Digital twins and simulation

Whether simulating an entire plant or focusing on a specific machine, digital twins and simulation provide insights that save time, reduce costs and ensure tire quality

by Pekka Vaittinen, Black Donuts, Finland

One of the most groundbreaking technologies in modern manufacturing is the digital twin: a virtual replica of a plant or machine that mirrors real-world manufacturing processes in a digital environment. For tire manufacturers, where complexity spans from raw material handling to final inspection, digital twins offer a powerful advantage. They enable companies to simulate each production stage, troubleshoot potential issues and experiment with new designs – minimizing risks and costs associated with physical adjustments. The result is greater efficiency and confidence in decision-making, especially for large-scale investments.

Digital twin technology offers substantial benefits for new (greenfield) and existing (brownfield) tire manufacturing plants and projects. In greenfield projects, where a plant is designed from the ground up, digital twins enable manufacturers to design the most efficient layout before a single machine is purchased. They can optimize material flow, machinery placement and workforce allocation by simulating operations. This ensures the plant meets current production demands and is well prepared for future growth.

In brownfield projects – upgrades or expansions of existing factories – digital twins can be just as transformative. Older factories often face inefficiencies due to outdated equipment or evolving production needs. By creating a digital replica of the plant, manufacturers can simulate various scenarios to identify bottlenecks and test improvements without interrupting production.

Take, for instance, a factory introducing a new tire design that requires modifications to the tire building machine. Rather than stopping production to adjust, manufacturers can use a digital twin to simulate the necessary changes and assess their impact on efficiency. This reduces downtime and ensures smooth transitions when implementing the actual modifications.

Predictive maintenance and risk analysis

One of the most impactful applications of digital twins is in relation to predictive maintenance. Manufacturers can predict when equipment will likely fail or require maintenance by collecting real-time data from machines and feeding it into the digital model. This proactive approach helps avoid unexpected breakdowns, extends equipment life and keeps production lines running smoothly.

In tire manufacturing, where production is highly integrated, even a single machine failure can disrupt the entire process. Predictive maintenance, powered by digital twins, helps resolve potential issues before they escalate, ensuring continuous production and minimizing costly downtime.

Beyond maintenance, digital twins offer a critical advantage in optimizing energy use across the plant. Manufacturers can simulate energy-saving strategies, experiment with new energy-efficient machinery or adjust production schedules without disrupting operations. This not only helps meet sustainability goals but also reduces operational costs.

Large-scale investments – whether expanding capacity, introducing new tire designs or upgrading equipment – often come with inherent risks. Digital twins enable manufacturers to test various 'what if?' scenarios before making significant financial commitments. Unlike traditional spreadsheet-based analyses, which may overlook important variables, digital twins incorporate real-time data and simulations to provide a holistic view of potential outcomes.

For instance, when considering the expansion of a production line, manufacturers can use digital twins to simulate how new machines will affect process efficiency, costs and energy consumption. This allows decision-makers to confidently assess the return on investment before committing, thus reducing uncertainty and risk.

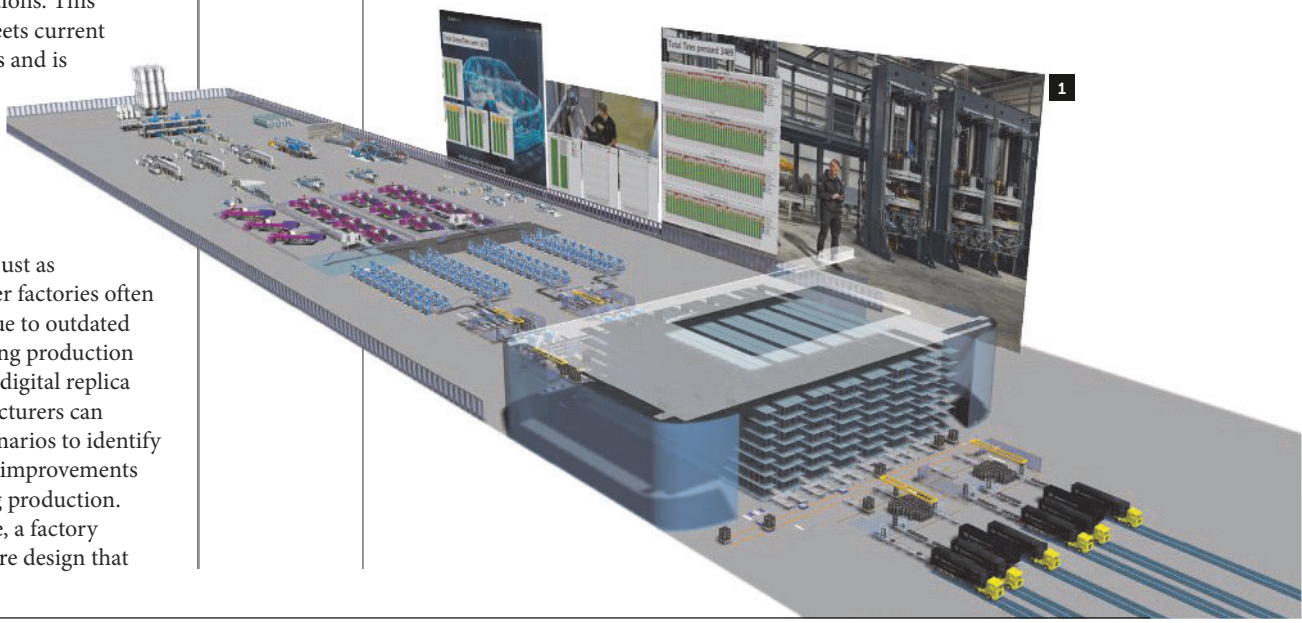

Figure 1: A digital twin of a tire plant