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Smart Factories for Small to Medium Manufacturers: How to get from Here to There

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SMART FACTORIES FOR SMALL TO MEDIUM MANUFACTURERS: HOW TO GET FROM HERE TO THERE

In the swarm of buzzwords surrounding today's manufacturing sector, the "Smart Factory" or "Factory of the Future" buzz is especially prominent. In this white paper featuring experts from Siemens Digital Industries Software, we'll unpack the meaning of the term, examine key considerations in understanding its value and explore a few important takeaways for how to take advantage of these technologies, including for small and medium businesses (SMBs).

In a sense, good factories have always been smart. Before sensors monitored equipment, skilled operators relied on their years of experience with specific pieces of equipment to monitor processes and equipment maintenance needs by feel, sound or touch. That legacy knowledge still exists—especially among North America's numerous manufacturing SMBs—and new operators are still capable of learning those skills. But in an increasingly complex manufacturing landscape with increasing workforce and training challenges, it's harder to develop and rely on.

Today, unprecedented computational capability and ubiquity is giving smaller manufacturing firms access to data which has previously been reserved for major players. If analyzed correctly, smaller firms can use this data to improve efficiency, sustainability, quality and time-to-market. The smart factory will be the only factory in the future, so getting from here to there is of paramount importance.

SIEMENS DIGITAL INDUSTRIES SOFTWARE EXPERTS IN THIS WHITE PAPER

Mike Denley, senior director of Strategic Programs and Initiatives at Siemens Digital Industries Software, currently leads the Siemens Cloud Application Solutions Program and Initiatives team. His academic and industry experience includes graduate and postgraduate work in Total Quality Management, software design and development, organizational change, Lean Six Sigma and business analytics with a focus in sustainability.

Rahul Garg is vice president of Industrial Machinery and Small to Medium Business Programs at Siemens Digital Industries Software. His multiple roles deliver solutions to help manufacturers develop competitive products and fill portfolio gaps using tools such as software-as-a-service to create effective go-to-market strategies, as well as business practices that support small and medium-sized manufacturing customers in achieving high performance. Rahul holds graduate and undergraduate degrees in computer science and computer engineering.

WHAT IS A SMART FACTORY?

A smart factory is a manufacturing facility that uses advanced technologies such as artificial intelligence and digital twins along with the Internet of Things (IoT), to improve efficiency and productivity. In a smart factory, machines and other equipment are connected to each other and to a central network, allowing them to communicate and share data in real-time. This enables the factory to respond quickly to changing conditions and customer demands. Smart factories also incorporate automation and robotics to perform tasks more accurately, consistently and efficiently than humans could.

SMART FACTORY TECHNOLOGIES

Cloud Computing | Smart factories rely on cloud-hosted computing resources to manage the high demands of the digital technologies in use. Today's cloud-hosted data storage and processing solutions are more secure, reliable, scalable and cost-efficient than all but the best on-premise solutions, making the cloud a perfect solution for smaller companies with limited IT data center space and budgets.

The Internet of Things | With computing devices embedded in equipment, sensors and even safety equipment, every part of the factory can be connected to the central software platform, making up the digital infrastructure of the factory. For any SMB that needs to pivot quickly between production runs, this connectivity is critical.

Sensors | Sensors collect equipment and process data for maintenance, quality and safety purposes in the smart factory. Today's sensors, when combined with edge devices, are capable of storing data, processing them or transmitting them to the cloud.

Reporting and Analytics Software | Software platforms such as ERP, PLM and business intelligence tools are critical, along with IoT analytics, for turning data into actionable insights. For example, a log of 100,000 temperature readings is useless without a graph indicating that temperature goes out of range toward the end of every month, for example. With that insight, maintenance changes can be planned.

Machine Learning and AI | This technology is becoming increasingly critical to Smart Factory strategies. As systems and data become more and more complex and multifaceted, machine learning algorithms can intake mass volumes of data and learn to find patterns where human data scientists can't. Smaller firms can use this to reduce setup times, design-to-production cycles and down time.

Digital Twin | Using advanced simulation software, factory designers can build a complete simulated twin of a piece of equipment, a line or even an entire factory, using this twin to plan, design, optimize and predict outcomes. More importantly, Closed-Loop Digital Twin provides continual feedback against models to help manage and predict operations including anomalies, defects and maintenance. This can be a game-changing edge for any small manufacturer in a highly competitive marketplace.

"THE COST OF BREAKING A TOOL DIGITALLY IS ZERO. THE COST OF BREAKING THAT TOOL ON THE MACHINE IS PRETTY HUGE."
Rahul Garg

WHY DO YOU NEED A SMART FACTORY?

MANUFACTURING IS BECOMING MORE COMPLEX

Complexity in manufacturing is like entropy: it's always increasing. Moore's law in the semiconductor industry is a perfect example. In other industries, even if the product isn't becoming more technologically advanced, process technology is advancing to draw even more cost out of the process while maintaining quality.

One example of increasing complexity is the growing phenomenon of mass customization, by which manufacturers allow each customer to configure the product to match their specific needs and tastes, while producing these customized items at a mass production scale. Smart factory technology makes this possible. For example, an automotive manufacturer can offer a customized bezel on the instrument cluster and allow the customer to design the color and texture of the part online. With G-code—the software language the tells a machine how to move—controlling the machine that prints or machines the part, each part costs the same as a mass-produced part. Without the need for dies or molds, economy of scale is less of an issue for manufacturing cost. However, manufacturers still need to define the right level of customization and set parameters that maximize value for the customer while maintaining an efficient process.

Another way manufacturing is becoming more complex is by the growing role of environmental concerns in production. For example, the full lifecycle of the product is now under scrutiny in a circular economy model. How can the product be recycled, reused or repaired? This is no longer a concern saved for only the largest of companies, as sustainability mandates are forcing suppliers further down the value chain to participate in meeting their customers' sustainability goals.

WHAT IS MASS CUSTOMIZATION?

Mass customization is a manufacturing strategy that involves producing goods or services as a part of continuous manufacturing operations, while still allowing customers to customize their products to their individual preferences. This is achieved by using advanced technologies such as computer-aided design and manufacturing, as well as flexible manufacturing systems that can quickly and easily adapt to changing customer requirements. Mass customization allows manufacturers to produce a wide range of products with minimal setup and changeover time, while still offering customers the ability to personalize their purchases. This can help manufacturers reduce costs and increase efficiency, while still meeting the unique needs of each customer.

REPEATABILITY AND PROCESS STANDARDIZATION

Collecting and analyzing data on every motion and operation of the equipment in the factory helps standardize and document processes, making them more repeatable and predictable. This is especially important for industries such as aerospace, where quality and regulatory compliance requires documentation and traceability, and in automotive, where OEMs rely on suppliers to produce quality parts according to specifications.

As equipment becomes more complex, this documenting and validation of process data becomes more complex. For example, compare a stamping press to a 3D printer. A stamping press applies a force to a billet of material and produces a part. The 3D printer may deposit thousands of layers of precisely melted polymer filament with each layer adhering at specific temperatures and cooling at a specific rate to minimize warping. The 3D printer requires much more complex monitoring to ensure it is performing correctly. Sensors, IoT and analytics – at the edge – are the enablers.

MITIGATING RISK USING SIMULATION

WHAT IS A DIGITAL TWIN?

A digital twin is a virtual representation of a physical object or system. It is created by using data from sensors, computer-aided design (CAD) models and other sources to create a detailed, real-time simulation of the object or system. In manufacturing, a digital twin can help optimize processes and identify potential problems before they occur.

For example, as Garg mentioned, a digital twin of a factory floor could be used to simulate and test different production scenarios, allowing manufacturers to identify bottlenecks and inefficiencies before they occur in the real world. Digital twins can also be used to monitor and control the performance of a physical object or system.

Simulation software has been used for many years in manufacturing for applications such as robot programming, product design and CNC toolpath programming. But advances in computing power and data access have vastly improved the value and quality of simulations to the point where, according to Garg, even the commissioning process of a machine on the shopfloor can be simulated. Every step of a process can be simulated, avoiding costs such as line stoppages and mistakes.

“One of the interesting parts is that once we simulate it and we have the behavior models, that becomes a state of a version of configuration for that plant. And we can use that to program the CNC machines or program the robots,” said Denley.

According to Rahul Garg, capabilities around simulation have improved so dramatically, to where we can get down to inside a factory, down to the smallest motor and evaluate the energy loss on that motor. Or we can go up to a machine, to validate the machine and optimize how that machine itself will be working; up to a production line, getting the kinematic validation, getting the geometry validation; and then all the way up to a factory, getting the complete throughput validation, getting the time validation, getting the logistics validation in a factory. The whole process of simulation has improved to where it has become an important step to undertake before you start production. The cost of this technology and the level of expertise required to conduct these simulations have both been significantly reduced in recent years, empowering smaller manufacturers to leverage these techniques in ways that have previously been beyond their means.

SENSOR MONITORING AND ACTIONABLE DATA

One of the challenges that manufacturers face as they begin to collect equipment monitoring data is what exactly to do with it. High-frequency data such as vibration or temperature readings can quickly stack up to massive quantities of digital data. Without the tools and strategies in place to parse it, it’s useless and may even become a hindrance.

The smart factory brings intelligence to that data collection. A sensor can tell you that a vibration of a motor housing is increasing, but smart analytics can tell you which bearing needs to be replaced. That's the gap between data collection and actionable data.

PREDICTIVE ANALYTICS

Actionable data also includes predictive analytics. With remote monitoring of equipment, trends and patterns in equipment sensor data can spot trends as they begin, giving maintenance personnel more time to plan maintenance, becoming predictive, rather than reactive (which leads to unplanned downtime) or preventive (which causes planned downtime, and may waste some value by replacing parts or equipment before their time). For any SMB that's struggling to hire skilled workers or fill a knowledge gap left by experienced workers who have moved on, predictive analytics can be a force multiplier.

SUSTAINABILITY

Sustainability is undoubtedly an important consideration for manufacturing today, whether it's one of the core values of your organization or your customers, or if compliance to sustainability standards is regulated in your area. Smart factory technology can better enable sustainable practices and compliance.

Simulation and digital manufacturing technologies can help shift product design to the concept of the circular economy, in which resources are kept in use for as long as possible and when they are no longer needed, they are recovered and regenerated into new products or materials. This approach is in contrast to the traditional linear economy, in which resources are extracted, used and then discarded.

"Just recently I was at a machine tool event where one of the vendors was demonstrating a new 5-axis milling machine. But what was more interesting in that whole concept was the lubricant and the cooling agent that was being used in the milling process. They had built-in processes where they could actually be recycling the coolant for the next three years. That's something you cannot just do in the end. That's something you have to think through your entire design process right up front when you are designing that machine. And a lot of that is driven by this whole nature of sustainability and circular economy requirements," said Garg.

REGULATORY COMPLIANCE FOR SUSTAINABILITY

Another smart factory technology that can help measure sustainability compliance is equipment monitoring and analytics. “Being able to go down to even the small motor and understand the energy footprint, the consumption pattern—that’s a big deal today about your carbon footprint and how that product is going to be built, manufactured as well as operated in the field,” said Denley. This analysis can also be done in simulation, before that motor is even installed. “I think that’s a really interesting item as we start now thinking about more of the social goals around CO2 reduction, a lowered carbon footprint and alternate energy sources.”

The automation of Industry 4.0 is the collection of data. It’s used for many factors; one is to improve, the other is the audit trail. Can I prove what I’ve done? Equipment data can help corporations meet internal sustainability goals, such as their carbon footprint, but also meet regulatory requirements set by the government. And for any SMB serving larger B2B customers, this ability may be the difference between winning a lucrative contract and being the runner-up.

EVERYTHING-AS-A-SERVICE

One interesting facet of the conversation of the smart factory is digital technologies make production so much more flexible and reconfigurable that it enables new ways of doing business. One new model popping up is the “as-a-service model”, which comes from the software world.

For example, rather than buying a piece of equipment such as a motor, a machine tool or even a jet engine, vendors will lease that equipment and provide it as a service to the factory. In this model, the mindset for factory managers is that it isn’t the equipment that’s needed, it’s the equipment output. Using IoT-connected monitoring technology, vendors remotely monitor the leased equipment, providing reliable maintenance. This shift reduces a company’s capital expenditures, instead turning the machine (or more accurately, its output) into an operational expenditure. A manufacturer won’t be tied to a particular piece of equipment for years to amortize the cost and achieve positive return on investment (ROI). With KPIs built into the service level agreement from the vendor, ROI can be more accurately priced into every contract.

Many SMBs are already leveraging this new model with the use of collaborative robotics (cobots) for production and material handling processes. This model allows a smaller manufacturer to put a super functional robotic arm on the shop floor in a matter of days instead of spending weeks commissioning and proving out a larger, more robust traditional robot. The model usually includes programming and troubleshooting help from the service provider, meaning they can efficiently deploy the cobot without having to spend time searching for highly skilled operators with experience in that particular brand of robot, all for one monthly fee.

Another application of this new as-a-service model is production as a service. For example, service bureaus such as Protolabs take advantage of automation and digitalization to the point where machine operators at Protolabs mainly load material into machines and unload finished parts. The custom parts are programmed into the machines remotely, and parts are traced and delivered to the customer using smart logistics.

NEXT STEPS

Small and medium-sized business owners may be thinking, “Of course I’ve been to the Siemens booth at a trade show and seen demonstrations of the ‘factory of the future’ or ‘smart factory,’ but it’s unrealistic to imagine the capital expenditure and time that it would cost to rip and replace an entire factory, while also investing in new technology and network infrastructure, not to mention the personnel training required.” These concerns are valid, especially with the pressure on today’s workforce and economy.

One answer to this concern is software-as-a service. In the past, a network-connected factory with computer analytics would require network cabling throughout the factory, with a server room and up-to-date data storage, processing power and cybersecurity investments. Today, it requires a monthly subscription to a service like Microsoft Azure or AWS. These cloud service vendors provide secure and scalable data storage and processing capabilities.

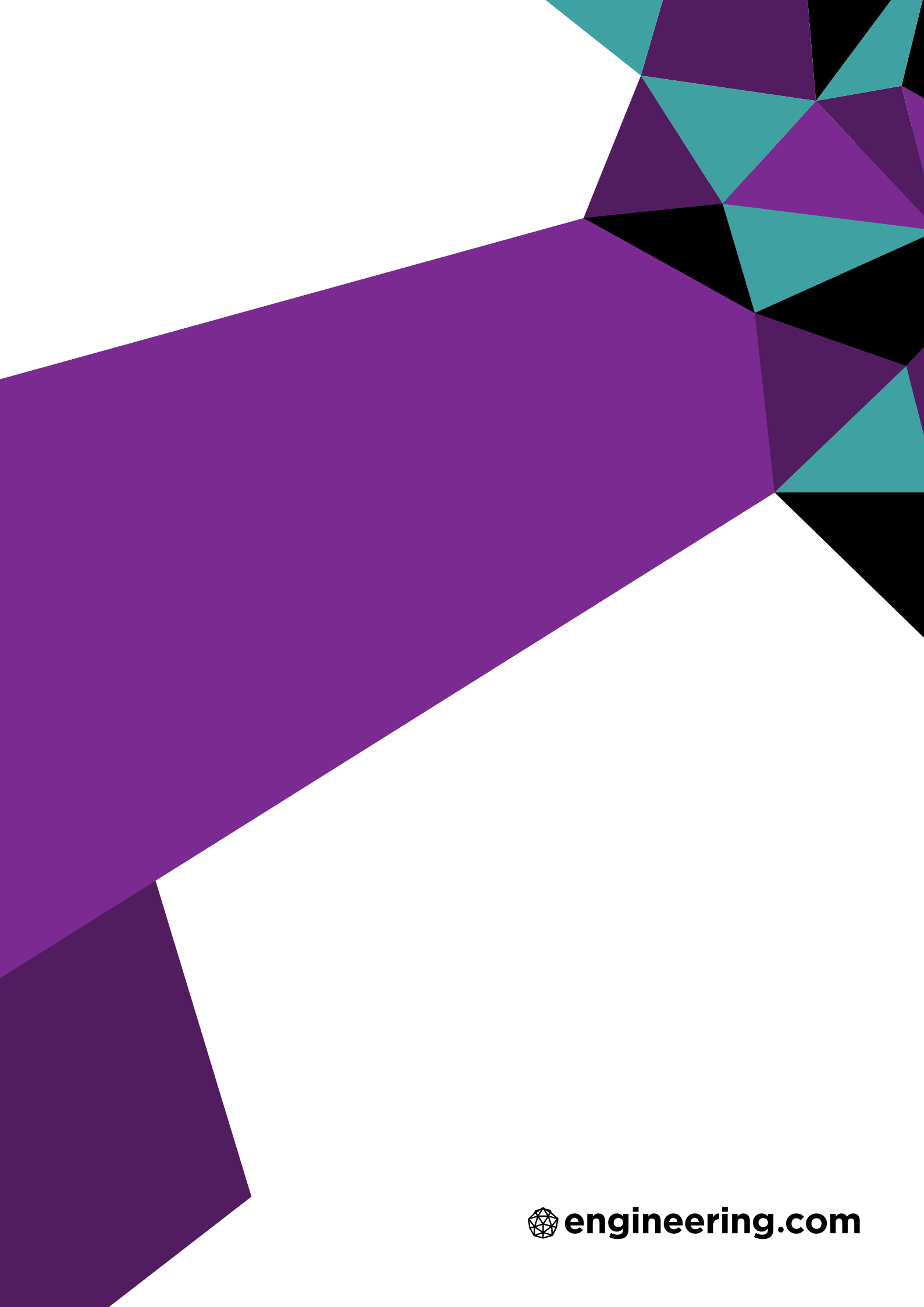
“So, bearing that cloud capability in mind, look at two things. One is, how do you start doing more virtual development of your manufacturing process? How do you start bringing in more of your digital twin and making small steps in that?” said Garg. “By evaluating your current production virtually, you can optimize and improve production, rather than rip-and-replace.

"The second is, how do you bring intelligence into your production process? Intelligence comes in through the IoT systems, through the manufacturing execution systems. So, keep those two vectors and start taking smaller steps so you become more and more virtual, and you become more and more intelligent," said Garg. These are systems that can be added to your current production system and equipment.

So, is it possible for a factory to get smart one step at a time? According to Denley, the answer is yes, through a process of iterative education and improvement. However, it may not be up to your organization leaders to choose whether to "get smart." The value and improvement driven by smart factory technology is leading your competitors to improve, and this movement will force you to make changes.

"How do you solve a multi-variable problem?" said Denley. "One variable at a time. And so, I think you start with one step. You start looking at a way to understand one of your steps of your processes and start perfecting that more. Now it's not that we haven't done that before, but now we can do it much faster and cheaper. You talked about, 'Can I get a new piece of equipment, a new drilling press to come in as an OpEx rather than a CapEx?' Why not? The risk is nominal and if they don't like it, you still have your original CapEx investment."

In today's manufacturing landscape, manufacturers have a "prove it to me" attitude towards smart factory vendors and engineers at organizations who are pushing for these investments. So, vendors and internal champions must start small, step by step, and building on past successes.



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