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MARCH 2023

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CONTROL

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Departments

Don't get caught with your sensors down

The East Palestine train derailment is a reminder why investment in technology is vital

THE photo my brother-in-law sent me was a bit shocking. Having covered the industrial sector for a few decades, I've certainly seen my share of photos of plumes of smoke from chemicals burning. However, this one hit closer to home.

It was in the days following Norfolk-Southern train derailment in East Palestine, Ohio, and the photo was taken from the front porch of a home just across the state line in Darlington, Pa. It's where my wife grew up and an area where many of my in-laws still live. All were safe and were spared evacuation orders, but figuratively, the fallout continues to hang over everyone's heads.

The train derailment and subsequent threat of a chemical explosion serves as a not-so-subtle reminder of the need for industrial safety. Safety is a task process control technology can play to fend off even more tragic accidents whether on the rails, along natural gas pipelines, or in chemical processing plants and refineries, to name a few—if the technology works.

In the case of the East Palestine accident, a well-publicized video shows a flaming rail car before the derailment. According to the National Transportation Safety Board, hot-box sensors detected a wheel bearing was heating up before it eventually failed. The detectors didn't alert the crew until it was too late.

Throughout my time covering oil and gas and now additional process industries, I wouldn't have enough fingers and toes to count how many presentations I've watched about predictive maintenance technology and feedforward control—probably 50 times over.

The technology to alert operators to potential dangers is omnipresent. You need look no further than the pages of this magazine or our website for those available technologies. Just as we talk about the need for investment in energy transition and cybersecurity, there remains an even more pressing need for many companies in the process industries, as well as manufacturing and transportation, to continually update their predictive maintenance and monitoring technologies. Costs are often an issue, especially for smaller operators, but the cost of not investing in maintenance and monitoring can outweigh those investments at any moment. It only takes one train derailment, one pipeline explosion, or one refinery fire to open a company up to civil litigation and an industry to further scrutiny and ire from the public, government and media.

And, let's be honest, the most important reason for investment in predictive maintenance is that no one wants to see homeowners or employees harmed. ∞

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To see the photo referenced and to read the full version of this column, visit ControlGlobal.com

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New report on level measurement

This new State of Technology Report from the editors of *Control* and ControlGlobal.com includes the latest information on tank level accuracy, misunderstood measurements and differentiated solutions for new market opportunities, to name a few subjects. This latest installment is part of our ongoing series of technology reports, which can be found monthly at ControlGlobal.com. They include reports on the latest developments in IIoT, temperature and pressure measurement, industrial networking and HMI/PC solutions, among others.
https://bit.ly/3ms14AD

Seeking net-zero
Executive editor Jim Montague reports on several aspects of the net-zero journey. Going green must be more than buzzwords and same-old efficiency. This series of articles explores how the experts reduce emissions and shift industries. Among the topics are: making the big pivot, organizing scopes and steps, guidance and directives, DIY sustainability experience, doing more with less, the electricity environment, rise of hydrogen, digitalization for green solutions, partnerships and support for energy transitions.
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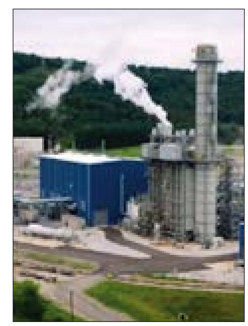

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50 years of radar level measurement
Emerson is celebrating 50 years of radar level measurement with this special report from the editors of *Control* and ControlGlobal.com. Learn the history of radar level measurement technology from its inception as a military aviation technology to the future of guided wave measurement and new market opportunities. This special report takes readers on a journey from the first uses of radar for tank level measurement in maritime applications to today's chemical process industry.
https://bit.ly/3mtpw4K

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https://bit.ly/3IWDm76

NEWS & BLOGS

How Coriolis technology makes hydrogen dispensing safer, efficient
Hydrogen is a sustainable fuel solution that's quickly gaining traction in the global marketplace. Genny Fultz, global product manager at Emerson, appeared on the Control Amplified podcast to discuss the increasing market interest in hydrogen, and the challenges of dispensing and safety.
https://bit.ly/3JcEVzg

Supporting the automation supply chain through turbulent times
Skip Tierno, chairman, and Teresa Sebring, president, Measurement Control & Automation Association (MCAA), appeared on the Control Amplified podcast to discuss how the association is assisting its members and partners in dealing with the challenges brought on by the COVID pandemic, the worker shortage and more.
https://bit.ly/3SYa10j

Regulatory gaps drive systemic under-reporting and poor situational awareness
In his Unfetterd blog, Joe Weiss explains why malicious IT and OT network cyberattacks continue to occur in almost every sector, including the electric grid, power plants, water/wastewater, pipelines, manufacturing, and transportation. They often aren't identified as being cyber-related and therefore aren't reported.
https://bit.ly/3ywYXOZ

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Smoothing the energy transition


Ovation Green is an intuitive system that aims to help the power generation sector flip the switch.

RENEWABLE electricity capacity has seen record growth in recent years. However, transitioning to cleaner energy systems or scaling up existing ones is a complex undertaking for power producers. What's the secret to success? Process automation, of course.

But implementation won't be a cinch for the power generation sector.

Wind turbines, solar arrays, lithium-ion batteries, hydrogen electrolyzers and hydroelectric power all use a wide variety of automation software and technologies. As renewable portfolios grow, the number of applied technologies will multiply, increasing learning curves and adding complexity to operations as solutions from different vendors require additional integration.

Emerson is aiming to smooth the transition through a single set of purpose-built software and solutions that support different technologies in one standardized, intuitive system. The Ovation Green portfolio is designed to help power generation companies meet the needs of customers navigating the transition to green energy generation and storage.

By uniting recently acquired Mita-Teknik software and technology with its own Ovation automation platform, renewable energy knowledge base, cybersecurity solutions and remote management capabilities, Emerson has created a new extension of its power-based control architecture, the company reported in an announcement. The resulting portfolio focuses on the emerging clean energy market to provide simplified renewables automation to help power producers build and scale sustainable operations.

"Countries around the globe are focused on transitioning to a clean energy economy in the coming decades, and while green energy is a simple concept everyone understands, the road to implementation isn't always clear," said Bob Yeager, president of Emerson's power and water solutions. "With the Ovation Green portfolio, our software, support and solutions are unified in one system from a single trusted provider to help power producers more quickly, easily and reliably manage their renewable electricity operations."

> "As renewable portfolios grow, the number of applied technologies will multiply, increasing learning curves and adding complexity to operations as solutions from different vendors require additional integration."

Full access to real-time and historical operations information empowers owners and operators with greater visibility and control of all renewable assets across the enterprise. Through an integrated portfolio of data-driven asset control and management solutions, Ovation Green technologies are designed to provide secure, standardized access to data, independent of equipment manufacturer or system type, across one or multiple sites.

By gathering, collating and contextualizing vast amounts of data created by renewable generation and storage assets, Ovation Green portfolio provides a clear view of renewable operations in a seamless space. The company states the portfolio "will empower actionable intelligence from a unified platform to drive faster, more informed decisions to increase availability and production, while reducing operations and maintenance costs."

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Global warming projection errors

The laws of process control teach us you must consider the delayed feedback effects of its component sub-processes

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"The common global warming models accurately consider the response of the atmospheric processes to the rise of global warming, but they often do not take into account the oceanic ones."

OCEANS cover 70% of our planet (more than 360 million km^2). They absorb 90% of the total solar heat received and also absorb more than a quarter of the carbon dioxide we emit. The mass of the oceans is more than a thousand times greater than the atmosphere (1.3×10^{21} kg vs, 5.5×10^{18} kg) and has a much higher inertia. The top few meters of the ocean store as much heat as the planet's entire atmosphere.

Solar radiation penetrates only the top 100 meters. The water below is not directly heated. The water cycle on Earth (Figure 1) is started by the sun warming the surface of the oceans and causing the water to evaporate. This increases the water vapor content of the atmosphere, which increases the rate of water circulation. This cycle provides fresh water for the planet, while evaporation cools the oceans. The energy obtained travels with the water vapor until released in the process of condensation precipitation.

Oceanic processes that are often neglected by global warming models include the effects of both the horizontal and the vertical "heat conveyor belts."

The process of the vertical ocean conveyor is as follows:

1. Global warming increases the water vapor content of the atmosphere. When it condenses, it becomes the fresh water supply of the planet. Evaporation requires heat, which is taken from the ocean, thereby cooling it. Increased evaporation increases the rate of water circulation on the planet by 7% per each 1 °C temperature rise.
2. The cooling caused by evaporation increases the density of the surface waters, making them heavier than the waters below. This causes the so called "thermohaline circulation," because as the warm surface waters are moved downward they force the cold waters below to rise. This circulation indirectly heats those layers that solar radiation cannot reach directly.
3. As evaporation removes fresh water from the ocean's surface, the remaining water becomes saltier (and therefore heavier) than the waters below. This process also increases the vertical circulation of the ocean's water, because as the saltier and warmer surface waters move downward, they heat the water layers below.

This "vertical water circulation" that brings heat to the lower levels is reduced as global warming increases. The increase causes the temperature of the surface waters to rise, reducing their density relative to that of the waters below. Therefore, if the density of the evaporating surface waters drop, the weight difference between that and the waters below drops, and this vertical circulation slows or eventually stops. The faster density increases with depth, the slower the vertical circulation becomes. As a result, less mixing takes place among the water layers, increasing global warming at the ocean's surface because it reduces the rate at which heat is transported down into the lower layers and more of it remains on the surface.

In my view, this is one of the self-accelerating feedback effects that many global warming models disregard. In other words, a process control analysis of the total global warming process shows that for now, thanks to the oceans, the atmo-

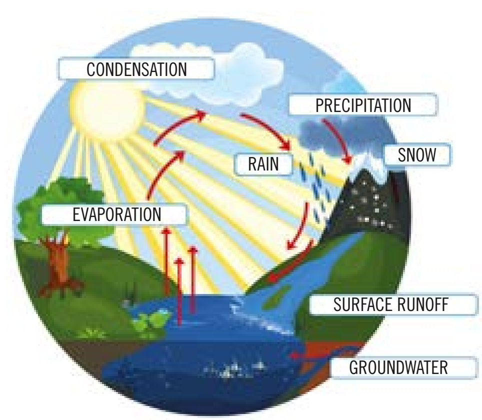

Figure 1: The evaporation cools the oceans and condensation warms the atmosphere, while each 1 °C of global warming increase raises the global water circulation rises by 7%.

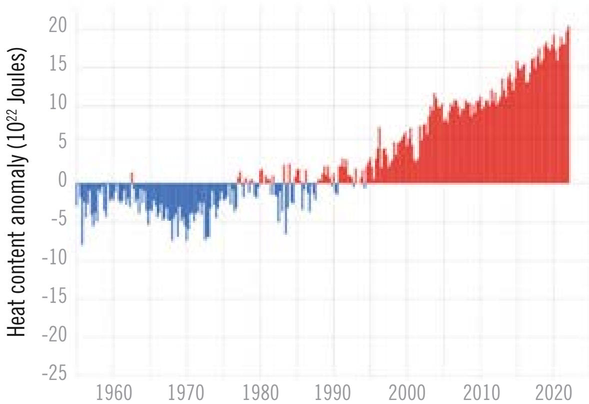

Figure 2: The accumulation of heat in the lower layers of the oceans slow global warming, giving the impression that the oceans cool the planet, but this energy doesn't disappear, it just moves into "temporary storage" at the lower layers. This heat, 2.0 x 10^{23} Joules in recent decades, will cause the same amount of heating in the future as the oceans return to their preindustrial heat balance.

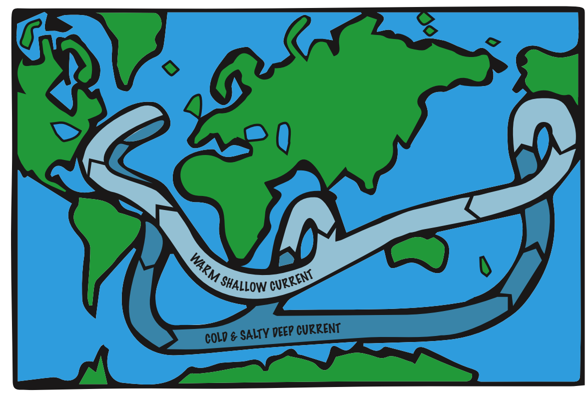

Figure 3: The "great ocean conveyor belt" is the major ocean current that moves water from the equator to the poles and cold water from the poles back toward the equator. If the belt slows, the climate changes and global warming increases.

sphere has been spared from the full extent of global warming. However, the heat already stored in the depth of the oceans (Figure 2) will eventually be released, causing added warming in the future. Thus, the stored extra heat energy in the oceans, even after our conversion to a green energy economy is fully completed, will keep warming the planet for decades (or even centuries). Therefore, the correct global warming projection models should consider this "ocean heat storage" effect.

The horizontal conveyor belt is often referred to as the "great ocean conveyor belt." It starts at the tropics and moves the warm water layer on the surface from the equator to the poles and returns the colder, saltier current at the bottom of the ocean back toward the equator (Figure 3). This conveyor slowly (in years to decades) turns over the water in the entire ocean from top to bottom.

Surface currents, such as the Gulf Stream, warm Europe and the east coast of the U.S. as they move north. Near Greenland, it gets cold and heavy enough to sink and return to the tropics as a gigantic colder, saltier stream at the bottom. It's my view, that global warming models should (but don't) fully consider the changes in the flow rates of these currents because they have a large and growing impact on the heat balance of the oceans. They not only regulate global climate, but their mixing supports the life of marine ecosystems, which supply a substantial portion of the world's food. Their mixing effects also control how heat, carbon, nutrients, and dissolved gasses are exchanged between the upper and lower layers of the ocean and when they slow. As this effect diminishes, global warmings increases.

As the low-density water generated by the melting on Greenland mixes with the higher density gulf stream, it reduces the density and therefore the flow rate of the sinking of the mixed colder, saltier waters.

As the ocean's conveyor belts slow, surface temperatures and global warming increase because less heat is conveyed into the lower layers. Because of this reduced mixing, less food is supplied to the algae, phytoplankton and other microorganisms that perform photosynthesis, and are often under the protection of corals. They split water using solar energy, and produce sugar from the resulting CO_2 and hydrogen, and generate much of the oxygen on the planet.

In the past, the oceans absorbed more than one-quarter of the CO_2 emitted, but as water temperatures increase, the solubility of CO_2 drops and the resulting "degassing" further increases the CO_2 content of the air. In addition, the basic chemistry of the oceans is changing fast because emissions during the industrial age made the water 30% more acidic. As a consequence, the coral reefs die and that destroys the healthy habitat that previously supplied food and protection to millions of plant and animal species. Based on all this, I believe that if global warming continues as it does today, the oceans soon will become too warm for coral reefs to survive.

The conclusion of my process control analysis is that the majority of global warming projection models are excessively optimistic because they don't sufficiently consider the yet-to-be-triggered oceanic processes. It's also because they don't realize that the inertia of these oceanic processes will continue to increase global warming even after greenhouse gas emission neutrality is achieved. ∞

Vestiges of 'The Right Stuff'

Are we witnessing a transformation of human thought in process control?

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"We don't need cocky and daring test pilots running our process, but most plants still need thoughtful people—not robots—to look after their assets and the safety of the occupants."

MY Microsoft Word and Outlook applications are determined to help me out, offering to guess words for me or even craft complete sentences or email replies. To a lesser degree—at least today—my pocket computer (smartphone) apps are designed to help as well.

"Vestigial" refers to an organ or limb that has withered from disuse or natural selection, such as your appendix, coccyx or little toe. Are we witnessing a similar transformation of human thought? Will curiosity and intelligence dwindle due to the availability of Google, AI, ChatGPT and the pointless distraction of social media?

Decades ago, dynamic matrix control (DMC)—now typically called model predictive control (MPC)—became robust enough to be applied to massive and critical processes, primarily in the hydrocarbon processing and refining/petrochemical industries. These end users could justify the cost, which included staff to deploy, commission and maintain the applications. That's because of the immense return-on-investment (ROI) of large units. One was the refinery crude tower.

A crude tower is a huge "still" that boils oil to separate it into marketable products. While it's not complex from the chemistry or physics perspective, controlling the distillation to produce on-spec distillates—jet fuel, kerosene, diesel and feedstocks for downstream units—is a challenge. Meanwhile, the fuel market is ever-changing and volatile. Meeting contracts, as well as opportunistic merchant purchases and sales, mean changes in crude rates and crude slates—which crudes are purchased to run—are routine.

An attentive operator, supervisor or process engineer typically relies on a mental "model" of how one should interact with the process. Even if your hands-on operator robotically follows orders and procedures, at some level there's a human who provides advice or direction based on thoughts or beliefs about how the process works. Their thinking is rooted in experience, as well as learning and logic around how temperature, pressure and flow affect the throughput and quality of the distillates.

At some level—at least in days of yore—there were specialists in various disciplines who imagined how to debottleneck and optimize the process. One such imaginative individual was the controls expert, who sold the idea that multivariable, model-based control could pay for itself in a couple of years. The refining and petrochemical community knew how pioneers such as Exxon and Shell succeeded, and many controls (DCS) upgrades were paid for on the backs of "advanced control" payouts. Decades later, many controls upgrades are now deferred due to losses from taking controls offline, even as parts and expertise to maintain DCSs from the 1980s become increasingly scarce.

A few individuals took note of an unanticipated side effect of the gradually more pervasive MPC. When it was offline, they found their staff noticeably less adept at running the crude tower and other complex, highly interactive processes. These processes ran with little intervention under advanced controls.

Younger operators, who succeeded those who helped the controls person "train" (identify) the models used by the system, didn't know of life without the trusty MPC. There's been awareness of this issue for decades, as Dave Strobhar of Beville Engineering notes in his article "Advanced process control: is it the operator's Best friend or worst enemy?" (https://bit.ly/3Zs0CAq). He suggests that management might challenge their operators to run a complex unit without MPC in the hopes of honing their skills, but few are likely to do so.

Legend (Hollywood) has it, the Mercury astronauts insisted on a window for their capsule and some manner of flight control, rather than just being a big hairless ape shot into space. We don't need cocky and daring test pilots running our processes, but most plants still need thoughtful people—not robots—to look after their assets and the safety of the occupants. Let's hope our smart device crutches and addictions don't extinguish all ambition, curiosity and creativity. ∞

Energy scavenging: the hunt for continuous power

How harnessing small amounts of ambient energy can become usable electric power

ONE constant required for any sensor or actuator is a need for power. Commonly used power sources for field devices include instrument air, hydraulics and electricity. Fortunately, wireless sensor networks (WSN), which include IIoT devices, don't require continuous power, and the power levels they do need are quite low. As a result, energy scavenging techniques are a viable option that can be considered.

Energy scavenging—also known as power harvesting or energy harvesting—is the process of capturing energy from a system's environment and converting it into usable electric power. Energy scavenging harnesses small amounts of ambient energy, which otherwise dissipate or get wasted. It allows electronics to operate where there's no conventional power source. This eliminates the need to run wires or manage batteries.

An energy harvesting system generally includes circuitry to charge an energy storage cell and manage the power, as well as regulate and protect the system.

The common sources of ambient energy that can be scavenged are:

- Light energy (captured by photovoltaic cells);
- Kinetic energy (vibrations and mechanical stress captured by a piezoelectric element);
- Thermal energy (captured by a thermoelectric generator); and
- RF energy (radio waves captured by an antenna, such as in RFID systems).

Solar cells are very common. However, when they depend on light as their only source, they have the disadvantage of not being able to harvest at night. This creates the need for battery storage. They also require maintenance to keep solar cell surfaces clean. For example, in Canada, that means snow.

One of the early WSN, piezo-based energy scavengers used the natural frequency of process pipes themselves to create what was effectively a "tuning fork" to oscillate and harvest energy from the oscillation. The problem with this system was the process operated at different process conditions. That moved it outside the scavenger's calibrated frequency range. No more oscillations meant no more energy.

A thermoelectric harvesting system is based on a thermoelectric generator (TEG), which consists of several thermocouples connected in series to a temperature differential to generate energy directly proportional to the temperature difference as well as the size of the TEG. Therefore, as the temperature differential changes, so does the available energy.

Some other ideas that could work in some applications include a turbine installed in the instrument air supply for an actuator, but with actuators being designed to minimize air consumption. This option would need a reliable air supply and continuously bleed to atmosphere. If you're running air to the device, chances are a reliable power supply is nearby as well.

Another idea is a paddle inserted in the process with a spring or hydraulic reservoir to push back, so oscillations can generate electricity like an offshore wave generator. This requires another penetration into the process line and a potential emission source. Since it's mechanical, it would likely need maintenance and a way to isolate it. The result is more complexity.

Meanwhile, miniature fuel cells, which have the advantage of not requiring replacements, are still in the research stage. If attached to a sensor "vent," they could provide 24/7 power.

As mentioned for each option, almost all energy scavenging systems have one or more limitations that restrict their use and the associated risk of not always being available. This is why every energy scavenging system requires some form of energy storage, which can be either a capacitor to bridge short fluctuations or, as is more often the case, a battery.

Energy scavenging will continue to evolve, largely driven by IoT applications in the commercial space. As this happens, we'll see the technology move to the industrial sector and a decrease in its dependence on battery storage. ∞

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"An energy harvesting system generally includes circuitry to charge an energy storage cell and manage power, as well as regulate and protect the system."

ARC turns digitalization into sustainability

About 1,000 visitors take in 70 sessions and 200 speakers in five tracks at ARC Industry Forum in Orlando

BACK in its usual early-February slot, the ARC Industry Leadership Forum once again filled about 1,000 brains to the brim with the latest intelligence on digitalization, cybersecurity, sustainability and energy transition. The 27th annual event in Orlando featured 200 speakers and analysts presenting 70 sessions in five tracks.

This knowledge will be crucial to end users, system integrators, suppliers and everyone else striving to cope with today's profound and accelerating technical, economic and environmental changes. In a Feb. 6 press conference, ARC and Microsoft presented the results of their recent, global survey of manufacturing executives in OT, IT and engineering technology (ET), which found that:

- 43% in North America reduced costs by implementing digital transformation (DT) programs;
- 20% in North America identified all relevant sustainability reporting standards and requirements;
- 55% in Europe reported measurable quality improvements due to DT;
- 90% in Europe have completed or are currently establishing emissions and energy targets or goals;
- 73% in Asia/Pacific anticipate deploying factory, artificial intelligence (AI) model building to off-premises cloud platform in the next three years;
- 94% in Asia/Pacific are presently tracking and executing sustainability actions plans;
- 60% in OT experienced improved quality after deploying DT technology;
- 76% in ET plan to deploy AI technologies using a cloud platform in the next three years; and
- 55% in IT report that DT increases productivity.

Coping with epic change

"There are a lot of new feedstocks, our industries are transforming, and we have to manage these changes carefully," says Allen Pertuit, VP of downstream projects at Shell (www.shell.com), in his Feb. 7 keynote address. "We also aspire to net-zero emissions by 2050, so we're positioning Shell to decarbonize in many sectors, such as pursuing renewable natural gas at a Kansas farm with 30,000 cows that creates feedstock for digesters, or converting vegetable and animal oils into gasoline and jet fuel. Dairies report they must show they're becoming sustainable, or consumers won't buy milk, cheese and other products.

"Sustainability is becoming a huge value driver. We're in an intense transition now, and imagining the tools we can use to drive the sustainability the world needs in our chemical products. These tools include our Powering Progress strategy that we launched in 2019-20 to produce cleaner energy and more sustainable products, and even repurpose a closed refinery into a biofuels plant."

Sandwiched between the world of OT and IT, Gabriel Gonzalez-Alonso of ZF Group (center) makes a point to Allen Pertuit of Shell (left) and Collin Masson of Microsoft (right) during the general session's panel discussion on Feb. 7 at ARC Industry Leadership Forum 2023 in Orlando.

Likewise, Gabriel Gonzalez-Alonso, senior VP for production management at ZF Group (zf.com), reports it's establishing smarter, more sustainable plants with its Digital Manufacturing Platform (DMP). This includes using OPC UA networking to connect existing plants. "This isn't just working together. It's creating and training one team, replacing equipment with digitalized versions, and making data management transparent for decision-makers in each facility," says Gonzalez-Alonso. "We're going to roll this out at 100 plants this year."

Briefings and exhibits

To help users digitalize and improve their sustainability, ARC Industry Forum featured its usual series of press conferences and exhibits, such as:

- Hexagon (hexagon.com) presented its Smart Digital Reality platform that reportedly merges the physical and digital world by using intelligent sensor-software systems for real-time data capture, integration and analysis, and enabling autonomous digital twins and a digital reality feedback loop, so users can be proactive, preventative and predictive.
- Inductive Automation (inductiveautomation.com) presented its Ignition Cloud edition software, which allows integrated systems to function more quickly by adding cloud-computing capabilities to its Ignition web-based HMI/SCADA software. Inductive adds that Ignition is now fully Sparkplug-compatible and has added an IEC 61508 driver.
- Phoenix Contact will release a 24-port Ethernet Advanced Physical Layer (APL) switch in June, which will let users skip using traditional I/O, go directly to sensors and power sources, and bring loop power to intrinsically safe (IS) and hazardous locations.

(continued on page 18)

SIGNALS AND INDICATORS

- **ABB** (go.abb/processautomation) reported Feb. 8 that global cement producer **Votorantim Cimentos** (www.votorantimcimentos.com.br) is achieving multi-site digitalization by adopting its industry-specific solutions, such as ABB Ability Expert Optimizer software and ABB Ability Knowledge Manager software to help it simultaneously optimize production and decarbonize operations.
- **Emerson** (emerson.com) reported Feb. 28 that it's challenging its employees, customers and suppliers to participate in the 2023 Earth Month Ecochallenge, a global competition to inspire individuals to implement science-based, sustainable behaviors in their daily lives. Registration is at earthmonth.ecochallenge.org.
- In accordance with its previously announced leadership succession plan, **Endress+Hauser** (endress.com) reported Feb. 22 that Klaus Endress will give up his responsibilities as president of the supervisory board at the start of 2024. He will be succeeded by CEO Matthias Altendorf, while the new CEO will be Peter Selders, the present head of the center of competence for level and pressure measurement technology. Steven Endress, managing director of Endress+Hauser U.K., will become the second family member on the supervisory board.
- **Bentley Systems Inc.** (bentley.com) reported Feb. 23 it's acquired **EasyPower** (www.easypower.com) to extend integrated and iterative power systems design and analysis for infrastructure digital twins, and broadens its comprehensiveness in infrastructure engineering. EasyPower combines graphics-based modeling and analysis to make solving complex electrical engineering problems more straightforward and accessible.
- **Honeywell** (www.honeywellforge.ai) announced Feb. 10 that chemicals and polyolefins manufacturer **Borealis Group** (www.borealisgroup.com) will implement Honeywell's UniSim Live software to build process models for optimizing operations through virtual process simulation. UniSim Live will allow Borealis to extend the utility of process models to near real-time process monitoring and focus on early event detection by using digital twins to improve plant reliability.

(continued from page 16)

- Schneider Electric (www.se.com) unveiled its specialized, global, end-to-end Industrial Digital Transformation Consulting the Deployment services to help users accelerate digital transformation planning and implementation for projects, such as sustainability, performance, digital operations and energy management.
- Phoenix Contact (www.phoenixcontact.com) reported it plans to release a 24-port, intrinsically safe Ethernet Advanced Physical Layer (APL) switch in June, which will allow users to skip traditional I/O, directly access sensors and power supplies, and use loop-powered Ethernet in hazardous areas.

P&G is 900th OPC member

The OPC Foundation (www.opcfoundation.org) reported Feb. 6 that it's proud to welcome Procter & Gamble (us.pg.com) as its 900th member. P&G uses digital technologies, including OPC Unified Architecture (UA) protocol, in its "constructive disruption" concept and Integrated Work System (IWS) excellence program. IWS is employed at more than 100 sites worldwide and in more than 450 non-compete manufacturing operations.

P&G is building on these successes by bringing artificial intelligence (AI) and machine learning (ML) to its equipment to continue advancing operational excellence. It also uses open standards to deploy technologies at scale, and OPC UA is part of the communication framework in P&G's automation systems, providing secure connectivity from sensor to cloud.

"It's crucial to P&G to have an operational ecosystem that can enable speed-to-value-creation and sustained operational excellence," says Jeff Kent, VP of smart platforms technology and innovation P&G. "We see the need to work collaboratively with automation industry partners and the OPC Foundation to drive scalable, repeatable and resilient intelligent operational technology implementations across our worldwide operations. Smart manufacturing technology architectures, IT/OT network communications, data engineering and data modeling, S/W applications and AI/ML algorithms all depend on the proven, progressive and practical adoption of the specifications that we adopt with our industry partners." ∞

Power supplies bring all the moves

Control's monthly resources guide

MANY TYPES FOR MANY NEEDS

This online article, "Power supply basics," covers AC-DC fundamentals and conversions, regulated and unregulated, linear, switched or battery-based, noise and ripple, how to choose the right one, and even some history. It's at www.teamwavelength.com/power-supply-basics

WAVELENGTH ELECTRONICS
www.teamwavelength.com

UNDERSTANDING THE UPS

This 87-minute webinar, "Understanding uninterruptible power supply (UPS) systems" by Craig Williams, covers the advantages and disadvantages of each type of UPS system, topologies and blocks, advantages and disadvantages, common misconceptions of UPS system designs, and power flow and general operation of each type. It's at www.youtube.com/watch?v=Kf-aATHXFcI

AMETEK SOLIDSTATE CONTROLS
www.solidstatecontrolsinc.com

AC/DC, SWITCHING AND PHASES

This online article, "Understanding AC/DC power supplies," explains currents, linear vs. switching, and single-phase vs. three-phase. It's at www.monolithicpower.com/en/ac-dc-power-supply-basics

MONOLITHIC POWER SYSTEMS
www.monolithicpower.com

GUIDE TO POWER ELECTRONICS

This website, "Lazar's power electronics guide," contains a wealth of materials on switched-mode power supply (SMPS). It covers circuits, schematics, printed circuit boards (PCB), software, inverters, generators, topologies, software, transformers and more. It also contains an electrical engineering reference guide, formulas, information on PSUs, UPSs, thermal design, power for solar and other resources, including links to other SMPS sites, freeware, tutorials and news.

LAZAR'S POWER ELECTRONICS GUIDE
www.smps.us

PRACTICAL DIGITAL CONTROL

This 30-page whitepaper, "A practical introduction to digital power supply control" by Laszlo Balogh, details the differences between analog and digital supplies, digitalizing variables, digital pulse width modulation, programmable functions and variables, and hardware examples. It's at www.ti.com/lit/ml/slup232/slup232.pdf

TEXAS INSTRUMENTS
www.ti.com

UPS TUTORIAL AND TEARDOWN

This 45-minute video, "UPS tutorial and teardown" by Dave Jones, explains the three main methods of UPS design, offline, online and line interactive, and opens an APC 2200XL rackmount UPS to see how well it matches classic block diagram theory. It's at www.youtube.com/watch?v=Fj7e3WGUKO8

EEVBLOG
eevblog.com

CONDITION THE SIGNAL

This 69-page tutorial, "Industrial signal conditioning," covers loops and analog signals, signal integrity and design examples, such as servo control, aluminum smelting and grounded thermocouples. It's at www.dataforth.com/catalog/pdf/DTF-Tutorial.pdf

DATAFORTH
www.dataforth.com

ON THE BENCH FOR CIRCUITS

This nine-minute video, "Instrument basics: bench power supplies," shows how to power circuits easily and safely, adjust basic control like voltage, and demonstrates current limiting. It's at www.youtube.com/watch?v=FfI3GRQbV0s

ELEMENT14 COMMUNITY
community.element14.com

BOARD DESIGN IN 7 STEPS

This online article, "AC/DC power supply design in 7 steps," lays out basic properties, printed circuit board layouts, sampling, welding, and more It's at www.fspgroup.com/en/knowledge-tec-23.html

FSP GROUP
www.fspgroup.com

LINEAR AC/DC VIDEO

This 50-minute video, "An introduction to linear AC/DC power supplies" by Tim Laux covers definitions, oscilloscopes, direct, transformers, capacitors, regulators and topology. It's at www.youtube.com/watch?v=brB1sZyJPls

SOLID STATE WORKSHOP
timothylaux.com/youtube

SWITCHED-MODE BASICS

This 14-minute video, "Basics of switched-mode power supplies (SMPS)" by Christopher Maier, covers capacitors and change pumps, inductors, switching elements, diodes, transistors, and types of SMPSs. It's at www.youtube.com/watch?v=e1rxYGp9bos

IFW-TU GRAZ
www.if.tugraz.at

CONFIGURE AND SPECIFY

This online article, "The basics of power supplies in industrial machinery" by Dave Perkon, covers configurations, specifications, voltage ranges and outputs, designing and protections. It's at www.controldesign.com/control/power-supplies/article/11321831/the-basics-of-power-supplies-in-industrial-machinery

CONTROL DESIGN
www.controldesign.com

O-PAS sets the pace

BY JIM MONTAGUE

The Open Process Automation Standard (O-PAS) standard starts up and prepares for conformance testing

FINALLY, after more than seven years of drafts, development, recruiting, designs and testing, the Open Process Automation Standard (O-PAS) is pulling away from the dock, chugging out of the station, and accelerating inevitably toward its long-sought goal of interoperable process controls. Woo woo!

"O-PAS is interesting and a key to the future of process automation. We need to align projects for crucial transitions like this, but they must be done with safe data transfers, and O-PAS is essential to achieving this," said Allen Pertuit, VP of downstream projects at Shell USA Inc. (www.shell.com), during his Feb. 7 keynote address at the recent ARC Industry Forum in Orlando, Fla. "I've been on the World Economic Council since 2018, where all the oil and gas majors have been trying to agree on standards for leveraging value. Now, O-PAS is available, and it's moving quicker than expected."

In fact, Shell has been implementing its own O-PAS testbed for more than eight months, and performed its factory acceptance test (FAT) this past December.

"We started by testing gateways that will allow us to communicate with O-PAS systems on the external side of our current DCS, and results were promising. So, we're continuing to work with the testbed, and have produced a greenfield O-PAS system that will be integrated with the gateway on the existing DCS," said Jacco Opmeer, co-chair of the Open Process Automation Forum (www.opengroup.org/opaf) and DCS subject matter expert at Shell, during a Feb. 9 video call at the ARC event. "The small greenfield system comprises distributed control nodes (DCN), O-PAS I/O and an O-PAS advanced computing platform (ACP), all connected to an O-PAS open connectivity framework (OCF). We also finalized the FAT recently, and we're presently joining both parts of our testbed, so they can migrate to a combined system. We'll continue testing functionality on both sides of the OCF backbone. We'll also move some applications from existing systems to an ACP defined by O-PAS, so we can understand its implications, help the standard develop further, and find out where we can do more.

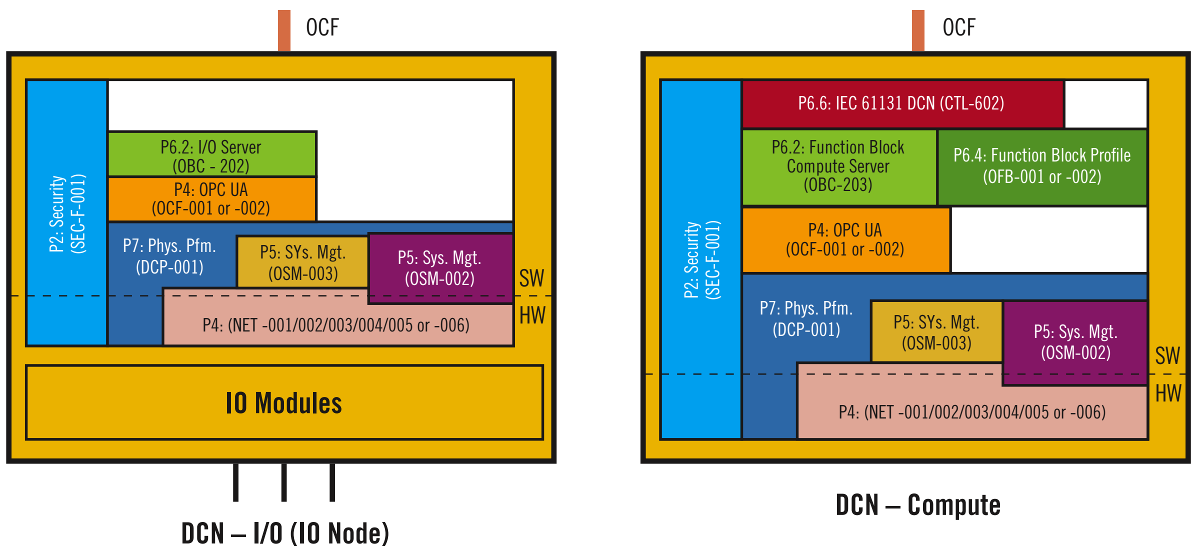

Figure 1: These profiles for "distributed control node (DCN)—I/O" and "DCN—compute" are two of the five developed by OPAF to clarify the roles and requirements that suppliers need to meet to produce products that comply with the Open Process Automation Standard (O-PAS), Version 2.1, that was finalized in the first week of February. This "Rosetta stone" for the physical platform defines locations in the O-PAS reference architecture where DCNs are deployed, and the conformance requirement profiles for each configuration, such as system management, OPC UA networking, security and others. Source: OPAF

"In the coming year, we'll continue testing, and see if we can start adding some certified products. We're asking our suppliers to get their products O-PAS-certified because we could save on some testing. The tests and trials have already pushed some O-PAS elements into projects, but we have to keep stepping forward, so we don't fall back onto old, familiar habits. For example, we've already done a successful UniversalAutomation.org (UAO) runtime test on a field trial, and we want to further explore the IEC 61499 standard that UAO is based on. We do all this because we believe that standards of standards like O-PAS will help us disclose data, and bring real time functionality to all layers in our systems, which will help us achieve our business goals"

Petronas and Reliance weigh in

Not surprisingly, some of the most earnest O-PAS initiatives are coming from regions with younger oil and gas facilities and histories and shorter histories in process control, such as the Middle East and Asia/Pacific.

"The future of distributed control is O-PAS. Petronas is committed to making O-PAS happen, so we're building a testbed with 200 I/O, including 100 analog inputs and outputs, and 100 soft-signal I/O," says Sharul Rashid, Instrument & Control (I&C) custodian engineer for Group Technical Solutions (GTS) and Project Delivery & Technology (PD&T) at Petroliam Nasional Berhad (www.petronas.com) in Kuala Lumpur, Malaysia. He's also co-chair of OPAF's certification working group. "We will be deploying the testbed at our Institute Technical Petronas (INSTEP) training plant in Terengganu, so we can bring in technicians to make mistakes and learn."

Zhafran Aziz, I&C staff engineer for GTS and PD&T at Petronas, works part-time on the testbed that's being built in collaboration with Yokogawa, and will even test Intel's O-PAS distributed control node (DCN) prototype. Construction started at the beginning of 2022, and the testbed completed its preliminary FAT this past December. Installation is scheduled for June and July, and it will be handed over to INSTEP later this year.

"We had some issues during testing and some unexpected items, but we're hoping to solve them during the next and final FAT in March," says Zhafran. "This will be worth it because we know the value of O-PAS is it can solve the problem of having to rip and replace equipment every 10-15 years."

Likewise, in some late-breaking news, Reliance Industries Ltd. (www.ril.com) reported Feb. 9 that it's implementing an O-PAS testbed for a trial run in one of the refinery sites at its Jamnagar facility in Gujarat, India. This project is being integrated by Yokogawa, and planned in different phases from testbed to field trial, while its FAT will be done at Yokogaw's Bangalore office. The testbed is expected to be delivered at the site in June.

"We've checked on the testing and use cases that ExxonMobil and others have done, but we want some firsthand O-PAS

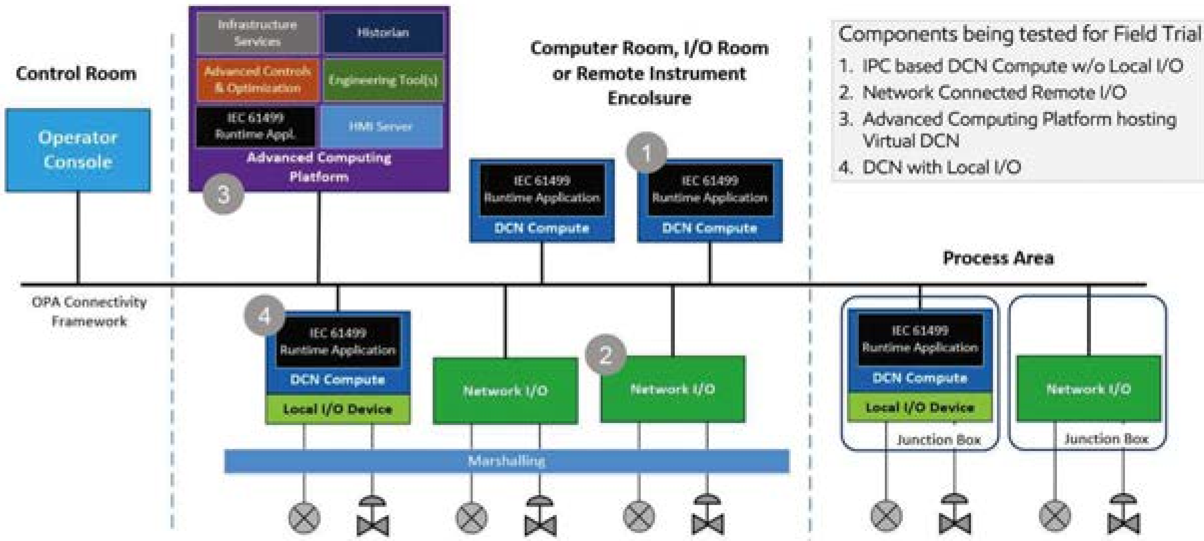

Figure 2: This simplified Open Process Automation (OPA) reference architecture shows what types of devices ExxonMobil and its OPA Testbed Lab are evaluating for conformance with O-PAS, V2.1 and whether they can meet ExxonMobil's requirements for field use. Components tested include: 1) industrial PC (IPC)-based distributed control node (DCN) computing without local I/O, 2) network-connected remote I/O, 3) advanced computing platform hosting virtual DCNs, and 4) DCNs with local I/O. They'll likely be deployed in ExxonMobil's OPA field trial that's expected to start operating later this year in a manufacturing automation system at an ExxonMobil facility in Baton Rouge, LA. Source: ExxonMobil

experience, too," says Kartik Fojdar, VP and head of the Instrumentation Centre of Excellence at Reliance. "We've tested and used traditional distributed control systems (DCS) at the highest rate in Asia, and they face the usual lifecycle and obsolescence issues. Currently, software and hardware are linked together. For example, front-end upgrades lead to back-end firmware upgrades, which leads to shutdown requirements. This is a time-consuming and costly affair.

"With O-PAS, if a hardware component such as an I/O or controller has a problem, we can upgrade it with any make and model we choose. This makes it feasible to use best-in-class components in one overall system, which will reduce costs. Plus, we won't have to shut down our whole system, so we can also do upgrades at any time. This gives us a lot more flexibility, which is very important in our industry. The bottom line is lifecycle costs of the system will decrease and system reliability will improve. Thus, O-PAS has potential to address the majority of our pain points. We're also likely to have the only O-PAS testbed in India, so we can make other end users and OEMs aware of it, and spread its message in our part of the world."

Latest OPAF headlines

Several well-known and new OPAF members presented their usual O-PAS progress report on Feb. 7 and 9 at the ARC event. Major new and upcoming milestones include:

- Publication of O-PAS, Version 2.1 for control functionality (publications.opengroup.org/standards/c230), Final edition during the week of Feb. 6, which is the fifth publication of the standard;
- Conformance certification starting in mid-2023 of products that conform to O-PAS requirements;
- Adoption guides for end users and system integrators are now in final review. They'll de-risk activities for potential users, and help them overcome their fear of trying O-PAS;
- Increasing prototyping projects and field trials worldwide by OPAF members and other end users learning about O-PAS how to implement it. ExxonMobil has a field trial. BASF, Georgia-Pacific, Dow Chemical and Equinor have prototypes. Saudi Aramco, Shell and Petronas have testbeds.
- Joint standards development and demonstration have started, including OPAF and the OPC Foundation's OPC UA Field Exchange (Fx), and OPAF and NAMUR/ZVEI's Module Type Package (MTP). Their goal is aligning the standards for controller-to-controller and controller-to-device communications.

Some last-minute tweaks

Shortly before it was finalized based on feedback from suppliers, OPAF's organizers made several clarifications and adjustments to O-PAS, V2.1, which let enable suppliers, partners, system integrators and users develop and deploy products and systems that comply with it, and deliver the interoperability that everyone is seeking.

"O-PAS, V2.1, defines a lot, and incorporates functions from IT, especially regarding systems management. Several suppliers questioned how to do systems management within the standard, so some compromises and adjustments were made to make it easier for them," says Don Bartusiak, co-chair of OPAF and president of Collaborative Systems Integration Inc. (CSI-automation.com). Now, V2.1, is clearer and specific enough for suppliers to build O-PAS-compliant products and systems."

Bartusiak summarized three significant additions that were made in O-PAS, V2.1, Final from the V2.1 Preliminary release. These consisted of:

- Clarifying DCN specifications in V2.1's Parts 1 and 7;
- Relaxing or significantly clarifying systems management requirements in V2.1's Part 5, which impacts conformance certification; and
- Adding IEC 61499 standard that covers event-based function blocks for process measurement and control systems.

Rosetta stone for DCNs

To clarify the standard's DCN section, OPAF also developed a five-part "Rosetta stone" for its physical platform. It basically defines the locations in the O-PAS reference architecture where DCNs are deployed, functions they perform in each spot, and the conformance requirement profiles they need. These profiles include system management, OPC UA networking, security and others (Figure 1). Compliant products will have to meet one or more of these five profiles:

- DCN—I/O,
- DCN—compute,
- DCN—compute + I/O,
- DCN—gateway, and
- Advanced computing platform.

"We needed to clarify the DCN because there are multiple profiles and instances of it in the O-PAS reference architecture, as well as software and physical manifestations," explains Bartusiak. "Each of five profiles shows what's required to make products in that space. (Figure 1)

Certification and adoption

Once V2.1's Part 5 was adjusted to make it practical for suppliers to launch products, they also need a pathway to certification, so users can be assured they're getting the interoperability that O-PAS promises. So far, verification labs include those accredited by the OPC Foundation (opcfoundation.org) and the ISA Security Compliance Institute, but others are expected to be named shortly. These labs will verify conformance to O-PAS and issue verification reports. Products that pass verification will be certified by The Open Group and will be listed in a publicly available registry of O-PAS conformant products.

Scheduled to start in mid-2023, the first wave will cover several basic performance and networking capabilities, including:

- DCP-001—DCN platform,
- NET-F-001—single Ethernet-to-Ethernet,
- NET-F-002—single Ethernet peer-to-peer,
- OCF-001—OPC UA client/server,
- SEC-F-001—IEC 62443-4-2 for cybersecurity,
- OSM-002—Redfish for system management with Baseboard Management Controller (BMC) chip, and
- OSM-003—Redfish without BMC chip.

To make these assignments easier to approach and handle, OPAF has been drafting and is preparing to launch adoption guides for participants in the O-PAS business ecosystem—end users, suppliers, system integrators, and service providers. Bartusiak reports they'll likely publish the first version in a couple of months, which is tailored for end users and system integrators (SI). They include information to consider when implementing open-process automation systems, and provide answers to frequently asked questions (FAQ).

"A recurring theme in the adoption guides is that knowledge and experience with O-PAS is the key to success for end user, system integrators, suppliers and service providers," concluded Bartusiak. "So, our priority for OPAF this year is end user activation with input and prioritization of feature sets for the next O-PAS release, and end user-oriented communications and events."

Trial on the docket

Even as more recent testbed projects start to snowball, ExxonMobil's pioneering testbed project and upcoming field trial is still out in front, serving as a model and inspiration for the others.

"There's a lot of data processing and other capabilities available at the edge, and we see Open Process Automation (OPA) as a platform that can give us many useful functions now and in the future. I view my new automation role as part of that digital transformation journey," says Ryan Smeltzer, OPA program manager at ExxonMobil Technology and Engineering Co. (EMTEC, corporate.exxonmobil.com) in Houston. "We created EMTEC a year ago to combine our research and engineering resources from across the corporation, and magnify their capabilities to better support our upstream, heritage downstream, chemicals and other businesses. This lets our engineers focus their know-how be used on the highest-priority operations and challenges without being siloed along organizational lines, and accelerates everyone's learning about R&D programs, such as our OPA program's testbed and field trial."

ExxonMobil was a founding member of OPAF that's developing O-PAS. During 2017-20, ExxonMobil executed a proof-of-concept (PoC) that stitched together heterogeneous components from different vendors. It also commissioned and operated a prototype OPA system on a pilot plant in New Jersey, and commissioned its OPA Testbed Lab near Houston from 2019 to the present. These initial experiments enabled ExxonMobil, system integrator Yokogawa and their partners to integrate, test and qualify products conforming to O-PAS, V2.1, and meeting ExxonMobil's requirements for field use (Figure 2).

All of this testing and experience went into developing ExxonMobil's design for its field trial, which recently completed front-end engineering and design (FEED), and is now at the detailed design stage. ExxonMobil plans to conduct its FAT this summer, and expects to start running the field trial before the end of the year at an ExxonMobil chemical facility in Baton Rouge, LA. At about 20 times larger than the pilot, the field trial has about 2,500 I/O points and about 100 loops.

Enjoying interchangeability

While its testbed and field trial look like any other process automation application, differences and advantages due to OPA quickly become apparent.

"The testbed is wrapping up validation of the software and hardware components we'll use to assemble an OPA architecture for the field trial—and eventually build automation systems that will run in our plants for years," says David DeBari, OPA technical team leader at EMTEC and co-chair of OPAF's application portability subcommittee. "The field trial is a risk-appropriate application and typical brownfield migration to new controls. We're replacing an existing DCS and a handful of obsolete PLCs, but this time we're moving to an OPA-based, open architecture, which is also networked with standard Ethernet, lots of OPC UA protocol, and some legacy serial communications. This looks like a regular DCS migration project, but the difference now is that it's also enabled by standards that provide interoperability and interchangeability."

Similar to most process industry end users, DeBari reports that ExxonMobil was traditionally constrained by proprietary controls and other technology from its suppliers. "We had to use the same Brand X for I/O, controllers and software. Now, we have the choice of using Brand X software, Brand Y I/O and Brand Z controllers, and getting the best features for each," he explains. "Sticking to standards like O-PAS can give us plug-and-play interoperability, no more proprietary lockouts or lock-ins, and our choice of products that fulfill our requirements. We used to see all the choices available in mainstream consumer areas like cellular, audio and video technologies, and we wanted that level of choice in our process controls and other industrial technologies. For example, with our cellular phones, we can use any device with our service provider. This capability comes with standardization. The old idea of requiring homogenous I/O, PLCs and software is long gone."

Share and share alike

Smeltzer reports that whatever ExxonMobil and its partners learn from the field trial will be shared with whoever wants to learn about OPA and use it to gain momentum towards a building a marketplace. "Our intent is to drive technology forward for our industry and add value to our business, but we need to do it in a reliable and robust manner for the lives of our assets," explains Smeltzer. "The first commercial application of OPA is our field trial in Baton Rouge, which focuses on improving performance and adding value for this manufacturing plant. These OPA program development activities have taken seven years, cost millions of dollars and require a lot of sweat equity, but we're willing share what we're learning and add to everyone's investment in the automation space."

Smetlzer adds the field trial's components will also perform analytics at the edge—next to sensors gathering data. "All of this is underpinned by O-PAS, which is why we need to keep pushing for commercialization, conforming O-PAS products, and keeping the standard updated," says Smeltzer. "All of this requires investment, whether it's in the kit and controls for the testbed or in the hands-on efforts of our people. We want to perform these operations better and cheaper, so we have to be convinced there's value is proposed solutions. Well, ExxonMobil is convinced that O-PAS has value, and that's why we and our partners invest in it, and it's why we're encouraging other potential users, companies and organizations to do the same." ∞

Savannah River gets an automation assist

The U.S. Dept. of Energy facility develops HMIs for the water/wastewater section of its radioactive soup-to-glass process

by Jim Montague

ONE reason it's hard to make big changes is they often come with a big scoop of self-consciousness. So, while everyone else seems to be implementing more sophisticated automation and controls, it can feel embarrassing to move some processes from manual to automation for the first time.

No worries. The trick is to be brave, focus on what's best for each process, organization and its end users, and remember that everyone else has made difficult transitions, so it's a good bet we can do it, too. For instance, 40-year-old Savannah River Mission Completion's (SRMC) main job is converting "radioactive soup" into glass for long-term storage, and Jim Coleman, advisory engineer at SMRC, reports it's been migrating from some of the manual and paper-based practices it uses to manage the water and wastewater applications that supports its environmental cleanup.

Coleman presented "Transfer assistant: helping an operator in a manual-only world" at Emerson Global Users Exchange 2022 in Dallas this past October.

Soup to glass needs water

SRMC is processing 36 million gallons of this radioactive waste, located in 51 tanks that are each more than 1 million gallons. This tank farm is located at the U.S. Dept. of Energy's (DoE) Savannah River Site (SRS) near Aiken, S.C. The original mission of the 70-year-old, 310-square-mile facility was producing and replenishing material for nuclear weapons, but its assignment in recent years has been supporting SRS's legacy cleanup project that's expected to take another 15 years (Figure 1).

To render the soup inert, SRMC moves it to a production canyon in a building with foot-thick walls and no onsite opera-

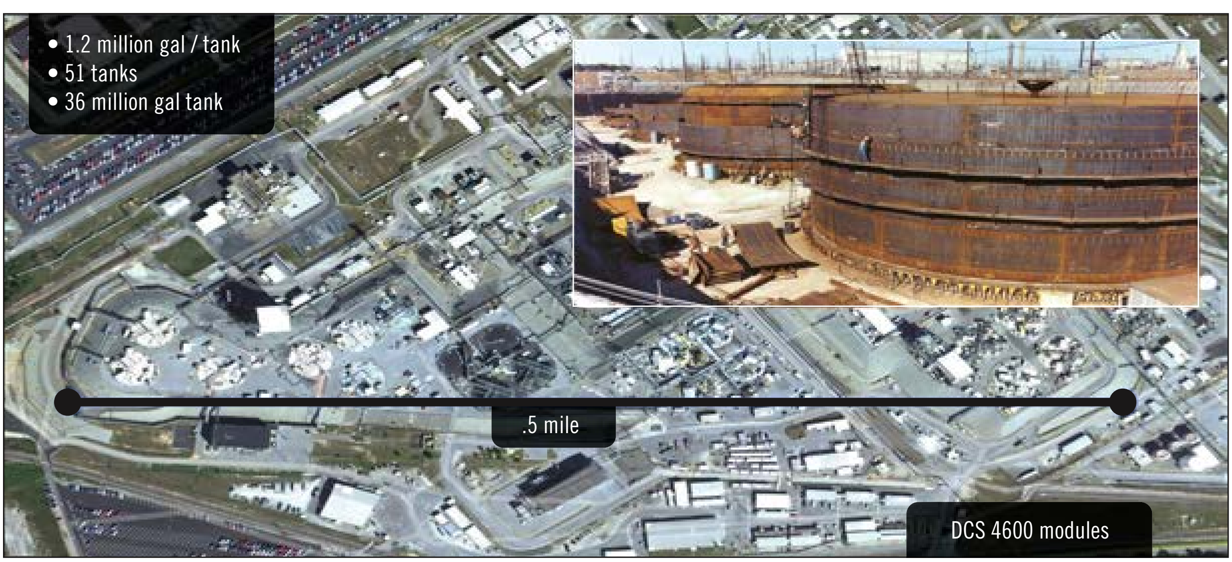

Figure 1: Savannah River Mission Completion's (SRMC) main job is converting 36 million gallons of "radioactive soup" into glass for long-term storage. This waste is located in 51 tanks that are each more than 1 million gallons at the U.S. Dept. of Energy's (DoE) Savannah River Site (SRS) near Aiken, S.C. Source: SRMC and Emerson

tors. The waste is mixed with sand, melted into glass, and put into 10-foot-tall cylinders that weigh 5,000 pounds each. This conversion process requires SRMC to operate floor drains, catch tanks, steam condensers and washers; complete about 800 manual transfers between tanks and other devices; and clear strainers on the drains that can get clogged with gook from multiple locations (Figure 2). These “doing stuff” actions are carried out by agitators, valves, pumps, tanks and other devices, which are controlled by a DeltaV DCS from Emerson (www.emerson.com), and bookended by paper permissions before they can operate and more paper reports to document their performance.

Aid from a simpler HMI

Coleman reported that SRMC recently began automating some of the water/wastewater applications that support its nuclear waste conversion process due to increasing errors and loss of expertise.

“We were seeing more boo-boos in our processes, and decided we needed to remove some from manual and automate them to help our operators,” says Coleman. “All of the original, veteran operators had long since retired, and we wanted to develop a transfer assistant (TA) that could work with DeltaV, which we’ve been working with for 21 years. We started with Version 5, and now we’re using Version 14, which is the latest.”

SRMC’s new digital, automated transfer assistant would concentrate mainly on the “doing stuff” and documentation sections of its water/wastewater processes. The new TA and its functions were developed in Emerson’s Operations Graphics package software.

“We also wanted to clean up our HMI graphics, and have one graphic screen per transfer operation, instead of the multiple transfers per graphic we had previously,” Coleman explains. “This would help our operators understand what was going on in a snap.” (Figure 3)

Coleman added that he and SRMC wanted a one-stop-shop of basic components for the transfer assistant, including signal and parameters characterized by “how far,” “how much” and other essential questions. It would also need to calculate mass balances, list what to resolve before hitting the go button, and automatically generate required reports. “We needed it to inform users what must be true to proceed with their operations and have a reasonable chance of success,” says Coleman.

Preserve and automate best practices

To get its staff to accept its automated TA, Coleman reported it would have to maintain the same look and feel as their existing HMIs, and use their familiar faceplates and details as much as possible. These include faceplates with standard selectors such as stop/go buttons. The details are similar to their earlier counterparts, but they’ve also added two new elements for landing point-help and ListView functions. In general, ListView displays lists to users, and is part of the Visual Basic for Applications (VBA) software in all Microsoft Office products.

“Many of our operators have been using the same on-screen displays for 20 years, and they don’t want to change,” Coleman says. “There had to something in it for them. Likewise, the new assistant’s underlying code also had to be enough like existing code, so it wouldn’t throw our developers for a loop. The magic of our new TA is it shows detailed data via ListView on the displays, enables one transfer per graphic, generates printed reports, and can’t start a process without an assurance of success. The best part is anyone can do this.”

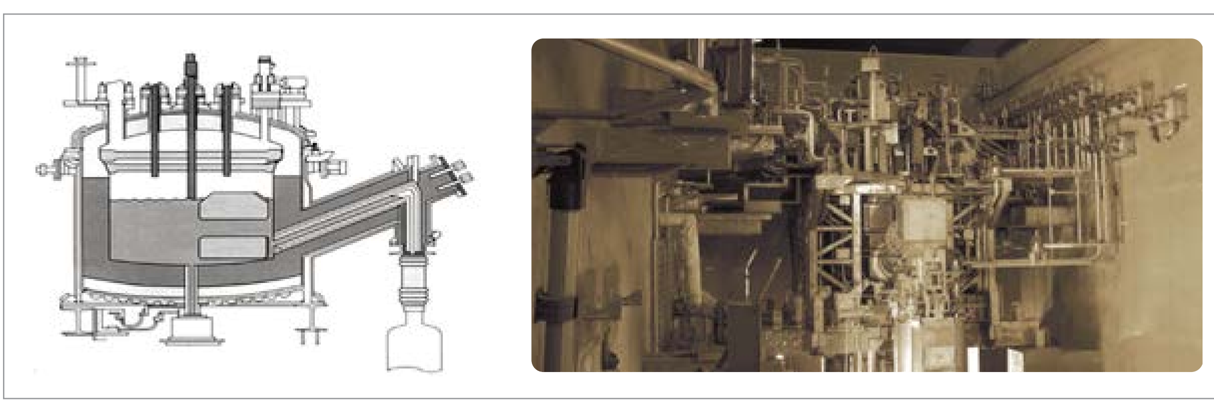

Figure 2: In SRMC’s unmanned production canyon, radioactive waste is rendered inert by mixing it with sand, melting it into glass, and putting it into 10-foot-tall cylinders that each weigh 5,000 pounds. This conversion process requires SRMC to operate floor drains, catch tanks, steam condensers and washers; complete about 800 manual transfers between tanks and other devices; and clear strainers on the drains that can get clogged with gook from multiple locations. Source: SRMC and Emerson

To formulate the code for its TA or another type of display-based assistant tool, Coleman used Control Studio software for SMRC's highly documented code for items, such as level parameters and logs of changes. Its developers use standard selection logic to pick two to eight items for functions they want to perform, and decide which chunk of code to run, such as a command-driven module or a bookkeeping function. "Instead of writing code to a screen, our software writes it to a parameter, and then the screen reads that parameter," Coleman explains. "These lists of parameters are the link between performance modules and ListView on the graphic."

SMRC's developers can also check pre-starts before interlocks during transfers, as well as compare contemplated actions to what's been done before, decide what to do, and use standard code to populate the parameters. They can even address sequential function chart (SFC) data that can't fit onto typical displays, and fill out the parameters for getting that data onto displays and reports. Also, Emerson has a ListView function that can move parameters from modules to ListView, which allows Microsoft to move it to DeltaV or elsewhere.

To generate reports, Coleman advised users to maintain their data in the Module/Report/Data/ParameterName format, generate their reports from data, and display, print, store and retrieve it as needed. He added that SMRC's operators and managers don't want reports displayed as Microsoft Word or Excel files or as Adobe PDF files, and recommend using an HTML viewer and opening files with Notepad software.

"This has been a big help because all our files look the same now," adds Coleman. "All this code is in the user.fxs file, and lets us use one piece of it for all our reports. We can also add a trend button to the screen, and employ a VBA script that uses an Emerson function to make a chart."

Figure 3: To reduce errors and make up for lost expertise, SRMC started automating some of its water/wastewater applications by developing a transfer assistant (TA) with a one-stop-shop of basic functions that could work with its DeltaV control system. It also used Emerson's Operations Graphics software to declutter and simplifying its HMI display from the multiple transfers per graphic it previously used (above) to just one screen per transfer operation. Source: SRMC and Emerson

Figure 4: To get its staff to use the automated transfer assistant (TA), SRMC gave it the same look, feel, faceplates and details as their existing displays, but added two new elements for landing point-help and ListView functions. This lets the TA show detailed data via ListView on the displays, enable one transfer per graphic, generate printed reports, and can't start a process without an assurance of success. Source: SRMC and Emerson

Coleman added that SRMC will likely add similar automated assistants to about 50 other transfer processes. "Where our old graphics had multiple transfers per screen, and were cluttered with unused items that contributed to operator errors, we now have one transfer per screen," Coleman concludes. "The benefits of implementing our TA is we've reduced errors in our transfers, freed our operators, and achieved more consistent documentation—and again, anyone can do it." ∞

by R. Russell Rhinehart

Feedforward control & disturbances

A DISTURBANCE'S MEASURED VALUE CAN BE USED TO PREVENT UPSETTING THE PROCESS

IF a disturbance is measurable, then its measured value can be used in feedforward control to prevent the disturbance from upsetting the process.

Feedback (PID, etc.) is like reactive maintenance. After you see the problem, start fixing it. By contrast, feedforward is like predictive maintenance. When you anticipate there will be a problem in the future, take action to prevent the problem from happening so it does not happen.

The "D" action in PID is anticipatory, but not in the feedforward or predictive sense. It leads the actuating error to anticipate what the error might become soon. This isn't feedforward. PID looks at the actuating error, the deviation from setpoint, which is the process response to a disturbance. The evidence of a disturbance isn't seen until after it starts to be expressed by the process. Even with "D" action, feedback doesn't respond until after the disturbance begins to show its effect on the process. Feedback looks at the process response, the present consequence of the past disturbance.

By contrast, feedforward looks at the disturbance variable, the cause of the future process deviation, not the actuating error. Feedforward acts before the actuating error would indicate action is needed.

An example by analogy

A human example: it was chilly in the morning, so he wore a jacket. After a while, the sun came up, and he started sweating and took off the jacket. That was feedback. The corrective action (removing the jacket) came after the problem (sweating, too-high body temperature) was sensed.

On the other hand, seeing the sun rising, knowing what would eventually happen, and taking off the jacket just prior to becoming uncomfortable is feedforward action because it's taken before an actuating error indicates it's needed.

Feedforward model coefficients

There are four coefficients in feedforward control (the action is often called a dynamic compensator). The most important are delay and gain, which are also the easiest to determine.

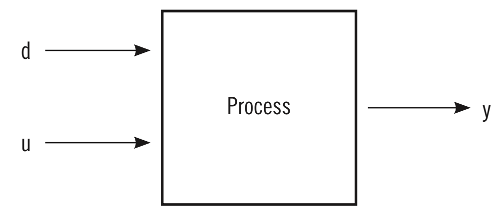

Figure 1: Process concept

1. **Delay:** When do you take the action? Take the jacket off at dawn's first sign of the sun rising? One hour later? If too early, he will be chilly for a while. The answer is: take action when you anticipate the disturbance (rising sun) will require removing the jacket. Don't take action immediately upon seeing the cause. Delay action until it's required, until the effect will happen. Maybe the delay is 4 hours, $\theta_{ff} = 4$ hrs.
2. **Gain:** How much action should you take? If he takes off the jacket, shirt and undershirt, then he may get chilly. This would be high gain, and too large of a control action. By contrast, if he just unzips the jacket, this may not be enough heat removing action, and he will get hot. That would be low gain, and too small of a control action. Maybe the gain is to remove the jacket and roll up his shirt sleeves per sunrise, $\Delta u = 1.3$ *items of clothing/sun*.
3. **Lag:** Should he remove all cover immediately, or start taking action progressively? Should he first unzip, then remove jacket, and finally roll up his shirt sleeves? This starts the taking action, but progressively lags or ramps it to the final value. What should be the lag time-constant? If you start predictive-corrective action after the delay, θ_{ff}, and want the corrective action to be complete by a certain time, t_{finish}, with effectively four time-constants in a lag duration, then $\tau_{lag,ff}=(t_{finish} - \theta_{ff})/4$.
4. **Lead:** If the control action has a delay in taking compensation, and that delay is longer than the delay for the disturbance, then you should take control action before the disturbance is knowable. (You need to be psychic to predict what nature is going

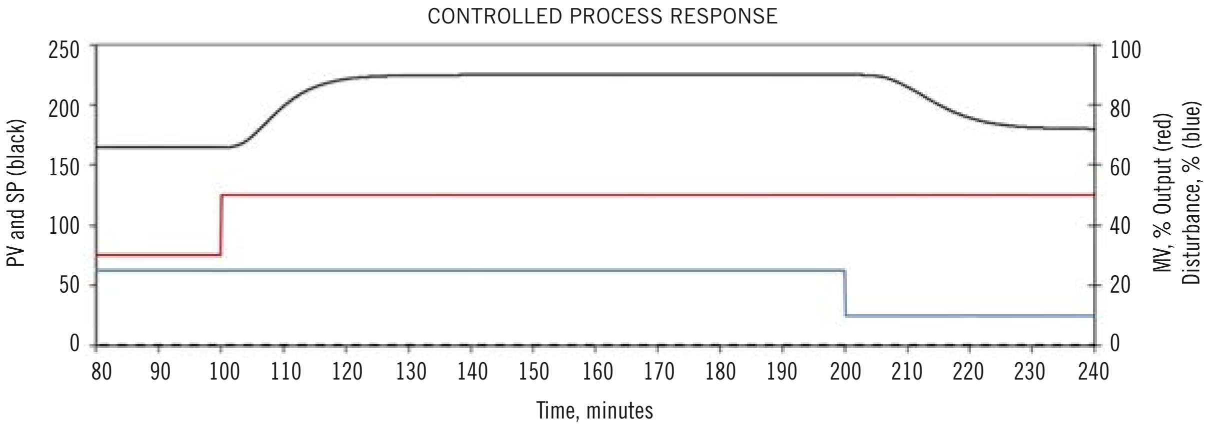

Figure 2: Process responses to "d" and "u"

to give you.) Since you can't take action before you know that action is needed, take excessive initial action, then lag back to the proper value. This is a lead. The ratio of lead-time to lag-time is the initial overage of action. If $\tau_{lead,ff}/\tau_{lag,ff} = 1.5$, then $1.5\Delta u = 1.5 \cdot 1.3$ *items of clothing* = 2 *items of clothing*. Initially, take off the jacket and shirt, then gradually put the shirt back on with sleeves rolled up during the θ_{ff} to t_{finish} interval. Alternately, if you have a feel for the initial kick relative to the final adjustment then:

$$\tau_{lead,ff} = \tau_{lag,ff} \frac{\textit{(initial correction)}}{\textit{(final correction)}}$$

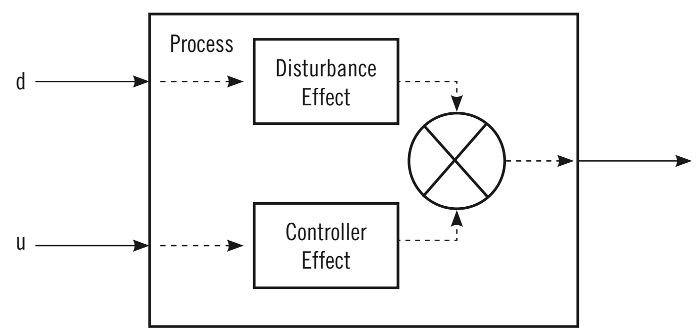

Figure 3: Process model details

The process model for feedforward control

We consider the process with output, y, being affected by both the measurable disturbance, d, and the controller MV, u. As illustrated in Figure 1, the process may be a reactor with yield as the output, y, with raw material composition the disturbance, d, and the controller signal to the reagent valve, u. Alternately, the process may be distillation with distillate composition, y, being affected by both column feed rate, d, and the signal, u, to the reflux flow control valve.

Both d and u affect y. Conceptually, as illustrated in Figure 2, from step tests in d and u, one can get FOPDT models for how y responds to either d or u.

From Figure 2, the FOPDT models are: for the disturbance $(3e^{-7s}) / (10s+1)$, the gain is 3 [CV units per %], the delay is 7 [min], and the time-constant is 10 [min]. For the controller effect, $(3e^{-4s}) / (7s+1)$, the gain is 3 [CV units per %],

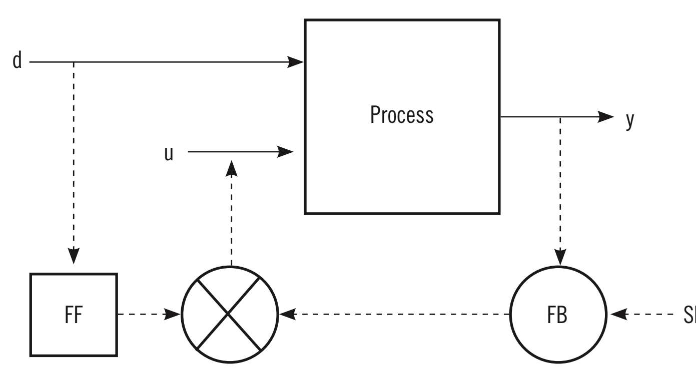

Figure 4: Feedback with feedforward

the delay is 4 [min], and the time-constant is 7 [min]. These are conveniently rounded values and determined using eyeball estimates from the steepest-slope extrapolation method. These are approximate values. You could use any preferred method to determine the model coefficient values.

However, one doesn't need single perfect steps from an initial steady state to a final steady state. I believe that experience could provide reasonable estimates for the gain and delays, and perhaps even the lead and lag.

Without such experience, I recommend using regression on multiple input changes, which don't need to be steps. The input changes might also be what naturally happens. However, when getting the response to the disturbance, keep the controller in MAN with a fixed output, or else the control action will confound the response. When getting the process response to the controller MV, make sure that the MV changes are large enough to overshadow the naturally occurring d impact on the CV. My FOPDT regression program [1] can be used to convert I/O data to the models.

Determining feedforward action

Intuitively, it's easy to determine the feedforward delay and gain from process response models. As illustrated in Figure 2, the delay for the process to show the impact of the disturbance is 7 min, and the delay for the process to express the impact of the MV is 4 min. Then the MV should respond to the d at 7-4=3 min after the d changes. This rule is $\theta_{ff} = \theta_d - \theta_u$.

If the gain of the disturbance impact on the process is 5 [CV/%] and d makes a +2 [%] change, then you expect the eventual process response to be +2*5 = 10 [CV units]. So, the MV needs to have a -10 [CV units] impact to cancel the d impact. If the gain of the MV impact on the process is 6 [CV/%], then, to create the needed -10 [CV units] impact, the MV needs to move -10/6=-1.67 [%]. This rule is $K_{ff} = -K_d / K_u$.

Both rules are from intuitive logic. As we'll see they're also outcomes of mathematical analysis, the lag and lead can be intuitively chosen also, but the logic is a bit complex. However, mathematical analysis of a model of the system can lead to gain, delay, lead and lag values.

To mathematically derive the feedforward action, use a simple concept that the u and d effects on the process are independent and additive. This model is illustrated in Figure 3.

Using FOPDT models for how y is affected by u and d in Laplace notation, the concept of Figure 3 is this mathematical model:

$$\hat{y} = \frac{3e^{-7s}}{10s+1}\hat{d} + \frac{3e^{-4s}}{7s+1}\hat{u}$$

We want to determine u such that the change of y is zero when d changes. So, set $\hat{y} = 0$:

$$0 = \frac{K_d e^{-\theta_d s}}{\tau_d s+1}\hat{d} + \frac{K_u e^{-\theta_u s}}{\tau_u s+1}\hat{u}$$

And solve for $\hat{u}$. Although the abstraction of Laplace is difficult, the algebra is easy. The answer to how u should change is:

$$\hat{u} = -\frac{K_d e^{-\theta_d s}}{\tau_d s+1}\,\frac{\tau_u s+1}{K_u e^{-\theta_u s}}\,\hat{d} = -\left(\frac{K_d}{K_u}\right) e^{-(\theta_d-\theta_u)s}\,\frac{\tau_u s+1}{\tau_d s+1}\,\hat{d}$$

$$\hat{u} = K^{ff} e^{-\theta_{ff} s}\,\frac{\tau_{lead,ff}\, s+1}{\tau_{lag,ff}\, s+1}\,\hat{d}$$

With data from the two FOPDT models from Figure 2:

$$\theta_{ff} = \theta_d - \theta_u = 7min - 4min = 3\ min$$

$$Kff = -\frac{K_d}{K_u} = -\frac{\dfrac{3y\_units}{d\_unut}}{\dfrac{3y\_units}{u\_unit}} = -1\ \frac{u\_units}{d\_unit}$$

$$\tau_{lead,ff} = \tau_u = 7\ min$$

$$\tau_{lag,ff} = \tau_d = 10\ min$$

In this case, the rule is, "Add the following action to whatever the feedback controller wants to do: when d makes a change, wait $\theta_{ff} = 3\ min$ before changing u. Make the change in u be $K_{ff}\,\Delta d = -1\ (u\_units)/(d\_unit)\ \Delta d$. But don't implement the entire change now. Jump to $\tau_{lead,ff} / \tau_{lag,ff} = 7\ min / 10\ min = 0.7$ of the ultimate value, then lag to the final value with $\tau_{lag,ff} = 10\ min$."

Characteristic of Laplace analysis, this analysis is in deviation variables. The change in the disturbance from a base value determines the change in MV:

$$\Delta u = K_{ff} \cdot \Delta d$$

The action isn't based on the disturbance value, but its deviation from a base or reference value.

Include feedback control

We still need feedback control. There are several reasons:

- Feedforward can only fix the measurable disturbance. Other disturbances will still affect the process. Feedback is needed to fix the others;
- The feedforward model isn't perfect. It's an FOPDT approximation. So, though feedforward help will be very good, it will not be perfect. Feedback is needed to trim the feedforward imperfection;
- If the disturbance measurement is in error (perhaps due to calibration drift), then the feedforward correction will be imperfect. Feedback is needed to compensate; and
- Feedforward can't move the process to a new set point. Feedback is needed to do that.

Typically, feedforward control action is added to the feedback action with a control structure illustrated in Figure 4.

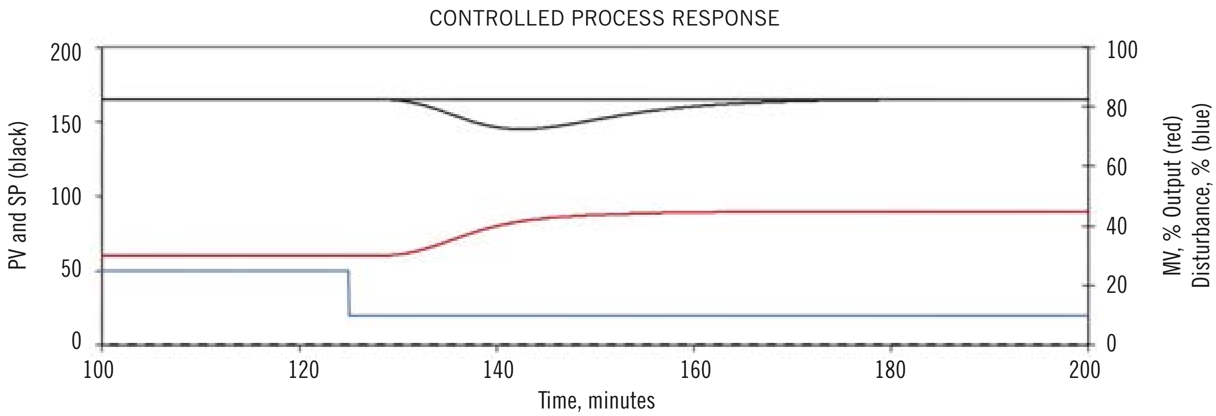

Figure 5: Control simulation: Feedback only

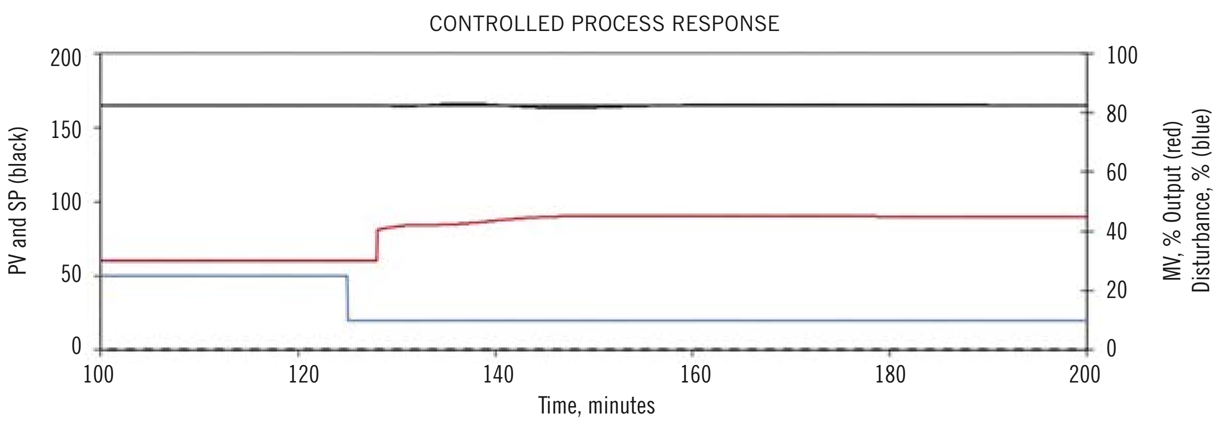

Figure 6: Control simulation: Feedback with feedforward

In a sense, this is like an override situation. The output of the feedback controller (FB) doesn't go to the process. The feedforward (FF) action is added to it. The sum of the two go to the process.

Here is the issue: if the FB action is 90% and the FF action is 20%, then the combined 110% is infeasible. Only 100% can go to the process. (Figure 4 doesn't show the override from the summation circle.) The override causes an effect similar to windup. If the FB controller wants to correct a CV error by lowering the signal by 5%, reducing its output to 85%, the sum is 105% and the valve remains 100% open. Nothing happens until the feedback output winds down to 79%.

If the feedforward controller is adding 20%, then the output of the feedback controller should be limited to 80%. If either using limits on the integral or external reset feedback (erf), the FF action needs to be included in the feedback bias limitation. For instance, the erf signal to the feedback controller must be adjusted for the FF contribution:

$$erf = MV_{actual} - FF$$

The control device should take care of all this for you. You need to determine the four FF coefficient values: θ_{ff}, K_{ff}, $\tau_{lead,ff}$, and $\tau_{lag,ff}$.

Illustration

First, here is an illustration of feedback alone. Figure 5 illustrates a tuned PID feedback controller (MV is the middle trace) with no feedforward action reacting to a disturbance (the lower step change). CV and SP are the upper traces.

Notice: the control action doesn't start until after the CV deviation is visible. When the deviation is small, the control action is small, even though it eventually needs to be much larger. The "D" action in the PID controller doesn't anticipate what the fully developed deviation will be.

Second, Figure 6 illustrates the same feedback controller and same disturbance, but with feedforward.

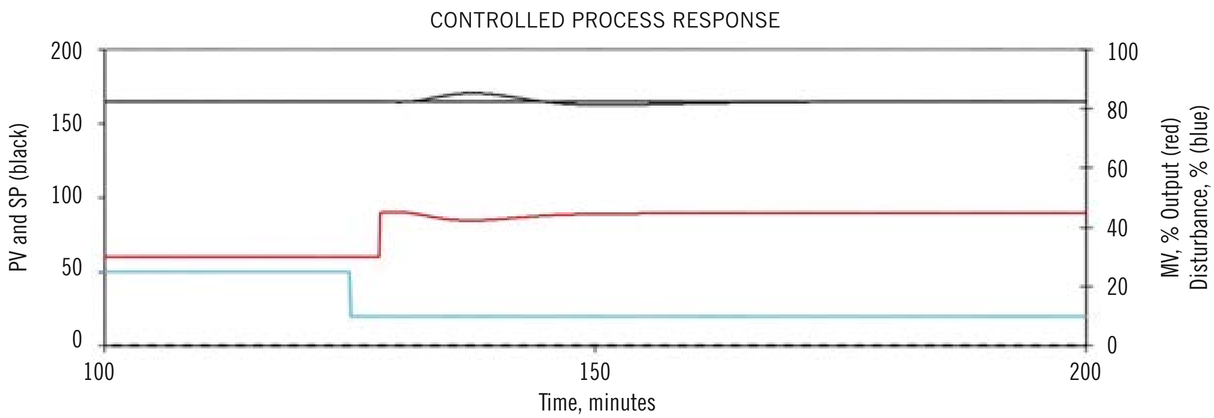

Figure 7: Control simulation: Feedback with simple feedforward

Figure 8: Control simulation with continual disturbance changes, feedback alone

Notice: there's a 3-min delay in the MV response (middle trace). The initial MV jumps to 70% of the final value, even when there's barely noticeable CV deviation (upper trace) at that time. The lag to the final MV value takes about 28 min, which is about 4 times the lag time of 7 min. There's nearly, but not perfect, cancellation of the d effect on the CV. The simple FOPDT models aren't perfect matches to the high-order process responses. Also, the additive and independent model of action is an approximation. Finally, the FOPDT coefficients are convenient values. So, for several reasons, compensation based on the simple models isn't expected to be perfect, but it is good. There's a feedback trim during the transient due to the residual CV deviations, which makes the combined feedback and feedforward MV response not a perfect lag from the initial jump to the final value. There is much better CV control than feedback alone.

Even a simple FF without lead and lag can be a very good prevention. Figure 7 illustrates the same situation but with both $\tau_{lead,ff}$ and $\tau_{lag,ff}$ set to zero.

Quality giveaway

How can you quantify the benefit of feedforward? Here is one method. Figure 8 illustrates the process in regulatory mode. The dotted line at the CV value of 200 represents the CV limit—perhaps a customer specification or a safety or operational limit. The process setpoint at 185 is 15 CV units lower than the limit. The disturbance continually causes deviations from the SP, which are countered by the well-tuned feedback controller. There are only occasional and very small PV violations of the limit. But if the setpoint is increased, closer to the limit, there will be many and significant violations of the limit.

We would like to have the setpoint closer to the limit. The 15 CV units deviation between setpoint and limit is termed quality giveaway. Consider that the CV represents impurity and 200 is the specification (maybe the units are ppm). Then, if the setpoint was at the specification, there would be many unacceptable purity deviations. In this example, to prevent purity violations, one must manufacture, on average, a product that's 15 units purer

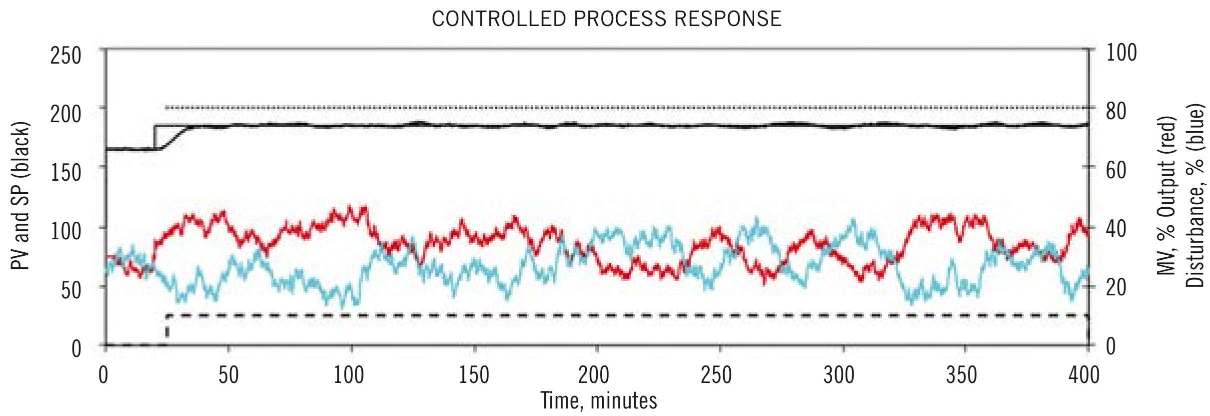

Figure 9: Control simulation with continual disturbance changes, feedback with feedforward

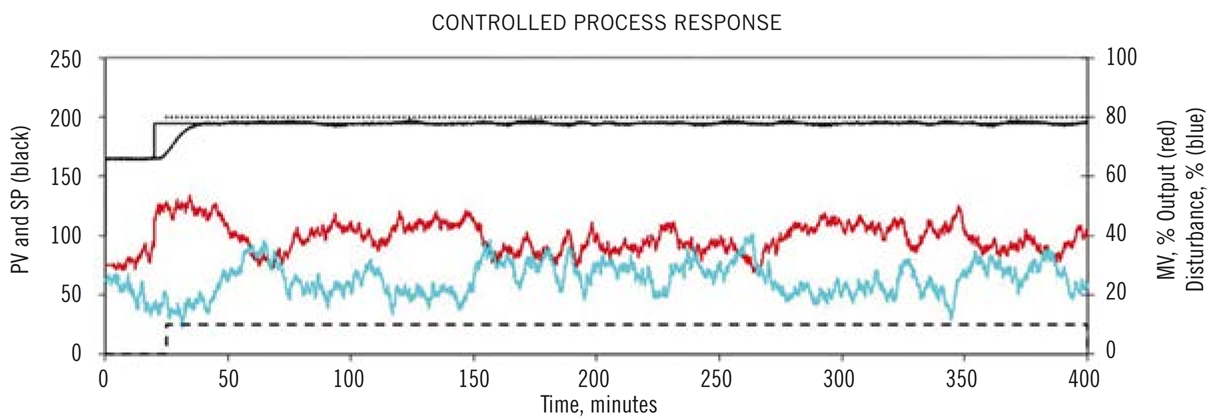

Figure 10: Control simulation with continual disturbance changes, reduced quality giveaway

than required. Higher purity requires greater energy input, or more culled product, or slower production, or some other operational aspect that can be converted to manufacturing costs. Process owners should be able to quantify such costs.

Figure 9 shows what happens with feedforward control helping the feedback controller. The setpoint is still 15 CV units from the limit.

Notice: there is much-reduced variation in the CV. At no time is the CV close to the limit. The MV (red trace) is a mirror image of the disturbance (blue trace) but with a bit of a delay.

Now that control is greatly improved, the setpoint can be closer to the limit. In Figure 10, the setpoint is just five quality giveaway units from the specification. There are no violations.

Takeaway

If a disturbance source is measurable and has a dominating impact on the CV, then feedforward action can be a substantial benefit to regulatory control.

Implement feedforward in the manufacture's devices, so that integral wind up, initialization, and MAN-AUTO transfer issues are properly handled.

You don't need perfect models. Often just intuitive values for feedforward gain and delay, and zero for the lead and lag time-constants, will provide substantial feedforward benefit.

You don't need to determine models from ideal step tests. Regression can be very beneficial in fitting models to data.

Feedforward assists feedback. It's not the primary signal to the final control element. It trims the feedback controller signal based on disturbance deviations from a base value.

You still need feedback control for setpoint changes, compensation for measurement errors, feedforward model errors and other disturbances. ∞

Russ Rhinehart started his career in the process industry. After 13 years and rising to engineering supervision, he transferred to a 31-year academic career. Now "retired", he enjoys coaching professionals through books, articles, short courses, and postings on his website www.r3eda.com.

Sizing instrument air supplies

Also, how to deal with the chimney effect on air flow

Q: I'd like to ask about the engineering practice or standard to define the instrument air demand for control, shutdown (single-acting/double-acting) and blowdown valves.

RAGAB ABDEL FATTAH
ragab.abdelfattah@tecnomareegypt.com

A1: One approach is to tabulate all the instruments and devices that consume air, and assume (as a starting point) that each end device requires 2 scfm, and account for future expansion by adding 10% for leaks and contingency.

You can Google available information at https://bit.ly/3xO0xeP.

Good luck and feel free to come back if you need any additional help.

AVIHU HIRAM
process control consultant
Avihu@HiramEng.com

A2: Calculate as follows:

1. Control valves are considered as continuous air consumption, and the calculations are based on vendor information. Generally, we consider 10 operations per hour.
2. Air consumption requirement for an on/off (shutdown/blowdown) valve for startup is taken from vendor data. To maintain the same on/off valve in open condition, continuous flow of 2 scfm is considered.

H.S. GAMBHIR
Harvindar.S.Gambhir@ril.com

Q: In the winter, when I drive or walk out from the underground level of a high-rise building, I can feel the cold outside air rushing in. I've been learning about the chimney effect, and I suspect that it's pulling in the cold air. Am I right? Is there a process control method to reduce or stop that flow? Would that reduce the heating load on a building?

Z. FRIEDMANN
graduate student
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A1: In winter, the density of cold, outside air is higher than inside. Since there are doors at the bottom and windows or other openings at the top, the chimney effect pulls in the cold outside air at the bottom. The size of the differential pressure generated by the chimney effect is a function of the temperature and humidity of the inside and outside and the height of the building. In case of tall buildings in the winter, it's in the range of about 2-10 inches H_2O.

The cold air inflow will stop when that differential pressure is reduced to zero, which will occur when the air pressure inside the building is increased until it's the same as the outside air pressure at the bottom entrances. I designed such a system for the 43-story IBM headquarters building in New York in 1980. One estimate suggested that it reduced the heat load on the building 10%. You can suggest that your building's operators do the same, but first remind them to check if the windows are strong enough.

If the inside pressure on all floors is increased to match that of the outside pressure at the bottom, the windows on the upper floors must be kept closed in the winter and be strong enough for the 2-10 inches H_2O differential pressure. This is important because later I heard that a design firm copied, but didn't fully understand the design. As the winter got cold, their weak windows started popping out onto the street.

As for the chimney effect, it's used in other applications. For example, in power plants where the returning warm cooling water from the plant is sent to the bottom of hyperbolic, chimney-shaped cooling towers, the outside air cools and partially evaporates it before being returned as cooling water to the plant (Figure 1). The water cools as its heat content gets reduced by the large flow of the air as it leaves at the top without requiring fans to drive the large air flow.

The chimney effect is also used in solar updraft towers (Figure 2), which convert the solar thermal energy to aerodynamic energy (wind). In this system, air is heated under a circular, greenhouse-

This column is moderated by Béla Lipták, who is also the editor of the *Instrument Engineers' Handbook (5th Edition: https://www.isa.org/products/instrument-and-automation-engineers-handbook-proce).* If you have a question concerning measurement, control, optimization or automation, please send it to: liptakbela@aol.com. When you send a question, please include full name, affiliation and title.

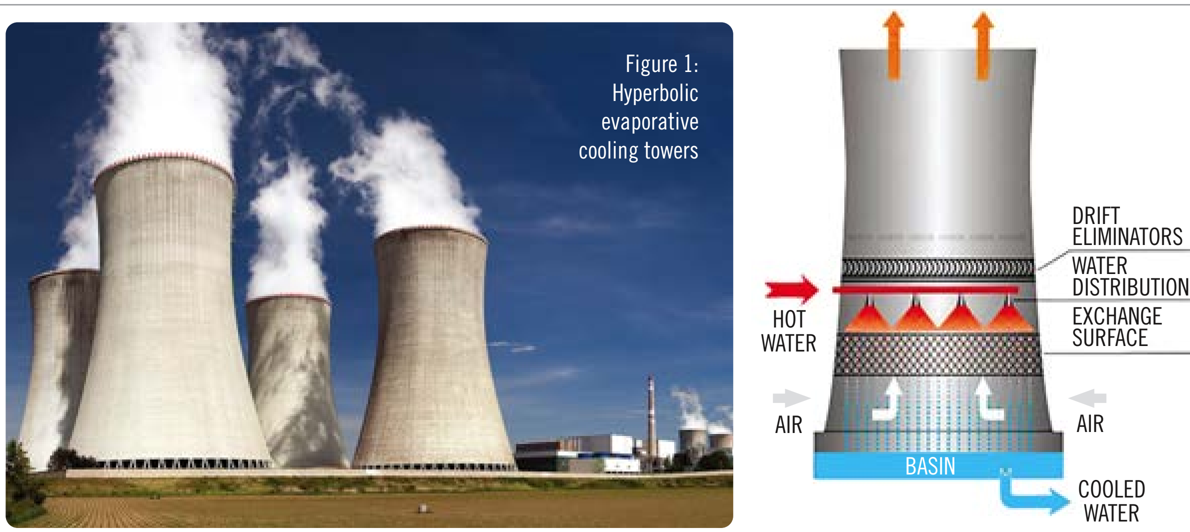

Figure 1: Hyperbolic evaporative cooling towers

like canopy where the sun heats the air, which rises up the tower while its aerodynamic energy is converted into electricity by driving an array of turbine generators. The first 50 kW working model was built in 1982 in Ciudad Real, Spain. The chimney of that model was 10 m (33 ft) in diameter and 195 m (640 ft) tall. The diameter of the canopy was 244 m (800 ft), covering an area of about 46,000 m^2 (11 acres). This prototype reached a maximum production of 50 kW.

Today, 50-MW to 200-MW installations are planned in Australia, China, Africa and Arizona. In Arizona, a tower twice as tall as the Empire State Building is included and expected to generate 200 MW. A plant in China is planned to consist of a 38 km^2 canopy and a 1 km (0.62 mi) tall tower to provide 200,000 homes with electricity. It's expected to abate about 1 million tons of greenhouse gases and cost some $800 million. These designs are expensive. They can only be considered in areas of high solar insolation, and where the land is unusable for other purposes, or where the land under the canopy can be used for agricultural purposes. Design variations include the addition of thermal storage by covering the ground with heat-absorbing surfaces, so power generation can continue during the night or when the sun isn't shining.

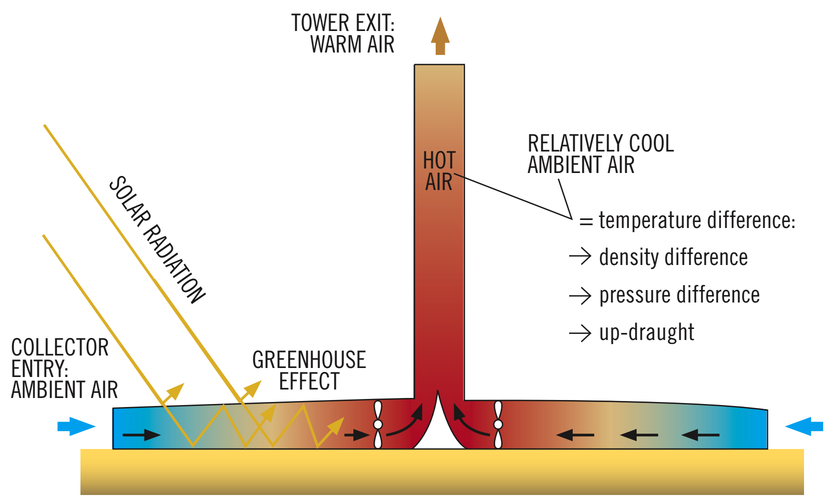

Figure 2: Solar thermal updraft wind turbine

In addition, these designs can incorporate transpired PV collector modules to obtain additional daytime output. This same concept was also used in ancient Persia by utilizing underground caverns from which cold air was pulled into palaces by employing the chimney effect.

BÉLA LIPTÁK
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A2: You can start a blower to start outward flow to prevent cold air from entering or take a hit and heat up the cold air that entered. Wind towards the entrance will make it difficult to prevent cold air from entering. As you know, clean rooms maintain positive air pressure in the room to prevent outside air from entering.

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www.automationdirect.com

EDGE-TO-CLOUD DATA AND CONTROL

To easily collect data from the field and move it to the cloud, EPC 1502 and EPC 1522 are PLCnext industrial, edge computers that integrate into existing IT infrastructure, closing the IT-OT gap. They have preinstalled software tools, such as Node-RED, local time-series database and a simple cloud connection, which reduce development and provision times. EPC 1522 has integrated Wi-Fi, while some models have a serial port for legacy connections. They also have a full-metal housing for passive cooling.

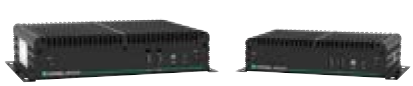
PHOENIX CONTACT
www.plcnext-community.net

PLC WITH ETHERNET PORT AND MICRO-SD SLOT

FL1F SmartRelay programmable logic controllers (PLC) from IDEC come with an RJ45 Ethernet port for remote downloading, uploading and monitoring. They're equipped with a micro-SD slot for program storage, transfer and data logging. Monitoring and controlling from a smartphone or tablet can be done via the SmartRelay App for iOS and Android devices. FL1F can network up to 16 SmartRelays, making it an ideal controller for simple automation tasks.

GALCO
www.galco.com

TWO BOX THIN CLIENTS WITH SECURE FIRMWARE



BTC12 and BTC14 are two, compact, industrial box thin clients with preloaded VisuNet RM Shell 5 firmware for security and stability in harsh environments. They employ Intel Apollo Lake and AMD Ryzen processors. RM Shell 5 embedded operating system has a simple, touchscreen user interface, security features and Windows 10 IoT Enterprise LTSB. Both BTC12 and BTC14 are built on an aluminum chassis with a fanless design, have a safe operating range of 20 °C to 60 °C, and no internal, moving parts.

PEPPERL+FUCHS
www.pepperl-fuchs.com

MODULARY EXPANDABLE WITH MODULES

Scalable Simatic S7-1200 basic controllers from Siemens have integrated inputs and outputs, communication options, and are modularly expandable. Digital and analog input, output and communication modules enable flexible adaptation to automation tasks. With integrated technologies such as high-speed counters, pulse width modulation, pulse sequence outputs, speed control and positioning, S7-1200 controllers are suitable for temperature control, pump and fan control, conveyor technology and packaging machines.

DIGI-KEY ELECTRONICS
www.digikey.com

SMALL WITH I/O AND COMMUNICATIONS

Compact Controller 100 is a small-scale PLC with a variety of remote I/O for use in smaller applications. CC100 has additional communication ports, including a serial port for connecting to numerous devices. It can interface with devices using protocols such as Modbus TCP/UDP, EtherNet/IP or EtherCAT with its two onboard Ethernet ports. Programmed with Codesys 3.5, CC100 can use the controller's built-in web server to develop HTML 5 visualizations at no additional charge.

WAGO
www.wago.com

SECOND BOARD FOR FUNCTIONAL EXTENSIONS

C6027 ultra-compact, fanless, industrial PC (IPC) offers high computing power in a compact form with an energy-efficient Intel Core i U processor. Compared to the existing C6025 IPC, this model adds a second circuit board level for customization with optional interfaces or function extensions, such as 6 x Ethernet ports (RJ45) or an integrated 1-second UPS to secure persistent data. The initial variant of C6027 with nine Ethernet ports is suited to be an IoT or security gateway for connecting modules.

BECKHOFF AUTOMATION
www.beckhoff.com

TWO NETWORKS IN ONE MODULE

iQ-R Series CC-Link IE TSN Plus module supports CC-Link IE TSN and EtherNet/IP networks in one module. CC-Link IE TSN is an open industrial network technology that combines gigabit Ethernet bandwidth with time-sensitive networking (TSN) allowing high-speed motion control, safety and standard communications by I/O devices. iQ-R connects CC-Link IE TSN devices to Port 1 and EtherNet/IP devices to Port 2 without affecting CC-Link IE TSN performance.

MITSUBISHI ELECTRIC
us.MitsubishiElectric.com/fa/en

EMBEDDED LINUX, GATEWAY FUNCTIONS

GRV-EPIC-PR1 edge-programmable, industrial controller from Opto 22 is an embedded Linux, real-time controller with gateway functions. Providing control, connectivity, data handling and visualization at the network edge, GRV-EPIC-PR1's modern design and sturdy unit features a resistive-touch, high-resolution LCD display for I/O, network configuration and troubleshooting. The LCD display lifts to provide easy access to the power button, power supply connectors, network interfaces, ports and status LEDs.

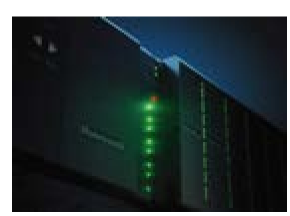
NEWARK
www.newark.com

ACCURATE, LABOR-SAVING LOOP CONTROL

Despite its compact 48 × 48 mm front panel, Model C1A single-loop controller achieves high accuracy of ±0.1% of reading (for thermocouple or Pt100 RTD), and high-speed response with a sampling cycle of 25 ms. Its 4.5-digit numerical display shows values from --19999 to 19999 in units of 0.01 °C. C1A also has labor-saving functions, such as a multi-status indicator that show process status at a glance, and communicates with PLCs without needing special programs.

AZBIL CORP.
https://tinyurl.com/3dm24ddz

PLC SUPPORTS IIOT EFFORTS



ControlEdge PLC combines with the Experion platform to reduce integration costs, minimize downtime, embed cybersecurity, and lower TCO with an extended lifecycle. This controller connects through all levels of process and business operations, and is one of the first supporting Honeywell's IIoT-ready initiative. ControlEdge also uses OPC UA protocol, and works with Universal I/O to enable remote configuration and late design change flexibility as part of LEAP project execution methodology.

HONEYWELL
process.honeywell.com

SPEED SOLVES CHALLENGES

FA-M3V series PLCs seek higher speeds to solve manufacturing challenges. Its Vitesse series has reportedly set industry speed records, while maintaining stable control, extensibility and reliability. It executes in 3.75 ns for basic instructions, 7.5 ns for application instructions and 37.5 ns for floating-point add instructions. This pursuit of speed also produced Yokogawa's Instruction, Processing, Response and Scan (IPRS) design, which features parallel and independent processing.

YOKOGAWA
https://tinyurl.com/m9rmtp3j

PAC WITH A-B RIO/DH+ PORT

NeoPAC is an open-architecture PAC with virtually unlimited memory and multiple, configurable ports. It supports up to two Allen-Bradley "bluehose" ports to interface to Data Highway Plus (DH+) or A-B Remote I/O (RIO) networks. NeoPAC can be connected to Ethernet or serial I/O, while also connecting to new and old Rockwell Automation controllers as a peer. This lets users of A-B PLCs upgrade obsolete devices without changing the A-B controller or buying costly interfaces. NeoPAC can even replace an A-B PLC.

SOFTPLC CORP.
800-SoftPLC, 512-264-8390; http://softplc.com

EXPANSION MODULE OFFERS OPTIONS

PLCs from Mitsubishi fit any industrial automation engineering need. With a wide variety of local and expansion module options running on AC or DC power, they provide multiple digital and analog I/O inputs, RS-485 SD connections, and memory card slots. In addition, each PLC also hosts its own IP address that, when coupled with the built-in Ethernet port, allows it to easily be connected and programmed into any established network.

MISUMI
misumi.info/PLC

EQUIPMENT & MATERIALS

AD INDEX

Keys to bioreactor temperature performance

Tight bioreactor temperature control is critical for cell health and productivity for modern biologics

GREG MCMILLAN

Gregory K. McMillan captures the wisdom of talented leaders in process control, and adds his perspective based on more than 50 years of experience, cartoons by Ted Williams, and (web-only) Top 10 lists. Find more of Greg's conceptual and principle-based knowledge in his Control Talk blog. Greg welcomes comments and column suggestions at ControlTalk@endeavorb2b.com

GREG: Last June, we learned from our dialog with automation engineer David Bruton how critical pH measurement and control was to bioreactor performance (see "Keys to bioreactor pH performance, Control, June '22, p. 40). Since we last spoke, Bruton has been busy starting his own company called "Tune The Process LLC" (www.TuneTheProcess.com). Here, he offers us his experience and expertise in temperature measurement and control.

Tight bioreactor temperature control is critical for cell health and productivity for modern biologics. What jacket temperature control system features help achieve tight temperature control?

DAVID: Most bioreactors have a jacket fed by a heat exchanger that's controlled through a split range to allow for heating and cooling with one control loop. With this split range, it's important that the physical side is designed correctly. Otherwise, there's only so much improvement that tuning the controls can do.

To keep the dynamics consistent and reliable, it's best to maintain the constant flow through the jacket and control the temperature through a makeup flow. The designer should choose a valve and system that minimizes abrupt changes to the flow, temperature or switching heat transfer mediums—especially at the split range point.

GREG: Is there a limit to how cold or warm a bioreactor's jacket temperature can be for cell health and productivity?

DAVID: Cell cultures are quite particular when it comes to their optimal temperatures. Mammalian cell cultures prefer to be around 36 °C to 37 °C, while insect cells grow more optimally at 27 °C. Overshooting the jacket temperature can be of special concern to prevent damage to cells or single-use bags at the edges of a reactor.

GREG: How do you minimize bioreactor temperature setpoint overshoot?

DAVID: Often, temperature control is required to meet a setpoint within tenths of a degree, so temperature overshoot is a great concern. Because batch cycle times are so long, waiting for a slow setpoint change can be a worthwhile tradeoff. Using a setpoint filter to slow down setpoint changes can eliminate overshoot when set to the reset time.

Other advanced features can be implemented to save on time as well. For example, lead-lag applied to the setpoint allows a larger initial bump to the setpoint change, while maintaining the slow approach to setpoint. Another option is using a full throttle startup, which entails setting the jacket controller to maximum allowable temperature until the reactor temperature is close to the desired setpoint. Then, reduce the jacket temperature and switch the control to reactor control.

GREG: Are there different temperature setpoints early in batch cycle to maximize cell growth and later in batch cycle to maximize product formation rate? How do you determine the best time for the setpoint change?

DAVID: There are often several temperature setpoints throughout the production run. All products and cell linings have different requirements to allow them to best express or produce the desired product. This is often tested by performing many runs at a lab scale before scaling up to production. Online analysis of cell growth during production runs could be used to verify and further improve the timing of these setpoint changes.

GREG: What are some best practices for temperature sensor installation to ensure temperature measurement is representative of batch temperature with an excellent signal-to-noise ratio?

DAVID: It's important to have the thermowell tip extend far enough into the bioreactor, so that it's not influenced by the cooler vessel wall. It's preferable to have it near or above the agitator, so it can see some significant fluid movement. The tip must be strategically located away from the gas spargers for dissolved oxygen control and pH control, so it won't be impacted by the bubbles. The insertion distance also needs to be long enough to minimize the heat conduction loss along the thermowell wall.

GREG: What type of temperature sensor is used to maximize measurement accuracy and speed?

DAVID: A spring-loaded, tight-fitting resistance temperature detector (RTD) in a stepped thermowell provides the fastest and most accurate response. The repeatability and drift of RTDs are two orders of magnitude better than thermocouples. The sensitivity, linearity and signal strength of RTDs are also outstanding.

GREG: There are many aspects of jacket temperature control that are misunderstood. The most common mistake is not keeping the jacket flow constant. This keeps the heat transfer coefficient more constant and higher since it's generally proportional to flow to 0.8 power. It also decreases fouling and jacket temperature sensor lag that dramatically increases below 1 fps. It also reduces the process dead time from transportation delay, and makes the process gain more linear since it's inversely proportional to flow.

How have you seen differing measurement locations impact control?

DAVID: Jacket temperatures measured at the inlet to the jacket can preemptively correct for utility disturbances and have a faster response. Jacket temperatures measured at the outlet of the jacket can better correct for disturbances originating in the vessel due to process disturbances in batch temperature. However, process disturbances are generally extremely slow in bioreactors. Changes in cell growth rate are exceptionally gradual, especially for modern biologics where batch cycle times are often 10 days or more.

GREG: The transportation delay of the piping between the jacket outlet and the jacket inlet is generally quite small if the jacket flow is kept constant. This small transportation delay is often smaller than the delay through the jacket. The additional delay in seeing a gradual process disturbance at the jacket inlet ends up having a negligible effect. The faster response of jacket inlet temperature control can translate to faster tuning and better setpoint response.

How do you handle the challenges of a reactor with both heating and cooling?

DAVID: If the jacket provides heating and cooling, I usually set a heat exchanger to heat and chill the water line to the jacket. It's important the split range does not send steam and chilled water directly to the jacket. The temperature extremes are too great and there are instabilities in the transition from steam to coolant due to residual bubbles. The same happens in the reverse direction from coolant to steam due to residual droplets. The traditional way to avoid this problem is using a heat exchanger in the jacket recirculation line. That helps the transition at the split range between heating and cooling the jacket water.

GREG: We found the heat transfer lag introduced by heat exchangers causes slower and looser jacket temperature control. The option of manipulating a bypass flow around the heat exchanger with the coolant flow fixed provides a faster but more complex jacket temperature response. The initial response to an increase in bypass flow around a heat exchanger will cause a fast increase in water temperature returning to jacket. However, the slower flow through the heat exchanger results in a secondary response of decrease in the temperature returning to jacket. The net response is still an increase in water temperature returning to jacket because the heat transfer coefficient is less for the slower jacket water flow through the heat exchanger.

DAVID: I'd imagine a valve position controller on the coolant flow could help with that secondary response and improve energy efficiency. ∞

Read an extended version of this article at ControlGlobal.com, including the "Top 10 things you don't want to hear about your temperature loops."

Lost in the sauce

Laser-like mission focus cuts through extraneous baloney

JIM MONTAGUE
Executive Editor
jmontague@endeavorb2b.com

"I know the results of good research and reporting when I see them, and O-PAS and its success are an example that anyone can learn from and follow."

IT'S hard to face new and unfamiliar situations. New schools, jobs, relationships, disciplines and technologies are filled with boatloads of new information to take in and unexpected tasks to complete, pass or fail. Maybe that's why the unknown is so feared—all the extra work.

Naturally, most of us would rather skip all this added labor, even if it means staying in abusive, inefficient and unprofitable positions. Anything to avoid nasty surprises. This may be the source of the traditional "if it's not broke, don't fix it" advice against tinkering and innovation.

I'm bringing this up now because I recently fell into several vast information oceans and bureau, and was forced to consider how I or anyone could keep our heads above water. Some are topics I'm trying to cover, such as the Open Process Automation Standard (O-PAS) in this issue's "O-PAS sets the pace" cover article (p. 20). In these situations, I remember a long-ago TV commercial for Mueller's Spaghetti, which was supposedly so tasty that it wouldn't get "lost in the sauce."

Well, I've been lost so often over the years that I got used to it. I used to get lost geographically, mostly covering new communities. Since then, I'm more often lost in new topics and technologies that I must learn about to cover them effectively. Of course, the inexorable shift from hardware to software has triggered huge changes that users, system integrators, suppliers and everyone else must learn about and harness to keep their operations efficient and competitive.

Naturally, the occupational hazard here is that we can get so lost in details, bureaucracies, technical requirements and busywork that we risk forgetting what our original jobs were supposed to accomplish. In trade publishing, for example, many of us become so focused on filling out metadata forms to improve search engine optimization (SEO) that we sacrifice producing content that readers will want to experience.

Personally, I marvel at the technical sophistication and technical capabilities of smart phones and social media. Unfortunately, I'm even more amazed that many users apparently have nothing useful to say to each other, or maybe just aren't concentrating on anything beyond breathless hyperbole about superficial baloney. There's no doubt that talk is cheaper than ever.

Granted, it's true the sheer volumes of the oceans of data been generated these days, plus having it electronically at our fingertips all the time can also makes it hard to internalize and analyze. It's difficult to do any critical thinking with a firehose stream in your face. This may be why the Internet supposedly increases ignorance rather than reducing it.

What to do? Well, I can only convey what works for me, and maybe spark some new strategies. First, I thrash around until I find something solid to hang onto. When traveling before GPS, I'd keep walking or driving around until I could find a gas station with a map, or until I began to recognize landmarks and get my bearings. When researching and reporting a topic, I obviously search online, but I still lean heavily on asking as many people as I can what they know about it, and then ask who they know who might know more.

Second, I focus on *Control*'s readers, and what's most likely to be "news you can use." This mission helps me prioritize and cut through huge amounts of extraneous material, and find the few nuggets of data that are most likely to be helpful. Most of the experts I interview advise everyone undertaking technical projects to first answer the question, "What do I want to accomplish?"

For instance, the members of the Open Process Automation Forum (OPAF) have maintained a laser-like focus on interoperability, and this helped them develop O-PAS faster than any similar effort before it. They also questioned and drew in as many other users and other experts as they could over the past six or seven years, and added what they knew to the their "standard of standards." I know the results of good research and reporting when I see them, and O-PAS and its success are an example that anyone can learn from and follow. ∞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