Available online at www.sciencedirect.com

ScienceDirect

Procedia Manufacturing 38 (2019) 1691–1696

Procedia MANUFACTURING

www.elsevier.com/locate/procedia

29th International Conference on Flexible Automation and Intelligent Manufacturing (FAIM2019), June 24-28, 2019, Limerick, Ireland.

Determination of Changes in Process Management within Industry 4.0

Andrea Benešová[a], Martin Hirman[a], František Steiner[a], Jiří Tupa[a]*

University of West Bohemia, Department of Technologies and Measurement, Univerzitní 8, Pilsen 301 00, Czech Republic

Abstract

The company's ability to adapt to rapid market changes will be among the key factors for Industry's competitiveness within Industry 4.0. The basic of flexibility is quick respond to customer requirements and well-set and controlled production processes. Processes of Industry 4.0 will be different from existing processes, not only in terms of using new technologies such as digitization or augmented reality, but also in terms of management and support processes. The main aim of the article is possible changes determination of process management within Industry 4.0. For that, the current production process will be compared with the process in Industry 4.0. The described changes within Industry 4.0 will also have an impact on the organization architecture of company. The changes will be also in the production environment and in the supply chain. The described changes in the process management will also have an impact on the company risks. The main risks of changes within Industry 4.0 will be summarized in the article.

Keywords: Digitization; Industry 4.0; Process Management; Risk Management; Smart Factory

1. Introduction

One of the important goals of each business is its competitiveness, i.e. the promotion of a particular business. The same goal will be important also for smart factories in the future. Competitiveness of companies depends on their

2351-9789
10.1016/j.promfg.2020.01.112

competitive advantages. The competitive advantage of a company is represented by various factors such as property ownership, technology, resources, highly qualified employees, but in the first place by flexibility. The company's ability to adapt to rapid market changes will be among the key factors for Industry's competitiveness within Industry 4.0. [1] The development and implementation of digitization and new technologies into production have caused changes in the industry, referred to as Industry 4.0. Industry 4.0 marks a new industrial revolution based on connection of virtual and real world. The main vision of Industry 4.0 is the emergence smart factories. [2] In the smart factory a machines will be connected to the Cyber-physical systems (CPS). This system will allow the communication and also cooperation of independent units (sensors, machines). The units will be able to decide independently, manage the assigned technological units and become an independent and full-fledged member of complex production processes. [3] The building blocks of smart factory are the nine foundational technologies – Autonomous robots, Internet of Things (IoT), Big data, Simulation, Horizontal and Vertical system integration, Cloud computing, Cybersecurity, Additive manufacturing and Augmented reality.

These nine technology trends will transform production into a fully integrated, automated and optimized production flow. Production processes must be connected to production planning, supply and customer processes. The timely analysis of the obtained data (Big Data) from the production processes will be important for planning resources, maintenance and managing of the flexible production. [4] Therefore, the company is forced to constantly adapt its business to the external influences of the market. Hammer and Champy describe these impulses as the "3C". Each C then represents one impulse - customers, competition and change. [5] The basic of flexibility is quick respond to customer requirements and well-set and controlled production processes. This is mainly related to business process management (BPM). Process management is characterized as a systematic activity that includes identification, description, measures, management, evaluation and improvement of processes. Different systems, methods, tools are used for this systematic activity. Management thus contributes the creation of new value in the production process. But the Industry 4.0 introduces a new approach to organizing and managing production.

One research question is linking with the future of the process management and its implementation for concept Industry 4.0. This paper tries to find answer for mentioned research question based on review of suitable technologies and methods for BPM and risk management implementation.

2. Literature review

Currently various unique process control and optimization solutions are used for process management. These solutions combine Internet of Things (IoT) technology and advanced process control methods based on mathematical modeling, predictive control or neural networks. Mathematical method is used to model a controlled system in detail and propose optimal settings for an existing management system for higher efficiency, higher quality, or resource reduction. [6] Furthermore, IoT technology is also used to measure process performance itself or only certain desired factors (pressure, temperature or humidity). [7] This industrial revolution will affect not only changes in manufacturing processes (implementation of new technologies) but also have an impact on the management of processes (Lean 4.0), related processes (supply chain), the organization architecture of company and Human Resources. [8] The Lean principles will be changed by the integration of specific Industry 4.0 tools and methods. The application of modern information and communication technologies (ICT) into Lean Production Systems can improve the performance of Lean Productions Systems by gaining more efficient production and logistics processes. [9]

2.1. Business process management (BPM)

Business Process Management (BPM) is a set of activities that relate to planning and performance monitoring of company´s processes. These activities are design, modeling, execution, monitoring, and optimization. Management is done over time and in the following steps – identification of process, established of goals, determination of the control algorithm, organization, decision and control. [10] The basis is the model of the process itself. In the Fig. 1, there is description of the production process.

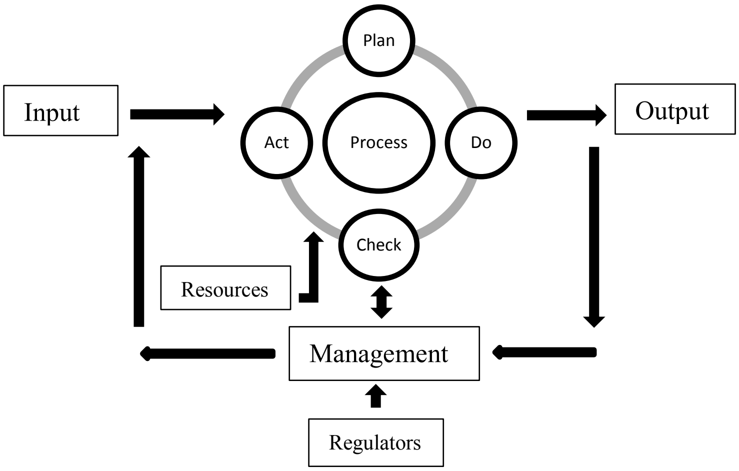

Fig. 1. Description of production process

2.2. General production process model

Each process is determined using these attributes:

- Inputs and Outputs of process
- Resources of process
- Process boundaries
- Owner
- Supplier/Customer

The customer is important for the analysis of the company's basic processes. The company must produce products that respond to the customer's requirements. For this reason the production process must be flexible, adaptable and varied. The customer may be external or internal. An external customer is a consumer who pays for the final product (output). An internal customer is a customer within the organization or the organization itself (the organization is a customer for its supplier). Another important attribute is the process resources, resources are further divided into human, financial, information and infrastructure. Regulators are the various laws, standards and internal regulations that affect the process. Deming or PDCA cycle is a management method used for control and continuous improvement of processes. This method has four step – plan (planning the intended improvement), do (implementation of plan), check (verification of the result of the implementation compared to the original plan) and act (implementation of improvements to practice).[11][12] This is a description of the general production process model by the BPM that will compare with Industry 4.0 production process model.

3. Comparison between current production process with the process of Smart factory

3.1. Production process of smart factory

The smart factory production process can be defined as connected and flexible manufacturing system. The devices will be connected by the Cyber-physical systems (CPS) and Internet of Things (IoT). A machine to machine communication (M2M) will be created. This manufacturing system will be continuous stream of data (Big Data) from production devices to learn and adapt production process to new demands. [13] The digital image of factory will be obtained in real time from the visualization of this data. This digital twin of factory will be necessary for manage the production process. Using a digital twin, companies can experiment, monitor, predict, simulate, and decide different situations in production. So companies can fine-tune all the details, but also any device errors without the risk of time or financial loss. [14] This is also related to Cybersecurity, the data from production and products will represent know-how of company. As a result, the number of cyberattacks is expected to increase. The attacks will be mainly aimed at disrupting the company's production process. This also will relate to changes in process regulators. The input of process will be a RFID sensor, QR code or barcode that will contain all information about product. Each product will be unique to the customer's requirements. The machine will communicated with sensors and on the basis of the necessary information from the sensor, adapt the production of the product and supply chain management. The IoT sensors can be used for communication between machine and supplier of material. At present, the process owner was responsible for the process. In most cases, the process owner is a person, for example company owner or employee. The process owner in smart factory can be a machine, system or a person. Because the machines and the system will customize the production process on the basis of the previously collected data. But the person who manages the entire system can also be the process owner. Changes in organizational structure and human resources also relate to this issue. It is expected that some professions will be replaced because only qualified employees will be able to control the new technologies. Companies will primarily need employees with skills and knowledge in information technology, for example to Cybersecurity and Data analysis sector. [15]

3.2. SIPOC (Supplier, Input, Process, Output, Customer)

The abbreviation SIPOC is a composite of the first letters of the English words: Supplier, Input, Process, Output and Customer. It is another method used to describe the process and it is a tool for process improvement. Also we use this method for description of general production process for compare with production process of smart factory. In the Table 1., there is a description of general and simplified production process by SIPOC. The brainstorming with experts was used for creation of this SIPOC.

Table 1. SIPOC of general production process

S	I	P	O	C
Customer	Order	Receipt of the order	Product specification	Production
Production	Product specification	Preparation of production plan	Production plan	Manager of production
Manager of production	Order	Order of materials (warehouse)	Delivery of material	Assembly line
Assembly line	Material	Production of the product	Product	Quality Department
Quality Department	Product	Quality control	Final product	Separation of packaging
Separation of packaging	Final product	Packaging of the product	Packaged product	Supplier
Supplier	Packaged product	Delivery	Packaged product	Customer

If we compare this simplified manufacturing process with the smart factory process, we will see that major changes occur with the suppliers and customers of the process. The customer and order of the product remains the same but the process of receipt of the order and output can be change. For the order, the customer can use the IoT service and then the output will be a sensor that will contain all the specifications of product from the customer. The customer of this sensor will be a machine that can communicate with this sensor and other devices in production. Using this communication, the system itself will plan and set the production plan and production process. The system and machine will contact the material supplier if necessary by the IoT sensors. The quality control of product should be performed by an employee. Packaging of the product will be provided by the machine which then contacts the supplier.

3.3. Risk Management

The implementation of new technologies will impact not only Business Process Management but also to Risk Management. To assess the risks, the company will be using the digital twin of production that will enable company predict, simulate different situations in production and thus reduce the potential risk. Within Industry 4.0, new risks are emerging for companies, the cybersecurity and Human Resources will be the biggest risks. The semi-quantitative risk assessment method was used for evaluating risks. The analysis of risks was provide in four steps – identification of risk, evaluation of probability, evaluation of impact and calculation of Risk value (RV). Risk identification was conducted based on brainstorming with experts and literary research. Then, impact (I) and probability of occurrence (PoO) were established for each risk. The value and levels of impact (I) are 1 (very low), 2 (low), 3 (medium), 4 (high) and 5 (very high). The value and levels of probability of occurrence (PoO) are 1 (rare), 2 (unlikely), 3 (possible), 4 (probable) and 5 (highly probable). [16]

$$\boldsymbol{Risk\ value\ (RV) = Probability\ of\ Occurrence\ (PoO) \times Impact\ (I)} \quad (1)$$

The risk value (RV) is calculated according to the equation. The risks can be classified by the risk value into several categories. The most common categories of risk value (RV) are 1 to 3 (low), 4 to 9 (medium), 10 to 15 (high) and 20 to 25 (very high). [17]

Table 2. The list of identified and evaluated risks

Identified risk	Probability	Impact	Risk value
Lack of own financial resources	4	5	20
Subsidy from the state	4	3	12
Lack of qualified employees	4	5	20
Lack of Cybersecurity	4	5	20
Lack of knowledge about Industry 4.0	4	5	20
Improper maintenance of the machine	2	5	10
Power outage	3	5	10
CPS system failure	3	5	15
Poorly evaluated data (Big Data)	2	5	10
Loss of know-how	3	5	15
Loss of customers	2	5	10
Production of defective product	2	5	10
Non-innovative product	3	5	10
Damage of sensor with product specification	1	5	5
IoT network failure	3	5	15
Crash (fire, chemicals)	1	5	5

4. Conclusion

Based on a comparison of the general process with the intelligent manufacturing process, it was found that from the point of view of the general description of the process no changes will occur. Process attributes also will be inputs and outputs, resources, process boundaries and supplier/customer. Changes appear only within individual attributes and division of processes. Because every smart factory production must to include the following Autonomous robots, Cyber-physical system and Internet of Things (IoT). The autonomous robots, Cyber-physical system and Internet of Things (IoT) will be a mandatory resources of production process. Cyber-physical system can also be understood as a management process of smart factory production process. On the contrary, Internet of

Things (IoT) can be understood as a supporting process. Another change is in attribute of customer, customer can be person but also machine or manage cyber-physical system (CPS). In the production process will appear new inputs in the form of sensors or codes (QR code, barcode) that will contain product specifications. Another change in terms of Business Process Management will be in the regulators of production process. As a result of the expected increase of cyber attacks, laws and standards will need to be updated. Similarly, standards relating to place the product on the market or customer protection. Horizontal and Vertical system integration will occur another change in terms of enterprise architecture. This will remove hierarchical levels to ensure a better flow of information. Temporary parallel structures will also be introduced such as project or realization teams. Following a risk analysis, it was found that very high risk of Industry 4.0 are lack of own financial resources, lack of qualified employees, lack of Cybersecurity and lack of knowledge about Industry 4.0. Corrective measures should be established for these risks.

Acknowledgements

This research has been supported by the Ministry of Education, Youth and Sports of the Czech Republic under the RICE – New Technologies and Concepts for Smart Industrial Systems, project No. LO1607 and by the Student Grant Agency of the University of West Bohemia in Pilsen, grant No. SGS 2018-016 "Diagnostics and Materials in Electrical Engineering" and by the Technology Agency of the Czech Republic under the project Software platform to accelerate the implementation of management systems and process automation — project No. TH02010577.

References

[1] O. Flak, G. Głód, Verification of the Relationships between the Elements of an Integrated Model of Competitiveness of the Company, Procedia - Social and Behavioral Sciences, Volume 207, 2015, pages 608-631,ISSN 1877-0428, https://doi.org/10.1016/j.sbspro.2015.10.132.

[2] J. Lee Smart Factory Systems, Informatik-Spektrum, 38 (2015), pp. 230-235.

[3] J. Lee A Cyber-Physical Systems architecture for Industry 4.0-based manufacturing systems A Cyber-Physical Systems architecture for Industry, Society of Manufacturing Engineers 2014 ; 3: 18-23. DOI: 10.1016/j.mfglet.2014.12.001.

[4] Alejandro Germán Frank, Lucas Santos Dalenogare, Néstor Fabián Ayala, Industry 4.0 technologies: Implementation patterns in manufacturing companies, International Journal of Production Economics, Volume 210, 2019, Pages 15-26, ISSN 0925-5273, https://doi.org/10.1016/j.ijpe.2019.01.004

[5] Hammer, M., Champy, J. Reengineering - radikální proměna firmy: manifest revoluce v podnikání. 3. vyd. Praha : Management Press, 2000. 212 s. ISBN 8072610287.

[6] Foxconn 4Tech, 'IoT pokročilé řízení procesů'. [Online]. Available: https://www.foxconn4tech.com/iot-pokrocile-rizeni-procesu. [Accessed: 12-May-2019].

[7] Alternativo, 'IoT čidla. [Online]. Available: https://www.alternetivo.cz/monitoring-a-iot-iot-cidla_c2119.html. [Accessed: 12-May-2019].

[8] Fatemeh Rahimi, Charles Møller, Lars Hvam, Business process management and IT management: The missing integration, International Journal of Information Management, Volume 36, Issue 1, 2016, Pages 142-154, ISSN 0268-4012, https://doi.org/10.1016/j.ijinfomgt.2015.10.004.

[9] U. Dombrowski, T. Richter, P. Krenkel, Interdependencies of Industrie 4.0 & Lean Production Systems: A Use Cases Analysis, Procedia Manufacturing 11 (2017) 1061–1068.

[10] Jan vom Brocke, Sarah Zelt, Theresa Schmiedel, On the role of context in business process management, International Journal of Information Management, Volume 36, Issue 3, 2016, Pages 486-495, ISSN 0268-4012, https://doi.org/10.1016/j.ijinfomgt.2015.10.002.

[11] Daniel Paschek, Larisa Ivascu, Anca Draghici, Knowledge Management – The Foundation for a Successful Business Process Management, Procedia - Social and Behavioral Sciences, Volume 238, 2018, Pages 182-191, ISSN 1877-0428, https://doi.org/10.1016/j.sbspro.2018.03.022.

[12] Krzemień E., Wolniak R. 2007. Analysis of process of constant improvement of six sigma. In Current trends in commodity science. Proceedings of the 9th International Commodity Science Conference (IGWT), ed. R. Zieliński. Poznan University of Economics Publishing House. Poznan, pp. 227-232

[13] Hermann Meissner, Jan C. Aurich, Implications of Cyber-Physical Production Systems on Integrated Process Planning and Scheduling, Procedia Manufacturing, Volume 28, 2019, Pages 167-173, ISSN 2351-9789, https://doi.org/10.1016/j.promfg.2018.12.027.

[14] L. Monostori, G. Erdos, B. Kadar, T. Kis, A. Kovacs, A. Pfeiffer, J. Vancza Digital Enterprise Solution for Integrated Production Planning and Control Computers in Industry, 61 (2010), pp. 112-126

[15] Andrea Benešová, Jiří Tupa, Requirements for Education and Qualification of People in Industry 4.0, Procedia Manufacturing, Volume 11, 2017, Pages 2195-2202, ISSN 2351-9789, https://doi.org/10.1016/j.promfg.2017.07.366.

[16] Radu L., Qualitative, semi-quantitative and, quantitative methods for risk assessment: Case of the financial audit, Analele Stiintifice ale Universitatii "Alexandru Ioan Cuza" din Iasi - Stiinte Economice Vol. 56, 01/2009, 643-657.

[17] Zuraini Jusoh et all, Determination of Hazard in Captive Hotel Laundry Using Semi Quantitative Risk Assessment Matrix, Procedia - Social and Behavioral Sciences, Vol. 222, 2016, 915-922