APPLYING AUTOMATION TO ENABLE SMART MANUFACTURING INITIATIVES

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Applying Automation to Enable Smart Manufacturing Initiatives

Executive Summary:

Manufacturers are under increasing pressure to boost efficiency and safety while reducing costs. Supply chain disruption increases the ship time and cost of materials. Global and political shifts lead to market uncertainty. A dwindling labor force reduces available work force. There is heavy competition for skilled workers. Customers demand greater flexibility and product customization even as they seek lower costs and faster shipments.

Today, under a storm of pressure, manufacturers are driven to adapt or fail. This has led many to explore smart manufacturing.

Smart manufacturing connects technology and information to physical activities to optimize processes and improve efficiencies. While it can potentially address many of the impediments and challenges facing manufacturers, several companies have been reluctant to utilize it. There isn't a standard process or system for the implementation, leaving production managers frustrated and confused when in the planning stages. Companies rely on dated, inefficient processes as they wait for guidance on their smart manufacturing ambitions.

This white paper addresses one area of confusion for many adopters, how automation enables smart manufacturing, helping to connect data and technology to production activities. The goal is to analyze how readily available automation tools can be used in the implementation of attainable smart manufacturing goals. We conclude the white paper with a look at the process of setting attainable goals, and how manufacturers can take the first step toward smart manufacturing.

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Introduction:

There has always been a cyclical, even symbiotic, relationship between advancements in technology and advancements in manufacturing. The industrial revolution in America[1] was driven by advancements in machine technology and new systems for transportation and communication. New machines that aided in production were brought from England, and manufacturers in the United States adapted their processes to improve efficiency and production output. At the same time, better transportation and communication systems opened new markets for the additional output.

Technology drives change in manufacturing. As new technology becomes available, manufacturers look at applications of that technology[2] for improving efficiency, output, operations productivity, safety, and quality. Over time, as more manufacturers adopt and use the new technology, it becomes an industry-wide standard.

Right now, we're in the midst of one such cycle. Smart manufacturing and new technology are shaping the future of manufacturing. Big data, IoT, machine learning and AI, computer controls, modeling, automation, and digital processes will revolutionize production just as much as Samuel Slater's water-powered textile mill[3] at the start of the industrial revolution. These new production tools and techniques are also known as digital manufacturing or Industry 4.0, but no matter what they are called, the benefits for companies are powerful.

Even as new applications for technology roll out, and manufacturing executives and product managers tentatively adopt new tools and software, many have seen only limited benefits. We are seeing a reduced cost in smart manufacturing technology. The tools are available. There have been case studies that small and mid-sized manufacturers will see faster returns[4] and an easier implementation and adoption of smart manufacturing. However, this hasn't led to widespread adoption of integrated smart manufacturing systems. There are small steps in isolation, but the full benefits across the industry aren't being seen yet.

The challenge facing adoption of smart manufacturing in the industry isn't cost or technology, but information. It's a challenge of communicating the practical implementation process, rather than the theoretical. It's understanding what, exactly, smart manufacturing and Industry 4.0 can (and can't) do, and what manufacturers can do right now to deliver greater efficiency.

Automation, both manufacturing and business automation, provides an easy entry point for companies into smart manufacturing.

What Is Smart Manufacturing?

Let's start with a clear and concise definition and vision of what is meant by smart manufacturing.

According to the research firm Gartner, smart manufacturing utilizes technology and information[5] to connect physical and digital processes for improving and optimizing, "... supply and demand requirements. This is accomplished by transforming and improving ways in which people, process and technology operate to deliver the critical information needed to impact decision quality, efficiency, cost, and agility."

Experts at the National Institute of Standards and Technology (NIST) and their research collaborators define smart manufacturing[6] as, "... the convergence of operating technologies (OT) and information technologies (IT) working together in a real time integrated fashion." Conrad Leiva, MESA International's Chairman of the Smart Manufacturing Working Group, sees it as, "... organizations, people, and technology work(ing) in synergy via business and manufacturing processes and technology-based solutions."[7]

While the experts and industry leaders wrangle over the terminology, standards, and minutia of smart manufacturing, there is critical information we can pull from the ongoing discussions.

First, we need to recognize that efficient production is as much based on accessible information and streamlined data transmission as it is based on the right tool. Manufacturing efficiency requires eliminating obstacles and barriers for every system and person, so that tasks can be completed with minimal effort or rework.

Reaching this goal requires collaboration not only between people, but systems. You need to orchestrate business and physical processes in both the real world and your digital infrastructure. Collaborative manufacturing systems should respond in real time to meet production demands.

Put another way, at each point or process in your manufacturing value chain, the entity creating value, whether it is an employee assembling a wire harness, the purchaser sourcing materials, the customer service rep taking an order, or a laser cutter etching metal, needs to have the correct information and materials to complete the task at hand as efficiently as possible.

When you create synergy between the digital and physical processes of your value chain, you create efficiency across it. That is smart manufacturing.

The Benefits of Smart Manufacturing

For manufacturers, the power of smart manufacturing isn't in additional technology. That's a step in the process, rather than the goal. The power of smart manufacturing is in addressing production and business needs. It is in using technology and systems to create business value.

According to a study by Deloitte and the Manufacturer's Alliance for Productivity and Innovation (MAPI), manufacturers who invest in and embrace smart technologies[8] see an average of 10 to 12 percent boosts in productivity, output, and utilization.

While smart manufacturing technologies enable and support these benefits, this uptick is ultimately the result of improving efficiencies, providing employees the information they need to complete work faster, and supporting decision-making across the business value chain. Waste is eliminated, both in materials used during production and activity during work. Smart manufacturing supports production precision, enabling targeted actions[9] that lead to the greatest output at the lowest costs. By supporting employees and providing manufacturers data and production intelligence, companies can better scale and are more agile in adapting to market conditions

By using data and targeting the impediments to production and business velocity with smart manufacturing[10], manufacturers see additional benefits. For example, these could include:

- The production team eliminating quality escapes and variances through access to real-time production and quality data, before they become an issue further down the value stream.
- Providing the team faster access to customer demands and requests, as well as supply status, with the capability to make targeted adjustments to production for better change management.
- Improved maintenance practices and more consistent uptime and quality through automated collection and analysis of machine data.

- Increased production efficiency when workers have immediate access to the correct work instructions and machine setup information.
- Sales providing customers a more accurate estimate of shipping and availability of product and orders by an accurate review of production schedules and inventory in real time.
- Quickly identifying product variances and materials that are out of spec using automated quality checks and reviews.
- Better managing slowdowns and optimizing machine utilization, adjusting workflow and processes to overcome obstacles, shifting work to open stations, and prioritizing work as needed with real-time production monitoring and visibility.
- Creating a historical record of work that can be used to track trends and identify opportunities for improvement by automatically recording data from production.

Manufacturers can see the benefits of smart manufacturing at any point in the value chain. The source of these benefits isn't necessarily the technology, but in overcoming business challenges or providing production solutions. The benefit is seen in improving an existing process, whether it's machine setup, planning, shipping estimates, or quality. It's in creating efficiency, rather than implementing a new process.

Smart manufacturing is using data, information, and technology to do work more efficiently. The goal is helping companies work smarter using readily available tools and technologies. It's automating basic tasks so workers can focus on higher priority work and supporting employees with the tools and information they need to work better. With smart manufacturing, companies can leverage that data that is a byproduct of work to reduce costs and increase output and quality.

With that in mind, let's look at how automation can be used in smart manufacturing to deliver benefits and greater efficiencies.

Manufacturing and Automation

The Ford Motor Company assembly line that revolutionized car production[11] and shaped modern manufacturing is widely regarded as a breakthrough in manufacturing automation. With the assembly line, work was delivered to the worker, rather than the worker wasting time moving to the point of production.

The car could be assembled step-by-step as it was pulled by the assembly line. Both skilled and unskilled workers could be used during the process, reducing the overall cost of the vehicle, and increasing production velocity.

As technology has advanced, so have the opportunities and functionality of automation for manufacturing. Today, manufacturers use automation[12] to strategically perform production tasks. Automation systems are designed to deliver output that once required manual labor.

With such a wide and diverse array of manufacturing processes, there is an equally wide array of automation tools that go into the systems that deliver that output. It impacts not only production, but the front office and service area as well, linking the value chain.

Automation in Production

Manufacturers often turn to automation for repetitive tasks[13] that require minimal human interaction. For example, made-to-stock products in high-volume production are suitable for automation. The output requires minimal customization with limited to no variance between products. This makes it an easy win for companies looking to improve through automation. These systems operate independently, handling tasks from start to finish.

There are three types of automation[14], suitable for a variety of manufacturing requirements and industries. They include:

Fixed Automation
Focused on producing a single product, with no variation in the operation or sequence. The tools, equipment, and machines can't be changed, but allow for more complexity in the integration, sequences, and coordination of machines in production. Typically, there is a higher initial cost for the automation, but it offers the highest production volume. Conveyor systems, automated assembly, and automated paint and coating are examples of fixed automation.

Programmable Automation
The configuration and operation of the manufacturing automation can be changed based on the input or programming of the system. New processes can be developed using the programmable system. It allows for variation in the products between batch runs. Investment may increase depending on the amount of variation needed in the automation. Industrial robots and Numerically Controlled (NC) machines are examples of programmable automation.

Flexible Automation
With a system designed around responding and adapting to changing production needs, flexible automation uses central computer control or Human Machine Interfaces (HMIs) to configure this system. This increases the variability in the output, such as the type or quantity of product, or even producing different products simultaneously. Flexible automation requires custom engineering, requiring a high initial investment, but offering the capability to produce made-to-order or custom products. Robotics production systems are an example of flexible automation.

Today, many (if not all) manufacturers are seeing benefits of automation[15]:

- Increased throughput. Automated systems can perform rote production tasks with minimal to no downtime.
- Eliminating variation and increasing quality. Human error and mistakes can be eliminated with the predictability and consistency of automation.
- Improved production agility. Some tasks are managed better by automation, allowing humans to focus on tasks that require human decision-making.
- Improved safety. Tasks that require repeated action are ergonomically better suited to automation, and automation can handle higher risk activities.
- Lower costs. After the initial investment, the increased output and reduced labor costs will lower the overall expense of production.

Automation in manufacturing is a growing field, with new applications and tools being developed continually.

Please note that the automation systems covered here include not only output systems for completing work, but also input systems such as sensors. With industrial automation sensors, an input (measure of a physical activity or quantity) is collected by the sensor, producing an output (trigger or relay of the measure to another predetermined input). This connection between the physical world, in these cases the manufacturing activity, to the digital world through the industrial automation sensors and other systems, is critical to smart manufacturing. The same connection is seen in automation systems for business.

Automation in Business

Business automation, or workplace automation as it is also known, uses technology to perform business tasks[16] and streamline processes so that employees can focus on higher priority work. In the past, the technology was too complex, too restrictive, or too expensive to make business automation a practical investment, but today with the rise of cloud computing, workflow automation, machine learning, and AI, most businesses utilize different forms of automation.

Some examples of business automation[17] include:

- Reporting. By integrating systems and automating data collection, information can be displayed in dashboards and reports that can be accessed at any time.
- Approval requests. Set criteria and workflows for approval requests so that when the criteria are met, an approval is automatically made.
- Email automation. An out-of-office notification or automated sorting of emails from specific senders are common examples of automation.
- Data entry. Set workflows for forms to automatically move information to a database or to create new entries in a log.
- Monitoring. Triggers can be used to monitor events, logs, or systems and then send a notification of a problem or error when data hits a set threshold.

Like manufacturing automation, business automation utilizes technology to manage time-consuming, rote tasks so that employees can focus on more important, higher-priority work.

In considering how automation can enable and empower smart manufacturing, it is important to also incorporate business automation as a component of the manufacturing value chain. With smart manufacturing, physical activities (manufacturing and production) provide input to a digital system, which can then create synergy to a front office business activity. For example, digital input on the completion or shipment of an order can automatically trigger billing, or a late shipment or quality escape can trigger a communication to a customer.

With smart manufacturing, that digital connection can be used at any applicable point in the manufacturing value chain.

The Impact of Automation on Smart Manufacturing Processes

There are several operations connected in a smart manufacturing process[18]. First, accurate information needs to be collected, stored, and accessible. Next, that information needs to be cataloged for retrieval, then directed to the key stakeholder that needs to use it. Finally, the stakeholder (whether a machine or a person) needs all the relevant information, tools, and materials necessary to complete work as efficiently as possible. Physical activities are connected and enhanced through digital systems, enabling work to be completed more efficiently.

When applied correctly, automation gives manufacturers the capability, even power, to meet those goals. Smart manufacturing is a tool for meeting business goals and overcoming process challenges, and not just using new technology.

Implementing Smart Manufacturing Through Automation

Let's look at how automation can be used in implementing smart manufacturing.

The first step is identifying the business challenge or production impediment to be solved through smart manufacturing. Many companies struggle with downtime on the shop floor, whether it's poor planning and scheduling, supply chain issues, or machine problems. In this example, we'll target machine shutdown and monitoring.

Look at the information or data that stakeholders need to overcome the problem. Industrial automation sensors[19] receive an input and then provide an output that can be used in a smart manufacturing process. This includes machines that overheat, causing downtime and delays in production. A temperature sensor can be used to monitor a machine to prevent it from overheating. The input (heat from the machine) will trigger an output (display for the maintenance team) to prevent the machine from shutting down.

In addition, adding a thermal shutdown circuit on the machine can prevent overheating. The output can trigger the circuit to prevent overheating, or cycle down the machine to prevent a full shutdown to keep production moving.

Next, consider who needs information from the machines and how it can be used. Consider how a planner or floor manager might use this information. With careful monitoring of the machines in use, schedulers can optimize production knowing more accurately the output of each machine before it overheats. They can more accurately estimate the workload on machines. They can provide this data to the sales team, allowing them to provide estimates and ship dates more accurately to customers. In turn, this will drive more sales.

For the floor manager, having a dashboard that monitors machines can help them prevent work slowdowns before they happen. When a machine is running hot, work can then be directed to another machine to increase plant utilization. A manager can set triggers on the dashboard to alert them when a machine is running hot, or when a machine is being underutilized and is available for more work.

From this example, we see that the manufacturer identified:

- A business need (increasing productivity on the shop floor).
- A problem (machines overheating and causing downtime) that was targeted as an impediment to the business need.
- Applicable manufacturing automation (industrial automation sensors and a thermal shutdown circuit) that was selected to overcome the problem.
- A smart manufacturing strategy (who can use this data and how production efficiency can be increased) designed to solve the need.
- An applicable business goal connected to the need, by providing key stakeholders (the scheduler and floor manager) the information (data from the sensors) and tools (a planning system) they needed to achieve the goal.
- An additional applicable business goal, delivering a more accurate estimate (machine output and runtime for the product) that provides the sales team the data they need to better estimate shipping and capacity.

From this, you can see that a focused and achievable smart manufacturing strategy can be implemented in relatively few steps. It starts by targeting a specific business need or manufacturing challenge. Next, the manufacturer looks at the available tools that could overcome the challenge. Finally, the manufacturer links the manufacturing process to the employees and business process that require it. The key stakeholders in the process are given everything they need to complete work as quickly and efficiently as possible.

Calculating the ROI of Smart Manufacturing

Tracking an ROI from this project is a relatively simple process. By reviewing an increase in machine utilization and decrease in downtime, an initial return can be calculated. Next, identify the increased accuracy of the estimate from sales, and how this impacts sales and new orders.

The return on this project can be used in launching the next smart manufacturing implementation.

When an automation tool can fulfill a role better than a worker, then automation is used. Where a human stakeholder needs to apply expertise or make a decision, then the stakeholder is given the relevant data at the point of the decision, and processes and systems are put in place for the decision to be carried out.

By focusing first on business goals, rather than a smart manufacturing end game, and leveraging readily available automation tools and technologies, the benefits of smart manufacturing are within reach for even small and mid-sized manufacturers across industries.

The Future of Automation and Smart Manufacturing

In the past, the cost of technology made smart manufacturing nothing more than a theoretical possibility for many companies. The startup cost of sensors, software, hardware, and technical expertise was simply too high. Many companies, especially small and mid-sized companies, didn't consider smart manufacturing an option.

Today, the cost of entry for smart manufacturing is much lower, making it possible for almost any manufacturer to leverage smart manufacturing[20]. Data collection and data storage are made possible through lower-cost cloud computing solutions. With cloud computing, manufacturers[21] can better store and disseminate relevant data. The cloud, and SAAS software, streamline implementation of systems to review and analyze the collected data. With many affordable solutions, users who need that data can easily access and use it.

The cost of automation and robotics[22] continues to drop. According to a study by Deloitte, manufacturers are investing in automation technology[23] like quality sensors or detection systems, energy management sensors and automation systems, and smart connected machines and tools. According to the same study, these manufacturers are finding value by building an ecosystem of linked entities and systems to solve challenges and deliver business needs and objectives.

At this point, we find that the challenge many companies and manufacturers face in adopting and implementing smart manufacturing isn't an issue with cost or technology, but information and expertise.

Business leaders need to see smart manufacturing not as a theory or concept, but a practical application of tools like automation, sensors and robotics, cloud computing, manufacturing databases and communication systems. They need to see smart manufacturing not as a topic in a white paper, but a solution to a shop floor challenge using readily available tools with a quick ROI that can increase efficiency, lower costs, and strengthen the business in an increasingly competitive marketplace.

Communicating that message is the challenge facing industry leaders and smart manufacturing advisers.

Conclusion

Manufacturers are facing growing challenges, from a labor shortage, to supply chain disruption, to disruption in the global marketplace. In the face of these challenges, business leaders are looking for solutions. They need to increase efficiency, reduce waste, cut costs, and deliver product faster and at a higher quality than ever before.

Smart manufacturing has long been a popular topic with analysts and industry thought leaders. Companies that have implemented and used smart manufacturing see tremendous benefits, providing manufacturers the advantage they need in overcoming the challenges they face.

In the past, the cost of entry for smart manufacturing was too high for many companies, too costly in both cost and internal resources. This meant that implementing a smart manufacturing strategy was only possible for enterprise and larger manufacturers.

Today, with new technology such as cloud computing, automation, robotics, and sensors, and the lowered cost and democratization of these technologies, smart manufacturing is available for more businesses. This includes small and mid-sized manufacturers. When these businesses focus their ambitions on addressing challenges and solving problems, they can reduce the scale of their initial steps, and any possible misgivings, toward smart manufacturing.

In the same way, automation tools, many of which are already in use in manufacturing processes, provide another gateway toward smart manufacturing. Automation provides the link between physical activities and digital systems that many production leaders may find confusing when considering smart manufacturing. By leveraging an existing or new automation technology, manufacturers can take steps toward a full smart manufacturing solution for the business need.

These smaller projects, using tools already in place, provide a manageable step toward an end goal of the increased efficiency, lower costs, and boosted productivity that manufacturers need.

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