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ORIGINAL PAPER

SMART FACTORY: THE REQUIREMENTS FOR IMPLEMENTATION OF THE INDUSTRY4.0 SOLUTIONS IN FMCG ENVIRONMENT – CASE STUDY

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ABSTRACT. **Background:** The Industry 4.0 and Smart Factory concepts have gained recognition in recent years and have caught the attention of many authors, which has been evident in various publications in recent years. However, the authors of the following paper have recognised the need for an analysis of the implementation steps of the aforementioned concepts. The results of this analysis can differ, depending on prevailing conditions in a particular country and the technologies and knowledge available.
Methods: On the basis of a literature analysis, the authors of this paper have studied and listed the main requirements for implementing technologies which allow a factory to be described as a Smart Factory. Basic terminology connected with the concept is also described.
Results: On the basis of a self-developed evaluation sheet, and an analysis of literature, the authors have stated the criteria according to which a factory can be described as a Smart Factory, and collated them using an evaluation sheet.
Conclusion: The authors would like to start a scientific debate on the topic of Smart Factories, and emphasise the need for detailed analysis of each step of implementation. The results of the paper show the advantages and disadvantages of modern management strategies and can be used as a guide for businesses which are considering implementing this technology.

Key words: Smart factory, Industry 4.0, Implementation, the newest business ideas.

INTRODUCTION

The production environment has been characterised by highly dynamic changes in recent years. Automation and computerisation are becoming more and more common. Optimisation and streamlining are carried out at various levels. It is common nowadays to use agile and lean management to improve production processes. Entrepreneurs use these concepts to maximise the utilisation of their assets and the availability of resources. On the other hand, new technological solutions are constantly being sought and their purpose is to provide the highest possible quality products and constant, highly reproducible processes. The financial outlays allocated to research and development are on the increase [European Commission 2016], along with a stronger and stronger emphasis on product innovation. It should be noted that the fact that the environment is turbulent is the result of customers' growing expectations and globalisation, which enhances the effects of competition. Gradually, the implementation cycle of new products is becoming shorter and is counted not in years, but months or weeks. That is why enterprises are forced to become more flexible and respond to volatility in markets more quickly. Industry in the 21st century is also characterised by a number of contradictions. Although eco-friendly strategies are established by accomplishing

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ambitious CSR plans, or supporting the battle against the greenhouse effect, there is still a record-breaking amount of waste being generated, as well as the fact that in many countries coal remains the main source of energy. It is also notable that, despite increasing automation and robotisation, there are still some processes carried out manually. This form of production is chosen by enterprises due to the lack of access to suitable technologies, and difficulties in increasing the flexibility of the process using current automation technology. Simultaneously, the problems associated with an ageing society are of increasing concern, alongside a dangerously low unemployment rate in many regions of Poland. Recently, members of the scientific and business communities have pinned their hopes on the success of Industry 4.0 as a remedy for the challenges faced by modern industry. This idea is often defined as the next industrial revolution.

The authors of the following article have decided to trace and identify the prospects of the Smart Factory concept. The essence of the paper is to indicate the attributes which should be distinct to enterprises at different levels of implementation of Industry 4.0 and Smart Factory ideas. Therefore, the authors have decided to organise the terminology and systematise the implementation process. The added value of the article, above all, is the evaluation paper, which may be used as a supportive tool for managerial staff in the transformation to Smart Factories.

INDUSTRY 4.0: SMART FACTORY

Industry 4.0 Concept

The term 'Industry 4.0' originated in Germany and has been in use since 2011 [Kagermann et al. 2011]. It involves the utilisation of wide communication networks [Qin et al. 2016], while using modern technologies (RFID, CPS, IoT, IoS, DM), in production [Lee et al. 2017]. Industry 4.0 was introduced and implemented as a part of High-Tech Strategy 2020, an Action Plan carried out by the German government. Similar ideas have occurred in other countries as well, but under different names, which can be illustrated by Industrial Internet [The Industrial Internet Consortium 2014] in the USA and Internet+ in China.

Industry 4.0 makes use of a modern IT tools. It is based on intelligent, flexible [Lee et al. 2017] and decentralised structures of production inspection. The idea is focused on the integration of Cyber-Physical Systems, based on IoT [Arseni 2016], and production, logistics [Lee et al. 2015], the service industry [Wang et al. 2016] and society's demands.

The purposes of Industry 4.0 are:
- enabling the communication and cooperation of people and machines with the systems of information and communication technology in real time,
- production of individual and non-standard items, manufactured in small production batches [Um et al. 2015] in Smart Factory, based on high automation and efficiency [Lee et al. 2017],
- enabling production process to occur in an flexible, efficient and eco-friendly way in compliance with high quality and low cost,
- attaining a global network of setting value [Frazzon et al. 2013], influencing business models and corporate structure [Kagermann et al. 2013],
- introducing devices to production process, enabling system management in a flexible and dynamic way, considering the importance of a customer [Prause and Weigand 2016].

The idea of Industry 4.0 is bound up with some other technological concepts, such as M2M, RFID, CPS, IoT, IoS or Cloud Computing. By using new technologies, the foundations of the Smart Factory concept are laid, and this idea is enforced as a part of Industry 4.0 theory and facilitates the implementation of radical changes in industry. These changes are required in order to meet increasing customer requirements and to adjust to the expectations of global market.

Smart Factory Concept

The smart Factory concept is a distinguishing feature of Industry 4.0 [Kagermann et al. 2013] (within which it is organised) and the basis upon which the implementation of higher levels of integration is made possible. The idea of a self-contained and intelligent factory has been in use since the beginning of the 21st century [Um et al. 2015].

According to the systematic literature review created by the authors, there are 1372 results in a search for Smart Factory on Web of Science and 1437 articles on Scopus. Using the specified requirements and limiting results to topics related to Industry 4.0, there are 419 unique articles which cover the topic of Smart Factories. In these articles, other topics are often raised. The most common are: internet of things, CPS, automation, big data, sustainability, lean, agile, green growth and others. The most intense development of the concept (regarding articles) began in 2012 (14 unique articles). In the following years the number of articles increased (2013 – 17 articles, 2014 – 35 articles, 2015 – 70 articles, 2016 – 134 articles, 2017 – 99 in the period until October).

A Smart Factory is defined as a smart, independent factory equipped with sensors and orientated towards support for people and machines in carrying out their tasks. A Smart Factory is also defined as a collection of systems which are fully integrated and interoperable and are able to work in real time in response to varying demand, circumstances in the supply chain and customer requirements [Chien 2017].

Its activity revolves around the communication between CPS and IoT, which monitors physical objects and processes in order to create a virtual copy of the physical world. Consequently, making decentralised decisions and remote control is facilitated. As it is based on global networks of cooperation, logistics, production and customers have an opportunity to affect one another in the cloud.

A Smart Factory is characterised by quick adaptation to changes in the market; it also enables goods to be produced in small batches, which are adjusted to customers' needs in an efficient and profitable way.

The purpose of a Smart Factory is to attain the paradigm of sustainable production, which would have influence on lifestyle, culture and organisations [Wang et al. 2016].

Research shows that enterprises that pay more attention to innovation are also the ones which experience the most impressive growth in turnover [Roblek et al. 2016]; thus, the Smart Factory concept should be understood as an opportunity for businesses. Implementing the idea deals with most of the needs of the modern production environment. Smart Factories may turn out to be a solution for the growing needs of customisation and also customers' input into the range of products offered by enterprises. Furthermore, it is likely to adapt to new standards without any loss of flexibility and efficiency. The changeability of the process, frequent changeover (retooling) or very short production cycles should be one of the main benefits of the automation and acceleration of the process, which is possible due to the utilisation of new technology and robotisation. High repetitiveness is also essential, and this goes beyond human capabilities. All of those qualities must not influence the quality of the goods manufactured; on the contrary, they should maintain the highest standards in accordance with World Class Manufacturing.

It should be noted that a Smart Factory is a unit characterised by a perfect flow of information, an ability to adjust to various requirements easily and a high level of data safety and which takes the special role of the customers into consideration. Owing to the technologies used, systems in a Smart Factory keep track of and are capable of using acquired real-time data in order to develop a model of virtual reality. According to this concept, the unit is equipped with a decentralised system able to make decisions on its own, respond to current and accurate information and notify senior staff if necessary.

IMPLEMENTATION PROCESS

Requirements for the Concept

The Smart Factory concept is based on integrated processes which should improve both flexibility and efficiency. Additionally, the idea of a smart production centre is very often presented as an opportunity to improve sustainability. These goals, as well as the successful implementation of the concept, may be accomplished thanks to 1) vertical integration of the participants within an enterprise [Prause and Weigand 2016], 2) horizontal integration with external participants [Kagermann et al. 2013] and 3) End-To-End Integration consisting of, amongst others, customers' requirements, design and product development and production engineering which facilitates product re-use at each stage [Wang et al. 2016]. Therefore, a Smart Factory demands high levels of teamwork skills [Liu, Q. et al.. 2015].

The implementation of Smart Factory ideas makes sustainable production attainable; the production tackles global challenges - which is, nevertheless, fraught with some technical, technological and organisational obstacles. The enterprise must possess financial resources and qualified staff to implement the concept and be characterised by an innovative approach, readiness to develop the production systems and strong integration, both internal and external; maturity and willingness to implement this quality are also essential [Schumacher et al. 2016]. Moreover, a high level of aggregation, analysis and data usage is imperative. This applies not only to the fast-moving consumer goods industry but can be treated as a common requirement. A Smart Factory is supposed to have access to various resources which enable the Factory to produce diverse and customised wares in small batches and to have a flexible production system at its disposal, which provides quick, automated retooling and optimal production.The implementation of a Smart Factory requires: 1) a proper network infrastructure, smart controllers, analytics software with integrated information systems and 2) the utilisation of new technologies, including: IoT, cloud computing, Big Data and technology using artificial intelligence.

Amongst the requirements essential to implementing the Smart Factory concept, the following are also mentioned [Hermann et al. 2016]:

- Interoperability - it is necessary to communicate efficiently using IoT and IoS between, 1) CPS within the enterprise and 2) an enterprise, CPS and people.
- Virtualization - it provides support for people while using complex technical systems. It is essential in order to control physical processes by CPS and create a virtual copy of the physical world, based on data deriving from simulation models which gain the actual data in accordance with safety regulations [Gorecky et al. 2014].
- Decentralization - it is required due to the soaring demand for customized products, which hinders central controlling and managing. CPSs are adjusted to make decisions independently, according to the designed model. Emergency situations in which a specific employee is assigned to the task constitute an exception [Ten Hompel and Otto 2014]. On-going inspection of systems and possibility of identifying items thanks to RFID technique provide fine quality of the action and high level of flow control [Cyplik, Patecki 2011]; moreover, it gives the chance to track the commodities in real time.
- Real-Time Capability - concerns the need for collecting and analysing solid and up-to-date information in real time. Current situation in the enterprise is permanently supervised and, as a consequence, the company may react immediately to any machine failure and shift the products to other devices [Tyrin et al. 2012].

The implementation of the Smart Factory concept provides e.g. flexibility, owing to its adaptability to volatile demand and optimisation of production of highly-customised goods in smaller batches, commensurate to the demand [Bateman and Cheng 2007].

It is expected that changes in production processes, as a part of Industry 4.0, are going to accelerate within the next 3 years. Industry 4.0, of which Smart Factories are a part, is going to provide integration of production processes and supply chains and make them more efficient and flexible [Roblek et al. 2016].

The analysis of implementation process

The authors of this article discovered an abundance of literature concerning the definition of a Smart Factory and its requirements. Based on these studies, it is easy to describe the features of a Smart Factory. Regrettably, despite such avid interest in this issue, the authors have noticed lack of clarity concerning the implementation of the concept and the practical aspects of its development. Amongst businesses, a lack of knowledge concerning the operational implementation of this concept has been identified. With reference to the above-mentioned knowledge deficit, the authors suggest a model procedure of implementation.

To start the realisation of Smart Factory concept, an appropriate level of maturity should be gained and a number of requirements should be fulfilled, including:

- the access to technologies, which will be used for automation and robotization of production processes,
- the access to qualified staff, who will be able to operate devices and software which will be installed,
- the ability to organized aggregation of data of production process,
- a repeatable production process, realized in accordance with acquired standards,
- the readiness to internal integration within a company and close cooperation with other links in the supply chain,
- the access to an appropriate capital budget.

After fulfilling the above-stated requirements, an enterprise can begin the implementation process. The process should begin with building a sufficient digital culture within factory [Wang et al. 2016]. This step consists not only of training staff and improving their knowledge but also encouraging teams to become individual initiators of change. Change in the factory requires full understanding of the concept within senior management and clear leadership. The next phase, which is a key phase in preparation for change and the utilisation of all available technologies, is to achieve perfection in the aggregation and analysis of available data. Data plays a crucial role in the management system, especially in a Smart Factory, where all decisions should be made on the basis of correctly aggregated data. It also must be stored safely, and secure from malware. Data management can be a key point and one of the biggest challenges for enterprises aspiring to become Smart. According to the authors' experience and available case studies, many companies are focused on gathering an extraordinary amount of data, without the capability to use and analyse it. Additionally, very often only certain individuals are familiar with the data collection process, which makes it difficult to replace those people or pass on their the knowledge to other employees [Wang et al. 2016]. It is a common mistake to gather data from systems which are not integrated, or to collect significant amounts of useless information. In a Smart Factory, there is a clear requirement to focus on crucial information which will be used within the production process, and will allow the management team to monitor it. It is also required to build appropriate expertise in the team and install the required technologies, according to an investment plan. This should allow a desirable level of automation to be reached, enabling robotics to replace operators. In further steps, they will be able to focus on research and development. Authors suggest that this process has to be gradual and treated more like an evolution than a revolution. This will make the change more feasible, and organisations will be able to fully integrate systems while avoiding mistakes and issues resulting from the complexity of the change. It is also very important to equip planned technology with all safety and quality requirements. Technology has to ensure efficient and stable production before it can be installed. The approach should be to choose technology according to current requirements, not according to the availability of different

options on the market. If requirements cannot be met, the implementation process has to be delayed until sufficient solutions are developed (thanks to intensive cooperation with machine suppliers).

During the implementation process, the enterprise has to focus also on integration. This has two different directions – vertical and horizontal. It requires high culture inside the company and also within the supply chain. It is also crucial from a data perspective, because is essential not only in the factory but also between suppliers and retailers. This data has to be transferred and stored safely, while being made available to co-operators. Cooperation should lead to a high level of predictability, which reduces operating risk [Lee et al. 2017].

In the next phase, after meeting all previously stated requirements, enterprises should integrate with clients, who play a key role in the production process as all the products can be fully customised. Therefore, technology has to be prepared to cater for atypical demands and to deal with the complexity of the production process. This is why integration with customers is based not only on the incorporation of a customer's interface into the system, but also on maximising the possibility of customisation. The above-stated proposal of implementation steps is only one of many possible ways to become smart within a factory. Choosing the right order is not as crucial as including all the listed steps and features. These should be considered as undisputed requirements to implement the Smart Factory concept. Each enterprise has to go through a phase of installing new interconnected systems and technologies, which work as part of the Internet of Things. Full integration of systems and increased automation still ensures agility and efficiency while all decisions are based on gathered, analysed data and supported by simulation models.

SMART FACTORY CONCEPT'S EVALUATION SHEET

On the basis of the requirements outlined in chapter three and the implementation process described, the authors prepared an evaluation sheet. The sheet can be used to identify and describe a particular factory and its level of implementation of the Smart Factory concept. The evaluation sheet should be used not only for a single examination of implementation within the company of Smart Factory concepts, but can also be used as a tool for systematic research on the features of the concept which are described in this paper. In this research, several factors should be taken into consideration. The sheet should lead to better understanding of current situation in the factory and see at which point on the "road to Smart" it is. On the basis of the sheet, areas which require improvement can be discovered, so reaching the next implementation phase is more feasible.

Authors suggest distinguishing three different implementation phases within company:
- aspiration phase,
- maturity phase,
- Smart Factory.

For each above stated phases, separate attributes were described. They consist of different features and characteristics which are crucial to reach next phase of implementation. These features were distinguished into three evaluation areas:
- human factor,
- technical / organizational,
- management.

Evaluation sheet is shown in Table 1.

On the basis of a systematic literature review and the results of a detailed case study, table 1 was formulated. The authors have distinguished implementation phases which are divided according to different factors, such as the level of maturity of the organisation or its ability to implement Smart Factory requirements. The evaluation areas shown in Table 1 are described in detail by the features and characteristics mentioned. A factory can be studied and matched to one of the three phases by a simple comparison to the described features from the table.

Table 1. Smart Factory concept's evaluation sweet

Implementation phase	Evaluation area	Feature	Characteristic
Aspiration	Human factor	Staff qualifications	Team has qualified individuals including IT specialists and automatics engineers.
	Technical / organizational	Cooperation, communication skills	Individuals are capable to work in teams.
		Financials	Budget is sufficient for investments into staff and technology.
	Management	Data	Enterprise aspires to aggregate available data effectively.
		Machine park equipment	Sufficient technology is available: including IT solutions.
		Tools and technologies	Automation and robotics of single processes. Part of the machine park is equipped in PLC steering.
		Vertical integration	Readiness to cooperate with other departments, within enterprise.
Maturity	Human factor	Staff qualifications	Operational employees have analytic skills and operate with available IT software.
		Cooperation, communication skills	Teams gain autonomy and can easily cooperate with others.
	Technical/ organizational	Data	Software and systems are fully integrated data wise. Enterprise is implementing Big Data concept.
		Tools and technologies	-Internet of Things is implemented gradually. More elements are included in the net. -Simulation models are used in decision process and production steering. -RFID (or similar technology) is widely used in the factory for track and trace. -Monitoring and cooperation is built within machine park.
	Management	Vertical integration	Full cooperation between departments.
		Horizontal integration	Readiness to cooperate with other companies in the supply chain and potential co-operators.
Smart Factory	Human factor	Staff	No operational employees in the machine park. Staff consists of expert. Employees are controlling the process and react to system warnings if necessary.
	Technical/ organizational	Data and its correctness	-World class in aggregation, analysis and data interpretation. -Aggregated data is effectively stored. Data is valid, up to date and allows sufficient production steering.
		Tools and technologies	Full integration of all installed tools and technologies.
		Research and development	-Big investment pressure in research and development area. -Staff is being moved to such departments from the shop floor if possible (skills and knowledge wise).
		Virtualization	Simulation models used for all decision required processes.
		Real-Time Capability	Monitoring of current state and real-time capability.
		Safety	Data base is fully secured.
		Horizontal and End-to-End integration	Factory as an integral element of a supply chain cooperating with companies within the branch and also outside.
	Management	Client	High level of integration with clients. Products highly customized according to market demand.
		Organizational structure	High level of autonomy and decentralization.
		Control	Demand driven planning according to single clients' orders.

Source: own work

It is worth underlining that the implementation process of the Smart Factory concept needs to be developed as an evolution. A revolutionary approach is undesirable. The process itself should develop all features within the factory and steadily move forward towards the Smart Factory phase. Employers should also be aware of attributes which are not included in the table above. These are the characteristics which should appear in each phase of implementation. A company, besides all other issues, should be ready for the upcoming change. Sufficient knowledge about the concept is also required. The steering committee must additionally be sure of the advantages and disadvantages of the concept and should support other employees during the change. Motivation should be recognised not only within the management team but also in production, in operating teams. At the same time, the company still needs to be focused on technological development and should concentrate on the market and its clients. Finally, each enterprise willing to move

towards implementing a Smart Factory should be aware of the financial risks and should be financially prepared. This includes not only investments into hardware or automation, but also into staff and training. These are preliminary requirements which are essential in the first stage of the process, and remain important at all implementation phases. Without these elements in place, it will be difficult to complete the implementation process.

It is also worth mentioning that the characteristics of an enterprise in the initial stages of implementation (like those described for the aspiration phase) should be updated or even improved in later phases. It often happens that some standards or processes are forgotten after some time and this cannot happen in a successful Smart Factory. The best example is the integration phase. In the aspiration phase, the enterprise is supposed to be vertically integrated and ready to cooperate within the factory (between teams or departments). The next stage, which is described in the maturity phase, is a step towards full integration between departments (improvement on the previous feature) and development towards horizontal integrity with other elements of the supply chain. In this stage, readiness for cooperation on the market should be mentioned, considering the usage of resources located in other supply chains, even in other markets. Finally, in the Smart Factory phase, the enterprise should be fully integrated, maintaining the previous adaptations. A Smart Factory should be able to produce flexibly, including insourcing demands from other markets and also using resources of other companies. The Smart Factory phase consists of End-to-End integration and a key role for the client (as production is driven by demands from clients).

SUMMARY

The Smart Factory concept is becoming more popular in both theoretical studies and practical cases. Due to number of different factors and requirements which Smart Factories have to face, it is extremely difficult to show a fully integrated factory which meets all the requirements to be called Smart. Not only is financial investment a barrier, but also the required technology, level of automation and IT software or ability to aggregate and use data safely is difficult to obtain. Even if the technology is available, it rarely meets efficiency or agility requirements. It may happen that tools or machines do not ensure the right level of quality for the process.

Implementing the Smart concept requires sufficient resources, qualified and trained staff and well organised processes, which are sufficiently flexible and innovative. This applies to all departments and elements in the supply chain. Automation is currently becoming more popular only to a certain extent. Some activities within factories (like preventive maintenance activities, controlling or value added services) have to be completed manually to maintain the expected agility. Despite these obstacles, the Smart Factory concept seems to be a very popular goal for modern production sites and is being discussed more frequently between entrepreneurs. Industry trends have been driven in recent years by the automotive industry. New technologies and management concepts usually originate in factories producing cars. This is why we can guess that first case of a fully Smart Factory will be implemented in the automotive industry. The main advantage of the Smart Factory concept which the authors of this paper would like to highlight is the high level of process standardisation, due to which the production process remains stable while maintaining a high level of flexibility and agility. Smart Factories can meet variable demands and clients' needs. Smart Factories also move staff from production (which is usually least safe area within factory) to other departments which do not affect health to the same extent. This also decreases the possibility of human error and further stabilises the production process. Staff are involved in decisions and managing processes, and can focus on research and development.

On the other hand, there are clearly some disadvantages of Smart Factories, such as high costs, lack of awareness among people involved in implementation, insufficient technology and limited capabilities to secure

data correctly. Nowadays, when cyber-attacks are so frequent and dangerous, the safety of data is especially important. Lacking the capacity to secure data in the right way is very risky. Recent examples showed that this can lead to major stoppages of production centres and long breakdowns.

Analysis completed by the authors indicates the complexity of the requirements which must be met in the evolutionary implementation process of an intelligent factory. The evaluation sheet which was prepared can be used as a tool for describing and rating the phase of implementation, and also can support management teams in setting further targets. A benchmarking process using the evaluation sheet developed can also be a part of further research. It is important to bear in mind all other factors and points which are not stated in the sheet, and which are treated by the authors as an undeniable necessity for initiating the process.

The profitability of Smart Factories is the aspect that most requires further research. To end up with a clear profitability statement, some serious discussions between factory representatives and software and hardware providers should be held. As a part of further research, the authors suggest answering the following questions, which could lead to a more detailed description of profitability:

- What can be achieved with Smart Factory concept beyond current production capabilities?
- Can we gain, thanks to implementation, faster and cheaper production?
- What is the cost of labour in the particular area and does it pay off to replace it with expensive equipment ?
- What is general return of investment in the case of Smart Factory implementation ?
- Do factories are mature enough to implement Smart Factory?

Obtained answers can lead to more detailed description of profitability case study and will indicate further steps of research.

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SMART FACTORY: WDROŻENIOWE WYMAGANIA ROZWIĄZAŃ KONCEPCJI INDUSTRY 4.0 W BRANŻY FMCG – CASE STUDY

STRESZCZENIE. **Wstęp:** Koncepcje Industry 4.0 i Smart Factory zyskują popularność i znajdują się w obszarze zainteresowań wielu autorów, co potwierdzają publikacje z ostatnich lat. Jednak autorzy poniższej pracy dostrzegli potrzebę szczegółowej analizy etapów implementacji wyżej wymienionych pojęć. Wyniki analizy mogą się różnić w zależności od warunków panujących w danym kraju oraz technologii i dostępności wiedzy.

Metody: Na podstawie systematycznego przeglądu literatury, autorzy niniejszego artykułu zbadali i wymienili główne wymagania dotyczące wdrażania technologii, które pozwalają określić fabrykę jako Smart Factory. Omówiono również podstawową terminologię związaną z koncepcją.
Wyniki: Na podstawie samodzielnie opracowanego arkusza oceny i analizy literatury autorzy opracowali wskaźniki, którymi powinny cechować się zakłady produkcyjne aspirujące do miana Smart Factory.
Wnioski: Autorzy chcieliby rozpocząć naukową debatę na temat Smart Factory i podkreślić potrzebę szczegółowej analizy każdego etapu wdrażania koncepcji. Wyniki pracy wskazują na zbilansowane zalety i wady nowoczesnych strategii zarządzania i mogą być wykorzystane jako podstawa dla środowisk biznesowych, które rozpatrują ich wdrożenie.

Słowa kluczowe: Smart factory, Industry 4.0, wdrożenie, nowoczesne koncepcje

SMART FACTORY: ANFORDERUNGEN FÜR DIE EINFÜHRUNG VON LÖSUNGEN DES KONZEPTES INDUSTRY 4.0 IN DER FMCG-BRANCHE – EIN STUDIENFALL

ZUSAMMENFASSUNG. Einleitung: Die Konzepte wie Industry 4.0 und Smart Factory gewinnen heutzutage an Popularität und erfreuen sich eines wachsenden Interesses seitens zahlreicher Autoren, was die betreffenden Veröffentlichungen in den letzten Jahren bezeugen. Die Autoren der vorliegenden Arbeit haben jedoch die Notwendigkeit einer detaillierten Analyse von Etappen der Implementierung der oben genannten Begriffe wahrgenommen. Die Ergebnisse der Analyse können in Abhängigkeit von Gegebenheiten eines Landes, von der Technologie und von der Wissensverfügbarkeit unterschiedlich ausfallen.
Methoden: Auf Grund einer systematischen Literaturübersicht erforschten die Autoren des vorliegenden Artikels die Hauptanforderungen für die Einführung von bestimmten Technologien, die eine Fabrik als Smart Factory bezeichnen lassen. Dabei wurde auch die mit dem Konzept verbundene Terminologie besprochen.
Ergebnisse: Anhand eines selbstständig ausgearbeiteten Beurteilungsbogens und der Analyse der Fachliteratur haben die Autoren Kennziffern, welche die den Namen Smart Factory anstrebenden Produktionsbetriebe kennzeichnen sollen, ermittelt.
Fazit: Die Autoren möchten eine wissenschaftliche Debatte zum Thema Smart Factory anbahnen und die Notwendigkeit einer detaillierten Analyse einer jeden Etappe der Konzepteinführung hervorheben. Die Forschungsergebnisse weisen auf die ausgeglichenen Vor- und Nachteile moderner Management-Strategien hin und können auch als eine Grundlage für die geschäftsführenden Ebenen, die eine Einführung deren erwägen, in Anspruch genommen werden.

Codewörter: Smart Factory, Industry 4.0, Einführung, moderne Konzepte

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