Smart Communication

Digital Twins: Mirror Image

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Digital twins have become one of the hottest IT topics in years. **They promise to revolutionize innovation and reduce time and cost of development**, as well as improving collaboration along the supply chain. But what are they really?

by Francisco Almada Lobo

Going under such monikers as Industry 4.0 or Smart Factory, the technologies involved offer such huge benefits in the way products are made that those who don't plan for and embrace this change will almost certainly be left behind. Modern manufacturing execution systems (MESs) are critical, long-term investments in the future of a business, especially for the manufacture of complex products such as semiconductors or medical devices. They offer a pathway for the transition from traditional, linear manufacturing models to innovative, dynamic models that increase efficiency, raise quality standards, and meet the changing demands of customers today and in the future.

Francisco Almada Lobo: The benefits of using a digital twin can be realized across production quality, efficiency, traceability, and new product introduction.

Within the smart factory philosophy sits a concept known as the "digital twin." This concept was first introduced by Dr. Michael Grieves in 2002 through his ideas on product lifecycle management (PLM). It involved mirroring what existed in the real world in a virtual space. The concept was later named digital twin and its application extended to more areas of manufacturing.

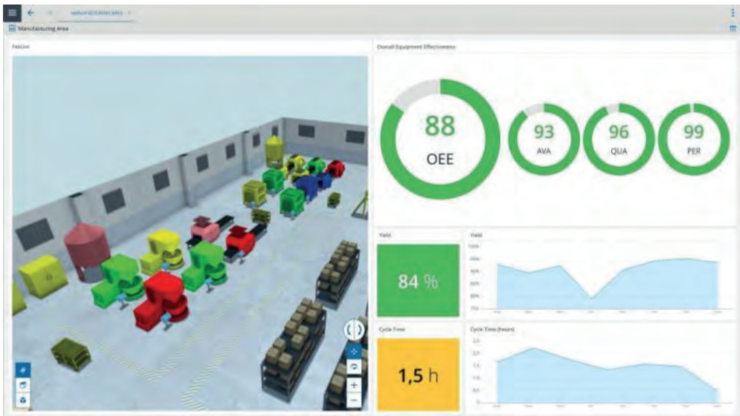
A digital twin can be defined as: "A virtual, computer-based copy of something real, modeled to realistically represent and control physical assets through their life cycle and be easily accessible at any time." Importantly, this definition leads to the fact that physical assets can only be represented and controlled properly if they can be modeled.

The digital twins are therefore not only mirror images, but are directly linked to their real-world counterparts: data "flows" from the physical objects into their virtual copy, allowing a correct understanding of their state, while the virtual copy influences its counterpart through information or instructions sent to the physical object and driving behavioral changes. A digital twin can even consist of multiple nested twins that provide a wider view across equipment and assets. For example, an oil refinery could employ a digital twin for a compressor motor, the compressor itself, and the entire multi-train plant. Depending on its size, the refinery could have anywhere from 100,000 to 500,000 sensors taking measurements which are then represented in the digital twin, which then enables operators to easily compare and benchmark things against one another and thus to understand what's working well and what's not.

The benefits provided by digital twins are gaining a lot of attention nowadays. They have been extensively cited by market analyst Gartner as being in the top 10 strategic technology trends in 2018 and detailed by IDC within IDC FutureScape: Worldwide IoT Predictions, which states: "By 2020, 30 percent of G2000 companies will be using data from digital twins of IoT connected products and assets to improve product innovation success rates and organizational productivity, achieving gains of up to 25 percent." More specifically, the benefits of using a digital twin can be realized across production quality, efficiency, traceability, and new product introduction. The technology enables visualization and control of products, processes, specifications, and attributes to enable optimization of quality. It identifies value-add and non-value add production steps and processes to help tune production efficiency. The modeling of the real-world entities also inherently means that everything about them can be registered, providing total traceability. When it comes to new product introduction, quick feedback and complete information helps to accelerate the introduction process.

Which is which?

The original digital twin has been presented as a concept that would span throughout the entire life cycle of the product (creation, production, operation, and disposal) and hence the association with the PLM world. Considering only the creation and production (manufacturing) phases, the digital twin models fall into three broad categories, which some authors further break down into additional ones: product design, process planning and validation, and execution. In product design, its use is more associated with PLM, with the control and visualization of designs, variations, and specifications. Process planning and validation helps with testing a product's manufacturability by providing the ability to plan processes, resources, and other related factors.



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In product design and planning, while the digital twin is being increasingly explored by PLM providers, at the execution level the power of the digital twin has not yet been fully explored. At first sight it might be surprising that this is the case, especially as IoT in manufacturing, or the Industrial Internet of Things (IIoT), becomes a true enabler for these models. According to Gartner, that's precisely why "digital twin in the context of IoT projects is particularly promising over the next three to five years."

However, to leverage the possibilities created by the relative ease of capturing and transmitting data from physical devices using IIoT technology, a strong model with the appropriate contextual information must exist on the virtual side. This system does exist, and it's called MES. Unfortunately, in the majority of cases, systems that are currently in use are burdened by legacy technology, and not prepared to become the digital twin.

Building a twin

Gartner says, "Organizations will implement digital twins simply at first, then evolve them over time, improving their ability to collect and visualize the right data, apply the right analytics and rules, and respond effectively to business objectives."

The first level of the digital twin implementation is quite obvious. All manufacturing physical objects have three main elements: a physical location, a state, and additional parameters. So, all that the MES needs to have to implement this first level is x, y, z coordinates, a state model, and a data set for storing values of parameters. Then, it's all about representing them in a screen and being able to update all of these in real time as changes happen. The representation of these entities, with color codes for the states, labels, or charts allow factory monitoring, covering areas such as the status of machines and the amount of material on the shop floor.

Color counts: Color codes for the states, labels, or charts allow better factory monitoring, covering areas such as the status of machines and the amount of material on the shop floor. Added realism 3D representation adds more value because it's a stepping stone towards virtual (VR) and augmented reality (AR).

A modern MES quickly implements and allows realtime updates of different equipment made available via a web browser to provide supervisors, managers, and engineers with an overview of what is happening throughout the plant. This can also be extended to a digital twin of multiple factories, enabling managers to oversee a complete, global organization from a remote, mobile device.

As digital twins will primarily serve functions to immediately assess and understand the status of production, the more realistic this representation is, the higher the value. At the same time, the shop floor is a very dynamic entity and if the update of the digital twin is very cumbersome, it will quickly be left behind and undermine its main purpose. That is why simple drag-and-drop technology enables rapid implementation of such models. Shapes can be quickly added to a layout, modified as required, and associated with specific equipment. The key aspect is to have a system which can be modeled and updated by the process owners (not only by IT specialists) as easy and quickly as possible.

A quantum leap

3D representation is more difficult to achieve but adds significantly more value because it's a stepping stone towards virtual (VR) and augmented reality (AR) scenarios.

With 3D models and added realism, achieved through allowing the import of existing computer-aided design (CAD) models of manufacturing entities such as equipment, the solution allows a virtual navigation inside the shop floor, in what can be seen as a parallel to Google Maps of the factory. Possibilities for the digital twin at an execution level continue as equipment can be associated with different MES entities. The status of machines can be color-coded for a clear overview of process lines. Moving assets can have real-time positioning coordinates, enabling the display of products, containers, and even human resources on the shop floor. This can be implemented using RFID tags, where position coordinates will be updated when close to RFID readers or, for totally up-to-date information, using WiFi triangulation systems and/or image recognition solutions. To ensure the visualization of the shop floor does not become too complicated, the model can be split into layers, so the user can choose to see just equipment, transportation systems, product flow, or human resources, for example. If all of this allows a great 3D representation of the factory, then using a demo copy of the factory allows a complete virtual reality system, which can be used for training or for simulations.

More than that, the true compelling scenarios arise with augmented reality. In an AR scenario, digital information is superimposed on top of what can be seen. This can be achieved using AR glasses or by pointing a smart mobile device at the equipment or product. The added information could comprise additional data, charts, warnings, or operating instructions. Value-add scenarios for the use of AR include quick views of maintenance requirements, product order information, complete process or product history, and KPIs for machines and products such as processing times, costs, and yield. Indeed, the application areas of this technology are only just starting to be explored, and future possibilities could be endless.

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Gartner, Inc., market analyst, Stamford, USA

Digital Twins: The future is here

At an execution level, the use of digital twin technology can add rich benefits to the shop-floor operating environment. The increasing amount of data from smart devices open a world of information that, if used correctly, can increase operating efficiency and help maximize the use of assets. With a future-ready MES to add context to data and coordination of processes, the digital twin can be used to provide clear plant visualization, including detailed information on equipment, product, and process KPIs. 2D and 3D models of the shop floor can be quickly and easily created with powerful graphical user interfaces tailored to the specific needs of system users. Alongside the clarity of all shop-floor processes delivered by the MES and factory digital twin, even more exciting benefits can be realized using VR and AR scenarios. By their very nature, the future moves more quickly towards high-tech industries. With the right partner, realizing the enormous benefits of I4.0, including the digital twin, need not be a long and painful process, but one that fits with business needs today and in the future.

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