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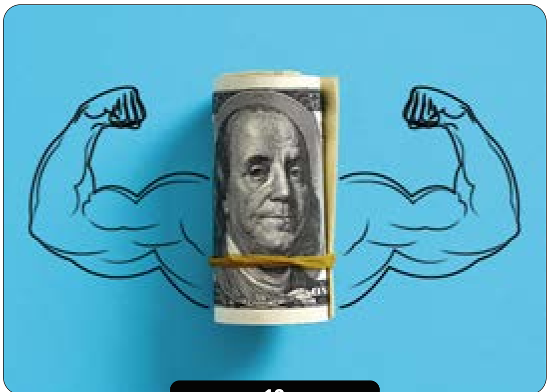

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Next-generation of high efficiency motors now available for potentially explosive environments

Petteri Hyytiäinen, Chemicals Global Industry Segment Manager, ABB, explains how the chemical industry can ensure safety and boost energy efficiency by deploying motors that offer up to 40% lower energy losses compared to commonly used IE3 motors.

The chemical sector is the second-largest consumer of industrial energy and the third-largest direct emitter of CO_2. Given the climate crisis, improving the energy efficiency in chemical production processes is now imperative.

Motors are at the beating heart of chemical production, powering critical applications from pumps and fans to compressors. These motor-driven systems claim most of the industry's energy, making them a logical starting point for energy efficiency improvements. Right on schedule and up to the task is the new IE5 Increased Safety SynRM motor developed to deliver energy savings and lower emissions.

NEXT-LEVEL EFFICIENCY

Electrical equipment efficiency is rated from IE1 (lowest) to IE4 (highest). And due to the latest Ecodesign regulation, as of July 2023, new motor installations and upgrades in Europe will require a minimum of IE4 for motors rated between 75 and 200 kW.

But these regulations don't address older motors already in use, leading many chemical production facilities to continue to waste energy with inefficient IE2 or IE1 motors. So, there is an immediate gain to be had by upgrading motors. ABB's IE5 synchronous reluctance (SynRM) motors deliver more efficiency, with up to 40% lower energy losses compared to IE3 motors. Furthermore, a SynRM motor must be paired with a variable speed drive to function correctly. That means a SynRM motor comes as part of a package that automatically brings the energy efficiency advantages of using a drive.

UPGRADING DELIVERS HUGE ENERGY SAVINGS

To show what's possible, the world's largest nitrogen-based complex fertilizer producer turned to ABB to boost the energy efficiency of its production facility in Porsgrunn, Norway. The upgrade project will ultimately yield annual energy savings of 32–40 GWh and cut CO_2 emissions by 12–19 kt — equivalent to the emissions produced by nearly 14,000 standard cars.

The first project phase involved the replacement of around 1,000 old low-voltage electric motors with IE3 motors, 75% of which also had drives added. The second, ongoing phase will replace an additional 2,500 motors with IE5 SynRM ultra-premium efficiency motors. Nearly 70% of these motors are fitted to pump and fan applications, proving significant energy-saving potential.

SAFETY FIRST

It is vital to use motor-drive packages with ATEX certification for applications in explosive atmospheres. But until now, a suitable SynRM motor has not been available. The arrival of SynRM Increased Safety motors now offers chemical manufacturers the most energy-efficient motor and drive technology available.

ABB is the first manufacturer to provide ATEX and IECEx certified SynRM motors suitable for explosive atmospheres. SynRM Increased Safety motors provide ultra-premium efficiency, increased reliability and reduced maintenance thanks to lower running temperatures, longer lifetime and fast return on investment. The motors produce lower CO_2 emissions and are sustainably manufactured, containing no rare earth elements.

COST-EFFECTIVE INSTALLATION

The motors can also help in specifying a more cost-effective installation. For example, in Zone 1, the cooler running design could allow the use of an increased safety motor, replacing the traditional flameproof motor with a special enclosure. In Zone 2, the improved loadability of SynRM motors, which enables more power to be delivered from the same size as an induction motor, is important. This could allow a smaller, and therefore lower-cost, motor to fulfil the same duty.

SynRM motors offer a seamless upgrade option for companies looking to modernize their assets. Because they are the same size as induction motors, replacement is straightforward and requires minimal process disruption. The motors are also compatible with ABB Ability™ Digital Powertrain, allowing remote monitoring of electrical motor-driven processes.

UNTAPPED ENERGY SAVINGS

Reducing energy consumption also lowers the total cost of ownership (TCO) over a motor's lifecycle. While less efficient motors might have lower upfront costs, TCO analysis shows that around 97% of a SynRM motor's TCO stems from electricity usage throughout its service life, with maintenance comprising just 1% and CapEx 2%.

OPPORTUNITY AWAITS

In the energy-intensive chemical sector, rising demand necessitates rapid energy efficiency solutions. The technology exists and is available right now to turn the tables on climate emergency. All that remains is to use it.

Learn more about the energy efficiency possibilities within the chemical sector in our whitepaper. https://bit.ly/3Ezj6qh

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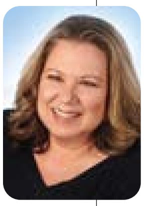
Folio Editorial Excellence Award Winner

Our Industry Sings Different Tune

Challenging work and recognition inspire workers, but cash is king



We can't ignore the importance of fair compensation.

Workin' 9 to 5, what a way to make a livin' / Barely gettin' by, it's all takin' and no givin.'

They just use your mind, and they never give you credit / It's enough to drive you crazy if you let it.

9 to 5, for service and devotion / You would think that I would deserve a fair promotion.

WHILE DOLLY Parton found inspiration for her song in office work, that doesn't mean we can't analyze her lyrics, and apply them to the chemical industry. And according to this year's salary and job satisfaction survey, there's more giving than taking in terms of compensation.

As you will find out in this issue's cover story, "Salaries Get Stronger," (see page 18), chemical engineering professionals are having a banner year. I will save the average salary reveal for Managing Editor Amanda Joshi to tell, but I will highlight a few of the responses we collected from your peers regarding pay, bonuses and satisfaction.

Agreeing with Dolly that they are lacking appropriate credit and job advancement, one respondent noted, "I am compensated well. However, promotions are given sparingly even when working at the competence of the next level. So, it takes much longer to get promoted than it should."

Flipping the song script, another survey taker said, "I am happy with the compensation and benefits I receive. I am on a bonus structure that is based on company performance, and I have a direct impact on how the business performs."

I'm not certain if this next response came from someone with tongue firmly in cheek (or going crazy), but the participant stated that "prestige/recognition" keeps them motivated in their career. "Little plaques mean the world to me," the respondent continued, even bringing Napoleon into the mix by paraphrasing the French military commander's quote – "A soldier will fight long and hard for a bit of colored ribbon."

Another survey participant draws inspiration from Intel Corp. co-founder Gordon Moore and his emphasis on innovation as a source of motivation. As the participant stated, they're "keeping Moore's Law alive another year, pushing the physical boundaries of technology." In 1965, Moore proposed that every two years, the number of transistors on microchips would double — essentially pointing out that computational progress will become significantly faster, smaller and more efficient over time.

Similarly, many survey respondents cited the opportunity to engage in cutting-edge research and development projects as a major driver of job satisfaction. The sense of accomplishment derived from solving real-world challenges, whether it's creating sustainable processes, facilitating safety best practices or developing life-saving drugs, is immensely rewarding and keeps the majority of the workforce on the job from 9 to 5.

However, while workers express the desire to find meaning in their jobs, we can't ignore the importance of fair compensation. The desire to feel empowered and contribute through innovation must be reflected in pay/benefits/compensation or workers will find a different way to make a livin'. That's something the industry can't afford as it's still contending with a skills shortage. ●

TRACI PURDUM, Editor-in-Chief
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WEB-EXCLUSIVE FEATURES

ECONOMISTS TALK FREE TRADE, EMISSIONS TARGETS & ARTIFICIAL INTELLIGENCE AT WORLD CHEMICAL FORUM

The conference kicked off with a discussion on the current economic outlook for the chemical industry, including policy and market challenges in the years ahead.

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CHEMICAL INDUSTRY EMBRACES EDGE COMPUTING

Challenges persist due to complex hardware and software ecosystems, but overcoming them can unlock the IoT technology's potential.

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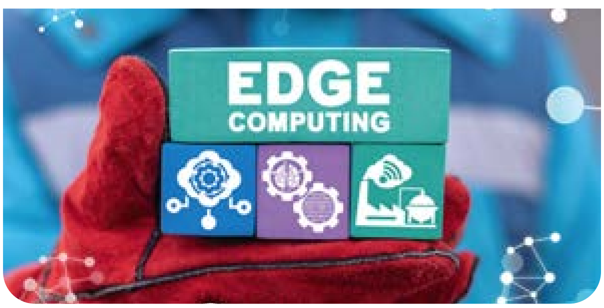

PODCASTS

CHEMICAL PROCESSING NOTEBOOK: PFAS REGULATIONS AND THE SUPPLY CHAIN

Learn more about the PFAS regulatory tide and how it may impact day-to-day operations for the chemical industry.

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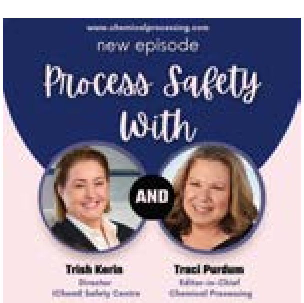
GAME-BASED LEARNING REVOLUTIONIZES PROCESS SAFETY EDUCATION IN THE CHEMICAL INDUSTRY



In our latest episode, we sit down with Dr. Cheryl Bodnar, one of the brilliant minds behind "Contents Under Pressure," an immersive game designed to teach process safety.

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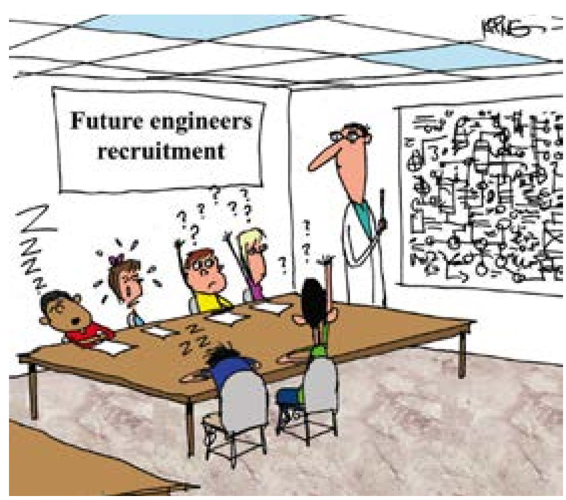

The Comical Processing page features drawings by award-winning cartoonist Jerry King.

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Unleash Innovative Solids Strategies

Five properties to keep in mind when looking for alternate processing routes

No wonder we find solids processing fascinating and frustrating.

WE'VE ALL heard the expression, "think outside the box." Solids processing is clearly an area where this is an appropriate strategy. Particulate solids don't play by the rules — and many of the rules we use to evaluate their behavior have exceptions. One of my favorites has to do with long-radius elbows. It assumes that the solids flow along the elbow in such a manner that friction is reduced. To some extent, that is correct if the particles knew they were supposed to slow down and not run into each other. The rule works when the velocity is low for a given particle strength. But even then, the elbow may suffer.

More often, the particles slam into one side of the elbow and bounce over to the other side. After repeated blows, the wall fails. Note that I'm not saying long-radius elbows will always fail, but that, given the right circumstances, they could fail. And when they do fail, it is an expensive repair. The weight and size of the elbow precludes a one-person job. This rule probably originated from experience with very low solids-to-air ratios and dilute-phase conveying systems, so particle-particle impact was minimal. As an aside, the reason for low solids-to-air ratios for materials like grain was to prevent pluggages due to rats, another good reason to think outside the box.

Process design is usually a straightforward extension of laboratory work and often small-scale pilot tests. However, getting a product to market or responding to a critical situation may require an unusual approach. I've been involved in many designs where all conventional processes either had a high technical or financial risk. In corporate jargon, "We can afford failures, but not below the waterline of the ship."

We had a process that required a very low particulate emission rate. All the conventional designs would wipe out profits for many years — unacceptable! I proposed using three well-established technologies connected in a different manner. Each one could be proven with a minimal amount of research, which was critical because we had less than a year to select the parameters for each device and build the full-scale unit. The key "outside the box" item was using a little-known phenomenon of reverse-flow cyclones to carry out a chemical reaction.

This case illustrates what I like to call "thinking outside the solids processing box." This method utilizes an understanding of several fundamentals of particulate solids and can point the way to discovering why solids don't always follow the rules we expect. Here are my top five properties to keep in mind when looking for alternate processing routes:

- **Particulate solids are two-phase mixtures**. You can change the way solids respond to external forces such as pressure or temperature. When the second phase is gas, the mixture is compressible, and the volume of the mixture is controlled by the gas. Take advantage of this difference, especially when particles are different shapes.

- **Solids have electrical properties.** The conductivity of the solid may vary from the surface throughout the solid. This can hold or repel particles and change the apparent density of the particle mixture. Fine particles can pick up a charge when flowing over conductive surfaces, but this becomes less important as physical size increases.

- **Solids have mechanical properties.** You can break particles using stress or abrasion, giving the mixture an additional phase to deal with. These two mechanisms can control the final particle size distribution and interact with the previous properties to further alter the mixtures' behavior.

- **Particle size adds complexity to the solid phase.** Particles may act individually or in combination. The preceding properties can alter the apparent size (think settling or reaction rate).

- **Solids can contain different chemical compounds.** The chemical species can be different, not only in the overall mixture but within individual particles. The result is different mechanical and electrical characteristics.

If you're looking to find a new product or develop a better process, particulate solids are the best candidates for thinking outside the box because of the many properties that can be manipulated. No wonder we find this technology area so fascinating — and frustrating.

TOM BLACKWOOD, Powder & Solids Columnist

Don't Let Risk Management Falter

A deep understanding of risks empowers us to make informed decisions

Risk management techniques keep hazards within acceptable bounds.

IN MY previous column, "Prepare For The Worst" (chemicalprocessing.com/33007918), I discussed my aversion to being on boats, which prompted me to explore cave diving several years ago. I can almost hear you thinking, "She must be crazy; that's so dangerous!" While cave diving is undoubtedly a high-hazard activity, it doesn't necessarily have to be an extreme gamble. In the industrial sectors we operate in, we regularly find ourselves in high-hazard environments without deeming it "crazy and dangerous." This is because we employ risk management techniques to keep those hazards within acceptable bounds. In life, we often take calculated risks in pursuit of enticing rewards. The true peril emerges when we fail to acknowledge these hazards or underestimate the potential consequences. It's at these moments our overall risk management falters, leading to unfortunate incidents.

To me, cave diving represents the epitome of risk management. Each time I ventured into a cave (the photo shows me entering a cave called Cocklebiddy in Western Australia), my life hinged on my ability to effectively manage risks. The facets of cave diving seamlessly align with all aspects of the IChemE Safety Centre Process Safety Framework. These components encompass leadership, knowledge and competence, engineering and design, systems and procedures, human factors, assurance and culture. At the heart of successful cave diving lie these fundamental prerequisites: skill, attitude, meticulous planning and top-notch equipment.

Let me take you through these core requirements:

Skill means being a competent cave diver — this is different to open-water diving. The buoyancy movement skills are very high level. Cave certification requires testing until reactions are second nature and the skill is both mental and physical. This is because cave divers must execute all skills in zero visibility and under extreme mental stress.

Attitude is about having the right culture in the dive team, positive leadership and psychological safety. We used to say, "Today is not a good day to die," when the dive we were about to undertake didn't feel right, and there was never any pressure to continue — a clear signal to abort that dive. While it sounds flippant, I used that phrase several times in my cave diving experience and lived to tell the tale.

Planning is centered on ensuring the effectiveness of your procedures, adhering to the principle of "plan the dive and dive the plan." Key elements within the planning phase encompass a comprehensive grasp of the site, its access and egress, air consumption estimates, dive duration, dive depth and the distance to be traversed. To aid memory, we abbreviated these vital aspects as 'SADDD,' a mnemonic that served as a reminder to account for all the essential steps. Given the complexity of these plans, it was imperative to carry a written copy during the dive to ensure no critical elements were overlooked.

Equipment encompasses a diverse array of items, addressing not only their design and arrangement for optimal functionality in challenging environments but also incorporating redundancy because one must anticipate equipment failures in worst-case scenarios. Striking the right balance between an adequate amount of redundancy and avoiding an excessive, cumbersome load was crucial, so we consistently pursued streamlined solutions. Following this, all equipment underwent assembly and meticulous checks, a collaborative effort between myself and my dive buddy, ensuring every component functioned precisely as required.

The arrangement of equipment represented a human factors challenge. It necessitated the ability to access and utilize every piece of gear, even in conditions of zero visibility, emphasizing the need for a meticulously planned layout that allowed for immediate access at all times.

I have since retired from the world of cave diving. As I mentioned earlier, cave diving represented the ultimate in risk management for me. Prior to each dive, I was acutely aware there was no search and rescue safety net available. As my life's priorities evolved, so did my tolerance for risk. When I was single, I found the level of risk acceptable. However, as I started a family, my risk tolerance underwent a transformation. This serves as a compelling illustration of how a deep understanding of the risks we encounter, coupled with established risk tolerance criteria, empowers us to make informed decisions, both in our professional endeavors and personal lives. ●

TRISH KERIN, Safety Columnist

Radar Reveals Insights into Fluidized Beds

High-frequency radar technique displays real-time changes of solids concentrations

A HIGH-FREQUENCY radar technique developed by researchers in Sweden measures what is happening inside fluidized beds with what they describe as "unrivaled" precision.

Their high-frequency pulse-Doppler radar technique operates at up to 340 GHz, giving high spatial and temporal resolutions, allowing the determination of even minimal changes to both solids velocity and concentration in real time with good penetration.

Based at Chalmers University of Technology in Gothenburg, the researchers demonstrated their technology on a 3.1-m-high circulating fluidized bed boiler, with $0.45 m^2$ cross-sectional area, using glass beads with a mean particle size of 106 µm, and particle density of $2,486 kg/m^3$. Air at ambient temperature was used as the fluidization agent.

According to Marlene Bonmann, a researcher in Chalmers' terahertz and millimeter wave laboratory, the plan now is to expand the range of solids concentrations that can be characterized while keeping or even increasing the current radar penetration distance.

She notes that either increasing the output power of the radar or working at lower frequencies can increase penetration but at the cost of reduced signal backscattering, which makes it harder to detect low solids concentration.

"The intended application will decide which frequency band is best to use. We are currently working on the development of a lower-frequency radar. Up to which levels of solids concentration the assumption of signal scattering will work will be tested experimentally. Deeper understanding of these possible effects will probably require some simulation work," Bonmann explained.

The researchers are also experimenting with the angle of incidence of the radar beam where it penetrates the process chamber to minimize the influence of static reflections.

"The radar beam can be narrowed by using a larger antenna/mirror. This will allow even more local measurements. We envision such improvement further ahead in time linked to the study of larger fluidized bed units," added Bonmann.

Meanwhile, the data gathered with the radar technique is already being used to study backmixing of solids in circulating beds.

"The richness of the data allows for quite a detailed characterization of the solids movement.

The Chalmers fluidized bed set up. The screen shows a real-time color map indicating the power intensity received, proportional to the solids concentration, and the velocity of the particles. *Source: Chalmers University of Technology.*

We work currently with the analysis of data and the design of experiments that target specific phenomena and specific sections of the fluidized bed reactors. Additionally, industry is showing some interest to use the radar for the measurement of solids fluxes and monitoring the agglomeration processes in full-scale combustion plants," Bonmann concluded.

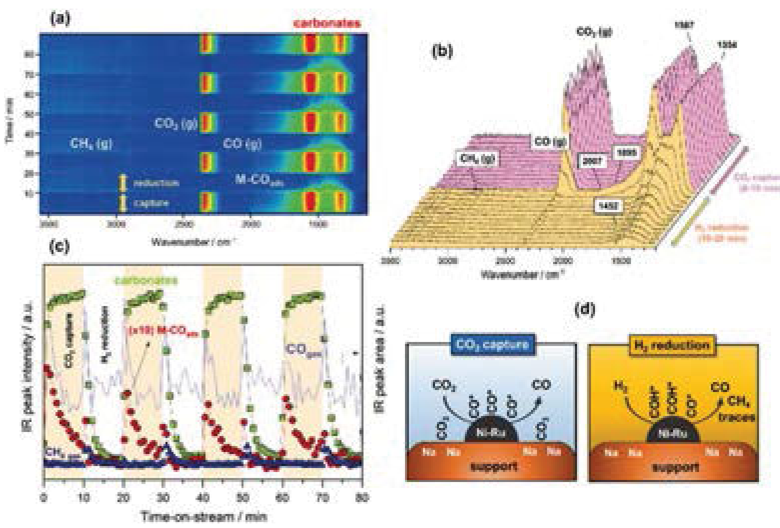
Novel Material Converts CO_2 Into Green Fuels

Process uses switchable dual-function nanoparticles to perform reactions

A NEW switchable dual-function material (DFM) developed by researchers at the U.K. University of Surrey captures and converts CO_2 into green fuels or useful industrial chemicals.

The DFM, NiRuNa/CeAl, consists of nanoparticles of a bimetallic alloy in combination with a dispersed Na-based adsorbent.

Using a technique called operando-DRIFTS-MS, the researchers observed the capture of CO_2 at the DFM surface and its conversion via three different reactions: CO_2 methanation; reverse water-gas shift; and dry reforming of methane.



This illustrative sketch shows the capture/reduction process on NiRuNa/CeAl. *Source: University of Surrey.*

"We now have a clearer understanding of how switchable DFMs are able to perform a multitude of reactions directly from captured CO_2, which will help us improve the performance of these materials even more via rational design," says Melis Duyar, chemical and process engineering professor and study lead.

One challenge is to overcome the coking observed at the Na-Ni/Ru interface during methane cracking.

"On the process side, we have seen that methane cracking occurs readily after all the adsorbed CO_2 has been consumed via the DFM reaction. Therefore, introducing an exact pulse of methane that is no more than is needed to convert all the CO_2 can offer a solution," she explains.

Another challenge is to optimize the design of the crucial interface between CO_2 adsorbent and catalyst.

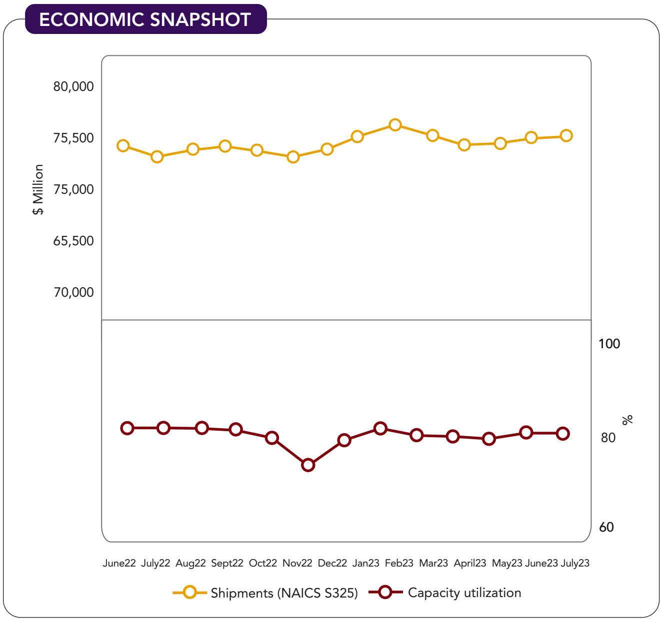
"Designing materials with uniform interfacial sites to maximize adsorbent-catalyst interaction is a key scientific challenge for minimizing side reactions as well as preventing the desorption of unreacted CO_2," she adds.

Next, the team hopes to develop computational tools both to speed up DFM discovery and to optimize the process involved. Advanced synthesis techniques will be investigated to increase CO_2 capture capacity and conversion, lower the temperature of operation, and minimize side reactions such as methane cracking.

"What is really powerful about this kind of study is that it provides valuable insight for designing the next generation of DFMs, meaning we can rationalize our material design decisions using fundamental understanding of the surface phenomena," Duyar says.

The researchers are currently collaborating with industrial partners on an upcoming project aiming to validate this technology using real CO_2 emissions.

"We believe this kind of collaboration can help us bring our technology to the field, accelerating the technology transfer to where it is needed. We have also filed a patent application that can allow companies to license our technology and use it to meet their carbon capture and chemicals production needs," Duyar concludes.



Shipments and capacity utilization both rose. Source: American Chemistry Council.

Benchmark Energy Efficiency

The R-curve method helps determine an energy transfer device's optimal operating point

A detailed process simulation can determine the R-curve.

EARLIER THIS year, I discussed a simple methodology to evaluate the efficiency and cost of your imported power. Here, I will demonstrate the R-curve analysis used to evaluate, benchmark and design heat and power systems and identify potential improvements.

The R-curve, in the context of chemical engineering and process optimization, refers to a concept used to determine the maximum shaft work — or energy transfer— required. It is used to analyze system performance involving multiple interconnected components, such as pumps, compressors, boilers, gas turbines, steam turbines and other equipment. This is then compared to the need for a hot utility, such as steam, to heat process streams.

A chemical plant will need shaft power provided by electricity (electrical motors) or steam turbines and gas turbines. The same steam is also used for reboilers, strippers, heating process streams and more. Based on the ratio between the two needs for steam, shaft power and heating, you can calculate the highest efficiency for heat and power possible for your plant. For this calculation, you can develop the R-curve.

The R-curve is a graphical representation of the relationship between the rate of energy transfer, or shaft work, and the heat required for a process stream. It helps engineers and operators identify the optimal operating point where the system can achieve the highest energy transfer efficiency. It also is used for designing a utility system and to identify the most efficient operation. Typically, the R-curve is determined by detailed process simulation of the utility system. In this simulation, all boilers, steam headers, gas turbines, steam turbines and other equipment like pumps and deaerators are considered.

Here's how the R-curve works: The energy transfer rate (shaft work) is the mechanical work done by a device like a pump, compressor or turbine. Usually, it is measured in units such as kilowatts (kW) or horsepower (hp). The energy needs from steam, often used for reboilers, stream heaters, stripping steam, vacuum ejectors and steam tracing, is typically measured in MMBTU/h or GCal/h. The ratio of these two energies used is shaft power divided by steam energy use (converting the numbers to identical units); it's generally plotted on the horizontal axis of the R-curve. The vertical axis displays the cycle efficiency of shaft work generation (Figure 1). The R-curve can reveal the following:

1. If the ratio of shaft work and (steam) heat is very small, the plant needs very little shaft work compared to steam uses. This means all power can be produced by efficient back-pressure steam turbines, and the cycle efficiency is over 80%.
2. If the ratio of shaft work is higher than the required heat, the plant needs a lot of shaft work. This can be delivered by imported power (green dotted line) and or condensing turbines (blue line), and the maximum plant efficiency is lower than 80%, according to the R-curve.
3. In Figure 1, the red cross shows the actual cycle efficiency for an oil refinery of 69%, while the R-curve shows a maximum obtainable efficiency of 88%.
4. In addition, the dotted green line and pink line show the maximum obtainable efficiency using a gas turbine power generator, one with gas co-firing on the steam generator to produce more steam and one case with no gas co-firing. The co-firing option is, in this case, more efficient in the power-to-heat ratio ranging from 0.3 to 1.1.

When designing a utility system, engineers can use the R-curve to adjust the components' sizes, capacities and operating conditions to achieve the desired optimal operating point. Carefully selecting the steam pressures, temperatures and equipment that efficiently generate steam from waste heat can produce maximum shaft work while considering factors like energy efficiency and reliability.

MICHIEL SPOOR, Energy Columnist

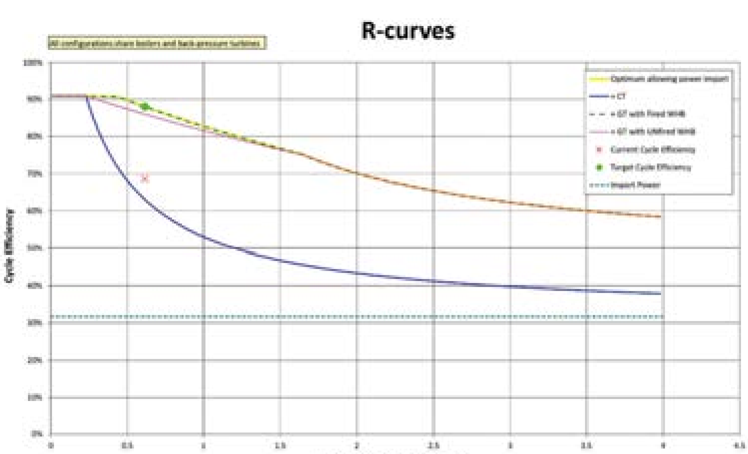


Figure 1. The R-curve helps engineers and operators identify the optimal operating point where the system can achieve the highest energy transfer efficiency.

NSTC Releases Sustainable Chemistry Report

National Science and Technology Council outlines strategy to advance sustainable chemicals

The report lays out a bold and ambitious vision.

SUSTAINABLE CHEMISTRY has become more central to business success than ever. Societal preferences and climate change implications are pressuring product manufacturers to develop, use and process sustainable chemicals. This trend is here to stay, and cultural, legal and regulatory drivers accelerating this trend are growing exponentially.

On Aug. 3, the Joint Subcommittee on Environment, Innovation, and Public Health Sustainable Chemistry Strategy Team (ST) of the National Science and Technology Council (NSTC) published its "Sustainable Chemistry Report: Framing the Federal Landscape." This report is an essential read.

The 2021 National Defense Authorization Act (NDAA) included the establishment of an interagency group led by the White House Office of Science and Technology Policy (OSTP) to coordinate federal programs and activities in support of sustainable chemistry, which led to this report.

The report provides a high-level overview of relevant topical areas around sustainable chemistry and identifies gaps and opportunities. Following the report, the ST will develop a strategic plan for how the federal government can leverage these opportunities to make significant progress in addressing the identified data gaps.

The report describes the state of federal sustainable chemistry activities and the scientific challenges and hurdles to improving the sustainability of chemistry. It also defines sustainable chemistry as "the chemistry that produces compounds or materials from building blocks, reagents and catalysts that are readily available and renewable, operates at optimal efficiency, and employs renewable energy sources; this includes the intentional design, manufacture, use, and end-of-life management of chemicals, materials and products across their lifecycle that do not adversely impact human health and the environment while promoting circularity, meeting societal needs, contributing to economic resilience and aspiring to perpetually use elements, compounds and materials without depletion of resources or accumulation of waste."

To progress sustainable chemistry research and development, the report emphasizes a need for coordination between the federal government and state and local entities, as well as outreach activities that engage or inform the public. It also suggests collaboration with international partners, stressing it's critical for economic and national security. According to the report, the strategic areas identified provide a roadmap for sustainable chemistry activities that, when addressed, will generate actionable information to guide federal agencies and sustainable chemistry collaborators and partners.

The capabilities and approaches developed in response to the report should lead to a holistic treatment of sustainable chemistry. The ST will collaborate with stakeholders, collaborators and numerous partners to generate information that will guide sustainable chemistry standards and metrics, decarbonization, circularity and methods for assessing sustainable chemistry. It will also fuel other innovative public health actions and help the United States realize its vision of clean drinking water and air and safe food for all.

Stakeholders cheering the concept of sustainable chemistry will applaud OSTP's preparation and release of this strategic plan. It lays out a bold and ambitious vision for advancing sustainable chemistry. Implementing this plan will require a sustained effort across the federal government over a long period, but the goal is an important and essential one that justifies the effort.

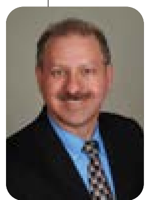
The report calls out the Toxic Substances Control Act (TSCA) as a key regulatory authority that overlaps with sustainable chemistry. The report focuses narrowly on the EPA's effort to regulate existing chemicals as a potential driver but neglects to discuss concerns regarding its TSCA Section 5 new chemicals review program that greatly inhibits commercial adoption of sustainable chemicals. Denying sustainable new chemicals means manufacturers and processors would be forced to rely on less sustainable, existing chemicals unlikely to be reviewed under TSCA Section 6 for decades.

As the strategy is implemented, the EPA must consider sustainability characteristics in its new chemicals review. Stakeholders in the sustainable chemical area and others aligned with enhancing the TSCA new chemicals review process are urged to read the report and engage in developing the strategy. ●

LYNN L. BERGESON, Regulatory Columnist

Lynn is a lawyer specializing in chemical industry regulations.
The views expressed herein are solely her own. This column is not intended to provide, nor should be construed as, legal advice.

Race-Ready Project Development Provides Edge



CHRIS NEFF
senior vice president of project development, aeSolutions

"I think one of the biggest challenges is the belief that process safety is a cost rather than an integral part of the operation."

IN THE evolving world of chemical processing, companies face a formidable challenge as they strive to keep pace with ever-evolving industry demands, develop novel formulations and deliver innovative products to market. Meeting customer needs often requires adjustments to production processes, including new plants, facility expansions and equipment upgrades. The successful execution of such projects hinges upon comprehensive planning, particularly when it comes to evaluating process safety risks.

Complex assessments, such as studies of overpressure relief devices, facility sitings and process safety procedure development, are crucial elements in this process. However, plant operators are primarily experts in running chemical plant operations, not project planning. To shed light on this critical aspect, *Chemical Processing* spoke with Chris Neff, senior vice president of project development for aeSolutions. In this discussion, Neff delves into the intricacies of the project-planning process and outlines methods for chemical manufacturers to integrate safety seamlessly into their projects.

Q. Can you tell us a little bit about why some process operations struggle when embarking on new projects?

A. An owner's primary responsibility is the operation of the plant. They need to ensure production and throughput to meet their current demands. They also need to adjust to changing market demands for the various products that they're producing. They have spent their careers making sure the plant runs and produces the products that are in demand and meet quality and quantity requirements. But what happens when they're asked to create a new unit or expand or upgrade their existing facilities? They're now being asked to enter the realm of project development and project management. These are disciplines that require skill, experience and practice to be effective. It's a bit like asking a race car driver and a pit crew to design and build a better car while the race is underway, to say the least. That's a real challenge.

Q. What happens when a chemical operation doesn't have adequate project-development capabilities?

A. Well, the interesting thing about it is that the operating companies often have qualified personnel to operate and maintain the facilities, and they're also qualified to assess the effectiveness of their plan to ensure the throughput and flexibility of their equipment to meet the production needs. They are invaluable to the process of developing the project as they have the hands-on experience to know what needs to be improved in the operation.

But they often struggle as project developers or managers in addition to their day job because, like any other discipline, project work requires practice and focus, both of which are sacrificed when it's treated like a part-time job. Some of the top reasons for project failure have been identified as little to no planning, lack of clarity, poor communication, scope creep, lack of risk management and over-allocated resources. All of these are addressed by effective project development. Project development is a higher-order process whose purpose is to ensure the goals of the project are well-defined, and all the necessary resources are in place to achieve those goals.

Q. Can you talk a little bit about some of the key steps to a project development plan?

A. Project development tends to fall into four broad categories. The first is discovery. To me, it's the most important, but each one is important. Discovery is often accomplished with studies that may look at feasibility, value vs. cost or a specific aspect of a project, such as risk and safety.

The key to project-development discovery is to ensure that the entire scope is identified regardless of what entity may accomplish that specific scope. In this stage, it is all about what needs to be done to refine and accomplish the owner's objectives. Next, you move to allocation. This is where you start looking at who is going to do what or what entity is going to do what. It's still early in the process. There are many deliverables that come out of an allocation, but the critical ones look at the division of responsibilities. And the third key is risk-management planning to ensure that what might happen is anticipated by the project team and plans are in place to respond to these threats or opportunities of things that might occur.

The process delivers the plan to succeed in delivering the owner's objectives. Now, you're ready for a kickoff, and that's when you really transition to a project-execution phase. The primary deliverable of project developers in this phase is the codification of the execution plan into the execution of the project, ensuring that all the discovery and allocation definitions are well understood and accepted by the stakeholders. This kickoff is often accomplished over a period of time as it transitions from the project developers to the project managers. Like any transition, it requires feedback between the parties to ensure that nothing is missed or misunderstood, and there will be adjustments that need to be made during that period.

And then, during the process of execution, the project developers perform quality-assurance activities. They primarily look to capture preventative techniques and proactive measures to improve the development process, so the next similar project will be an improvement over the last project. Development is a discipline, like any discipline, that requires both practice and learning. The quality-assurance step is critical to determine what worked or what could have been done better.

Q. Safety is important, obviously, in a processing environment. How can chemical manufacturers address safety within a project development plan?

A. I think one of the biggest challenges is the belief that process safety is a cost rather than an integral part of the operation. Oftentimes, the safety group is seen as a roadblock to the project. Some of this is due to this lack of identification early on with the studies necessary to develop the project. When you narrowly define the objectives of the project and don't have solid discovery, you lose the opportunity to avoid process safety risk and instead are constantly reacting to and trying to mitigate them. It's a bit like building the race car and then trying to protect the driver only after the car has been built. At that point, everything you do is likely to restrict the car from performing the way the car designer was expecting.

Conversely, if the risks are studied before the car is built, they may be reduced in ways that do not have a significant effect on performance and do not degrade that performance. I won't say they'll enhance the performance, but if you think about it, if the driver is less focused and less concerned about his safety because of the inherent safeguards in the car, he's going to be more focused on the race. And that's the way we need to look at it from a chemical-processing standpoint, as well. The ultimate goal is to produce the products people consume. And by getting safety involved early and driving toward an inherently safe plant, that gives chemical processing operations a much better opportunity to do that.

Q. Can you talk a little bit about the process aeSolutions has developed to help organizations with the project-management process?

A. Our project-development engineers work through discovery allocation kickoff and quality assurance as a partner to our clients and to our project teams and theirs. This works well because it ensures practice and learning for all the stakeholders. It drives a positive start with a focus on planning a clear and well-communicated scope, a solid risk-management plan, and division of responsibilities designed to properly allocate resources to all the scope requirements. On that last point: We believe in the best athlete for the event, or in this case, approach. If the team already has the strongest players for a given task, then we're definitely going to use their skills. But we'll use third parties and team with the owner, and at times with the owner service providers, to build a solid team, which is what drives project success.

Going back to the car analogy, it's like designing and building a car following a well-organized process for the project team to deliver a vehicle that keeps the operator safe while driving peak performance in the race environment. This, in turn, positions our clients to win the race and be ready for the next one, even if the race conditions have changed dramatically. It just requires another plan and another well-executed project to win that race.

PODCAST ACCESS:
Listen to the entire conversation via podcast at https://chemicalprocessing.com/33009373

For more information, visit: www.aesolutions.com

SALARIES GET STRONGER

ANNUAL SURVEY REVEALS CONTINUED POSITIVE JOB OUTLOOK AND EARNINGS

BY AMANDA JOSHI, MANAGING EDITOR

CHEMICAL PROCESSING first started conducting its Job Satisfaction and Salary Survey in 2005. In the nearly 20 years since, results have shown chemical industry positions can sometimes be a roller coaster ride, with ups and downs and twists and turns. COVID-19 in 2021 provided one such twist with some dips due to hiring freezes, but nothing as drastic a drop as the Great Recession. Fortunately, in 2022, we saw a rebound, with chemical engineering professionals having a banner year, and 2023 is no different. With that said, there are a lot of positives to report from this year's results, and we'll start with the financials.

First, the average salary and average raise both rose to their highest levels since we began conducting this survey. Chemical engineering professionals reported an average salary of more than $135,000 — up from $121,500 a year ago (Figure 1). This sits comfortably between other industry salary surveys, with the U.S. Bureau of Labor Statistics reporting a median salary in 2021 (no data yet for 2023) of $105,000 for chemical engineers. On the other side of that conservative number, the American Institute of Chemical Engineers (AIChE) recently revealed their members receive an average salary of $150,000.

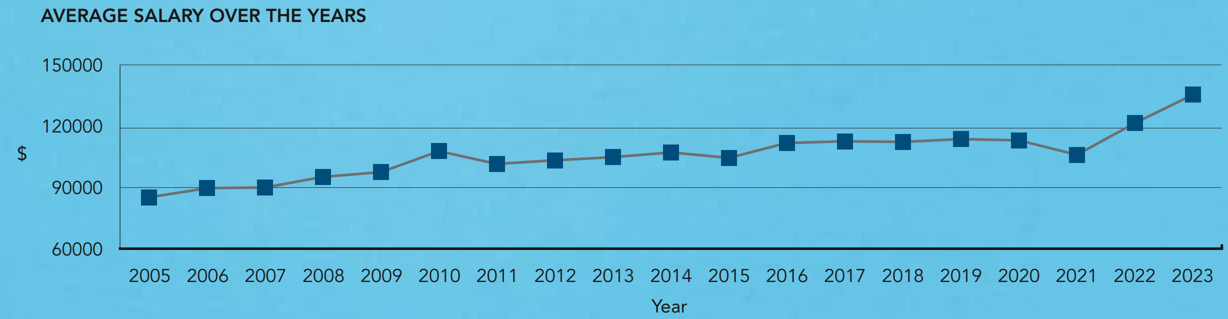


Figure 1. After falling in 2021, the average salary continues to rise to its highest level.

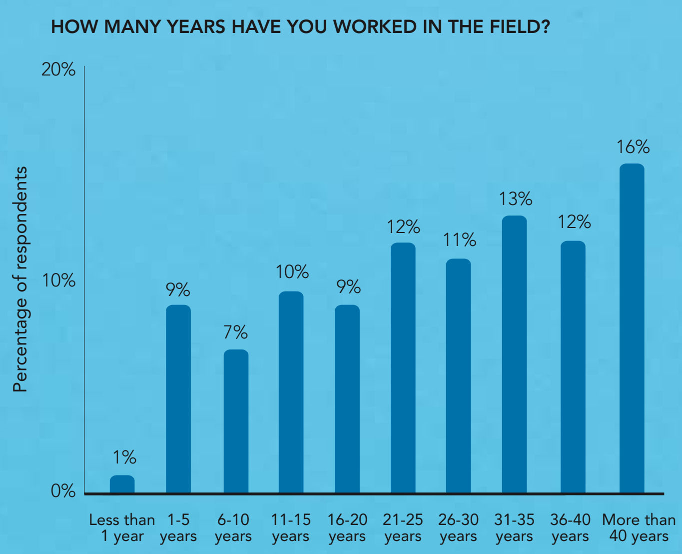


Figure 2. More than 40% say they have been in the industrial field for 31+ years.

Figure 3. Companies dolling out raises continue to climb, with the majority of respondents having received a pay increase.

One noticeable trend that sheds light on the higher salary report is the age and experience of our respondents: When added up, more than 40% of our workers say they have been in the industrial field for 31-plus years (Figure 2). In 2022, just 28% were well-seasoned professionals. In addition, of the 40%, 16% say they have been working for more than 40 years, double the 8% in that category last year.

(By the way, for some context, from year to year, we typically see no more than a 2%–3% variation in any particular response to our salary survey questions, so any increase above that certainly deserves mentioning.)

Both salary and raise increases could also be linked to 69% (63% in 2022) reporting a salary bump within the last year (Figure 3), with experienced experts likely receiving even higher salaries. In addition, our respondents, on average, received almost a 5% increase in their salaries, up from 4.16% in 2022.

More than 50% received a pay increase between 2.5% and 5%, similar to 2022, but those reporting salary adjustments between 5.1% and 7.5% jumped 5% from last year, and the 7.6%–10% range nearly doubled from the year prior to almost 10%. Those reporting smaller pay increases of less than 2.5% dropped nearly 12% from last year.

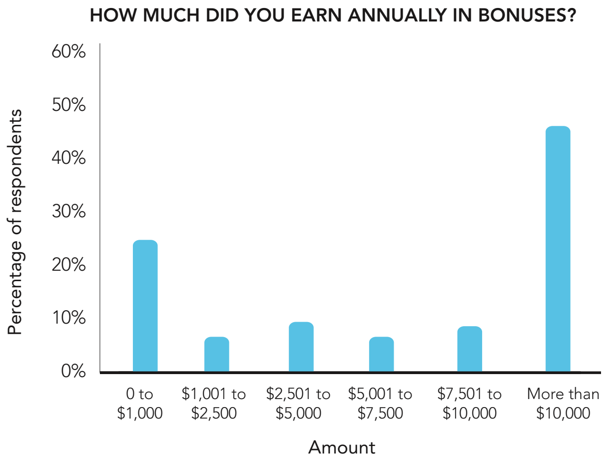


Figure 4. Nearly half of our respondents reported bonuses of more than $10,000 this year.

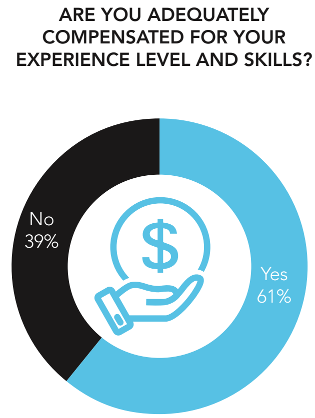


Figure 5. More than half of respondents feel their experience matches their compensation.

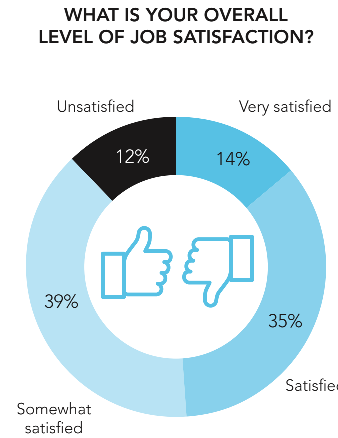


Figure 6. Most respondents are at least somewhat satisfied, if not more, with their jobs.

BENEFITS OF A BONUS

In addition to the generous salary increases, engineers also earned hefty bonuses. The average bonus was $8,415; in 2022, the average bonus was $7,480 and $6,015 in 2021. In fact, nearly half of respondents (46%) reported receiving bonuses of more than $10,000, up from just 37% last year (Figure 4). A sampling of write-in responses confirms the survey findings that bonuses are rising.

"I receive a good base pay with a potential bonus opportunity of 15% of base, with a multiplier applied. For the past several years, the multiplier has been greater than 1," shared one respondent.

"The compensation grows via bonus and has grown year-over-year," reported another survey participant.

"I am happy with the compensation and benefits I receive. I am on a bonus structure that is based on company performance, and I have a direct impact on how the business performs. It has certainly incentivized me to give my best because it will ultimately pay off for me if the company is successful at exceeding targets," explained another.

In fact, respondents share that their bonus structure is tied to either the financial performance of business units (38%) or based on meeting/exceeding performance expectations (37%).

"I am satisfied with my compensation. My annual bonus (max 20% of salary) is tied to company performance (20–50%) and also to personal performance (20–50%)," noted one contributor.

"The bonus has a strengthening and motivation aspect as it is usually given at Christmas and so it enhances the team loyalty," suggested one commenter. "The compensation is fair and comparative to industry."

Most respondents (61%) agree that they receive fair compensation based on their experience level and skills (Figure 5). But this percentage has decreased from the 70% who reported feeling adequately compensated in last year's survey. Some comments indicate this could be attributed to several factors, including rising health care costs and inflation.

"I believe I am compensated well, and my company's benefits are great, but the increase in pay has not kept up with inflation, and benefits for those who work on site every day are not comparable to those who can work from home," shared one respondent.

"I believe I am fairly compensated for the work that I perform, I believe [there is] room for improvement, but I am not dissatisfied with my current compensation. I am dissatisfied with the fact that inflation is outstripping my annual salary increase, but I do not blame that on my employer," said one participant.

"I am well compensated for my peer group and field. Current inflation is outpacing increases inverse the last few years," cautioned another.

WORKLOAD WOES?

Overall job satisfaction sits at 88% (Figure 6), which fell slightly from 2022's 91%. Write-in responses indicate increasing workloads may have contributed to the slight decline.

"[I'm] compensated well, but for the workload, duties and responsibilities, it is not where it should be," said one participant.

A recurring trend in previous surveys, heavy workloads continue to be a significant drawback, with 47% of respondents identifying it as one of their top three grievances about working in the field (Figure 7).

"Compensation would be adequate if I had reasonable work hours," lamented one contributor.

"For the workload and job scope based on company need and the company's organizational maturity, [my compensation and benefits] are below par," shared another.

"If you want to get to the top, put in the hours and continuously learn, advised one contributor."

"Consider non-manufacturing work to avoid long hours and being on call 24/7," cautioned another.

Despite the long hours, the largest detractor remains the lack of recognition with 54% placing it in their top three dislikes.

"[The job is] challenging work without recognition. If you need external recognition, this isn't the job for you," advised one participant.

JOB SATISFACTION OVER THE YEARS

Chemical Processing has been conducting its annual salary and job satisfaction survey for nearly 20 years. For a look back at past surveys, visit any one of links below.

2022 — https://bit.ly/3P4Oa7A
2021 — https://bit.ly/3sHDv6B
2020 — https://bit.ly/39iASOq
2019 — https://bit.ly/3f8HTD3
2018 — http://bit.ly/2O3n6Xs
2017 — http://bit.ly/2mnxZEo
2016 — http://goo.gl/NOaC4R
2015 — http://goo.gl/YtU0xd
2014 — http://goo.gl/IroA1C
2013 — http://goo.gl/NckQ5c
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2011 — https://bit.ly/3DgbgB3
2010 — https://bit.ly/3DgooWJ
2009 — https://bit.ly/3fcEedd
2008 — https://bit.ly/3TL40Er
2007 — https://bit.ly/3fjORuH
2006 — https://bit.ly/3zlABbF
2005 — https://bit.ly/3UbeCMB

The work environment rounded out the list of top three occupational dislikes.

Still, 75% of participants also say the challenge and stimulation of their work ranks among the top three things they like best about their job (Figure 8). In fact, it's the most significant contributing factor to overall job satisfaction or

WHAT ARE THE TOP 3 THINGS YOU DISLIKE ABOUT YOUR JOB?

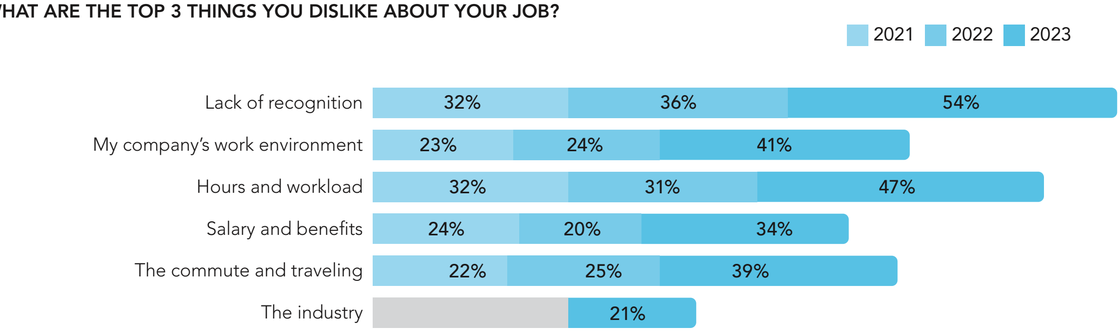

Figure 7. Lack of recognition and the hours and workload continue to be top detriments.

WHAT ARE THE TOP 3 THINGS YOU LIKE ABOUT YOUR JOB?

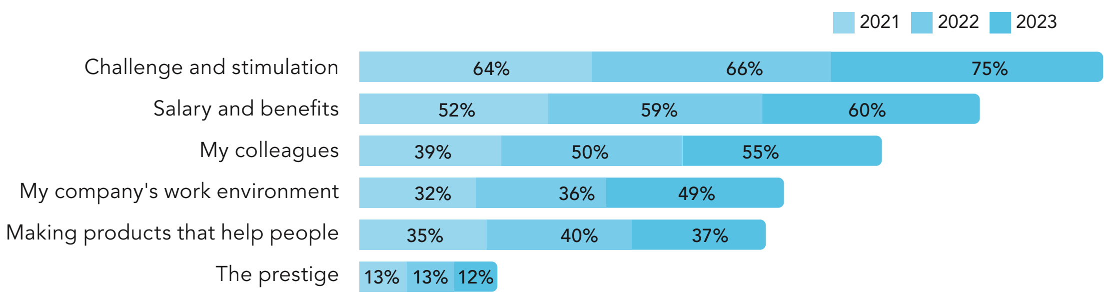

Figure 8. Challenge and stimulation rank highest in job satisfaction, followed by salary and benefits.

dissatisfaction, followed by salary and benefits (Figure 9). Echoing this sentiment, 60% listed the salary and benefits as one of their top three likes, and working with colleagues took the third spot.

We also asked participants what keeps them motivated in their career, and many said it's their coworkers. Other motivating drivers? The list is extensive, ranging from family to learning new skills, mentoring young engineers and even retirement.

"I retire in less than three months, so I'm up to my ears in transition activities. I am motivated to pass on as much of my (admittedly old-fashioned) process and operations and cybersecurity knowledge, but the pace of change is rapid," commented one survey participant.

THANK YOU A special thank you to all those who participated in our survey for 2023. We appreciate you taking the time to provide us with quality data and comments that shed light on industry workforce conditions. We could not have put this together without your valuable insight.

HIRING NOW

Retirement is a goal for many survey participants, and with that, job opportunities could lie ahead for many others.

Martha Moore, chief economist and managing director of economics and statistics at the American Chemistry Council, recently noted in her 2023 Mid-Year Situation & Outlook webinar hosted by *Chemical Processing* (https://bit.ly/3E88aA0) that chemical industry employment has been on the rise after dropping for several years. Last year, employment hit its most recent peak: "550,000 people were employed by chemical manufacturers, earning on average well over $97,000 last year. These are well-paying jobs that help support local communities," she shared.

Our survey participants echo this trend, with 27% reporting staffing levels are significantly higher than a year ago, a 3% rise from 2022 (Figure 10). In addition, nearly 50% report staffing levels have held steady over the last 12 months. In 2022, just 40% said staff levels stayed the same.

"We do expect to see some weakness in chemical industry employment," cautioned Moore. "This year, we're expecting payrolls to erode by about 3,000 as the industry shifts down a bit, but going forward, growth in chemical industry employment will resume in the latter part of the year.

WHAT SINGLE FACTOR CONTRIBUTES MOST TO YOUR OVERALL JOB SATISFACTION?

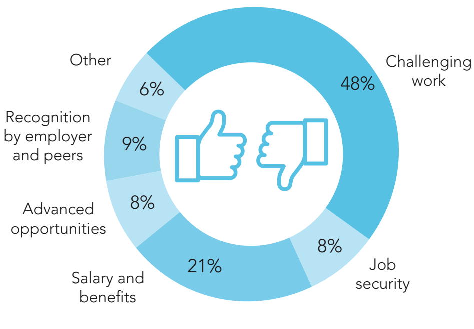

Figure 9. A consistent response over the years, providing challenging work is key to happy workers.

WHAT IS THE PROFESSIONAL STAFFING LEVEL AT YOUR SITE NOW VERSUS 12 MONTHS AGO?

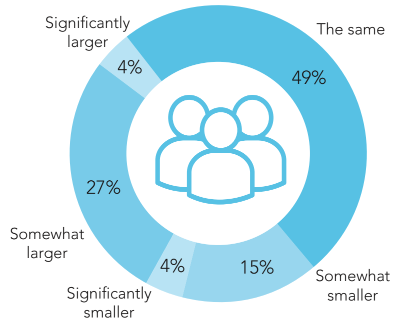

Figure 10. Staff levels continue to reflect a hiring trend with those reporting somewhat larger staffs rising 3% from last year.

ARE YOU CONCERNED ABOUT JOB SECURITY?

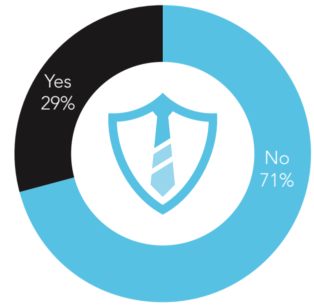

Figure 11. More than 70% of respondents aren't concerned about potential job loss.

WHAT ARE THE CHANCES THAT YOU WILL BE LAID OFF OR FIRED WITHIN THE NEXT TWO YEARS?

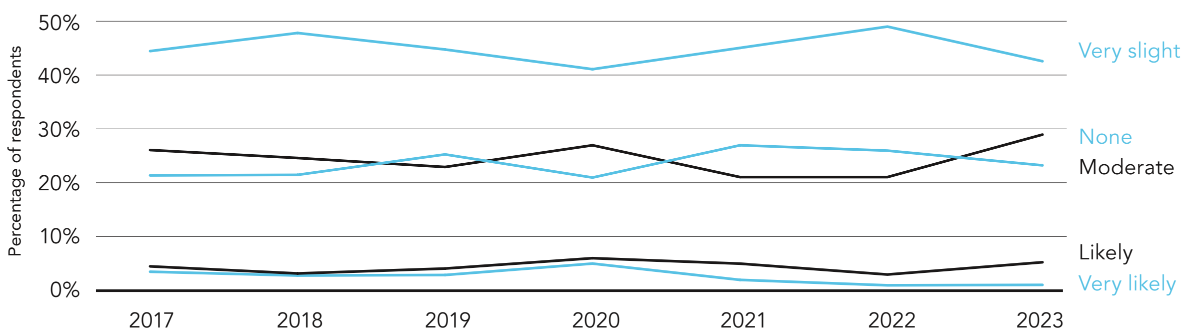

Figure 12. When combined, more than 70% of respondents say the likelihood of losing their job is either none, or very slight.

Average age of respondents is 52

In fact, 70% of our respondents say they aren't worried about job security (Figure 11), an 8% jump from 2022 and an all-time low for our survey. In addition, 72% say they believe the chances they'll be laid off or fired within the next two years is slim (43% said the chance is "very slight" while 29% said "none") and less than a one-quarter say chances are "moderate."

Furthermore, more than 50% said they intend to stay with their current employer for five years or less, and of that number, 11% say they'll switch jobs (or perhaps retire) in less than a year, up from 7% in 2022.

Both job security and the potential move to a new employer could be attributed to the strong demand for chemical engineers and the shortage of skilled workers.

"We're seeing some labor hoarding across the economy," said Moore. "That's one of the interesting features of this cycle. It's so hard to find qualified people, and it takes a lot to lay people off at this point."

In fact, many of our participants, when asked what keeps them up at night, mentioned finding and hiring quality engineers to replace retirees.

"[It's a] great time to get into engineering; our workforce is graying, with not enough young people willing to work the hours required. The exciting challenges are well worth the efforts, including promotions and better opportunities," noted a contributor.

Enhancing Safety with High-Fidelity Simulation

Minimizing risk through predictive insights and real-world training

BY WILLIAM HUGHES, P.E.

ANYONE WHO has worked with large chemical processes for a few years knows that it's impossible to predict every potential danger, as the universe is very creative when it comes to causing disruptions. Personnel who design large chemical processes or processes involving high amounts of energy have used equations, lab experiments, pilot plants and thought experiments to predict scenarios that may arise during operation. They understand the frustration of processes not working as intended or, worse, failing in an unexpected way.

For many years, engineers relied on this invaluable mechanical design insight and experience, as well as information gathered from end users, to help keep large chemical manufacturing processes safe. Over time, a framework known as the Hierarchy of Controls took shape to provide personnel with guidelines to configure processes and maximize safety. These guidelines have helped manufacturers produce solutions for process safety concerns, such as eliminating dangers, substituting less dangerous options, managing dangers with engineering, implementing safety procedures or providing operators with safety equipment.

Using the Hierarchy of Controls framework (Figure 1) with today's high-fidelity process simulation tools, chemical producers now have even greater insight into their operations. The general value of simulation is its ability to verify the proper order of operations in a control scheme. For example, a simple "tie-back" type simulation, in which the outputs of the control logic are fed to the inputs, can validate that a flow path will be opened before a pump is started (i.e., to confirm that there will be no water hammer). A simple accumulator function can simulate a rising tank level based on the flow rate through a control valve or variable speed pump. These basic approaches can help an operations team avoid hours of troubleshooting during a project start-up and bring the process online faster.

For process safety applications, however, simple approaches cannot provide the level of certainty that large, fast or high-energy chemical processes require when it comes to preventing, detecting and managing dangerous situations. In this instance, a more detailed simulation will reveal unanticipated process behaviors that can drive the control system, the process or both into unstable or uncontrollable regimes. By expanding the simulation to include upstream and downstream processes, it becomes possible to predict unexpected influences that would normally only manifest after commissioning is complete. For a real-world example of a commissioning project, see the sidebar on page 26, "Shorten Safety Commissioning Time with Simulation."

APPLYING HIGH-FIDELITY SIMULATION

The following applications illustrate how chemical producers can benefit from high-fidelity simulation to mitigate risk in their processes:

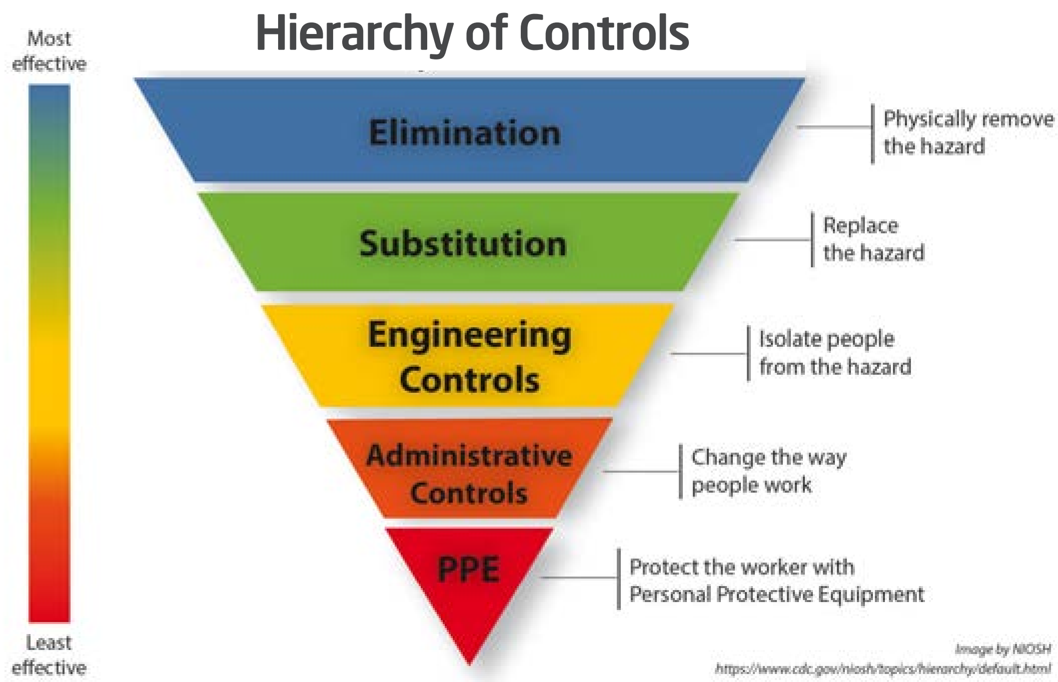

Figure 1. This framework provides personnel with guidelines to configure processes and maximize safety.

Insight into safety protection layers – When combined with other layers of protection, safety instrumented functions (SIF) can protect chemical processes from intolerable hazards and drive process behavior, which may not be obvious from an analysis of the process or control design alone. For example, a shut-off valve for a reactant flow closes at the same instant a pump receives a command to stop from the controller running the SIF. In such cases, the inertia of the motor could lead to a pressurized line. Analyzing SIFs often involves weighing the pros and cons of undesirable situations.

Practical operations personnel would not tolerate having to run through multiple different unsafe scenarios to find the best approach on real-world production equipment. A simulation offers the ability to run scenarios and the various types of corresponding responses, so personnel can determine the best solution during unfavorable situations.

Take the simulation outside the controller – Higher levels of simulation fidelity require calculations and objects that are beyond those typically available in a programmable logic controller (PLC) or distributed control system (DCS). Many products and services exist to provide more detailed simulations of a process, which can interface with a simulated software controller or a physical controller via Open Platform Communications (OPC). Process modeling software can use OPC to read outputs from and write inputs to the PLC or DCS, and the control logic will never know the difference.

Generally speaking, process-modeling software uses equations from physics to calculate relationships among pressure, temperature, flow and other process variables. Some software exists that supports the simulation of chemical reactions as well, offering the ability to determine reaction rates, heat generation or consumption, phase changes and other properties of interest. Most process-control schemes won't need that sort of detail, but simulation can reveal important information about a process when it is needed and used properly.

Effective production operations – Let's look at a real-world example to understand how simulations can be effective to production operations. Toby McAlister, a senior engineer with Maverick Technologies, a Rockwell Automation company, has experience building his own in-controller simulations, as well as using a third-party, external simulation environment. According to McAlister, the projects where he used a third-party simulation development platform saw enormous time savings as it already had purpose-built tools and objects in it compared to a custom-built, in-controller simulation where he had to

SHORTEN SAFETY COMMISSIONING TIME WITH SIMULATION

A major chemical production facility migrated from a late 20th century distributed control system (DCS) to a modern off-the-shelf DCS. Like most facilities, this chemical plant had very robust but outdated safety systems implemented in the old control system. As a part of the migration to the new DCS, the development team used a high-fidelity process simulation to test the process control. This involved running through the batch process to verify that the migrated system behaved the same as or better than the old system as reflected in MES data.

The testing also involved running through every recipe and – critically – allowed the testing of every safety instrumented function (SIF) multiple times to validate that each one would trigger in response to the criteria established in the safety system design. Most of this was accomplished by a handful of engineers who were able to test the product recipe or safety function, reset the simulation and test the next one. Operations were never interrupted in the real plant during this testing. The operations personnel observed final demonstrations of the new control system running with the simulation during validation testing.

When start-up time came, operations and engineering knew the control system would perform correctly if the instrumentation worked correctly. This allowed the start-up team to focus on validating the instrumentation and its failure modes. Once everything appeared to be working on the instrumentation side, a single demonstration of each SIF was all that was required to get the go-ahead to start production. Without prior testing against a simulation, each SIF would have to be tested multiple times, often requiring exclusive use of the facility, preventing any other work from proceeding.

Additionally, as with all new control systems, there were opportunities for improvement in the process control, recipe system and safety system. Using high-fidelity process simulation, the engineers and operations management were able to identify multiple potential pitfalls and address them before going to the field. This approach prevented bad batches and product loss, saving time, money and frustration for the entire facility.

first build the simulation tools and objects and then implement them in the controller. An added benefit of using external simulation, he says, is it avoids the requirement to remove or disable logic after the factory acceptance test (FAT). Being able to go to the field with the exact logic that was already tested and accepted is a much more effective and efficient process.

STANDARDS AND SIMULATION

The past decade or so has seen a revolution in standards development for many different types of engineering fields. Without standards, engineers must plan, design and execute their projects from scratch or, at best, use the lessons learned from previous projects as a starting point. Process safety typically involves the IEC 61508 standard, but the time has come to provide personnel with high-fidelity simulation standards to aid in mitigating risk in safety processes and help provide best practices for process simulation.

PROCESS SIMULATION TRAINING

Training is key to achieving good operational outcomes. The quality of the training is directly related to the quality of the outcome. A new operator or an experienced operator moving to a new role can easily learn how to control normal operation. One common approach is to shadow an experienced operator. But when it comes to hazardous environments and having to deal with uncommon, emergency or dangerous situations, on-the-job training is much less desirable.

Training for emergency or dangerous situations is often a "lessons learned" presentation that perhaps includes some manufacturing execution system data in charts with before-and-after pictures. In training personnel, it's just not practical for a company to trigger a dangerous event with real equipment to provide the much-needed hands-on experience.

A process simulation training program lets plants train operators in various scenarios without disrupting regular production. Operators at any skill level will benefit by practicing on novel or uncommon operations. When it comes to safely responding to emergencies, the more detailed and frequent the training, the better. During simulation-based training, staff might also uncover ways to improve facility operations.

By using high-fidelity simulation tools, chemical companies can enhance real-world applications and workforce training. This enables accurate prediction and mitigation of chemical safety risks, leading to higher production efficiency, less downtime and improved overall process reliability and safety for both personnel and the environment. ●

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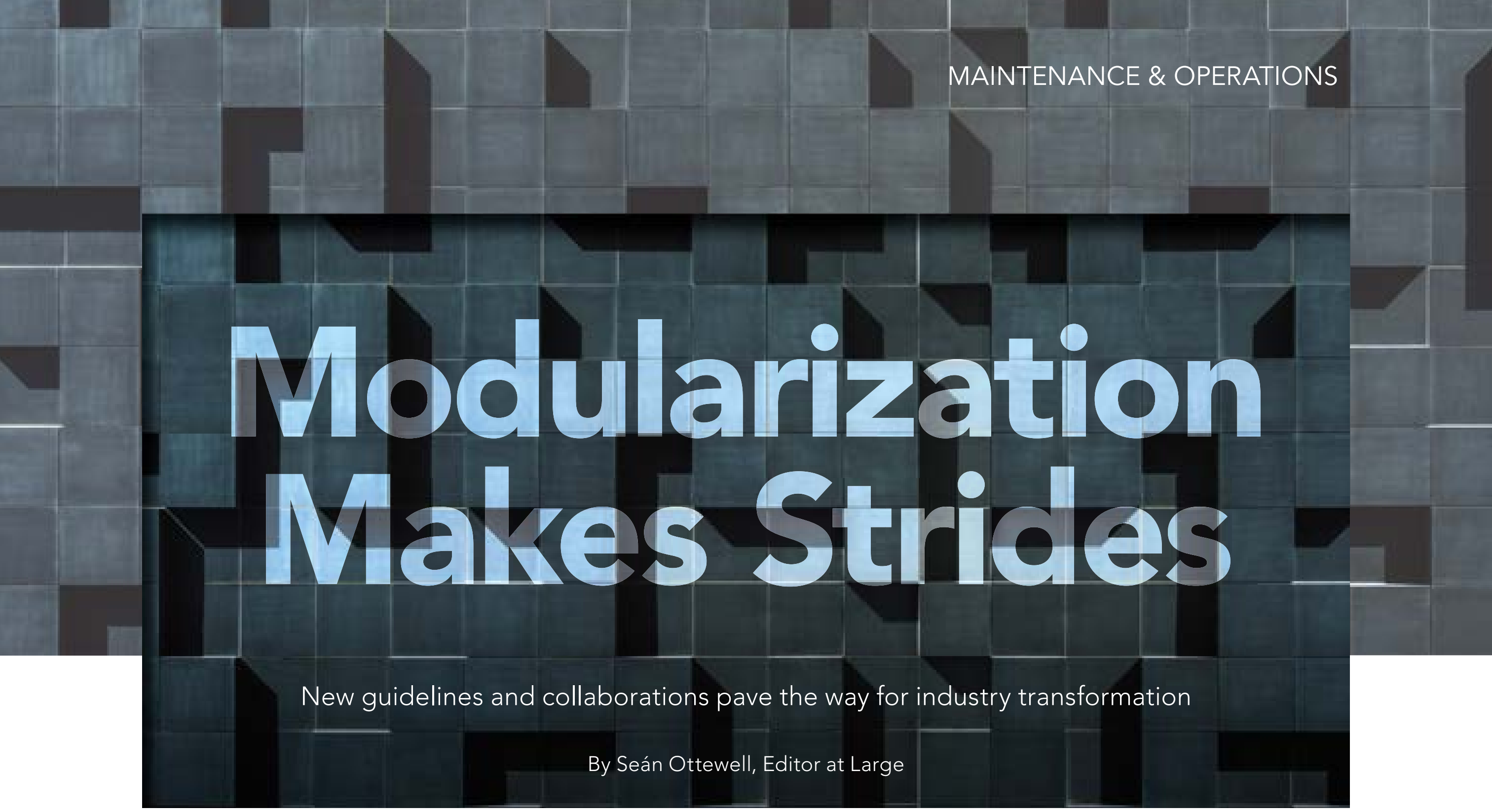


Modularization Makes Strides

New guidelines and collaborations pave the way for industry transformation

By Seán Ottewell, Editor at Large

INDUSTRY REPORTS about the potential benefits of modularization acknowledge that several obstacles remain before chemical plants can implement this strategy. The most common challenges cited are the need for standards in equipment and automation, as well as new business and service models.

However, progress is occurring in these areas.

In Germany, for example, a 2016 white paper on modular plants published by the German Society for Chemical Engineering and Biotechnology (Dechema) laid bare the gaps in skills and knowledge needed for the industry to capitalize on modularization.

One key action to spring from this was the Dechema/ProcessNet working group, which drew together experts from companies such as BASF, Bayer, Clariant and Evonik and several universities to develop and advance ideas.

Michael Heeger, senior engineering manager of technical services within the process engineering unit of BASF's group research division at Ludwigshafen, Germany, points to two significant developments since the white paper was published.

First, the initially temporary Dechema/ProcessNet working group is now a permanent body.

Secondly, guideline committees have been formed under the umbrella of the Association of German Engineers (VDI). Their efforts are encapsulated in two main guidelines: VDI 2776 (modular plants) and VDI/VDE/NAMUR 2658 (automation engineering of modular systems in the process industry).

"These activities prepared the way for the manufacturer-neutral use of modular approaches by defining the interfaces to enable the components of the modular systems to interact, while leaving the manufacturers sufficient freedom to design their own products individually," explains Heeger, BASF's representative on VDI and Dechema modular plant working groups, on the importance of the guidelines.

"The technical control level, which in classic systems is usually executed by a process control system above the equipment level, is shifted to the module level in modular plants. In addition to the procedural components, such as machines and apparatus, and the control hardware, each module is equipped with the required data set to independently carry out the intended process functions," he adds.

MODULARIZATION CHALLENGES AND PROGRESS

While some of the design fundamentals are still either in the draft or project stage, the guidelines already contain information on the safety and approval of modular systems, as well as operation and maintenance recommendations.

"This enables a broad manufacturer-neutral use of modular systems and has already led to the launch of the first modular product lines on the market," says Heeger, noting the guideline committees hold numerous events with industry representatives to exchange experiences and create use cases.

In terms of BASF's own experiences, the company continues its long-term investigations into the use of customized containers for small-scale, decentralized activities.

"In the future, BASF will check whether modular systems and modular-type packages (MTPs) can be used more in the research environment. A project has just been launched to test such modular approaches and MTP in research facilities for analytic applications, for example," Heeger says.

On the other hand, he notes that much of the existing infrastructure of chemical companies does not yet allow the broad application of modular concepts because, for example, it is not yet MTP-compatible.

"In addition, modular approaches can generate higher investment costs in the first step compared to stick-built systems," Heeger explains. "This is due to the more universal design that is used with modules to make them widely useful for future applications. However, this advantage will only be measurable in future applications."

On a broader scale, Heeger recommends companies considering modular approaches must carefully tailor those approaches to their individual businesses and surroundings. Further, they must plan for the future by considering which modules could be used in subsequent applications.

Another essential is that suppliers have a clear understanding of how the modules will be used, right from the infrastructure planning phase.

Heeger also notes that the type of approvals applied for and received from authorities are crucial. Being able to apply them flexibly, for example, for groups of samples rather than individual ones enables a much wider use of modular approaches.

A NEW MINDSET

Like BASF's Heeger, ABB is developing and using the VDI/VDE/NAMUR 2658 guideline. In fact, the company already has products to meet the released revisions of parts 1 to 5 of the standard, while it will be implementing parts 7.1 and 10 in the future (Figure 1).

"Over recent years, several reports have highlighted the most common hurdles facing modularization, which include standardization and interfaces, automation, regulations, apparatus development, scale-up, logistics and supply chain management, planning process and new business and service models," explains Axel Haller, global industry manager chemicals and life sciences, ABB, Energy Industries, Mannheim, Germany.

Ralf Jeske, ABB modular automation SME based in Minden, Germany, calls on teams responsible for planning and designing new manufacturing facilities to change their mindset and adopt a new design paradigm that opens new opportunities for the implementation of modular technologies.

"As with other emerging technologies and standards, there's a Catch-22 situation in which many end users wait for a technology demonstration or maturity in their

STANDARDIZATION OF MODULAR AUTOMATION IN VDI/VDE/NAMUR 2658 AGILE, STEPWISE DEVELOPMENT OF THE INDIVIDUAL PARTS

		Version 1.0						Version 1.1					
2658-x	Title	WG	CP	ID	**PD**	IR	**PR**	WG	CP	ID	**PD**	IR	**PR**
1	Basic concept				6/17		10/19					10/22	3/23
2	HMI - concept				1/18		11/19			9/22	Erratum:		3/23
3	HMI - interfaces				3/19		9/20			9/22	Erratum:		3/23
4	Process control				8/20		10/22						
5	Runtime - concept				4/22	12/22							
5.1	Runtime - OPC UA			1/22	10/22								
6	Alarm Mgmt. - concept				1/21	→PI							
7	Alarm Mgmt. - modeling				2/21	→PI							
7.1	Alarm Mgmt. - OPC UA			12/21		→PI							
8	Safety - concept												
9	Safety - interfaces												
10	Diag./Maint. - PEA		12/21	to be published as NE 184									
11	Diag./Maint. - plant												
12	Validation/Commissioning												

WG: Working Group established • CP: Concept Paper • ID: Internal Draft • PD: Public Draft • IR: Internal Rlease • PR: Public Release

Figure 1. Progress is being made in development of the modular automation standard VDI/VDE/NAMUR 2658. *Source: ABB.*

Figure 2. Modularization could offer added value to BASF's research activities. *Source: BASF.*

respective industries but then delay starting to pilot to assess benefits," he says. "It's a risk-averse behavior, which delays the experimentation and the learning associated with the pilot/experiment. Once the first references are built, the concept has the potential to become mainstream, and the early adopters have already addressed learning curves, minimized risk and validated the areas in which they'll gain competitive advantage.".

It's also about learning. For example, ABB carried out its first modularization pilot project with Bayer in late 2018 and helped the company increase automation efficiency and production flexibility. "ABB learned that modular automation is a continuous process that needs to adapt to upcoming new versions and enhancements," adds Haller.

DO THE ECONOMICS STACK UP?

It's a point considered in detail in "Decentralized modular production to increase supply chain efficiency in chemical markets: an example of polymer production," a 2021 paper published in *The Journal of Business Economics*.

Using data supplied by a polymer manufacturer whose identity remains confidential, the authors demonstrated important synergies between modular production concepts and local sourcing and that it is crucial to select an appropriate technical design for the modular production system.

To do this, they used a mathematical formulation to optimize modular production networks in the specialty chemical industry. The model uses a new type of constraint for modeling relocations, allowing it to be optimally solved for several scenarios.

The results show that if local sourcing is used, it is often possible to reduce the distance to both suppliers and customers by the appropriate placement of the production facilities.

An autonomous operation of the production facilities and flexible processes also substantially reduced the delivery distance and the production network cost. As a result, shorter delivery distances can also improve the carbon dioxide balance of the production network.

The paper notes that these two options for the technical design can reduce the operational costs for each production facility or the costs for the modular plants in use.

"If the production of base polymers is part of the core business of a company, local sourcing options may not be viable because they are associated with the loss of the profit margin for base polymers," the authors note. "However, our case study has shown that both autonomous production facilities and flexible production processes can already lead to a more efficient production network."

According to co-author Tristan Becker, chair of operations management, school of business and economics, at RWTH Aachen University, Germany, the model can be applied to other processes, particularly those at the end of the value chain.

"Here, modular production concepts allow for product customization to demand and can also support postponement strategies," he explains. "Furthermore, high demand uncertainties or a large volatility favor the application of modular production concepts, since the flexibility allows for an efficient response to these types of customer demands."

So, for example, Becker believes the model could be applied to the decentralized modular production of medicines and vaccines, enabling a swift response to demand and reducing the complexities of transportation in the supply chain.

He also points to potential uses for crop-protection product manufacturing, which experiences short-term demand for specific products and must contend with spoilage issues.

"Our models might need to be adapted for an application to a specific case, but the general idea remains valid," he adds.

The paper suggests that future research could apply the proposed mathematical formulation to determine the suitable capacity module sizes for engineering, enabling the design of modular plants based on market demand requirements. It also could be used to evaluate the financial impact of collaborations between companies associated with modular production networks.

"We are seeing companies which use modular production facilities in certain cases and expect the adoption to grow," Becker says. "However, the collaboration between companies is still limited and needs to be enhanced. From a research perspective, we are observing a rapid growth of the literature on optimization methods for planning issues that arise in modular production networks."

THE FUTURE OF MODULARIZATION

Article co-author professor Stefan Lier of the department of logistics and supply chain management in the faculty of engineering and economics at the South Westphalia University of Applied Sciences, Meschede, Germany, highlights other potential advantages and challenges of modularization.

For example, standardized modules help with improved project budgeting and timelines. "On the other hand, their fit to a particular case may not be 100%, lowering the potential cost efficiencies," he says.

So Lier believes that manufacturers of modular systems will have to work more closely with each other to achieve optimum equipment standardization, while at the same time working to meet specific user demands.

He adds that MTP technology is helping address the automation challenges of modularization while enhancing supply chain management with flexibility in capacities, product variety and location as well as increased resilience.

ABB carried out its first modularization pilot project with Bayer in late 2018.

Both Becker and Lier note that for broader applicability, new concepts for small-scale apparatuses are required for a wide range of process steps.

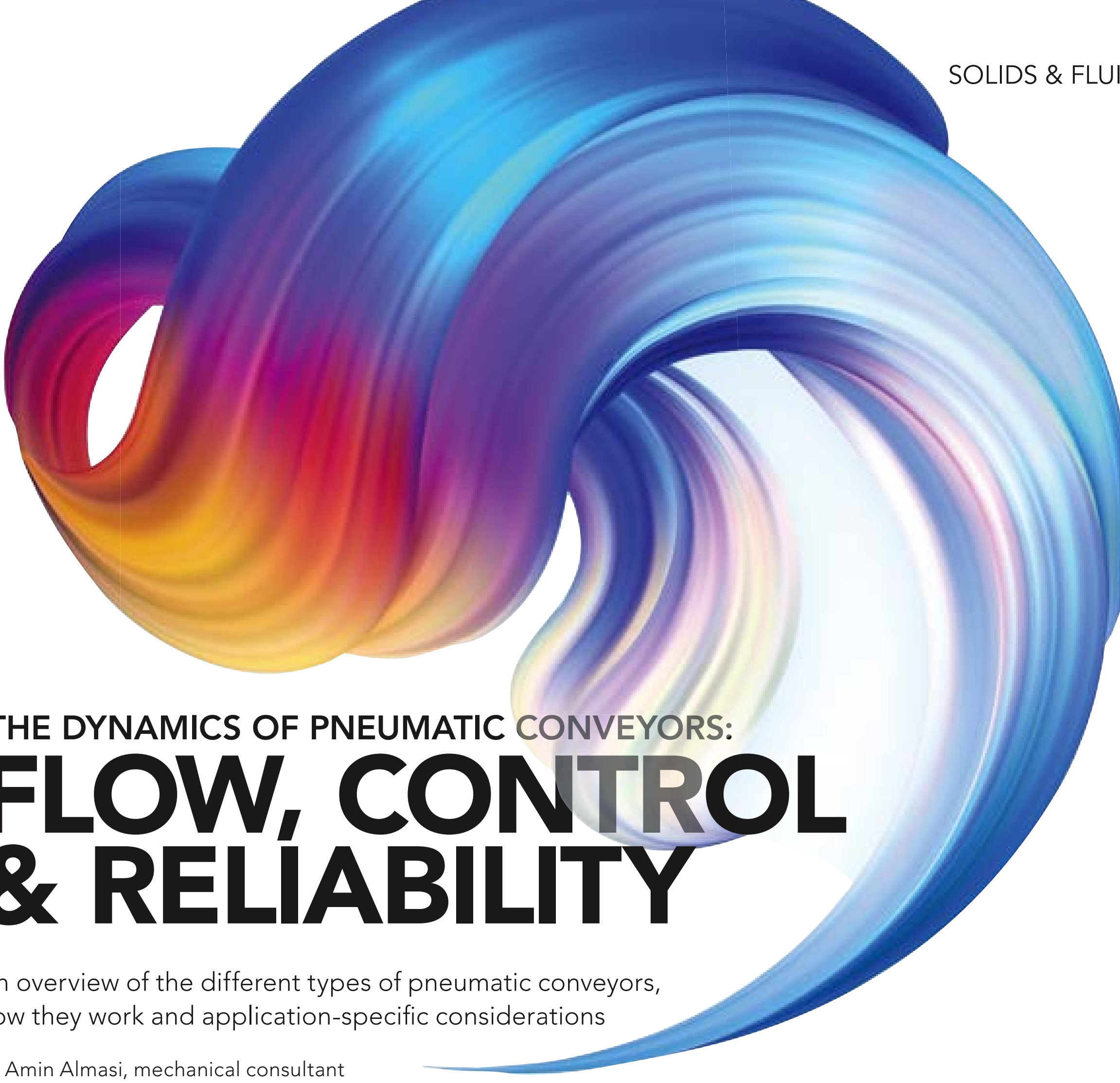
For instance, they have assumed long-term leasing contracts for facilities in the case studies. Flexible short-term leasing contracts could additionally promote the site flexibility of modular plants. Furthermore, different companies could be responsible for the construction of modular plants and operation of a modular production network, opening up the possibility for new business models.

Commenting on the research in the paper, BASF's Heeger notes that the benefit of modular approaches competes with the economy of scale of large-volume systems and the BASF Verbund model.

"Modular plants will not play a major role for products manufactured in large quantities in an existing plant network," he says. "Nevertheless, I am convinced that there will also be applications at BASF where modular systems offer added value. In addition to research facilities [Figure 2], this can include production facilities for products with medium to small volumes for local or strongly fluctuating markets."

Heeger adds that this can also result in interesting approaches for new business models within the company and with external cooperation partners.

"Here, for example, an in-house pooling of MTP-enabled modules, which are supplemented with modules from the external market on a purchase or leasing basis, is conceivable," he shares. "Especially in times of great financial pressure, leasing models are an option to reduce investment hurdles. The future will show if the market offers such options on a larger scale, but the possibility for the manufacturer-neutral description is given by the modular approach." ●



THE DYNAMICS OF PNEUMATIC CONVEYORS:

FLOW, CONTROL & RELIABILITY

An overview of the different types of pneumatic conveyors, how they work and application-specific considerations

By Amin Almasi, mechanical consultant

PNEUMATIC CONVEYORS orchestrate the seamless transfer of diverse bulk materials, from powders and solids to particles and products. They can deliver material across complex routes, seamlessly changing direction when necessary, in an enclosed, dust-free configuration. Yet, engineers and operators often don't fully understand pneumatic conveyors to take full advantage of system capabilities. Little has been published on the potential of pneumatic conveyors, even though they are simple, flexible and versatile systems.

Pneumatic conveyors use pipes or ducts as transportation lines carrying a mixture of bulk materials. They move bulk solids through the piping by suspending the material in a stream of air or gas over vertical and horizontal distances, up to hundreds of meters.

Figure 1. In pressurized or pressure systems, the bulk material is charged into an air or gas stream operated at higher than atmospheric pressures. *Source: Kansas State Bulk Solids Innovation Center.*

Bulk materials in the form of fine powders are especially suited to this transfer method, although it's possible to transport particle sizes up to a centimeter in diameter. For some applications, such as fine-grinding or pulverizing processes, pneumatic conveyors are the only possible means of transport.

A closer look at how pneumatic conveyors operate, including their flow, control and reliability challenges can help operators and engineers gain a better understanding of their advantages and limitations.

PNEUMATIC CONVEYOR BASICS

A pneumatic conveyor's essential elements include a motive air source, a feeder or similar bulk material-introduction device, a conveying line, a termination vessel (such as an air-material receiver) and a collection/separation system. The motive air source is also called an air mover. This is a fan set or blower set, often one operating machine and another on standby. The feeder delivers the bulk material via different methods, including airlocks, injectors, screw pumps and special pressure vessels. The bulk material's physical properties as well as conveying capacity and function influence the configuration and operation of the pneumatic conveyor.

Figure 2. Vacuum systems use a system pressure lower than atmospheric pressure. They use a separator and a positive-displacement blower set between the vacuum charge side of the system and the pressure discharge side. *Source: Kansas State Bulk Solids Innovation Center.*

Pneumatic conveyors handle a wide range of capacities, from several kilograms to tens of tons per hour. These conveyors have been designed and manufactured in many different models and materials, such as different grades of carbon steel, stainless steel, alloy steels and others. Moreover, fluctuations in the feed rate resulting in overloading or under-loading will not affect or damage the system. The enclosed nature of a pneumatic conveyor prevents contamination and associated safety and reliability issues. This also prevents contamination of the handled bulk materials and plant environment, avoiding dust generation and allowing the safe transfer of contamination-sensitive bulk materials, including dusty and hazardous materials.

There are four basic types of pneumatic conveyors: pressurized, vacuum, a combination of pressurized and vacuum, and fluidizing.

In pressurized or pressure systems, the bulk material is charged into an air or gas stream operated at higher than atmospheric pressures. The velocity of the air stream maintains the solid particles in suspension until it reaches the destination, which could be the consumption point, a processing unit or a separating vessel — usually an air filter, cyclone separator or similar.

Vacuum systems operate similarly, though they use a system pressure lower than atmospheric pressure. Pressure-vacuum systems combine the features of these two techniques, with a separator and a positive-displacement blower set between the vacuum charge side of the system and the pressure discharge side.

Figure 3. Dilute-phase conveyors move bulk materials suspended in an air stream from the positive pressure of a blower or fan set upstream of bulk material intake points or by a vacuum pump that removes air from the system downstream of bulk material discharge points.
Source: Kansas State Bulk Solids Innovation Center.

Fluidizing systems operate on the principle of passing air through a porous membrane, which forms the bottom of the conveyor, thus giving finely divided, non-free-flowing bulk solids the characteristics of free-flowing bulk material. This technique is commonly employed in transporting bulk solids over short distances — for instance, from a storage bin to the charge point to a pneumatic conveyor. Fluidizing systems are advantageous because they reduce the required conveying air volume, thereby minimizing power requirements.

In a pneumatic conveyor, the system's air mover (fan set, blower set or similar) changes the air pressure in the conveying line. Typically, the air mover's location determines whether it generates pressure or vacuum. A typical pressurized conveyor configuration includes an air mover installed at the start of the pneumatic conveyor. For a vacuum-type conveyor, the air mover is located at the end of the conveyor to create a vacuum in the system. The operation of the air mover would adjust the pressure (positive pressure or vacuum) and the airflow for the conveyor system. This can be done through different methods, and it would provide the needed control for the pneumatic conveyor.

The capacity of a pneumatic conveyor depends on many factors, such as the bulk density, energy within the conveyor and the length and diameter of the conveyor. One advantage of a pneumatic conveyor is the ability to handle a diverse range of bulk materials and solids using a single system. For example, a pneumatic conveyor can manage powders with various bulk characteristics, as well as flakes, pellets, capsules, tablets and other friable materials. The flexibility of the system allows for the transportation of multiple ingredients.

SIMPLE, COST EFFECTIVE AND VERSATILE

Some engineers may think pneumatic conveyors are complex or expensive. But the opposite is true. These conveyors are very flexible, cost-effective and versatile. The pathway of the pneumatic conveyor can be decided based on existing obstacles and available opportunities, for instance, bypassing installed equipment and facilities or using existing openings in structures, such as walls, roofs and floors. They are easy to integrate into plants, processing units and production environments where machinery, equipment and other obstacles often exist. They also occupy minimal floor space.

Pneumatic conveyors typically have fewer moving parts than conventional mechanical conveyors, such as belt or screw conveyors. Pneumatic conveyors are more straightforward, more reliable, more compact, and lighter than many other conveyor types. A pneumatic conveyor uses a basic, small-diameter pipeline to transfer bulk materials. Designers can arrange the pipeline with bends to fit around existing equipment, giving the system more layout flexibility.

Figure 4. A dense-phase conveyor can handle materials such as different sands, feldspar, ashes, glass cullet, alumina, glass batch mix, carbon black, resins and beans.
Source: Kansas State Bulk Solids Innovation Center.

DILUTE PHASE VS. DENSE PHASE CONVEYORS

Pneumatic conveyors fall into two classifications: dilute phase and dense phase. Either one can run under pressure or vacuum. As a rule of thumb, dense-phase types are usually suitable for fine-grained powders, and dilute-phase systems handle coarse-grained, granular materials.

Dilute-phase conveyors. These systems move bulk materials that are suspended in an air stream from the positive pressure of a blower or fan set upstream of bulk material intake points (in pressurized versions) or by a vacuum pump that removes air from the system downstream of bulk material discharge points.

The faster the air/gas velocity, the more bulk material moves. As the airspeed picks up, larger particles become entrained and moved. The start point where the conveyor picks up speed is generally considered the system's most critical area. Because the bulk material drops from a static state to the airstream below, it should immediately become entrained.

The airstream velocity is also a critical parameter because there is a minimum speed that bulk materials are picked up and entrained at the feed point. The airspeed required to pick up the bulk material depends on each particle's size and density but can range from 16 m/s to 40 m/s. Obviously, a portion of the energy the air mover provides is consumed for the frictional loss. Higher speeds mean higher frictional losses.

A dilute-phase conveyor usually operates at a relatively high velocity at a low-pressure differential. The ambient air temperature, humidity and altitude can affect the operation of a dilute-phase pneumatic conveyor.

Dense-phase conveyors. A dense-phase pneumatic conveyor transports particles at a high pressure and low velocity but does not suspend particles in the conveying air. This method is suitable for gently moving fragile or abrasive materials with particles 18 mm and smaller over long distances, typically more than 50 m. It can handle materials such as different sands, feldspar, ashes, glass cullet, alumina, glass batch mix, carbon black, resins and beans. The system conveys material at a relatively low speed to reduce materials degradation, air consumption, and abrasion on the pipeline, bend and diverter contact surfaces.

This system also can stop or start with the conveying line full of bulk material. In many cases, operators load the system and process the material in batches. In this instance, operators load the bulk material into a special pressure vessel called a blow pot or transporter. When the vessel is full, the material inlet and vent valves close and compressed air enters. The compressed air extrudes the bulk material from the pressure vessel into the conveyor line and to the destination. Once the vessel and conveying line are empty, the compressed air shuts off, and the vessel is ready for reloading. This cycle continues on a batch-type basis.

To overcome resistance in the conveyor line over a long distance, supplementary air injectors (also called air boosters or air assists) can be placed along the conveying line. These injectors provide additional air to help maintain conveying velocity, transfer bulk materials over long distances and minimize line plugging. Operators also can use them to gently restart flow when bulk materials remain in the line after the conveying cycle. It's also important that operators use an air injector with a high-pressure manifold to prevent back-feeding of bulk material into the compressed air system.

Dense-phase vacuum conveying is also appropriate for gently conveying fragile or abrasive bulk materials in short distances, typically 40 m or less. This system is suitable for transferring powder and granules at a medium/low rate (20 tons per hour or less) in applications such as unloading systems. A less commonly used semi-dense phase conveyor configuration uses a pressure vessel with a fluidizing bottom to handle semi-abrasive powders and fluidizable powders that need aeration to discharge into a conveyor line. Better options exist for fragile bulk materials or bulk materials containing large, variable or both large and variable particle sizes. As a rule of thumb, the largest particles handled by this method are approximately 6 mm.

LIMITATIONS AND CHALLENGES OF PNEUMATIC CONVEYORS

A typical pneumatic conveyor requires more energy to operate compared to other types of bulk material conveyors. Therefore, pneumatic conveyors need more installed power and consume more electricity to move a certain amount of bulk material. Pneumatic conveyors are not considered energy efficient because of the amount of energy required to create positive air pressure (or vacuum) and the associated frictional losses.

In fact, in applications with the same transfer rate over the same conveying distance, a pneumatic conveyor can require two to eight times the horsepower of a mechanical conveyor. A pneumatic conveyor usually requires a more complicated collection system than a mechanical conveyor because the pneumatic system has to separate the conveyed bulk material from the conveying air/gas at the system's end.

There have been some limits on differential pressures. As a very rough indication, the maximum conveying pressure is around 6–7 Bar for pressure systems and 0.5–0.7 Bar for vacuum systems; however, some applications have used pressures beyond this limit successfully.

Some bulk materials have characteristics that make them difficult to convey in a pneumatic system. Examples include a bulk material with a large particle size and high bulk density and an extremely sticky bulk material, which tends to build a coating on any material-contact surface. In a pneumatic system, such buildup often leads to total pipeline blockage. These difficult materials can be easier to transfer in a mechanical conveyor that's been carefully chosen to handle them.

Particle degradation is a reported problem. For many applications, such degradation has no effect at all, but for some this is a critical issue. Prediction of degradation levels for any given pneumatic conveyor and conveyed bulk material represents a significant challenge. Particle degradation can occur in many ways, including pipeline wall collisions in both bends and straight sections, particle-to-particle collision and degradation specific to the conveyor feeder, such as a screw feeder or rotary valve. Dealing with such a problem has always proved complex.

The issues raised by particle degradation include increased bulk material dustiness, changes in bulk material handling characteristics and changes in material appearance. This could lead to poorer bulk materials and a consequent real and perceived reduction in quality. Ultimately, these factors can give rise to problematic operation of downstream systems and a reduction in bulk material value. Experimental and empirical data are keys to solving this challenge.

FINAL NOTES

Pneumatic conveyors offer benefits like operational flexibility but also have downsides, such as capacity limitations and high power consumption. They find common use in applications involving fine powders, primarily in low to medium capacities for specific services and plants. Notably, they are applied in fine-grinding services and pulverizing processes. Proper attention to detail in design, sizing, selection and configuration is crucial for preventing issues and frequent shutdowns. Operational histories would be a good source for the selection and application of pneumatic conveyors, specifically to answer hard questions regarding sizing, configuration, and detail design for a specific application. ●

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Tap Innovative Heat Exchanger Solutions

Adding a product recycle line adapts a heat exchanger for extreme operating-rate ranges

The client's requirements created a challenging exchanger problem.

EXTREME OPERATING ranges can challenge many different types of equipment. A recent client had an existing heat exchanger that needed to operate with a range in product rates from 100% to 25%. This 4:1 operating range creates numerous challenges. The exchanger service was cooling a product stream that then went to a product tank. The client used cooling water to cool the product.

Failure to cool the product at the high rate would lead to high tank temperatures that could create product quality and safety problems in the tank. Excessive cooling at low rates would cause low temperatures with and increase product viscosity. In fact, with low flow rates and high viscosity, the flow regime in the exchanger could change from turbulent to laminar. With even small flow maldistribution in a heat exchanger, the laminar flow and high viscosity could cause the exchanger to gel or solidify. Regions of the exchanger would be plugged by a waxy solid, increasing pressure drop and reducing overall cooling.

One brute-force solution to this problem is to use two exchangers in parallel. One exchanger would be in service for flow rates from 25%-50% and the second exchanger would be added in parallel to allow for operation in the range of 50%-100%. This setup increases costs by employing two smaller units instead of one larger unit, along with extra piping and valves. Additionally, control valves are required, or an operator must manually open and close valves. In this case, the expected periods of low-rate operation are typically short. But in other situations, if the parallel second unit was out-of-service for a while special care may be required to avoid dead-leg problems [1].

While the occurrence of extreme low-rate operation would be uncommon, having two parallel exchangers was not optimal since the client sought a system with minimal operator involvement.

Source: Shutterstock

PRESSURE DROP

The client's requirements created a challenging exchanger problem. If the exchanger was over surfaced at low rates, the viscosity would rise and potentially create waxy solids. Additionally, even if the duration was short, low velocity could cause substantial fouling [2]. The cooling water rate could be reduced during low rates to help resolve the product viscosity problems, but that might create low-velocity fouling problems on both sides of the exchanger.

If the exchanger had acceptable velocity at the low product rates, pressure drops would be roughly 16 times higher (42) when the rate was four times higher at the high product rates. Also, a traditional arrangement of process on the shell side and cooling water on the tube side would require mechanical features to prevent erosion and elastic vibration problems. Flipping the cooling water to the shell side wouldn't have helped. The erosion problems would persist with the high process velocity and require special care to avoid channel-head leaks due to high pressure drop.

SOLUTION: A PRODUCT RECYCLE LINE

The most practical way to resolve the 4:1 range requirement was to add a product recycle line. Product would be recycled from the exchanger outlet upstream of the pump that sent product to the exchanger. The exchanger would now be configured to operate with the proper velocity at 100% of rates. If rates dropped below 50% or if the outlet temperature dropped too low, a control valve on the recycle line would allow flow to recycle and keep velocities and outlet temperature in the correct range.

Of course, this requires a new line, a control valve station and appropriate control and line changes. When it was operating, the recycle line would also reduce energy efficiency by increasing the relative amount of duty sent to the cooling water system. However, since the duration of the recycle operation would be short, the energy-efficiency loss was tolerable. While not free, the proposed recycle line had a cost acceptable to the client. It also helped reliability in other areas by improving pump operation [3].

While recycle lines can help solve low-flow problems, they do not replace careful thought in setting flow-rate ranges required. Building for extreme ranges in operating rates imposes costs in equipment, energy efficiency and reliability. That's why it's crucial to verify the necessity of these fluctuations before incorporating them into the design. ●

[1] SLOLEY, A. W. "Watch Out for Dead Legs," *Chemical Processing*, October 2011, Vol. 74, no. 10, p. 48–49.
[2] SLOLEY, A. W., "More Exchanger Area Can Pose Pitfalls," *Chemical Processing*, February 2012, Vol. 75, no. 2, p. 37–38.
[3] SLOLEY, A. W. "Kayo Cavitation," *Chemical Processing*, July 2006, Vol. 69, no. 7, p. 51–52.

ANDREW SLOLEY,
Troubleshooting Columnist

Closed Impeller Withstands Toxic Materials

The AHLSTAR A single-stage pump range now offers a closed impeller. The series of end-suction single-stage centrifugal pumps is designed to work with all types of liquids in industrial applications. The pumps are available with six different impellers, each designed for specific applications. A closed impeller offers a reliable option when processing flammable or toxic liquids. Due to the modular construction, the need

for spare parts is minimized. The pumps are available in various sizes and materials, the most common ones being ductile iron, duplex stainless steel and super duplex.

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The Type 1000P, 1005P and 1010P pressure regulators are complete closed-loop servo systems consisting of two solenoid valves, an internal pressure sensor and electronic controls. One valve functions as inlet control, the other as exhaust. An internal or external feedback pressure

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ControlAir LLC
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www.controlair.com

PVDF Disc Option Handles Corrosive Media

The BYV Series thermoplastic butterfly valve now includes a solid polyvinylidene fluoride (PVDF) disc option combined with a glass-filled polypropylene (GFPP) body to address extreme corrosive applications. The GFPP body/PVDF disc allows for valve operating temperatures up to 240°F (115°C). Its engineered hand lever material incorporates UV inhibitors for enhanced outdoor performance. The body also features reinforced lug holes and can be ordered with full-face over-molded 316 stainless steel threaded lugs. Available in ANSI150 and DIN/EN PN10 flange patterns, the valve ranges in size from 2-in. to 12-in. All sizes are rated at 150 psi (10 bar) at 70°F (21°C) non-shock.

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High-Speed Disperser Minimizes Dust

The floor-mounted HSD-15 high-speed disperser features an air/oil hydraulic lift with a telescoping cover. The cover allows the end user to mix different batch sizes and prevent stratification while keeping the vessel covered throughout the mixing cycle. This also helps contain dusts and vapors for improved operator safety and cleanliness. The 12-in. disperser blade operates up to 1,590 rpm to induce turbulent flow within a low-viscosity batch, creating a vortex to pour in dry ingredients for fast wetting. The blade speed may be changed as the batch thickens or increases in volume to maintain the vortex and rate of material turnover. The cover's ⅓ hinged port eases adding powders into the 150-gal. stainless steel vessel.

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www.mixers.com

Level Indicator Withstands Moisture

The BinMaster BMRX-100 rotary level indicator is an electromechanical device used in solids and powders to prevent bin overfills, dry runs or to shut off a process. It has no printed circuit board, so it's impervious to moisture and vibration found in tough processing environments. By alerting to full and empty vessel conditions, it prevents waste and saves time when handling bulk materials with a bulk density of 2 lb to over 100 lb/ft^3. The enclosure is designed to rotate once installed, making it easy to ensure conduit entries are pointed toward the ground, mitigating the risk of moisture damaging internal components.

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REACH Animal Tests Could Top 11 Million

Study shows animal testing continues despite push to use alternative methods

"There is a long road ahead toward the ultimate replacement of animal testing." —George Streck, REACH

THE NUMBER of hazard assessment tests carried out on animals since the European Union (EU) registration, evaluation, authorization and restriction of chemicals (REACH) initiative launched in 2006 could top 11 million following revised regulation.

This is according to a study published in July by the Johns Hopkins University Center for Alternatives to Animal Testing (CAAT), Baltimore, Maryland, and the University of Konstanz, Germany (CAAT-Europe).

Using data supplied by the EU's European Chemicals Agency (ECHA), Helsinki, the researchers found that 4.2 million hazard assessment tests have been performed on animals since REACH's launch. Of these, 1.3 million are currently being used in ongoing studies.

An additional 3.5–6.9 million animal tests are expected due to a revision proposed last year that aims to align chemical rules with the EU's ambition for safe, sustainable chemicals that preserve the internal market and protect health and the environment.

However, animal-free, alternative test methods were found to be rarely used. So-called read-across methods, which predict toxicity from comparisons with structurally similar, already tested chemicals, were rejected in 75% of cases, the study noted.

In response, the researchers from Konstanz and Baltimore advocate the use of animal-free alternative methods called new approach methodologies (NAMs).

"Some of these new methods are not only suitable for large-scale chemical screenings but also provide more meaningful results than animal testing, as the chemicals are tested on human cells — naturally in a petri dish," noted Thomas Hartung, director of the CAAT-Europe and professor of pharmacology and toxicology at the University of Konstanz.

"Animal-free alternative methods are available for an increasing range of test purposes. The goal must be to adapt the legislation to the current state of scientific knowledge," added Marcel Leist, professor of in-vitro toxicology at Konstanz and co-director of the CAAT-Europe.

The CAAT researchers emphasize the importance of bringing scientists, national and international authorities, and industry together to advance the introduction of alternative methods.

Their call came a month after an ECHA workshop to consider how best to develop an assessment framework that both reflects scientific progress and incorporates NAMs into the REACH process.

The workshop looked at strategies to enable faster progress toward an animal-free regulatory system — a situation the EU committed to over a decade ago.

However, the ECHA must reconcile two — for now at least — apparently contradictory situations. On the one hand, the organization is committed to improving the safety assessment of chemicals to promote innovation in safe and sustainable products.

On the other, while it recognizes NAMs are not a one-for-one replacement for current testing methods, the ECHA also acknowledges the need to build confidence in the chemical industry that NAM-based safety assessments can be as effective as animal testing.

So, the workshop was used to build a common understanding among all industry stakeholders of what NAMs can achieve in the short and long term.

"We don't believe that [protecting] health and the environment versus no animal testing is an either/or situation. We think we can do both," noted ECHA executive director Sharon McGuinness.

Representing the European Chemical Industry Council (Cefic), Chantal Smulders, who is also Shell's global head of product safety science and regulatory advocacy, presented a comprehensive four-point action plan to facilitate a responsible transition, increase acceptance and foster confidence in NAMs.

"The future of regulatory testing is animal-free. One day soon, we can get there if we put in place the right regulatory framework and support," she noted.

Other speakers emphasized the need for a common and agreed-upon international roadmap for NAMs' adoption. This, they said, must have clear, concrete and achievable milestones, plus data reporting, sharing and interpretation.

"Standardization is so important as it allows regulators to become more familiar with elements of the methods, rapidly assess adequacy of the information, and easily share and link information to existing sources of information on chemicals," emphasized Smulders.

Summing up the meeting, Georg Streck, REACH policy officer, said, "There is a long road ahead toward the ultimate replacement of animal testing, but we believe that by developing a framework, creating a long-term vision, ensuring international harmonization, and improving information on uses and exposure, we can pave the way for a safer and more sustainable future in chemical safety assessments." ●

SEÁN OTTEWELL, Editor at Large

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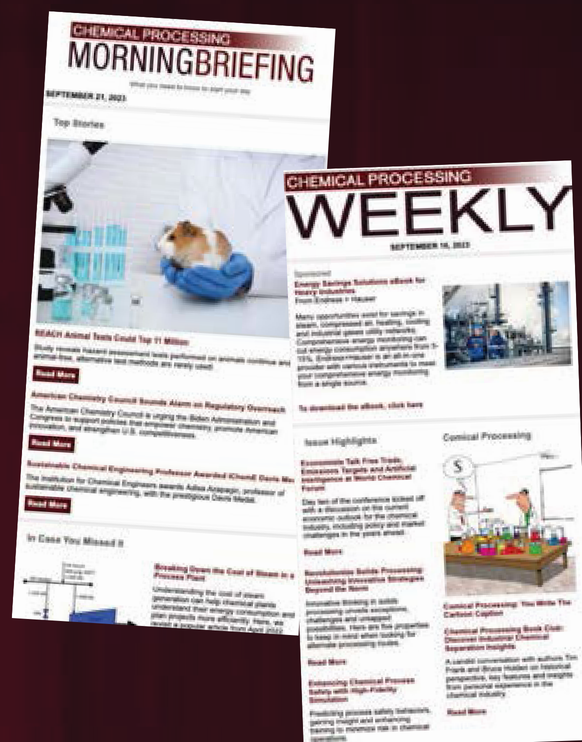

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