

Siemens Digital Industries Software

The smart factory

Defining the factory of the future

Executive summary

Developed countries are investing a lot of effort in advancing the concept of the smart factory. They expect it will enable them to maintain superior production efficiency and keep production jobs.

But what is a smart factory? This white paper focuses on the details and reviews some of the concepts that help make a factory smart. The breakthrough strengths and technologies of the smart factory include shop-floor connectivity, advanced robotics, flexible automation, automation standards, virtual and augmented reality and energy management.

Abstract

A smart factory is a fully digitalized factory model representing a production system, a digital twin for production[1], which is completely connected to a product lifecycle management (PLM) data repository via sensors, supervisory control and data acquisition (SCADA) systems, programmable logic controllers (PLCs) and other automation devices. In a smart factory, all the events happening on the shop floor during production are recorded and the relevant ones are pushed back to the PLM system either directly or through the cloud.

The shop floor is an integral part of the digital thread, using one communication and automation standard for all manufacturing technologies, allowing plug-and-play configuration and use. Smart factories are highly energy efficient, with integrated monitoring to allow for a self-adjusting decision-making process. The information rendered by the digital thread is studied and analyzed using artificial intelligence (AI) technology, and its main findings are sent back to product development, manufacturing planning or facility planning.

One application that is a big enabler of the smart factory is Siemens PLM Software's Intosite™ software, a cloud-based application[2] for sharing digital manufacturing and production information in a 3D context. Using Intosite fosters collaboration and cooperation between departments and disciplines based on a simple, intuitive user experience.

Figure 1, Intosite is a cloud-based application that provides smart-map navigation of virtual factories around the globe, enabling collaboration through the use of key manufacturing data, such as this production performance chart accessed from a tag on a machine.

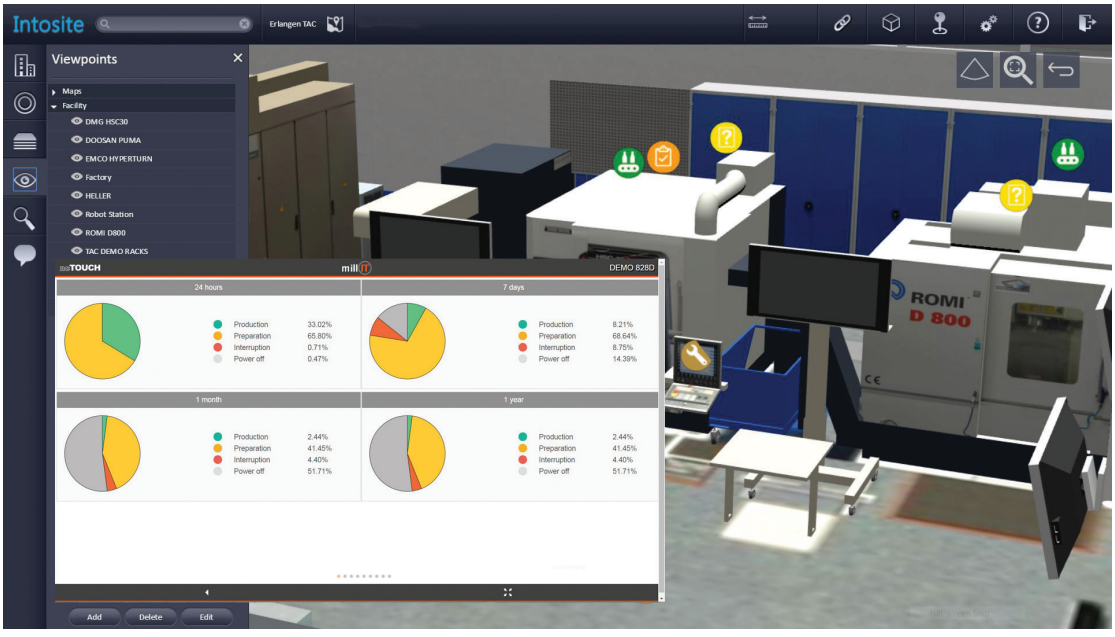

Figure 1: A cloud-based application that provides smart-map navigation of virtual factories around the globe.

Fully connected

A smart factory is based on a set of manufacturing concepts such as full connectivity, flexibility, agility, lot size of one, parts, subassemblies and products moving on automated-guided vehicles (AGVs).[3] With no predefined route, the AGV moves from station-to-station based on the manufacturing process plan, but can re-plan its next location based on the availability of production, a production machine, or assembly inspection station.

At any point in time and on-the-fly the AGV recalculates the trip to its next production location, while the necessary electronic work instructions are dynamically sent to that new location. Robot, machine or 3D printer instructions will upload to the next station and wait for the new job to arrive. The same is true for cutting tools, fixtures, jigs or any other production resource needed for the next production step.

All production devices will be fully connected and at a minimum will communicate their location, status (working, waiting or blocked), temperature, humidity, etc. In cases in which the production system is a computer-controlled machine or station, the information could be much richer. In cases in which the station is a manual station, or based on an older machine, the information is collected via attachable sensors.

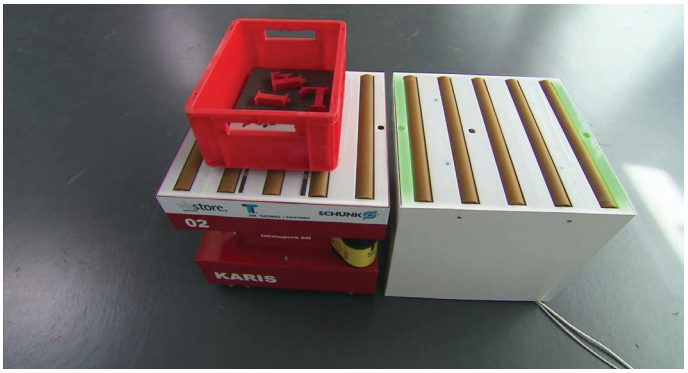

Figure 2: This is a KARIS AGV equipped with a vision system and artificial intelligence. It communicates with the factory's manufacturing operations management system and negotiates with other AGVs to determine its next task and route.

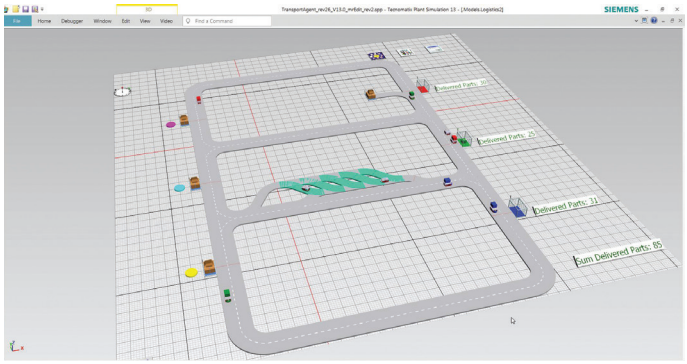

Figure 3: Pictured is Siemens Digital Industries Software Tecnomatix Plant Simulation software being used to simulate a factory operation with KARIS AGVs. The goal of this simulation is to optimize the number of AGVs and charging stations (and their locations) to meet production demand.

To make the system as flexible as possible, resources can communicate with other resources, parts, subassemblies and products. In the factory of the future, each product will carry a chip that stores all relevant production and quality-inspection information. When the product arrives at a station, the chip transmits to the production station the process that needs to be executed; the tool, fixture and machine programs to be used, other necessary raw materials or parts and the required worker skills.

Also, some of the production resources will be located on top of moving platforms. This will further increase flexibility because it will allow for on-demand delivery of new resources to the part or product. For example, a computer numerical control (CNC) robot could be placed on a moving AGV platform so it could be sent to the right location to perform a machining or polishing operation without needing to move the part or product from its current location.

In such a case, it will be possible to 3D print a part or subassembly and complete the perfect job by sending a robot to perform the finishing operation right after the 3D printer finishes creating the part.

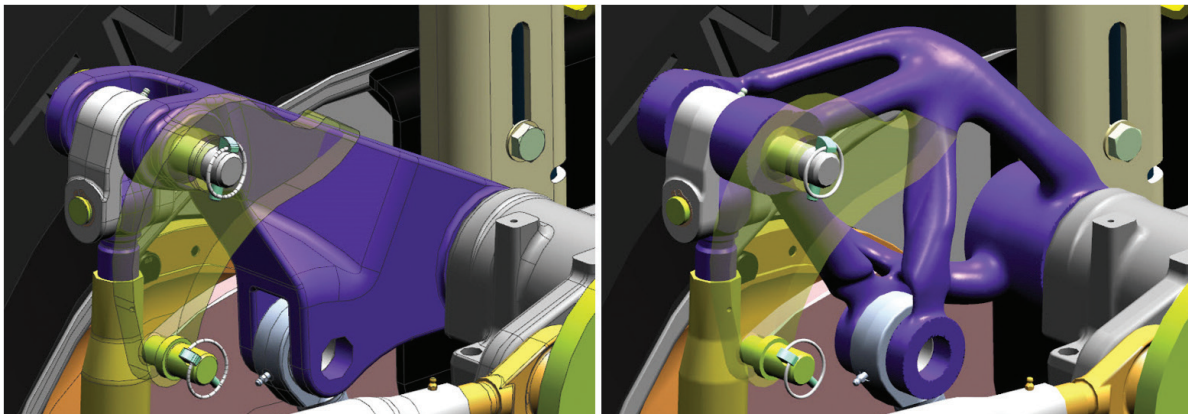

Figure 4: The part on the left is designed for conventional machining. The organic-shaped part on the right has been optimized for additive manufacturing with reduced mass and equal strength. New Siemens Digital Industires Software additive manufacturing solutions with generative design and simulation technology yield reimagined parts like the one on the right with topology-optimized shapes for performance and weight.

Ensuring enhanced uptime and productivity

A cloud-based manufacturing operations management (MOM) system collects information from resources, providing much better and more adaptive factory maintenance systems and processes, thus ensuring high uptime and better productivity.

The information collected during production from the process, part, product and production resources is shared with the product design and manufacturing planning departments. The information helps to improve the product, make the manufacturing process more robust, and help the production management personnel identify best practices by comparing production processes in different plants around the globe.

In the smart factory, people work alongside cooperative robots (cobots), which have more sensors and are more human-aware. Robots with vision systems and AI can perform autonomous tasks, move to new locations, replicate work done by humans and adapt to evolving situations, such as changes to the position of parts or products.

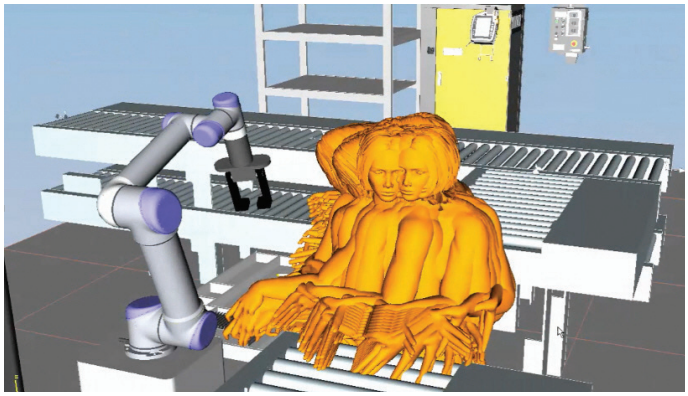

Figure 5: Siemens Digital Industries Software is exploring ways to virtually model and plan human-robot interactions using a digital twin with its Tecnomatix Process Simulate software to better assess the risk of tasks and the environment for safety-regulation compliance.

Facilitating the learning curve

Learning in the smart factory will be facilitated by the use of virtual reality (VR) devices. These devices will enable production employees to walk through the production lines inside the production system in a virtual manner, well before they will be installed on the shop floor. Using these VR tools, maintenance crews will be trained on how to maintain these complex manufacturing systems, while the production teams will be able to learn how to use the systems and execute the production tasks.

Once the physical production line is established, shop-floor workers can use augmented reality (AR) techniques to guide them through the production process, overlay process animations of the next production step on the real part or product, and validate that workers executed the process correctly. Using such capabilities, workers are able to maneuver robots and assistors so they can get to spots that are not otherwise reachable.

All changes on the shop floor are recorded automatically and uploaded via the MOM system to the PLM repository, such as Siemens Teamcenter® software.[4] Therefore, once the manufacturing engineering and production system design teams are asked to develop a new process for launching a new product on an existing line, they will be able to do so with minimal loss of data.

Energy efficiency and minimization of carbon dioxide (CO_2) emissions during production are key measurements of performance for the smart factory. The energy aspect is taken into account at the design phase via the use of smart simulation models, which help to identify ways to reduce energy consumption and CO_2 emissions during design and the operation phase. Siemens offers tools that can be deployed today to provide accurate energy and CO_2 data during production.

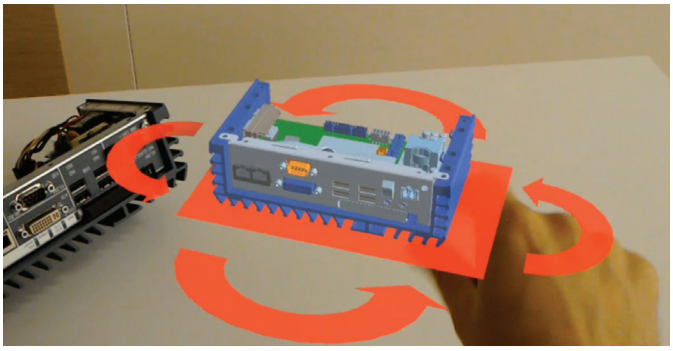

Figure 6: Siemens is exploring ways to use VR/AR environments to create and deliver more meaningful electronic work instructions for shop-floor operators, such as this assembly sequence created with Tecnomatix Process Simulate and shown using Microsoft's HoloLens.

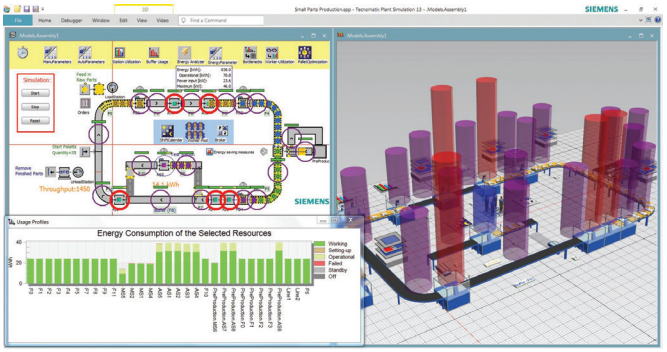

Figure 7: This Tecnomatix Plant Simulation software model shows an energy analysis of an assembly process, charting and visualizing power consumption for production resources, and highlighting in red the resources that consume the most energy.

Conclusion

Closing the loop from real to virtual can help a manufacturing company achieve a high level of continuous improvement over time. As you consider adopting the smart factory concept, contact Siemens PLM software to learn how we can help you successfully execute this transformative strategy.

References

1. For an overview, see the video presentation "The Real Value of the Digital Twin," Siemens Digital Industries Software, 2015: https://www.youtube.com/watch?v=gK5sHDfBMP4
2. For more information, see https://www.plm.automation.siemens.com/en_us/products/tecnomatix/intosite/
3. For more information, see http://www.industry.usa.siemens.com/automation/us/en/industrial-communications/wireless-control/pages/automated-guided-vehicles.aspx
4. For more information, see https://www.plm.automation.siemens.com/en_us/products/teamcenter/

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