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GET SMART ABOUT OEE

and turn technology investments into business outcomes

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Technology investments are made to solve specific business problems. In our technology-enabled world, enterprises of all sorts are allocating precious capital to make their operations "smart." For manufacturers, becoming "smart" is about more than investments in digital transformation and enabling technologies. Smart manufacturing is about the pursuit of continuous process improvement. Standard key performance indicators like Overall Equipment Effectiveness (OEE) may seem easily solved but can be significantly enhanced by technologies that nest under the broad idea of the Internet of Things (IoT). But linking IoT and other technologies directly to OEE at scale–from the machine- to line- to plant-level–requires a measured, strategic approach. At the end of the day, it doesn't matter how much data you collect or how quickly you collect that data if you cannot translate it into actionable insights that solve specific business problems.

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Matthew Giordano, Technical Evangelist, Rockwell Automation

DEFINING OVERALL EQUIPMENT EFFECTIVENESS

Fundamentally, OEE is a math problem. It's a function of measuring availability (productive time), performance (cycle time), and quality (waste/scrap). By multiplying the percentage of availability, performance and quality, you can derive an OEE score with 100% being the Holy Grail of sorts. The higher the OEE number, the lower the associated costs.

The principal was pioneered by Seiichi Nakajima and serves as the core of key manufacturing methodologies, including Total Productive Maintenance, Lean manufacturing, Six Sigma and World Class Manufacturing. OEE was further developed by the Japan Institute for Plant Maintenance, a nonprofit established in 1969 with the stated goal of "promoting safe, secure and reliable production and maintenance activities, as well as stabilizing and improving quality, in the world of industry through supporting problem-solving related to the enhancement of productivity, equipment-management technologies, and maintenance technologies and skills."

"What it really comes down to is trying to reduce cost," explained Rockwell Automation Technical Evangelist Matthew Giordano. "OEE is a way to get a handle on that and get started on that cost reduction. [It] helps us identify where the opportunities are. Unless you are looking at OEE, that is a hard question to answer."

Drilling down further, we categorize the six big losses beneath the three OEE metrics. Availability covers equipment failures and breakdowns, as well as time spent on setup and adjustment. Performance encapsulates idle time and reduced operational speed. And quality encompasses process defects and reduced yield.

While OEE has clearly been around for decades, approaching it as a function of technology-backed investments has steadily gained mindshare (and investment) in the past few years. In fact, researchers with the University of Zaragoza in Spain and the Technological University of Panama, writing in the journal Applied Sciences, conducted a survey of OEE-focused scientific and research publications to track general interest as well as ongoing concentration of OEE-related research. They found that "OEE is an emerging topic that can be used as input information for decision-making in business. Industry 4.0, which is based on cyber-physical systems and information digitalization, facilitates the accumulation and transformation of real-time process information into decisions to reduce uncertainty in the results."

They further found a close tie between the use of OEE measurements with Lean Manufacturing and factory maintenance programs, but noted that OEE "is adaptable to different domains by measuring the effectiveness not only of production equipment but also the effectiveness of material, economic and human resources."

In terms of how a typical manufacturer measures OEE today, "A lot of customers are still in the manual state...using clipboards, gathering manual accounts at the end of the shift or at the end of the day, or matching up material used with what they need to meet for their production goals," Rockwell Automation Solution Architect Terry Gansen explained in an interview with Enterprise IoT Insights.

He continued: OEE is "utilized as far as matching up their production goals and trying to figure out, if they're not meeting their orders, what are the potential causes--was it a particular area of the facility, was it a particular process? Then they can start to focus on accounts in specific areas. More and more customers want to forecast ahead and understand if they have the capacity to take on an order. Having better insights into what their current production is allows them to better forecast."

Three Categories, Six Big Losses

Availability (downtime)	1. Equipment failure (breakdowns) 2. Setup and adjustment
Performance (speed/throughput)	3. Idling 4. Reduced speed of operation
Quality (defects)	5. Process defects (scrap, repairs) 6. Reduced yield (from startup to production)

Courtesy of Rockwell Automation.

DIGITAL TWIN CASE STUDY: BUILDING A VIRTUAL PUMP

With an eye on using virtual simulation during product development in order to improve physical performance, reduce development costs, and increase product time-to-market, Ansys worked with partners PTC, Flowserve, NI and HPE, to build a digital twin of a typical pump used in a process industry.

The physical asset was outfitted with various sensors (all fitting under the broad term Internet of Things) measuring pressure at the inlet and outlet, accelerometers to gauge vibration, and devices to measure rate of discharge flow. Additional equipment was used to capture this data, feed it into a localized computing system and pushed into PTC's ThingWorx platform. When this all came together, operators were able to virtually mirror the pump and monitor operations, detect anomalies and conduct predictive analysis.

In an effort to demonstrate how digital twins can be used to troubleshoot physical problems and push the correct fix the first time, the group closed the physical valve by 50%. The sensors and analysis tools suggested the pump bearing could only hold on for a few days without an intervention to stop vibration caused by the partial valve closure. However, according to an Ansys case study, what wasn't explained was "why the pump was vibrating or what possible solutions could be considered."

> "You can't manage what you can't measure"
> ***– Peter Drucker***

Using the digital twin of the pump, as informed by the sensor inputs, the team conducted root cause analysis by launching a 3-D simulation. Using HMI readings and the virtual rendering, it became clear that the pressure change based on the valve closure was creating vapor bubbles inside the pump that were imploding and creating vibration.

Ansys described the resolution: "By disconnecting the system model from the physical pump, the system model's HMI could be used to try various potential fixes...The system model predicted that opening the valve would solve the problem. To validate this potential fix, a second 3-D simulation was performed on the offline system model with the opened valve. The 3-D results showed no vapor bubbles." When this fix was applied to the physical pump, the problem was solved.

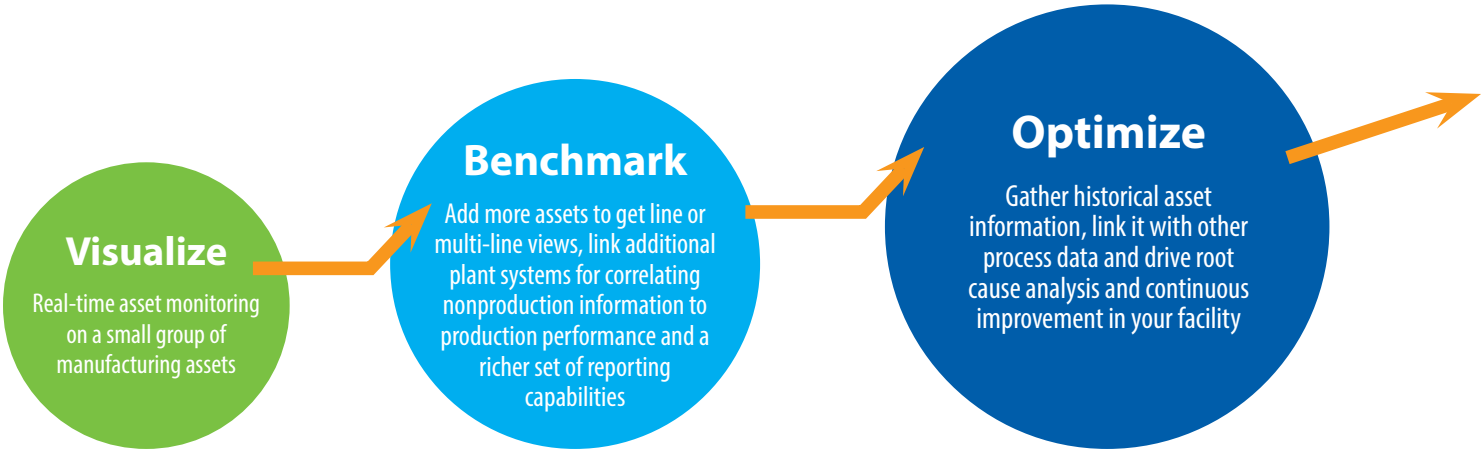
This use of IoT sensors, edge computing and other data intelligence tools to create a real-time, virtual view of a physical asset clearly shows that digital twins can streamline and de-risk the troubleshooting process. Properly utilized data allows plant operators to understand not just the problem, but the consequences and solutions, quickly and without the need for hands-on experimentation. The net result is faster problem solving and reduced downtime; the management of this incident further informs maintenance activities that will help optimize asset performance in the future. And, extending the digital thread from this digital twin, pump designers can improve designs for future versions of the asset.

Beginning in November 2019, Rockwell Automation and Ansys partnered to provide customers "access to a streamlined, holistic, end-to-end solution for design, automation, production and lifecycle management.

PUTTING DOWN THE CLIPBOARDS AND SCALING OEE

So how do you make that initial transition from the manual, clipboard approach to OEE to taking a technology-enabled, systemic approach to driving operational efficiency against your KPIs? Giordano broke it down into three steps:

1. **Visualize**
2. **Benchmark**
3. **Optimize**



Courtesy of Rockwell Automation.

The first step of visualization, he said, puts a stake in the ground by collecting relevant information that can be presented to decision makers who can then start the ball rolling on action. Visualization "is that foundational element."

For benchmarking, visualization becomes part of a broader solution that brings in data from different value streams, collecting downtime data and connecting it to financial information to start considering downtime in dollars and sense, for instance. Plant operators could also layer in things like alarms and notifications that are triggered when OEE drops below a predetermined threshold. "I can start to correlate when I'm seeing poor quality," Giordano said, "What is the information coming out of the lab versus what I'm seeing on the shop floor? It starts to broaden the value of OEE and its data. Benchmarking takes that OEE core and expands it in terms of the kind of analysis I can do and the data I can visualize."

The optimization step is, again, further broadening the scope of OEE. This is where the ability to do things like predictive analytics come into play--using structured data to understand when and why a machine or part is likely to fail and intervening before unplanned downtime hits your OEE valuation. "This OEE journey, you can start at any one of these levels or you can start at visualization and work your way up," Giordano said. "We designed [this] to be value-add at every step of the way."

Getting into the nuts and bolts, Rockwell Automation's Terry Gansen, a solution architect, said he works with customers to address the visualization step by looking for sensors and automated processes already in place from which data can be pulled without further capital spend. From there, with increasing granularity and visibility into operations, you can swap out those clipboards for something more accurate and replicable.

With benchmarking in place and optimization underway, "That's when we start to look at these events that occur and find out if there is a statistical correlation," Gansen said. "Then we can start to perform that prediction–after so many cycle counts this machine generally starts to need lubrication or some type of adjustment. This lets us not only track but change the manufacturing environment faster."

In terms of moving from a limited pilot to broader deployment, or scaling up an initial deployment, Gansen sketched out the process. "You have the top-level enterprise, below that multiple sites, below that areas, and within areas you have lines, and within lines there are work cells. Having that structure, you can work on one particular machine...then start to roll that up in terms of that machine across its line, then compare different lines at one facility." And then the virtuous cycle kicks in.

This notion of scaling up the scope of OEE initiatives was noted in IEEE's Xplore publication. Prasanna Kumar Illa and Nikhil Padhi set out to explore how the IoT, big data and edge analytics figured into creating a smart factory. For IoT and OEE outcomes derived from it, "It is essential that companies have a longer-term view and an appetite to make significant investment...a realistic approach will be to start small and gradually increase the scope to include multiple functional areas and business processes."

In relation to OEE, and other manufacturing KPIs yield and cost per unit, "IoT has favorable impact on OEE and yield," they

"If you come up with three to five basic data points, you can start to use that same foundation and expand it across multiple machines and lines and work cells and continue to scale up."

Terry Gansen, Solution Architect, Rockwell Automation

Rockwell Automation

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Finding loss in the cement making process

While cement may seem like a simple product, it's a complex recipe involving more than a dozen ingredients that have to be carefully mixed before contributing to the built environment we all occupy. To ensure consistent quality and the costs associated with material waste, cement

manufacturers need to monitor weight, temperature and other factors in the production process.

Rockwell Automation and system integration partner Kruse Controls worked with a leading packaged cement manufacturer to develop and implement visibility and optimization tools to correct process inefficiencies. In addition to reducing cost and waste, the customer wanted visibility on PC and Apple devices, as well as a central repository for recipes.

To shift away from a largely manual data collection process, Kruse Controls used Rockwell Automation's FactoryTalk software for manufacturing intelligence, FactoryTalk View Site Edition for setting up a thin client solution set, and other tools to collect and correlate production of new batches with historic production data.

In addition to providing a new level of visibility from remote workstations, the solution set migrated cement recipes into an SQL database, and formed an audit table for recording recipe adjustments. For each batch, the system tracked start/end times, ingredient set points and batched amounts, and further was able to tie downtime to specific physical assets – all collected in web-based browsers for ease of use.

The sum result was granular visibility into production data enabling real-time visibility into process problems that, when correlated with specific points in the system, resulted in identification of $90,000 per month per line in losses. In addition to a transition from manual data collection and reporting, corporate execs gained high-level insight into plant operations, plant managers got an hourly view of plant-level operations, and supervisors were able to look into specific lines, and employees could view KPIs on displays installed in break rooms.

Harvesting data for smooth wine production

Rockwell Automation also worked with a U.S. winemaker that was struggling with unplanned delays and stoppages of their bottling line, which was running at 65% efficiency. The producer didn't have any insight into the root cause of existing problems, and also wanted to explore the potential for increasing throughput capacity.

Using Rockwell Automation's FactoryTalk solution, the winemaker was able to pull data off of its bottling line and set up real-time production monitoring, tracking, troubleshooting and optimization with management gaining insight into plant floor operations via a customized reporting tool.

Giordano explained: "They didn't really have insight into areas for improvement. They needed to maximize efficiency and their potential capacity so they could deal with changes in demand." With an OEE solution set put into place, "They were able to do things like root cause analysis so they could understand what was really dragging down production...At the end of the day, they had really good results in terms of they were able to reduce stoppages and bring their efficiency up from" 65% to 85%.

wrote, "which in turn helps in reducing cost per unit. In some cases, we observe linear improvements and in other cases it can be non-linear. Improvement is driven by multiple factors such as equipment readiness, top management buy-in, budget allocated, expertise of the team involved, effective cross-functional collaboration etc.…"

"Having that organizational structure in place automatically starts to align the data and the information," Gansen said. "If you come up with three to five basic data points, you can start to use that same foundation and expand it across multiple machines and lines and work cells and continue to scale up." This scale enables more deep analysis and optimization, allowing a manufacturer to start breaking down production by part, by operator or both. You can even drill further down to look at shifts and individual employees to gain insight into particular sets of knowledge or training and then automate that to make it consistent and scalable.

To Gansen's point about using OEE to isolate and improve the performance of individual machine operators or other workers, this aligns with findings from rresearchers with the Khalasa College of Engineering and Technology's Department of Mechanical Engineering in India. Writing in the International Journal of Advance Research and Innovation, they posited that, "OEE is a people-oriented concept that starts by fully harnessing the human thinking capabilities which are normally concealed in the industries. The OEE initiatives can be depicted as a set of activities for accomplishing the maintenance-enhancement improvements including autonomous maintenance; focused improvement; planned maintenance; quality maintenance; education and training; development management; and safety, health and environment."

Implementing industry-accepted best practices for OEE helps factory operators "outscore traditional maintenance practices towards improving process performance. Attentive OEE implementation over a reasonable time period can extensively increase the consciousness of central capabilities in [process performance]. OEE is a vital concept and a basic technique for achieving considerable profits."

TURNING DATA INTO A SERVICE

With a strong grasp on the visualization, benchmarking and optimization that underlies OEE, manufacturers can go beyond streamlining their own processes. Robust, managed data can provide a value-add or even monetizable customer-facing service.

With a deep understanding of the ebb and flow of a factory floor based on real-time insights, manufacturers can structure this data in a way that's easy for high-value customers to consume. Consider a large retailer that's ordering paper towels from a manufacturer. In addition to wanting detailed insight into product tracking and delivery, they also want to know what the supplier is doing to improve the buyer's experience.

Gansen explained that if a manufacturer can show its customer the information related to orders and product lots, that customer will then want to know, "How does that compare week-to-week or month-to-month? Each time they use the reporting tool, they'll want to know at least four more things. It's a very valuable way of gaining further insights. It's becoming a service now that you can sell back and use to differentiate. Smart manufacturers are saying, 'We could take these reports and deliver data as a service."

Editor's note: James Blackman, global editor in chief of Enterprise IoT Insights, and Juan Pedro Tomas, editor of In-Building Tech, contributed to this report.

FactoryTalk Metrics:

FactoryTalk Metrics gives you the data that can reveal new ways to increase production, reduce costs, and increase quality. By generating accurate reporting of real plant floor activity, this software gives you important insights into using existing equipment and labor more effectively. FactoryTalk Metrics reports on OEE, but it is more than just an OEE reporting tool. OEE can tell you how a machine is performing over time; it cannot tell you why the machine is performing at that level. FactoryTalk Metrics answers the "why" question, uncovering the root-causes of downtime and loss to help you make real improvements to performance.

Factory Talk Historian:

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Factory Talk View Site Edition:

FactoryTalk View Site Edition (SE) meets the demands of each of these groups, providing robust and reliable functionality in a single software package that scales from a stand-alone HMI system to a distributed visualization solution. With FactoryTalk View SE, HMI challenges in process, batch and discrete applications are managed in a single software solution that enables critical visibility in real time when and where you need it.

About Rockwell Automation: Rockwell Automation is dedicated to industrial automation and information and makes its customers more productive and the world more sustainable. Rockwell Automation integrates control and information across the enterprise to help industrial companies and their people be more productive. Beginning with a deep understanding of clients' best opportunities for productivity, Rockwell Automation combines differentiated technology and domain expertise to deliver the positive business outcomes most important to customers. The result is a boost in productivity through simplification of customer experience at every step, from initial solution development through services and support.

To learn more, click here.

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