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The Process Digital Twin: A step towards operational excellence

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Introduction

At the heart of manufacturers' digital transformation efforts are a combination of cloud- and edge-based technologies, including high-performance computing, IoT, and advanced analytics. These technologies enable firms to digitally connect and model physical assets or products – creating "digital twins" that replicate the physical world and enable sophisticated analysis and advanced simulation.

New technologies, such as low-cost connectivity, mixed reality, and artificial intelligence, are used to build digital twins for individual products that enhance equipment capabilities. These Product Digital Twins are helping manufacturers improve performance throughout the equipment lifecycle.

But more is possible with technology than simply improving the lifecycle of single products. This paper offers a description of the "Process Digital Twin," which enhances the business value delivered by Product Digital Twins. The Process Digital Twin is the next level of digital transformation, compounding Product Digital Twin benefits throughout the factory and supply chain. This paper highlights some advanced manufacturing scenarios that Product Digital Twins do not support and proposes the Process Digital Twin as a method of enabling them on a machine, factory, and supply chain level. It closes by highlighting companies that are partnering with Microsoft to pilot Process Digital Twins and provides Microsoft's vision for supporting their implementation.

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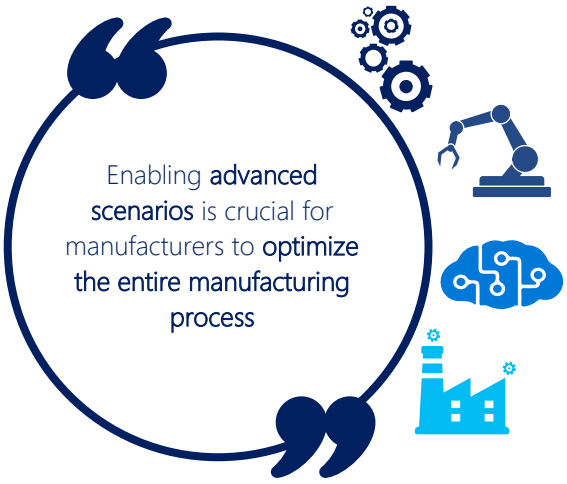
Product Digital Twins alone cannot support advanced manufacturing scenarios

Though Product Digital Twins are increasing efficiency, reducing downtimes, and boosting worker productivity, there is still room for improvement. Currently, manufacturers have no way to simultaneously work on both the digital and physical models of a product – they can only work on one or the other. This leaves them unable to make adjustments in real time, inviting delays and line shutdowns when a production change is needed.

Product Digital Twins also don't enable collaboration across the virtual environment, so humans cannot collaborate in-process with machines. And, while Product Digital Twins do extend predictive capabilities, as a stand-alone they don't support advanced reasoning alongside humans.

For example, a computer numeric control (CNC) machine might detect an imperfection and indicate that it needs repair. But it is not yet smart enough to know that shutting down for repairs will cause bottlenecks and production delays. The decision to shut down must be made by an engineering technician reasoning through data from the entire line. For an engineer to make a significant change to production, like shutting down the machine, they must have line-of-sight. Employees working remotely can't implement these decisions, increasing downtime if they aren't able to order a fix right away.

To prevent the same imperfection in future versions of the CNC machine, the manufacturer must pass the information about the machine's performance back to the supplier. They do this by transferring data from one location to another, but the supplier only sees



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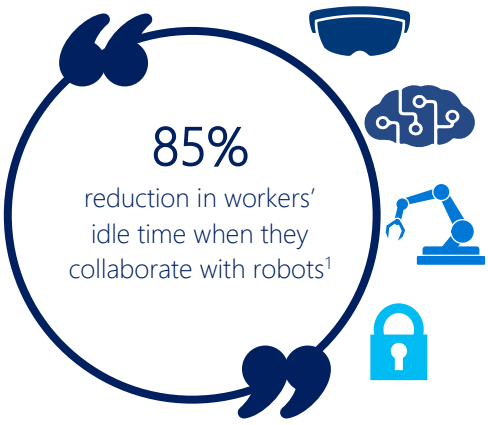
information about their own machines, not how they interact with others in the factory.

Enabling these advanced scenarios is crucial for manufacturers to cross the line from optimizing the equipment lifecycle to optimizing the entire manufacturing process, within the context of all plant activity. The most efficient way they can enable these scenarios is to take advantage next wave of digital twin capabilities to build Process Digital Twins.

What is a Process Digital Twin?

The Process Digital Twin enhances the Product Digital Twin beyond a single machine to encompass the entire production environment. The Process Digital Twin uses mixed reality, artificial intelligence, and high-performance computing to optimize not only equipment but the entire manufacturing process. High performance computing facilitates in-process performance analysis. And, multiple organizations across the supply chain can immerse in the same virtual model, at the same time, from anywhere.

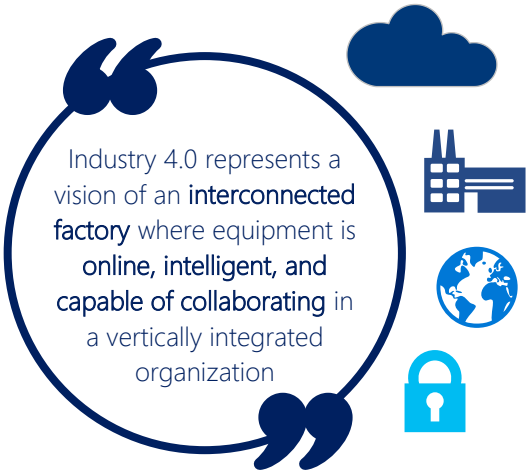
Like the Product Digital Twin, the Process Digital Twin enables manufacturers to leverage mixed reality capabilities. But with a Process Digital Twin, manufacturers can utilize immersive holograms to simultaneously work in both virtual and physical models. These holograms receive data from across the process to represent the entire system and the relationships between its components.



Together, cognitive data and artificial intelligence from individual components enables manufacturers to build an immersive virtual replica of what is happening across the entire factory floor. This working environment supports true machine-to-machine-to-people collaboration (M2M2P), with an, "85% reduction in workers' idle time

when they collaborate with robots."[1] Engineers can solve problems by reasoning alongside machines while they are in-operation, whether they are working on the floor or in a remote location.[2]

The streamlined collaboration provided by bridging virtual and physical environments is why the Process Digital Twin is a new class of digital twin. Its capabilities not only build on those of Product Digital Twins but also present a net new value proposition to the manufacturing world and enable manufacturers to achieve efficiencies and insights not possible before.



Achieve the operational excellence of Industry 4.0

Manufacturers can gain efficiencies by applying the principles of Industry 4.0, a vision of an interconnected factory where equipment is online, intelligent, and capable of collaborating in a vertically integrated organization.[3] Process Digital Twins enable manufacturers to implement these principles by assisting with vertical integration, horizontal integration, and end-to-end engineering optimization.

Vertical integration. This new class of digital twin, based on mixed reality technology, helps manufacturers better integrate their operations. They can virtually connect internal processes, and are able to work simultaneously on physical and virtual models to make process changes in the moment.

Horizontal integration. Because of the holographic environment, manufacturers can easily immerse in processes across supply chains and design engineers can use mixed reality to experience how products work in operation.

End-to-end engineering optimization. Using a Process Digital Twin, design engineers of one organization can now interact with

[1] How Human-Robot Teamwork Will Upend Manufacturing, Will Knight, MIT Technology Review, 2014
[2] Industry 4.0 and the digital twin: Manufacturing meets its match, Deloitte, 2017
[3] Recommendations for implementing the strategic initiative Industrie 4.0, Acatech, 2013

manufacturing engineers of another. They can leverage insights gained from intelligent mixed reality and data from Process Digital Twin interactions to simulate design changes and continuously improve product quality and plant performance.

Ultimately, the new level of productivity and connectivity brought by mixed reality and Process Digital Twins helps manufacturers efficiently implement the design principles of Industry 4.0 to improve speed of response and reduce waste and costs.

Enable advanced scenarios and improve production processes

Process Digital Twins enhance the benefits of a Product Digital Twin as well as enable advanced scenarios in three areas of the manufacturing process – at the machine level, the factory level, and the supply chain level.

Machine level. The cognitive capabilities of a machine connected to a Process Digital Twin are enhanced by data from across the factory. Data improves machine intelligence and provides the foundation for more robust self-healing and predictive capabilities. Just like Product Digital Twins, Process Digital Twins constantly collect near-real time data. But unlike the Product Digital Twin, Process Digital Twins give machines access to a bank of contextual information from the overall process. A CNC machine that's part of a Process Digital Twin can understand on its own that repairs are needed and that a temporary shutdown is the best fix, based on machine and production line history. Enhanced M2M2P interactions mean the individual machine can seamlessly cascade its decision to the rest of the factory. Machines connected by the Process Digital Twin can use data from results across the process to deepen their learning and make decisions in context, as well as interact with peers – both machines on the line and human employees.

Factory level. The Process Digital Twin also enables intelligent, machine-level decision-making at a factory level, driving employee and plant productivity. By integrating across the production line, Process Digital Twins can present engineers in remote locations with options to

fix the CNC machine, instead of requiring an engineer to spend time reviewing data from across the plant to make a decision. If a technician wants to initiate the fix, Process Digital Twins help them look at the entire downstream process and select the best time for repairs.

With a Process Digital Twin, the employee can make this decision anywhere. Immersive, mixed reality visualizations of the process help employees work remotely and collaborate with teams in disparate factories or global locations. Design engineers make decisions based on information shared with manufacturing engineers, using holograms of the production line as it moves overlaid with current data and maintenance information.

This level of collaboration supports more informed decision making and avoids unnecessary line shutdowns, enabling employees to ideate and test a fix remotely before implementing it on the machine. Technicians can make quick, effective repairs, no longer requiring line-of-sight (though regulations that govern this area are still catching up with this capability). They can interact with the hologram and instruct the CNC machine, for example, to stop production in order to prevent more damage to the cutting tool. This unprecedented flexibility of operation and visibility onto the production floor helps optimize and accelerate maintenance measures, decreases down time, and increases the availability and reliability of the entire plant.

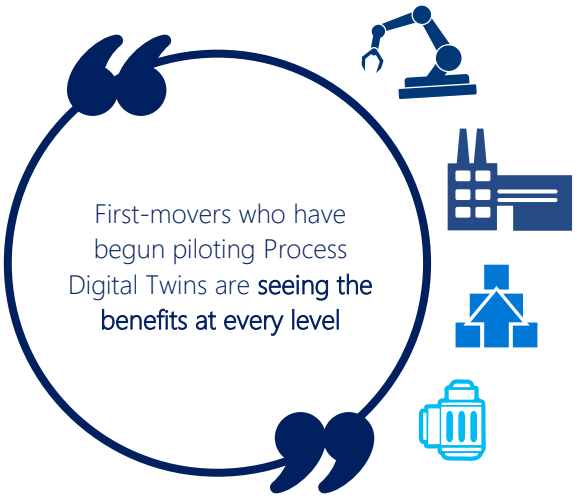
Supply chain level. The supply chain level is where the Process Digital Twin adds the most value. Process Digital Twins enable digital integration across internal factory processes while machines are in-operation and production is ongoing. This principle of vertical integration is critical as manufacturers move toward one-size-fits-one business models, creating custom products for individual customers. Using a Process Digital Twin inside a factory enables the manufacturer to quickly adapt the entire process if needed for a new product on the line.

Quickly adapting new products to meet customer demand also means accelerating time to launch. Process Digital Twins help manufacturers create a more robust horizontal value network and improve collaboration across suppliers. For example, a Process Digital Twin can

show the manufacturer of the CNC machine the issue with the cutting tool as it occurs in their customer's factory. This provides manufacturing customers a better machine and higher quality of product.

With the connection of the entire production environment, manufacturing engineers can re-engineer processes for any plant, from anywhere. Simultaneously, the equipment's design engineers can interact with machines in-operation. This means that manufacturers can have end-to-end engineering integration across their entire supply chain, on a global scale.

First-movers who have begun piloting Process Digital Twins are seeing the benefits at every level, from better-running machines to more efficient factories and supply chains.



Customer value of implementing the Process Digital Twin

Imagining how a Process Digital Twin can enhance factories isn't hard, but how do manufacturers actually implement one? While certain capabilities are still in-work, there are companies who are already piloting early versions of Process Digital Twins to drive their digital transformation.

Comau

A worldwide leader in industrial automation, Comau collaborated with Microsoft and ICONICS to develop a Process Digital Twin solution that helps manufacturing companies improve efficiency and cut costs. The solution, demonstrated at Hannover Messe 2017 works across the value chain. Technicians are using the mixed reality of Microsoft HoloLens to remotely monitor factory machines, giving manufacturers a new way to interact with data on the factory floor via natural gestures and hands-free operation.

When a problem is detected, the solution creates an immediate alert and identifies the corrective actions and competencies required to fix it, closing the flow by scheduling a call to the right resource. Workers can interact inside holograms superimposed over their real-world production environment, or even work on the process remotely, giving

enhanced insight into operations, wherever they are.[4] Eventually, employees will be able to use these holograms to interact with data and gain insights across the value chain while other suppliers immerse into the same hologram.

Schneider Electric

As a global specialist in energy management and automation, Schneider Electric wanted to help their customers better manage energy and processes across complex operational systems. Schneider has partnered with Microsoft to create enterprise-grade applications for Product Digital Twins in the areas of training and product management. They are using the capabilities of HoloLens today to lead on-site technicians through the repair process from start to finish. At a factory level, Schneider Electric's solution would enable manufacturers to begin training team members before a factory is built and provide them with remote guidance.

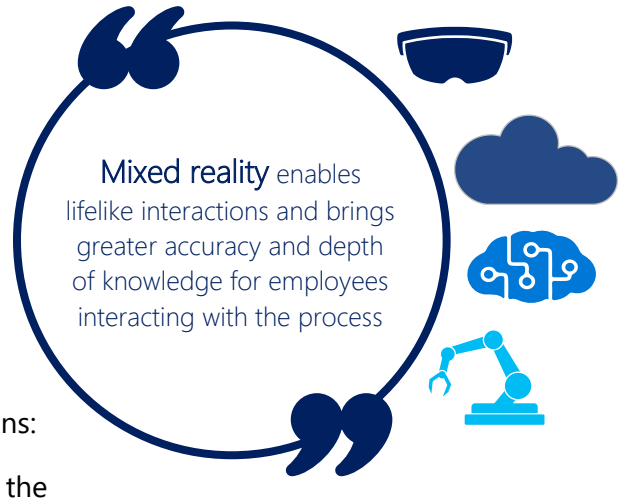
[4] Comau leads the digital transformation in the industrial world together with Microsoft and ICONICS, Comau, 2017

Microsoft's differentiators

Microsoft sees the implementation of the Process Digital Twin as part of a strategic digital transformation journey for manufacturers.

We are committed to helping manufacturers enhance their product lifecycle management and their manufacturing performance by incorporating mixed reality and intelligence capabilities.

Mixed reality enables lifelike interactions and brings greater accuracy and depth of knowledge for employees interacting with the process, either from afar or while making a fix on the factory floor.



Microsoft technology also helps manufacturers harness the power of machine learning and artificial intelligence in their Process Digital Twins:

- **Cognitive Services and advanced analytics** are the basis for the advanced predictive capabilities and in-process simulation that make the difference when it comes to machines anticipating repairs, downtimes, and impact on the production line
- **Bot Framework** visual and speech recognition enables natural language conversation with a twin to make these decisions
- **Artificial Intelligence** acts upon the entire Process Digital Twin to provide new insights across the supply chain

We envision a future where every product, factory, and process are connected and can be monitored and adapted from afar. Manufacturers who implement Process Digital Twins will take the principles of Industry 4.0 to new heights of performance, vertically integrating their factories and establishing even deeper connections across the horizontal value network.

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Conclusion

If manufacturers are looking to implement a Process Digital Twin, it is crucial they have a trusted, experienced partner like Microsoft to help them along the way. Microsoft offers the most complete set of capabilities and experience required to make your Process Digital Twin experience worthwhile – providing the most comprehensive portfolio of products and services, an open and accessible platform, industry-leading security, and scalable cloud solutions.

Next steps

- Visit aka.ms/digitaltwin to learn about implementing a Process Digital Twin
- Watch the Envision presentation from the Microsoft Manufacturing team to learn more about Process Digital Twins and Industry 4.0
- Watch our webcast to learn how Microsoft can help make your digital transformation a reality
- Contact your Microsoft representative to arrange a strategy discussion

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