# REVOLUTIONIZING PLANT PERFORMANCE WITH THE DIGITAL TWIN AND IIOT

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# **Disruption Demands Digitalization and the Digital Twin**

#### Manufacturing is Undergoing a Revolution

The manufacturing industries are getting more challenging. Manufacturers must evolve as new technologies remove barriers to entry and enable new, digital players to challenge market share. Operational efficiency is no longer enough to compete in today's era of digitalization and Industry 4.0.

To remain competitive, companies have to maintain high productivity while offering unprecedented levels of flexibility and responsiveness. We believe this is a fundamental disruption that will change the status quo. To survive, manufacturers need to digitalize operations in order to improve speed, agility, quality, costs, customer satisfaction, and the ability to tailor to customer and market needs.

#### Raising the Bar with Digitalization: The Digital Twin

One of the most compelling digitalization opportunities is adopting the digital twin. This approach combines a number of digital technologies to significantly improve quality and productivity. It starts with comprehensive, virtual models of physical assets – products and production lines – to help optimize designs. But the value is much greater because the physical and virtual twins are connected and kept in sync with real data from the Internet of Things (IoT) and Industrial IoT (IIoT). Further, companies can use analytics to analyze digital twin data to develop deep insights and intelligence that allow for real-time intervention and longterm, continuous improvement.



#### DIGITALIZATION IMPORTANCE TO BUSINESS STRATEGY

#### The Digital Twin's Impact on the Plant

The digital twin holds significant productivity and quality opportunities for the plant. It can be used to understand when the plant isn't operating as intended. It can identify or predict equipment issues that can result in unplanned downtime or correct process deviations before they result in quality slippage, scrap, and rework. In addition, it can significantly further benefits already achieved by six sigma programs and support greater continuous improvement. Let's learn how manufacturers can leverage the digital twin to improve plant performance and product quality.



# How the Digital Twin Drives Value

#### **Develop Comprehensive Virtual Models (the Virtual Twin)**

First, let's step back to discuss what a digital twin is and, more importantly, how it creates business value. Digital twins consist of a virtual model and a physical item that are identical. At the core, the virtual component of the twin is a model that is rich enough to simulate and predict the physical item's behavior. These representations can be used to optimize and validate designs early in the product or asset lifecycle and are subsequently kept in sync with the physical item throughout its life.

The digital twin concept can be applied to a number of different physical items:

- Products (equipment, devices, etc.)
- Production (machines, lines, plants)
- Infrastructure (cities, etc.)

#### **Connect the Virtual and Physical Twins**

The real power of the digital twin comes from connecting real-time sensor data from the physical twin to the virtual twin using the IoT and/or IIoT. This allows companies to use the virtual twin as the context to monitor the physical twin to determine if it is performing as expected. There are other benefits as well, such as tying real-world data and design dimensions together to replace design assumptions and expectations with measured facts to improve both the physical asset and future designs. The digital twin is a virtual model of a physical item. The model represents a specific product, configuration, piece of equipment, plant, city, or other physical asset with enough fidelity to simulate, validate, and optimize performance and behavior.

The digital twin is connected and kept in sync with its physical twin over its lifecycle and can be used to collect, aggregate, display, and analyze operational data to improve performance, gain real-world insights, and close the loop between the virtual model and physical experience.



## How the Digital Twin Drives Value

#### Put Digital Twins into Action with Analytics

The goal of the digital twin isn't just to connect designs with physical items. The value comes from creating new insights that can be quickly acted on to improve performance. Companies can leverage twins to create realtime, actionable information that can be put into use. This can be as simple as dashboards comparing measured values to control limits, or it may use advanced analytics including machine learning to create intelligent alerts that can result in immediate intervention.

#### Gain Intelligence from Deviations Between Experience and Expectations

Companies can gain valuable insights if the behaviors of the virtual and physical twins are not in sync with each other, which can result in identifying:

- Something wrong with the physical asset that can be corrected
- Something wrong with the virtual model or simulation that leads to new understanding and provides knowledge for future modeling and simulation efforts

With this general background on digital twins, we'll now focus on how the digital twin helps drive unprecedented levels of plant performance and product quality in manufacturing.





# **Applying Virtual Twins in the Manufacturing Industry**

#### **Target the Right Virtual Twins for Manufacturing**

There are many ways to gain value by applying the digital twin approach in the manufacturing industries. In the plant, the typical ways to create value are from creating twins for products and for production assets. Let's discuss how to create and drive value from each of these.

#### **Develop Virtual Twins of Products**

The first way many people think of the digital twin is as a digital model of a product. This typically starts with a 3D CAD model, but also captures much of the information captured in model-based design approaches. For today's smart products, the model typically incorporates electronic, software, and systems designs.

The virtual product twin can be used to simulate and communicate planned product behavior and predict product characteristics like throughput, torque, energy consumption, or other performance characteristics. To do this, the virtual twin must accurately represent a specific configuration or unit of the product and be kept up to date with changes. The product model should also include production requirements to support a design anywhere / produce anywhere strategy.

#### **Create Virtual Twins of the Plant**

One manufacturer's product may be the equipment in another's plant. The virtual model concept extends to equipment, work stations, lines, and entire plants. These twins should completely model production at the appropriate level of granularity for their intended purpose.



The twin can also include the virtual twin of products being produced and the operators running the plant.

These models can be used to simulate and optimize production plans, plant layouts, materials flows, and equipment. Manufacturers can use the models to virtually operate the plant all the way down to control code in order to detect collisions, bottlenecks, and analyze throughput. This allows them to optimize production behavior virtually to get designs right before making physical investments.

Finally, virtual twins can be used to develop code for CNC equipment that can be run and validated on virtual PLCs using an approach known as "software in the loop." This code can then be used for virtual commissioning to speed ramp up and changeovers.



# **Creating the Complete Digital Twin in Manufacturing**

#### **Gain Greater Value from Connected Digital Twins**

The value of digital twins specific to manufacturing is greatly enhanced when the virtual and physical twins are connected via the IIoT. Manufacturer operations can produce a lot of data. For example, companies may already have MES and other control data, but they traditionally have trouble unlocking the value from it. The value of this data is made tangible when it's put into the context of the digital model. Connecting the virtual and physical twins allows companies to compare actual to expected results and behavior of plants, product lines, work cells, machines, and even the products produced. The digital twin helps them gain intelligence from the data instead of simply storing it away.

#### **Connect and Analyze Plant and Product Virtual Twins**

Manufacturers can learn a lot from discrepancies between expected performance predicted using the virtual twin and measured performance of the physical twin. The twin defines what "good" looks like in production and what "right" looks like with the products. Variances from simulated values may identify issues in the plant that can be diagnosed and remedied to bring performance back into plan.

A more complete digital approach leverages analytics and the cloud. Analytics creates deeper insights to gain product and process intelligence. Let's take a look at how the intelligence derived from the digital twin drives tangible business value for manufacturers. Is a Virtual Model a Twin?

This is a hotly debated question. It generally comes down to differences in terminology. Product and production modeling have been around for a long time. They are now much more comprehensive and more integrated across design disciplines.

Virtual twins allow engineers to simulate and predict behavior. They help optimize performance well before the physical twin even exists.

Whatever you call them, models are valuable on their own and used to drastically improve plant performance through better planning and optimization.



# **Improve Equipment Performance and Availability**

#### **Monitor and Optimize Equipment Performance**

The first way we'll examine the business value of the digital twin in the plant is by improving equipment performance. Today's manufacturers need to get the most out of available production assets. Manufacturers can use the digital twin to monitor equipment and production via the IIoT. They can aggregate, filter, and analyze sensor and control data in the context of the virtual twin to find issues. The resultant information can be shared in dashboards and put into action with alerts so issues like reduced production rates can be addressed before they arise or escalate.

#### **Predict and Improve Equipment Availability**

One of the most promising ways manufacturers improve productivity is through predictive analytics. Instead of maintaining production equipment on estimated service intervals, manufacturers can monitor equipment to identify when it begins to show signs of wear or failure, such as higher temperatures or vibration. But analytics can also find hidden patterns, anomalies, or trends in operational data that may indicate a pending equipment failure.

Transitioning to predictive service allows manufactures to reduce downtime and avoid the cost of unnecessarily taking equipment offline for maintenance when it's not necessary. Of course, not every issue can be predicted, and in those cases IoT and the digital twin can provide the intelligence needed to improve issue identification, reduce repair time, and analyze root causes. The resulting enhanced productivity from better equipment performance and availability directly drives improved profitability.

### EXPLORE NEW BUSINESS MODEL Equipment as a Service

Manufacturing equipment suppliers are also leveraging IIoT and the digital twin. There may be an opportunity for the plant to shift the responsibility of keeping equipment running optimally to the equipment manufacturer or a service company. New, service-based models dictate that the manufacturer only pays for operational time, and incentivizes the supplier to provide promised performance even if it means upgrading or replacing equipment to meet service level agreements.

There are additional advantages to the servicebased model beyond financial benefits. Equipment suppliers can benchmark equipment on a broader scale by looking at equipment across their customer base. This gives them more knowledge that allows them to increase mean time between failure, reduce downtime, and speed resolutions when issues do occur.

Many manufacturers are also exploring this Product as a Service (PaaS) business model for their own products and customers. This may be an additional source of value from digital twins and the IIoT.



### **Improve Product Quality**

#### **Monitor and Maintain Product Quality**

The next way that digital twins offer tangible business value to plants is by improving quality. Manufacturers can use the IIoT to monitor production and compare it to the digital twin to find goods that are trending out of spec. For example, they could compare product tolerances with IIoT feeds from metrology devices to find anomalies. Then, they can use trend charts, histograms, or dashboards with alerts to identify potential quality slippage.

#### **Control and Assure Process Quality**

In addition to measuring production output, manufacturers can monitor the production process to build quality in. They can collect KPIs like cycle times or track control parameters to identify when processes aren't fully in control so they can intervene.

### EXPLORE THE BENEFITS Digital Twin and IIoT

The digital twin and IIoT can put data into action to detect and mitigate issues before creating out of spec products, saving time and money. They can also be used to identify and analyze issues to determine root causes, for example if quality deviations are linked to training issues or substitute components. This can help feed six sigma projects with opportunities for continuous improvement. These benefits can dramatically improve quality and bottom line profitability. Manufacturers can also use analytics to understand the relationship between variability in production specifications and output to help identify factors that lead to quality slippage. They can use artificial intelligence (AI) to gain insights from a combination of enterprise system data, environmental conditions, operator information, equipment setup, and machine settings. This can help them close the loop between engineering and actual resulting product performance characteristics, for example finding relationships between equipment settings or environmental factors and defects. They can also leverage AI to identify early indicators that production isn't behaving as expected in order to identify and correct errors in real time.





### **Next Steps**

#### The Digital Industrial Revolution Requires Action

Today's manufacturers need to deliver high operational efficiency in order to compete. It's time for them to digitalize to gain important benefits – agility, productivity, quality, cost, customer satisfaction, and responsiveness – and remain competitive into the future. Manufacturers can apply the digital twin concept to products, plants, or both to drive new levels of quality and productivity. The digital twin and the IIoT are key digitalization enablers with tangible, proven value.

#### **Get Started**

To get started, manufacturers can choose between a number of valuable initiatives to leverage the digital twin, IIoT, and analytics. For example, they can use the digital twin, IIoT, and analytics to:

- · Gain equipment intelligence and improve uptime
- · Shift from preventative to predictive maintenance
- Monitor production to rapidly identify and correct quality or productivity issues
- Leverage actual results from the physical twin to improve simulations by feeding the digital twin with observed production scenarios and parameters
- Explore new business models by applying digital twin capabilities to their own products

It's time to leverage the IIoT to connect the virtual and physical twins. The digital twin approach improves productivity and quality to maintain and grow market share in the era of digital transformation and Industry 4.0.



#### Recommendations

The ultimate goal is to become a digital manufacturing enterprise. The most important recommendation, however, is to get started, learn, and grow benefits over time. Manufacturers can start small and expand value by building on the foundation of their early initiatives. It's important, though, to consider needs like equipment connectivity and security. Leveraging an integrated platform of digital solutions designed for the manufacturing environment can help. A platform approach also helps ensure that early investments are repeatable and can be used as a foundation for further value.





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### **About the Author**

Jim Brown is the President of Tech-Clarity, an independent research and consulting firm that specializes in analyzing the business value of software technology and services. Jim has over 20 years of experience in software for the manufacturing industries. He has a broad background including roles in industry, management consulting, the software industry, and research.

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Jim is an experienced researcher, author, and public speaker and enjoys the opportunity to speak at conferences or anywhere he can engage with people with a passion to improve business performance through software technology.

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