AUTOMATION 2024

NOVEMBER | VOLUME 5

IIOT & DIGITAL TRANSFORMATION

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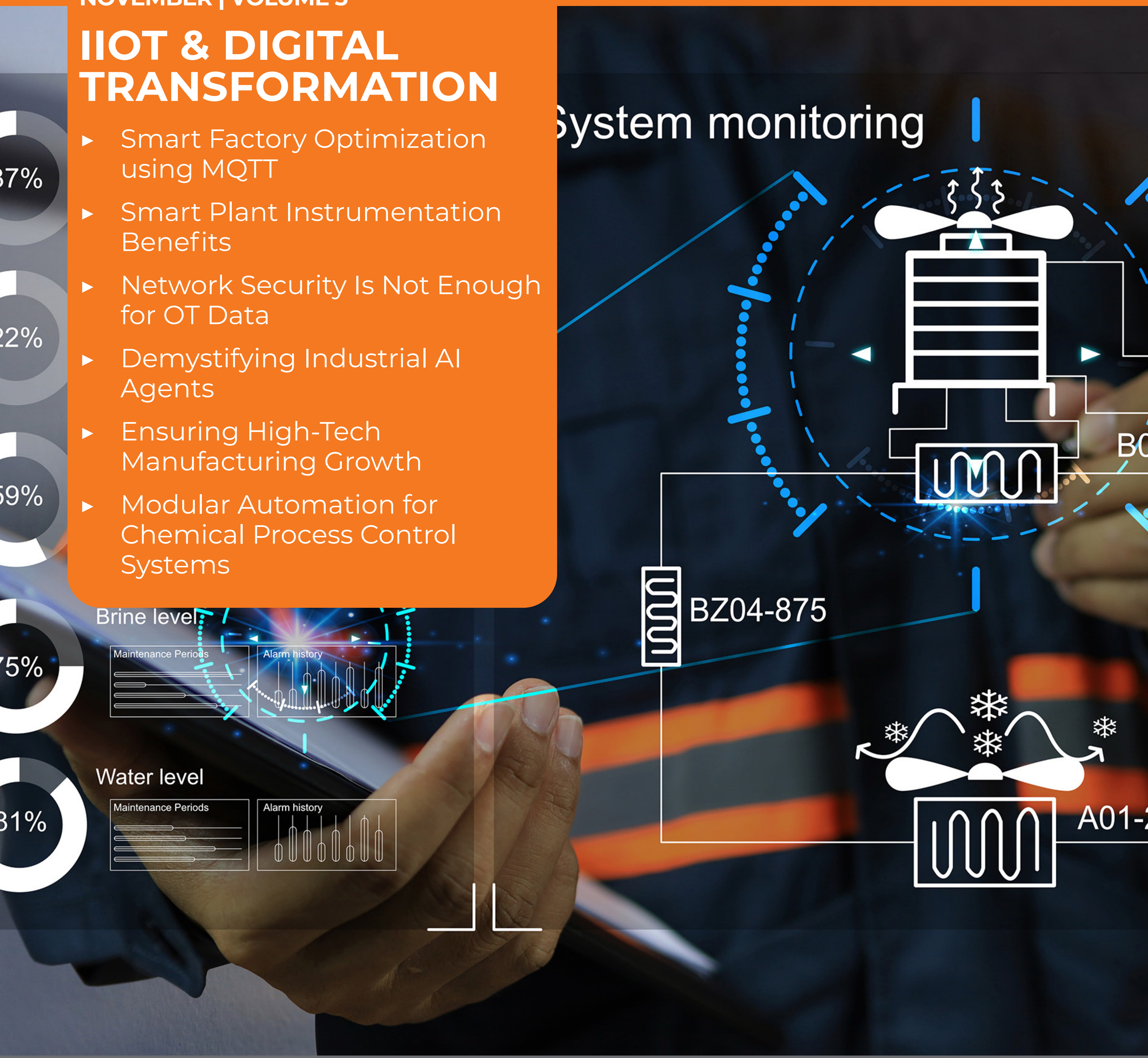

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Introduction

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Digital Transformation & Continuous Improvement

Digital transformation is more than just a buzzword. It's the latest in a long line of approaches to continuously improving industrial operations. That's why this edition of AUTOMATION 2024 leads with a look at continuous improvement methodologies from ISA author Grant Vokey, whose latest book is "CoE: The Key to Data-Driven Manufacturing." Here he shows how Lean, Six Sigma, ISO-9000 and Theory of Constraints methodologies compare and how to choose and apply one of these approaches based on your production goals.

Elsewhere, you'll learn how integrating innovative technologies ranging from generative AI to modular automation to heartbeat diagnostics for condition monitoring can improve manufacturing resilience and competitiveness. So many new technologies require the digitalization of what still may be analog processes in today's Smart Factory, but the rewards are there for those who make the move. The subject matter experts gathered in this issue have a lot of wisdom to share.

Find insights and advice in these pages and in earlier editions of AUTOMATION 2024 and *InTech* digital magazines through Automation.com, the publication arm of the International Society of Automation. And look for announcements highlighting the digital transformations coming to ISA publications in 2025. You'll find more and better automation content in streamlined packages and more ways to continuously improve operations, innovation, cybersecurity, and more.

Renee Bassett, Chief Editor
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CONTINUOUS IMPROVEMENT: WHICH METHODOLOGY IS BEST?

Lean, Six Sigma, ISO-9000 and Theory of Constraints are all effective. Choose based on your production goals.

By Grant Vokey, Vokey Consulting

Talk to a consultant of any continuous improvement (CI) methodology, and they will indicate (or come right out and state) that their methodology is better at achieving improvements than any of the others. In consulting with many companies over the years (and reading countless posts on industry websites), I am surprised by the number of companies that define one of these methods as being better than another (in general) or that a CI method of choice is the only one that will ever be required.

Lean is better than the theory of constraint, ISO-9000 is better than Six Sigma and the comparisons go on. But which methodology is better than the others?

The answer is "it depends."

What it depends on is determined by what you are trying to achieve. In other words, what are the goals manufacturing (or any business really) needs to improve, and how do you want to improve them?

The more common methodologies used in manufacturing include Lean, Six Sigma, ISO-9000 and Theory of Constraints. Each of these methodologies has been considerably successful, and there is ample money to be made in consulting for each. But there have also been some failures with each of them. In my research, I found that these failures are primarily due to improperly implementing the methods or selecting the wrong methodology for what they were trying to accomplish.

A general understanding of these methodologies is required before the aspect of "which is better" can be explored in detail. The following is a brief review of each methodology, looking at the background and the premise by which each methodology works. The descriptions of the following methods are highly simplified but should provide enough explanation for comparison.

Where Lean and Six Sigma are focused on analyzing and improving the actual processes, ISO-9000 is a management methodology.

Understanding Lean

The purpose of using the Lean methodology is to determine small and ongoing incremental waste reduction and, therefore, process improvements (as a result of reducing waste) to increase the effectiveness of the manufacturing process and to move toward a production line setup of "one-piece-flow" with no wait times or buffers between operations. As with Six Sigma, the Lean initiative provides the methodology and tools needed for analysis as a foundation for the company's CI program. The primary concepts of Lean can be summarized into two key goals, voice of the customer and supply the customer on demand.

Voice of the customer. Analyze the processes the company uses to deliver its product or services. Determine the steps within those processes that add value (from the customer's perspective) and then systematically remove (or reduce) any steps that do not add value and would be considered a waste. The main driver of this concept is to ask the customer, "Is this step something they are willing to pay for?" If it is not, figure out how to remove or minimize it. As a result, any aspect of the company's operation that does not add value would be considered waste (wasted labor or wasted material). Action would then be taken to eliminate or reduce this waste using predefined methods and tools from the Lean framework.

Example: In manufacturing, the only reason for doing inspections is because of the manufacturer's inability to produce without errors. As a result, just about any inspection operation would be considered a waste. However, exceptions like aerospace, where customers will pay for inspections, are possible. The Lean initiative would then require that the manufacturer determine the need for inspection (errors being observed) and determine process changes that will prevent those errors. Now that controlled and managed processes are preventing errors, operations can reduce the number of inspections performed to find those errors.

Supply the customer on demand. The product should be available only when the customer asks for it and only in the quantity the customer requests. If the customer has not ordered the product, there is no reason to be working on it. The result of this approach is that, theoretically, a product should not be released to work in process (WIP) unless it is directly linked to a customer order, and it should be made to satisfy the customer order as quickly and reliably as possible. The target process would not need buffering, and there would be zero waste from scrap, rework/repair or excess inventory.

To move toward this goal, the company removes the need for buffering WIP, for example, having a balanced line with all operations having approximately the same cycle time and staying within the estimated takt time needed to deliver the product when expected.

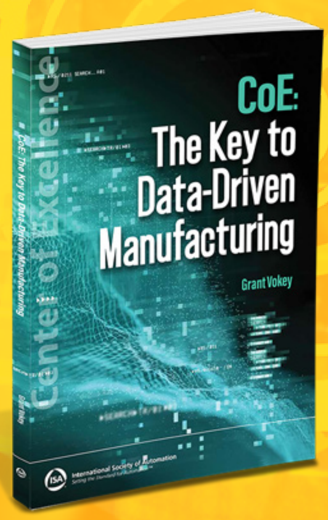
The company also removes the possibility of lost time because of equipment failure and manages line changeover to new products, which includes equipment setup times that target single-minute changeovers. If equipment is not needed for a product run, it is to sit idle, be available for maintenance or be used by a different product during that time. At no time should a product be worked on anywhere in the system if it is not directly tied to a customer order.

Example: Under this concept, any production schedule used to move product to finished goods inventory that is not already associated with a customer order would be considered waste. Also, under this concept, a company should reduce the need for maintaining finished goods inventory unless a customer demands it.

When examined from a manufacturing perspective, an issue with Lean is that it is arguably not suitable for some industries. For example, when looking at a seasonal product like lawn chairs, a single company is not likely to have the facilities to provide the market with enough product to satisfy an on-demand manufacturing delivery for an entire season. Companies that make lawn chairs must estimate the demand well in advance and start production well before a single order is received. In this scenario, using some Lean concepts would probably not be as fruitful. It could be argued that sales could locate a different market that would provide a more consistent product flow, but as lawn chairs are a highly local market, this is not likely to be of much benefit to the manufacturing floor.

Further Reading on Continuous Improvement

In his latest book, "COE: The Key to Data-Driven Manufacturing," Grant Vokey describes how many companies have implemented a digital transformation team called a Center of Excellence, or CoE. Readers can learn how to develop the skills needed to achieve digital transformation and take it beyond the manufacturing floor. Vokey's other ISA book, coauthored with Tom Seubert, is on manufacturing execution systems.



Understanding Six Sigma

The purpose of using the Six Sigma methodology is to identify process improvements that will invoke a major step in the effectiveness of the manufacturing process. The primary concept of Six Sigma is to use a rigorous set of process management and analysis tools to drive all the characteristics of a process (and product performance) as close to the target characteristics as possible.

For example, a curing oven may have an acceptable temperature range. With Six Sigma, it is not sufficient to maintain the temperature anywhere within the acceptable range. Six Sigma would require understanding the correct target temperature and would perform a series of analyses to determine why the oven temperature drifts away from the target temperature. After identifying the causes, an effort will be made to determine which cause has the greatest impact on the drift. Then, a change would be made to the oven or process (depending on the cause) to minimize the drift as much as economically possible.

Finally, once the process was normalized (implemented as part of normal production without unexpected deviations), it would be reanalyzed to ensure that the implemented change achieved the expected performance improvement.

As Six Sigma looks at process capability from a target perspective, thereby driving toward achieving Six Sigma capability (i.e., a quality level of 3.4 defects per million opportunities), it is frequently used to determine and fix issues to achieve jumps in process capability. Whereas with Lean, the expectation is to achieve smaller incremental steps in removing process waste.

Understanding ISO-9000

Where Lean and Six Sigma are focused on analyzing and improving the actual processes, ISO-9000 is a management methodology. The purpose of ISO-9000 is to provide a management model for companies to use to establish a program for managing CI itself. Based on the concept of “say what you do and do what you say,” ISO-9000 looks to have a company progressively define all the processes within manufacturing and use process auditing to ensure that these processes are followed. In addition, ISO-9000 requires that the effectiveness of defined processes have a means of being measured (it does not explain what the measurements are to be) and that, according to specified measurements, the processes are improving over time.

ISO-9000 requires a company to develop business and management-level processes to ensure improvements are made continuously. It does not define a specific analysis and improvement methodology; however, it does require one.

The constraint within a manufacturing process defines the throughput of the entire process.

Understanding Theory of Constraints

When looking at the Theory of Constraints (TOC) strictly from a manufacturing perspective, it is another operational methodology with a framework of procedures and tools used to help operations clarify the goals of a process, define the limiting factors of that process (called the constraint) and then take two distinct and concurrent directions: Maximize the throughput of the constraint through various actions; and make process improvements that increase the throughput of the constraint.

The primary driver of the TOC is that within any process (or system), there is always something that is a constraint or a limiting factor. The constraint within a manufacturing process defines the throughput of the entire process.

The key understanding of the TOC is that regardless of the activities that occur elsewhere in the process for improvement, improving the throughput of the constraining operation is the only way to improve the throughput of a line. Furthermore, if time is lost at the constraining operation from downtime or improper scheduling, that time is not recoverable. As a result, effort should be made to schedule material to the floor and any preceding operations to the constraint to ensure that the constraining operation is scheduled and loaded to its most efficient capability.

The flow rate through the constraint should be the driver of all other activity (referred to as the drumbeat to which production follows). Any preceding operations should be scheduled to ensure enough of a buffer in front of the constraint so it can continue if other operations are shut down (e.g., due to scheduling demands).

Additionally, only enough material that can be processed through the constraint in a scheduled period should be pulled onto the floor. This process is like a rope pulling the material as needed. All of this has given rise to the term drum-buffer-rope to describe TOC scheduling concepts.

If there is a need to improve the production line throughput and/or the revenue generated from a production line, action must be taken to improve the constraint.

Now that we have a basic understanding of these methodologies, which is better? The answer is “none of them.” It depends on what the company is trying to achieve. Additionally, they will likely need to use each methodology at different times within a company’s improvement cycles.

Using the methodologies

Using the following manufacturing scenario, I will show how each method—and combinations of methods—can be used to address throughput and cost issues. The details of the actual product or the particulars of the production line are not required. For the sake of attempting to be brief, many of the concepts presented have been highly simplified, and the operations discussed are not representative of any industry.

Here’s the scenario: A discrete manufacturing company has a production line with a takt time of 60 seconds to meet delivery requirements (i.e., one production unit is required off the line every

60 seconds to meet scheduled customer demands). The actual throughput for the line varies from a product every 55 to 70 seconds, with the line averaging 68 seconds (the latter two values being well above the required takt time). The production line has a first-pass yield (FPY) of 75 percent (i.e., 25 percent of products require extra work to be usable). It also has a scrap rate of 10 percent (10 percent of production cannot be used and is written off), meaning that 90 out of 100 units processed by manufacturing will be sold (the 10 percent scrap is part of the 25 percent that requires extra work). This could make it harder for the company to achieve a market price point.

Applying ISO-9000. The first issue to be looked at is the effectiveness of the company's CI program. In this case, assume that the company has an ad hoc CI program based on reviewing customer complaints and fixing the problems the customers complain about. Historically (according to operations management training programs) only about 1 in 8 customers will complain about a problem. Most will just take their business to another manufacturer (that is a lot of lost customers before a problem is recognized or even corrected), which makes for an ineffective strategy for CI management. Another concern about the ad hoc strategy is that many of the issues that cause the line to miss its takt time go unresolved because the customer only sees the products that go out the door, and most problems causing variation in meeting takt time are only visible internally.

To help start the manufacturing floor on the right path to properly managing its CI program, the company should implement ISO-9000. This would require defining the processes (including a means of measuring the processes) and ensuring that these processes are being followed. Each of the other methodologies also requires measuring the manufacturing processes in one manner or another, but ISO-9000 is used to define a program of CI management. Although there is a requirement to measure and improve the manufacturing processes, ISO-9000 does not explain how the processes are to be analyzed, only that they are. In addition, process auditing ensures that processes are defined and followed (this is process standardization).

Through analysis, operations will map out the process of making a product, specifically define each step and train production operators to follow the defined process. This will reduce the amount of common cause variation within the process, making it easier to determine the reason for special cause variation. The production line improves process capability by determining and correcting special cause variation.

Standardization may or may not improve the process capability. If standardizing may not actually improve the process, then why standardize? One of the hardest types of problems to fix within a process is those that happen intermittently. When a process has many factors causing variation, there is considerable fluctuation in the performance measurement results. Certain variances that could benefit or deteriorate a process may occur in one production run and not occur for the next couple of production runs. This makes it very hard to analyze the analysis results. After processes have been standardized, there are fewer variances to track, fewer interactions between variances and—most importantly—more consistent results. This makes it much easier to determine and control the root cause of each variance.

The company has implemented ISO-9000, standardized most of the manufacturing-level processes and is now certified. Actions are being taken to define, monitor and correct process deviations and reduce process variation. The company is well on its way to properly managing its CI program (this is highly simplified). What does the company do next? As a result of the process standardization that was implemented with ISO-9000, the company has probably seen some improvement in process capability. Although it is not a certainty, it is not uncommon to see improvements in some process key performance indicators (KPIs). Looking back at the scenario above, the company had an FPY of 75 percent. Achieving a 10 percent improvement would bring the FPY up to 82.5 percent.

However, from the perspective of manufacturing effectiveness (efficiency in particular), although FPY is important, it is not the only concern. Improving manufacturing efficiency also means improving the cost of manufacturing, which is frequently measured by "cost per unit of production." Lean can be implemented to address this issue.

To understand the aspect of the "cost of manufacturing," here is a simplified example of the cost of the scenario above. Assume that there are five production operations in manufacturing the product, a total direct labor cost of $50 and a total material cost of $25 (both per unit of production). Each operation consumes approximately 20 percent of the total cost of labor and material, which brings the example scenario to a total manufacturing cost of $75 per unit of production and consumes $15 of that cost per operation (again, the costing is highly simplified).

Applying Lean. Having documented all the manufacturing processes as part of their ISO-9000 certification and used ISO-9000's requirement for internal process auditing to ensure they are being followed, the operations staff now has better visibility of all the process operations and will likely have found some operations (or substeps) that were not expected. Lean's focus is to reduce waste within a process to make production more cost-efficient. Hence, the company decided to implement Lean.

In this case, the processes will be analyzed to determine which operations are required (according to the customer) and which are redundant or unnecessary. An example of an unnecessary step might be an "end-of-line" inspection operation that was implemented to ensure that a once-common mistake is no longer happening. This inspection may have been implemented while reviewing the overall process to find the actual cause of the mistake. Then, after the process was updated to ensure the mistake can't happen, the inspection was not removed. This review of operations in Lean is called value engineering, and the methods used in value engineering are specifically defined within the Lean methodology.

Assume that the company has now performed several value engineering events and has improved the effectiveness of the processes. As part of the value engineering, the manufacturing engineers would reevaluate the "end-of-line" inspection. Recognizing that under the Lean mindset, inspections, in general, are non-value-add (they are only used because of a lack of capability in manufacturing quality), one activity would be to determine whether the inspection is still needed.

If the problem still exists, the engineers will determine the root cause and update the process to reduce occurrences or ensure that it can't happen. The inspection operation is then revisited, and if it is no longer needed, it can be formally removed. In many companies, these end-of-line inspection operations are frequently continued long after the problem has been fixed because of a "that's the process" mindset. Assume that the problem was properly closed and the inspection operation was removed from the process. Looking at the cost of manufacturing, we can recognize the improvements.

In the original process of five operations and $15 consumption per operation, the manufacturing cost can be updated to a total cost of approximately $60 ($75 - $15 = $60). Keep in mind that this is a simplified example.

Also, through these Lean analysis events, let's say changes have achieved an average operational cycle time of 63 seconds (ranging from 58 to 65 seconds) and improved FPY to 85 percent. In addition, the company is still using ISO-9000 to define and improve managing the CI program overall.

Once these Lean events have stabilized and the processes have become well understood, it is time to engage in more in-depth analysis to determine what is causing the remaining fallout. The methodology used from this point on depends highly on the kind of problems that are found. There may be process-related issues that are detrimental to the product quality.

An example is the damage in electronics manufacturing that used to happen due to static electric shocks to the product from people handling the production unit without static control. Using proper static control procedures is now common throughout the electronics manufacturing industry. For these types of problems, it is common to use Lean methods to determine what is causing the waste resulting from additional need for repair and rework.

Applying Six Sigma. Other types of problems may result from process parameters that drift because of instability in the controls or wear

from extended use of the equipment. Although some Lean methods may still apply, it may be better to resolve these issues using Six Sigma.

The process will be analyzed using Six Sigma methods to determine the normal distribution of the major factors that cause variances. With Six Sigma, there is a specific target value for process/product performance and a need to understand which parts of the product or process (including equipment settings) have the most influence in maintaining that target as well as process parameters that cause changes from one production run to the next (known as "Gage R&R"). By controlling the parameters that cause variation within a production run and from one production run to the next, Six Sigma tries to ensure a process is both repeatable and reproducible (the R&R part from above). This may involve tighter control of parameters, updates in equipment or changes in the product (material use or design influences).

Six Sigma's DMAIC (define, measure, analyze, improve, control) analysis process is specifically developed to investigate these problems. From this point on, process management and a company's CI program should isolate specific problems and perform in-depth analysis into the root cause of these problems.

In this case, I want to emphasize the importance of investigating specific problems. At any one time, a production line should be focused on determining, isolating and resolving one issue at a time. Many times, a production line will try to resolve multiple issues on seemingly disparate problems only to have either the analysis or the solution testing of one problem interfere with the analysis or solution testing of another problem. This can cause skewed analysis or testing results and skewed or downright wrong decisions being made in CI management.

But why should a production line engage in this level of analysis? An easy solution to achieving the required takt time would be simply increasing the amount of people or equipment needed to get product out the door. The problem with increasing the number of people or equipment is that it adds cost to the process of making a product and the potential of creating more variation (possibly making the situation even worse). Reducing variances using methods like Lean and/or Six Sigma is the only way to ensure that production costs are reduced.

Applying the Theory of Constraints. In Lean, one of the primary directions that consultants give is to use a line set up based on "one-piece flow," as discussed in the Lean overview earlier. This requires all the operations for a particular product to be available within a production line and that all operations be in close physical proximity to allow for efficiently moving production units between operations one unit at a time. In addition, all operations in the line setup must be very close in cycle times. The concern over this kind of setup is that it assumes that production volumes are high enough to need continuous production or that a production line can sit idle during low-demand periods.

An alternate concept could be to find several low-volume products that share many production operations and resources, which allows them to be manufactured on the same production line with minimal line change effort. This would enable a one-piece-flow setup, and switching from one product to another for scheduling would be easier due to the similarities in production processes.

In many production environments, this is not always possible. When these production line configuration requirements do not apply, Lean's one-piece-flow setups cannot be used effectively.

When multiple production lines share only a couple of high-cost resources, or if operations within a single production line have significant differences in cycle times, there will always be one constraining operation. In this case, TOC is the best line management methodology. The key driver of line management is to recognize and properly manage the constraining operation. If time is lost at the constraining operation (e.g., due to equipment failure that causes the constraining operation to stop), this time is permanently lost and cannot be recovered.

When a production line uses TOC, the CI initiatives must address the priority of what must be improved and the goal for improvement. If the goal is to reduce waste or cost, Lean may be the preferred methodology. However, if the goal is to improve the line throughput or increase revenue, TOC must come into the picture. A couple of improvement strategies that can be used are: Reduce the cycle time of the constraining operation (increasing the number of production units that the constraining operation can process); or reduce the failure rate of the products that go through the constraining operation (increasing the rate of production units that successfully complete the constraining operations and all operations after it).

It is important to recognize that using the above two strategies on a nonconstraining operation will not improve throughput regardless of the line setup. Even in a one-piece-flow environment, this concern may still hold true as there will still be a marginal constraining operation (the operation with a cycle time closest to the planned takt time).

As part of an initiative to decrease the cycle time of a one-piece-flow environment, there needs to be a review of the original takt time the line was designed to achieve. The review would likely result in redistributing the activities in each operation and possibly adding or removing operations to achieve the takt time. It is important to understand that in one-piece flow, you can increase the number of operations (thereby increasing the full process cycle time) and maintain the takt time if each operation's cycle time is kept at or below the takt time. It will take longer for the first unit to come off the production line, but the takt time will be maintained for each additional production unit.

Using TOC provides focus on the critical operation that determines production throughput and the overall production schedules. It also focuses process improvement and product improvement on problems that affect that critical operation's throughput.

Final thoughts

Returning to the original question, "Which CI methodology is best?" There is no simple answer. In looking at CI from a production perspective, it is important to understand the improvement goal (what you are trying to improve.) Only when you know this can you determine which CI methodology will be best for that specific goal. Each methodology can contribute to implementing an efficient, cost-effective and profitable manufacturing process.

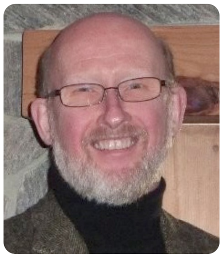
ISA-9000 is used to create an effective CI program, an essential component of a successful manufacturing company.

Lean analysis improves the cost of manufacturing by determining which operations are required and which are redundant or unnecessary. Lean also directs focus to CI procedures for selecting improvements that affect production costs. Lean analysis can be a key component of an effective CI program.

Six Sigma analysis identifies the parameters that have the greatest effect on variation within a production run and from one production run to the next. This method is used to ensure that a process delivers output as close to the target as possible, which helps ensure that the process is both repeatable and reproducible. This also is a key to an effective CI program.

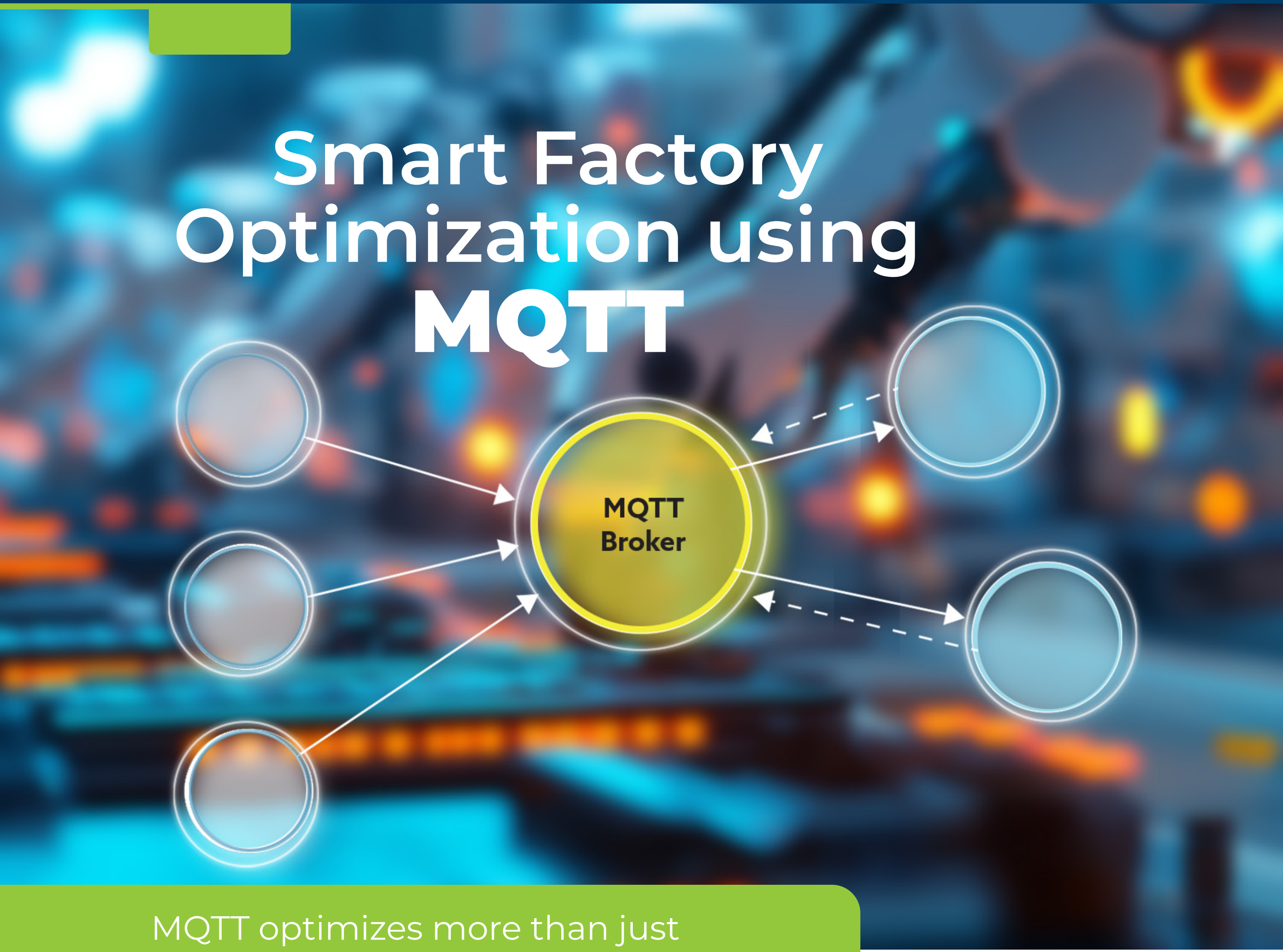
Theory of Constraints (TOC) focuses on critical operations that determine production throughput and overall production schedules. It also focuses process and product improvement on problems that affect throughput.

ABOUT THE AUTHOR



Grant Vokey is the principal consultant for Vokey Consulting with 20 years of diverse manufacturing operations experience and 15 years of integrating information technology (IT) systems into the manufacturing floor. Vokey's experience, coupled with continuous training and 10 years as a certified operations manager, has provided him with an excellent understanding of industry best practices and best-in-class utilization of manufacturing execution systems (MES). He has been a subject matter expert for developing industry-leading MES applications/solutions and a lead consultant on implementations of MES in various verticals (electronics, industrial equipment, automotive manufacturing and metal fabrication).

Smart Factory Optimization using MQTT



MQTT optimizes more than just transmission architecture.

By Aaron Kuo, MOXA

Compared to traditional factories, smart factories require a large number of sensors to collect onsite information and connect to information technology/operational technology (IT/OT) systems, thereby optimizing processes such as order processing, production and more. Managing the significantly increased communication demands to minimize costs, enhance efficiency and prevent cybersecurity vulnerabilities are critical issues. This article explores smart factory optimization using the MQTT protocol.

Optimizing onsite network transmission and data acquisition

MQTT is a highly efficient protocol widely used in Industrial Internet of Things (IIoT) applications. Its lightweight packet structure allows data to be transmitted efficiently within limited bandwidth. Unlike other request-response pattern protocols, MQTT's publish-subscribe messaging pattern does not require all edge devices to be online simultaneously. Devices only need to connect to the broker when publishing or receiving data, hence reducing bandwidth waste. Additionally, its active messaging feature significantly enhances real-time performance compared to other request-response protocols.

In addition to its lightweight packets and active transmission capabilities, MQTT also optimizes the transmission architecture between onsite operations and systems. For example, in machine data collection applications, devices send their collected data to a central MQTT broker, which acts as the intermediary, allowing IT systems to retrieve and analyze the data for optimizing production processes. With MQTT, IT systems no longer need to separately connect to onsite devices to obtain data; instead, they retrieve the necessary information via the broker. This not only optimizes the data transmission path but also provides a unified and efficient communication method.

In smart factories, where data-intensive applications are common, it is crucial to prioritize data transmission based on the importance and urgency of the data. Real-time data must be sent immediately, while data that cannot be lost requires a reliable transmission mechanism. MQTT addresses these needs by offering three different quality of service (QoS) levels:

1. QoS 0: at most once—In this mode, the client sends a message to the broker without confirmation of receipt and there is no notification about delivery to subscribers. The publisher only knows the message was sent, but not if it was received. While QoS 0 is the fastest, it is also the least reliable.

2. QoS 1: at least once—The client expects the broker to acknowledge message receipt. If no acknowledgment is received within a set time, the message is resent until confirmed. QoS 1 is more reliable than QoS 0, but it may be slower.

3. QoS 2: exactly once—Ensures each message is delivered only once through a four-step handshake process (initial publish, PUBREC, PUBREL and PUBCOMP), making it the most reliable but slowest QoS level in MQTT.

Security is a crucial issue in IIoT. From past experience, cyberattacks typically originate from outside the factory, so the first step to enhancing cybersecurity is installing a secure router. However, without internal defense mechanisms, breaching the router can lead to significant losses. The MQTT protocol offers strong protective measures; users can set up username and password authentication for the broker to ensure trusted access and use SSL/TLS to encrypt communications, thus ensuring the security of internal communications.

Connecting edge devices to an MQTT broker

To implement MQTT communication, users can add MQTT gateways to existing edge devices for protocol conversion, which enables efficient onsite data collection. However, smart factories often need to collect large amounts of data and adding a gateway to each device can be costly. The Moxa ioThinx 4510 addresses this issue. As a modular remote input/output (I/O), the device can collect large volumes of I/O data at once and poll RTU devices onsite using the built-in Modbus RTU protocol. It then communicates with the MQTT broker using the northbound MQTT protocol and significantly reduces the cost and effort of deploying an MQTT network onsite.

ABOUT THE AUTHOR

Aaron Kuo is a product manager at Moxa, a leading brand in industrial networking and control equipment. He specializes in the development and planning of modular remote I/O and PAC systems, with a strong focus on IT-oriented communication solutions for remote I/O products.

Maximizing Smart Plant Instrumentation Benefits

By Nathan Hedrick , Endress+Hauser

Reap smart plant instrumentation benefits with heartbeat diagnostics, verification and monitoring.

Smart plant instrumentation provides end users with opportunities to make informed decisions as well as plan and execute thoughtful maintenance strategies. Having devices equipped with features such as Heartbeat Technology, enables plant personnel to gather process data so they can make educated and quick decisions regardless of how they interface with their instruments including their laptop, phone or tablet. Answers to frequently asked questions are listed below.

Q: What is Heartbeat Technology?

A: Heartbeat Technology is comprised of three aspects: heartbeat diagnostics, heartbeat verification and heartbeat monitoring (Figure 1). This technology enables preventive, proactive and/or predictive maintenance depending on how a user chooses to employ it. Heartbeat Technology continually audits the instrumentation it is enabled on to ensure it is operating at peak conditions.

Instrumentation equipped with permanent and extensive self-monitoring capabilities offers end users a high degree of confidence regarding reliable performance. In the event of an error or upset process conditions, Heartbeat Technology can even relay and convey messages to operators before running into failure, which gives them the opportunity to be proactive, avoiding plant shutdowns.

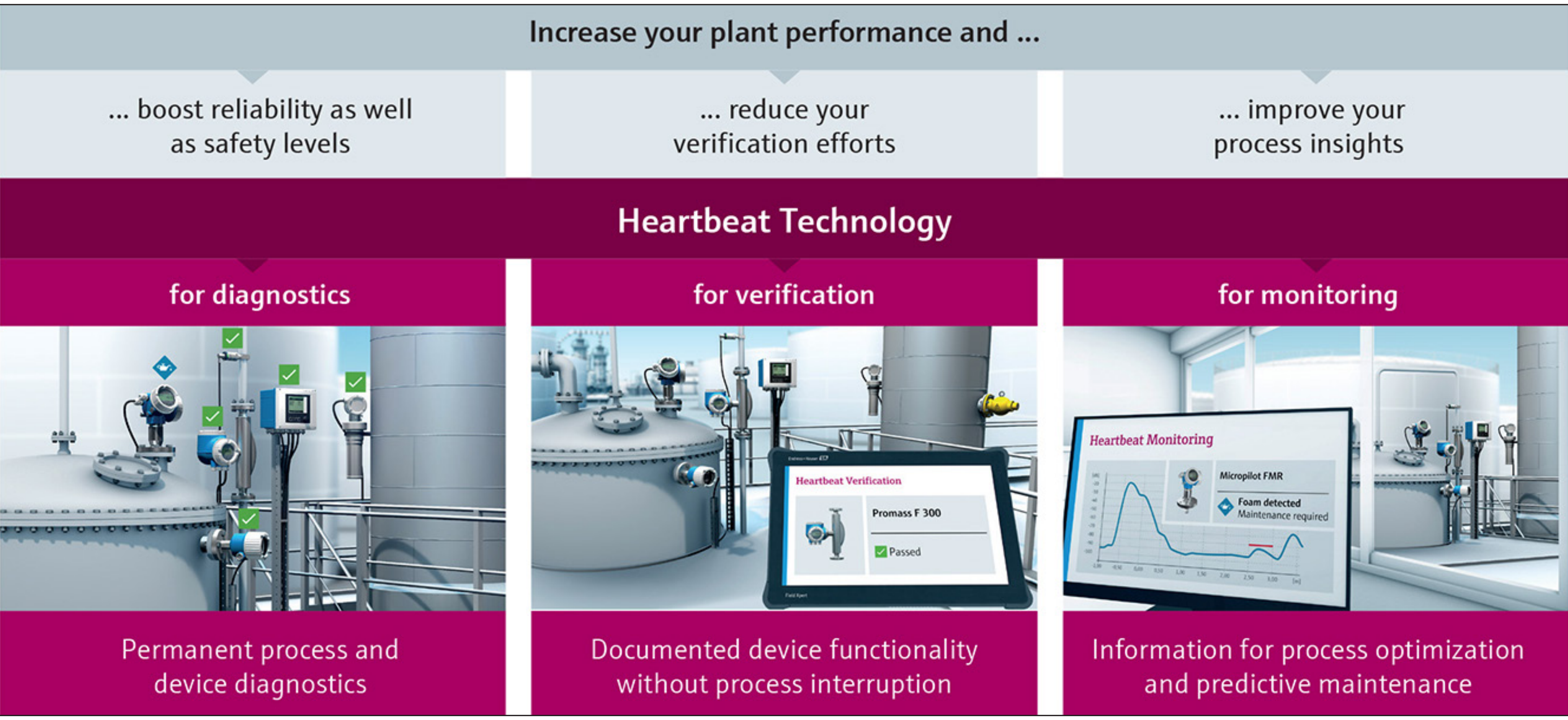


Figure 1. Heartbeat diagnostics, heartbeat verification and heartbeat monitoring are three aspects of Heartbeat Technology.

Q: Why should users consider implementing smart online diagnostic and verification technology in their processes?

A: Smart plant instrumentation with online diagnostic and verification capabilities enable better process control, efficiency gains, better quality and can eliminate downtime and shutdowns. They also generate additional data that can support decision making regarding the process. They provide a preventive measure to enhance your maintenance strategy.

Instrumentation equipped with permanent and extensive self-monitoring capabilities offers end users a high degree of confidence regarding reliable performance.

Q: Where do I start when I already have multiple measuring points in my process but want to add these capabilities?

A: The best place to start is with an installed based audit (IBA), which a user can perform on their own or be provided as a service. Many users already have smart instruments installed in their operations today, but there is a lot of untapped potential. It's quite possible that the user already has what they need in terms of the installed base, and they simply need to make a few upgrades rather than purchasing new equipment. For example, many of the products Endress+Hauser provides can be upgraded in the field to include Heartbeat Technology if it was not purchased originally.

This can be a much more cost-effective way to start gaining experience without the need to purchase entirely new equipment. The other recommendation would be to start with a process that you know has a challenge you would like to resolve. Some common application challenges where Heartbeat Technology can provide preventive, proactive, and/or predictive maintenance include buildup, corrosion, foaming and entrained gas/gas breakout.

Q: What does this kind of technology add to a process that similar technologies don't?

A: Heartbeat Technology ultimately allows end users the opportunity to gain process data and insights right into their process. Without technology features like online diagnostics, verification and monitoring, there are risks and gaps between the plant personnel and the process because users will not know the health status of their instrumentation. While other manufacturers do offer some of these same elements, Endress+Hauser employs a consistent methodology and availability across the broadest range of process measurement technologies. Having a consistent offering across a broad portfolio allows simplicity for its users.

Q: I have instruments with Heartbeat Technology currently, but how do I know if I am reaping all the benefits?

A: The best place to start is to engage with a local Endress+Hauser representative. It may be that you are already leveraging Heartbeat Verification but could benefit from Heartbeat Monitoring based on your current application needs, for example. However, it also should be mentioned that not every application calls for every aspect of Heartbeat Technology. Just because additional data may be available, it doesn't mean it's 100 percent relevant to your application.

ABOUT THE AUTHOR

Nathan Hedrick is the product group marketing manager at Endress+Hauser USA, He oversees level, flow, temperature and pressure products for the company. He began his career with Endress+Hauser in 2009 as a technical support engineer and became the flow product marketing manager in 2015, named the national product manager for Flow in 2018 and national product manager for multiple product lines in 2020.

Network Security Is Not Enough for OT Data

The modern enterprise needs secure access to data from OT to increase efficiency and cut production costs.

By Xavier Mesrobian, Skkynet

Everyone agrees that network security is essential for information technology (IT) systems. Cyber attacks can cause huge problems or force crippling ransomware payments. Securing operational technology (OT) networks is even more critical. One successful exploit on a production network might halt production, incur huge costs and even put lives at risk.

Before the days of Industry 4.0, Internet of Things (IoT) and digitalization, it was simple to secure OT networks and data by simply disconnecting them (by air gap if need be). Unfortunately, that is no longer an option for any company that wants to stay competitive. The modern enterprise needs secure access to data from OT to increase efficiency and cut production costs.

This kind of data access must be secure, but securely accessing OT data does not have to be overly complicated or costly. A good solution may not be as expensive as you might think. Whatever level of network security you have, there are easy and affordable ways to gain secure access to OT data.

Data security: Different from network security

The reason is that data security is different from network security. Although data security can be implemented alongside network security—and be fully compatible with it—the goals of each are not the same. The difference is much like home security.

Running a system without network security is like leaving a door open, which allows anyone to enter your house. Unwanted visitors can steal things or hold your family members hostage. You're also exposed to viruses from any infected person who walks in.

Securing the network

To secure the network, a company might implement zero-trust network access which comes at a significant cost. Such a solution often uses virtual private networks (VPNs) to restrict network access to a limited number of authorized people.

Using a VPN is like allowing only invited guests with a key to enter your house. These guests can still be carrying unwanted viruses that might infect your household. A VPN that extends from the IT network

to OT extends the security perimeter to enclose OT. Should anyone in IT receive a phishing email or plug in a thumb drive with a virus on board, the malicious code could easily propagate to OT.

An invisible mail slot

For data access, a better solution—which is both cost-effective and secure—is to close the network to everyone and set up secure data connections. It's like pushing open an invisible mail slot in your door and exchanging messages with an authorized mail carrier. Nobody enters the house to bring in a virus or hold your family members hostage. When you close the mail slot, it blends back in with the door. Only the mail carrier knows it's there and only they can drop off or pick up messages.

For industrial systems, the invisible mail slot is an outbound firewall port at the plant. The mail carrier is typically a tunnelling application or MQTT broker running onsite or in a demilitarized zone (DMZ). If you are using a DMZ, the IT side can implement the same mail slot interface and keep all IT inbound firewall ports closed as well.

Using a DMZ is recommended by the EU's NIS 2 Directive and NIST SP 800-82 as the best way to segregate OT and IT networks. Each network must be secure and any data connection between them must also be secure. Network security and data security should work hand in hand.

Network security and data security should work hand in hand.

Viable options

Whatever level or type of network security you deploy, you need the right software and services to gain secure access to your data. If you need to isolate your OT system from IT or the cloud, you can use MQTT or Sparkplug to make outbound connections while keeping all inbound firewall ports closed. Some tunnel/mirroring software, such as Skkynet's Cogent DataHub, is equipped to do this and more. Unlike MQTT, this kind of tunnel/mirroring solution can pass data seamlessly across a DMZ in both directions, which maintains the connection status and data quality information at every step.

To make an even more secure connection and ensure one way data flow, you can use a data diode. This is a hardware device that allows and enforces only one-way communication and prevents any kind of message from the destination getting back to the source. Some tunnel/mirror solutions are fully compatible with data diodes and can even be used to aggregate data sources on the sending side or to distribute data to various clients on the receiving side.

Working together

The thing to remember is that network security and data security are both important. They may be implemented separately, but they should work together as one unit. No matter what level or type of network security you have, Skkynet provides the technology and know-how you need to fully integrate it with data security.

ABOUT THE AUTHOR

Xavier Mesrobian is the vice president of sales and marketing at Skkynet, a global leader in industrial data connectivity. With more than 25 years in the industry, Skkynet software and services are used in more than 27,000 installations in 86 countries including the top 10 automation providers worldwide.

Demystifying Industrial AI Agents

Generative AI offers a significantly better interface to complex data under the right conditions.

By Dr. Francois Laborie, Cognite

With all the hype around generative AI for industry, it seems as if there is a new buzzword almost every day. The latest? "Industrial Agents." Few standard definitions of this term exist yet for industry, but this one is close: "An industrial agent is an agile and robust software entity that intelligently represents and manages the functionalities and capabilities of an industrial unit." Put more simply, industrial agents perform specific tasks in a human-like manner when trained with the right data and when using the right artificial intelligence (AI) model and capabilities.

The operational copilots that everyone is talking about or the chatbot you use when trying to rebook your flight are examples of various types of AI agents. They aim to automate or simplify a specific or constrained workflow to improve the user's productivity. But today's agents that use limited preprogrammed logic are no match for the Gen AI-based agents of the future.

If we take inspiration from the movies, we're getting closer to Iron Man's "Jarvis" assistant—a supercharged intelligent virtual agent that communicates via voice commands and helps Iron Man do his best work. While we're a far cry from this type of cross-functional intelligence (due to the no-risk, high-reliability nature of industrial operations), the technical building blocks and terminology exist today to develop specific and trustworthy industrial agents for particular operator domains (Figure 1).

Why does this matter now?

For decades, industrial operators have been trying to use data and AI to optimize production, minimize outage risk, streamline production and make smarter daily decisions. But unfortunately, the impact on factory-floor operations has been underwhelming so far.

The way users interact with digitally enhanced industrial processes has not been intuitive, which makes it challenging to actually improve key workflows and realize productivity gains. Technology that doesn't offer dramatic workflow improvements does not get adopted.

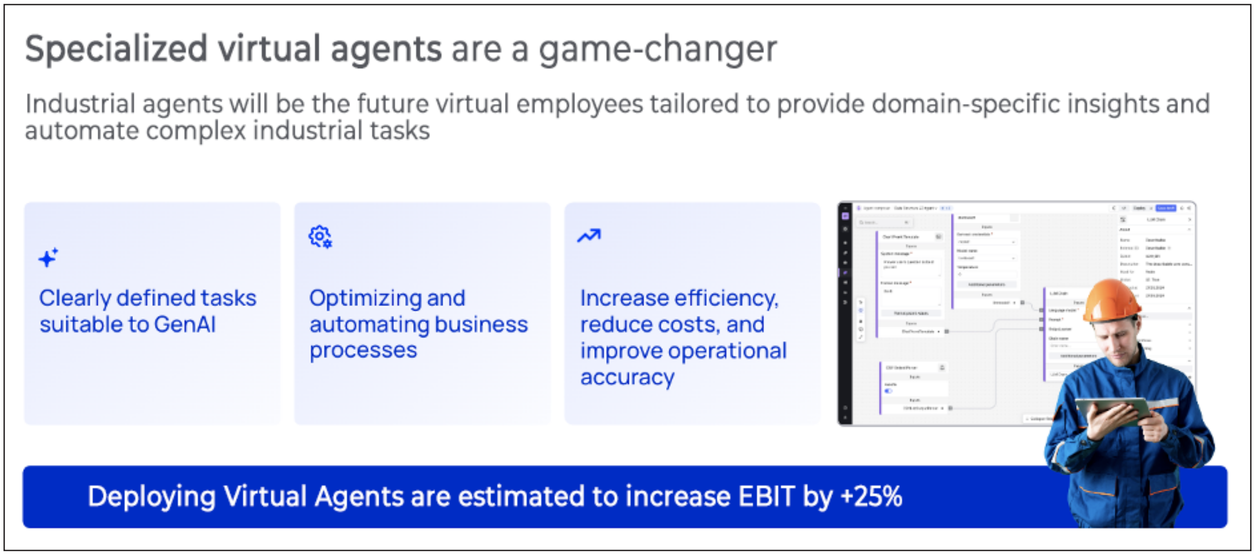


Figure 1. Industrial agents offer automation and intuitive access to information.

In flight, if Iron Man couldn't speak conversationally with Jarvis and he had to manually look up information with precise terms, his workflow (and mission outcomes) would suffer. In the field, operator workflows are precise and well-established. Information must be trustworthy and instantly accessible, using handheld devices and simple commands instead of relying on lines of SQL code.

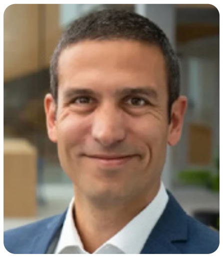
Generative AI offers a radically better interface to complex data (when structured and accessed under the right conditions.) Even though an operator may not be able to ask their agents the same breadth of questions as Iron Man could to Jarvis, their interface to answers becomes more human and intuitive than ever before, which makes it adoptable into a workflow.

How did Iron Man [presumably] go about building Jarvis? While we don't know for sure, we can hazard an educated guess that:

1. **He started with simple access to complex data.** Whether you are trying to improve operational dashboards or introduce industrial agents, both start with an industrial data foundation that uses AI to contextualize information at scale.
2. **He perhaps used a knowledge graph to contextualize all his data.** In the industrial space, large language models (LLMs) depend on data in context that return higher accuracy outputs because agents can be trained on narrow data sets based on their explicit objective.
3. **He mastered model and agent orchestration.** Industrial transformation has a lot of moving pieces and proper orchestration of purpose-built or partner models that can make or break a program.

All three pieces are critical to get right to deliver industrial agents that you can trust.

ABOUT THE AUTHOR



Dr. Francois Laborie is the EVP general manager of Strategic Projects at Cognite. He helps industrial customers improve their productivity with industrial AI agents by leading the strategy and commercialization of Cognite's Atlas AI offering. Discover everything you need to know about AI agents in Cognite's definitive guide.

Ensuring High-Tech Manufacturing Growth

Understanding and integrating innovative technologies remains crucial for manufacturing resilience and competitiveness.

By Adrian Wood, DELMIA

In the rapidly evolving landscape of high-tech manufacturing, companies are constantly navigating a complex array of challenges regardless of their size. For example, Intel's efforts to ramp up production capacity to keep pace with growing demand for semiconductor chips is a crucial move as industries from computing to consumer electronics require these components at an unprecedented rate. Similarly, Apple has faced significant hurdles in managing its supply chain for new product releases, putting a spotlight on the dynamic nature of tech industry demands.

These examples underscore how the demand for unique and customized products is exploding and requires manufacturers to efficiently produce a wide variety of product variants while contending with constrained assembly lines and limited resources. This landscape is further complicated by supply chain volatility and intensifying regulatory pressures, particularly as electronics become integral to more complex and connected industries. In this context, understanding and integrating innovative technologies remains crucial for manufacturing resilience and competitiveness.

Legacy and aging technology solutions pose significant barriers to addressing these challenges. These outdated systems often lack the flexibility required to support the rapid agility necessary when producing a wide array of product variants. They are typically plagued by inefficiencies and are unable to seamlessly integrate with newer digital technologies such as the Internet of Things (IoT) and artificial intelligence (AI). This inhibits process optimization and real-time data analysis which is pivotal for decision making and enhancing productivity. In addition, legacy systems are frequently incompatible with the sophisticated cybersecurity measures needed to protect sensitive information in a connected industry environment. As a result, reliance on these obsolete technologies can lead to increased downtime, higher operational costs and a diminished ability to meet stringent regulatory demands, which can undermine a manufacturer's competitive edge.

Industry 4.0 has emerged as a transformative force by reshaping manufacturing through digital transformation, agility and sustainability.

The transformative power of Industry 4.0

Amidst these challenges, Industry 4.0 has emerged as a transformative force by reshaping manufacturing through digital transformation, agility and sustainability. By integrating advanced digital technologies into the manufacturing process, companies can achieve unprecedented levels of operational efficiency and flexibility.

Digital transformation facilitates real-time data collection and analysis, enabling manufacturers to swiftly make informed decisions. This agility allows for rapid adaptation to market changes and disruptions, ensuring continuous production efficiency. Additionally, the focus on sustainability not only reduces environmental impact but also enhances profitability by optimizing resource use and minimizing waste.

The imperative to adopt Industry 4.0 arises from its potential to revolutionize manufacturing by greatly improving competitiveness and long-term sustainability. This transformation is crucial for both large and small manufacturers, as it allows them to optimize operations and innovate effectively. Industry organizations advocate for its adoption not only to maintain global competitiveness but also to comply with evolving regulatory standards, ensuring that businesses of all sizes can safeguard their future growth and progress in the manufacturing sector.

Key technological innovations of the last decade

Over the past decade, several key technologies have been at the forefront of transforming high-tech manufacturing and supporting Industry 4.0:

- AI and machine learning (ML) enhance processes by simulating human intelligence and driving quality control systems for real-time inspection and waste reduction through consistent quality assurance. They also aid predictive maintenance by forecasting equipment failures, which minimizes downtime and costs.
- IoT creates interconnected systems where devices communicate seamlessly, promoting smart manufacturing. IoT sensors continuously monitor equipment performance, which provides valuable data to ML algorithms that improve decision making.
- Virtual twins allow manufacturers to create digital replicas of physical systems, which enables simulation and optimization of manufacturing processes before real-world implementation. This innovation reduces costly errors and boosts overall efficiency.

Manufacturers have prioritized and adopted these technologies by investing in digital transformation. This fosters a culture of innovation and strategically aligning business objectives with cutting-edge technological advances.

Transformation journey guidance

Choosing the right technology partner for digital transformation in manufacturing is essential, and offers both benefits and challenges. A well-selected partner can significantly boost operational efficiency by providing advanced technological solutions that streamline processes and increase productivity. Their expertise can accelerate the transformation journey with tailored solutions that meet specific manufacturing needs. This collaboration can lead to innovative strategies for optimizing supply chains, improving product quality and reducing time-to-market.

The right partnership also allows manufacturers to leverage cutting-edge technologies like AI, IoT and virtual twins. These solutions enable real-time data analysis and predictive analytics, which offers valuable insights for decision making and promoting a proactive management approach. Additionally, the partnership can help ensure compliance with regulatory standards through robust cybersecurity measures to protect sensitive manufacturing data.

However, selecting a technology partner comes with challenges. The wrong choice can result in integration issues, where legacy systems and new technologies fail to sync. This leads to increased operational downtime and costs instead of the desired efficiency gains. Differences in organizational culture and strategic goals can also create friction, and this can undermine collaboration efforts.

Another challenge is assessing the partner's long-term viability and commitment to innovation. A partner without forward thinking strategies can hinder a manufacturer's growth, which leaves their digital solutions outdated as new technologies emerge. Thus, manufacturers must carefully evaluate potential partners and consider not just their current offerings but also their vision for the future.

While the right technology partner can enhance manufacturing capabilities through effective digital transformation, careful consideration is crucial to mitigate the risks of integration failures and strategic misalignment. A successful partnership requires shared goals and a focus on innovation.

Advanced technologies enable value

These technologies collectively empower manufacturers with enhanced efficiency, quality and flexibility. AI-driven systems streamline production by automating routine tasks and optimizing schedules, often enabling human planners to focus on strategic, value-added activities. This shift not only reduces operational costs but also minimizes time-to-market, which is a critical factor in the fast-paced electronics industry.

AI and ML significantly improve quality assurance by providing real-time insights into production processes, identifying anomalies and preventing defects before they escalate. This proactive approach to quality control ensures that products meet exacting standards and enhances customer satisfaction and brand reputation.

The integration of IoT and virtual twins fosters a culture of continuous improvement. By simulating changes and testing configurations virtually, manufacturers can identify the most efficient and cost-effective solutions, therefore minimizing downtime and maximizing resource utilization. This agility is crucial in maintaining competitiveness in a marketplace characterized by rapid technological advances and shifting consumer preferences.

Overall, manufacturers have realized significant value across all aspects of operations:

- **Production efficiency:** AI systems have boosted production efficiency by 30 percent, cut operational costs and reduced time-to-market by 20 percent.
- **Quality assurance:** AI and ML have improved defect detection by 40 percent. This has resulted in ensuring standards and lowering return rates by 25 percent.

- **Operational flexibility:** IoT and virtual twins have minimized downtime by 35 percent and improved resource utilization by 15 percent.
- **Predictive maintenance:** AI and ML cut equipment downtime by 50 percent and reduced maintenance costs by 20 percent.
- **Resource optimization:** Digital transformation has reduced waste by 20 percent and boosted profitability and sustainability by 15 percent.
- **Accelerated design cycles:** Virtual prototyping has shortened design cycles by 40 percent which minimized time-to-market for new devices.

Looking ahead

In the high-tech sector, adopting innovative technologies has become essential. Industry 4.0 provides a framework for turning challenges into opportunities through digital transformation, agility and sustainability. As AI, ML, IoT and virtual twins advance, their integration into manufacturing processes will enhance efficiency, quality and flexibility, which is crucial for devices from communications equipment and smart phones to consumer wearables and connected appliances. By investing in these technologies, manufacturers can effectively navigate the complexities of the modern market, thereby ensuring resilience and long-term success in an ever-evolving industry landscape.

ABOUT THE AUTHOR

Adrian Wood has spent 30 years in customer-facing positions with DELMIA including sales, marketing, strategy and service. His focus has been on problem solving and development of rapid growth segments to enable customer success across industries from Hi tech to retail and logistics and disciplines such as supply chain, manufacturing simulation and analytics. For more information about how DELMIA can improve your manufacturing game, visit us here or read our eBook titled “Achieving Transformational Growth in High-Tech Manufacturing.”

Modular Automation Enhances Chemical Process Control Systems

Modular automation solutions are helping create adaptable automation solutions to meet changing needs.

By Axel Haller, ABB

The need for chemical producers to enhance the agility of their production processes is calling for a new breed of process control system that can help them embrace change. As part of an industry estimated to be worth more than $5.2tn, the world's chemical producers face an increasing array of challenges that are calling for it to rethink its conventional approaches to production and process control.

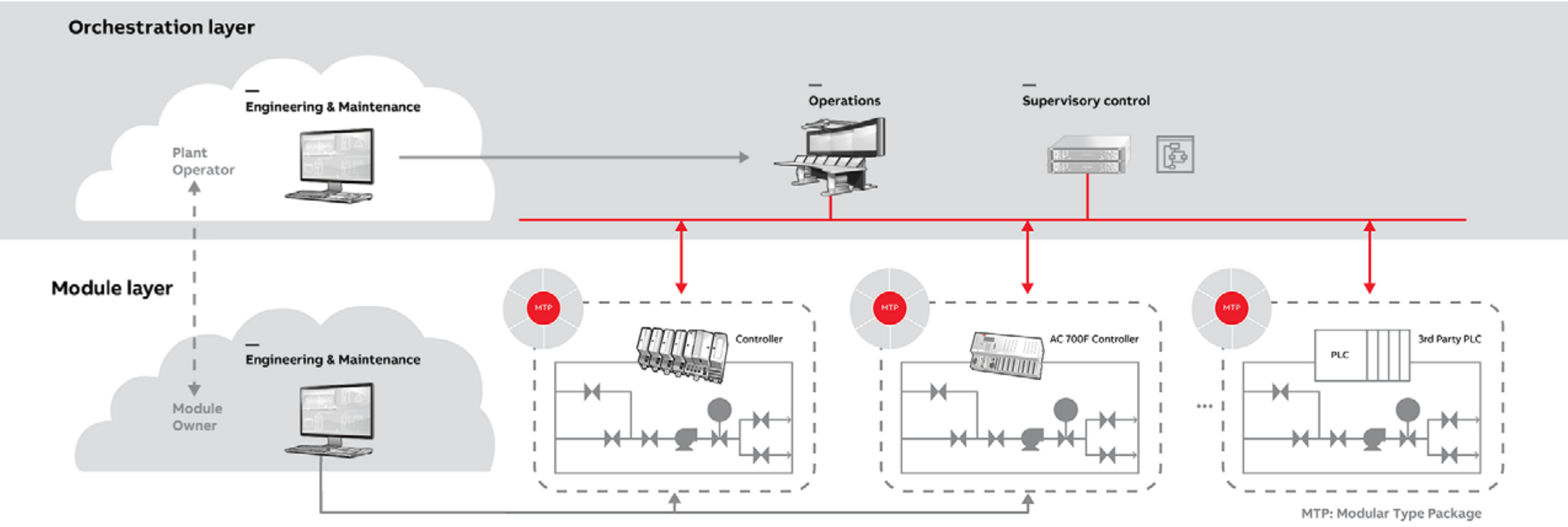
A key challenge is the rising focus on sustainability. Producers are increasingly expected to find ways to minimize their carbon emissions and reduce their ecological footprint through the development and implementation of eco-friendlier production techniques, more efficient recycling of chemicals and waste reduction.

Unpredictable material costs and disruptions to supply chains also have an impact, especially when it comes to the feedstocks and energy crucial to chemical production processes. The fluctuating prices of oil and gas can significantly impact production expenses and profitability.

Added to this is escalating regulatory scrutiny. Governments worldwide are tightening regulations to control emissions and ensure the safe handling of chemicals. Compliance with these regulations can be resource, time and cost-intensive, which demands substantial investment in new technologies and infrastructure, as well as keeping a closer eye on the performance of existing production processes.

The highly competitive nature of the chemical industry, coupled with growing demands for customization and faster delivery times are also calling for companies to adapt quickly, either by ramping their processes up or down or rapidly developing new products. Advances in digital technologies including artificial intelligence (AI), machine learning (ML) and the Internet of Things (IoT) offer growing opportunities to achieve new levels of production agility but using them also brings its own set of challenges, which include the ability to integrate them into existing process control architectures (Figure 1).

Figure 1. Advances in digital technologies offer growing opportunities but using them presents challenges, which include the ability to integrate them into existing process control architectures.



Another pressing concern is the industry's rising skills shortage. Difficulties in attracting and retaining skilled workers means that engineering teams are becoming increasingly stretched, which compels producers to find new ways of using their existing people more effectively, which includes through greater use of automation and digital technologies.

Changing demands require a changed approach

Meeting these challenges requires a radical departure from the monolithic automation systems that have traditionally been used to manage and control plants. In these systems, a master controller is used to execute custom-built source code to manage sequencing, motion and input/output (I/O) throughout the production line. As such systems are typically designed and optimized for a particular plant layout, product range and ideal throughput, they offer limited scope for accommodating future changes.

While suited for conventional large scale, mass production of single products where demand cycles are either constant or highly predictable, these systems lack the flexibility needed to cope with the growing raft of challenges facing today's producers, especially when it comes to meeting the demands for faster, more flexible production. With an increasing trend toward customization, there is a need for producers to shift from lines geared for mass production toward ones designed for smaller batch production.

With systems designed for specific plants or processes, it also can be difficult to replicate them across other sites, which presents potential issues for companies operating from multiple locations. In particular, as both systems and the expertise to support them will likely end up differing from site to site, it can be complicated to achieve a consistent company-wide benchmark for areas such as quality, cost and energy consumption.

This necessarily entails a rethink in the design of process control systems in two ways. First, there is a need to move away from traditional centralized architectures toward new concepts that enable a fast response to changes in production that will ensure maximum efficiency without incurring maximum cost.

Second, in making this move, there is the opportunity to consider how best to integrate the opportunities offered by Industry 4.0 and IoT technologies that can be used to optimize both process and worker performance and transform plant maintenance and operation.

Many of the challenges facing chemical producers are addressed by designers incorporating new technologies backed by edge and cloud computing that offer expanded possibilities for enhanced interaction with production plants.

Moving from a monolithic to a modular automation system can reduce downtime by 50 percent, decrease capital expenditure for automation engineering by 50 percent, and lower life cycle management costs by 20 percent.

Examples include using advanced sensors and analytics to optimize energy use and minimize waste products to address the industry's environmental responsibilities and cost-saving imperatives. This focus on sustainability is not only reducing the industry's ecological footprint but also enhancing its economic viability and helping ensure regulatory compliance through improved monitoring and reporting.

Advanced control algorithms are also helping make the decisions needed to deliver higher product quality and consistency, which reduces the variability that can occur with manual processes as well as enhancing production efficiency, which allows companies to respond more nimbly to market demands and outpace their competitors.

Meanwhile, as the impact of skills gaps becomes more pronounced, a range of new solutions are being developed with intuitive interfaces and smart diagnostics—from smart handheld devices to augmented reality (AR) headsets—that can be used to augment the performance of engineering teams whether they are in the control room or performing maintenance in the field.

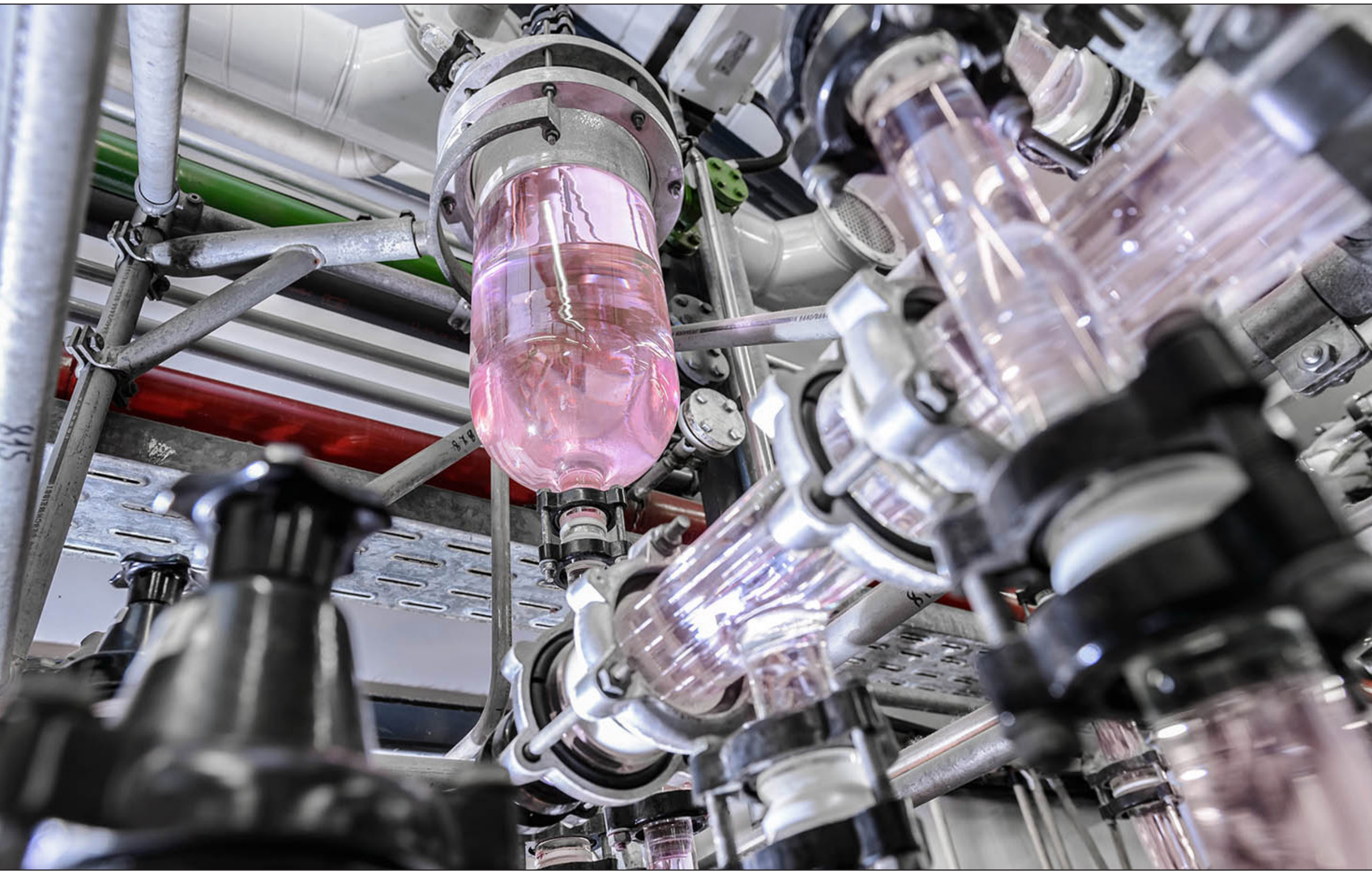


Figure 2. Modular automation offers the flexibility needed to attain dynamic and flexible process control systems.

The solution is modular

The modular automation concept offers the solution to achieve the flexibility needed to attain dynamic and flexible process control systems capable of meeting both current and future production challenges (Figure 2). The concept breaks the system into blocks, where discrete processes are equipped with their own intelligence, which is then fed back into the central controller.

As control functions are distributed to smaller, less powerful and less costly controllers handling each of the modules, the central controller doesn't have to be as powerful as one used in a conventional monolithic arrangement. As each module is effectively acting as a plant within a plant, processes can operate semi-autonomously, which allows changes or optimizations to be made without completely rewriting the code for the entire process. Existing parts of a process can be adapted or removed, or new parts added without affecting the other modules around it or compromising the process in any way.

Decentralizing control functions allows more data to be gathered from each individual module, which optimizes specific parts of the production line instead of consolidating it all at a central point. This results in greater agility and flexibility to adapt production lines to accommodate product variations or changes in production volume. Moving from a monolithic to a modular automation system can reduce downtime by 50 percent, decrease capital expenditure for automation engineering by 50 percent, and lower life cycle management costs by 20 percent. Time to market can also be decreased by up to 40 percent, with products that can be rolled out much more quickly as the time needed to put new production processes into action is reduced.

Decentralizing control functions allows more data to be gathered from each individual module, which optimizes specific parts of the production line instead of consolidating it all at a central point.

Ensuring interoperability

It has long been realized by automation manufacturers that proprietary systems that offer little or no interoperability severely hamper the capabilities of process control systems and their ability to adapt to changing circumstances by stifling innovation and tying customers into specific systems.

For this reason, collaboration and transparency have been key drivers in the development of both automation technology and the standardization needed to enable maximum interoperability. Today's modular automation technologies are based on VDI/VDE/NAMUR 2658, which standardizes the framework of interoperability between the media transfer protocols (MTPs) that form the layers in the system between each individual module and the central controller above it (Figure 3). The MTP contains the information necessary for the module to be integrated into the automation system, including archive, human-machine interface (HMI), process control, history and safety.

Adhering to the VDI/VDE/NAMUR 2658 standard ensures that any module can be integrated into any automation system, allowing complete interoperability across multiple system vendors and product ranges. This benefit makes modular automation compelling, as original equipment manufacturers (OEMs) and customers are not confined to existing systems but instead given the freedom to enjoy the benefits of a truly agnostic automation environment.

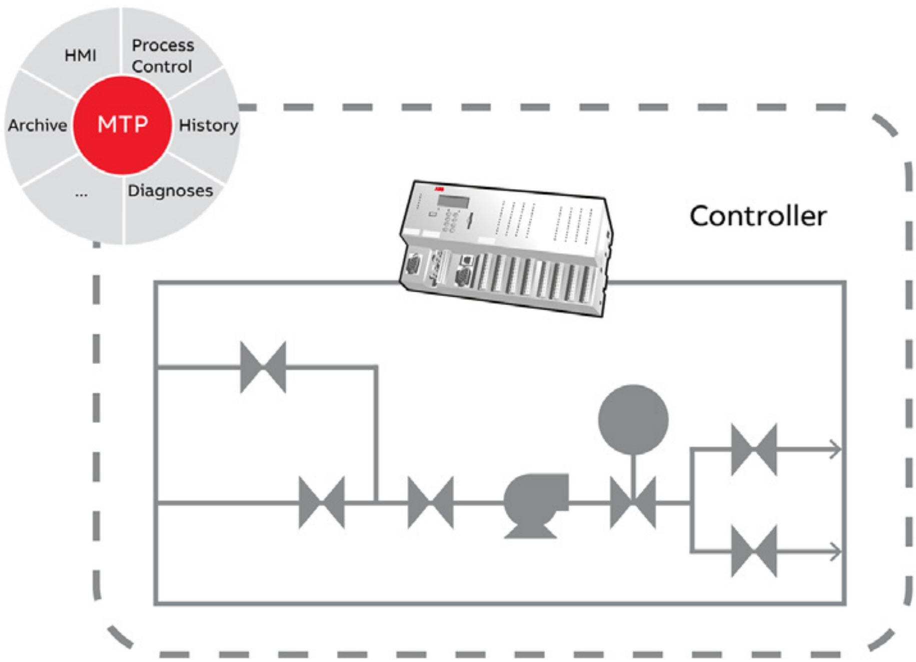


Figure 3. Modular automation technologies are based on protocols that standardize the framework of interoperability between the MTPs that form the layers in the system between each individual module and the central controller above it.

Another benefit of the modular approach is the ability to respond more quickly to changes in demand, whether in terms of quantity or products. The ability to create MTP blocks for specific applications facilitates ramping up and down production without affecting other modules. As such, a key benefit of modular automation is the ability to number up or number down to meet changing production demands. Compared to scaling, which typically involves adjusting an existing process to increase or reduce its capacity, numbering literally entails adding or reducing a production unit according to what's needed. As well as increased flexibility, this approach helps reduce the risk and disruption of ramping production, as production can be maintained while new systems are added.

Evolving the role of the DCS

While distributed control systems (DCS) have provided a proven and longstanding way of handling the functions needed to keep plants running safely and efficiently, there is a growing need for them to adapt to handle the changing requirements of industrial users. In particular, users now expect systems to be more dynamic to unlock the possibilities offered by an expanding range of technologies that help deliver the next generation of process control systems.

The opportunities available through modular automation change the role of the DCS from that of a centralized, complex system to one that is more flexible, scalable and user-friendly and is better suited to the dynamic needs of modern industrial processes. In effect, the role of the DCS evolves to become a process orchestration system that manages tasks and processes such as initiating the production process, collecting feedback on operational performance, handling information and returning commands for each module. By enabling each module to anticipate the actions of other modules, the process orchestration system ensures all parts of the process are working together to achieve optimal production.

This approach is what has made the concept of "plug and produce" possible. Now a new module can be dropped into an existing process and function seamlessly within the wider automation architecture, with the MTP performing a similar role to that of a driver installed on a PC. As well as speeding up implementation, this approach also makes it easier to duplicate operations across multiple sites and establish consistent best practices.

Unlocking new possibilities

For chemical producers, the possibilities offered by the plug-and-produce model offer an attractive route to accelerating time-to-market, which boosts uptime and cuts production costs. Furthermore, by enabling manufacturers to swiftly adapt and number up or down their processes and systems to meet customer and market demands, it offers a way of streamlining the introduction of new products and adjusting production capacity with minimal engineering effort.

By adopting standardized modules and interfaces, modular automation enables plants to achieve greater engineering efficiencies, which leads to cost reductions. Processes can be designed and tested without the need for actual hardware, and maintenance becomes more straightforward and cost effective, as individual modules can be serviced without taking the entire system offline.

Moreover, modular automation supports a granular approach to data collection, which allows for the optimization of individual production line components. It also aligns with “cybersecure by design” strategies, which provides compartmentalized security safeguards that can contain cyber threats more effectively than monolithic systems without halting production.

This modular approach is particularly suited to the specialized requirements of fine chemical production, with its small volumes, short production runs or parallel production of multiple products in limited quantities. It provides a more standardized, off-the-shelf alternative to traditional monolithic systems, which helps chemical companies address workforce shortages and reduce reliance on expensive engineering, procurement and construction (EPC) services for automation system design, implementation and maintenance.

The chemical industry is on the cusp of a technological revolution, with modular automation and IoT converging to offer unprecedented real-time data and automation capabilities. Modular automation, combined with IoT, is not only transforming plant design and fabrication but also providing cost-effective solutions that simplify engineering, increase production flexibility and help chemical producers seize new market opportunities.

IoT sensors enable real-time process monitoring, predictive maintenance, supply chain optimization, energy conservation and remote monitoring and control, all of which enhance product quality, safety, plant efficiency and environmental compliance.

Process control systems of thefuture

The integration of IoT with modular automation catalyzes a transformation in the chemical industry, which enhances safety, efficiency, product quality and environmental sustainability. As the industry faces current and future challenges, these technologies are poised to create the chemical process control systems of the future that will unlock new potential for enhanced production and performance.

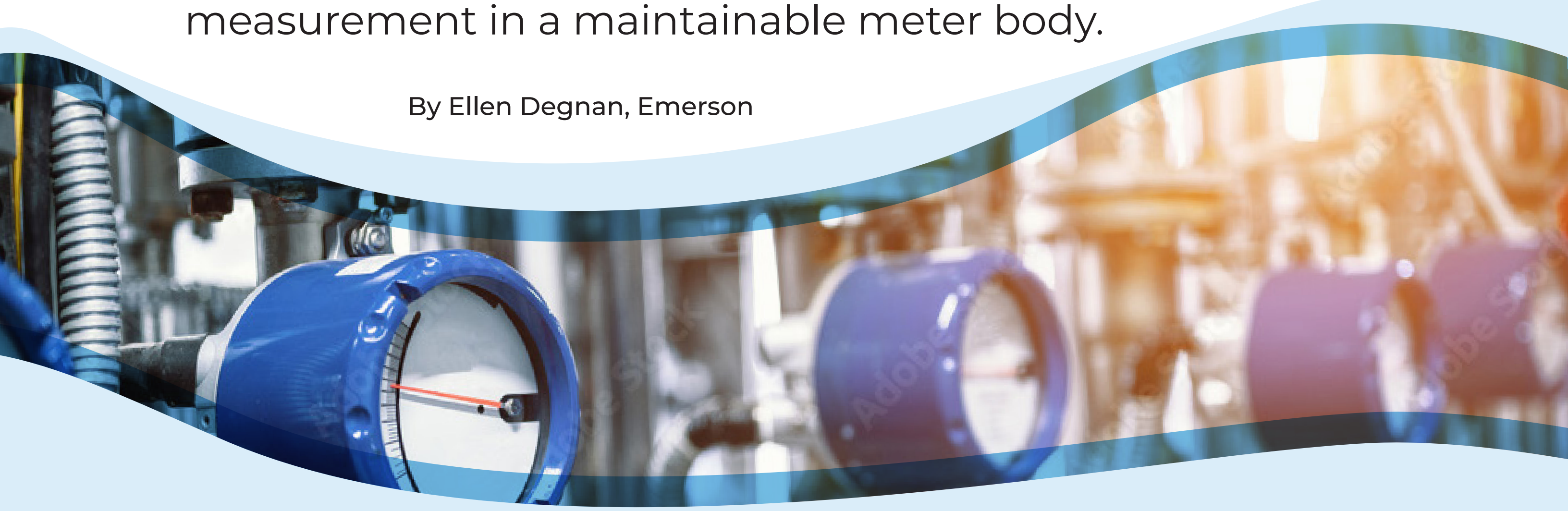
ABOUT THE AUTHOR

Axel Haller is global industry business manager for Chemicals and Life Sciences at ABB.

Flowmeter Design Addresses SIL Reliability and Process Control Challenges

A vortex flowmeter design provides three independent safety measurements and a process control variable measurement in a maintainable meter body.

By Ellen Degnan, Emerson



Large, continuously operating chemical plants and refinery processes are often faced with the need to measure critical flows that feed both interlocks and process control systems. Since these interlocks may go years between test intervals and the price of inadvertent shutdown is so high, two out of three (2oo3) safety integrity level (SIL) trip voting schemes are common. This then requires four independent measurements of the same process flow.

The common solution to this application has historically been a single orifice with up to four sets of process taps feeding four separate differential pressure transmitters. Unfortunately, those static pressure process connections are expensive to install, difficult to maintain and are prone to plugging and freezing. This article describes a solution for critical flow applications that is less costly and significantly more reliable than the alternatives.

To improve reliability and avoid unplanned downtime, many critical flow interlocks are set up in a 2oo3 trip voting arrangement.

Critical flow measurement challenges

Many petrochemical applications involve critical flows that must be carefully controlled to provide safe and efficient operation. In many situations, measurements from these same flows are fed into safety interlocks to protect equipment and personnel. The process flows may involve liquids, steam or gases, and in all cases are carefully monitored to ensure the proper ratios and flow rates are maintained. If flow drifts too far from design, the plant is often tripped offline, which results in expensive downtime and significant loss of production.

To improve reliability and avoid unplanned downtime, many of these critical flow interlocks are set up in a 2oo3 trip voting arrangement. This ensures a safe shutdown when required, while avoiding unnecessary trips due to a single transmitter failure. In such cases, the plant then needs four separate measurements of the same flow—three to feed the safety interlock and a fourth to feed the control system proportional-integral-derivative (PID) loop as its process variable. Each reading must be independent to avoid common cause failures, yet all must measure the same flow. This is not a trivial challenge.

While it is possible to install four separate flowmeters on the same line, the length of pipe required for such an installation would be significant because each flowmeter usually requires straight runs of piping before and after the transmitter. A common solution is to install a single orifice with four separate differential pressure transmitters measuring the drop across the orifice, but this approach has several drawbacks.

The first problem is one of independence; ideally each meter should have nothing in common with the others. In the case of an orifice with four transmitters, the orifice itself is common to all four, so a damaged orifice, or one with water trapped upstream, would affect all four readings. Another problem is cost. Installing four separate sets of orifice taps and static tubing is expensive, particularly if the static lines must be heat traced. The tubing is also prone to plugging and freezing, which makes the signals less reliable. Fortunately, an innovative process flowmeter design has entered the market, and it is specifically designed for these types of applications.

Quad vortex flowmeter

For many applications, vortex meters are often the best flow measurement technology. These meters have vertical shedder bar installed in the flow path of a gas, liquid or steam process line (Figure 1). As the fluid moves past the obstruction, it creates tiny eddies or vortices on alternate sides of the bar. This effect is similar to what causes a flag to wave in the wind, or whirlpools to form as a paddle moves through water.

The rate of vortex formation is directly proportional to flow, so the vortex flowmeter uses a sensitive sensor within the shedder

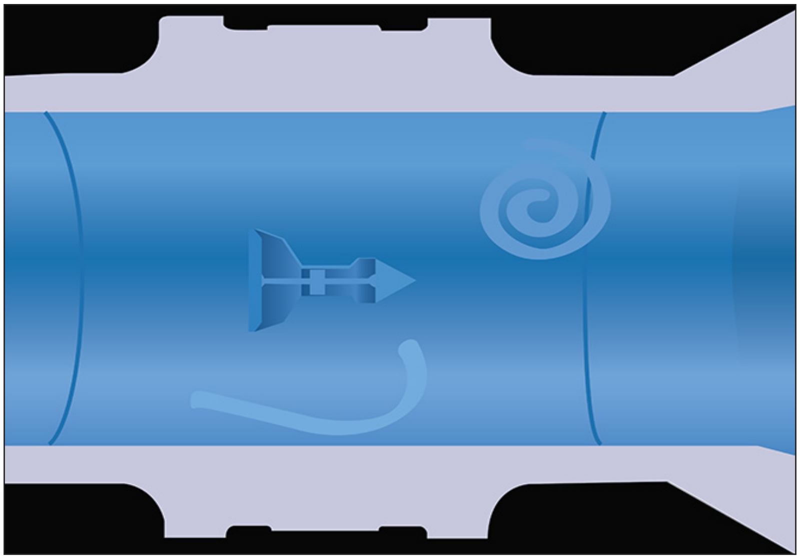


Figure 1. Top view of a vortex meter in operation. Fluid flow from left to right moves past a shedder bar, which forms vortices on alternate sides. A sensor embedded in the bar detects the vortices and converts that reading to a fluid flow measurement.

bar to count the eddies as they are formed. This count can then be converted to a volumetric flow. Pressure drop through the meter is minimal, and turndown can be as high as 20:1. Vortex meters do exhibit a phenomenon called low flow cutoff where the meter reading drops to zero at very low flow rates or high fluid viscosities. Otherwise, vortex meters are accurate and quite repeatable, making them often the best option for process and safety interlock flow measurements.

While it is possible to put four individual vortex meters in series to measure a particular flow, it would be quite unwieldy as each meter would require as much as 35 pipe diameters upstream and 10 diameters downstream. Fortunately, an innovative design combines four meters into a single body (Figure 2). The quad vortex meter design provides four completely independent flowmeters, each using its own sensor, but the meter only requires the straight run piping of a single unit.

Internally, each pair of vortex sensors is tied to a single shedder bar, but each has its own flexure sensor so common cause failures are minimized. The two shedder bars are parallel to each other and situated such that the second shedder bar amplifies the signal of the first, which avoids crosstalk and interference between the transmitters.

The new design works well for critical liquid, vapor or steam flow measurements and it is offered in sizes of 2 inches to 12 inches with a wide variety of body materials and flange ratings up to 1,500 psig. The meter can handle process media temperatures from -330 degrees F to 842 degrees F, which makes it suitable for cryogenic and superheated steam applications. It also eliminates the static connections required for orifice plates.

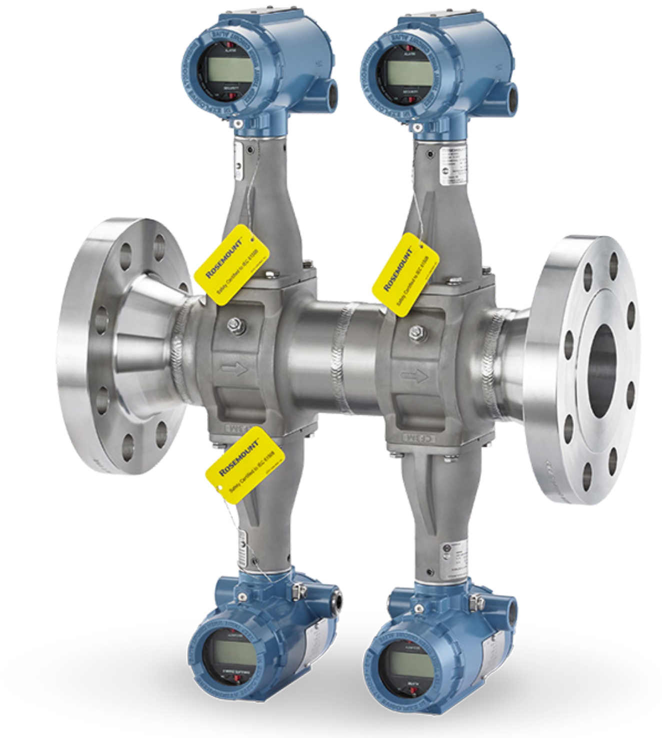


Figure 2. This vortex flowmeter incorporates four independent vortex meters within a single meter body. Three meters feed a 2oo3 SIL 3 capable interlock, while the fourth is used for process control.

This greatly reduces installation costs and eliminates the ongoing reliability problems associated with static sensor line heat trace, plugging and freezing.

While vortex sensor failure is exceedingly rare, the design allows the sensors to be replaced without removing the meter from service (Figure 3). The sensors can be ordered with a small bleed valve, typically referred to as the critical process valves, that allows the technician to confirm there is no pressure in the sensor compartment. Once confirmed, the sensor can be removed and replaced while the other three meters remain in operation.

The ability to maintain and repair a single meter while keeping the other units in operation can save significant costs in downtime and lost production.

Figure 3. This vortex flowmeter can be ordered with small bleed valves (middle, left side) that allow technicians to confirm a lack of sensor compartment pressure, and to then safely replace the sensor while leaving the remaining meters in operation.

Case study

A common critical flow application can be found on coking furnaces where multiple streams of process products are fed through a furnace (Figure 4). During furnace operation, it is critical that the flows through each path remain somewhat balanced to avoid tube overtemperature and failure.

Superheated steam is also periodically fed into each pass to remove coke from the tube walls and introduce emergency steam into the tube passes on shutdown. These flow measurements are critical to continuous furnace operation, so 2oo3 safety interlocks and a process measurement are required.

One refinery had been using a single orifice plate with four transmitters for this application, but continuous problems with impulse

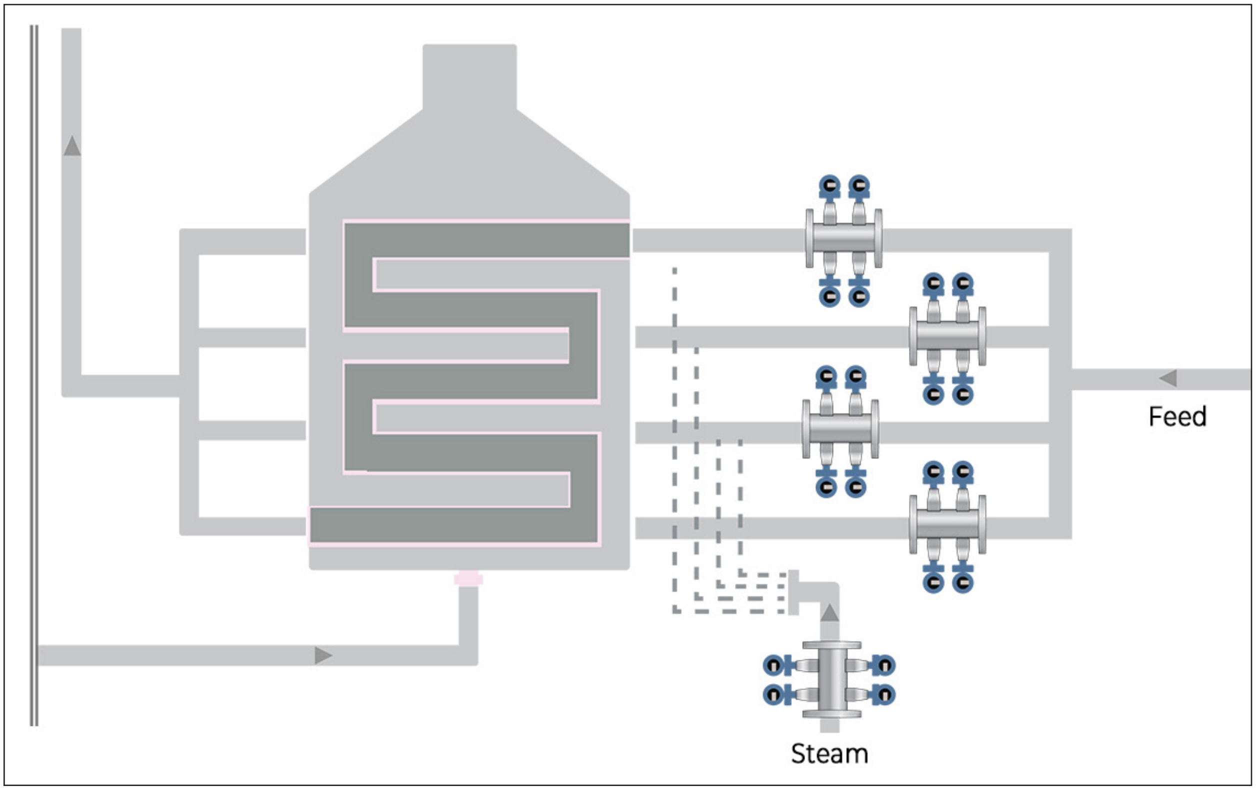


Figure 4. A common application for the quad vortex flowmeter can be found in a delayed coker furnace, which must maintain similar and consistent flows through each pass to avoid tube damage and to monitor steam flows for periodic cleaning and emergency shutdowns.

line plugging and freezing created significant maintenance costs and downtime. The orifice plate arrangements were replaced with quad vortex meters. Ongoing maintenance costs dropped dramatically and inadvertent outages and trips caused by sensor line plugging were eliminated. The meters have since been operating continuously with no measurement issues.

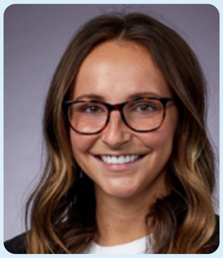
Final thoughts

Large, continuous chemical and petrochemical plants often run for years between outages and require 2oo3 SIL 2 or SIL 3 rated flow interlocks to enable these extended runs. In these applications, a quad vortex meter is often the preferred solution. Its compact design requires the same upstream and downstream meter runs as a single meter, yet it provides four completely independent flow measurements. Each meter can also be maintained and repaired without removing the other meters from operation. The design eliminates the problematic static pressure sensing lines associated with the traditional multi transmitter orifice plate solution, which reduces installation and maintenance costs.

For critical flow measurement applications in safety-related applications, four separate flowmeters have been the traditional solution, but these types of installations have issues related to cost, required upstream and downstream piping runs and maintenance. Quad vortex flowmeters provide all the advantages of four separate meters, while addressing the issues associated with these traditional designs, making them the best choice for many of these types of applications.

All figures courtesy of Emerson

ABOUT THE AUTHOR



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Remote Wireless for Less

By Dr. Vitaly Milner, Ph.D, Tadiran Batteries

Choosing the right battery can save money now and for decades.

Batteries are at the heart of most remote wireless devices, yet they are often considered an afterthought instead of a forethought.

When seeking to optimize a battery-powered device, the most cost-efficient solution is ideal: one that does not underperform and therefore damages brand reputation; or, conversely, does not wastefully overperform to add unnecessary bulk and expense. However, identifying the right-sized solution is easier said than done when considering all the variables and trade-offs involved.

Start by knowing your application. There is a common misconception that all batteries are essentially the same and disregarding the fact that each application has unique power requirements. Most low-power devices draw micro-Amps of average current with pulses in the multi-Amp range, typically requiring the use of a primary (non-rechargeable) battery. In addition, a small but growing number of low-power devices draw higher amounts of average current measurable in milli-Amps with pulses in the multi-Amp range, which can prematurely exhaust a primary battery. Such applications often require an energy-harvesting device in combination with a rechargeable Li-ion battery to store the harvested energy.

Numerous primary (non-rechargeable) batteries are available, thus requiring a fundamental understanding of the relative strengths and weaknesses of each competing chemistry. Key performance parameters to consider include:

Operating voltage – the battery's voltage can directly impact the size and weight of the device. Since it takes two 1.5v cells to deliver the same voltage as a single 3.6v cell, specifying a higher voltage battery could potentially reduce the size and weight of the power supply by 50%, and in some cases require the use of fewer cells. Where size and weight are not major considerations, choosing a lower voltage battery may be an acceptable trade-off to save money.

Low self-discharge – A battery's annual self-discharge rate is key to determining its potential operating life. Alkaline cells, for example, have self-discharge rates as high as 60% per year, requiring an oversized power supply to compensate for the expected energy loss. In situations where the device is easily accessible for battery replacement, and the operating environment is moderate, choosing a less inexpensive battery with a high self-discharge may be appropriate.

However, if the device is intended for long-term deployment at a remote site and must operate reliably for extended periods, even decades, then the application demands an ultra-long-life battery with a very low self-discharge rate.

Bobbin-type $LiSOCl_2$ cells deliver decades of reliable performance to help mitigate the risk of a highly disruptive and expensive large-scale battery.
Photo courtesy of Aclara.

While self-discharge is common to all batteries, bobbin-type $LiSOCl_2$ batteries stand apart for having the lowest self-discharge rate of all, mainly due to their unique ability to harness the passivation effect.

Passivation involves the formation of a thin film of lithium chloride (LiCl) that covers the surface of the anode of an inactive battery to act as a separation barrier from the electrode, thus limiting the chemical reactions that cause self-discharge. When a continuous current load is applied to the cell, the passivation layer causes initial high resistance and a temporary drop in voltage until the discharge reaction starts to de-passivate the battery. When the battery returns to an inactive state, the passivation layer begins to return, thus requiring another round of de-passivation.

The level of passivation is determined by numerous variables, including the cell's construction, its current discharge capacity, the length of time in storage, the storage and discharge temperature, and prior discharge conditions, as partially discharging a cell and then removing the load affects passivation over time. While ideal for extending battery life, passivation must be carefully controlled to avoid over-restricted energy flow.

Battery manufacturers differ in their ability to harness the passivation effect through the use of proprietary cell construction techniques and higher-quality raw materials. These differences can be substantial. For example, a superior quality bobbin-type $LiSOCl_2$ battery can feature a self-discharge rate of 0.7% per year, retaining over 70% of its original capacity after 40 years. By contrast, a lower grade bobbin-type $LiSOCl_2$ battery can have a much self-discharge rate of up to 3% per year, exhausting 30% of its original capacity every 10 years, making 40-year battery life unachievable.

Resensys structural stress monitors are mounted beneath bridge trusses and other hard-to-access locations. These monitors require ultra-long-life bobbin-type $LiSOCl_2$ batteries to minimize the need for costly and dangerous battery replacements.
Photo courtesy of Resensys.

Harsh environments. Battery performance can be severely reduced by prolonged exposure to extreme temperatures. Specifying a battery that is ill-suited for the operating environment may require the use of oversized batteries to compensate for an expected drop in voltage under pulsed load. Exposure to extreme temperatures often requires the use of bobbin-type lithium thionyl chloride ($LiSOCl_2$) cells that have a temperature range of -80ºC to +125ºC.

Specifying the ideal power supply takes on greater importance with long-term deployments at remote sites and harsh environments, where it is prohibitively expensive to access the battery (i.e. a structural stress sensor mounted beneath a bridge truss) or impossible to replace it once installed (i.e. a seismometer located on the ocean floor). Choosing the right battery is also critical for large scale deployments (i.e. municipal AMR/AMI metering network) where a systemwide battery failure could be costly and highly disruptive.

The IIoT has dramatically increased demand for low-power devices that require periodic high pulses to power two-way communications and other advanced functionality.

Don't confuse power with energy

Battery power (the amount of current consumed over a short-term period) is often confused with the total amount of energy required (total battery capacity consumed). Certain wireless devices draw relatively high amounts of power (continuous high-rate current for brief periods), requiring the use of specialized batteries such as a TLM Series lithium metal oxide battery or TLI Series industrial grade rechargeable Li-ion battery that have been modified to deliver high-rate current. Common examples include surgical power tools that operate for a few minutes, devices that perform actuation functions (i.e. valve control), and specialized mil/aero applications (i.e. projectile guidance), to name a few. However, most remote wireless applications do not require a high power-per-energy ratio, so choosing a high-power battery would be wasteful by adding unnecessary bulk and capacity.

Are high pulses required?

The IIoT has dramatically increased demand for low-power devices that require periodic high pulses to power two-way communications and other advanced functionality.

Inexpensive consumer-grade alkaline batteries can deliver the required high pulses due to their high-rate design but have serious drawbacks that make them unfit for long-term deployments, including low voltage (1.5 V), a limited temperature range (0°C to 60°C), and crimped seals that may leak. Most notably, alkaline cells have a high self-discharge rate of up to 60% per year, which is highly problematic for long-term deployments.

Bobbin-type $LiSOCl_2$ batteries are overwhelmingly preferred for remote wireless applications due to their extremely low-self-discharge rate of less than 1% per year, along with their high energy density, high capacity, and a wide temperature range of -80ºC to +125ºC.

One downside to bobbin-type $LiSOCl_2$ batteries is an inability to deliver high-rate current due to their low-rate design, resulting in transient minimum voltage (TMV) when first subjected to a pulsed load. To overcome the TMV challenge, PulsesPlus™ batteries were developed that combine a standard bobbin-type $LiSOCl_2$ cell with a patented Hybrid Layer Capacitor (HLC). This hybrid solution uses the bobbin-type $LiSOCl_2$ cell to deliver low-level background current in the 3.6 - 3.9 V nominal range while the HLC generates high pulses to support two-way wireless communications. The patented HLC also features a unique end-of-life voltage curve

Ayyeka AI-enabled edge devices utilize ultra-long-life bobbin-type $LiSOC_{l2}$ batteries to monitor the long-term performance of hard infrastructure, delivering the energy required to enable enhanced data intelligence that recognizes patterns, detects anomalous events, and supports real-time reporting and predictive modeling.
Photo courtesy of Ayyeka.

plateau that can be interpreted to provide 'low battery' status alerts that enhance predictive maintenance programs.

While supercapacitors perform a similar function for consumer electronics, they are generally unsuited for industrial applications due to numerous drawbacks, including added weight and bulkiness; a high annual self-discharge rate; a narrow temperature range; and the need for expensive balancing circuits when multiple supercapacitors are linked in series, which adds bulk and draws additional current to accelerate self-discharge.

Primary batteries and rechargeable Li-ion batteries can be utilized in tandem.

Long-life rechargeable Li-ion cells

Low-power devices that draw average current measurable in milli-Amps with pulses in the multi-Amp range may require the use of an energy harvesting device in combination with a rechargeable Lithium-ion (Li-ion) battery to store the harvested energy.

Consumer-grade Li-ion batteries have severe limitations, including a maximum battery life of roughly 3 years and 300 full recharge cycles. These cells also have a narrower temperature range that does not permit them to be discharged or recharged at extremely cold temperatures. Additionally, if more than 300 full recharge cycles are required, additional cells may be necessary to reduce the average depth of discharge per cell. Consumer-grade Li-ion cells are also unable to generate high pulses.

By contrast, TLI Series industrial-grade rechargeable Li-ion batteries can operate for up to 20 years and 5,000 recharge cycles while delivering up to 15 A pulses and 5 A continuous current. TLI Series cells also feature an extended temperature range (-40°C to 85°C) that allows the battery to be charged and discharged at extremely cold temperatures.

Primary batteries and rechargeable Li-ion batteries can be utilized in tandem. For example, applications using small solar PV panels may require extra rechargeable Li-ion batteries to accommodate a worst-case scenario such as five straight days of cloudiness. Bobbin-type $LiSOCl_2$ cells can serve as a backup power supply that recharges the Li-ion batteries on sunless days, potentially permitting the use of smaller PV panels and/or smaller batteries during polar winters or in situations where extended battery storage is required.

You need to consult an expert

With long-term battery deployments, there are no one-size-fits-all solutions. You should consult with an experienced applications engineer who can assist you in matching the power management solution to your specific requirements for voltage (maximum, nominal and shut-off), constant current, pulses current (size, duration, and frequency), expected operating life, storage life, and expected temperatures both during stage and operation, and more.

When evaluating competing battery chemistries, make sure that you receive fully documented and verifiable long-term lab test results along with real-life data from batteries performing in the field under similar loads and environmental conditions, both during storage and deployment. Customer references should also be requested and contacted.

Bobbin-type $LiSOCl_2$ batteries can be combined with a patented hybrid layer capacitor (HLC) to deliver up to 40-year service life along with the high pulses required to power wireless communications.
Photo courtesy of Tadiran.

Over many decades, Tadiran has developed a large and continually growing database that accurately predicts long-term battery performance under virtually all scenarios. Tadiran also monitors customer-supplied batteries from the field that have been operating under virtually all performance requirements and environmental conditions. Similar testing is also performed on competing brands.

Since bobbin-type $LiSOCl_2$ batteries are slightly more expensive, you must calculate whether the added investment is warranted by the long-term savings, taking into consideration such factors as the need for future battery replacements, since the cost of a battery change-out will far exceed its cost.

For long-term deployments at remote sites and extreme environments, it invariably pays to invest a little more for a battery that can operate maintenance-free for the entire lifetime of the device. A knowledgeable applications engineer can help identify the right-sized power management solution.

ABOUT THE AUTHOR

Vitaly Milner, Ph.D. is product and marketing manager at Tadiran Batteries. He has more than 20 years of experience in industrial roles, including 14 years in the battery sector. Milner specializes in innovative battery applications for IIoT, transportation, oil & gas, telecom, utilities, and more. He has a Doctor of Philosophy degree in physics and mathematics from Lomonosov Moscow State University.