a series of small-scale test batches with various super-saturation levels to assess a variety of key parameters to get answers to some crucial questions:

- *Average particle size*. What are the mean size and overall PSD?
- *Growth time*. How long did it take to get to the above size?
- *Metastable zone width*. How super-saturated was the solution when crystals formed?
- *Yield*. How much solute did the isolated product contain?
- *Product purity*. How much of the solution ended up in the isolated product?
- *Product shape*. What did the crystals look like?
- *Filterability*. How easily did the crystals filter?

These tests showed little change in the product while altering the particle size. However, the various super-saturation levels provided enough information to modify the PSD in the draft-tube crystallizer. We then conducted more-comprehensive tests in a supplier's pilot plant to determine the cut size for the fines destruction loop.

We weren't as lucky with another product that was made in a forced-circulation device. The desired PSD required a new agglomeration step. We were able to perform it in the dryer — but not easily because doing process development in a production environment is messy. The plant did have another fluid bed that used a disperser to increase the average particle size and we were able to play on that experience. During development of that dryer, we found that we could mix fine particles from the dryer's baghouse into the disperser to act as a pseudo-cement. That wouldn't have been possible if the baghouse had been integrated into the dryer, which is a common design that can cause instability in the fluid bed.

Frequently, a customer will request a smaller product. While you might think achieving that would be a simple task, crystal shape is an important characteristic. Some chemicals don't have the same reactivity when the shape is altered. A customer for a baking product we made wanted a much finer size because it improved the "mouth feel" of the product. Grinding the original product led to disappointing results. By going back to the experimental design parameters as outlined above, we found a set of conditions that not only produced a smaller particle but also gave an even better "mouth feel." Having the experimental design parameters allowed us to offer this upgraded product and command a higher price.

One point about doing development in a plant: I worked with a company that had a policy in which engineers who designed a new plant or process ran it for a short period before the unit became commercial. This had the advantage of evaluating the fundamentals of the design in case a slightly different product was desired. It also helped in training operators and giving them a better feel for the process. The lessons were invaluable and allowed us to change the product, if needed. ●

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Don't Jump the Gun

Evaluate causes and service life left before rushing to repair

As a general rule, be skeptical of layout drawings.

THE BOILER feedwater line to the reactor coils failed after 24 years. It had been patched several times but no records were kept. The superintendent noted that valve flange bolts mysteriously fell apart. Yet, one manager dismissed concerns because he thought 24 years was a pretty good service life.

Cutting out a section before the line failed would have been nice but production had a "run to failure" attitude. Now, an elbow looks like a spaghetti strainer with 85-psig water gushing out; a clamp has bought some time but what next? Put in a more expensive alloy? Make the pipe wall thicker? These are common impulses.

Instead, I heeded the words of Gene Kranz, the chief flight director during the Apollo 13 mission: "Work the problem. Don't make matters worse by guessing."

I laid out a plan: evaluate how boiler chemicals are added and monitored; collect history on the pipe; determine the pipeline fluid chemistry upstream and downstream; do a complete metallurgical study of the failed pipe and fresh pipe around it; and perform a start-to-finish inspection of all 550 ft of the pipeline. One critic complained that the boiler feedwater pump, tank and boiler line didn't show any corrosion; I wasn't deterred: one line at a time.

I collected data on the boiler feedwater chemicals. As often occurs, the additions were based on shift lab analysis — definitely not steady state.

The chemical supplier agreed to test water samples and predicted that chlorine in the city water was the culprit. Sure enough, the lab report indicated chlorine is a problem. However, as I then pointed out, the side reaction of ClO^- (hypochlorite) with sodium sulfite (the O_2 scavenger) can produce HCl and, more importantly, deprive the system of scavenger. The hypochlorite reaction is more exothermic than the scavenger reaction. So, I insisted on waiting to see what the metallurgy study revealed.

The metallurgy study involves destructive testing. Samples are dye-tested with acid for inspection of the metal crystals and spaces between them. X-raying of other samples determines precisely what's left in the metal and what corrosion has washed away. In addition, tensile testing shows how the mechanical strength of the metal compares to literature values.

The inspector ran positive material identification, i.e., x-ray fluorescence, and ultrasound thickness (UT) measurements on spots from beginning to end of the pipeline. I marked up a Google map of the pipe run because it was outside; as a general rule, be skeptical of layout drawings. The map showed the sample points for the inspection. After insulation was removed, each pipe sample was marked with a number. The results came back showing a variety of pipe schedules, materials and thicknesses.

Compensating for temperature is important in UT measurements. ASTM E797-95 notes that sound velocity changes by 1% for carbon steel and austenitic steels per 100°F difference between the calibration temperature, say, 68°F, and the wall temperature, typically measured with an infrared gun. So, for a pipe wall thickness measurement of 0.18 in. at 250°F, the actual thickness is 0.176 in.

The hoop stress calculation showed failure wall thickness was just about the wall thickness measured at the hole.

Therefore, I decided to do a quick calculation of the remaining pipe life and the corrosion rate: CR = $(t_{original} - t_{measured})$/spent life of pipe × 1,000 mills/inch = mills/year; then, $(t_{measured} - t_{failure})$ × 1,000/CR = remaining absolute life (with no safety factor).

Another reason why you have an inspector onsite is to determine how much of this cancer must be cut away. You certainly don't want to weld onto thin pipe. Of course, because thickness is a critical measurement, you might want to have a UT gun onsite not only to confirm tie-ins but also to determine pipe schedule and tank wall thicknesses.

This crude first step made two things clear: 1) the remaining life was at least five years, not nearly as short as feared by those wondering how they'd find $130,000 during a pandemic; and 2) the corrosion might be showing a pattern with shorter life upstream than downstream.

A common problem in maintenance is jumping the gun and doing repairs before they really are required. ●

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Catalyst Promises to Ease Plastic Recycling

Nanoparticles convert polyolefins into high-value upcycled products

PLASTICS RECYCLING continues to draw the attention of researchers and industrial firms working to tackle the growing global pollution crisis in single-use plastics (see, "Industry Breaks the Mold for Discarded Plastics," http://bit.ly/2Do11Qe, and "How Industry Tackles Plastics Plague," http://bit.ly/2v6SfOT).

Now, the U.S. Department of Energy's Ames Laboratory, Ames, Iowa, has developed a novel catalyst that converts polyolefin plastics such as polyethylene and polypropylene — commonly found in everyday plastic items such as grocery bags and food containers — into high-quality components suitable for producing high-value products such as fuels, solvents and lubricating oils. It could potentially turn these and other used plastics into an untapped resource, believe the researchers.

Scientist Wenyu Huang of Ames Laboratory designed a mesoporous silica nanoparticle consisting of a core of platinum with catalytic active sites. Long polymer chains thread through the catalyst via silica pores that surround the site. With this design, the catalyst is able to grasp and cleave the longer polymer chains into shorter pieces that have the most potential to be upcycled into new, more-useful end products. An article in *Nature Catalysis* contains more detail.

"This type of controlled catalysis process has never before been designed based on inorganic materials," notes Huang, who specializes in the design of structurally well-defined nano-catalysts. "We were able to show that the catalytic process is capable of performing multiple identical deconstruction steps on the same molecule before releasing it."

Furthermore, this controllability could lead to design systems that exclude certain large nonlinear molecules, as well as optimize the center point of the product distribution.

"The narrow pore in mesoporous silica could slow down or prevent the diffusion of large nonlinear molecules in the pore, and thus the access of polymers to the active sites located at the end of the pore. This will increase the reactant selectivity and, ultimately, the product selectivity," explains Huang. "… However, this will require much more research to achieve a better understanding of the molecular-level reaction mechanism."

The researchers have recycled the catalysts for several cycles, suggesting the catalysts are quite robust. The special confined structure of the active Pt nanoparticles inside the mesoporous silica shell strengthens the catalyst, says Huang.

Furthermore, their susceptibility to poisoning would be the same as Pt catalysts already in use. "We would note that the catalyst remains active even in the presence of impurities in post-consumer polyethylene films, used in grocery bags," adds Aaron Sadow, a scientist at Ames Laboratory and director of the Institute for Cooperative Upcycling of Plastics (iCOUP).

The researchers foresee this catalyst being able to handle a mixed stream of polymers of different structures, such as polyethylene and polypropylene that form the bottle and cap of plastic milk containers.

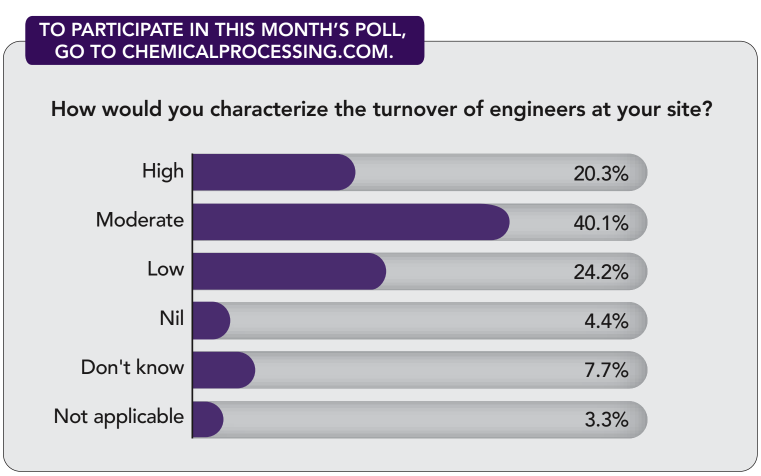
"The design of catalytic materials could allow conversions [of] mixtures of two or more plastics by using larger diameter pores, or it could convert one kind of chain in the mixture, using the pore to exclude bigger chains," reckons Sadow.

"We could design nanoparticles targeting different polymers and use sequential processes to achieve the conversion of mixed polymers," suggests Huang.

Producing the nanoparticles with active sites on a larger scale does pose some issues, namely, developing new synthesis processes to achieve large-scale production of the structured catalysts. "We are currently developing flow processes for polymer upcycling," says Huang.

iCOUP, a DOE Energy Frontier Research Center (https://science.osti.gov/bes/efrc/) consisting of several universities and led by Ames Laboratory, will expand and continue the research. To learn more about its work, visit http://bit.ly/2WrZZZb.

The team has a provisional patent on the catalyst and processive process and is exploring commercial collaborations.



More respondents reported moderate turnover of engineers.

Sponge-Like Structure Boosts Desalination

A PROCESS that creates crosslinked, hybrid advanced water channel-polyamide (AWC-PA) nanoparticles bound together in novel sponge-like structures (Figure 1) promises more efficient desalination, believe its developers, an international team of researchers based in France, Saudi Arabia and Italy. During testing under industrial conditions, the biomimetic desalination membranes demonstrated 75% higher flow and 12% less energy consumption than those currently used in commercial facilities.

AWCs are synthetic compounds that form pores permeable to water molecules while rejecting ions.

Up to now, a lack of fundamental understanding of how best to incorporate AWCs, starting from their colloidal self-assembled superstructures, at the nanoscale to facilitate the selective transport of water has hampered optimization, say the researchers.

The key challenge is the need for adaptive gentle interaction between the PA and water channels to prevent the formation of defects, the team found.

A recent article in *Nature Nanotechnology* reports on tests of the new membranes at 65 bar applied pressure with a 35,000-ppm sodium chloride feed solution at pH 8. "This is representative of seawater desalination and crossflow conditions of full-scale systems," notes Mihail Barboiu, research director at the Institut Européen des Membranes, Montpellier, France, which is coordinating the work.

"To assess the performance of the bio-inspired membranes with real seawater, low-recovery experiments were also performed using the American Standard for Testing and Materials recipe for substitute ocean water as feed solution," he adds.

The membranes sustained their performance even when exposed to relatively harsh environments representative of real systems, where membranes undergo cycles of physical and chemical cleaning, often involving acidic, basic or amphiphilic compounds.

The researchers have considered several methods to handle the challenges of scaling-up the new membranes while at the same time improving their performance both in terms of permeability and selectivity, says Barboiu.

"One of the creative strategies is to combine the classical polyamide reverse osmosis membrane material, known for its scalability via integration within a typical roll-to-roll processing system, with the highly permeable and selective AWCs. We need add only one more step to the classical PA production process to achieve this," he explains.

In fact, the next phase of work will focus on implementing roll-to-roll production of the new membranes.

The process already has attracted interest from a number of industrial concerns, states Barboiu.

SUPERIOR STRUCTURE

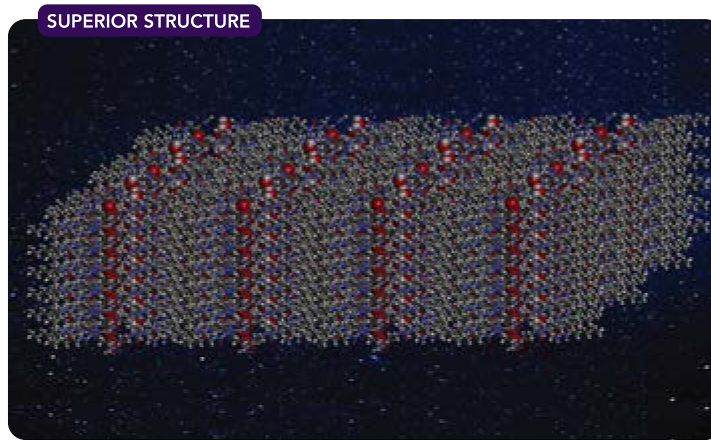
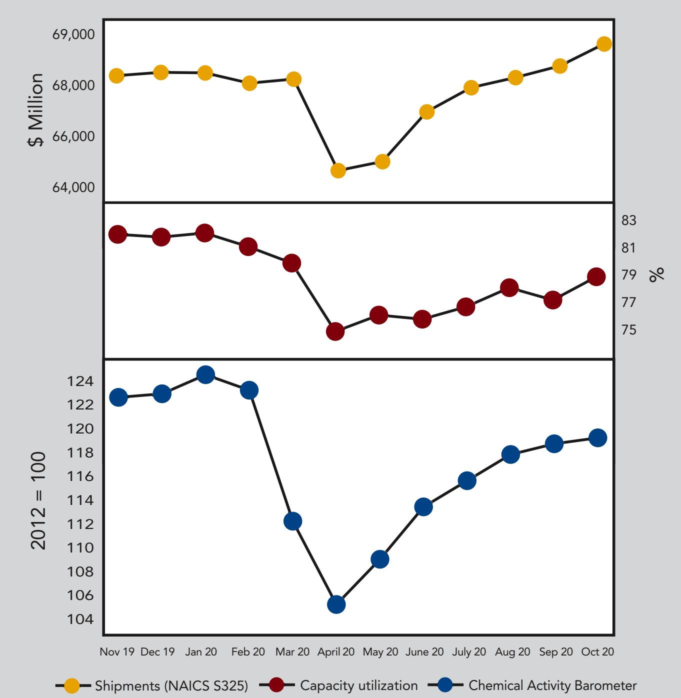


Figure 1. Artificial water channels inserted into a polyamide membrane boost desalination performance. *Source: Mihail Barboiu, Institut Européen des Membranes.*

ECONOMIC SNAPSHOT



All three metrics rose. *Source: American Chemistry Council.*

Leap Over Barriers

Be wary of several hurdles that can hinder project implementations

The engineering team endorsed the project. The sustainability team did not.

THE TECHNOLOGY is proven, the cost is reasonable, the return on investment (ROI) is good. We have a great project, right? Maybe not.

It is amazing how many different things can stand in the way of success. I gave one example in an earlier column (May 2020's "Double Up on Cogeneration," https://bit.ly/3fcqABC), where an equipment upgrade I proposed failed to provide the expected energy savings because the plant operators didn't know how to run it. Lack of adequate workforce training is a fairly common challenge in industry. The examples below, drawn from projects in various parts of the world, illustrate several other barriers that can hinder the implementation of promising projects.

Permits. The legal authorizations to operate equipment are usually intended to ensure safety and protect the environment, but sometimes they have counterintuitive consequences. For example, a colleague identified a simple modification that would significantly improve the efficiency of a large fired heater, and reduce emissions. The initial economic screening looked very promising, but site management immediately vetoed the idea because code requirements had changed after the fired heater was installed. The equipment, now grandfathered, could continue to operate; however, if any modifications were made, the grandfathering would no longer apply, and the fired heater would have to be brought up to the current code requirements — a prohibitively expensive upgrade.

Regulations outside the plant boundary. Many companies are now developing renewable energy sources (e.g., solar energy farms and wind turbines) to displace electricity produced from fossil fuels. These facilities require a great deal of space and, depending on land availability, they often have to be placed a considerable distance from the plant they serve.

A multinational company conducted a feasibility study for a solar energy farm, and set an aggressive schedule to implement the project. A critical requirement was the use of existing grid to link the new power source to the existing production plant. However, local grid regulations did not allow wheeling (i.e., transmission of third-party power through the grid). As a result, negotiations between the company and the grid regulator to enact changes that would allow the project to proceed delayed the initial schedule by many months.

Boundary definitions. A prefeasibility study several years ago for a cogeneration project at a large chemical complex — to replace several boilers while at the same time reducing electricity imports by about 80% — was positive. While many technical challenges existed, the initial assessment indicated these could be overcome at a reasonable cost; the project's ROI easily satisfied the company's requirement.

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The engineering team endorsed the project. The sustainability team did not — because the cogeneration project increased the amount of energy the complex imported. Their accounting system was based on energy flows across the plant boundary. It treated a Btu of fuel as equivalent to a Btu of electricity. Using that method, their conclusion was correct. However, their methodology ignored that the power plants produced the imported electricity using fossil fuels at an efficiency of less than 40%. If you extended the boundary to include fuel used by the power plants, it was clear that the cogeneration project would greatly reduce the overall amount of fuel fired to supply the combined heat and power requirements of the complex. However, the company's sustainability report was based on the sustainability team's methodology; there was great reluctance either to change their reporting system or to approve a major project that would adversely affect their sustainability metrics.

Supply chain. The same company had another problem. The cogeneration facility required natural gas — much more than was available from the existing supplier. The lack of an alternative supplier in the area posed an additional major obstacle. The combination of these two barriers stalled the project; it did not proceed beyond the prefeasibility study.

Many other factors can present hurdles to project implementation. If you have any examples you'd like to share, please let me know. ●

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EPA Fee Controversy Continues

Payments from manufacturers subject to an evaluation fee were due January 2, 2021

Following who pays what and by when has been a challenge.

THE TOXIC Substances Control Act (TSCA) authorizes the U.S. Environmental Protection Agency (EPA) to collect fees from chemical manufacturers (including importers) to defray a portion of the costs associated with TSCA implementation efforts. The TSCA fees rule requires payment for eight categories of fee-triggering events under TSCA, including EPA-initiated risk evaluations under TSCA Section 6. The EPA must prepare a preliminary list of manufacturers subject to fee obligations for EPA-initiated Section 6 risk assessments, which it did (see, "Are You on the List?" https://bit.ly/34drWIz, and "EPA Tells Businesses to Pay Up," https://bit.ly/3eGPhq3). Since then, who pays for what has led to significant controversy. Here is why.

BACKGROUND

On January 27, 2020, the EPA issued the preliminary lists of manufacturers of the 20 high-priority chemical substances for risk evaluation subject to fee assessment. The notice identifies the circumstances required to self-identify as manufacturers of a high-priority substance.

On March 25, 2020, the EPA announced it would consider issuing a revised rule to include potential exemptions to the fees rule in response to stakeholder concerns. By narrowing the scope of the current requirements, the agency believed it could "significantly" reduce the burden on businesses. The EPA may also propose changes consistent with TSCA's requirement to reevaluate the fees rule every three years, and stated it would issue proposed amendments later in 2020, but as of press time in December hadn't done so.

In the March notice, the EPA also announced a "no action assurance" for three categories of manufacturers: those that import the chemical substance in an article; produce the chemical substance as a byproduct; or produce or import the chemical substance as an impurity. The agency agreed to exercise enforcement discretion regarding the self-identification requirement for these three exemption categories. Businesses erroneously listed on the preliminary lists of fee payers or that fall into one of the exemption categories could certify as such to avoid fee obligations.

On September 4, 2020, the EPA issued the "final" lists of manufacturers subject to fees. It decided not to assess a fee to importers who were importing only small quantities of the 20 high-priority substances just for research and development (R&D) purposes. On November 25, 2020, the EPA updated the interim final list to include additional manufacturers not identified on the final list of companies and does not include manufacturers that self-identified in error or imported the chemical solely for R&D purposes. The EPA added that, due to the public health emergency, it was exploring options for payment flexibilities (certain prospective fee payers advocated for installment payment options).

Payments were due January 2, 2021. This date is 120 days from publication of the final scopes of the risk evaluations for the 20 high-priority chemical substances now undergoing risk evaluation.

DISCUSSION

For anyone in this space, following who pays what and by when has been a challenge. The specific basis for an individual company's addition to or removal from the lists is not clear in all cases. The EPA already has invoiced certain manufacturers of the 20 high-priority chemical substances for risk evaluation subject to fee payments. In the invoices of which we are aware, the EPA requests one-third of the fee owed, due January 2, 2021 but doesn't state the due date(s) for the remainder of the fee. Under the fees rule, the entire fee was due by January 2, 2021. While the deferral is a welcome development for most fee payers, greater transparency on how and when the EPA is invoicing for the fees would also be welcome.

In the final rule, entities that fail to self-identify for purposes of fee assessments will be subject to TSCA non-compliance penalties. This penalty is distinct from the fee entities might otherwise been assessed if they had self-identified in compliance with the fees rule (in addition to penalties). Depending on what the penalty might be, some manufacturers may get perverse incentives to take a chance they will evade being caught and subject to a penalty less than the fee itself would be, and decide not to report. Any financial gain obtained by non-compliance should be a substantial factor for the EPA's consideration in assessing penalties. ●

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BRIGHTENING OUTLOOK BUOYS U.S. CHEMICAL INDUSTRY

Despite the pandemic, most segments should see moderate growth

By Kevin Swift and Martha Gilchrist Moore, American Chemistry Council

A YEAR ago, at the end of 2019, our outlook for the U.S. chemical industry was for modest but positive growth. Amid the backdrop of a maturing economic expansion, challenges from protectionist trade policies, a global manufacturing slowdown, and uncertainty about the upcoming U.S. presidential election, the industry faced multiple headwinds. As news of a novel coronavirus in China captured the world's attention during the first month of the year, companies prepared for a significant supply disruption as it became clear that quarantine directives to contain the outbreak would substantially impact manufacturing in China, the world's largest chemicals producer. Just two months later, by the end of March, as much as half the world's population was under some kind of lockdown order and demand for goods and services collapsed with unprecedented speed and severity.

COVID-19 has been a classic "black swan" event. Nobody at this time last year anticipated a global pandemic that would close borders and shutter businesses, plunging the world into the fastest and deepest downturn since the 1930s. Between February and April 2020, more than 22 million Americans lost their jobs as large swaths of the U.S. economy were closed for business and a majority of office workers were forced to work remotely from home.

The global pandemic hit the pause button on the $84-trillion global economy. Spending fell throughout the world and across all economic sectors in a matter of weeks. With more than 85% of basic and specialty chemicals sold to industrial consumers, all but a handful of products suffered substantial negative impacts. However, several chemicals — those tied to personal protective equipment (PPE), disinfection and sanitation products, medical supplies and equipment, and protective barriers — saw soaring demand that partially offset devastating declines in demand for other products. Plastic packaging also got a positive bump through food distributors redirecting bulk foods intended for institutional markets into smaller household-sized packages, alleviating shortages at the retail level.

Despite the increased demand for several COVID-19-critical materials, overall U.S. chemical production fell in 2020 but not as much as that in just about every other manufacturing sector. Motor vehicle production dropped sharply, as did output in its lengthy supply chain. However, housing made strong gains in 2020 due to shifting patterns of remote work and record-low interest rates. Most other end-use segments declined, though.

A TURNAROUND

While the downturn was rapid and deep, with second quarter gross domestic product off by nearly a third (on an annualized basis), the recovery that likely began at the end of that quarter has been swift and demonstrates the resiliency of the U.S. economy, supported by unprecedented Federal stimulus and a broad expansion of unemployment benefits. However, moving into the end of 2020, the strong rebound during third quarter tapered off and the U.S., like most of the rest of world, experienced a troubling surge in the number of new cases, hospitalizations and deaths from COVID-19. With renewed restrictions across much of the country, the outlook remains uncertain as the worsening health situation casts clouds on confidence, mobility and spending. Fortunately, a number of vaccines seem poised for widescale use while the medical community has made significant gains in treatment for patients, improving outcomes for millions of infected people.

As the world emerges from this health crisis in 2021, the American economy continues to boast fundamental advantages. The U.S. has undergone significant tax and regulatory reform in recent years and American workers are among the most productive in the world. In addition, the U.S. enjoys an energy advantage that is the envy of many nations. Protectionist policies enacted during the Trump administration harmed many U.S. manufacturers and consumers but the incoming administration likely will take a more-measured approach to trade that will stimulate U.S. economic growth. The American Chemistry Council (ACC) looks forward to working with the Biden/Harris administration and members of Congress to ensure the right policies are in place to support sensible, science-based regulations and robust and responsible energy and infrastructure development that will keep our industry and economy on a path to strong growth.

As factories reopened toward the end of the second quarter and inventories were drawn down, demand has firmed across many economic segments. However, restrictions on trade movements during the lockdowns and weakness in many trading partner economies caused a significant drop in U.S. exports of goods in 2020. As a result, industrial production fell by 6.9% in 2020, with declines in nearly every industry sector. With the recovery in place, however, industrial production will continue to strengthen and should increase by 3.7% in both 2021 and 2022. Growth expectations are positive for all industries in 2021

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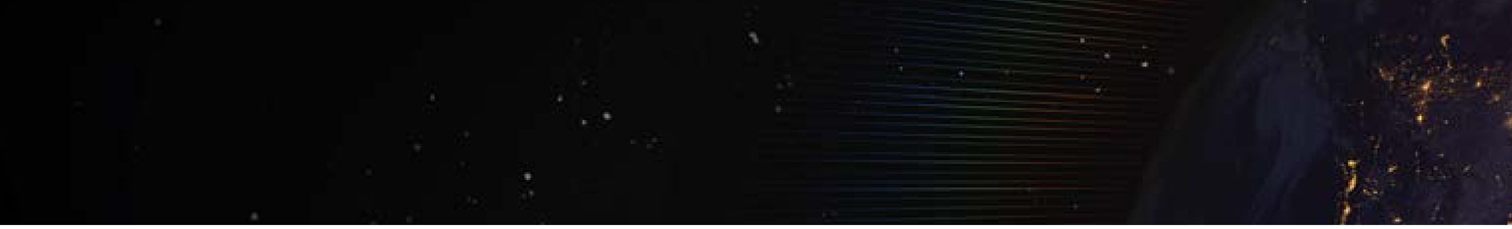


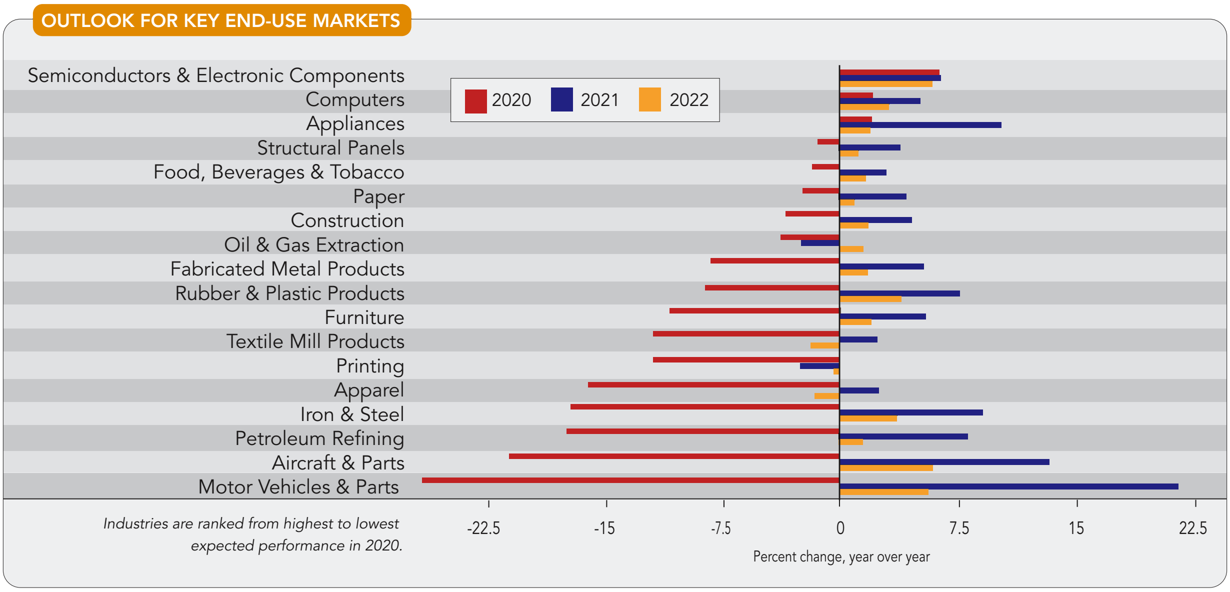


Figure 1. Most sectors should achieve good growth through 2022.

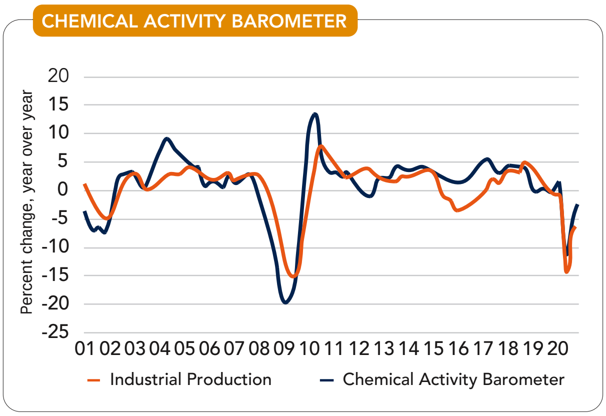


Figure 2. This leading indicator points to continued recovery this year.

except oil and gas; motor vehicles, aerospace, appliances, iron and steel, petroleum refining, and plastic and rubber products should show the largest gains (Figure 1).

The Chemical Activity Barometer — an ACC-developed composite leading index of broader industrial activity — rose for the seventh straight month in November. While key indicators are mixed, they remain largely positive and point to continued recovery in the U.S. economy in 2021 (Figure 2).

Light vehicles are an important market for chemicals, representing over $3,170 in chemicals per vehicle. Sales were very strong during 2015–2019, averaging almost 17 million units each year. However, the U.S. light vehicle industry experienced sizeable lockdowns and, as a result, sales should total only 14.4 million in 2020. A V-shaped recovery in this industry is occurring and sales should rise to 16.4 million in 2021. An eventual return to normal job and income levels as well as some continuing pent-up demand will support this rebound. The outlook is for sales to improve and remain at elevated levels over the next several years. (Editor's note: In addition, the automotive market likely will play an important role in the advance of circular chemistry, i.e., use of renewable and end-of-life materials. See: "Cars Can Drive Circular Chemistry Ahead," https://bit.ly/3mWMpc0.)

Housing also consumes a lot of chemicals; 2020 should show a gain (despite COVID-19) to 1.34 million units as many households move from urban areas to suburban, ex-urban and rural areas. Low mortgage rates also provided some much-needed stimulus. Expected growth in household formation — the leading determinant of housing demand — coupled with job and income gains in the long-term will support continuing, albeit more modest progress through 2025. However, shortages of labor and available lots will constrain the pace of growth. Housing starts are set to edge higher to 1.38 million in 2021 and 1.36 million in 2022. This is a market that could surprise to the upside.

Going into 2020, the American chemical industry was poised for positive (but weak) growth. Following a challenging 2019 that reflected ongoing trade tensions and slower growth abroad, the industry faced further headwinds as the global economy struggled to maintain growth. As it unfolded, the pandemic initially disrupted chemical supply chains that ran through China. Then, broad lockdowns sent economies around the world off the rails and demand for chemicals in many important end-use markets declined sharply.

Policymakers quickly recognized the important role of the chemical industry in producing the materials to combat COVID-19 (fibers and resins for PPE, hand sanitizer and disinfectant ingredients, packaging materials for retail food distribution, medical plastics for test kits and ventilators, safety barriers, etc.). The U.S. Department of Homeland Security designated chemical manufacturing an essential industry because of its critical role in providing these materials.

Despite increased demand for materials related to the pandemic response, chemicals that support other end-use markets, e.g., durable goods, oil and gas extraction, refining, etc., saw a sharp fall in demand during the lockdowns. As the recovery emerged in the third quarter, demand for chemicals firmed. In 2020, chemical production (excluding pharmaceuticals) likely fell by 3.6%, the largest decline since the Great Financial Recession, but one of the better performances within the manufacturing sector.

Chemical production also declined in most worldwide regions in 2020 but should rebound, in some cases even more strongly than in the U.S. (Figure 3).

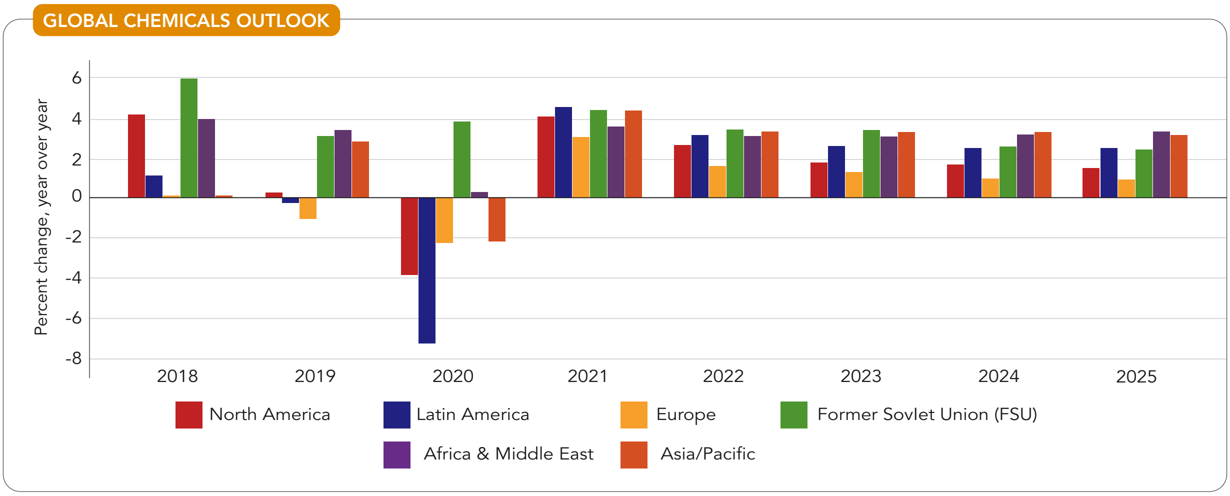


Figure 3. Worldwide growth in chemicals output should occur.

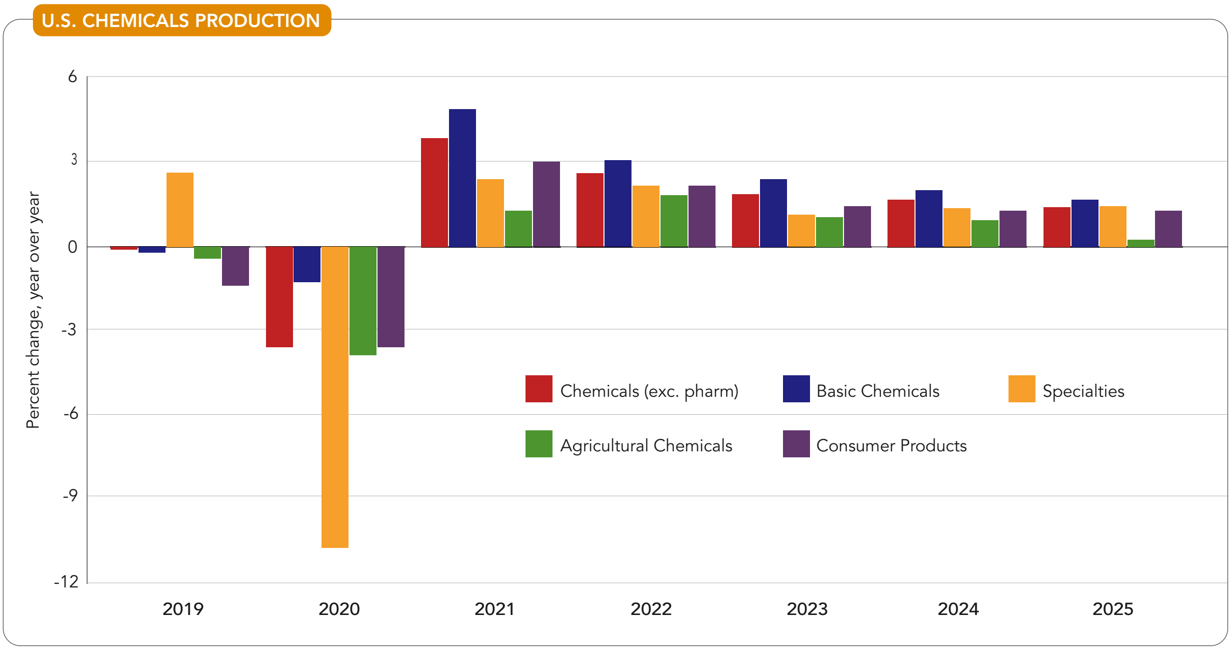
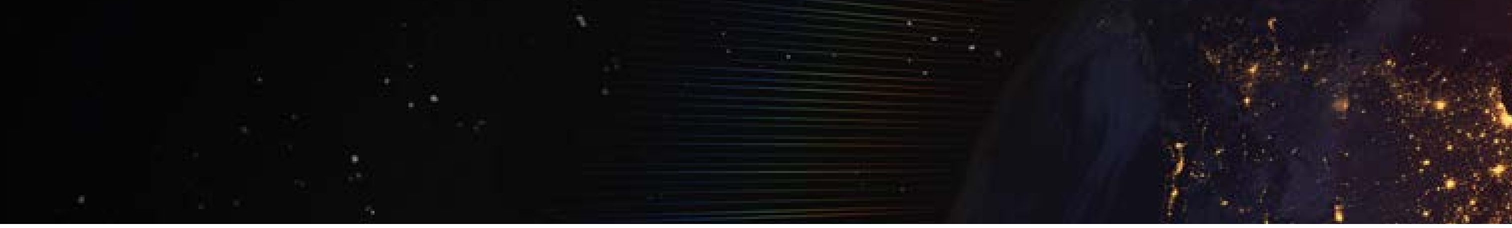


Figure 4. Output of basic chemicals should pace the ongoing rebound.



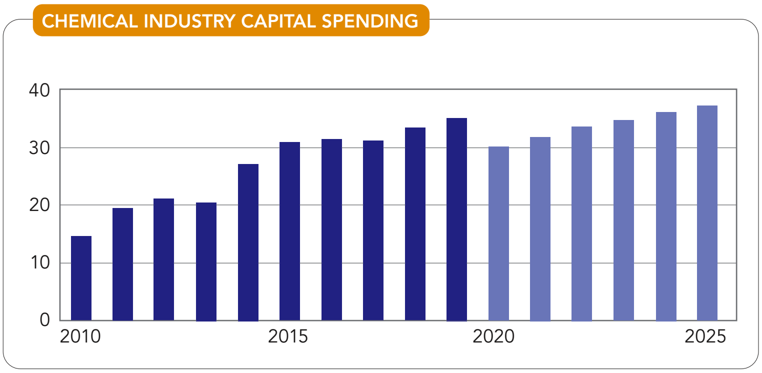


Figure 5. Investment in U.S. production plants will continue to increase.

PROSPECTS BY SEGMENT

As the recovery continues to build and end-use and export markets strengthen, chemical output should rebound by 3.9% in 2021 and 2.7% in 2022 (Figure 4). The competitive advantage that U.S. chemical production enjoys due to investment in unconventional oil and gas resources will foster this growth. Looking ahead, as the world economy climbs out of the deepest recession since the 1930s, growth rates through 2025 likely will lag those of the previous five years. Capacity utilization dropped to 78.4% in 2020 as demand fell at the same time new capacity came on line. A slower pace of capacity growth and stronger demand will push operating rates up through 2025.

U.S. basic chemicals (inorganic chemicals, petrochemicals, plastic resins, synthetic rubber, and manufactured fibers) continue to enjoy a competitive advantage. Going into 2020, higher tariffs were only the first hurdle to a difficult year. During the lockdowns, demand from many end-use customers, both domestic and abroad, collapsed. Basic chemical production declined 1.3% in 2020, as strong demand for plastic resins partially offset weaker growth in other segments. In fact, plastic resins were the only major chemical segment to post growth in 2020, up by 0.9%. Production of petrochemicals and organic intermediates that supply the resin segment among others fared relatively well, declining by only 0.9%. Inorganic chemicals fell by 1.9%. However, with tire production at a small fraction of its usual levels during the second quarter, synthetic rubber fell by 18.9%. Manufactured fibers, a segment under long-term structural pressures, fell by 11.7%. All basic chemical segments should rebound strongly in 2021 as customer markets and the trade environment improve, and shale-advantaged feedstock production expands.

While the year was challenging for basic chemicals, it was especially difficult for specialty chemicals. Even before the pandemic, specialty chemicals had started the year on a soft note with weakening customer markets. As end-use market demand fell through the second quarter and energy investment collapsed, specialty chemicals declined by 10.8%. However, as the industrial sector recovers in 2022 and beyond, specialty chemicals' growth will resume.

Within the U.S., all regions saw declining chemical production in 2020 — with the largest drops in the specialties-heavy Northeast, Mid-Atlantic and West Coast regions. During 2021, the recovery that began in the second half of 2021 will evolve and all regions will see growth. The Gulf Coast region should experience the largest gains.

The chemical industry, which is the largest energy-consuming sector in America's manufacturing base, continues to benefit from investments to take advantage of the U.S. energy abundance. While gains in U.S. energy production stumbled in 2020 due to the unprecedented collapse in transportation demand brought on by social distancing measures, the U.S. remains the world's largest energy producer.

As the COVID-19 recession accelerated, many companies delayed or extended projects. In addition, heightened uncertainty led to cancellation of some projects. As a result, chemical industry capital spending likely fell by 14% in 2020 and will experience only a modest 4.8% gain in 2021. Growth will remain moderate in subsequent years but could pick up afterward if the business environment proves supportive. By 2025, U.S. capital spending by the chemical industry should approach $37.3 billion, nearly three times the level of spending at the start of the last cycle in 2010 (Figure 5). Investment for bulk petrochemical and organic intermediates, along with that for plastic resins, will dominate. Spending for instrumentation, process equipment, and structures presents strong opportunities during this period.

Following seven years of solid job growth, chemical industry employment fell during the pandemic because of demand declines in other segments. Overall, the industry lost 14,900 jobs (2.7% of its workforce) in 2020. Looking ahead, employment should recover and stay relatively steady through 2025 as increased productivity offsets output gains. Chemical workers are among the highest paid in the manufacturing sector (averaging $87,500 in 2019) and those earnings support local communities. (Editor's note: Salaries of engineers in the industry range even higher, see: "Salary and Satisfaction Survive the Pandemic," https://bit.ly/39iASOq.)

U.S. exporters in 2019 faced headwinds coming from escalation of trade tensions and uneven growth abroad. With retaliatory tariffs in place and continued trade tensions, chemical exports declined 2.5% in 2019. Imports also fell by 3.9% with the imposition of U.S. tariffs and a weakening manufacturing sector. In 2020, of course, the pandemic negatively affected port access and aggregate demand for goods dramatically. Globally, trade volumes declined 12.4% in 2020, only slightly less than during 2009. Chemical exports

also fell sharply, down by 9.0% to $124.0 billion. Imports also dropped for a second year, by 4.9% to $96.8 billion.

UPBEAT OUTLOOK

At the end of 2020, the U.S. chemical industry was well into its recovery from the pandemic-induced recession. Because of its significant contributions to the response to COVID-19, the industry's losses in 2020 were comparatively less severe than those in other manufacturing sectors. Moving forward into 2021, the industry will continue its recovery and, spurred by the ongoing advantage from abundant U.S. energy resources (in particular, natural gas liquids), production and exports are poised for growth.

The new capacity started up recently and slated to come online in the years ahead puts the U.S. in a top competitive position for the foreseeable future. More than half of the investments announced since 2010 have been completed or currently are under construction. As the global economy expands and key-end use markets strengthen, we expect growth in basic chemicals as well most other chemical segments through 2025. As new production expands to meet growing global demand, the U.S. chemical industry will remain a key employer, providing high-paying jobs and supporting local communities. Provided that access to export markets remains open to American producers and U.S. energy development continues, shale-advantaged chemicals sourced from the U.S. will meet much of this growing global demand.

Significant risks to this outlook include, most prominently, the containment of COVID-19. As of presstime, infection rates in the U.S. and Europe are climbing once again, leading to new restrictions on mobility. While several vaccines are progressing quickly, meaningful vaccine distribution may not occur until well into 2021. Despite the recovery currently underway, the momentum of the world economy can't gain traction until the health crisis abates.

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Consider Low-Flow Risk Assessment

Decreased operating rates caused by the pandemic can pose hazards | By GC Shah, Consultant

MANY PLANTS now run at reduced rates because of COVID-19. This can result in low flows that present unique safety and operational problems. So, here, we'll look at risk assessment for low flows and possible mitigative approaches.

Plant design and equipment sizing usually consider equipment turndown. However, the tacit assumption is that low rate operations will be short term. Thus, prolonged operation at low rates gets scant attention.

In view of today's situation, you should perform a low-flow risk assessment. While you can do this in many ways, adopting the following steps generally fosters an efficient evaluation:

- Assemble a small group of experienced individuals from Operations, Maintenance, Safety and Engineering.
- Establish protocols for conducting the low-flow risk assessment.
- Divide the plant or sections of it into manageable segments or nodes that contain equipment — for example, pumps, compressors, heat exchangers, valves, pipes and control systems.
- Consider the impact of prolonged low-flow operation on each component of the nodes.
- Prioritize corrective measures.

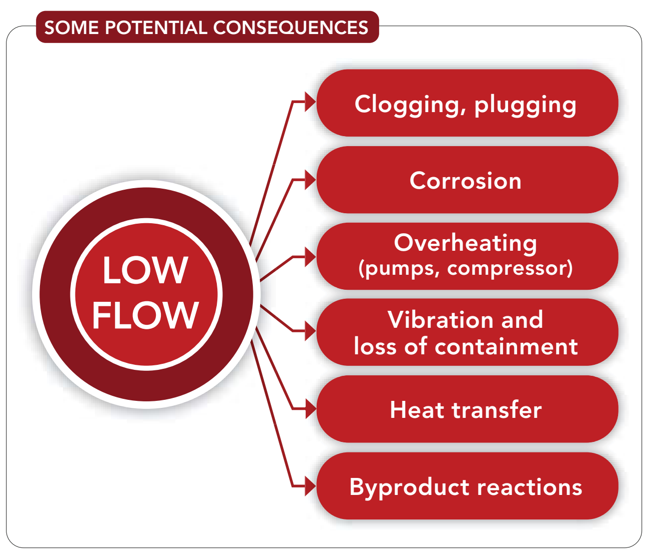

Figure 1. Low flow can lead to a variety of adverse impacts.

As Figure 1 indicates, the adverse consequences of low flow can include clogging/plugging, under-deposit corrosion, pump or compressor overheating, excessive vibration and loss of containment, poor heat transfer and byproduct reactions. Of course, clogging and plugging depend on the size distribution of solids or particulates, which, in turn, depends on the process and nature of the fluid. As a rule of thumb, experts consider that velocities below 2–3 ft/s increase the chance of plugging.

It's worth noting that low flow has some positive aspects as well. Low flow to a pump will require less net positive suction head and, hence, would help avoid or minimize the chance of cavitation when limited suction head is available for the pump. Low velocity will reduce the erosive impact in services such as those involving sand and slurry.

However, in risk assessment, we must focus on adverse consequences and the means to minimize safety/operational risk.

NODAL COMPONENTS

Now, let's look at some important components. Of course, this list isn't comprehensive but it does provide examples of the types of key issues to consider and potential mitigation measures.

Pumps:

Plugging on the suction side and pump internals might occur. Plugging can further reduce flow to the pump, which, in turn, might cause cavitation depending on the liquid and its temperature and pressure drop. If a plug on the suction side creates vacuum, air could ingress, resulting in a potential fire in systems handling flammable fluids. Problems of cavitation, internal wear and air ingress are less common with positive displacement pumps but can't be ruled out altogether.

Low velocity could cause solids to deposit on pipe as well on pump internals, with a potential for under-deposit corrosion. (See: "Keep Under-Deposit Corrosion Under Control," https://bit.ly/2ZtVq2V.)

Typically, pump rates below ≈15% of the design best efficiency point could lead to vibration or overheating. The minimum flow point depends on the pump design and type of fluid. Refer to pump curves and the vendor's input for safe minimum flow operation. Excessive vibration could cause damage to pump components including shaft, seals, wear rings and bearings and, eventually, could result in loss of containment.

Consider:

- Operating a single pump if a service uses multiple pumps. Pumps with variable speed drives likely could accommodate low flow operation by appropriate speed reduction. If system pressure drop allows, think about trimming impeller size but realize this reduces pumping efficiency.
- Monitoring suction pipe, pump casing and insulation if solids have high corrosion potential.
- Adopting minimum flow recycle, also called spill back flow.
- Monitoring vibration and using fire and gas detectors and alarms to detect and warn of leakage from seals/flanges.

Compressors:

In a centrifugal compressor, flow rates below the surge line rapidly result in vibration, unstable operation and severe damage to rotor, shaft, seals and bearings. For flammable gas service, sub-surge flow rates quickly could lead to loss of containment and potential fire. Obviously, unstable operation also will adversely impact upstream and downstream units.

Interestingly, low-flow operation in certain ranges of flow tends to minimize potential liquid entrainment from the demisters, suction drum or suction scrubber.

Consider:

- Using anti-surge system controls and algorithms. You must provide sufficient margin above the surge line so the operation stays away from surge in the event of upsets, including rapid change in flow rates to the compressor.
- Running one compressor, rather than two, at low loads.
- Relying on unloaders or flow recycle for low-flow control of positive displacement compressors. Fixed-speed motors typically drive large compressors, so varying speed usually isn't an option.

Heat exchangers:

Low flow operation will enhance fouling, scaling and sedimentation. Depending on metallurgy, this could lead to under-deposit corrosion. In addition, heat transfer will decrease. In some systems, this would entail more frequent cleaning/maintenance. Heat-sensitive materials could suffer higher rates of decomposition.

Consider:

- Monitoring trend in pressure drop and heat transfer coefficient.
- Using corrosion inhibitors.

Instrument systems:

Low flow operation will impair the performance of several types of sensors and transmitters.

Thermocouples and resistance temperature detectors in thermowells will show slower response, which will affect temperature control loops adversely.

Many flow meters, such as Coriolis, turbine and thermal ones, have large turndown ratios that could accommodate low flow operation without significant loss of accuracy. However, others, such as orifice plate meters with limited turndown (3 to 4), may need resizing. At low flows, gear meters could experience increased fouling.

Any pH probes in fouling/scaling service would demand more aggressive or frequent cleaning.

Although not a common occurrence, some extractive sampling systems for gas chromatographs could require repositioning of the sample tap in the pipe.

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Consider:

- Re-ranging and re-calibrating sensors/transmitters that low flow operation could affect.
- Monitoring the performance of critical instruments, including those in safety instrumented systems.
- Cleaning pH probes more frequently.
- Ensuring thermowells are installed in high turbulence areas. For critical services, you may need to adopt a voting arrangement (e.g., 2oo3).
- Checking control valve openings. Typically, openings below 20% could pose controllability problems. In such cases, think about downstream throttling or replacing with a smaller valve.

Piping:

Liquid systems containing suspended solids will show a higher likelihood of deposit formation and potential under-deposit corrosion (depending on metallurgy) in low flow operations. Low vapor flow also could accelerate de-entrainment of liquid streams in piping systems. Stagnant liquid would facilitate solids deposition on pipes and could lead to under-deposit corrosion.

Consider:

- Providing appropriate treatment levels of corrosion inhibitors/dispersants (if applicable).
- Recycling flows (similar to spill back flows on pumps) for pipe segments exposed to low flow regime.
- Implementing appropriate monitoring of all potential locations where solid deposits can form.
- Periodically checking pipe thickness and insulation and updating service life based on observed corrosion rates.

Distillation columns:

Tower operating range is set by weeping/dumping at the low end and flooding at the upper end. Because distillation involves a number of subsystems, including pre-heater, column, overhead condenser, reboiler, system controls and other columns (if part of a distillation train), operating/safety problems due to low flow could manifest in multiple systems.

Possible issues that could arise include:

- Fouling or scaling systems could impair heat transfer in the pre-heater; this could cause unstable flow to the column.
- Low liquid/vapor traffic in the column could lead to unstable column operation — for instance, weeping, column dumping, and potential vapor flow through the downcomers.
- Low liquid traffic through the reboiler could foster fouling and diminish boil-up, which, in turn, will reduce vapor traffic through the column and contribute to enhanced weeping/dumping of the column.
- Control systems could become unstable because the control valve could fall outside the "good-operation-low limit," i.e., below 20% open.

Partly because of multiple interactions, distillation operations will necessitate systematic troubleshooting efforts: monitoring operations, heat transfer rates, pressure drops and product quality.

Consider:

- Avoiding structural changes to the system, e.g., blanking off part of the trays, changing the type of packing, altering weir height, replacing the preheater or the reboiler with a smaller unit, etc., unless you expect low flow operation to endure for a prolonged period (several years).
- Making changes that will allow reasonable operation for the duration of low flows — for example, reducing the pressure of the column, increasing reflux/boil-up to boost vapor/liquid traffic, using inhibitors that could retard fouling, or maintaining stripping steam or wash oil (refining operations) to minimize poor stripping and coke formation, respectively.
- Filtering out as many suspended solids as practical before sending feed to the distillation system, including the pre-heater.

PROCEED PROPERLY

Low-flow risk assessment should be thorough and efficient. It should focus on identifying safety/operational issues of the equipment as well as upstream and downstream systems. Proper documentation and follow-up, of course, are an integral part of effective risk assessment. ●

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Think More About Tanks

Safe storage depends on proper design and plant practices

By Amin Almasi, mechanical consultant

TANKS COME in different types, sizes and configurations and play diverse roles at process plants. They store feedstocks and final products as well as intermediates and semi-finished material. Most tanks at chemical facilities are above-ground welded-steel units; stainless and alloy steels, concrete and other materials also find use.

The design, construction and operation of tanks require great care because leaks, spills and loading/unloading can present safety and environmental risks. Large storage tanks for process liquids demand particular attention in design and selection of construction material. Tanks should undergo rigorous checking and testing before going into operation. In addition, they should have a containment area or retaining wall (bunding) that provides at least the capacity of the tank. While leaks shouldn't happen, it's prudent to prepare for the worst-case scenario.

TYPES OF TANKS

Tanks fall into two general categories: pressurized and atmospheric pressure. Pressurized tanks usually store liquids that evaporate. Tank types can be broken down further into fixed-roof and different types of floating-roof variants.

Tanks inside process units typically are medium/small size that provide several hours of hold-up. Large storage tanks usually reside outside process battery limits on tank farms or offsite areas, and generally hold at least a day's worth of material. Time variations in supply of raw materials and demand for products influence the size and number of storage tanks. Larger storage tanks have gained increasing favor in recent decades; because of this, the loadings and design (such as for seismic events) for these larger storage tanks has become more important.

Many storage tanks sit on earth foundations with a concrete ring at their periphery. They may not have anchoring devices.

Now, let's look at some common types of tanks.

API tanks. The American Petroleum Institute (API), www.api.org, has established standards for tanks. API-650 provides minimum requirements for above-ground steel cylindrical storage tanks roughly equal to the pressure of the atmosphere (not greater than the weight of the roof). By meeting additional requirements, higher internal pressures are allowed. API-620 suits products such as liquefied gases that have high internal pressure to store contents at, say, a maximum of 1 barg, as well as services involving cryogenic temperatures.

Fixed-roof tanks. Liquids stored at near-atmospheric pressure may experience breathing losses. Tank cooling during the night may draw air in, then vaporization occurs to saturation, followed by expulsion of the vapor mixture as the tank warms up during the day. Volatile liquids consequently suffer a material loss and also a change in composition because of the selective loss of lighter constituents.

Floating-roof tanks. These find wide use to minimize the effects of breathing losses. A pad floats on the surface of the stored liquid/fluid. It has a slightly smaller diameter than that of the tank (as a very rough indication, 20–40-mm less). One of several available methods seals the annular space between the float and the tank shell. Typically, a seal is attached to the roof perimeter and contacts the tank wall/shell, reducing evaporative loss of the stored liquid. The seal system slides against the tank wall as the roof goes up and down with the liquid level in the tank.

Many working liquids, including numerous hydrocarbons and other chemicals, emit extremely volatile vapors that pose combustion, toxicity, pollution or other risks — and that collect in the space between the roof and the liquid. The rim seal on the floating-roof tank keeps these emissions from escaping into the environment. It's possible to install mechanisms to capture this vapor, enabling its use at the plant, sale to interested parties, etc.

Floating-roof tanks come either with an external floating roof and or an internal one. An external floating roof consists of a deck, fittings and rim seal system. Decks are of three general types: pan, pontoon and double-deck — with pontoon and double-deck types now more favored. An internal floating-roof tank has a permanent fixed roof as well as a floating roof inside.

A floating roof may not function normally if the rooftop is out of balance or the tank body distorts. Many cases of sunken roofs have occurred. For instance, the roofs of several external floating-roof tanks sank after heavy storms — for a variety of reasons (low capacity of the roof drain, etc.). External designs are more prone to such risks.

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TANK DESIGN

This is complex and can be challenging and confusing. Many loading cases and scenarios usually require simulation and proper evaluation. Besides all possible internal pressure situations, the designer may need to consider wind, seismic and potential vacuum cases as well as dead and live weights from structure/platforms, thermal loads, settlement conditions (differential, tilt, etc.), critical loads during tank installation (usually short term) and others. Different formulations and approaches, such as the "1-foot method," "variable point method," etc. (in API-650 or other codes), can calculate shell wall thicknesses (shell courses) and finalize the design of a tank including details of roof, roof-shell junction, etc. Today, you can use advanced software for tank design.

For high or low operating temperatures, the allowable stress of the material decreases. As a result, the required wall thickness increases. This relationship often is slightly non-linear but linear methods can provide a rough estimate. In addition to causing hoop stress and longitudinal stress in the tank wall, the slight internal pressure creates a tensile force (pressure × area). This force pulls upward on the tank wall. The weight of the tank and roof counter this force. If the net force is upward in any operating case or condition, you should install anchor bolts to hold the tank down.

An often-overlooked scenario is the possibility of the tank experiencing a slight vacuum. This generates a compressive stress in both the hoop and longitudinal directions — and can represent a potentially severe condition, particularly for large thin-walled tanks that might be vulnerable to buckling. It mandates checking all possible buckling modes and computing the allowable compressive stress at each point of concern and comparing it to the actual compressive stress.

Determining the maximum allowable working pressure for both the internal and external (vacuum) pressure cases usually is required. This involves iteratively changing the pressure until extreme pressures are found for the tank.

Seismic loading cases generally are critical ones for many tanks, particularly large thin-walled ones with heavy liquid content. For the seismic analysis, you should consider fluid/structure interactions. The seismic loading closely relates to sloshing of the liquid content in a tank with the tank base subjected to a horizontal and vertical ground motion. Usually such an analysis requires use of an advanced finite element method.

Dynamic loadings such as seismic loading cases can create different failures/buckling modes for tanks. The failure-mode from a seismic force varies from tank to tank. It might be a buckling of the cylindrical shell, e.g., so-called "elephant foot bulge" mode or "diamond pattern buckling" mode.

Because tanks in chemical plants often contain large volumes of combustible, toxic or otherwise hazardous materials, they pose substantial risks. Indeed, tanks have caused many significant incidents. A small accident may lead to multi-million-dollar property loss, costly production interruption and expensive spills or other environmental damage.

COPING WITH LIGHTNING

Traditionally, tank accidents most frequently arise from lightning. Lightning-related fires generally stem from one of two causes: a direct strike or its secondary effects, such as the bound charge, electromagnetic pulse, electrostatic pulse and earth currents. When a storage tank is in the direct strike zone, flammable vapors exposed to the heating effect or the stroke channel may ignite. In some cases, a direct lightning strike on a tank has resulted in its roof blowing off and massive destruction.

A storm cell induces a charge on the surface of the earth and structures projecting from the surface under the cell. This charged area varies in size but is relatively large — much larger than the direct strike zone. The risk of a secondary-effects-related fire far exceeds that from a direct strike.

The rim seal of a floating-roof tank is the most likely place for ignition. Therefore, tight sealing to prevent the escape of vapors and fluids is essential for safety. The vent valve also a likely place. So, you always should install a flame arrestor. Ideally, lightning protection of a tank should exceed the requirements of existing lightning-protection standards because such conventional standards often aren't adequate to deal with extreme cases.

PREVENTING HUMAN ERRORS

Traditionally, maintenance error is the second most common cause of tank incidents. Other culprits include equipment failure, crack and rupture, leaks and piping breaks, static electricity, open flames, etc. Good engineering and site practices could have avoided most of these accidents.

Catastrophic failure of a tank potentially can occur when flammable vapors in the tank catch fire or explode. Welding operations on the outside of an operating tank or one not purged properly as well as sparks from hot works (e.g., using a cutting torch or grinder) on a nearby

piece of equipment have led to many accidents. Mechanical friction produced during installation, maintenance or repair also can generate sparks that can ignite flammable vapors.

Hazard reduction measures are important to prevent such incidents. These include stringent hot-work procedures, such as requiring a permit, having a fire watch and ensuring the presence of fire extinguishing equipment, as well as proper testing for explosivity, and covering and sealing all drains, vents, manways, open flanges, etc.

Incidents also have happened where flammable liquids trapped in the seal ignited during a tank cleaning operation. Many fires have occurred while cleaning supposedly empty tanks of explosive/flammable liquid that weren't purged properly. Sometimes the cleaning chemicals themselves ignited. Electric sparks and shocks also can ignite flammable vapors or liquids, resulting in fire or explosion.

In addition, problems can arise from operational errors — with overfilling the most frequent culprit. When a tank containing flammable liquid overfills, fire or explosion usually is unavoidable. Any spark nearby may ignite flammable vapor released from the tank. Sometimes vapor from an overfilled tank will travel to an ignition source (such as a flare, boiler or furnace stack, incinerator, heater, automobile engine, etc.) and then ignite. Overpressure also causes many incidents and much damage. Correct operational procedures could avoid such risks. In addition, installation of a more-effective gas detection and emergency isolation system could prevent or mitigate such accidents. (For details on gas detection, see "Ensure Adequate Fire Protection," https://bit.ly/2JJ8zQb.)

During normal operations, most tank damage stems from age deterioration, corrosion and seismic motions. Many tanks suffer cracks. Often these cracks occur at the tank bottom or the edges of welds. Corrosion can afflict tank bottoms and defective welds. Welds also can fail.

Failure of valves, instruments and other connected equipment can impact tanks. Indeed, problems such as frozen valves (unable to close, open, etc.), vent valve failures, burst valves, etc., have caused many instances of damage to tank systems. Heating of viscous or heavy liquids (such as heavy oil) to increase their fluidity has led to other incidents when a heater malfunctioned or an instrument/thermostat failed. This led to fluid overheating that resulted in flammable vapor release and further risks to the tank. ●

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Source: Total

Wearables Win Wider Role

Pandemic fosters use of devices to enhance operations, testing and worker safety | By Seán Ottewell, Editor at Large

THE ACCEPTANCE of wearable technologies of many different stripes was increasing before COVID-19. However, the pandemic has underscored the value of lightweight, safe and cost-effective wearable devices and boosted their use by chemical makers to improve operational efficiency, speed equipment testing and improve worker safety.

Total, Paris, has used wearable technology from RealWear, Huntsville, Ala., for nearly three years now. The U.S. company's flagship product, the HMT-1 headset, is a ruggedized Android-class tablet computer that frees workers' hands for difficult or dangerous jobs. The headset simply clips onto hard hats.

Total's first application of RealWear's headsets came in 2018 at its Grandpuits refinery in Seine-et-Marne, France, followed closely by a second at its Lyndsey refinery in Immingham, U.K. (Total agreed this summer to sell that refinery to the U.K.'s Prax Group.)

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Software posed one of the major hurdles with these early applications because the subject matter experts (SMEs) based in France and the front-line workers used different operating systems. The addition in 2020 of Microsoft Teams overcame this obstacle as both sides of the technology "border" were familiar with its use.

In July 2020, Total announced the world's first commercial deployment in the chemical industry of Microsoft Teams on RealWear at its polypropylene plant in La Porte, Texas. Clipped onto a hard hat, the device runs voice-enabled Microsoft Teams and enables plant workers to use both hands for complex work procedures while remotely communicating in real time with SMEs wherever they are in the world.

"There has been widespread adoption of Teams by Total employees prior to Covid-19. This made the combination of the RealWear connected helmet and Teams easy and fast as everyone involved was already familiar with the application. Once the device had its own Microsoft generic account, it could be added to any Teams call or meeting just as if it were another employee," explains Nabil Lamia, senior process engineer and digital leader, refining and chemicals, for Total.

"Not only is the communication audible and visual from the field but the same content you might normally expect in a Teams meeting screen share can now also be seen by the wearer in the field. This applies to things like drawings, diagrams, procedures, process trends, etc.," he adds.

For example, Lamia cites the handling of an intermittent thrust bearing vibration issue reported by the night operations staff at LaPorte. Lamia and other SMEs in Total's "smart room" (Figure 1) at its 12-million-mt/y refining and petrochemicals complex at Gonfreville, France, guided the superintendent of maintenance at LaPorte in checking the suspect equipment. Following the investigation, Total's SME in charge of machinery development allowed the unit to continue operating with ongoing monitoring.

Since then, the company has used the connected helmet in many other applications. For example, company engineers and a wastewater treatment specialist who was working from a home office in Lyon, France, due to strict pandemic lockdown conditions simultaneously supervised repairs executed on the scraper bridge of the oil skimmer at the Grandpuits refinery, easing checking and approval.

Similarly, the connected helmet was used while inspecting the outer screen in the continuous catalytic reformer regenerator at Total's refinery in Port Arthur, Texas. Reformer network and UOP specialists witnessed the inspection and interacted in real time with the process engineer in the regenerator through Teams.

The high quality pictures allowed remote specialists easily to notice in livestream that the chlorination section was slightly fouled by catalyst fines which wasn't the case in the burn section above.

To date, Total has installed 55 RealWear devices worldwide and is adding more.

"The idea is to have at least one pair of devices per site in our upstream, midstream and downstream activities. We strongly believe that this digital tool will be a must-have tool even post-Covid," says Lamia.

The appetite for wearable technology is particularly strong among process and electrical/instrumentation engineers, together with operations and maintenance technicians, he notes.

The latest move from Total is the launch of a concept study with one of its digital partners for integrating tailor-made augmented reality on RealWear devices to assist outside operators during critical procedures.

"The goal is to create a virtual 'technical angel' that will show the operator step-by-step procedures to be executed, including cross-checking with the operator in the control room and/or remote support of a SME. A proof of concept is ongoing in one of Total's refining and chemical sites," he concludes.

VIRUTAL STRING TESTS

Meanwhile in November, Venture Global LNG, Arlington, Va., announced the arrival of the first two liquefaction trains at its Calcasieu Pass LNG export facility in Cameron Parish, La. Now being connected to their respective cold boxes, the two 0.6-mt/y trains and mixed refrigerant compressor skids arrived less than 15 months after the project's final investment decision — which the company is hailing as both a major project milestone and a step change in LNG construction.

The trains came from Baker Hughes' manufacturing facility in Avenza, Italy, more than two months ahead of the contractual delivery date. This only could have been achieved, say the companies, by their use of novel virtual string tests carried out by Baker Hughes engineers in Italy using wearable technologies.

A string test is a major project milestone performed on the first full set of equipment. Replicating and simulating site operation conditions for the complete system, is the only way to prove all the major components function together as they should.

Every component destined for the final project site is commissioned and validated to verify functionality. Putting the components together for the test enables identifying — and resolving — any fit or assembly problems. The test performs a mechanical running assessment and measures equipment vibration and bearing temperatures at full speed and full load. The auxiliary and control systems also are calibrated, which minimizes these activities in the field.

Baker Hughes field service engineers used a Smart Helmet — an industrial wearable that combines a hard hat with various cameras, computer vision and sensors — to let everyone participate in a walkdown of the string test equipment in Italy (Figure 2). It enabled real-time communication so Venture Global's engineers could view specific parts of the equipment package.

SMART ROOM

Figure 1. Experts based at refinery in France remotely guided inspection of equipment at Texas plant. *Source: Total.*

Figure 2. Engineer in Italy uses helmet to share data with people around the world during equipment test. *Source: Baker Hughes.*

Baker Hughes addressed technical questions right after the test; Venture Global signed the String Test Acceptance Certificate the same day, which is rare.

Baker Hughes introduced remote string tests several years ago but Venture Global was the first to adopt the fully remote approach. In addition to its standard service offerings already available remotely, such as monitoring and diagnostics, Baker Hughes has extended the use of remote technology to outage preparation for customers as well as virtual training, inspection and repairs on critical rotating equipment in operation in the field.

"Any personnel conducting an activity like a string test or factory acceptance test (FAT) can utilize wearable technology to allow remote or virtual monitoring. For some of the FAT protocols, wearable technology applications require more pilot testing to overcome existing requirements for a live witness. In terms of future applications, we are continually working with our customers to determine opportunities where wearable technology can further enhance remote collaboration and onsite safety," notes a spokeswoman.

WORKER SAFETY

Guardhat, Detroit, specializes in developing wearables, infrastructure and software platforms to provide a safer and more productive work environment for workers in heavy manufacturing industries.

Its own connected-worker software platform collects and analyzes real-time data gathered by wearables such as the HF1 and HC1 smart hard hats, and the TA1 tag, which provides location tracking, audio-visual (AV) telecommunications, workers' safety features such as alerts for emergency help, proximity detection and AV media collection features. The company's Rhea Android app complements these wearables; it provides location tracking and core safety features plus a mobile version of Guardhat's own safety control center.

The chemical industry uses the technology in a diverse range of applications including personal protective equipment (PPE) compliance, checking the condition and vitals of workers, hazard and environment monitoring, man/machine interactions and ensuring lone worker safety. Turnaround management also is a major application.

In one example cited by Indranil Roychoudhury, Guardhat's chief operating officer, deployment of its hardhats, tags and connected-worker software platform increases worker safety and productivity at a plant with a nitrogen silo area operated by a global chemical company.

"In this zone, the oxygen level can dip to alarming levels and cause injury as well as fatalities. The workers are required to wear oxygen masks to monitor their oxygen levels. Very frequently workers did not comply with the oxygen mask PPE requirement," he notes.

Once wearing the Guardhat hardhat and tags was mandated, the devices alerted the worker and that person's supervisor if the oxygen masks weren't being worn. They did this scanning for oxygen masks as workers approached the hazard zone, which was geo-fenced on the Guardhat connected-worker software platform.

Another chemical company focuses on human condition monitoring. It uses Guardhat-supported devices to monitor workers' heart rates and, so, to give an indication of their exertion levels. Any worker approaching the defined threshold levels of exertion — as configured by the chemical company on Guardhat's software platform — gets an alert, as does the person's supervisor and the central safety center to ensure availability of immediate help or evacuation if needed.

A third example involves monitoring of man/machine interactions in a chemical company's warehouse. Suspecting that forklifts were being driven way above the permitted speed, the company fitted its forklifts and drivers with Guardhat tags. The devices use ultra-wide band technology to monitor location accuracy and connect in real time to the company's worker software platform.

"It was found that there were numerous near collisions that were avoided thanks to the Guardhat technology alerting the worker about an approaching vehicle in real time. This data led the company to institute corrective action and route planning for the forklift drivers," he explains.

Guardhat is teaming with other companies to expand and improve the technologies it offers, reveals Roychoudhury. For example, it is working with real-time physiological monitoring specialist FireHud, Norcross, Ga., on novel fatigue-monitoring technology and mobile human-monitoring specialist EquiVital, New York City, on intrinsically safe devices to keep tabs on exertion. The company also hopes to further integrate gas detection technologies offered by various manufacturers into Guardhat's own offerings, he adds.

DUAL-MODE CAMERA

Figure 3. This wearable unit can provide both optical and thermal images. *Source: Pepperl+Fuchs.*

NEW PRODUCTS

Meanwhile, vendors continue to expand their wearable offerings. For instance, Pepperl+Fuchs, Twinsburg, Ohio, has added two wearables to its ecom family of instruments.

The Ex-Camera Cube 800 attaches to hard hat and headband accessories while its dual cameras allow users to choose between optical and thermal modes (Figure 3). The integrated thermal imaging camera provides infrastructure health analysis and trending information while the optical camera provides high definition video and images. The integrated light ring and laser aiming pointer ensure high quality visuals.

Also new is the Smart-Ex Watch, which the company says is the first intrinsically safe smartwatch for use in Zone 2 and Division 2 hazardous areas. Based on the Samsung Galaxy smartwatch, it can be synched with ecom devices such as the Smart-Ex 02 smartphone while integrated global-positioning-system, movement and heart-rate sensors can monitor the current status of critical values and ensure quick access to the work site in the event of an emergency.

In August, Emerson, St. Louis, launched an enhanced version of its location awareness technology that includes social density management and contact tracing. Part of the company's Plantweb digital ecosystem, the updated technology specifically is aimed at tough industrial environments such as those found in the chemical industry. The company says it will better safeguard employee safety and help create new work processes and practices for operational continuity.

In November, Yokogawa, Tokyo, announced an enhanced version of its Field Assistant software. Field Assistant R2.05 now supports Windows tablets and RealWear's head-mounted computers as well as Android phones and tablets.

Valve Upgrades Take Pressure Off PSA Unit

Increased reliability in tough service leads to substantial savings

By Neil Dalal, Emerson

PRESSURE SWING adsorption (PSA) units are notoriously challenging for control valve assemblies, primarily due to requirements for frequent valve stroking. The assemblies often must cope with hundreds of thousands of cycles per year and must adhere to the tight shutoff requirements of ANSI Class V or Class VI to maintain industrial gas purity and efficiency. While control valves are designed to handle frequent stroking and cycling, it is rare to require frequent full strokes and tight shutoff.

A refinery and petrochemical complex on the U.S. Gulf Coast had installed a PSA unit in the mid-1990s to supply purified hydrogen to its olefins chemical plant. From the start, the unit's control valves required frequent repair or replacement, which regularly reduced hydrogen production. In 2010, minimizing this maintenance downtime became critical to overall facility production when the refinery began using purified hydrogen from the PSA unit. However, only after a fairly recent complete replacement of valves did the site — which annually loads or off-loads an average of more than 2,500 vessels, representing about 100 million bbl (4 billion gal) of crude oil and alternative products — achieve the PSA unit performance desired.

PSA PARTICULARS

The PSA process removes impurities such as carbon dioxide, hydrogen sulfide, sulfur and nitrogen from impure hydrogen, which is a byproduct from other units. The purified hydrogen from the PSA unit not only is needed by the olefins plant but also is required by the refinery to produce clean fuels such as ultra-low-sulfur diesel and used in hydrocracking, hydrotreating and ethylene cracker furnaces.

Based on the efficiency of PSA technology and the size of the facility, producing and purifying hydrogen onsite is more cost effective than purchasing it from an outside source.

Because purified hydrogen improves catalyst life, product quality and processing feed, the performance of PSA units is extremely important to the efficiency and profitability of chemical and refining facilities. An inefficient and unreliable PSA unit causes reduced operating rates of hydrotreaters, hydrocrackers and other downstream units, resulting in lower overall facility utilization.

The complex's olefins PSA unit consists of four adsorber beds for purifying hydrogen (Figure 1). It includes more than 50 control valves, each of which is continuously cycled fully open to fully closed to achieve adsorber pressure setpoints. This enables continuous production of purified hydrogen as well as regeneration of the adsorber beds.

Each PSA bed alternates between two stages — adsorption and desorption.

- *Adsorption*. This is a high-pressure cycle for adsorbing impurities such as CO_2, H_2S, sulfur and nitrogen and routing the lighter components (mainly hydrogen) out the overhead.
- *Desorption*. This low-pressure cycle regenerates the bed by releasing the impurities (hydrocarbons) to the tailgas header.

Regeneration involves four basic steps: 1) depressurizing the adsorber to tailgas using the hydrogen in the top of the bed to pressure or purge other adsorber beds;

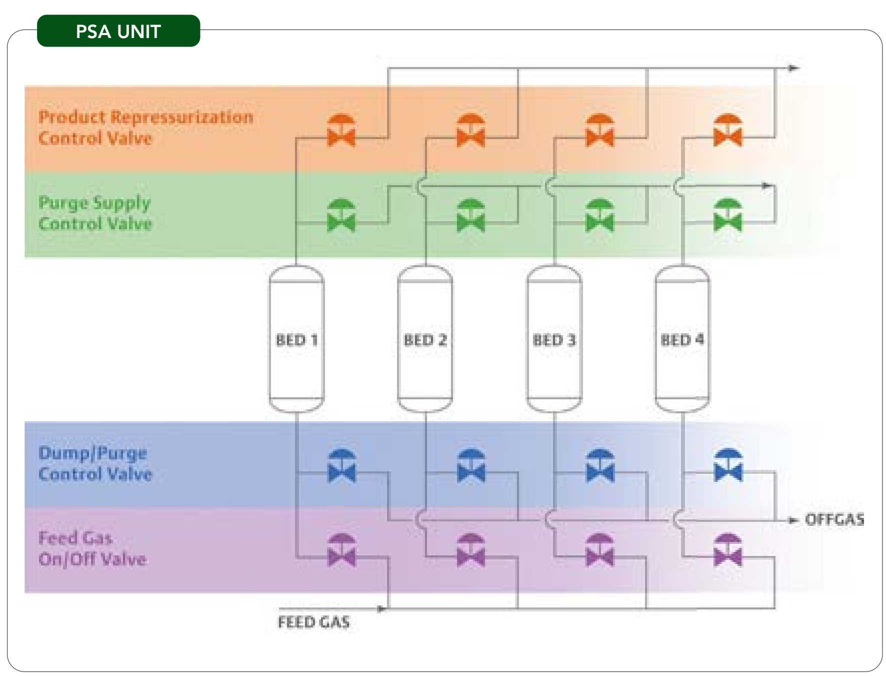

Figure 1. Four adsorbent beds for purifying hydrogen require more than 50 control valves.

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SUITABLE FOR SKIDS

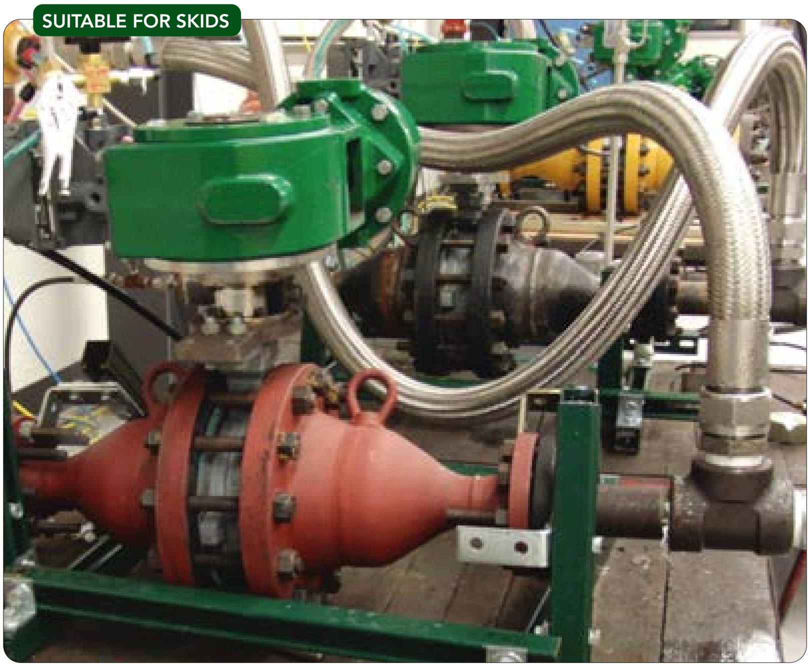

Figure 2. Valves must be compact to fit on the skid of a PSA unit.

2) releasing hydrocarbons during this depressurization to the tailgas header out the bottom; 3) purging the adsorber at low pressure with hydrogen to release impurities from the adsorbent; and 4) pressurizing the adsorber to high pressure with hydrogen provided by adsorbers in the depressurization step.

RELIABILITY BECOMES CRUCIAL

Despite ongoing reliability problems with the valves in the PSA unit, in 2010 the site completed a piping project to route purified hydrogen to the refinery complex. In 2012, the valve maker recommended and made changes to its valves — but they still failed within months.

The unit experienced issues with both the installed butterfly and sliding-stem-style control valves. The butterfly valves had seal leakage as well as shaft and bearing failures. Greater wear on soft seals created bed pressurization and sequence issues. Drive shafts failed during operation due to fatigue and cracking, preventing the valves from opening and closing. Bearing failures led valves to seize, hindering the performance of the PSA bed.

The sliding-stem-style control valves incurred piston actuator seal leaks, increased packing friction, and positioner-linkage and valve-stem failures.

With both valve styles, packing leaks caused loss of hydrogen and safety concerns.

Because failures were expected, the complex stocked a complete spare valve for each assembly — at a total cost of $500,000. These replacements often were installed and restocked within a matter of months.

In addition, each failure disrupted the sequential operation of the PSA unit. Correcting the problem required bringing all four beds down. Typically, fixing or replacing the valve(s) took two days, leading to reduced hydrogen production, downstream unit run rates and overall facility utilization. On average, the site suffered six unplanned unit trips per year due to valve failures.

Eventually, site personnel contacted Emerson and Puffer-Sweiven, its local Emerson Impact Partner, to address the valve issue.

ENGINEERING A SOLUTION

Over the last two decades, Emerson has invested engineering and testing time to gain approval from all licensors that design PSA and other process units requiring high-cycle valves. (The PSA licensors included UOP, Linde, Hydrochem, Air Products and CBI Lummus.) Emerson reviewed the entire scope of licensor specifications for valve approval, compiled similar requirements for each licensor, and then sought initial licensor approval. In its state-of-the-art flow lab, Emerson developed dedicated space for high-cycle testing based on these specifications and successfully passed all licensor testing requirements.

Requirements included:

- testing for 1,000,000 cycles;
- Class VI shutoff;
- bi-directional flow;
- precise and accurate control;
- full open and close every three minutes; and
- stroke speed of less than two seconds.

For the Fisher 8580 high-performance butterfly valve, it took almost two years to complete testing of different seal materials, monitor seat leakage and check wear on the components to meet all the above requirements. In addition to the strict testing criteria, the valves also needed to fit into small envelope dimensions because many PSA units come as compact skid packages (Figure 2).

Based on approval from all licensors, Emerson supplied replacements to the refiner for the 50 PSA valves; these included both rotary butterfly (8580) and globe (GX and easy-e) valves, each with a Fisher Fieldvue DVC6200 digital valve controller (DVC).

Even though valves in PSA units typically are on/off rather than modulating, installing a DVC is a best practice. In addition to controlling a valve, the DVC will monitor valve health during operation and, using Emerson software, can predict valve issues before they occur, enabling proactive maintenance.

A common failure point in a PSA unit with valves using non-Fisher positioners was the spool piece. Dirty air caused the spool piece to seize, preventing control and valve operation.

During the operation of a valve, many issues can occur through degradation. These include tubing leaks, tears in the actuator diaphragm, seizing between bearing and shaft, broken shafts, etc.

A Fisher Fieldvue DVC6200 with Performance Diagnostic tier can monitor and run diagnostics while a valve is in service. Technicians can check the health of the valves through Fisher ValveLink and AMS monitoring software. ValveLink software provides recommended actions for technicians to take to address a particular alert.

A RESOUNDING SUCCESS

In the first eighteen months after the Fisher valves were installed in May 2018, there were no unplanned unit trips or reactive maintenance needs — with the valves executing 17,648,392 total cycles (i.e., a position change greater than 1%–2%).

The project aim wasn't to increase the hydrogen separation capacity beyond existing design but rather to improve reliability to increase recovery from an estimated average 40% of the hydrogen in the incoming feed to 60%. This goal was met — with impressive financial results.

Based upon improved PSA reliability and operating consistency, annual benefits include $3 million for reduced hydrogen losses to the fuel system, $3 million for increased ethane-furnace firing-rate capability, and $3.5 million for decreased operating-rate losses resulting from low tailgas BTU events — for a total of $9.5 million per year in operational cost savings.

The refiner not only has increased profitability at the site by changing to Fisher control valves but also has improved safety by reducing environmental emissions from packing leaks. ●

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Can Totes Cope?

Winter raises additional concerns about use for tanker truck loading

THIS MONTH'S PUZZLER

We meter corrosion inhibitor (an aqueous mixture of sodium benzoate and sodium nitrite) into tanker trucks containing our product, ethylene glycol radiator fluid. Previously, we metered the inhibitor into lines to the product tanks. Corporate and our customers can't seem to decide if they want to continue the current approach or revert to the original system. Complicating this further, corporate is grappling with whether to increase the injection rate by 25%. Now, it's October in Indiana and winter is coming. "What are we going to do when winter comes?," an operator complained. Money is tight, I told him.

We use 275-gal totes of inhibitor, and go through 8 or even 12 on some days. Storage space limitations restrict us to only six totes near unloading; the others are stored way across the plant, taking a fork truck about 30 minutes to deliver.

Safety already is upset by the lack of containment around the totes. Because the whole system is "temporary," we're using a ½-in. air-diaphragm pump and a ¾-in. garden hose strung 75 ft from the totes outside the dike wall to the loading arm 18 ft above ground level.

Sales is thrilled because the chemical in the totes includes new additives the customer wants. Production is concerned about the additional inventory filling its warehouse and yard — and also displeased with the slow filling rate that adds 20 minutes to the operation and requires an operator on standby because the measurement is by tote level. I'm not happy that we're wasting ingredients due to all the leaks. I'm not sure how quality control feels about this.

How can we prepare for winter at this late date? Should containment of a water solution worry us?

ASSESS MULTIPLE ISSUES

Consider the following:

1. To alleviate storage space problems, think about increasing the concentration of sodium benzoate and sodium nitrate. Doubling the concentration, if feasible (according to solubility), would lower the number of daily tote requirement from 12 to 6. Of course, you also must ensure the metering pump's stroking requirements or speed allow this, because you only will need half the rate of addition.

2. The 275-gal tote system entails considerable handling, raising the potential for leaks and spills. If space is available, consider installing a tank to eliminate tote handling if this fits in with long-term strategic marketing goals. Obviously, available space and number of deliveries (say, per month) from the corrosion inhibitor vendor will influence tank capacity. Because "money is tight," this may be a difficult decision requiring careful thought.

3. Because the tote system relies heavily on daily receipts of inhibitor, traffic disruptions or delays could adversely impact business and customer goodwill.

4. The freezing point of an ethylene glycol (EG) solution gradually drops as the glycol content rises. A 60% solution has a -60°F freezing point. Survey your system for water content and dead legs, and consider heat tracing where potential of freezing exists.

5. The problem description gives the impression that most departments don't favor the tote system. Consider what's involved in reverting back to the original system. Does it pose any potential production/safety/environmental issues that need addressing?

6. It seems that the switch to the tote system was made in a hurry. For future projects, implement a management-of-change system. This may require diplomacy in "educating" your marketing folks.

GC Shah, consultant
Houston

IMPLEMENT REALISTIC OPTIONS

You're in a typical bind for a plant engineer — expected to do miracles with nothing. You have two distinct challenges: 1) preventing freezing; and 2) increasing the pumping rate. The storage and fork truck issue is merely an inconvenience. I won't get into using automation or a large heated storage tank because you couldn't get the money for those now.

Try to find some spare warehouse space. If none is available, identify a location where you can hang heavy tarp as an A-frame or expandable modular frame. You probably can't buy anything ready-made that fits 275-gal totes with enough space. The tarped enclosure should allow for moving totes in and out quickly.

I solved a similar problem at a plant by creating a 2×4 frame with a tarp on a curtain rod so an operator could access an individual tote. I left sufficient room around the totes to allow good ventilation for heated air.

Now, I come to the hard part: heating. You need a portable heat source. Electricity gets expensive to set up and use; so, too, does steam, with the added risk of water creating a slip hazard. I suggest a propane heater providing 24,000 BTU/h for six totes in the enclosure; you'll use about 3 gal/d of propane per tote at about 0°F outside temperature and 75°F inside temperature. The danger with any kind of heater is fire, so leave plenty of room around the heater and protect it with bollards.

Keep the fittings, hose and pump inside the enclosure. This will protect the pump and shorten the length of pipe needing heat-tracing. (I suggest self-regulated electric tracing.) Moreover, inside fittings will ease the operators' job of connecting totes.

I derived a crude thawing equation for water to disabuse operations from thinking about that as an option: θ, the thawing time, h, = 3.07 $V^{0.2061}$, where V is in gallons (at 75°F room temperature). This doesn't account for salt freezing-point depression. For a 275-gal tote of water, θ = 10h. That should convince anyone that thawing totes is a fool's errand.

Consider temporary blankets and pad heaters for the totes being unloaded directly. Blankets for totes run about $200 each and are hard to unwrap. Bottom pad heaters cost about $1,000 each. Heating with a pad uses about 1,600 W at 115 VAC.

As for increasing the filling rate, first look at the utilities. I assume you're using an air-operated diaphragm pump because it's most common for temporary installations. See if the line pressure drops when that pump is running. Watch it for a day; if the pressure is above 80 psig, then you can re-size for a larger pump. The cost is minimal, although you may have to rely on level measurement of the tote instead of flow measurements as the meter may be over-range.

Dirk Willard, consultant
Wooster, Ohio

MARCH'S PUZZLER

We use a variety of solvents at our pharmaceutical plant. Until recently, we largely ignored the vent system feeding our thermal oxidizer (TOX). Although the decanting and distillation tower for separating solvents works flawlessly, the TOX system sometimes acts up; the environmental regulators forced us to install a backup system. Lately, the vent system drew our attention when vapor detectors caused a trip during new solvent unloading. Then, everything went haywire. I was sent by corporate to investigate.

The operator claims the suction is very bad and truck drivers complain about the fumes. I found out that, to avoid the fumes, the drivers hook up and walk away and the operator watches from the control station. Plant engineering gripes that a series of expansion projects connected to the system without addressing underlying problems. With budget cuts, corporate says there isn't any money. One engineer grumbles that the vent alarm is faulty; he says the over-loaded distributed control system suffers from a power supply problem that causes alarm trips.

As I expected, the utility piping and instrumentation diagrams are a joke. The line sizes are missing and many vent connections either don't appear or go to unused tanks. I found a show-stopper: a tank with a blind flange removed from a vent nozzle. Maintenance is pretty sure the slide gate is closed on the abandoned tank and says not to worry about it. I drew up a quick flow diagram to begin my investigation (Figure 1).

A walkdown of the system showed corrosion and water vapor at some of the flanges, duct joints and two blowers, (F-55 and F-400, the main blower). The other blower (F-65) looks clean because the tank hardly ever is emptied. Maintenance says the corrosion is normal.

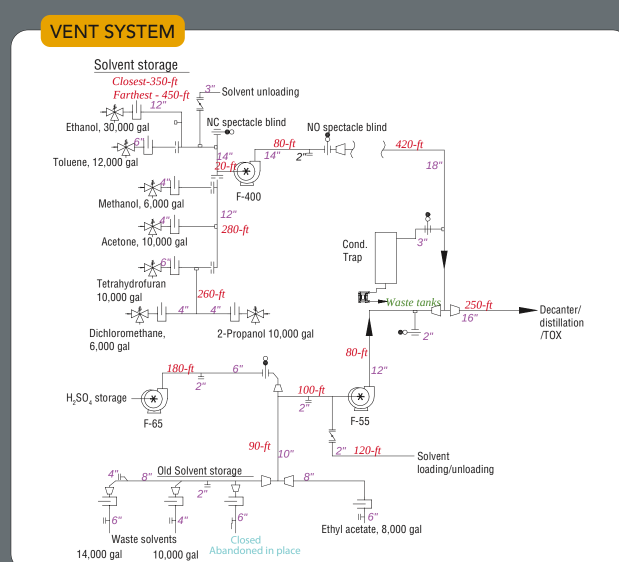

Figure 1. Long-ignored system caused intermittent alarm trips and now has gone haywire.

Where should I start? What should I do about the abandoned tank?

Send us your comments, suggestions or solutions for this question by February 12, 2021. We'll include as many of them as possible in the March 2021 issue and all on ChemicalProcessing.com. Send visuals — a sketch is fine. E-mail us at ProcessPuzzler@putman.net or mail to Process Puzzler, *Chemical Processing,* 1501 E. Woodfield Rd., Suite 400N, Schaumburg, IL 60173. Fax: (630) 467-1120. Please include your name, title, location and company affiliation in the response.

And, of course, if you have a process problem you'd like to pose to our readers, send it along and we'll be pleased to consider it for publication.

Check Your Heat Transfer Fluid

Consider a variety of tests to pre-empt problems

> You must take the samples from the right part of the system.

A MONITORING program for heat transfer fluid (HTF) often is essential, as I pointed up in a recent column, "Don't Hobble Your Heat Transfer Fluid," https://bit.ly/37Fn000. So, let's now discuss what an HTF monitoring program might include.

First, you must take the samples from the right part of the system. You need samples from the flowing fluid in the system to get a true representation of its condition. Don't take samples from the expansion tank; in many systems, HTF in the expansion tank is nearly stagnant.

You are looking for three sources of problems: oxidation, thermal cracking and contamination. Specific tests look at each area. The most important oxidation test is for total acid number (TAN). Thermal cracking tests include distillation range, viscosity and flash point. Contamination testing includes the Karl Fischer water test for checking for leaks into the system as well as metals tests. Particulate tests indicate both oxidation and thermal cracking.

If necessary, get an outside laboratory or the HTF supplier to run the tests. A vendor often comes back with recommendations, not just results. Nevertheless, you still must understand the tests and what they may mean. So, let's delve into some them.

• *Total acid number.* This is a measure of acids present (commonly determined via ASTM D664 and D974); these normally result from oxidative degradation forming carboxylic acids. Carboxylic acids are the reaction products of oxygen with the HTF at high temperature. As TAN number increases, corrosion and fouling rates rise.

A fresh HTF typically should have a TAN of 0.01–0.05. The HTF supplier should indicate the maximum TAN number before the fluid needs replacement. If you don't have any value specified, consider at least partial fluid replacement when the TAN exceeds 1 and total fluid replacement when the TAN goes beyond 3.

Distillation range. Thermal cracking creates smaller molecules. These molecules have lower boiling points. The ASTM D2887 GC method for boiling range distribution by gas chromatography generates the equivalent of a batch distillation curve for 15 stages of distillation with a 5:1 reflux ratio. This curve will show increased content of both low-boiling material (from thermal cracking) and high-boiling material (from polymerization). Too much low-boiling material can cause vapor pressure problems and require venting from the expansion tank. High-boiling material eventually will polymerize and create deposits.

Viscosity and flash point. These are much simpler tests than the distillation one. Decreased viscosity and lower flash point both indicate low-molecular-weight (cracked) material. However, they aren't as sensitive as the ASTM D2887 distillation test. Increases in viscosity result from polymer formation and usually correlate with high fouling rates.

Water content. The ASTM has defined more than 20 test techniques for water content based on Karl Fisher methods, including ASTM D1744 and D6304, which commonly are used. A high water level is a symptom of leaks into the system or arises due to condensation of water from the expansion tank vapor space during shutdowns. Water leaks increase corrosion rates and create a potential safety hazard due to flash vaporization during startups. Metals tests often will identify sources of water leaks. Water should be vented from the expansion tank during heating.

Metals. Metal content of the base oil used to formulate an HTF should be under 1 wppm. However, proprietary additives used by suppliers frequently contain significant amounts of metals. If corrosion occurs in the system, metals content will rise; levels under 50 wppm normally are considered acceptable.

Solids. You should dilute the sample with ASTM precipitation-grade naphtha and then filter it — typically with a 0.8-micron cellulose filter. Solids include both inorganics (from leaks and corrosion) and organic materials (from thermal cracking and polymerization). New HTF should have zero solids content. You can wash the solids gathered with various solvents to determine the breakdown between inorganic and organic.

Replacement criteria and troubleshooting indicators depend upon the specific HTF. However, you should sample and analyze often enough to establish trends for the HTF quality. More-frequent sampling also will help catch problems like leaks that can lead to rapid changes. In normal operation, check an organic-fluid HTF system annually. A problem system demands more-frequent analysis — often quarterly or even monthly. ●

ANDREW SLOLEY, Contributing Editor
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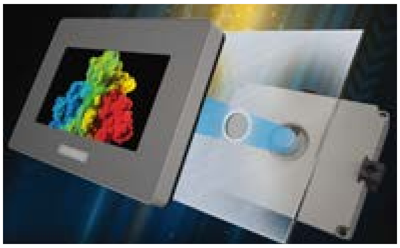
Flowmeter Reduces Process Interruptions

SonoPro Portable clamp-on ultrasonic flowmeter offers transit-time ultrasonic technology to deliver accurate, reliable flow metering in a portable design. Matched precision transducers and signal processing circuitry measure the flow of most liquids over a range of velocities. Clamp-on transducers create no wear, zero pressure loss, and do not require process interruptions to install them because they are externally attached to pipe. With the addition of external temperature inputs, the flowmeter can provide a reliable energy (Btu) or mass flow measurement. SonoConfig instrument interface software works in conjunction with the flowmeter to provide valuable setup, diagnostic and data logging tools.

VorTek Instruments
303-682-9999
www.vortekinst.com

HMI Simplifies Installation

The STM6000 modular human-machine interface (HMI) series is available in two display sizes: 4-in. and 7-in. with easily interchangeable back ends. This modular unit paired with the company's HMI development software can be used to optimize operations and machine information. The clear display with 16 million colors, gradation and transparency options, and aluminum front panel, improves operability. The HMI can be separated with a 3-, 5-, or 10-m cable



accessory to install the display module on the panel door and the rear module on DIN rail with a dock station adapter. Set up and use is said to be simple and easy. Connectivity options include Ethernet, serial and USB ports.

Pro-face America
800-289-9266
profaceamerica.com

Air Conveyor Withstands Corrosive Environments

Type 303 stainless steel 3 NPT-threaded line vac air-operated conveyors convert ordinary pipe into a conveying system for bulk materials. The chemical- and corrosion-resistant line vacs operate at higher temperatures, providing longer life and lower maintenance. Designed for simple attachment to standard plumbing pipe couplers, their durable construction employs a larger inside diameter, aiding in conveying bigger parts and greater volumes of material over long distances with ease. The conveyors use minimal amounts of compressed air to generate an instant vacuum on one end, with high output flows on the other. Regulation of the compressed air pressure also provides fine-tuned control of the conveyance rate.

EXAIR Corporation
800-903-9247
https://exair.co/108-3tlv

Dual-Shaft Mixer Offers Advanced Capabilities

To meet intense shearing and homogenization requirements, the model CDA-25 incorporates a high-shear rotor/stator into a dual-shaft mixer. Instead of a conventional high-speed disperser blade, the rotor and slotted stator mixing head, also often called a homogenizer, affords more advanced deagglomeration and emulsification capabilities. In addition, a two-wing anchor promotes bulk flow and uniform batch temperature. Dry-running double FlexiLip seals on both agitator shafts suit vacuum operation up to 29.5-in. Hg. The dual-shaft mixer also includes a portable mixing vessel with heating and cooling jacket.

Charles Ross & Son Company
800-243-7677
www.mixers.com

Vacuum Pump Boasts Energy Efficiency

The Cobra NX 0950 A Plus dry, oil-free vacuum pump can run with pressure control or at a constant rotational speed, making it energy efficient. The pump precisely maintains the desired pumping speed at a prescribed rotational speed. It can also sustain the required vacuum level, regardless of how the process conditions change. A variable-speed drive provides a pumping speed range from 200 to 950 m^3/h and reaches an ultimate pressure of 0.01 millibar. All operating data are recorded and saved. Access data directly on the built-in display or transfer it via a Modbus TCP/IP client/server protocol. Its Industry 4.0 capabilities also enable remote control.

Busch Vacuum Solutions
800-872-7867
www.buschusa.com

Flowmeters Afford Process Visibility

The GT1600 Series of glass tube variable-area flowmeters is designed for low- and high-flow gas and liquid applications where viewing the process is important. Type 316 stainless steel construction and a polycarbonate shield ensure safety and longevity for both indoor and outdoor use. The adjustable, transparent scale improves readability and allows for offset correction to compensate for process variation. In addition, the process connection can rotate 360° so users can view from all directions. An alarm also is available for automatic monitoring of critical flow conditions. To ease installation, connection options fit existing piping arrangements, or mount to a panel or wall.

Brooks Instrument
888-554-3569
www.BrooksInstrument.com

Mesh Cartridge Quells Flames

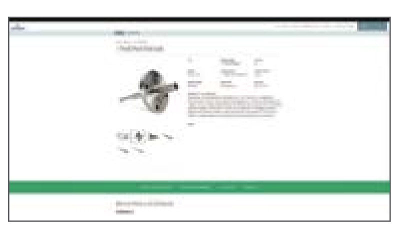
The Interceptor-QV explosion isolation device uses a differential pressure switch that continuously monitors the pressure drop across a mesh cartridge, alerting operators if buildup of dust occurs on the mesh. The stainless-steel mesh cartridge is located directly in the flow of clear air return. A deflagration propagating through the clean return line will make contact with the mesh cartridge, which immediately and passively removes energy from the flame as it passes through the mesh. This forces the flame to transfer its energy to the high surface area of the mesh, thus quenching the deflagration and preventing any flame to pass beyond the device.

CV Technology
561-694-9588
www.cvtechnology.com

Transmitter Facilitates Remote Monitoring

Pressure Ranger is an LTE-M cellular pressure transmitter that provides plug-and-play, instant connectivity of pressure sensor data to the cloud over cellular networks. This cellular transmitter brings pressure data to the cloud for remote monitoring, control, and alarming of assets from any web browser, including those on mobile devices. The unit also utilizes MQTT/Sparkplug communications to integrate into third-party hosts. A built-in GPS receiver reports location of devices to the cloud, providing a map of all connected assets. It also sends maximum, minimum, average, and instantaneous pressure. Certified for use in Class 1, Div. 2 environments, the unit can operate in challenging environments, offering a safer alternative to local operators.

SignalFire Wireless Telemetry
978-212-2868
www.signal-fire.com



Digital Tools Aid Maintenance Management

MyAssets toolset is designed to help users execute their maintenance plan more effectively. The toolset provides instant access to device and technical documentation, replacement part details and spares, and walkdown reports to help plant personnel better maintain and manage the useful life of Emerson devices. Easy access to curated, relevant device content enables faster creation of work packets, reportedly reducing time from hours to minutes. Digital walk-down reports provide detailed analyses of a site's device conditions, regardless of manufacturer, and prioritized recommendations for next steps, guiding faster and more predictable shutdowns, turnarounds, and outages. Up-to-date manufacturer information is connected to installed products by serial number, ensuring confidence in spare and replacement parts selection.

Emerson
888-889-9170
www.emerson.com

Bulk Bag Filler Accommodates Low Headroom

A low-profile, combination bulk bag/drum filler allows filling of bulk bags and drums in low headroom areas. When filling bulk bags, full-length forklifting tubes integral to the rear-post fill head allow incremental height adjustments secured with hitch pins to accommodate bags of all popular sizes, from 42 to 59 in. (1,067 to 1,499 mm) tall, and widths to 45 in. (1,143 mm). The filler is equipped with an inflatable bag spout seal, a feed chute dust vent, and a low-profile densification deck that de-aerates material in bags weighing up to 2 tons (1.8 metric tons) as they are being filled.

Flexicon Corporation
888-353-9426
www.flexicon.com

VR-Based Simulator Enhances Training

The Immersive Field Simulator virtual reality (VR) and mixed reality-based training tool incorporates a digital twin of the physical plant to provide targeted, on-demand, skill-based training for workers. A smooth, virtual walkthrough familiarizes workers with the plant. It includes avatars that represent virtual team members. The simulator's cloud-hosted, device-agnostic platform, which incorporates flexible 3D models, grows with the user as plant operations change. The simulator is customizable to meet specific instructional needs; project team members and plant subject matter experts can easily create customized training modules. The system supports training a digital-native workforce, enabling employees to learn by doing while increasing knowledge retention.

Honeywell
877-841-2840
www.honeywell.com

Gas Distribution Program Fosters Safety

The Swagelok gas distribution program suite of services and fully engineered subsystems are designed to help enhance safety and increase uptime of industrial gas distribution systems. The company's gas distribution advisors evaluate existing gas distribution systems to identify any potential leak points, as well as opportunities to improve performance and simplify maintenance. They then provide actionable recommendations to improve existing system designs or explain how to incorporate standardized Swagelok gas distribution subsystems to overcome challenges. By eliminating potential leak points in existing systems or integrating subsystems designed for easier use and maintenance, companies can reduce the risks posed to personnel by underperforming gas distribution systems.

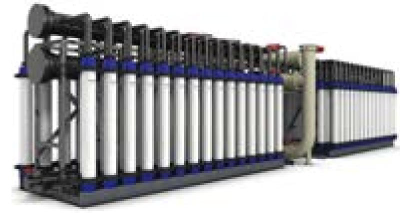
Swagelok
440-248-4600
www.swagelok.com

Process Chillers Use Less Refrigerant

The TCX 4-90A process cooling chiller range features a compact, all-in-one water chiller with an air-cooled condenser and integrated hydro module, with units available in a variety of sizes. The chillers are designed for cooling water (or a mixture of water and glycol) for a range of industrial segments. The chillers' microchannel condensers require 30% less refrigerant, making the units more environmentally friendly while lowering potential maintenance charges over the life of the chiller. The Elektronikon Mk5 Touch controller comes in most models, putting control at the user's fingertips. In addition, Smartlink 24/7 monitoring is available as part of a chiller's package.

Atlas Copco Compressors LLC
803-817-7434
www.atlascopco.com/air-usa

Membrane Increases Surface Area with Same Footprint



The X-Flow XF75 ultrafiltration (UF) membrane element is designed for new water treatment projects as well as to enhance the performance of existing systems within the same footprint. The outer dimensions are the same as those of existing X-Flow membrane elements with membrane areas of 55 m^2 and 64 m^2, but redesigned internal workings and modified materials create extra membrane surface area. By maintaining the existing element outer dimensions and increasing the total surface area to 75 m^2, users gain more membrane surface area per unit of weight or volume than the average of similar X-Flow UF technologies available today, the company says.

Pentair
936-224-2152
www.pentair.com

Flowmeters Handle Large Flow Capacity

XFM57, XFM67 and XFM77 digital flowmeters with extended flow rates up to 1,000 L/min are now available. They offer calibrations for up to 10 different gases and internal conversion factors for up to 32 gases. Flow rates are displayed in 23 different volumetric or mass flow engineering units including user defined ones. The flowmeters support various functions including programmable flow totalizer, high and low flow alarms, automatic zero adjustment, two relay outputs, jumper selectable 0–5-Vdc or 4–20-mA analog outputs as well as status LED diagnostics. Optional local 2×16 characters LCD display with adjustable back light provides flow, total and diagnostic readings simultaneously.

Aalborg Instruments
800-866-3837
www.aalborg.com

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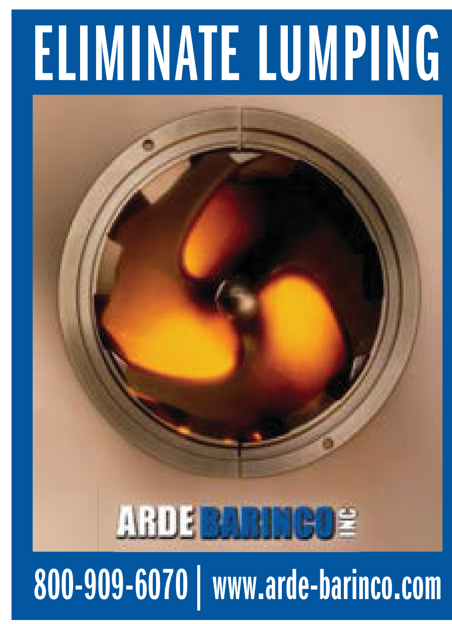

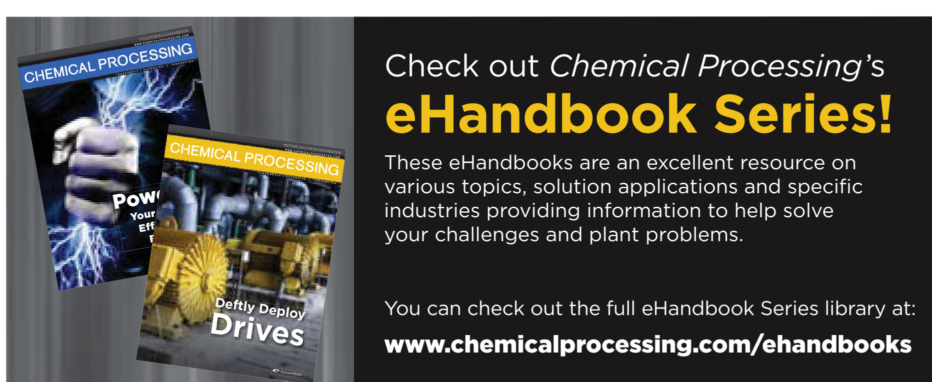

EU Eyes Waste Heat

Several projects aim to reduce the impact of energy-intensive processes

The payback period of the 200-kW system is estimated to be under 10 years.

THE LATEST CORDIS results pack — a roundup of research funded by the European Union (EU) into promising technologies for reducing the impact of energy-intensive industrial processes — spotlights efforts to enable taking greater advantage of waste heat.

The brochure focuses on eight projects, including new generation organic Rankine cycle (ORC) systems, novel heat exchange and thermal energy storage technologies, and innovative heat pump technologies.

Spanish research foundation Technalia, San Sebastián, Spain, is coordinating two of the projects.

The first, Indus3Es, focuses on recovering low-quality waste heat, which the report notes often is neither practical nor economically viable today.

The report shares that, overall, a large portion of waste heat in energy-intensive industries has a temperature below 200°C. Yet, economically viable heat-recovery technologies have been limited primarily to medium-to-high-temperature waste-heat sources.

Under Indus3Es, a low-cost system based on absorption heat transfers (AHTs) has been developed to maximize heat recovery at temperatures below 150°C. Turkey-based petrochemical company Tüpraş has installed and demonstrated the system.

"The AHT developed within Indus3Es effectively recovers and revalues low-temperature waste heat at competitive costs. Using a waste steam of around 100°C, it produces a higher temperature stream, becoming reusable in refinery operations. Overall, it leverages about 50% of low-temperature heat that would otherwise be discharged to the atmosphere," explains researcher Asier Martinez-Urrutia.

Essentially, an AHT works in reverse of absorption chillers. Both consist of a condenser, an evaporator, absorber and generator. The difference is that the absorber and evaporator now run at a high pressure and the condenser and generator at a low pressure.

The payback period of the 200-kW system in Turkey is estimated to be under 10 years; the researchers stress this is a very positive value for a first capacity level prototype. They are now looking to develop systems that work at much bigger scales: a 1-MW AHT would reduce payback to two years, for example.

Also coordinated by Technalia is the TASIO project focusing on exploiting waste heat recovery technologies based on the ORC. This ORC version uses an organic fluid instead of water. Vapor from the fluid, which has a much lower boiling point than water, powers a turbine that can be directly coupled to a generator to produce electricity or to a compressor to compress air for mechanical work. It differs from a typical ORC which uses indirect exchange of heat to the organic fluid via a heat transfer fluid.

As project manager Pedro Egizabal notes, TASIO is the first application of direct-heat-exchange-based ORC technology to energy-intensive industries. "The benefits of eliminating the intermediate heat transfer fluid, makes the process simpler, enhances heat transfer efficiency and reduces maintenance costs," he says.

The TASIO team successfully demonstrated the technical and economic feasibility of the direct heat exchange ORC technology to produce up to 2 MW of electric capacity in an operating cement plant.

The system also reduced water consumption as a high-pressure pump provided water to cool the waste gas. In addition, a small-scale demonstrator validated a 15-kW ORC module to generate compressed air.

Finally, researchers conducted feasibility and cost analyses associated with applying ORC technology to a pilot plant for the treatment of petrochemical sludge.

The report notes that fundamental to this project's success was new coating/steel substrate combinations for production of components for the higher-temperature conditions relative to a conventional ORC.

(Editor's Note: For more ORC applications, see December 2020's article, "Consider ORCs for Waste Heat Recovery," https://bit.ly/3oJXRIn.)

A briefer mention is made of the ongoing DryFiciency project, which aims to develop technically and economically feasible ways to upgrade low-temperature idle waste heat streams into process heat supply at temperature levels of up to 160°C. This project focuses on industrial drying and dehydration processes applications. Its key technical elements include high-temperature vapor compression heat pumps: two closed-loop heat pumps for air-drying processes and an open-loop heat pump for steam drying processes.

Currently, three European process companies are demonstrating DryFiciency under real operational industrial drying processes.

The CORDIS report concludes that while such technologies will enhance the competitiveness and sustainability of energy-intensive industries, they will require policy maker support for further adoption.

View the full report at https://bit.ly/3gxxToS.

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