International Journal of Engineering &Technology, 13 (2) (2024) 326-329

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

A study article on the use of digital twin in the packaging industry

Manisha Deshpande [1] *, Mr. Sameer Deshpande [1]

[1] *Government Institute of Printing Technology Mumbai, Maharashtra India*
**Corresponding author E-mail: msdeshpande2010@gmail.com*

Abstract

After the COVID pandemic, the packaging requirements have ever growing due to the safety and security of the inside product. The total market value of packaging materials at a global level was nearly 896 billion U.S. dollars in 2022. It is forecast that this global market value will increase upto approximately 1.15 trillion U.S. dollars by 2030.1 In Industry 4.0; the workforce, machines, and processes are linked through digital networks.2 Data and Digital twin control production processes have emerged as a powerful tool. The digital twin has multiple advantages in the packaging sector, from cost and time savings to sustainable packaging development.

Keywords: *Applications; Digital Twin; Industry 4.0; Scope; Types.*

1. Introduction

A digital twin is a virtual replica of an object or system designed to reflect a physical object accurately. It uses real-time data, simulation, and machine learning to make decisions. The process or object to be studied is fitted with various sensors related to important areas of functionality. These sensors produce data about different parameters of the performance of the physical object or process. The data is processed using special customizable software and its output is applied to the digital version or digital twin. If this data is accurate and relevant, then the digital twin can carry out various simulations, analyze performance problems, and create necessary adjustments. The major aim is to obtain the information for improving the original physical object.[3] A digital twin is a computer program that uses real world data to create simulations that can forecast performance parameters of the product or process. The simulation is based on the data received from the current condition of the physical asset and data about it in the past. The software can integrate the Internet of Things (Industry 4.0), artificial intelligence, and data analytics to improve the output. The use of Internet of Things (IoT) sensors makes it possible to transfer real-time actual data to create virtual replicas in the digital world. [4] Digital Twin gets the data from the surrounding environment in real time to mirror the original version. It can give information on behavior. [5] Digital twin technology uses sensors, Internet of Things (IoT) devices, data analytics, and artificial intelligence to capture real-time data and simulate the behavior and characteristics of the physical counterpart in a digital environment. This virtual representation allows for monitoring, analysis, and optimization of the physical object or system in a virtual space. Digital twin technology enables better decision-making, improved performance, and increased efficiency in various industries.[6].

2. Scope of digital twin in packaging manufacturing companies

The digital twin can help in workflow optimization, improving workroom conditions, finding root causes of wastage, managing logistics, better communication from manufacturer to end user, etc. A few of these are illustrated here.

2.1. Workflow optimization in packaging design

The digital replica of the product which is made through real-time data obtained from the men, machines, and materials available in the company can identify flaws in the design which can allow for redesigning, long before the product launch in the market. The digital twins of the customers can give insights into the possible reactions to the product for improving the appeal of the product or its positioning on the shelves/aisle in the store. The designers can use virtual products to evaluate the packaging utility such as its appeal to the customers in terms of colors, legibility, shape, materials used, and ease of handling; of a specific product in a simulated real-world environment. It will minimize the time and other resources required for physical sampling. The digital twin will also allow speedy repetitions and any alterations in the design. The use of digital twins in packaging design allows for real time monitoring of a product's performance such as pilferation, spillage, tearing, opening, rub resistance, etc. throughout its lifecycle. Deploying the digital twin results in saving time; in planning, production, logistics, and delivery to the end user. It is achieved through continuous repetitions and optimizations of product designs which would be otherwise a time-consuming physical exercise.

2.2. Quality assurance

Manufacturers and end users can digitally replicate the handling, transportation, and storage of products. They can also identify potential flaws and vulnerabilities before production begins. It will help in minimizing wastage and costs. The data received through various digital interactions can be shared across the company and with stakeholders and partners for performance review. From a security viewpoint, the digital twin can track and trace, authenticate, and prevent counterfeiting. The manufacturer can get information on the journey of the product from the factory to the distributor to the market to the end user through a cloud deployment for digital twins.
The use of digital twin technologies can enable easy communication and remote collaborations regardless of location between manufacturers and customers. The customers and the workforce can be better educated about the product. Customers can virtually try out products and check how they work increasing the possibility of a purchase. The opinions of the customers can also help in devising sustainable packaging solutions.[7] Leading food companies are building a digital twin framework with their suppliers and end-customers which allows them to gain the insights to make or redesign products. The digital twin can estimate modifications with IoT feedback from retail, food service, or digital consumer surveys.

3. Actual applications of digital twin technology

- Pearson Packaging Systems, a US packaging machinery manufacturer has been using digital twins of its products to carry out trials virtually instead of the physical world. It has helped in time saving from order to delivery. The workers use the digital twin for training on different product parameters. It is also used to support problem-solving for equipment at the customer's end by enabling support staff to diagnose faults from remote locations. The company can generate the code to drive robotic palletizing operations much faster in the virtual world using Emulate3D than previous manual work. [10]
- Wayne Automation Corporation, a US supplier of automated packaging equipment uses the digital twins to demonstrate to its customers the feasibility of solutions at an early stage in a project to analyze and validate the structural design and supervise testing in a digital environment thus saving workforce, time and expenses by using Emulate3D support.
- Tronrud Engineering, a machine building company in Norway, has manufactured a food packaging machine for the food industry, which can pack 300 wrapped food bags per minute into boxes. Using digital twins, required 90% of the previous analog building time. The company completed the installation and commissioning 75% of the previous time.[11] Tronrud created a digital twin using Siemens technology, which consists of NX Mechatronics Concept Designer (MCD). It is a multi-discipline integrated system engineering software, Simatic S7-PLCSIM Advanced, which enables realistic simulations of controllers without the real hardware, and the Totally Integrated Automation (TIA) Portal, a digital framework for mechanical and electrical design and automation engineering to test and identify failures before real commissioning takes place.

Fig. 1: Direct Interaction Using VR and AR Source – B & R Industrial Automation.

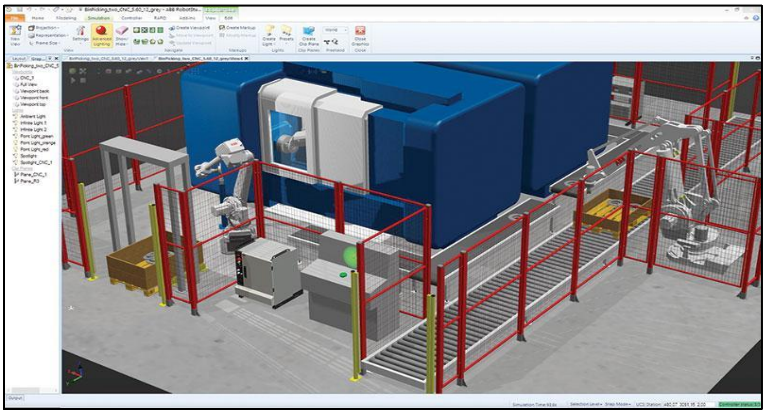

Fig. 2: Simulation Using ABB's Robot Studio [11].

Fig. 3: Digital Twin Technology for Primary Packaging. Source – Siemens.

Fig. 4: Smart Packaging.

4. Digital twin developers for the packaging industry

Following are a few of the leading developers of digital twin technology for the packaging industry.

- Esko has developed 3D Design Studio software which designs labels in 3D to perfectly fit structural packaging designs with Studio's patented print modeling technology. It uses the data obtained from actual production such as temperature, humidity on the shop floor, or the material performance at the time of converting, etc. This is synchronized with 3D models with printed packaging material and it results in the creation of a digital twin. It can create 3D content, movies, virtual packshots, or a virtual shopping shelf. It can increase productivity by using real production data to produce accurate and impactful packaging. The designer can virtually try different substrates, inks, varnishes, foils, and holograms and share them simultaneously with the customer to achieve the required result. It reduces the number of physical prototypes and eliminates the cost and delays of analog photoshoots. [12].
- Digimarc has developed the Digimarc Illuminate platform, a digital twin software that uses logic and customizable rules that enable the products to capture data, record events, and automate actions. [13].

4.1. Building a digital twin

Table 1: Maor Stages in Building A Digital Twin

SN.	Building Digital Twin	Major Contents
1.	Planning	Type, sequence, ownership
2.	Creating basic version	Data compilation and analysis
3.	Scaling	Additional data layers and analysis, simulations, use of AI

There are three major steps in creating a digital twin:

- Planning - A plan should guide the types of twins suitable for a company, the sequence for building them, the way their capabilities will evolve, and their ownership and governance structures.
- Creating a basic digital twin - In this stage, the product-related data is compiled. It helps in providing a visual representation. Based on it, the data science professionals build out one or two initial digital twins.
- Scaling - When basic digital twin is in operation, a company can scale the operations by adding more data layers and analytics to support new use cases. At this stage, companies go for the simulations from digital twins and take autonomous actions or decisions by using AI and advanced modeling techniques. [5].

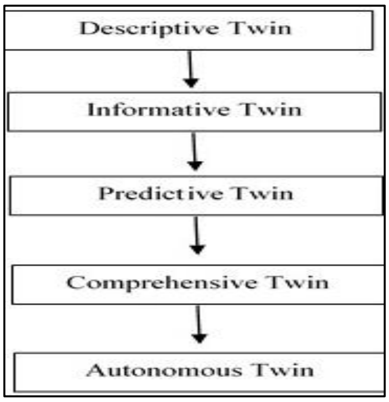

Fig. 5: The 5 Levels of Digital Twins [14].

According to Autodesk, there are five levels of building digital twins. First, Descriptive twin is a live, editable version of design and construction data where the users specify the type of information to be included and the type of data to extract. The second level i.e. Informative twin has a layer of operational and sensory data to compile and verify data to make the systems work smoothly. The third Predictive twin can use operational data to gain insights. Fourth, the Comprehensive twin simulates future scenarios and considers "what-if" questions. The fifth, i.e. Autonomous twin uses Artificial Intelligence (AI) and Machine Learning (ML) to make autonomous decisions.

5. Benefits of digital twins in packaging

- Better research and development of the products and processes because the collected data can help in product refinements before starting actual production.
- Improved efficiency by mirroring and monitoring production systems, with an aim to achieving and maintaining peak efficiency by predicting maintenance schedules, and optimization of materials and workforce throughout the entire manufacturing process.
- Sustainable packaging development by collaboration between machines, materials, workforce, distributors, and customers which also results in a reduction in lead times.

6. Conclusion

Following are the challenges in the implementation of digital twins:

- Leadership mindset to invest money in the deployment of digital twin technology to train the manpower, and educate all the stake-holders.
- The data is not easy to acquire because it is not organized.
- Manufacturers lack adequate expertise in data management practices.
- Lack of digital skills between IT and non-IT experts in the virtual commissioning of digital twins.

The future of digital twins is wide because of the upgradation in data processing software. So, digital twins are constantly learning new skills and capabilities, which means they can continue to generate the insights needed to make better products and efficient processes.

References

[1] Madhumitha Jaganmohan, '*Market value of packaging material worldwide from 2020 to 2022 with a forecast from 2023 to 2030*, by region' Published on statista.com November 2023 issue published on 10-01-2024. https://www.statista.com/statistics/1422303/global-packaging-material-market-value/#:~:text=Global%20packaging%20material%20market%20value%202020%2D2030%2C%20by%20region&text=The%20total%20market%20value%20of,by%202030%20across%20all%20regions.

[2] Article, *'Industry 4.0: Digitalization in the Printing & Packaging Industry'*, published on Drupa website https://www.drupa.com/en/Home/Focus_subjects_%7C_drupa_2024/Industry_4.0_Digitalization_in_Print_Packaging_%7C_drupa

[3] Article published on the IBM website https://www.ibm.com/topics/what-is-a-digital-twin

[4] Technical knowledge article on the twi-global website, 'What Is Digital Twin Technology And How Does It Work? https://www.twi-global.com/technical-knowledge/faqs/what-is-digital-twin#HowDoesDigitalTwinTechnologyWork

[5] An article *'What is digital-twin technology?'*, published in McKinsey Explainers on 12-07-2023 https://www.mckinsey.com/featured-insights/mckinsey-explainers/what-is-digital-twin-technology

[6] Article, 'Digital Twin Technology for Primary Packaging', published in Machine Dalal magazine on 29-02-2024 https://magazine.machinedalal.com/digital-twin-technology-for-primary-packaging/

[7] Meaghan Ziemba, *'4 Ways Digital Technologies Revolutionize Packaging Design and Processes'* Published in the Packaging Digest Magazine on 18-08-2023 https://www.packagingdigest.com/smart-manufacturing/4-ways-digital-technologies-revolutionize-packaging-design-and-processes

[8] Mark Juhasz, *'The Digital Twin Emerges as Tool For Rapid FoodTech Product Iteration'*, Published in The Spoon magazine on 07-02-2022 https://thespoon.tech/the-digital-twin-emerges-as-tool-for-rapid-foodtech-product-iteration/

[9] Rockwell Automation article, *'Accelerate the deployment of innovation with digital twins'*, Published in the Packaging Europe magazine published on 12-05-2023 https://packagingeurope.com/accelerate-the-deployment-of-innovation-with-digital-twins/9791.article

[10] Stephanie Neil, *'Digital Twin Double-Take'* article published in OEM Magazine published on 17-12-2019 https://www.oemmagazine.org/engineering/machine-design/article/21104216/how-packaging-and-processing-machine-builders-are-using-digital-twin-technology

[11] Beth Stackpole, *'Digital Twin Makes Virtual Commissioning a Reality'*, article published in the Automation World Magazine on 22-01-2019 https://www.automationworld.com/products/software/article/13319468/digital-twin-makes-virtual-commissioning-a-reality

[12] Esko Studio, 3D Packaging Design Software https://www.esko.com/en/products/studio

[13] Digimarc product information, *'Cloud Intelligence for Every Item'* https://www.digimarc.com/product-digitization/digital-twins

[14] Sarah Jones, *'What is a digital twin? How intelligent data models can shape the built world'*, an article published on Autodesk website on 30-06-2022 https://www.autodesk.com/design-make/articles/what-is-a-digital-twin