SIEMENS
Ingenuity for life

Siemens Digital Industries Software

Smart manufacturing

Taking a digital thread approach for industrial machinery

Executive summary

The industrial machinery manufacturing sector is experiencing an innovative surge in technological advancements based on smart manufacturing. This is in response to the daunting task of validating and managing contemporary manufacturing and assembly operations to achieve a premium level of quality while optimizing cost.

In machining, manufacturers are asking for additional content, sensors and feedback on how production and manufacturing processes are executed. This information is leveraged into the manufacturing digital twin. For example, when making the machining tool, an inspection data process is added to create traceability for designing, manufacturing and closing the loop process based on a high-fidelity digital twin. The next crucial step is linking the digital twin of the product with the digital twin of the machine.

Abstract

Smart manufacturing allows industrial machinery manufacturers to extract information and drive it into manufacturing operations, including computer numerical control (CNC) programming or inspection and assembly processes. This information is used to formulate a digital twin at the product level.

The manufacturing industry – process and trends

There is a need for a comprehensive solution to realize every step in the manufacturing process, including idea creation, developing the product via machining, executing in manufacturing and extending across the entire service life based on the digital twin. This process enables machine manufacturers and designers to create value, drive down cost and compress delivery schedules. Moreover, it allows for closing the loop faster between manufacturing operations and engineering.

The manufacturing industry is in a continuous process of change due to the following trends:

- **Connectability** – Customers expect machines to communicate with other machinery in the plant via the machine's original equipment manufacturer (OEM)
- **Adaptability** – With the information generated by sensors and capabilities, smart machines can recognize changes in upstream products and processes and adjust to dynamic operating conditions. This is a type of artificial intelligence for machinery, which creates customer expectations for highly flexible machines capable of producing multiple types of products
- **Predictability** – Increasing emphasis on the simulation and predictability of a machine's performance in the field requires a high-fidelity digital twin of the machine. This process is complicated at higher speeds, with more significant use cases and increasingly sophisticated machinery
- **Extendability** – Predictive maintenance and adaptive performance can extend the life of a machine in the customer facility. The objective is to create more value for a manufacturing customer in many areas while optimizing cash flow

Another significant shift to address with a smart manufacturing approach is production-as-a-service, in which customers buy machine capacity instead of purchasing the machine. This emerging dynamic is primarily happening with equipment manufacturers that lease machines. The difference is paying for performance only when using the machine. Therefore, the OEM has a vested interest in ensuring the machine is always running optimally. If the machine needs upgrading to meet production requirements or requires general service, the OEM is responsible for correcting these performance improvements or downtime issues and has the incentive to get it up and running quickly to maximize cash flow.

3D printing, digital twin and smart manufacturing

In the last several years, there has been a move towards 3D printing/additive manufacturing. From a machining perspective, it allows the machine designer to consolidate components via the additive manufacturing process, leading to less expensive parts, superior reliability and increased durability.

The digital twin plays a role in this process. From a smart manufacturing perspective, the digital twin requires more than just additive manufacturing. It also includes postprocess machining along with several make-ready processes for industrial machinery assembly – an entire new class of machinery that's worth the investment. The digital twin encompasses more than merely designing parts or mechanical components, adding the flexibility and adaptability to reflect the electrical part, the software and the programmable logic control (PLC). When a multidisciplinary approach is incorporating a digital twin, it is critical to have the right software to manage it.

Siemens Digital Industries Software provides the most comprehensive executable digital twin with the software to realize every step in the manufacturing process, from creating the idea and producing it with machinery to executing, manufacturing and extending its service life.

Siemens has been a leading provider of industrial automation for a number of years and today we're the largest industrial automation supplier in the world, understanding how technology needs to be integrated into the machinery.

Manufacturing disciplines and the manufacturing space

Whether mechanical, electrical or software, the manufacturing disciplines need to generate coordinate measuring machine (CMM) or inspection files to automate the process of the system manufacturing of parts. In the engineering space, it's imperative to simulate the software, execute the product and provide a physical domain. From an electrical perspective, there can be diverse manufacturing requirements, especially if the manufacturing equipment is from multiple vendors.

Machinery customers often have requirements that specify the machine needs to contain only certain manufacturer's components. This is common in electrical and fluid areas, where the customer has standards for machinery in their plants. The machine builder can also choose different hardware based on exports to different regions.

The functionality of these machines might be similar; however, their configuration from an electrical and mechanical composition could be entirely different. This variability is what machinery builders need to reflect in their digital twin. It's not only building the part and executing it, but managing delivery, manufacturing, operations and quality. There's a need to manage manufacturing operations for providing insight into coordinating all these activities to deliver the correct parts at the right time.

A comprehensive approach, low volume and highly complex

One of the differentiators of smart manufacturing and additive solutions is the learning approach. It solidifies the dynamic process of additive manufacturing. It's a multidisciplinary approach incorporated into a comprehensive digital twin, and it is critical to have the right software to manage all of this.

Engineers provide the optimal design to balance cost and durability based on what they know about machine dynamics based on up-front simulation. There is also a consideration for the historical record from manufacturing. Currently, there is a closed-loop environment where manufacturing can use the same model for machining and fabrication, and based on the machining simulation, they provide accurate cost estimates. Using an integrated change management process, manufacturing can inform engineering about the real cost drivers for the part. In turn, engineers can iterate quickly on a solution that provides the same durability at a lower fabricated cost.

Siemens follows this multidisciplinary approach so manufacturers are continually seeking ways to take advantage of the most recent innovative thinking. This methodology aims to enable the user to profit from every aspect of the manufacturing process.

Also, there are different scales of volume. So when building PLCs, human machine interfaces (HMIs) or motor controllers, there's enormous bulk and every second becomes an opportunity for saving money. Therefore, by having an operations control management execution or manufacturing execution management tool, you'll have a fine-grain analysis to assist in driving value into the manufacturing process. So the manufacturing machinery, along with viewing the assembly, results in a detailed analysis that feeds information back into the engineering space to provide a closed loop of continuous improvement.

Bill-of-process and quality

Another piece of this process includes the bill-of-process (BOP) or the directions for building a machine. There's a methodology for building each part and rolling that part into optimizing the assembly process. This results in capturing what can be implemented into the schedule, while the assembly is ready for processing it.

Moreover, quality is integral to every step in this process. To ensure quality requirements, all machines and fabricated parts must accommodate the conditions of the machine shop. It's vital to use this information to qualify all methods for creating the part correctly. Also, there are crucial factors in using the appropriate machine, evaluating the sequence scheduling and incorporating flexibility into the process.

Collaborative knowledge with a forward-thinking, innovative mindset serves to promote a premium quality product in smart manufacturing while optimizing cost. This learning approach creates a competitive edge for solution providers to have an end-to-end solution, from manufacturing, design, service and back into the business system.

Smart manufacturing – assembly and layout of the shop floor

Smart manufacturing requires a smart assembly layout – getting the right parts and machines in the correct place on the assembly floor at the right time. A beneficial software solution requires simulating the positioning of the machines on the floor, eliminating high-traffic areas, removing bottlenecks due to slowness in receiving materials and optimizing work cell locations for world-class utilization.

Having everything more or less within arm's reach improves efficiency; however, the factory also requires process simulation. Therefore, order and functionality are the standards for overall conflict resolutions for fostering adaptability, predictability and extendibility. These necessary resolutions mean finding the required tools, whether it involves humans or machines, to perform a quality job.

The shop floor and simulation

There's not merely a focus on the shop layout capabilities, but a need for process simulation at the human level to factor in problematic issues, which don't usually surface until complications occur in the field. Simulating these issues is valuable for continuously improving the design and development process and includes machine assembly and scheduling of machines on the product lines.

This process simulation results in spending less time in commissioning and debugging (a well-known issue with PLC code generation) to applying simulation of parts and kinematics, including physical stress and fatigue analysis earlier in the design and development process, which helps get the machines to the customer, faster.

Also, one of the most powerful tools is the ability to simulate the control, or automation code, in the model with true kinematics and motion. There are hundreds of use cases and operation sequences the PLC code was meant to address. In today's environment of compressed delivery and zero-defect factory acceptance, the risk is too high with today's complex, software-driven functionality. Machine collisions based on software are simply too expensive to fix during machine commissioning, especially for sophisticated, multi-function machines, such as those used for packaging. Having virtual commissioning tools that can be used to thoroughly test out the machine use cases using an HMI input simulation is both powerful and necessary. If the machine builder has a true digital twin, those simulated motions in the 3D model can also be used in dynamic finite element analysis (FEA) studies to make sure the rapid start and stop motions do not result in excessive fatigue.

This positive result means a company generates more revenue, reducing the margin of erosion from errors and quality issues. However, none of these benefits could occur without the digital twin. There are countless examples of companies implementing the digitalization of machining or manufacturing centers, reaping more money, thus justifying any extra cost in this investment, which then results in faster machines via digital twin for software development and validation.

Conclusion

The manufacturing of machinery is an elaborate dance between the supply chain, internal manufacturing and assembly, so a united knowledge management piece is crucial to success. Smart manufacturing provides the portability to create the design and transport it to a remote facility while retaining the quality and reliability of the manufacturer's product. This flexibility is a significant value-add for smart manufacturing – tying in both the design and extension into manufacturing operations and operations management.

Smart manufacturing allows a company to extract information and drive it into manufacturing operations, including CNC programming or inspection and assembly processes. This information is then used to formulate a digital twin at the product level.

Siemens is continuously working to help industries across the world take advantage of this fast-growing technology. Its ability to provide a comprehensive solution to realizing every step in the manufacturing process, including idea creation, developing the product via machining, executing and extending across the entire service life based on the digital twin, is helping customers succeed in highly competitive markets across the world.

Siemens Digital Industries Software

Headquarters
Granite Park One
5800 Granite Parkway
Suite 600
Plano, TX 75024
USA
+1 972 987 3000

Americas
Granite Park One
5800 Granite Parkway
Suite 600
Plano, TX 75024
USA
+1 314 264 8499

Europe
Stephenson House
Sir William Siemens Square
Frimley, Camberley
Surrey, GU16 8QD
+44 (0) 1276 413200

Asia-Pacific
Unit 901-902, 9/F
Tower B, Manulife Financial Centre
223-231 Wai Yip Street, Kwun Tong
Kowloon, Hong Kong
+852 2230 3333

About Siemens Digital Industries Software

Siemens Digital Industries Software is driving transformation to enable a digital enterprise where engineering, manufacturing and electronics design meet tomorrow. Our solutions help companies of all sizes create and leverage digital twins that provide organizations with new insights, opportunities and levels of automation to drive innovation. For more information on Siemens Digital Industries Software products and services, visit siemens.com/software or follow us on LinkedIn, Twitter, Facebook and Instagram. Siemens Digital Industries Software – Where today meets tomorrow.

siemens.com/software

81161-C3 1/120 C