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HOW 'INTELLIGENT TWINS' ARE REDEFINING THE FUTURE OF MANUFACTURING

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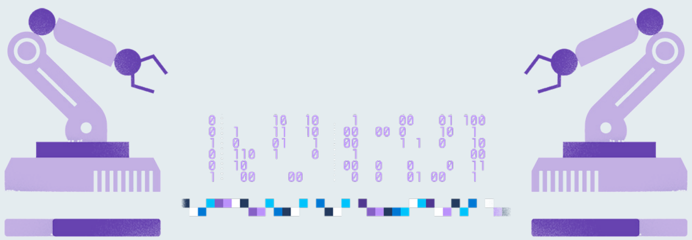

The Factory Of Tomorrow

Imagine the factory of tomorrow. Imagine production lines that rarely hit a snag, and machinery fine-tuned to operate at full efficiency. Imagine a manufacturing process that generates zero waste with low energy consumption. Downtime? A thing of the past. Breakdowns are anticipated long in advance, and repair work scheduled to avoid interruptions. When the product spec is tweaked or raw materials are changed, the system reorchestrates itself on the fly to maintain quality. In the factory of tomorrow, costs are minimised – and output is maximised.

This might sound like fantasy. But thanks to businesses’ developing the skills and acquiring the means to capture, harness and visualise ever greater volumes of data – coupled with the ability of artificial intelligence (AI) to optimise and predict – it is becoming reality. How? Through an emerging technology known as a ‘digital twin’.

The term ‘digital twin’ has many definitions, but broadly it refers to a digital representation of a real-world object. In manufacturing, a digital twin might be anything from a single component to a complete machine, factory or supply chain. These digital twins are fed by data from their physical equivalents. The data could come from sensors, monitoring equipment, cameras or control software, and could span everything from power usage and throughput to wear and tear. This means the digital twin is an exact reflection of a specific physical object’s attributes and behaviour.

The virtual models can be purely numerical or can visually represent their real-world counterpart. But they allow manufacturers to improve operations in ways that were hitherto impossible. This presents significant opportunities for the consumer goods and other manufacturing industries – sectors already operating on thin margins but now also weathering economic headwinds.

The applications of digital twins include not only performance monitoring but, crucially, precise simulation. Testing, optimisation and scenario projection can take place in the safety of a virtual environment before changes are made in the real world. The benefits are clear. Risk is removed from operational decisions that are expensive to reverse, problems can be solved before they happen, efficiencies can be brought to light at an early stage, and progress towards automation can be accelerated. All of which serves age-old business imperatives – reducing costs, increasing revenue – as well as new priorities such as sustainability.

Digital twins are a core technology of 'Industry 4.0', a term used to describe a generational shift in industrial processes brought about by the digitalisation of manufacturing. As factories embrace transformative technologies – the internet of things, artificial intelligence, cloud computing – an array of new capabilities can be unlocked. The bringing together of the physical and virtual worlds through digital twins is seen as one of the most powerful ideas. Indeed, a recent Future Market Insights report predicts that the global digital twin technology market will grow at 22.6% annually to hit a total value of $72.65bn by 2032.

"At the end of the day, in manufacturing, you want to maximise your production output, at the lowest possible energy consumption and at the optimal maintenance cost," says Jesper Mikkelsen, group VP of services at industrial parts supplier Rubix. "Digital twins can help you do that. But on a practical level on the factory floor, the journey is only just starting."

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The Birth Of Twins

The idea of a digital twin has been around for decades. In 1970, when Apollo 13 was damaged on its way to the moon following an explosion in an oxygen tank, it was a simulator in Houston that incorporated data from the real accident that helped NASA bring the crew back alive. But digital twins weren't crystallised as a manufacturing idea until 2002, when Dr. Michael Grieves introduced it on his executive course in Product Lifecycle Management at the University of Michigan. Eight years later, his colleague, the space technologist John Vickers at NASA – where Grieves was a consultant – coined the term itself. Since then it has featured heavily in conversations about the future of manufacturing.

The concept itself, says Lina Huertas, industry executive for manufacturing at Microsoft, has also evolved. Around 2013, artificial intelligence (AI) emerged from its most recent winter, with the rise of machine learning fuelling a surge of investment and breakthroughs. This caused digital twins to evolve – the 'intelligent twin' was born. "With traditional digital twins, you could see how a product would go through a process," says Huertas. But it would be down to a human to turn that information into an action. "Intelligent twins, on the other hand, can make decisions on the fly and change the process in the factory autonomously." This automation saves time, improves efficiency, finds patterns in the data and creates forecasts. It also learns as conditions change and unlocks new applications such as predictive maintenance. As a consequence, the people in the business are able to shift their attention to the most complex problems, risks and innovations.

Right now, we're at an inflection point for digital twins – after years of experimentation and debate, manufacturers are adopting them in earnest. "Industry has seen the proof of value of digital twins – that these things work," says Huertas. "But the stage I think we're going through now is being able to scale."

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How Digital Twins Are Delivering Real World Value

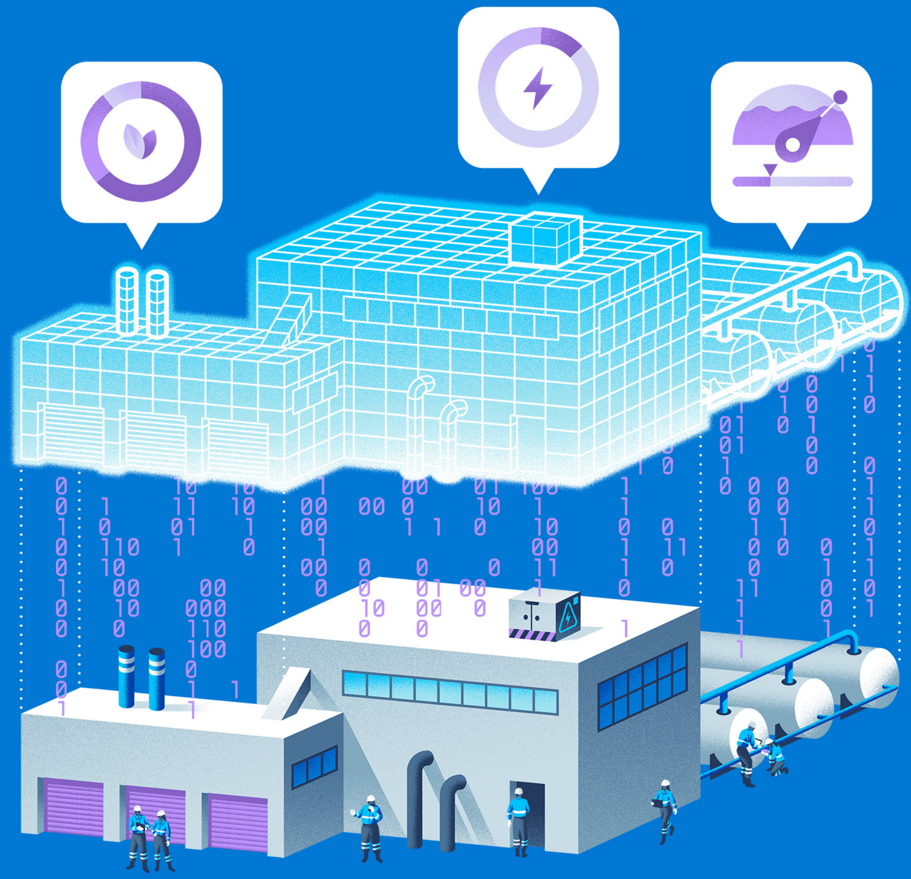
As digital twin adoption grows, businesses are unlocking efficiencies across a number of key areas...

Reducing energy consumption

Energy efficiency and the cost savings it brings are paramount for the manufacturing industry. Digital twins can monitor power consumption, distribution and wastage, allowing factory managers to model different operating scenarios and optimise energy efficiency. This could involve repurposing waste energy or reducing consumption across mechanical aspects of production. "For example, one of the biggest consuming areas in a factory is the motor-driven systems that keep production lines moving," says Rubix's Jesper Mikkelsen. "The motor generates power and you control how that power is used with a valve that opens or closes – whether it's for air or hydraulic pressure – but the motor's still working at full speed." Clearly, that's a waste of energy – and that's where a digital twin can come in. "You can use it to analyse the need for power versus the output of the motor, which lets you optimise its speed and can give you massive energy savings."

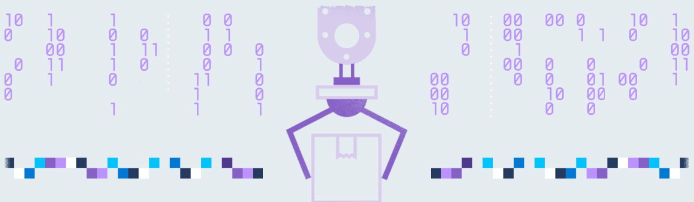
Optimising production processes

Production processes are underpinned by multiple variables – how much time an industrial oven spends baking a snack, say, or how much heat and pressure goes into blow-moulding packaging. Fine-tuning those procedures through trial and error wastes materials, time and money. Digital twins can refine a new process virtually, before it's deployed for real. Ben Ellins, IT director for manufacturing at Reckitt, which produces hygiene, health and nutrition products, says that a major use case in his world would be mixing tanks. "You fill up your tank and as you're spinning it up, based on revolutions and some level of simulation, you can model the state of the mixture," he says. "The outcome is: you've got a better understanding of when you are fully mixed, so you don't have to mix as long." This can speed up production, reduce energy costs and also cause less wear and tear to parts.



Improving quality

Digital twins have a clear role to play in optimising product quality, in particular when producing products that have natural variation in their raw materials – a regular occurrence in the food and drink world. Take AB InBev, for example, the world's largest brewer. It has invested in virtual models of its factories that span everything from brewing equipment to packaging lines. "Brewing is a complex chemical and biological process," says Lina Huertas from Microsoft, the company behind AB InBev's digital twins. "So monitoring and predicting the process parameters and inputs is critical to make sure that they have the right quality, the right flavour." The digital twins enable them to make tweaks rapidly and with lower risk, thereby reducing wastage and maintaining output.



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Predicting problems

Perhaps the area where digital twins are perceived to add particular value is avoiding downtime. The capacity of digital twins to make predictions means that problems can be solved before they occur...

Anticipating production snags

A unified digital twin of a whole system means that the impact and occurrence of hard-to-predict events caused by a number of different factors, across multiple discrete processes, can be better anticipated. British Sugar is one company that plans to take advantage of that capability and join the digital twins movement. Over the past few years, the company has invested in a private 4G network at its four factory sites. They are now implementing an Industry 4.0 strategy with data and digital twins as a key theme. Sil Sehra, its head of information systems, paints a picture of how this could help in sugar processing. "Sugar beet comes in, it gets washed, and gets put on the conveyor. While that conveyor's going, we push lots of water through it," he says. "There are pinch points where if the beet gets clogged up, someone needs to manually go in there and take it out. If you can digitise that, you can model that: how is the process happening? What's going on? Am I going to have a pinch point?" That intelligence could reduce bottlenecks and remove the productivity hit associated with ad-hoc fixes.

Predictive maintenance

The other vital way digital twins can help minimise downtime is by identifying the need to service or fix machinery before it breaks. Every time a machine has a fault, the digital twin records the event and logs the data associated with the machine's components. Soon, it has enough data – tuned by expert knowledge honed over many years – to recognise patterns between the status of certain components and the time to a breakdown occurring. When it spots that same pattern emerging in the data in the future – on that same machine or others like it – it can notify the

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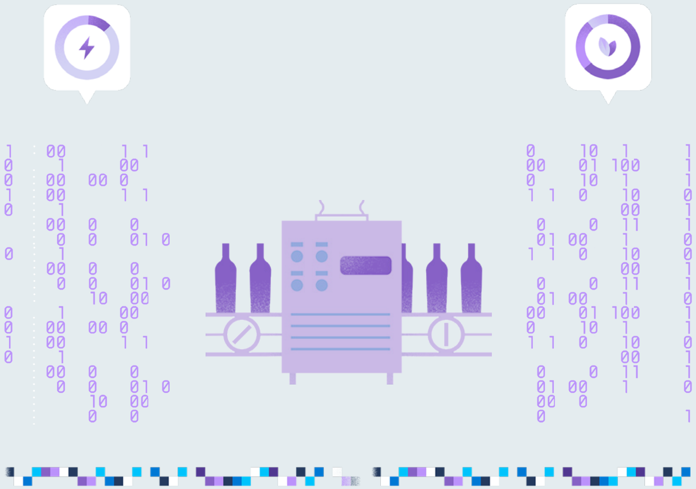
maintenance team who can add lubricant, say, or replace a part. This is much less costly than production grinding to a halt, or a small fault cascading into a more expensive problem.

But the approach can also be used to maintain entire buildings, bringing health and safety advantages. “Many factory buildings were built 100 years ago and can suffer from problems like corrosion, which can cause structural incidents,” says British Sugar’s Sil Sehra. “If you have the right data matrix for the building you can preempt issues and say, ‘You need to watch the corrosion here.’”

What’s more, the maintenance activity itself can be optimised – digital twins allow you to test different maintenance schedules so that these can be synchronised with production plans to maximise output. “It’s about understanding the right time of doing your corrective actions,” says Rubix’s Jesper Mikkelsen. “It’s like with your car: suddenly having a red light on the dashboard tells you something is wrong, but you need to decide when would be a good time to actually get that looked at.” The digital twin can help you understand if you can leave it until the factory shift is over, for example, when there’s no trade-off with output.

Enabling efficient collaboration

Digital twins can underpin emerging forms of teamwork. Virtual representations of real-world objects are a key component of what many technologists refer to as ‘the industrial metaverse’. It is a loose term that, broadly speaking, refers to virtual experiences that can add value to standard industrial activities, particularly through working with others. This might be about collaborating on engineering projects, for example. If users who are in different places geographically can see a digital twin of a piece of machinery – and are able to interact with it in this virtual space, perhaps using VR headsets – it can make problem solving faster and more effective. Or consider maintenance. If a mechanic is using an augmented reality headset, a remote support team can see the problem in context and provide AR support informed by a digital twin to help solve the problem.



So Why Aren't Digital Twins Ubiquitous?

While adoption of digital twins is picking up, they are far from commonplace in consumer goods manufacturing. "From an implementation perspective, it's not there yet," says Mikkelsen. For those looking to deploy the technology within their organisations, challenges around cultural resistance, workforce skills and legacy infrastructure will all need to be borne in mind.

Digital twins require new skills

Digital twins are multidisciplinary, drawing on knowledge of manufacturing, engineering, data analytics and computing. People who have knowledge of all those things are rare, and this can deter implementation – or, worse, lead to the creation of digital twins that are never used. One approach is to hire specialists or partner with dedicated providers. "The latter is why some consumer goods companies have been able to scale this across loads of factories," says Microsoft's Lina Huertas.

So, what about your existing staff? Don't think you can do without them. "You have these very experienced people in factories who know these machines so well they can almost hear when something is wrong," says Mikkelsen. This expertise is vital for setting the parameters of digital twins and also overruling them when necessary – because the computer doesn't always know best. The machine, in turn, can learn from the human input and improve its own decision-making. "I've seen companies take a heavy tech approach, and a more analogue approach," says Mikkelsen. "Where I see it land best is a beautiful combination of the two."

Legacy infrastructure is a challenge

If you have a brand new factory, implementing digital twins is simpler. The machinery may already be digitised and therefore digital twin-ready. With older equipment you have to retrofit sensors and systems, which is an additional engineering challenge and expense.

"In European manufacturing, it's not new, fancy production sites – you have a lot of old equipment," says Mikkelsen. "Also, if you have acquired other companies' facilities over the years, all the equipment is different and that inhomogeneity is a challenge." Compare that to a system of new factories all using similar equipment – a digital twin can be rolled out at scale with greater ease and lower cost.

A lack of standards

Digital twins are at their most powerful when they can talk to each other. This is not only because it allows whole processes to come into view, but also because AI makes better decisions when it can draw on a larger number of relevant datasets. That can only happen if all the digital twins are collecting and recording their processing data in a standardised format. Scaling a network of digital twins also relies on the systems running the digital twins using the same computer architecture – something that Ben Ellins says is a priority for him at Reckitt. "The approach I continue to push and recommend is if we want to do these things, we need to invest in a consistent architecture." Ideally, this would be a 'composable' architecture, meaning that elements are modular – they can be added or removed as required. This makes the system flexible so it can be easily adapted in the future as processes change and the use of digital twins evolves with them.

Cost of implementation

At a time when the cost of borrowing is high, consumer confidence is down and the economic outlook is precarious, digital twins may be thought to represent a potentially unappetising cost. Yet technology, skills, commercial models and architectures have evolved such that digital twins can now be delivered in stages, proving value within a few weeks. "It costs money," says Ellins, of getting the right computer architecture in place. "But it's an investment that will allow us to build and build. And then the use cases will pay for themselves."

Where Next?

The future of the digital twin is perceived to be less about new developments in the concept itself, and more about new levels of implementation.

Right now, many digital twins simply model a specific machine or sequence of processes. It's much rarer for a company to model the entire system of everything that happens inside a factory, from delivery of raw materials all the way through to the packaging lines. But Mikkelsen believes there is value in doing so. "The end-to-end view is where a lot of future use cases are going to lie," says Mikkelsen. "That's particularly important for energy management, but also for combining performance data and predictive maintenance with production output for process optimisation."

But the digital twin concept can be extended well beyond a single factory. Integration with other manufacturing facilities, warehouses and distribution centres presents the opportunity to unify and manage enterprise data across a great many twins and processes to find subtle efficiencies across a business' entire ecosystem. In theory, this network could also extend to digital twins outside of the company. This could help a business optimise supply chains and work around interruptions more effectively.

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Some futurists have looked at this direction of travel and formed a hypothesis: in the future, isn't it reasonable to think that a great many objects and processes will have digital twins? Perhaps these will converge at unprecedented magnitude, they suggest, to create a vast landscape of virtual organisational assets, encompassing a whole matrix of suppliers, manufacturers and retailers, including their business processes, physical infrastructure and human resources.

If this comes to pass it would mean that all manner of processes and products can be simulated with greater scale and fidelity than ever before. But it could also open up new opportunities entirely. Consider product digital twins and the circular economy. If you want to enable circularity in the wider supply chain, product digital twins can provide information around disassembly, materials and reusability or even insights to extend operating life. "All of that comes down to digital twin technology," says Huertas, "and that digital twin travelling with the product, and you being able to make sense of it with your own systems."

For this grand vision to happen, however, a number of hurdles would have to be overcome. For one, there are trust issues. "Companies have to be willing to trust enough and collaborate enough that they do actually share the data," says Huertas. There would also have to be global standards and conventions for how digital twins are designed and how their data is recorded. "How would a model talk to another one?" asks Ellins. "Is it something like an API? Or is it more inherent to the cloud space they're sitting in? It's so theoretical that we just don't know yet."

If it does happen, it may be an organic rather than deterministic process. "I think it might happen by accident," says Ellins. "So it isn't someone saying, 'I want an entire simulation of my supply chain' and putting in the investment to do that. It's more that it would happen incrementally."

Although organisations are already scaling digital twins across factories, this level of integration might sound far off. But economics can prove profoundly motivating. And remember: the factory of the future was also but a pipe dream once.

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