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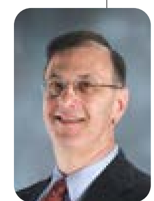
Can Students Avoid School Daze?

Online engineering education during the pandemic only can go so far



"I don't know how e-learning will fill the coaching/mentoring/advising/handholding that is often needed."

— R. Russell Rhinehart

THE WISDOM of sending students into classrooms this semester remains contentious. Striking the best balance between returning to some semblance of normalcy and responding appropriately to health concerns stirs heated debate that often involves politics and socioeconomic issues. Universities are making hard choices — most often limiting in-person classes. But what does opting for online courses actually mean in terms of a chemical engineering education?

To get a real-world perspective, I touched base with R. Russell Rhinehart, emeritus professor of chemical engineering at Oklahoma State University, Stillwater. He is one of those increasingly rare chemical engineering professors who spent time in industry (13 years) before pursuing an academic career. He regularly discusses the dichotomy between what schools teach and what companies require (see, for instance, "16 Things About Being an Engineer That They Don't Teach at University," https://bit.ly/3ki32Ol and "R. Russell Rhinehart on Closing the Academic-Practice Gap," https://bit.ly/2Dhm3jz).

Here's what he had to say:

"Some classes can be taught on-line without any problems. These are the ChE theory classes, with a traditional lecture followed by individual study, homework preparation, and tests that assess whether the students understand the fundamental lecture topics. It would be like traditional distant education… Although, many courses can be taught this way, the issue is tests. If students are in-class, the tests can be monitored. To maintain validity, my distance ed students had to go to a local school, church or government office to have a proctor that would ensure that test conditions are not violated…

"For the instructor, the diverse schedules, necessary to accommodate access and availability of proctors, is a nuisance. For example, you can't release solutions until all students have submitted the materials.

"Students frequently need clarification or need help. For a mature student, an email exchange is all that is needed. But, for the newer students, the one-on-one help/coaching during office hours is essential. I don't know how e-learning will fill the coaching/mentoring/advising/handholding that is often needed by 18–20-year-old novices.

"I also don't know how we are going to handle the design or unit operations classes… ABET [the engineering accreditation organization]… requires laboratory experiences. In my opinion, the design and unit operations classes should be managed with significant real-time coaching about technology, engineering, life-skill, and approach to problems by the instructor. …Working on real equipment is essential to clarify the procedures, time, effort, safety, etc., that graduates should understand. I don't see how e-classrooms can provide the necessary and minimally adequate design and lab experience.

"Maybe ABET and industry need to relax the criteria and expectations for engineering education until we can get back to in-person coaching.

"But of course, many schools don't understand the need for active coaching by practice-oriented instructors… So, maybe all schools should just give up on preparing the engineering persona, revert to just the intellectual measures associated with engineering science, and let industry manage the training needed to give graduates a right perspective."

What's your thinking on engineering education during the pandemic? ●

MARK ROSENZWEIG, Editor in Chief
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Bolster Your Solids Processing Toolbox

Take advantage of various types of software when changing or improving a process

The National Aeronautics and Space Administration offers a variety of free software.

JUST WHEN you think your plant is running just fine, someone in marketing wants you to change the product — slightly. This request may stem from customer input or in response to concerns about product quality. On the surface, it appears perfectly reasonable. However, your experience has shown that small changes to a particulate solid can upset the process in very unpleasant ways.

When asked to help with this issue, I start with the model the plant used to design the original process — if it has one. Older plants often lack one because modeling of solids processes is a rather recent phenomenon. However, today we can call upon several sophisticated and exciting tools:

- Unit operations design modules for various solids processing operations: drying, filtration, agglomeration and even conveying operations;
- Computational fluid dynamics (CFD) programs that finally are becoming user-friendly, especially in laying out the grids and reducing run time; and
- Computational chemistry (CC) programs that are able to run some problems involving solids.

If you don't have these tools, I suggest getting them and training your staff on how to use them.

The learning curve on these tools only will get steeper if you wait too long before using them. I recently bought an all-electric car and discovered a new way to drive that markedly reduces the drudgery. This car even can come when I call it on my cell phone! When people ask why I ventured into this technology, I remind them that lots of folks made a leap of faith in 1903 by buying a product from a guy named Henry Ford. They wanted to be part of that technological movement. It's also the reason why *Chemical Processing*'s editor bought a scan tool (see: "Automation: Zeroes and Ones Add Up But...," https://bit.ly/30mdvk4). While his can't do everything that a more sophisticated device can, he may be able to diagnose many simple problems and fix them.

Like an old dog learning new tricks, I struggled in the early days to master CFD, CC and even a few of the flow modeling programs. I started with some CFD programs that used simple mesh designs. These, available free from the National Aeronautics and Space Administration (https://go.nasa.gov/2XoP97l), gave great insight into the flow of particulate solids. Prior to these programs, we had to set up elaborate scale models and visually trace particles to determine the best way to separate or blend them. With these programs, in one instance I was able to find an elbow design that allowed U.S. Environmental Protection Agency method-five sampling to be representative after a half-radius bend. This enabled conducting sampling in an hour rather than ten hours using conventional methods that required a special dispensation from a regulation that specified hourly samples.

Our pharmaceutical division had been straining to deal with the tremendous workload of investigating new drug candidates. A few years earlier I had found a program published by IBM as freeware to estimate the reactions between different elements. I used it to predict reactions in the gas phase for the reduction of nitrogen oxides. With a little tweaking, the same program worked well in estimating the potential polymorphs of a chemical by estimating the backbone energy of the variations.

A research program in our pharmaceutical division encountered a clumping problem that I suggested might stem from a polymorph. The researchers hadn't been able to find any polymorphs in their investigation until one of the chemists pointed out that she may have seen one. I ran my little program and discovered six possibilities — with two being very likely. Later, this was confirmed and a method developed to avoid the troublesome chemical. The division went on to purchase a more-comprehensive program, reducing development time of new drug candidates.

You must use process flow models if you want to improve or alter a product and still understand how byproducts or energy requirements will change. That's the first step you should take when asked to change a product slightly. You may want to look at models for unit operations along with CFD and CC programs. Start with simple programs, especially free ones. This will allow you to find what features are important when subsequently buying commercially available software. ●

TOM BLACKWOOD, Contributing Editor
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Plug Gaps in Aqueous Solution Data

Some shortcuts are useful for estimating physical properties

The dearth of available physical property data is amazing.

A NEW project landed on my desk involving a tank, pump, agitator, heat exchanger and feed system for sodium thiosulfate ($Na_2S_2O_3$). As usual, the vendor of the compound provided absolutely no physical properties. So, I had to scrounge for physical properties for this aqueous salt solution.

Unfortunately, a lack of such data isn't unusual. I'm amazed at the dearth of available physical property data if your needs go beyond simple hydrocarbons.

When you face such a situation, your goal should be to find a property-versus-temperature regression equation or even one that includes concentration. That's the only way you can optimize equipment without wasting a lot of time generating data on physical properties.

Like many engineers, I've got spreadsheets for physical properties of common pure organic compounds. Obviously, this didn't help for the aqueous solution.

Here's how I solved the problem. (If you have access to a corporate library with an extensive collection of journals and references, stop right here — I'm wasting your time.)

To size the tank, pump and heat exchanger, I needed density (specific gravity), viscosity, heat capacity and thermal conductivity. You likely will have to make a tradeoff between accuracy and consistency of the data. An engineering calculation within 10–15% generally is good enough; finding one accurate within 5% may be difficult and require a lot of time — and may not provide robust results in the target parameters you're working with: temperature, pressure, concentration, etc.

The best approach is to spend some spare time scouring the Internet, text books, brochures, design guides and such for methods and then adapting them to spreadsheets. You'll want to test the data again and again for limitations.

I found a 2007 article "Model for Calculation of Viscosity of Aqueous Solutions" by Marc Laliberte in the *Journal of Chemical Engineering Data* and a table of concentration versus specific gravity for $Na_2S_2O_3$ in the 8th edition of "*Perry's Chemical Engineers' Handbook*." I discovered the 1992 book "Properties of Aqueous Solutions of Electrolytes" by Ivan Zaytsev and Georgiĭ Aseyev contains an equation for thermal conductivity of salt solutions as well as values for a parameter used in that equation for scores of salts.

The specific gravity (*SG*) was the greatest challenge. I had to hand-fit a curve to approximate the temperature effect. I was looking for an equation in the form $SG = A$ (T, °F) + B (concentration, wt-%) + C. I had *SG* at a range of concentrations at 20°C (68°F) from Perry's but only was interested in one concentration (30%) at a higher temperature. Fortunately, *SG* is a nearly linear equation; so, the approximation works if you can find a similar salt, in my case — Na_2SO_4. You can access some specific gravities at: https://bit.ly/2DeFAB4.

The viscosity method presented in the *J. Chem. Eng. Data* article provided a good starting point. I modified it because I had a better equation for water. This model worked well for the salts covered in that article. Again, as with density, if you can't get an exact match, use a salt similar to the one you're working with.

You can estimate heat capacity (*Cp*) by a method proposed by Vosseller in 1973: $Cp_{mix} = 1 - 0.7 \times X_i$, where X_i is the fraction of salt. See: https://bit.ly/3fpwZsi.

If you need the *Cp* at a range of temperatures and concentrations, refer to the Dimoplan method described here: https://bit.ly/33sS1DQ. It's a little complicated, involving a look-up table. For 30% $Na_2S_2O_3$ with a molecular weight of 158.1, this method gives a *Cp* at 100°F of 0.764 BTU/lb.-°F. In comparison, the fixed *Cp* via the Vosseller method is 0.79 BTU/lb-°F.

For the thermal conductivity of aqueous salt solutions, it's best to refer to the Zaytsev and Aseyev book.

As with *SG*, you can approximate physical properties in the same solvent by finding data on a chemically similar compound. Avoid mixing cations, if possible; sodium is closer to potassium than calcium. In theory, charge affects the size of the cation or anion in a polar solvent like water.

Another useful technique is what I call a pseudo-spline curve fitting. This method involves matching the best curve for a property over a specified range. It works well with AND and OR gates nested in a spreadsheet. Try to avoid extended polynomials and multi-linear equations. If you must use them, be cautious.

DIRK WILLARD, Contributing Editor
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CALL FOR CONTRIBUTORS

As an author of articles for *Chemical Processing*, I appreciate that it goes to an audience of practitioners, including some with deep knowledge of chemical engineering unit operations. I thought some of these experts might welcome sharing their insights in a book that I now am working on. It aims to treat chemical unit operations in an integrated, holistic way, rather than via the conventional siloed approach.

I am looking for contributors who have skills at each stage of the process from lab-scale/R&D, through pilot plants to full-scale production and finally optimization or as I call it, Putting-It-All-Together, for actual case histories/war stories. We will also cover decommissioning of plants. Authors should be able to discuss unit operations at each stage and then relate how these technology/process decisions impact the next stage.

Anyone interested in contributing to the book can contact me via barry.perlmutter@bhs-filtration.com for more details.

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KUDOS FOR DECEMBER 2019 ISSUE

I just had to write and say what a kick I get out of your publication, especially December's.

I teach the capstone Chemical Process Design class for chemical engineers at UC Berkeley each Fall. I just finished my fourth year of this, but just hit 40 years in industry last summer (Dow Chemical, J&J, Novartis, and several pharmaceutical startups). I figure my role is to not just teach the basics of design to these very bright but very naive students, but also to give them a taste of industrial issues and problem-solving — things that should help them no matter where they end up.

This issue hit on several things that I emphasize:

I liked what Dirk Willard said about watching people work and look for problems (Don't Stop at the Drawings, http://bit.ly/30WTNdr). Don't just sit in your office and look at what the computer tells you.

Alan Rossiter's hydraulic survey story (Don't Get Tangled Up by Complexity, http://bit.ly/2RXSk2c) is just like one of mine where a sleepy-looking operator solved a steam flow bottleneck that baffled all of our engineers.

Andrew Sloley's article (Is Buying Used Equipment Really a Bargain? http://bit.ly/30Z6i89) was a great example of used equipment not being a bargain. I teach my students my "Baker's Dozen of Rookie Design Mistakes" and that's one of them!

Maybe all of you would appreciate the response I got on the final exam, where I posed a safety incident and had them propose instruments that could have prevented it, then asked if they had any other thoughts. About a third of them wrote to "go look in the damn tank." Maybe when I get better at this I'll get to where all of them say that!

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UNCONFINED VAPOR CLOUD EXPLOSIONS

The article entitled "Forestall Fire and Explosion Hazards from Liquids" in the February 2020 issue was concise, comprehensive and well-done. However, I suggest one correction regarding the following sentence:

*This can pose risk of fire, flash fire or, **if** the vapor resides within a vessel or a building, explosion.*

Confinement does greatly increase the risk and severity of explosion. However, we also need to alert the readers to the risk of *unconfined vapor cloud explosions*, which can also result from the loss of containment of flammable liquids.

One well-known example is the 1974 incident at Flixborough, U.K., in which an elevated release of cyclohexane (flash point -4°F) at a temperature over 300°F ignited, exploded, and caused extensive damage and loss of 28 lives.

Another, more recent example is the 2005 incident at Buncefield, U.K., in which an overflow of petrol (flash point -45°F) from a storage tank evaporated, ignited and exploded with extensive damage to the large tank farm and to many nearby buildings.

There are many other examples of unconfined vapor cloud explosions. ●

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Additive Eases Thermoset Recycling

Cleavable comonomer spurs end-of-life breakdown

THERMOSET PLASTICS are well known for their durability and heat-resistant qualities. However, the strong chemical bonds holding them together have thwarted efforts to break them down to allow recycling.

To more easily break down the materials but still retain their mechanical strength, chemists at the Massachusetts Institute of Technology (MIT), Cambridge, Mass., have developed a way to modify them using a cleavable comonomer.

The process involves adding silyl ether monomers to the liquid precursors that form the thermoset polydicyclopentadiene (pDCPD). The researchers discovered the silyl ether monomer, when included at a level of 7.5–10%, breaks down pDCPD into a soluble powder upon exposure to fluoride ions. The researchers next used the recycled powder to form a new pDCPD thermoset.

To demonstrate recyclability, the team dissolved thermoset fragments into fresh monomer and cured following standard protocols. An article in *Nature* contains more detail.

"The resulting recycled material showed mechanical properties similar or superior to that of fresh thermoset. Moreover, we anticipate that the poly-dicyclopentadiene fragments may find value in other 'upcycling'-related applications. We are in the process of scaling up our recycling workflow, with a target of having these data ready by early next year," say the researchers.

"That new material has nearly indistinguishable, and in some ways improved, mechanical properties compared to the original material," adds MIT chemistry professor Jeremiah Johnson.

"Indeed, the mechanical properties were the same as well as the high temperature thermal stability. We did observe a modest decrease in the glass transition temperature when adding our comonomers to pDCPD. We are currently evaluating a few approaches to increase the glass transition temperature, which should readily address this potential issue," notes Peyton Shieh, a postdoctoral fellow at MIT.

"The cleavable monomer will provide a modest increase in the overall cost, on the order of ~10%, though this is only an estimate and with the identification of new synthetic routes it may be lower," says Shieh.

"Moreover, this cost can become negligible in the context of composites, when high-value reinforcement materials such as carbon fiber are used," he adds.

In addition, the researchers believe their approach could apply to a range of other plastics and polymers, such as rubber.

"This work unveils a fundamental design principle that we believe is general to any kind of thermoset with this basic architecture," stresses Johnson.

"This will benefit all classes of thermosets, including thermoset plastics, elastomers, and gels. We could also install cleavable bonds into thermoplastics to render them degradable," believes Shieh.

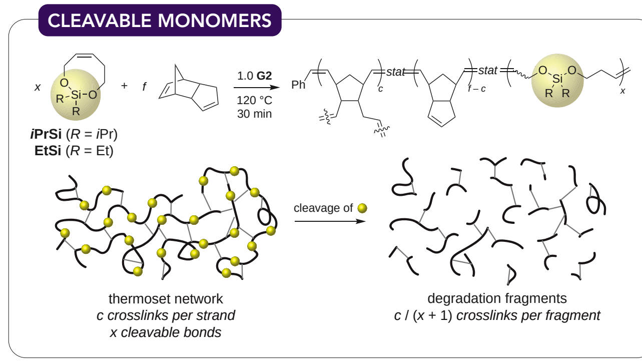
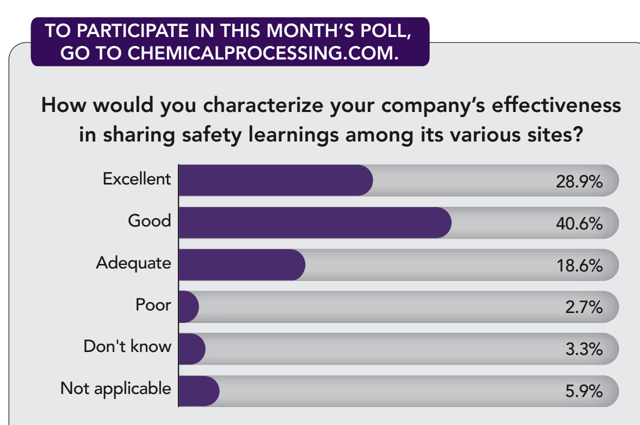


Figure 1. The introduction of x cleavable bonds within the strands of pDCPD with c crosslinks provides degradation fragments with ⟨c/(x + 1)⟩ crosslinks per strand. *Source: Jeremiah Johnson, MIT.*

The team now is working on incorporating the cleavable comonomers into industrial resins: "In our manuscript, we demonstrated using cleavable monomers to make the industrial thermoset pDCPD degradable and recyclable. We are now exploring opportunities to commercialize our approach, including identifying strategic partners, to implement our approach on scale," says Johnson.

The team also is in discussions to commercialize its silyl ether monomers for research use. An initial techno-economic analysis on the synthesis of the silyl ether monomer indicates a minor impact on the overall cost of material.

"Our comonomers can be viewed as 'additives', meaning they can simply be blending into an existing liquid resin and curing can follow the same manufacturing workflow without need for other changes. We hope that this approach will simplify adoption of the technology, since infrastructure changes should be precluded," Johnson concludes.



More than two-thirds of respondents considered the effectiveness of sharing safety learnings as at least good.

Reactor Makes Light Work of Alkane Conversion

RESEARCHERS AT Eindhoven University of Technology (TU/e), Eindhoven, the Netherlands, have developed a method for immediately converting gaseous, low-molecular-weight alkanes including methane, ethane, propane and isobutane to more complex compounds. The reaction occurs in a continuous-flow photoreactor at room temperature using a decatungstate catalyst being irradiated with a 365-nm light source.

PHOTOREACTOR

Figure 2. Conversion of gaseous alkanes to more complex compounds occurs at room temperature. *Source: Timothy Noël, Eindhoven University of Technology.*

"While the activation of liquid alkanes with decatungstate has been known about for many years, the activation of gaseous alkanes is much more challenging," says Tim Noël, associate professor with the micro flow chemistry and synthetic methodology group in TU/e's department of chemical engineering and chemistry.

Achieving success, he adds, requires addressing two fundamental problems: prohibitively high bond dissociation energies of C-H bonds in gaseous alkanes, which makes them very tough to activate, and the technological challenges of bringing them into contact with a photocatalyst.

The new reaction also avoids the extreme conditions currently needed to activate the C-H bonds in liquid alkanes, later purification steps and associated byproducts.

The researchers carried out 38 different reactions between light alkanes and olefins. Conversion levels varied from 56.7% to 97.6% and yields from 47.9% to 91.5%. An article in a recent issue of *Science* provides details.

"The maximum capacity of the reactor we have got to so far is 15 mL. However, this is a commercially available reactor that can be scaled by a factor of ten — which would lead to production of 10–20 g/hr under current conditions," explains Noël.

He believes a rotor-stator spinning disk reactor (RS-SDR) that the group currently is developing could produce better results.

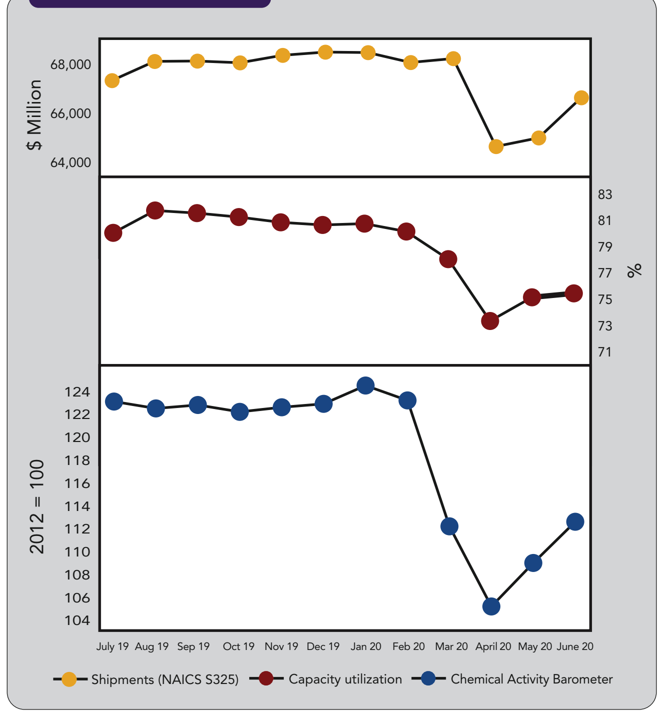
"The advantage of this reactor is that it provides highly intensified mass transfer between the gas and the liquid phase. As we have shown for a singlet oxygen reaction, this not only leads to high yields in short reaction times but also to increased selectivity, i.e., excellent process optimization. We anticipate that similar results are feasible for methane/ethane/propane activation."

The RS-SDR has a capacity of 64 mL, which eventually should enable 1 kg/d production by the end of 2022.

Noël's team also is looking for catalysts that can activate C-H bonds in the visible light spectrum. "Sources such as LED technology are much cheaper and more energy efficient," he notes.

He anticipates a great deal of interest from industry in the new technology once the team demonstrates that the chemistry involved can be scaled. ●

ECONOMIC SNAPSHOT



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

Speak the Language of Refrigeration

Use a simple equation to determine the maximum efficiency of refrigeration equipment

Consider a vapor-compression refrigeration system as a heat engine running backwards.

IN LAST month's column, "Speak the Language of Energy Efficiency," https://bit.ly/2E9YV6N, we saw how the simple Carnot efficiency equation, $\eta = 1\text{-}T_c/T_h$, can provide many insights into the design and operation of some of the most common power-generating equipment — heat engines, including steam turbines, gas turbines and internal combustion engines. In the power-generating step of their operating cycle, they expand a hot, pressurized gas, lowering its pressure and temperature, with or without phase change. Another common device — the mechanical refrigerator or vapor-compression refrigeration system — does the opposite.

Vapor-compression refrigeration systems have a wide range of applications, from domestic and commercial refrigerators, air conditioners, water coolers, refrigerated trucks and railroad cars to large-scale applications — many of which are at much lower temperatures — in chemical and petrochemical plants, oil refineries and gas processing plants. Depending on the application, they may use a variety of working fluids (refrigerants), including ammonia, various hydrocarbons, and hydrofluorocarbons (HFCs).

In the simplest form of these systems, liquid refrigerant is depressurized into an evaporator, which also serves as the sink to remove heat from (and thus refrigerate) the material or the space needing to be cooled. The combination of pressure reduction and heat input causes the refrigerant to vaporize; the operating pressure dictates the refrigeration temperature. The vapor then enters a mechanical compressor, which boosts its pressure to a level that allows the vapor to condense against an external coolant (usually air or water, at close to ambient temperature) in a condenser. From here, the refrigerant is again depressurized and returned to the evaporator to restart the cycle.

Consider a vapor-compression refrigeration system as a heat engine running backwards, thus the Carnot efficiency equation can work here. However, the conventional definition of energy efficiency (useful energy out/total energy in) isn't very helpful when we consider refrigeration. A more useful parameter is the "coefficient of performance for refrigeration," COP_r, where COP_r = useful cooling provided/work required. We can rearrange the Carnot efficiency equation for this application:

$$COP_{r,ideal} = T_c/(T_h\text{-}T_c)$$

Here, $COP_{r,ideal}$ is the coefficient of performance for an ideal refrigeration system, with any given refrigeration temperature (T_c, the cold end of the cycle) and corresponding heat rejection temperature (T_h, the hot end of the cycle), both expressed on an absolute scale. High values of COP_r (whether ideal or not) correspond to the most efficient operation, as they maximize useful cooling while minimizing the work requirement. However, unlike conventional efficiencies, COP_r can attain values greater than 1 (or 100%); by inspection of our equation, $COP_{r,ideal} > 1$ if $T_c > ½T_h$.

The actual values of COP_r with real refrigeration systems are much lower — typically 50% or less of the ideal value. Nevertheless, just as we found for heat engines, the ideal equation provides hints at how we can improve the efficiency of both the design and the operation of real equipment. First, we seek to eliminate or minimize the non-idealities of our system, then we consider how we can manage the parameters in the equation to maximize COP_r.

Ideal heat transfer occurs without any temperature difference, but that's not the case for real heat transfer. Designing the evaporator and condenser in our refrigeration system with the smallest practical temperature differences (subject to technical and economic constraints) reduces non-ideality, and we operate and maintain them to keep them clean. Likewise, we minimize unnecessary frictional losses; energy efficiency is a key factor when choosing the working fluid and compressor.

COP_r increases as T_c increases and T_h decreases. Lowering the temperature of the external cooling medium reduces T_h (the condenser temperature). This favors the use of cooling water over air; we design and operate the cooling towers for the closest practical approach to dew point. The temperature to which we need to cool our process largely controls T_c (the evaporator temperature). However, many process streams are refrigerated over a wide temperature range, for example, from 80°F to -180°F. We could use a refrigeration temperature a few degrees below -180°F to do all of the cooling. However, we can save energy by cooling in stages, using cooling water to remove as much heat as possible, and then refrigeration at progressively lower temperatures (say, 0°F, -100°F and -185°F). There is a trade-off, however: Increasing the number of stages saves energy but increases investment and adds complexity. ●

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EPA Eyes Carpet Chemicals

A significant new use final rule targets PFAS substances found in imported carpets

Additional future regulation is likely.

THE U.S. Environmental Protection Agency (EPA) continues to regulate "forever chemicals," named such for their persistence and risk to the environment and health. On July 27, 2020, the EPA issued a long-awaited final rule amending significant new use rules (SNUR) issued earlier on such chemicals — one pertinent to certain perfluoroalkyl sulfonate chemical substances and the other on long-chain perfluoroalkyl carboxylate (LCPFAC) chemical substances. To some, the final rule reflects comments on the proposed rule issued five years ago; to others, the rule weakens to the public's detriment a proposal the Obama Administration issued. This article discusses the rule and its implications.

BACKGROUND

Certain per- and poly-fluorinated (PFAS) chemicals are known to pose both human and environmental health risks. For years, the EPA and other agencies globally have regulated these chemicals to abate identified risks. In 2015, the Obama Administration proposed changes to two SNURs regulating certain perfluoroalkyl sulfonate and LCPFAC chemical substances. Frustrated with the delay in issuing the rules in final, Congress mandated in Section 7352 of the National Defense Authorization Act for Fiscal Year 2020 that EPA "take final action" on the 2015 proposed rule by June 22, 2020.

The EPA last amended the perfluoroalkyl sulfonates SNUR in 2013. The SNUR identified the manufacture (which includes import under the Toxic Substances Control Act (TSCA)) of the covered substances for "any use" as a "significant new use" for which commercial manufacture is impermissible, absent the submission of a significant new use notification (SNUN). However, the SNUR did not waive the article exemption and wouldn't apply if the chemical were, for example, applied to carpet or otherwise found in an "article," which is defined as a manufactured item formed to a specific shape or design. The EPA proposed to amend the SNUR in 2015 to disallow the article exemption for imported carpets only.

In 2013, the EPA issued the SNUR for LCPFACs. The final SNUR designated as a significant new use the manufacturing and processing of covered LCPFACs for use in carpets or to treat carpets. Imported carpets were not exempt under the article exemption. The import of articles other than carpet that contained covered LCPFACs was unaffected by the SNUR, meaning the article exemption was applicable.

The final SNUR issued in July 2020 adopts the changes proposed in 2015 for the perfluoroalkyl sulfonates and disallows the article exemption with regard to imported carpets. The final rule effectively closes the door on the import of carpets containing covered substances absent the submission and approval of a SNUN. The import of other articles containing the covered substances are not affected. The 2020 final rule similarly adopts the changes proposed in 2015 regarding the LCPFACs (as later revised earlier this year). The LCPFACs implicated include three separate groups of substances totaling over 200 substances.

The SNUR requires persons to notify the EPA at least 90 days before manufacturing or processing these chemical substances for the significant new uses described in the notice, which is "any use." Manufacturing or processing for the significant new use is prohibited until the EPA has conducted a review of the notice, made a determination on it, and taken required actions. Ongoing uses can't be subject to a SNUR, thus the final rule excludes them.

DISCUSSION

The final issued SNURs have been a long time in the making. The need to meet TSCA Section 5(a)(5) requirements for including imported articles in SNURs contributed to the delay. While the EPA doesn't plan at this time to use its authority under TSCA Section 6(a) to regulate PFAS, additional future regulation is likely, thus continuing the agency's nearly two-decade effort to identify and manage the risks associated with this broad category of substances. Depending upon the November elections, change could come sooner rather than later.

The final SNURs will have a significant impact on entities importing carpets given the elimination of the article exemption. Three separate groups of LCPFACs were identified in the SNUR. Importers of carpet, automotive parts, furniture, and certain electronic components will need to be especially diligent to ensure their articles do not contain any listed chemical substance. Failure to be vigilant could result in enforcement action and imported products denied entry into the United States.

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Monitor Your Water Quality

TOC analyzers can help protect equipment, maintain productivity and reduce plant shutdowns.

AMANDA SCOTT
Product Management Leader, SUEZ – Water Technologies & Solutions

If you don't measure it, how can you control it?

ONE OF the most commonly used compounds in the chemical industry is water – not only as a solvent in processing, but also as an energy carrier in the cooling or heating cycle. Monitoring water quality can predict performance and protect equipment.

Chemical Processing spoke with Amanda Scott, product management leader for the Sievers* product line at SUEZ – Water Technologies & Solutions. We discovered how implementing critical control points, such as total organic carbon (TOC) analyzers for monitoring closed-loop cooling water systems, can help ensure efficiency and productivity.

Q: What particular issues should a plant check for in a closed-loop cooling water system?

A: Closed-loop cooling water systems offer many advantages—the chemistry can be precisely controlled and it's designed to be highly efficient. These systems are recognized by various regulatory agencies as the best available technology to minimize the impact on environmental life and water use. However, leaks can occur, and any unmonitored leaks can significantly impact performance, damage assets or even cause plant shutdowns. Proactively monitoring water quality can help mitigate risks, as well as prevent three critical issues: scale, corrosion and fouling.

Q: What issues can TOC analyzers detect?

A: TOC analyzers measure all organic compounds, and thus, all carbon contaminants. We know that some organics can oxidize to organic acids, such as acetic acid, and reveal harmful corrosive ions. For example, sulfonated or halogenated organics may not be harmful and can go undetected by ion sensors at room temperature. However, exposure to a boiler system's high temperatures and pressures can generate harmful chlorides and sulfates. If undetected, these compounds can accumulate over time, damaging pipe walls and equipment.

Traditional monitoring methods such as pH or conductivity might not be able to detect these chemicals before oxidation. TOC analyzers will rapidly detect ionic and nonionic organic contaminants to help prevent acid corrosion. TOC analyzers also monitor inorganic carbon (bicarbonates, carbonates and carbon dioxide). This helps plants correct the cation conductivity result from the presence of carbon dioxide. It's necessary to monitor and remove carbonates to reduce scaling.

The presence of organics can affect a process in several ways. Source water organics, such as polysaccharides, humic acids or chlorinated organics from water treatment systems, can hinder treatment efficiency. Monitoring organic changes in the source water is critical to preventing membrane fouling, optimizing chemical dosage and maintaining acceptable water quality levels for boiler make-up water.

Organics can also be food for microbial growth. Instead of waiting to see if you have a biofouling problem, monitoring the organics can help eliminate this potential issue and prevent microbial growth from occurring. Furthermore, TOC data can be used to troubleshoot unknown issues. If the TOC remains constant, but an issue occurs, you can pinpoint it as an inorganic ingress. Using these tools can prevent catastrophic damage, higher operating costs or unplanned blowdowns that reduce productivity.

Q: Why are traditional monitoring techniques not as effective at spotting leaks like this?

A: With a closed-loop system, the chemistry is really important. When you're using traditional tools like pH and conductivity, you might not be picking up all the key contaminants. pH tools can be overwhelmed by corrosion controlling chemicals and conductivity will obviously only detect ionic contaminants. Glycol has emerged as a difficult-to-detect compound that can have significant corrosive effects on a plant. For instance, at room temperature and pressure, glycol is difficult to detect especially at trace quantities. Furthermore, at higher temperatures and pressure, glycol breaks down and yields organic acids that can degrade plant equipment.

We've heard from several plants that even a 12-ounce leak can cause catastrophic damage and a plant might need to shut down. You need a tool that has superior sensitivity to quickly alert the operators if something's wrong. TOC accurately recovers glycol at the concentration where it matters, often at µg/L levels.

Q: Are operators alerted right away?

A: With continuous online monitoring tools for organic carbon, operators can obtain results within minutes. As mentioned, TOC analysis yields complete oxidation and recovery of all organic compounds present in a sample. This can be used for establishing a baseline, detecting a change and reacting to the results. The sensitivity of TOC analyzers is a differentiating characteristic from other monitoring tools such as sensors.

Results delivered by sensors are compared to a reference point, while analyzers detect the true amount of the contaminant that is present in the sample. Sensors may provide faster results, but often have less sensitivity, less accuracy and cannot typically be verified with check standards. Sensors need more frequent calibration due to interferences, but they tend to be lower capital costs. Analyzers will have a higher capital cost, but they prevent drift. It all depends on the amount of risk a plant is willing to take. A high risk would be no monitoring, a moderate risk would be sensors that could drift and a low-risk situation would be to use an analyzer as a critical control tool.

Q: What does an effective testing procedure entail?
A: The end goal is water-treatment optimization — the ability not only to apply the right chemistries and processes, but to monitor water quality. First, one needs to understand what the data will be used for. It can align with the need to understand the plant's process, protect equipment or drive productivity. Identifying goals, setting limits and determining monitoring points will allow plants to validate process assumptions.

I have an example from a plant that began developing its process by examining its cooling-water loops. The plant tested condensate and condensate spiked with glycol. For this plant, it was important to detect glycol leaks. (Two of their sister plants had to shut down for several days because a glycol leak went undetected.)

Results revealed the contamination was caused by small glycol leaks entering the boiler feedwater pump in two possible ways, both involving faulty seals. The plant was able to identify where the problem was coming from, what tools to use and set limits. It was determined that condensate TOC should be 200 µg/L. If a sample is over 200 µg/L, operators should analyze another sample to confirm, or switch to an alternate feedwater pump. Setting plant limits and developing actions based on data allows operators to react quickly to upsets.

Q: How does this monitoring help meet regulatory compliance?
A: From an external standpoint, guidelines exist for boiler feedwater quality. Some power organizations like EPRI recommend less than 100 parts per billion (ppb) or µg/L of TOC. While the VGB, European technical association for power and heat generation, recommends less than 200 ppb. The higher temperature and pressure systems require higher steam purity.

TOC ANALYZERS

Sievers M5310 C Analyzers are available in portable, laboratory and online configurations. Accurate, fast and reliable results for water-quality monitoring.

Internal guidelines might also exist from equipment manufacturers. The boiler itself or the turbine could require certain parameters to be met to ensure equipment integrity and reliability.

Q: How do the Sievers TOC analyzers differ from all their alternatives?
A: SUEZ offers a portfolio of TOC solutions tailored to specific monitoring needs from ultrapure to wastewater. For example, an analytical tool for ultrapure water must provide stable, sensitive results. Wastewater analyzers must be able to process complex matrices and particulates.

All TOC analyzers oxidize organics to carbon dioxide, then measure the carbon dioxide. However, there are a variety of methods to oxidize and detect carbon dioxide.

For source water, boiler feedwater and condensate, SUEZ offers the Sievers M-series, a versatile and simple analyzer. These analyzers are easy to maintain, deliver maximum uptime and offer an operating range of 30 parts per trillion (ppt) to 50 parts per million (ppm) or mg/L. They're available in laboratory, portable or online models.

For complex streams with higher organic particulates and salts, Sievers offers the InnovOx family of TOC analyzers. Sievers InnovOx has a dynamic range of 50 ppb to 50,000 ppm. It can analyze samples with high temperatures, solids, dispersed oil and particulates of up to 800µm.

Q: Is there anything you'd like to add?
A: If you don't measure it, how can you control it? If plants spend time and money on systems for power generation, cooling and water treatment, it's beneficial to put in critical control points to ensure those systems are efficient and productive. ●

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Drones Fly Higher

Fast payback and increasing capabilities elevate role at plants

By Seán Ottewell, Editor at Large

DRONES CAN carry out incredibly detailed inspection work with potentially huge safety and economic benefits, as the experiences of Flyability, Chevron and Thyssenkrupp show. At the same time, makers of sensors and manufacturers of drones — also known as unmanned aerial vehicles (UAVs) — are working to deliver the next generation of technologies demanded by an increasingly enthusiastic chemical industry.

Formed in 2015, Flyability, Paudex, Switzerland, has sold more than 1,000 of its Elios drones to over 450 customers. The UAVs handle critical infrastructure inspection for chemical, oil and gas and power generation facilities (both fossil fueled and nuclear).

Its latest version, Elios 2, is an intuitive-to-fly drone fitted with an RGB camera, a powerful lighting system, and sensors used in aircraft stabilization. It is designed to perform reliably in environments not suitable for use of a global positioning system, in dark, dusty and troubled airflows, beyond line of sight and, particularly, in places that no other drone can access.

"Preventing human exposure to dangerous situations like confined spaces entry [Figure 1] and work at height is definitely the most compelling benefit of using drone technology," says Marc Gandillon, Flyability's head of marketing.

At the same time, the overall savings achieved from reduced downtime, lower operation costs, and increased quality and quantity of data are enormous, he stresses. Most users recover their initial investment within a year, some within one flight. One customer saved $500,000 with a single inspection, he notes.

"Adopting drone technology has a non-negligible implementation cost. This includes equipment acquisition and maintenance, user training, and any changes that have to be made to the inspection process itself to allow for the use of new equipment/technology. However, having drone technology in your asset maintenance operations is a mindset. You know you'll save someone's life down the road and, with the proper involvement

SAFER INSPECTION

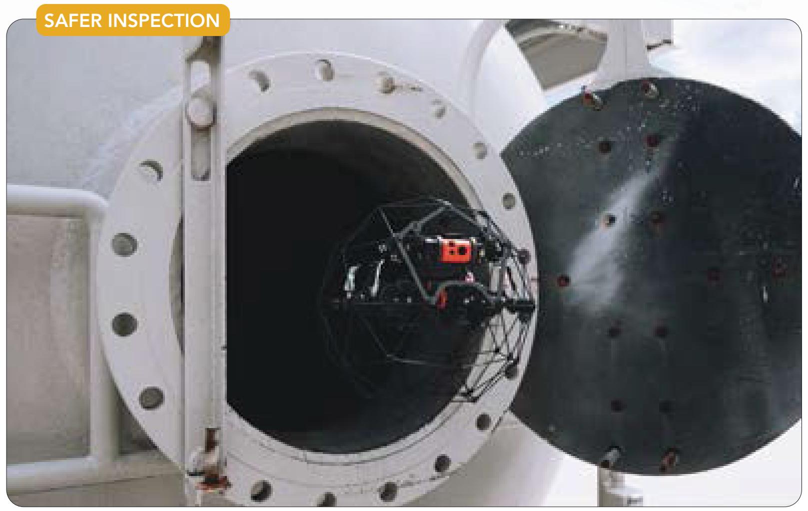

Figure 1. Besides keeping people out of harm's way, using a drone generally offers a fast payback on the initial investment. *Source: Flyability.*

in your drone program, you will improve your figures," Gandillon adds.

Right now, the primary attraction of Elios 2 is its visual data that allow users to remotely assess the inner condition of assets to spot cracks, pitting or other anomalies, he notes. However, the company constantly receives requests to integrate other monitoring devices such as ultrasonic thickness, radiation and even gas sensors. "A lot of people would like to be able to map their assets using a LiDar (laser imaging, detection and ranging) sensor. These are all tracks for our technology to evolve along," he says.

REFINERY RESULTS

One company that has been involved with Flyability since 2015 is Chevron. The most recent maintenance program using Elios 2 took place in April at its El Segundo refinery, El Segundo, Calif.

"Four main benefits are associated with using UAVs/drones: increased safety margins; reduced risk; improved efficiency — getting more work done in less time, with fewer people, and saving money; and delivering high quality data more quickly — typically within minutes of completion," notes Larry Barnard, downstream & chemicals, manufacturing, unmanned aerial systems governance at the refinery.

He points to many quantified benefits. For example, the El Segundo facility has over 800 company-owned power poles that require inspection every two years. Pre-UAV, this task would involve three boom trucks with buckets, five contractors and cost more than $1,000/pole — typically with only three poles inspected per day. Now, one small UAV with a 20-megapixel camera and one operator can inspect 20 poles/hr. "So, we've reduced the risk of working at heights and in close proximity to dangerous conditions. Also, the UAV provides a high resolution 'record' of the asset that can be stored/saved/compared over time," he adds.

Similarly, pre-UAV vessel inspections typically needed 2–3 days on a turnaround schedule with scaffolding time and costs playing a big part. Now, inspection of the entire vessel only takes a few hours, without any of the confined space entry requirements such as rescue equipment, hole watch, communications and permitting. "Again, we get very good data that can be archived, attached, referenced and compared over time," says Barnard.

In addition, during the turnround at El Segundo, one of Chevron's Elios-2-trained process engineers operated the drone inside three crude unit furnaces to inspect refractory and furnace tube integrity.

"We were able to inspect the fin tubes in the convection section to determine whether or not carbon dioxide blasting was needed to clean them and restore their efficiency. The drone data helped determine that we could forego the cleaning at this outage — a very significant saving," stresses Barnard.

It's important to understand that "inspections" take many forms, he explains. "Process engineers were very interested in performing inspections related to 'operability and conditions' of components that affect operability of equipment and process envelopes. This is a very interesting perspective and completely disassociated from a 'compliance type' regulatory agency inspection re: integrity of equipment and protection of environment and surrounding community."

Process engineers make ideal UAV operators, Barnard feels. To ensure their skills remain sharp, he advises having a qualified subject matter expert institute training policies and develop documentation.

However, he cautions, there's still a significant way to go to remove the stigmas and concerns associated with drones. "They vary widely but are typically related to training, regulatory requirements, skills to safely use and maintain the equipment, and, of course, what to do with all the data they generate."

Looking to the future, he believes UAV autonomy is key — but hurdles remain. For example, few UAVs on the

market are capable of self-launching, on a scheduled frequency, and remotely from one or more fixed locations. Even fewer have the onboard computer vision and artificial intelligence (AI) needed to detect and report anomalies. In addition, regulatory agencies have a very onerous waiver/safety case process for approving drones that are flying beyond the visual line of sight. "So they do not allow UAVs without waivers, test data, proof of capability and, in some cases, vehicle certification. They are treated as one-offs and the agencies involved are not yet set up to manage a large number of requests," he notes.

Even so, Barnard believes these hurdles will be overcome, and, within the next five years, UAVs could be launched on pre-configured missions and be able to detect anomalies along the flight path on their own — with pilots perhaps becoming a thing of the past.

"It's entirely feasible to expect this level of autonomy on commercially available UAVs within five years using a combination of enabled aircraft in small, fixed housing locations enabled with edge/computer vision sensors, performant network connectivity, and data analytics platforms managing the AI and broadcast to the 'user/customer.'"

He envisages a time in the near future when Chevron's drones are taking off from multiple locations simultaneously and, within 30 minutes of landing, sending him an email identifying a potential issue, or texting him saying: "No anomalies found, next scheduled flight is tomorrow at 4 pm."

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ONGOING EVOLUTION

"Drones will get more and more automated and equipped with visual positioning and collision avoidance systems, for example the Skydio 2 drone," reckons Philipp Esser, digital device product manager at Thyssenkrupp, Essen, Germany. "This way, it will be possible to program different inspection missions into drones. In combination with automated data analysis, this then allows a continuous monitoring of industrial plants. When collecting data continuously over a long period of time, advanced data analytics models can learn to predict failures and problems that slowly develop over time, which would not be possible with single, manual inspections."

Thyssenkrupp uses commercially available drones. The Skydio 2 drone cited is manufactured by Skydio, Redwood City, Calif., and combines a proprietary AI system with a 4K60-high-dynamic-range camera, a 3.5-km wireless range and 23 minutes of flight time. A mobile phone, beacon or hand-held unit (Figure 2) can control the drone.

CONVENIENT CONTROL

Figure 2. Hand-held unit can control drones sent out to detect issues and inspect equipment. *Source: Thyssenkrupp.*

Thyssenkrupp developed its original drone skills on company cement plants, mines and coke plants. While strict regulations prohibited drone use at operating chemical plants, they did serve as useful inspection tools during shutdowns, he notes.

Today, its customizable drones easily can create 3D scans or maps of buildings — and so are a very helpful tool for documentation of building processes such as new build projects. The same 3D data also ease carrying out reengineering of certain parts of a plant during revamps.

Nevertheless, inspections remain the major use of drone technologies. "Many of our customers' plants have a high thermal footprint, so we focus on thermal inspections with drones. Using drones for the inspection of bigger areas is usually quicker and safer and allows customers to get an overview of a situation from a distance, which is often not possible when walking around walkways inspecting equipment manually," he says.

Typical uses include for detecting a variety of issues, e.g., deformation (through 3D measurement), hot spots or failed insulation material, pipe congestion, and cracks or corrosion. Other common chores are estimating general heat loss and inspecting confined and indoor areas that pose health hazards to inspection staff.

"Depending on the case, we use different platforms. So, when talking about inspections, there are several ways to do it, ranging from a rather manual approach to a fully automated approach," Esser explains.

For example, during manual inspections, a customer's own experts at a site can check the live video feed from the drone. (Some of these experts have been trained to fly drones by Thyssenkrupp pilots.) Another option is to upload images to the cloud. This gives inspection staff the opportunity to analyze them and create reports from the data recorded.

Thyssenkrupp also has developed machine learning algorithms that can automatically analyze the pictures to detect critical conditions, cracks or other problems. "This way, we can filter a huge dataset and even present the critical problems on a map or 3D model of the plant. So, it is easier to, for example, localize the cause of a problem," he adds.

"What differentiates us from other drone service providers is that we have deep knowledge of the plants we are using the drones in. This makes it easier for us to find the relevant use cases and to (manually or automatically) analyze the recorded data. Most drone service providers only deliver the pictures without a report on the findings," explains Esser.

For process engineers unused to or unsure about drone use, Esser suggests booking a service that includes different inspection scenarios. "If the inspection delivers value, I would recommend to invest in drone technology and train a few people on site. This way inspections can quickly be done, regularly, without the need to book external pilots."

That way, the process engineers themselves can analyze the data, with support from Thyssenkrupp experts, or the company's data analytics algorithms.

DUAL-SENSOR MODULE

One example of an advance in drone technology occurred in July when

thermal-imaging infrared camera specialist FLIR Systems, Wilsonville, Ore., launched Hadron. The company claims the unit is the first dual-sensor module suitable for drones. It includes a 12-megapixel visible camera paired with the company's Boson 320×240 resolution thermal camera with up to a 60-Hz frame rate.

The launch followed close collaboration with drone manufacturers Vantage Robotics, San Leandro, Calif., and Teal Drones, Salt Lake City, Utah, to perfect the module for use on lightweight drone airframes.

Vantage Robotics has integrated Hadron into its microgimbal platform. It features proprietary stabilization technology as well as the dual sensor and can be fitted to existing UAV airframes and potentially other robotic platforms.

"Hadron is far and away the lightest and smallest combined visible-thermal sensor that has ever been commercially available," says Tobin Fisher, Vantage Robotics ceo. "For an aircraft where you're trying to push the limit on flight performance, every gram matters. The ability to get these sensor capabilities in a package this small makes an enormous difference," he adds.

Teal has integrated Hadron within its 1-kg Golden Eagle UAV platform. Taking advantage of the module's compact size to create a lightweight yet dynamic payload helps preserve battery life and maximize flight time on a small airframe, notes the firm.

"Hadron enables us to speed development and time-to-market for small airframes with thermal and visual sensors," notes George Matus, Teal Drones founder and CEO. "Its high quality, low weight and compact size allows for rapid integration to quickly develop prototypes."

The launch comes 18 months after FLIR acquired Aeryon, Waterloo, Canada. Aeryon's vertical takeoff and landing quad-copter airframes integrate multiple sensors, including FLIR thermal technology, to provide users with immediate high-resolution intelligence, surveillance, and reconnaissance capability — a military/industrial crossover that increasingly is driving developments in drone technology.

The Future is Circular

Chemical makers must move away from "take-make-waste"

By Peter J. Nieuwenhuizen, Enerkem

ONE WORD summed up the career advice offered in the classic 1967 movie "The Graduate." A neighbor, Mr. McGuire (played by Walter Brooke), took Benjamin Braddock (Dustin Hoffman) aside and simply said: "Plastics." McGuire had it right. Plastics were phenomenally successful. Their versatility and low cost underpinned many convenient new products and components that impacted every aspect of modern life. In fact, 1967 might well mark the high point of the public's enchantment with the chemical industry. The luster tarnished during the 1970s and 1980s as greater awareness of the industry's environmental problems emerged (see, e.g., "Earth Day is Golden," https://bit.ly/2C5dUy0).

That high point tracks very well the second of the two significant waves of innovation and development experienced by the chemical industry (Figure 1). The initial wave, which dates back to the mid-1800s, saw the emergence of the first "chemical" products such as paints and soaps derived from natural materials like oils and fats. The second wave, which began in the early part of the 20th century, exploited abundant fossil feedstocks like coal and oil to create a plethora of new products, including plastics.

However, the innovative boom of the petrochemical wave largely had run its course by the 1990s. The last 25 years mostly have seen incremental improvements. This coincided with society becoming increasingly concerned about the use of fossil fuel resources, the related carbon dioxide (CO_2) emissions, and the disposal of waste, including plastics. In fact, despite their clear sustainability benefits, plastics now symbolize all that's problematic about our "take-make-waste" economy: taking resources from the earth, making products that are used once or just a few times, and then discarding them as waste. The waste either winds up in a landfill, decomposes or goes to an incinerator, causing CO_2 emissions. Often, the waste isn't managed at all; the plastics in our oceans are but one very visible aspect of just that. In short, this *linear* nature of our business practices is the prime concern.

THE THIRD TECHNOLOGY WAVE

The first wave of chemical industry development was overtaken by the second one — slowly at first, then rapidly. Similarly, while the petrochemical wave has been flatlining, a third wave of innovation — that of circular chemistry — has started to emerge. Circular chemistry moves away from take-make-waste. It involves circular business models that don't extract fossil raw materials and that avoid wastes. These focus on three approaches: turning waste into new materials; using renewable nature-derived crops to make products; and applying renewable energy to manufacture products.

1. *Waste material recycling.* A primary strategy to change our current linear model is to use the waste that we produce as a raw material. This certainly isn't new. We've been recycling aluminum and batteries for quite a while and increasingly are retrieving valuable raw materials from electronic waste.

There's no doubt that as we move into the circular economy we will have to recycle more and more materials. A prime focus should be the enormous amounts of waste that we create, much of it municipal solid waste (MSW). Unfortunately, MSW isn't an easy material to work with. Unlike oil and gas, it is heterogeneous, containing components as different as plastics and peels. It also is variable. Even waste from one location will change in composition and humidity by season, sometimes even within one week. Using waste may require extensive sorting — by citizens or in waste sorting centers. Alternatively, you need technology that can deal with the variability. This is what my own company Enerkem, Montréal, (www.enerkem.com) has developed. It has spent 25 years perfecting a technology for gasification of household waste with as little pre-treatment as possible. The process turns the waste into a mixture of carbon monoxide (CO) and hydrogen (H_2), also known as syngas. Syngas is a great building block for chemicals and fuels. It traditionally was made from coal; even today, companies like Sasol use coal to make their products. In contrast, Enerkem syngas consists entirely of molecules that previously would have been landfilled or incinerated — it's "recycled carbon." This circular syngas can replace the oil and gas that the chemical industry currently relies upon. It can serve as feedstock for myriad products the chemical industry makes today. By using waste as a feedstock, the chemical industry tackles two important issues: fouling of the environment and dependence on fossil materials.

2. *Substitution by bio-feedstocks.* A second circular strategy uses bio-derived renewable feedstocks like sugar and agricultural biomass to replace current fossil feedstocks. Biomass is circular by definition. Plants and microorganisms take CO_2 out of the atmosphere and build biomass when they use the energy of the sun to convert it into materials like wood, sugars or vegetable fats. The chemical industry can convert these materials into the products that we use in everyday life. Moreover, doing so eliminates the problems posed by some materials such as agricultural wastes, which now are discarded or burned and add to CO_2 emissions.

Bio-based materials can be drop-in substitutes — exactly equivalent molecularly to the fossil material they are replacing — or functional equivalents — having a different molecular structure but performing the same or similarly.

Solugen, Houston, (www.solugentech.com) provides an example of the first type. This startup has identified and optimized naturally occurring enzymes that can turn sugar into hydrogen peroxide, a chemical commonly used in the production of paper products. This hydrogen peroxide is identical to that produced conventionally. However, Solugen hydrogen peroxide is biogenic and circular, derived from only natural raw materials, while current hydrogen peroxide is fossil-derived and, thus, leads to CO_2 emissions.

An example of functional equivalence comes from startup Holiferm, Manchester, U.K., (www.holiferm.com). It has developed fermentation technology to make so-called sophorolipids, natural cleaning agents produced by bacteria. They not only are excellent cleaning agents but also are non-toxic and biodegradable when they end up in the environment. Sophorolipids can replace traditional cleaning agents in many applications, avoiding fossil raw materials and emission of fossil CO_2 and hazardous substances. As the chemical industry moves away from linear fossil products, it increasingly will seek bio-feedstock substitutes to deliver the same benefits that customers are used to — but at lower impact for people and the planet.

3. *Reliance on renewable power.* The final circular strategy uses renewable electricity from wind and sun to make materials. We are in the early phases of this development but its most-talked-about example is hydrogen — particularly production via electrolysis of water (see, e.g., "Hydrogen Gives Electrolysis a Lift," https://bit.ly/30vPA1B). When the electricity for the water splitting is produced from coal or gas, the resultant hydrogen still is fossil-based. The game-changer is the development of low-cost renewable power that, over time, will give the chemical industry

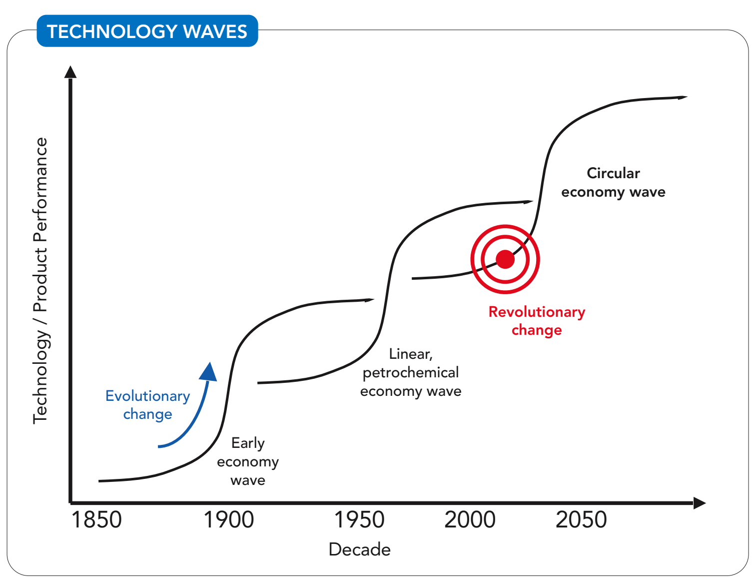

Figure 1. The chemical industry is facing challenges that will promote a circular economy.

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a cheap source of electricity. This will enable production of hydrogen without emission of CO_2. This hydrogen can serve as a feedstock for chemical making and as a transportation fuel. The holy grail is to convert CO_2, extracted at sites that emit lots of CO_2 such as power plants, and react it with hydrogen. This makes chemicals in a process comparable to how Enerkem turns syngas from waste into chemicals. While profitable commercial exploitation still is a long way off, we surely will see exciting developments in this field in the next 10–20 years.

INFLECTION POINT AND CHALLENGES

Solving the plastic waste crisis, moving away from oil and gas, stopping emissions of CO_2 and hazardous substances — in short, moving to a circular economy — will pose a challenge of massive proportions. It will take society at least a generation, maybe two. The pervasive role of chemicals in our lives means the chemical industry must make a vital contribution to this transition. For every linear take-make-waste solution existing today, the industry must develop an alternative that uses bio-based or circular raw materials or renewable energy. It also must devise a circular business approach to deal with all the waste caused by its products. Tackling the plastics in our household waste is only the beginning.

Can we even do this? Based on experience, there should be no doubt. Just looking back at how the second wave of chemical innovation transformed the world in little over 50 years should give us confidence. As a society, we have the ingenuity, creativity and resolve to come up with products and solutions to vastly improve

human existence. The sheer number of circular developments and startups shows that we have come to an inflection point of circular chemistry: the moment that a trickle becomes a stream and when industry participants accept that, this new technology wave will break through.

That said, there will be challenges. First and foremost, circular approaches generally are more expensive than the take-make-waste approach that we've followed so far. Fossil raw materials were made by planet earth "for free" and disposing of our waste and CO_2 has incurred limited cost. To make circular approaches competitive, governments can facilitate and stimulate industry and its customers. For example, government can mandate that all plastics contain a certain, increasing amount of recycled material. Or it can regulate the maximum amount of fossil-derived ingredients allowable in common cleaners, stimulating producers to find bio-derived alternatives. Last but not least, government can set a price on emissions, such as is being proposed for those of CO_2. Such edicts will compel producers to innovate, looking for new solutions to comply with these measures in the cheapest possible way. This will generate new jobs and wealth.

A second challenge is the availability of capital to finance the startup and scaleup of circular approaches. This is particularly important at times of radical change, when existing companies may be stuck in old ways. New startup companies provide essential innovation dynamism and speed to make the transition to the new technology wave. Although more capital is needed, we are seeing an increasing availability of funding for the circular transition. For example, the European Commission and the European Investment Bank recently announced the European Circular Bio-economy Fund (www.ecbf.vc). Ultimately with €250 million to invest, it will provide funding for late-stage startups, closely aligned with the European Green Deal (https://bit.ly/33vsqKM).

A WORD TO THE WISE

As the cliché goes, the stone age didn't end because we ran out of stones. We just moved on to something better. Equally, the petroleum age won't end because we will run out of crude oil. It will end because we will move on to a better way of making products — one that doesn't rely on extracting fossil materials and turning them into waste and CO_2 emissions. Rather, we increasingly will employ circular processes, using waste, biomass and renewable energy. The chemical industry will play a vital role harnessing these technologies to supply the ingredients, components and materials needed to produce all those essential convenient everyday products that make up modern life. Are you looking for a promising new business for the coming decades? Focus on one word: circular. ●

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Get the Most from Your Screw Conveyor

Pay attention to a number of factors to ensure smooth operations and long life

By Jim Collins, KWS Manufacturing, and Aaron Mire, Motion Industries

WHAT ARCHIMEDES created centuries ago is still one of the most versatile means available to processors for providing enclosed transfer of materials. Indeed, Archimedes' screw forms the foundation for devices conveying thousands of products, ranging from dry and free-flowing to wet, sticky and sluggish. While moving materials horizontally, vertically or at an incline, this conveyor's wide range of configurations, components and construction materials suit it for handling the most problematic materials and application requirements. This versatility makes the screw conveyor the most common mechanical bulk solids conveyor in the marketplace.

At its simplest, bulk materials enter the screw conveyor, riding in the bottom of the housing as the screw shears through the substance, moving the product forward with each revolution and pushing it closer to its destination. A typical screw conveyor consists of flights mounted on a pipe in an enclosed housing, supported by bearings (Figure 1). The most common housings are U-shaped, but specific applications may require tubular troughs. An installation can use one or more screw sections to cover the desired distance. For longer conveyors, hanger bearings suspended from the top of the trough can support multiple screws between each section. Another way to cover longer distances without excess deflection is to increase the pipe diameter or allow the screws to ride in a special liner installed in the housing. The inherent design of the screw conveyor enables providing multiple inlet and discharge points if desired.

Screw conveyors are totally enclosed with trough covers for safety and material containment. Using a flanged cover bolted on 12-in. (or closer) centers with a high-quality compressible gasket between the trough and the cover is the most effective way to get a tight seal on a screw conveyor. Gasket material is available in black for standard applications and white for chemical, food and other sanitary applications. The cover is manufactured from stainless steel or carbon steel to match the trough construction materials; the thickness of the cover's steel and its turned-down edges provide rigidity, improving its ability to seal the trough. Very dusty applications may require thicker covers that provide additional rigidity.

Many applications, including myriad ones in chemicals manufacturing, demand screw conveyors with special config–urations and construction materials to decrease maintenance, operating costs and incidents of premature equipment failure.

TYPICAL SHAFTED SCREW CONVEYOR

Figure 1. Although developed in antiquity, the design suits myriad modern applications. *Source: KWS Manufacturing.*

DESIGN AND INSTALLATION

Calculating the demand load based on material characteristics and selecting appropriately sized screw components (trough, pipe, flights, shafts, bearings and motorized drives) is crucial for an accurately designed screw conveyor. A properly designed and installed screw conveyor should satisfy the needs of any tough application for many years.

As with many other types of rotating equipment, screw conveyors require proper alignment to achieve successful, long-lasting operation. The easiest way to check alignment is with a string. Secure the string line to one end of the screw conveyor at the trough-end centerline, and pull the string line tight to the opposite end of the screw conveyor. This will let you see misalignment of the trough sections.

The screw conveyor's full length must be aligned both horizontally and vertically. You should check for both horizontal and vertical misalignment every five feet with a measuring tape. Measuring the distance from the string line to the edge of the trough horizontally shows the screw conveyor misalignment in the horizontal direction. Similarly, measuring the distance from the string line to the trough flange's bottom gives the vertical misalignment. Document each horizontal and vertical measurement. The relative differences in the measurements indicate how much you must move each trough section to achieve proper alignment. (For more information, see: "Screw Failures," https://bit.ly/2PwghwM).

Screw conveyors that are longer than, say, 25 ft, can create a common misalignment problem with multiple hanger bearing locations. Because the screw is fixed at the bearing locations, misalignment causes application of bending loads at the hanger locations that are immediately reversed during every revolution. The effect of these cyclical forces is similar to that of bending a paperclip back and forth until it breaks. Cyclical loading finds the weakest zone of the screw, which normally is close to the hanger bearings, in the screw bushing area. So, fatigue due to misalignment is the culprit for failures at or near the hanger bearings. This fatigue failure is the reason for a clean break in the affected area.

An alternative to multiple screw sections and hanger fatigue problems is to mount the screw on larger-diameter pipe with a heavier wall thickness to span longer distances, while decreasing deflection and eliminating the need for hanger bearings.

PRODUCTS, PROBLEMS AND SOLUTIONS

Some services call for use of stainless steel for all product-contact surfaces in the screw conveyor to prevent contamination or corrosion. Using a carbon steel screw in these applications isn't appropriate; instead, a stainless steel ribbon screw (with a shaft) is the best option. To provide successful release of sticky material and avoid buildup, specify polishing of the ribbon screw flight surfaces or the entire screw to a fine finish or electropolishing to a mirror finish. Another option is coating the screw and conveyor surfaces with a nonstick material, such as polytetrafluoroethylene (PTFE), suitable for your application.

When conveying wet or sticky material, sticking product can lead to clogging and reduced capacity. In such services, an appropriate choice is a conveyor with shaftless screws without a center pipe to eliminate areas for the product to stick. Such a conveyor normally has a high-strength carbon steel spiral and a stainless steel trough with a reduced-friction liner and high-torque drive unit.

Conveying abrasive materials like titanium dioxide calls for screw conveyors manufactured from specific abrasion-resistant materials. Standard carbon steel and stainless steel components will wear rapidly in these applications, causing frequent conveyor maintenance and downtime. To avoid higher operating costs and premature equipment failure, opt for screw flights made from abrasion-resistant plates or have hard surfacing applied to the flights, pipe or troughs. The hard surfacing itself can comprise various blends of carbon, chromium, tungsten, cobalt, molybdenum and other exotic materials applied over softer standard construction materials to extend component life and decrease unnecessary downtime. The best combination for your application depends on the conveyor component's base material, as well as your conveyed material, application requirements and operating environment. (See: "Screw Conveyor Solutions for Four Problem Applications," https://bit.ly/3fwM0IZ).

In a heat-transfer screw processor (also called a heating or cooling screw conveyor), a heating or cooling medium continuously circulates through a hollow trough jacket or the screw (or both) to move heat to or from the material. In the screw, the medium flows through the pipe or hollow flights.

Some bulk materials will tend to pack under pressure during conveying; this packing will form a hard layer in the bottom of the housing. Often, the layer will break loose in pieces and be conveyed downstream. Then, a new layer will form and again break loose. In rare applications, a bulk material will create a permanent layer in the housing's bottom. This layer will build up over time and result in screw deflection in the center. Because each screw end is held fixed by the bearings, the pushing up of the screw in the center causes enormous cyclical forces on the center pipe of the screw as it rotates. Every revolution of the screw results in a

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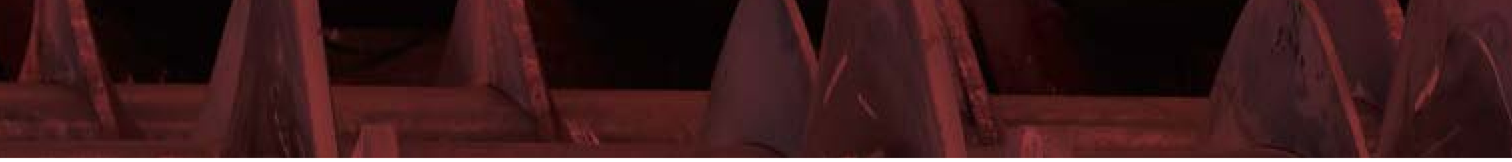

complete reversal of the center pipe's forces. Fatigue failures often are simple to identify because the break is virtually perpendicular to the center line of the screw conveyor and typically occurs in the screw sections' center. A solution is to add trough liners to decrease the gap between the outer diameter of the screw and the housing (Figure 2). If the material layer is very thin, then it will break loose and be transferred downstream. Using a ¼-in.-thick abrasion-resistant plate for the liner material will provide longer life than mild steel.

Adding cutter teeth or weld-on hard surfacing to the outer diameter of the screw flights is another option. This decreases the gap between the screw and housing as well as affords a surface to cut through the hardened layer. Carbide teeth on the outer diameter of the screw will cut through almost any hardened material in the housing.

As stated previously, the key to solving the problem is removing the hardened material in the bottom of the housing. Pairing use of liners with either mounting the screw on larger pipe or adding cutter teeth most certainly will solve just about any issue of this kind.

SHAFTLESS CONVEYOR WITH TROUGH LINER

Figure 2. The ceramic lining enables smooth conveyance of wet or sticky materials. *Source: KWS Manufacturing.*

CANTILEVER DESIGN

Figure 3. This effectively handles applications such as hydrofluoric residue conveying/bulk handling. *Source: KWS Manufacturing.*

SOLVING A SPECIFIC PROBLEM

A processor used residue screws of a cantilever design (Figure 3) — in this case, a custom version, 17½-ft long and 11½-in. in diameter — for an application involving extreme temperatures, hazardous gases and abrasive product. To meet the plant's preventative maintenance program for its equipment, the screws must last at least 9 months. Another supplier had attempted to reduce the cost of the screws with a solid shaft inserted the length of the pipe, but those screws only lasted 3–4 months before failure.

After a few meetings and site visits with a third-party specialist to see the equipment in operation, a new design was engineered. It features Hastelloy for better sealing, a custom drive shaft heat-shrunk deep into the pipe, sectional flighting with specific hard facing for the application and particular tolerances. The new design not only met the operating company's price point target but also, more importantly, provided the design life needed. This has resulted in a large cost saving by avoiding unnecessary teardown of the equipment due to a failed screw.

SOLID ADVICE

The centuries-old, simple and reliable screw conveyor remains the best option for many applications. Optimizing a device for a particular service requires an understanding of the factors that contribute to a screw conveyor's performance and life. Making the right choices is the key to increased production and elimination of unnecessary downtime and maintenance costs. ●

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Intelligent Wearables Transform Operational Performance

Technology helps improve safety, productivity, compliance and knowledge transfer

By Roberto Velasco Gutiérrez, Braskem Idesa, and Veronica Turner, Honeywell

BRASKEM IDESA'S Nanchital plant in Veracruz, Mexico, is the company's flagship manufacturing site. It is one of the largest integrated polyethylene (PE) facilities in the Americas, producing 1.05 million tons of ethylene and PE per year from ethane. The plant was built to reduce the gap between Mexico's local PE production and demand and to satisfy increasing requirements of the plastic processing industry.

A joint venture between Brazilian petrochemical company Braskem and Mexico-based Grupo Idesa, the firm was formed in 2010 and began production in March 2016.

To strengthen its competitiveness and position the company for Industry 4.0, parent company Braskem drew up plans for the digital transformation of its global businesses. The initiative mainly focused on three areas: production, logistics and administration. It resulted in identifying a number of operational improvements at the Nanchital plant that digital technologies likely could deliver.

CLOSING A GLARING GAP

One key area of concern was the widening disparity between the technology found in the control room and that used by workers around the plant. While Braskem Idesa's control room operations had evolved steadily in line with the latest advances in process automation, its field staff continued to manually perform many tasks such as taking equipment readings, solving operational problems and conducting field training. Use of laptops, tablets, mobile phones and other portable technologies around the plant was sporadic.

Field training was a particular concern because the new generation of workers Braskem Idesa was trying to attract were conditioned to learning with the support of technology aids. Training new operators at a pace faster than normal for the petrochemical industry was a major challenge for Braskem Idesa, and innovative technology would certainly help to achieve this goal. In addition, knowledge transfer from experienced operators to the new ones was also a concern.

The technology gap also was noticeable when field staff conducted inspections around the plant to identify situations that might require maintenance or reliability attention, detected through observation or field readings. Whenever such a situation was spotted, field operators used traditional radio communication to alert control room supervisors. However, the people in the field lacked cameras or video equipment to help capture and convey the finer detail or urgency of the issue. Without the full picture, the control room couldn't always authorize the fastest, most effective response.

To bridge the divide, Braskem Idesa decided to equip its field workers with the latest digital technology. By empowering workers to increase safety, reliability and productivity at Nanchital, the company believed the monitoring and control of the site's production process would significantly improve — leading to safer operations, enhanced profitability and business success.

The initiative was christened Cyclops, after the mythological creature with one eye. In many cultures, a single eye symbolizes intelligence, wisdom and enlightenment — one who is "all-seeing." Braskem Idesa started activities related to the initiative in November 2018.

To turn its Cyclops vision into reality, Braskem Idesa conducted a thorough search for a technology partner and selected Honeywell, a pioneer and market leader in intelligent wearable devices. Honeywell not only shared the company's vision but also offered proven technology and a competitive cost/benefit ratio. Honeywell subsequently proposed an outcome-based solution comprised of hardware, software and services, plus supporting plantwide WiFi infrastructure.

INTELLIGENT WEARABLES PLAY KEY ROLE

The centerpiece of the Cyclops initiative is — appropriately — an intelligent, digital visual display built into a lightweight hard hat (Figure 1); it is designed to improve productivity, collaboration and compliance with process procedures, capture the expertise of experienced workers and provide critical insights and information to field-based trainees and support staff. By incorporating Honeywell's Intelligent Wearables program, a combination of hardware, software and services, Braskem Idesa benefits from technology that responds to voice commands and software that brings live data, documents, work procedures and health and safety information into view. It also captures and streams live video and pictures back to the control room, facilitating a fast, effective response to unfolding incidents.

Honeywell supplied its intelligent wearable devices for plantwide use with a range of software applications to help field workers improve speed, safety and reliability.

For example, workers needing support or advice can call via their voice-controlled headsets an expert in the central control room or elsewhere who can then provide input in real time. Honeywell calls this application Expert on Call. Recently, this helped avert a potential incident that could have put lives at risk. A field operator spotted a developing gas leak and contacted Expert on Call for help. The instant availability of knowledgeable resources and specific guidance on how to stop the leak reassured the operator, enabling him to calmly carry out the necessary procedure.

In addition, embedded video support eases troubleshooting; field workers can view videos that demonstrate key tasks wherever they may be in the plant. Video also allows field operators to share unfolding incidents with control room supervisors and make instant collective decisions on how to contain them. In the past, supervisors typically had to see reported issues for themselves — sometimes leading to a 20-min. delay before any action was taken.

Meanwhile, common and complex tasks such as inspection rounds have become easier thanks to voice-controlled software that provides step-by-step instructions and eliminates the need to carry clipboards, pens and flashlights.

Moreover, the intelligent wearables are helping field workers to expedite routine tasks such as monitoring equipment startup and shutdown (Figure 2), inspecting and verifying raw material shipments, collecting evidence of unsafe processes and conditions around the plant, and streamlining the delivery of equipment for maintenance.

On a strategic level, the solution is helping Braskem Idesa capture and share expertise and data throughout the organization and provide Nanchital's 200 field operators with relevant information and insights wherever and whenever

HIGH-TECH HARD HAT

Figure 1. Lightweight unit features an intelligent built-in visual display and can capture and stream videos.

MONITORING STARTUP/SHUTDOWN

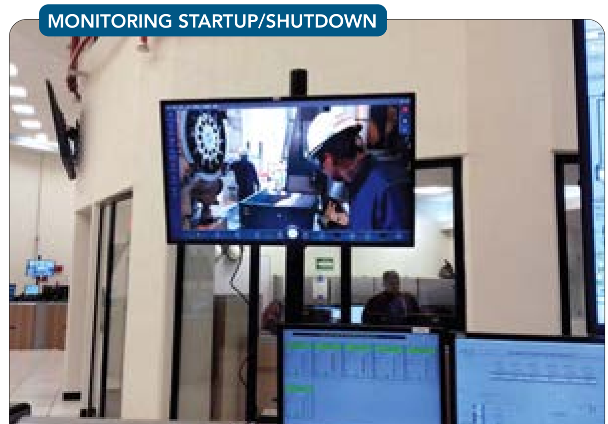

Figure 2. Intelligent wearables enable visually following activities to change the status of equipment.

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"If You Let It, Technology Transforms Procedures and Enhances Safety," https://bit.ly/3gqbGId

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required. Connecting field workers with remote advice also reduces the need for site visits from experts and empowers workers to continue learning, share knowledge with peers and perform to Braskem Idesa's best standards.

Nanchital's field workers resoundingly have embraced Honeywell Intelligent Wearables. More-experienced engineers cite the radical increase in education and knowledge transfer. In addition, the innovative design naturally appeals to newer engineers. Indeed, Braskem Idesa feels that intelligent wearables provide a strong incentive for next-generation talent to join the company. Moreover, their use underscores its strategic ambition to lead the implementation of Industry 4.0 in Latin America.

SUCCESS SPURS MORE MOVES

Based on the implementation's success, Braskem Idesa is planning additional deployments of Honeywell technology at Nanchital to tackle business challenges such as meeting tightening environmental and safety standards, improving compliance while achieving cost savings, reducing waste and increasing plant efficiency.

One of the next implementations will focus on optimizing inspection rounds. Nanchital will use software that's part of Honeywell's Forge suite to digitalize workflows, to enable increased compliance during field operator rounds, reduced manual effort and enhanced collaboration and decision-making between the field and control room.

Additionally, given the enthusiasm for intelligent wearables evident at Nanchital and their impact on performance there, parent company Braskem is closely following the results of the Cyclops program with the intention of implementing it in selected sites around the world.

For both Braskem and Braskem Idesa, Cyclops marks a milestone along a carefully orchestrated Industry 4.0 journey. Significantly, it puts a company's most valuable assets — its skilled plant workers — first. ●

ROBERTO VELASCO GUTIÉRREZ is Coatzacoalcos, Mexico-based industrial director of Braskem Idesa. **VERONICA TURNER** is business development leader at Honeywell, Houston. Email them at roberto.velasco@braskem.com and veronica.turner2@honeywell.com.

Are Fractionator Failings Fixable?

Renovated distillation column poses numerous issues

THIS MONTH'S PUZZLER

We replaced corroded internals and did numerous repairs called for after an inspection of our distillation column. Among the projects, we swapped out pipes and cleaned the feed/product heat exchanger and the reboiler, and put in new control valves and a new feed flowmeter. We've now commissioned the unit but are unhappy with the results: product quality from the condensers is marginal; the temperature profile is "unusual" and we can't increase rate through the tower as expected. I suspect the commissioning work either didn't follow company guidelines or was poorly managed.

My sleuthing uncovered several issues: 1) pressure readings appear to be lower than expected; 2) the inspector found a number of trays disrupted; 3) that person also discovered several additional broken valves, which apparently has been an on-going problem for the last three years; 4) an inspection by the company responsible for relief valve maintenance detected severe fouling on the relief valve located on the top head — previously, we had cleaned the valves before sending them to the shop, so the inspector didn't see their as-removed condition; 5) the temperature readings also seem out of whack; 6) the corporate engineer who was responsible reckons the new feed flowmeter is the culprit for the poor tower performance and claims he left its calibration to us. When I asked about hydro-testing and cleaning prior to turning the unit over for commissioning, the supervisor didn't have any paper work to share; he sent me to the constructors, who said I'd have to get approval from the corporate project engineer. I can't find much in the files. I talked to maintenance, hoping to find some commissioning reports, but only found a few case files of what they did in the past when they were in on commissioning.

What do you think went wrong? What can be done to get us back on track?

CONSIDER THREE POSSIBLE ANSWERS

The Puzzler presents many different problems but not really enough details except for some generalities. This reply only addresses three of the six questions posed by the engineer.

Question 1: Why do pressure readings appear to be lower than expected? Column pressure is a measure of vapor mass inventory in the column. Vapor mass inventory balances by reaching a steady state based on enthalpy in (feeds plus reboiler duty) equaling enthalpy out (products plus condenser duty). Column pressure controls adjust some combination of enthalpy flows so pressure is stable at a steady state. If the overhead exchanger is cleaner, a lower differential temperature (DT) is needed to remove the required condenser duty. Some column control configurations will allow the column pressure to drop to reduce the overhead DT and to move the overhead condenser duty to meet the enthalpy balance. If not pressure controlled but allowed to float until enthalpy balance is reached, a lower-than-expected tower pressure is the result of (a) higher condenser capacity than before, (b) lower reboiler capacity than before, and (c) colder feed. The comments here focus on the condenser because of the notation that the overhead relief valves were fouled. Perhaps the overhead exchangers were fouled as well and now are clean?

Question 2: Why did the inspector find disrupted trays? Damaged or blown-out trays never are good for performance. Is there any evidence that trays are disrupted in the current unit? Tower pressure profiles would be one way to catch if trays are blown out. A normal pressure profile for a sieve or valve tray on a 24-in. spacing would show a pressure drop of 0.06–0.15 psi per tray. Numbers might be higher or lower than this if specialized designs are used or in unusual systems. Other ways to verify if trays are disrupted are to look at thermal scans of the vessel or to get a service to gamma scan the column. The three leading causes of tray disruption are flash vaporization due to water entering a hot tower, high liquid levels at startup, and improper installation.

Question 6: Would feed flowmeter miscalibration cause tower problems? This might happen if the calibration was terrible and an attempt was made to run the tower at absolute maximum capacity. However, the flowmeter by itself causing the problem is unlikely. Most conventional trays will run well at rates between 50–100% of design and routinely can be pushed to around 110% of design if standard design margins were used. If the tower has been modified in the past, the original design "allowance" already may have been used and flexibility might be less. Within plant constraints, vary the feed rate by -20% to +10% of normal rates. If performance does not change over this range, it's unlikely to be a flowmeter problem. At the limit, you can check flowmeter rate by looking at the pressure drop and valve position on feed control valves. This typically will allow you to estimate a rate within 5%.

Andrew Sloley,
principal consultant
Advisian, Houston

EVALUATE THE NEW INSTRUMENTS

Consider the following related issues:

1. Causes for not being able to establish normal feed rates to the column could be external to the column, column internals, or both. Conduct a pressure survey to identify sources of flow restrictions. Use one accurate pressure gauge or pressure transmitter and take head pressure corrections into account. Although it would be relatively easier to correct flow problems in the feed line, similar correction in the column could be cost-intensive; locating restrictions in the column interior may require an x-ray of the column. Of course, this could be pricey but will help you spot internal restrictions or errors in installation and subsequent planning for opening the column and repairs.

As an extension to the above, if the feed control valve stays more than 75–80% open at your current flows, the control valve probably is too small. For a short time only, try opening the bypass around the control valve to see if that helps improve flows.

2. Because pressure and temperatures are lower than normal, there could be several external (to the column) causes: flow of heating medium to the reboiler — if the heating medium is steam, you must make sure steam traps are working properly (e.g., for a short time, you may bypass a steam trap to see if steam flow can be increased); a pressure survey around the reboiler could show if there is restriction in the reboiler.

3. The flow meter malfunction could stem from many causes, including, for example, flow meter selection, installation and calibration. Without information on the process liquid, it is difficult to come up with specific recommendations. As a rule of thumb, though, the flow meter should follow upstream and downstream straight run requirements; for "fouling service," avoid flow meters such as turbine meters and orifice plate/dP cells with impulse lines. Calibration could reveal problems such as zero-offset and non-linearity.

You also hinted at a management issues that need to be corrected. Consider updating procedures for project

CHECK OUT PREVIOUS PUZZLERS

To see all the Puzzlers that have been published over the years, go to: www.ChemicalProcessing.com/voices/process-puzzler/.

execution and responsibilities. Ensure proper records are developed. It may seem, at times, that the documentation slows you down but, in the long-run, proper documentation is priceless and, in some cases, is a regulatory requirement.

Before Operations accepts a project, make sure all inspections have been performed and verified. In one incident I encountered, the cause of premature flooding in a column was traced to inadequate clearance of chimney trays. In the hurry to get the column up and running, this detailed inspection inadvertently had been left out.

GC Shah, senior advisor
Wood, Houston

FOCUS ON FOULING

Clearly some of the problems with the tower have been going on for a while but recent improvements in inspection procedures now are identifying them. Other issues may have been caused by attempts to increase tower throughput. In addition, commissioning errors may have created a fog so that these two categories are difficult to discern.

Based on the fouling at the top of the column, it seems obvious that condenser fouling limits the tower. I'm not sure what fouling has to do with the tray valves but it's clear that this should be the real goal of the efficiency effort.

Your first step is to capture a sample of the material that fouled the relief valve. After that, sample other areas — focus mostly on the condenser side but don't leave out the reboiler and feed preheater. Also, sample the trays as well as upstream and downstream streams. If you can't sample everything now, get what you can and obtain better samples next time; this issue isn't going away — it's been there for years.

As for the flow meter, I wonder if it is over-range. I have seen this problem before — where a meter was operating near the maximum and, with an equipment increase, a larger instrument is installed that won't cover the full range of the measurement unless the throughput increases. The same setback can occur with control valves where they operate poorly at the lower range of their curves.

Obviously, you're in a political pickle. The corporate engineer blew it and has some control over the plant managers. If you can solve this problem without stepping on any toes, you will win the gratitude of the managers and perhaps even those in corporate. The trick will be avoiding bringing up that farce of a hydro-test and focusing on the fouling problem in the tower. Your next step is to review the procedures and contracts to ensure this type of mistake is prevented.

Dirk Willard, consultant
Wooster, Ohio

NOVEMBER'S PUZZLER

We shoot sulfuric acid into our yeast fermenters as a nutrient. When we bought the facility three years ago, it had two fermenters. Since then, we've added another fermenter as well as expanded our packaging lines and other parts of the plant (see Figure 1). We now are seeing delays in the injection time that are affecting our yields. We must inject the right amount of acid during a precise ¼-hr window to maximize yield and product quality.

I think the culprit is compressed air, which we ignored in the expansion. I generated a diagram of the users of the compressed air system.

The technology expert at corporate instead blames corrosion in the valves in the top of the acid egg. "I've seen it a dozen times," he declares. He also says the actuator may be fouled. The air for the valves used to come from the compressor but a new instrument air system was installed to eliminate oil that was fouling control valves.

I talked to the boiler-house operators who manage the compressor. They note the compressor tripped several times in the last three months and the dryer is having trouble keeping the air wet bulb down to -20°F — in fact, they say it sometimes runs at 32°F. This brought a "See, I told you" from the corporate engineer, who claims the water in the air was causing corrosion in the acid egg valves. The operators also mention a drop reported in pressure whenever the new packaging line is running. The foreman there tells me that half the lines frequently are down. The fermentation operator says blowing down the egg line after shots leaves acid in the lines.

Do you think corporate is right? Is there anything we can do about the problems with the compressor?

Send us your comments, suggestions or solutions for this question by October 9, 2020. We'll include as many of them as possible in the November 2020 issue and all on ChemicalProcessing.com. Send visuals — a sketch is fine. E-mail us at ProcessPuzzler@putman.net or mail to Process Puzzler, *Chemical Processing*, 1501 E. Woodfield Rd., Suite 400N, Schaumburg, IL 60173. Fax: (630) 467-1120. Please include your name, title, location and company affiliation in the response.

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

FERMENTER FIASCO

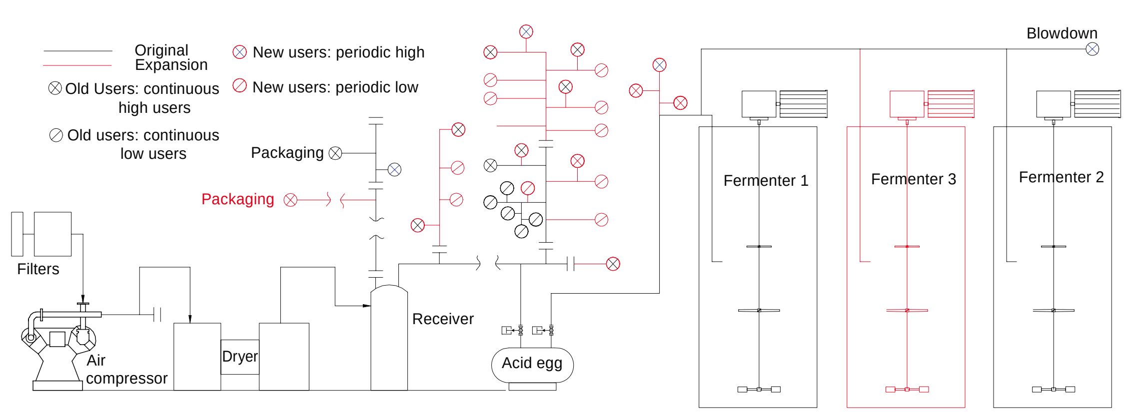

Figure 1. Problems with injecting acid into the fermenters are decreasing yields and product quality.

Scrutinize Superheating of Compressor Feed

Using a saturator often can provide significant benefits

Reducing compressor temperature can increase compressor capacity.

COMPRESSOR SUCTION saturators can serve to reduce superheating of compressor feeds — perhaps even to drop the compressor suction all the way to the dew point at the inlet. The two major reasons to decrease or eliminate superheat in compressors are (1) to control the temperatures in the compressor or (2) to cut the head required.

The gas's temperature rises through the compressor. Too high an inlet temperature yields too high an outlet temperature. Two of the many reasons for wanting to control temperatures in a compressor are to avoid interstage cooling requirements and to reduce fouling.

In cryogenic liquid storage, heat gains vaporize part of the liquid. The vapor formed, typically called boil-off gas (BOG), if not usable, must be compressed and then recondensed. A BOG compressor often has very cold suction conditions to enable multiple stages and achieve high discharge pressures without needing interstage cooling. For such a compressor, a refrigeration system would have to provide the interstage cooling. So it's convenient and cost effective to avoid the interstage cooling. Essentially, the compressor is its own refrigeration system. The temperature limit in this case comes from the limits on compressor seal system.

In other systems, reactive feeds foul the compressor. The hotter the operating temperature is, the higher the reaction rate — and the fouling rate. Cooling the compressor feed increases run duration between cleanings and reduces machinery problems from fouling deposits. In extreme cases, some reactive systems (such as certain polysilicon ones) become explosive if the temperature gets too high.

Reducing compressor temperature can increase compressor capacity. Lower temperature feed has a higher density, so more mass can enter a capacity-constrained positive displacement compressor. In a centrifugal compressor, the lower temperature (and higher density feed) decreases the polytropic head required for a given discharge pressure.

Table 1 compares three types of suction desuperheaters, including two common options.

For a liquid source with enough pressure, the cheapest option is an in-line desuperheater. It allows easy control of the amount of superheat. This type of desuperheater requires injecting liquid through a spray device into the vapor. This imposes pressure drop on the liquid. The best implementation uses a variable-area constant-shear (constant pressure drop) injection system. This helps keep the liquid drop size constant.

If liquid isn't available at high enough pressure, a bubbler often is a good choice. The liquid only needs to be at the gas pressure. Vapor is bubbled through a distributor below the liquid surface to create saturated vapor. The equipment is simple and nearly foolproof.

The bed approach will work but often requires much higher expenses for internals and controls. So, its use is rare — and usually should be questioned. ●

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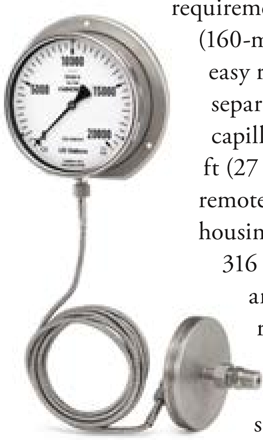
COMMON SATURATOR OPTIONS

	Type		
Factor	**In-Line**	**Saturator Bed**	**Saturator Bubbler**
Action	Injects liquid into the gas	Runs vapor counter-current through a vessel with contacting internals	Injects vapor below the surface in a pool of liquid
Requirements	Higher pressure liquid available		
Pressure drop on vapor	Very low	Low if packed	Depends on liquid depth
Knock-out pot required upstream of compressor	Yes	Yes, but may be integrated with saturator vessel	Yes, but may be integrated with bubbling vessel
Cost	Low if liquid available at sufficient pressure but can be much higher if pump is necessary for liquid injection	High because requires large vessel and most extensive controls — pump or other liquid-handling equipment likely needed	Medium because vessel is smaller and level control is straightforward
Temperature control via	Varying liquid rate	Vapor bypass	Vapor bypass
Superheat control	Simple if full saturation is not desired	Simple if full saturation is desired	Simple if full saturation is desired
Effectiveness	High	Temperature control may be slow	Temperature control may be slow
Comments	Best implementation uses constant-shear variable-area injection device	Overly complex and costly without any significant benefit over bubbler vessel	

Table 1. Usually choose an in-line device, whenever suitable, and generally avoid a saturator bed.

Gauge Measures Liquid Level in Tanks

The TC tank level gauge provides liquid level measurement for any shape vented storage tank or vessel. The analog dial is scaled to customer requirements, while the 6-in. (160-mm) size provides for easy reading. Indication is separated by an integral capillary line, up to 90 ft (27 m) facilitating the remote mounting of the seal housing. A choice of Type 316 stainless steel fittings and mounting configurations allow for either external or internal (submerged) installation. The model does not require power; this makes it an ideal primary indicator or back-up for electronic devices.



Ashcroft Inc.
203-385-0635
www.ashcroft.com

Conveyor Design Prevents Contamination

Model 1450 is a flexible screw conveyor with a 4½-in. (114-mm) outer diameter polymer conveyor tube and carbon steel floor hopper and discharge housing. Round, square, flat or beveled flexible screws in any length from 10 to 40 ft (3 to 12 m) convey free- and non-free-flowing bulk material including products that pack, cake, seize, smear or break apart. The only moving part contacting material is the inner screw, which self-centers as it rotates, providing ample space between the screw and tube wall to minimize or eliminate grinding. Fully enclosed, the conveyor tube prevents product and plant contamination, while the gentle rolling action imparted by the screw prevents the separation of blends.

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

Mixing Skid Maintains Batch Uniformity

The newly designed model VSL-400 is a customized conical vessel on a movable skid with a progressive cavity pump rated for 10–30 gal/min. It is capable of mixing and pumping low-to-moderately viscous products. A 5-hp inverter-duty motor drives a flange-mounted turbine mixer equipped with two axial-flow impellers. The 34-in.-dia. upper blade and 18-in.-dia. lower blade maintain batch uniformity from start to finish of the pumping sequence. Both mixer and pump are controlled from a NEMA 4 weather-proof control panel which includes a thermal protection system that disengages the pump motor if a set temperature is exceeded.

Charles Ross & Son Company
1-800-243-7677
www.mixers.com

Control System Surveys Field Assets

The Master Controller is an information system providing complete monitoring, control and management of field assets — both remotely and on-site. A flexible interface and customizable master screen are designed to provide process equipment management, complete pump monitoring, 32-channel gas detection system management, location status at all levels, emergency shut-in and notification, on-site controls, as well as remote cellular and computer interaction. The system includes PLCs; wired and wireless communication; secure cloud storage; telemetry; real-time data logging; generated charts and reports; alerts received by SMS text messaging or email; remote access and control of equipment, and more.

Otis Instruments
979-776-7700
www.otislink.com

Electric Diaphragm Valve Offers Fast Cycling

The eDiastar 5-Series diaphragm valve with the dEA smart actuator allows fast retrofitting of GF manual diaphragm valves without disassembly. The valve is designed to regulate and close volume flows automatically. The system addresses automation of hand-operated valves that are isolated or not accessible to a compressed air system thereby preventing actuation. The valve can be controlled as open/closed, 4–20-mA positioning, Profibus or Modbus. Available materials are PVC, CPVC, polypropylene, ABS, and PVDF in sizes 1- and 2-in. (d32 and d63). Pressure rated at 150 psi, end connections can be ordered in socket, threaded, flanged, fusion socket, or fusion spigot.

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ADVERTISER INDEX

Chemicals Drive Car Advances

Developments in technology and materials focus on improving automobile performance

Advanced plastics are the norm in automobiles.

OPINIONS DIFFER, but the relationship between the automobile and chemical industries probably began with the invention of the rigid thermosetting plastic bakelite in 1907 and its use by Rolls Royce for the knob on a gear lever.

Today, advanced plastics are the norm in automobiles — and their influence only continues to grow.

Henkel, Düsseldorf, Germany, for example, has taken aim at engine covers, transmission covers and electronic components integrated with a growing number of plastic parts that need to be sealed to the core component unit.

At the moment, the most commonly used plastic-to-metal substrate sealing method is the press-in-place (PIP) process. This involves manually applying a solid rubber gasket or O-ring onto the parts; it risks displacement during compression.

The company's new Loctite AA 5884 polyacrylate gasketing technology makes possible the direct dispensation of a liquid gasket onto the customers' part.

These static gasket materials positioned between two flanges held together by fasteners close the gaps between these surfaces to prevent leakage of fluids or gases. Automated, high-precision equipment applies a bead of liquid elastomer to form the gaskets. To keep the sealing functional and leak-free for a prolonged period, the gasket must resist the medium being sealed. At the same time, it must withstand the application's temperature, pressure and the joint's micro-movement.

Ultraviolet light within seconds cures the liquid gasket, which becomes a solid compression gasket with no knit line. This reduces the risk of rework and leakages. It also lowers the overall cost by automating the gasketing process and eliminating the inventory and complexity of the PIP solid gaskets.

Meanwhile, high-performance automotive component supplier Husco, Waukesha, Wisc., in collaboration with SABIC, Sittard, the Netherlands, plans to develop innovations for next-generation vehicles based on Ultem resin polyetherimide (PEI).

Husco has over a decade of experience with Ultem resin. It uses the PEI in components for the electro-hydraulic control valves that govern variable valve timing, variable displacement oil pump control, and cylinder deactivation control — all of which enhance fuel efficiency and vehicle performance.

"We require extreme precision and micron-level dimensional stability across a broad temperature range that starts at -40°C and goes up to well over +150°C in applications like engine valve components, which need to survive sometimes as many as 700 million cycles over their lifetimes and constant vibration loads," says Matt Schmitz, Husco's engineering programs director.

"Ultem resin is the best thermoplastic we have found that meets those needs. The other major benefit it offers is being amorphous, which reduces impacts from process settings that may be seen with other high-temperature-rated semi-crystalline materials," he adds.

The two companies now are developing new technologies for drive trains and braking systems.

Meanwhile, polyurethane ester and polyurethane ether foam specialist FoamPartner, Wolfhausen, Switzerland, is focusing on vehicle comfort and acoustics.

"One of the key advantages of electric vehicles is the ability for fast acceleration and low-noise drives. But the latter places higher demands on the insulation of the passenger compartment against rolling and wind noises," says Kay Kosar, head of marketing and sales, acoustics & thermal solutions, Europe at FoamPartner. "At the same time, the power consumed by heating and air conditioning must be minimized to ensure maximum driving ranges. In both disciplines, our advanced foam solutions are in their element," he adds.

Together with mobility think tank and long-time partner Rinspeed, Zumikon, Switzerland, the company has developed a concept car to illustrate how effective its tailor-made acoustic and thermal insulation foams can be in new generation vehicles.

To meet the automotive sector's rising demand for its foams, FoamPartner is "significantly" expanding production capacity at its Duderstadt site in Germany.

Meanwhile, Clariant, Charlotte, N.C., has tackled time and cost issues associated with batch-to-batch reformulations of automobile color coatings.

Its Hostatint SI range of pigment dispersions show what the company describes as "unparalleled compatibility" with the diversity of industrial coatings bases, plus a tinting consistency capable of repeatable color matching to U.S. automobile industry standard shades.

Clariant describes the new pigment dispersions as the first "drop-in ready" answer to problems frequently caused by a dispersion's incompatibility with various industrial coatings bases — notably, inconsistent tinting and finished product color float, or post application color rub-up. ●

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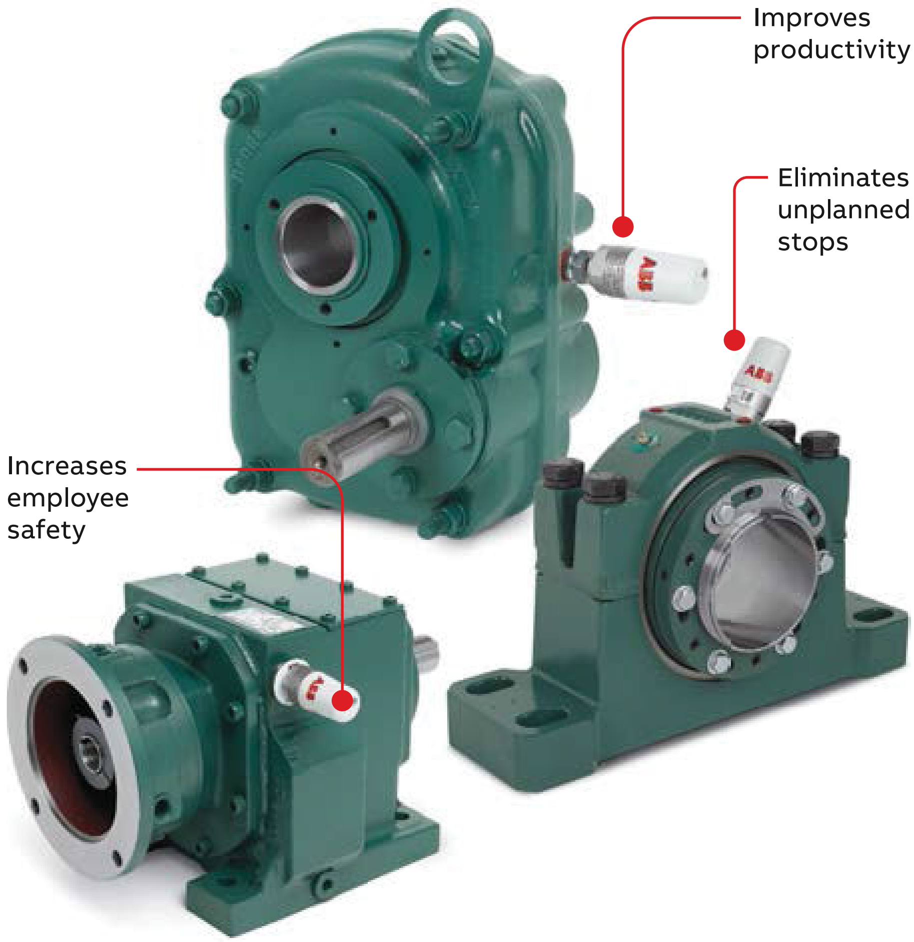

Condition monitoring

For mechanical components

The ABB Ability™ Smart Sensor for mechanical products is an easy-to-use, wireless sensor which monitors the health of mounted bearings and gear reducers. The sensor provides warnings when health status declines, reducing the risk of unplanned downtime. In addition, connectivity and trend data allow maintenance to be planned proactively instead of reactively, and remote monitoring capabilities keep employees away from areas that are difficult or dangerous to access.

Operate safely. Reduce downtime. Improve reliability.