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VISUALIZATION OF INDUSTRIAL PRODUCTION WITH THE DIGITAL TWO CONCEPT

Peter Trebuňa
Technical University of Kosice, Faculty of Mechanical Engineering, Institute of Management, Industrial and Digital Engineering, Park Komenskeho 9, 042 00 Kosice, Slovakia, EU, peter.trebuna@tuke.sk (corresponding author)

Marek Kliment
Technical University of Kosice, Faculty of Mechanical Engineering, Institute of Management, Industrial and Digital Engineering, Park Komenskeho 9, 042 00 Kosice, Slovakia, EU, marek.kliment@tuke.sk

Štefan Kral
Slovak legal metrology n. o., Hviezdoslavova 1124/31 974 01 Banská Bystrica, Slovakia, EU, kral@slm.sk

Ladislav Rosocha
Technical University of Kosice, Faculty of Mechanical Engineering, Institute of Management, Industrial and Digital Engineering, Park Komenskeho 9, 042 00 Kosice, Slovakia, EU, ladislav.rosocha@tuke.sk

Richard Duda
Technical University of Kosice, Faculty of Mechanical Engineering, Institute of Management, Industrial and Digital Engineering, Park Komenskeho 9, 042 00 Kosice, Slovakia, EU, duda@taurisgroup.sk

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Abstract: The paper deals with the implementation of the concept of digital twin in industrial practice. The goal of the digital twin is to investigate the interaction of real production processes with digital simulation models, which are a detailed virtual copy of all processes, material flows, and possible states in a real production system. The interaction of production equipment and equipment simulation models will bring new insights into the dynamics of production and logistics processes that are currently accelerating.

1 Introduction

At the beginning of the research, physical product information was limited and mostly recorded only on paper. Nowadays, the rapid development of information technology supports not only the development and maintenance of a virtual product, but also caused a rapid development in the area of product design.

Virtual products (Figure 1) are essentially indistinguishable from their physical counterparts. The rise of "Digital Manufacturing" has led to the enrichment of data collected for the product. The transition from manual data collection to digital collection was due to various methods of non-destructive physical exploration based on 3D scanning, sensory imaging, the use of gauges and coordinate measuring machines, lasers and cameras.

Based on this fact, it is time to investigate how a digital and potentially useful concept helps in understanding the physical product. The concept should primarily aim to reduce costs and promote innovation in the production of quality products.

Decades of development have enormously increased the volume and richness of data that can be obtained from the virtual and physical form of the product. On the virtual side, the volume of information has radically increased, behavioural characteristics have been added so that you can not only visualize the product but also test its capabilities and performance [1].

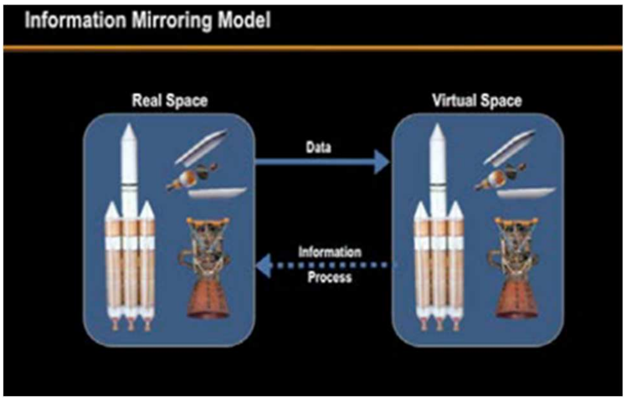

Figure 1 Digital Twin concept model

Now we have the ability to create lightweight versions of the virtual model. We can change the geometry, characteristics and attributes that we require without unnecessary detail. This dramatically reduces the size of the models and allows faster data processing.

These lightweight models make it possible to simulate complex systems using simulation software, including their physical behaviour in real time and at reasonable computational costs. Using lightweight models allows them to be replaced more quickly, reducing time and, of course, improving product quality through a deeper understanding of product information by all stakeholders.

If necessary, we can simulate the production environment that creates the product, including most operations, such as automated and manual, that represent the production process. These operations include assembly, robotic welding, forming, milling and others.

Additional information about the physical product properties is collected on the physical side of the concept. We can collect data from computers that perform operations on the physical part and understand what operations at which speed and power were used. For example, we can collect the tightening torque of each screw that secures the fuel pump to the engine to ensure that any screwing of the pump is performed successfully and will fail in the future [2].

The amount and quality of information about virtual and physical products has been increasing over the past decade. The problem arose in the two-way connection between the real and the virtual world. Today, global producers can work with either a physical or virtual product. So far, no connection has been developed between the two products, so we can work with both at the same time.

A typical way to do this is to develop a fully annotated 3D model, then develop a production process that will implement this model with a description of the process and a description of the production materials. Advanced producers can then simulate the production process digitally.

In many cases, however, the usefulness of a virtual model decreases (Figure 2) due to the non-use of 3D models and the deployment of “only” 2D models.

There are producers who transmit 3D models to the production hall layout by placing them in work cells. However, there is no real integration and connection between the virtual model and the physical product in the factory. Here, the model serves only as a reference, and one has to do with the connection between the virtual and the physical product on an ad hoc basis.

Figure 2 Inserting real objects into virtual space

Information from the physical product should overlay the virtual product and highlight the differences that need to be addressed.

Simultaneous view and comparison of physical and virtual product will be successful mainly in the production phase of the product.

The essence and purpose of the digital twin is to create a research system from which it will be possible to retrieve all the important data that arises in real production and logistics systems. The creation of a digital twin enables the creation of a seamless flow of all processes based on the rapid processing of monitored data. In order to achieve this goal, it is necessary to focus on how to eliminate the barriers separating the digital and real world and how the data can be evaluated.

2 The goal of a digital twin

The goal of the digital twin is to investigate the interaction of real production processes with digital simulation models, which are a detailed virtual copy of all processes, material flows, and possible states in a real production system. The interaction of production equipment (workstations, lines and enterprises) and equipment simulation models will bring new insights into the dynamics of production and logistics processes. The analyses should be conducted on a cyber-physical production system (physical devices connected to a digital twin) and should contribute to the emergence of new production and logistics management strategies in industry. The achievement of the main objective will only be possible with the synergy of simulation technology research and industrial practice.

Using a digital twin (simulation model), various analyses and evaluations of production states will be carried out, which will be able to influence the ongoing production on several levels. From proposals for possible solutions to the situation (operator, planner, manager, or owner decides on the application of the proposal) to the possibility of self-retrospective applicability of the proposal to the real production process.

It is precisely the development of algorithms that enable the digital twin to design sophisticated solutions for current production situations can be called the secondary direction of future research. Both directions are equally important, but their directions are different. The primary objective addresses the interaction of systems and the secondary objective will be the evaluation of analyses and causality research between the proposed solutions, which will arise from different states in production.

The concept should also include the impact of Industry 4.0 on production and logistics systems nowadays, as well as research into the optimization of material flow as part of future production operations. The aim will be to investigate the procedures for introducing electronic Kanban into the material flow within the established workplace. For the needs of the electronic Kanban system, it is necessary to identify all possible obstacles and limitations that the system may entail. Similarly, research needs to focus on the availability of technologies that will allow the use of electronic Kanban.

A digital twin should be able to provide information on:

- work cell capacity,
- employee utilization,
- capacity in the field of in-process stocks,
- material movement,
- downtime,
- energy balance of processes,
- the time of completion of production of individual orders, but also of individual pieces in the order,
- preliminary price calculation of costs for individual production variants,
- value, which is formed by the production for the customer, but also the value that does not bring the customer value on the product (e.g. standing material in the warehouse).

The digital twin is a detailed virtual copy of all processes, material flows and possible states in a real production system [3].

Visualizes the entire production process, providing a unique insight into the dynamics of the entire production system. Based on information captured at real workplaces, the digital twin is updated at precise time intervals to provide information on the current production status and the planned production status. The digital twin will make it possible to align production capacities with the design production plan and will be able to respond operatively to emerging production situations through proposals to change the production plan (operational planning).

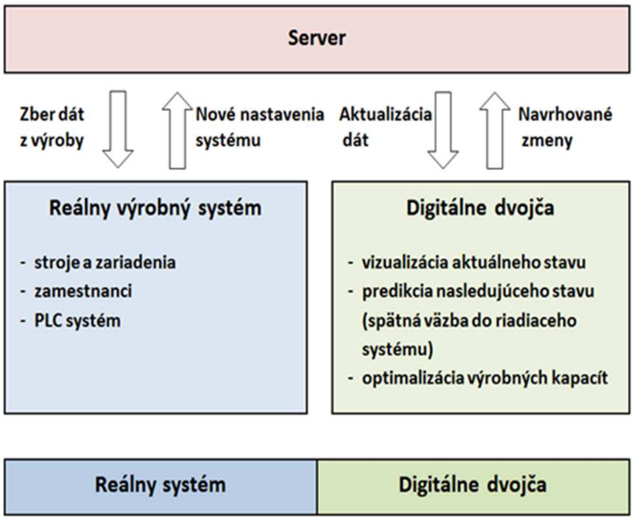

Figure 3 Connection scheme of real production and digital twin

Interconnection of the real production system and the digital twin will be possible through the server, where the information stored from the control system, PLC systems and the values of the individual scanned values will be located. Figure 3 shows the basic diagram of the interconnection of real production and digital twin [4].

If there is a change in real production (breakdowns on machines, conveyors, change of staff cycles, etc.) or a change in the production plan (the order is cancelled, it is necessary to include a new order with a higher priority in the production plan, etc.) the digital twin is used to simulate possible states in real production (based on changed parameters), without interfering with real production, thus not endangering the ongoing production and providing the information needed to change real production.

For individual variants of the production plan, a preliminary price calculation of the cost of the order will be performed together with the expected time of completion of production of individual orders.

3 Smart industry and readiness of the Slovak Republic

Slovak industry needs to increase its competitiveness. To fulfil this goal, Smart Industry seems to be one of the decisive procedures, in which the “Digital Twin” principle is the basis for increasing the operational efficiency of manufacturing companies.

The result of the Digital Twin should be a variable production model in digital and physical representation (interconnected) based on the principles of Smart Industry. This model will be adaptable to specific production situations in newly prepared projects as well as in existing production at the applicant's customers [5].

Using this concept, it is possible to examine, simulate and optimize specific processes for manufacturing companies in Slovakia in order to maximize their operational efficiency, eliminate their cost and thus significantly strengthen their competitiveness. This procedure minimizes the risks, significantly shortens the start-up of new projects and reduces the costs associated with the start-up of new projects [5].

The transformation of Slovak as well as world industry has already begun. Many companies have begun to invest in upgrading their production facilities. The first workplaces are based on the principles of human-robot cooperation, as well as the digitization of production processes is becoming more common. However, it is necessary to add that a large number of production plants in Slovakia are constantly considering the extent to which they need to invest in new technologies. In other industrialized countries, the situation is comparable and a great innovation boom across the EU can be expected [6-9].

The digital twin is beginning to influence the Slovak industry in several areas. The first is the education of young people at the university and popularization of technology in Slovakia. The result should be increased interest in the study of technical fields at the university, which will increase the number of professionals in the field of Smart Industry, which will make Slovakia a more lucrative environment for foreign investors. The project will raise the profile of Slovak engineers at world level.

However, the main area of influence is to strengthen the competitiveness of industrial companies in Slovakia. The technical nature of this concept should be a unique demonstration of the possible direction of smart factories.

The principles on which the digital twin is based will allow in the laboratory environment to optimize the most critical production processes, which will ultimately lead to:

- making more efficient use of our existing natural resources,
- more efficient use of human resources,
- initiating wider innovations in manufacturing companies,
- interconnection of all systems in factories,
- jump productivity, flexibility,
- expansion of mobile technologies in industrial production.

4 Conclusion

With this concept, it is possible to bring a whole new quality of design and set-up of production processes based on the principles of Smart Industry, increase competitiveness and at the same time ambitiously offer this service further.

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