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Leveraging the value of the digital twin

The concept of the digital twin has been around for more than a quarter century, but for a long time its practical application was constrained by the limits of the computer. However, advances in computing means those constraints no longer exist, so the digital twin is now a fact of life in manufacturing, and its prominence will continue to grow.

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Executive summary

Why is Siemens PLM Software talking about the digital twin, and what can the digital twin bring to industrial companies?

There can be many definitions of the digital twin. From our point of view, a digital twin is a set of computer models that provide the means to design, validate and optimize a part, product, manufacturing process or production facility in the virtual world. It enables you to do these things quickly, accurately and as close as possible to the real thing – the physical counterpart. These digital twins use data from sensors that are installed on physical objects to represent their near real-time status, working condition or position.

Siemens has recognized the value of the digital twin for a long time. When we began developing software for advanced robotics more than 25 years ago, we enabled the development of full 3D models for automotive body assembly cells. These models could be used to simulate, validate and optimize robotic operations before they were executed on the shop floor. With an extremely high degree of fidelity, our applications could not only simulate a cell, but also enable its near perfect virtual commissioning.

Nonetheless, advances in computer science have made it possible to broaden the scope of the digital twin to include many more capabilities, information, inputs and outputs. It also helps you develop and introduce new products to the market much faster than ever.

Today we can support digital twins for product design, manufacturing process planning and production using the Smart Factory loop and via smart products.

The full value of the digital twin can be realized by its support for product design, manufacturing process planning and production.

Deploying a digital twin

A classic deployment of a digital twin includes three pillars: product design, manufacturing process planning and feedback loops.

1. Product design

A digital twin includes all design elements of a product, namely:

- 3D models using computer-aided design (CAD) systems
- System models (using systems engineering product development solutions, such as systems-driven product development)
- Bill-of-materials (BOM)
- 1D, 2D and 3D analysis models using computer-aided engineering (CAE) systems such as Simcenter™ software
- Digital software design and testing using application lifecycle management (ALM) systems such as Polarion ALM™ software
- Electronics design using systems developed by Mentor Graphics

Using these elements results in a comprehensive computerized model of the product, enabling almost 100 percent of virtual validation and testing of the product under design. All of this eliminates the need for prototypes, reduces the amount of time needed for development, improves the quality of the final manufactured product and enables faster iterations in response to customer feedback.

2. Manufacturing process planning

The Siemens solutions available today enable the development of three models critical to any manufacturer:

- Manufacturing process model – the how – resulting in an accurate description of how this product will be produced
- Production facility model – the where – providing a full digital representation of the production and assembly lines needed to make the product
- Production facility automation model – Describing how the automation system, including supervisory control and data acquisition (SCADA) systems, programmable logic controller (PLC) hardware and software, human-machine interface (HMI) hardware and software, etc., will support the production system

The value of the digital twin in manufacturing offers a unique opportunity to virtually simulate, validate and optimize the entire production system. It also lets you test how the product, with all its primary parts and subassemblies, will be built using manufacturing processes, production lines and automation.

With this digital twin we can also incorporate logistics. The digital twin of the in-process logistics systems can help planning teams design an effective sideline logistics solution to feed the production lines. Process logistics could be part of the manufacturing process' digital twin and also the physical part of the logistics system. The automated guided vehicles (AGVs), racks, containers and conveyers would be part of the production system's digital twin – that is, the Smart Factory.

We must emphasize that while smaller manufacturing organizations might not need all the elements of a digital twin, even they will absolutely need some of those elements. Without those elements, a small, agile manufacturer won't be able to continue to succeed against its competition.

The value of the digital twin in manufacturing is that it gives you the opportunity to virtually simulate, validate and optimize entire production systems.

3. Feedback loops

There are two feedback loops that have a significant impact on most manufacturers – the Smart Factory loop and the smart product loop.

Smart Factory loop

The feedback loop starts with the Smart Factory. This is a fully digitalized factory model of a production system connected via sensors, SCADA systems, PLCs or other automation devices to the main product lifecycle management (PLM) data repository. In the Smart Factory, all events on the physical shop floor during production are recorded and directly pushed back to the PLM system or through the cloud. Artificial intelligence (AI) technology is used to study and analyze this information, and the main findings are sent back to either product development in manufacturing planning or facility planning.

Why is this important? About only one week after the start of production, the production facility and the manufacturing process will change. New ideas will be implemented, new working methods will be deployed and new suppliers might be selected; all requiring changes to the production system or process. Since these modifications will certainly impact the future, updating them in the system at this stage is becoming a must.

Production systems outlive the product lifecycle, and many of our customers use their production systems to make multiple products. These factors contribute to the increasing need to regularly capture these changes in the PLM system, which can later be used to distribute this information to all parties.

The information collected during production can also serve as the basis for improving the maintainability of manufacturing resources. With this information, we can enable much better (sensor) condition-based maintenance, and thus increase uptime and productivity.

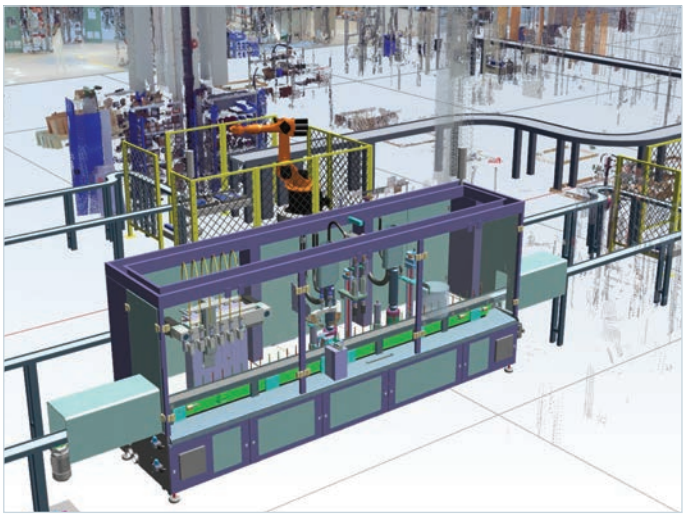
Smart product loop

Almost every product made today is a smart product. Many of our customers are looking for ways to improve the connection with their smart products while they are being used by their customers.

Monitoring product use can provide a lot of knowledge for improving products. More than that, connecting to these smart products can generate a new type of business model that may result in more competitive offerings.

For example, aircraft engine producers can sell flying time rather than their engines. When an airline company buys engine flying time, it ends up spending less of its capital budget and gets even better service, benefiting from the manufacturer's commitment to provide a higher level of service maintenance. The engine manufacturer only gets paid when the engines are in use, so it has to constantly monitor its engines, offer advice on how to use and service them, and even do some of the maintenance, repair and overhaul work.

You can find smart products everywhere. For instance, we have a customer who produces heavy lifting cranes. A few years ago, the customer modified its products to become smart cranes. The company's end customers can buy hourly lifting power rather than the actual cranes. Through installed sensors, the company collects use information and then provides the end customers with feedback on how to use the cranes to achieve a longer lifecycle and more lifting power.



The value of the digital twin is seen in the Smart Factory loop and the smart product loop.

Conclusion

The bottom line is the real value of a digital twin is that it enables flexibility in manufacturing so you can reduce the time needed for product design, manufacturing process and system planning, and production facility design. A digital twin improves quality and even supports new business models that offer opportunities for small-to-midsize companies to expand and bring more high-tech capabilities into their shops.

Digital twins will help companies become more flexible, reduce time-to-market and costs, improve quality and increase productivity at all levels of the organization.

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About Siemens PLM Software

Siemens PLM Software, a business unit of the Siemens Digital Factory Division, is a leading global provider of software solutions to drive the digital transformation of industry, creating new opportunities for manufacturers to realize innovation. With headquarters in Plano, Texas, and over 140,000 customers worldwide, Siemens PLM Software works with companies of all sizes to transform the way ideas come to life, the way products are realized, and the way products and assets in operation are used and understood. For more information on Siemens PLM Software products and services, visit www.siemens.com/plm.

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