STUDY OF THE DIGITIZATION LEVEL OF MANUFACTURING COMPANIES

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Abstract: Today, advances in ICT are exponential in nature, and many technologies are now being added from which businesses can benefit from their application in their processes. Digitization is a wide area that already finds active application in businesses processes. It helps create new possibilities in terms of improving process performance, responding more quickly to changes, or helping to reduce costs for different production areas. In general, digitization in an enterprise can be understood as having specific financial as well as personnel requirements. There are few levels of digitalization that we can achieve (document digitalization, digital factory, virtual factory, and smart factory). The research goal of the article is a detailed description and comparison of the individual digitization levels and their tools. The article contains two case studies in which the analysis of processes in the form of questionnaires defines the appropriateness of the level of digitization. Also, based on the analysis, it is possible to say each of the levels of digitization has a particular area of application depending on the nature of production. The main findings of the case studies are that irrelevant digitization is costly and personally demanding without achieving more significant results without analysis. Companies' more efficient operation can be achieved even if the company does not use the latest technological advances and what simple changes need to be incorporated.

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Introduction

According to Gregor et al. (2017), two main driving forces influencing future factories' development are technological development and globalization. Globalization includes offshoring & reshoring or changing customer behavior - local versus global turbulence.

Nowadays, manufacturing companies stand on the edge of the fourth industrial revolution. ICT-based machines, systems describe the factory of the future. Factory networks can independently exchange and respond to information to manage industrial production processes, which is enabled by the arrival of new digital technologies (De Carolis et al., 2017). When designing, optimizing or verifying processes, support tools are used that transfer many of the calculation tasks to the computing device. Support tools are developing in relation to the digitalization level of the manufacturing company by (Ojsterek et al. 2020).

Digitalization is already a concept that plays an essential role in industrial engineering. Digital technologies have changed the way manufacturing works, and the way product is design just as it's transforming operations and production processes (Calabrese et al.). Digital technologies are the main drivers of the last industrial revolution: era Industry 4.0. When designing new production systems, software tools and supporting, accessories are taken into account, achieving a certain level of process digitization (Gregor et al., 2018). Depending on several factors, it depends on the company what degree of digitization is needed in their organization. We are talking about factors such as the type of production, the number of product variants, the company's size, the financial resources available, and much more technologies (Pedan et al., 2017).

Several digitization levels are described: the lowest level is the digitization of documents in the company and basic operations, the next level is the digital factory. The digital factory is directly connected to the virtual factory, and the last level is the so-called intelligent factory, which is about connecting the digital

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virtual and real world. Digitalization is not just about a smart factory, but digitalization also brings a change in management, production planning, quality tools, and techniques (Dewa et al., 2018).

At its core, the article describes digitalization tools depending on the company's progress level in Industry 4.0 and the condition necessary to reach each digitalization level. The research goal of the article is a detailed description and comparison of the individual digitization levels and their tools. The article contains two case studies in which the analysis of processes in the form of questionnaires defines the appropriateness of the level of digitization. The case study deals with two different companies and their achieved digitalization degree and appropriate shift due to production specification.

Theoretical Background

In this section will be some necessary information about four digitalization levels and their support tools and the selection of suitable digitalization. Figure 1 is the development of a support tool for different levels of digitalization.

First level: Document digitalization

Document Scanning and Digitization refers to the process of scanning paper documents and converting them to electronic documents, capturing important information, and saving the form in a central repository for easy retrieval later. A good document management software will save time and money by eliminating unproductive activities like storing and retrieving documents from folders and cabinets. Problems with digitization often involve privacy concerns, as digital production capacity can serve to look at all aspects of a production operation. Grijalvo et al. (2021) found that Sufficient protection of company data needs to be ensured before digitalizing sensitive company data can begin.

Second level: Digital Factory

The digital factory is a revolution based on digital technologies' application in the rapid design and testing of new products and production systems. Today, a digital factory's advanced systems integrate product development and production processes with product resources (Product-Process-Resource) through data (Worobel et al., 2017). The development of a digital factory occurs thanks to the development of information technologies. The application's development is initiated by the customers' requirements, which are reflected in the high variability of the products and the production

management requirement in a short time at low costs. Computer simulation is one of the crucial technologies of the digital factory. It has found wide application in verifying complex systems' operation and has gradually evolved from simple solutions through object-oriented approaches to today's agent simulations with virtual reality, evolutionary optimization, artificial intelligence, and strong computing power (Krkoska et al., 2017).

The digital factory's support tools include reverse engineering technologies, digitalization (3D laser scanning), rapid prototyping of products and production systems, computer simulation, and virtual development of products and production systems (Gregor et al., 2017).

Third level: Virtual Factory

At present, the term virtual factory means a virtual representation of physical and non-physical objects and entities such as production and transportation equipment and processes, systems, workers, data or the whole environment (Kliment et al., 2020). The virtual factory in this form is therefore used to monitor physical objects and non-physical entities as well as processes in real space and time, as this technology allows you to create a very detailed digital image with accurate data. As already mentioned, the digital factory represents physical objects in digital form (products, processes, resources). The created digital images are usually up-to-date at a particular time. We must upgrade (Fusko et al., 2019). A virtual factory idea lies in blending a digital enterprise and real-time data collected in the so-called duality real - the virtual world.

The virtual factory application's technological possibilities are possible mainly thanks to the use of the latest ICT and sensors in the organization and management of advanced production, which has been designated the Internet of Things (Vogt, 2020). Digital data and a virtualized production environment use another new technology called Cloud Computing to implement fast computing services. These two technologies form the basis for an intelligent factory (Loske et al., 2019).

Fourth level: Smart Factory

Modern real factories, using the most advanced technologies, are referred to as Smart Factory. Smart Factory, or in the broader sense of Smart Industry, represents the digital, virtual, and real world's connection into one (Micieta et al., 2019). The Smart Factory is a flexible system that can self-optimize performance in a wider network, adapt to new circumstances, and learn from them in real or almost real-time and autonomous management of the entire production process. Factory walls can also combine with a global network of similar production systems and even with a digital supply network more broadly (Micieta et al., 2020).

Smart factory should be:

- Integrated
- Optimized
- Transparent
- Proactive
- Agile

Smart Factory can be considered a system that collects data on real processes and creates a digital copy (digital twin) in a digital environment. It is possible to implement the simulation and calculation of future states. However, Smart Factory does not end with the implementation of a digital twin. With the help of algorithms and artificial intelligence, it performs data mining from historical data, relationship correlation analysis, or future state prediction, evaluates it, and optimizes real company processes (Mikusova et al., 2020). There are no traditional chains in a smart factory, but a factory network and all processors are connected. Some OEMs in the automotive industry are already experimenting with smart factories' principles. They register individual customers whose number is growing intensely and change their vehicle's details until the assembly is wholly completed. However, the developed solutions are still costly and uneconomical (Mocilan et al., 2017). These are prototypes rather than serial solutions.

Selection of suitable digitalization

Even though digitalization is there to make work more efficient, it is not always the last digitisation stage suitable for every company (Ristvej et al., 2020). Therefore, there is a need to identify the main features that affect the level of digitalization. Figure 2 shows a condition for a different level of digitalization.

Figure 2: Condition for a different level of digitalization

Result and discussion

This chapter aims to present the empirical evidence gathered from two case studies that not every company has the right specification and support tool to go through all four digitalization levels. And if they want to tell the smart factory about their company, what corrective measures are further proposed. The Case study takes place in two different companies, and the analysis takes about 16 hours. The analysis was carried out over two working days of the company for eight hours; the analysis aimed to find out as many facts as possible about the company. Workers will focus mainly on observing production and logistics. The analysis of the workplace is further supported by a questionnaire filled in by the company's employees. Questionnaires about support tools were prepared before analysis in the company, and responsible people for digitalization answered the question. The questionnaire consisted of 20 questions. The first eleven was about to get more information about the character of manufacturing. The questions were of the type: What methods are used to produce products? What innovative technologies does the company use? Does the company meet daily, weekly, and monthly production plans? What is the average productivity of workers? What is the average productivity of machines? Etc. These questions aimed to find out whether the company has a sudden need to improve. Suppose the answers to the questions were positive and therefore that the company operates smoothly and meets the set standards. In that case, it is not necessary for the company to necessarily transform its production. However, if the answers to the questions have been negative, interventions in the form of process improvement are necessary. The individual tools of digitization are also mentioned in the questions, and workers have to choose which of the tools would be suitable for production. Then four about skills of workers with new tools like robots, AGV (Automated Guided Vehicle) or CNC (Computer Numeric Control). These questions asked whether workers already have previous experience with innovative technologies and would be prepared for change. And some open questions about where they see an

opportunity to improve production, the disadvantages in production, what they think about changes in production, etc.

Case study A

Case A is a company operating in the electrical and mechanical engineering industry. The company is focused on installing automated service systems in public transport. In Slovakia, the production contains three assembly lines provided by operators. A non-automatically Milk run system supplies an assembly lines system. In workplaces, the operator using paper documentation. For production planning workers using Enterprise Resource Planning (ERP) system. Table 1 shows relevant points of a support tool that is able to use or company already using in Case A depends on analysis. The questionnaire found that the company is meeting its goals, but employees lack technical documentation at the workplace. Since most processes are assembly workers, they need quickly available information about the assembled product and its visualization.

Table 1: Case A			
	Document scanning.	Document digitalization is in progress; they are already using the ERP system.	
	Workplaces with digital documentation.	Production workplaces are missing digital documentation. Corrective action may be the installation of screens with access to technical documentation.	
	Digitalisation of product.	Since there are few variations of a product, it is necessary to have additional documentation of every product, even with small changes.	
	The digitalization of the production system and computer simulation.	The digitalization of the production system goes together with computer simulation when real data from the production adjust to various unexpected situations.	
Source: Authors			

Table 2: Case B			
	Document scanning.	All documents are in electronic form.	
	Workplaces with digital documentation.	Not every workplace has a computer available, but digital islands are made in the production to which every employee has access.	
	Digitalisation of product.	Every variation of products is in digital form.	
	The digitalization of the production system and computer simulation.	The company has employees who take care of the digitization of the company's processes and use computer simulation to evaluate workplaces' conditions and used machines.	
	Introduction sensors.	The company uses sensors to control and improve operations, predict equipment failure.	
	Introduction ICT and cloud computing.	ICT in the company support managing production, finance, inventory, orders, and relationships with suppliers and customers.	
	Wireless technology.	Devices are connected wireless.	
	Real time monitoring and data collection.	Not all devices have a real-time monitoring system. Some of the machines have real-time monitoring, but data are only available for a few hours.	
	Location system.	Sensors in production support the location system. AGV has a location system and some materials.	
	Factory network and connected processes.	Some of the processes are already connected, but there is a lack of company-wide interconnection.	
Source: Authors			

Consider the realities of the company; it is possible to get the company to the second level of digitization. The third and fourth levels are currently unavailable due to supporting tools and technologies that are not in the company.

Case study B

Case B is an automotive supplier focused exclusively on cockpit electronics and leading the transition of digital cockpits to autonomous management. The company uses automatic conveyors to move goods with one line per type, and AGV supplies the lines. Both humans and robots operate on assembly lines. For production planning, workers using Enterprise Resource Planning (ERP) system, and the warehouse

uses the software warehouse management system (WMS). Table 2 shows relevant points of a support tool that is able to use or company already using in Case B depends on analysis. Based on the analysis, we know that the company already uses digitization in production and logistics. What the company lacks is current and real data, making it easier to plan outputs. And also insufficient use of machines in the workplace, which is also related to outdated data.

This company has the potential to be a smart factory. They are already on the second level: the digital factory. They are currently not working on a virtual model, but the company is using a support tool that is needed. To become a smart factory, the company need to work on real-time monitoring and data collection and essential factory network.

Conclusion

While today's development in ICT allows for the application of technologies that could not have been applied to enterprises until a few years ago, the cost of implementing such solutions is a relatively costly matter for the company. It is complex to identify a level of digitisation that will help a real business make savings at the appropriate cost of achieving them. Each of the levels of digitization contains its specific tools, which is also reflected in their implementation costs. Technological and structural analysis in the form of questionnaires helps in learning the optimal level of digitization. The research goal of the article was a detailed description and comparison of the individual digitization of levels and its tools. The article provided a description of case studies where the analysis of processes was made by forming questionnaires for the purpose of defining the appropriate level of digitization. The analysis results show that the last level of digitalization is not suitable for every company. Research encourages joint investment in some support tools but, on the other side, specifies the most appropriate digitalization level. It all depends on each company's support tools, with one company not being able to achieve the same digitization degree. Appropriate digitization will allow the company to grow and also return on investment as soon as possible. So, profits increase with the finest possible deposit. Further research in the descriptive area will be carried out towards a larger number of participants in the analysis, each of the participants being evaluated by the same test.

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