Aspects of Training in the Field of Operations Management with Respect to Industry 4.0

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***Abstract*—Industry 4.0 is considered as a set of related technology and digital solutions that, on the one hand, support the development of automation, integration and real-time data exchange in production processes and, on the other, lead to changes that business, society and humans (either as consumers, or as employees) should be adapted to. New production environment based on the Internet of Things, Industrial Internet, Cloud-based Manufacturing and Smart Manufacturing, creates also new requirements for the operations managers running the production system.**

The present paper discusses the requirements concerning education and training in the field of Operations Management, particularly with a view on ensuring efficient management of the production system with respect to an Industry 4.0 environment.

***Keywords*—Industry 4.0, Internet of Things, Digitalization, Smart Manufacturing, Manufacturing System, Operations Management Training.**

I. INTRODUCTION

The entry of Industry 4.0 and the challenges it brings are subject of broad discussions in the scientific community and business world. No matter that the first two industrial revolutions span over three centuries, the latter two occurred only within three decades. After the digital revolution, in the late 1980s, we are now beyond the threshold of the next major revolution – so-called "Industry 4.0".

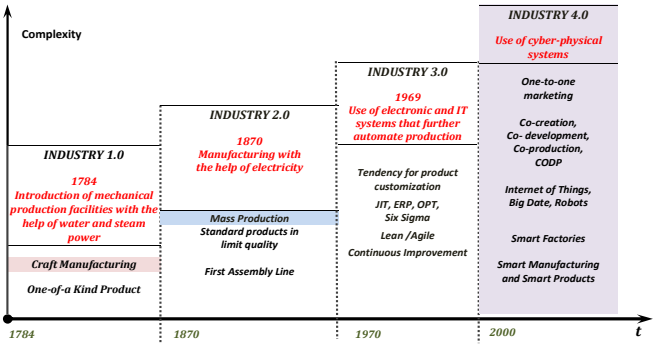

Fig. 1. From the First Industrial Revolution to "Industry 4.0"

The rapid pace of technology development leads to unprecedented automation and digitization of the manufacturing operations and business processes, as well as to developing of a new value creation concept. Digitization of manufacturing is a good opportunity to achieve intelligent industrial automation, through which a free movement of industrial products can be realized worldwide. These new manufacturing and management principles and technologies, based on Industry 4.0, are expected to contribute to a complete optimization of business activities, which is expressed in:

- increasing productivity,
- efficient use of resources and energy,
- effective cooperation with the actors in the logistics and supply chains, and
- increasing value added for customers.

Having above in mind, the introduction of digital technologies into manufacturing is becoming a key factor for the development and survival of Bulgarian enterprises in the global market environment. To achieve this however, it is necessary to form an entirely new vision, both for the design of the enterprise production system itself, and for operating and managing it.

The purpose of present article is to examine the peculiarities of Industry 4.0 and the so-called Smart Manufacturing, in order to establish requirements for the training process in the field of production and operations management, so as to ensure an effective management of the enterprise production system.

II. INDUSTRY 4.0 AND THE FUTURE OF MANUFACTURING

The term "Industry 4.0" is born as the logo of a German government's initiative aimed at enhancing the competitiveness of German industry through integrated product development and manufacturing in the so-called Smart Factories. Building a Smart Factory is possible by virtue of Cyber-Physical Systems (CPS), through which communication between the participants in the supply chain is achieved (humans, machines and products) [1,3]. CPS are able to process data in real time, they can perform self-control and interact with people via interfaces. The physical and virtual worlds merge into production, creating a new manufacturing environment in which intelligent and customized products are created that contain information/knowledge of the manufacturing process, and could be individually "passed" through the entire logistics/supply chain.

A. Industry 4.0 Components

In the literature [2,6,7, etc.], the following components of Industry 4.0 are discussed to be the important ones:

- *Cyber-Physical-Systems (CPS),* where the integration between the physical world and the virtual one takes place;

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- *Internet of Things (IoT)*, which is defined as the Internet of CPS components. The components in this case are: intelligent machines, embedded self-regulating systems, hardware, software, etc. uniquely addressed objects and networks that intelligently interact with each other to achieve a common goal;
- *Internet of Services (IoS)* – it enables service providers to offer their services via Internet, providing users with access and the opportunity to use different channels to the service itself;
- *Smart Factories.* This component is based, on the one hand, on the integration of all the resources needed to carry out production processes, which automatically exchange information, and on the other hand, the manufacturing subsystem becomes sensitive and intelligent enough to:
  - foresee the need for spindle maintenance of machinery and equipment,
  - control the processes for an individualized products manufacturing,
  - perform self-learning.

B. Industry 4.0 Design Principles

Industry 4.0 is based on six design principles [5]. Table 1 provides how these six principles could be derived by above discussed main components of Industry 4.0:

TABLE I. DESIGN PRINCIPLES ASSOCIATED WITH INDUSTRY 4.0 COMPONENTS [5]

	CPS	**IoT**	**IoS**	**Smart Factory**
Interoperability	✓	✓	✓	✓
Virtualization	✓			✓
Decentralization	✓			✓
Real-Time Capability				✓
Service Orientation			✓	
Modularity			✓	

- *Interoperability:* It is a very important enabler of Industry 4.0 expressed in terms of the ability of Cyber-Physical Systems, people and Smart Factories to exchange information with each other through the Internet of Things and Internet of Services;
- *Virtualization* is expressed in terms of creating virtual copies of Smart Factory, which is made by connecting sensor data from the physical processes monitoring with virtual models and enterprise or process simulation models;
- *Decentralization:* the ability of Cyber-Physical Systems within Smart Factory to make decisions on their own;
- *Real-Time Capability* is expressed in terms of the ability to collect and analyze real-time data and visualize the results for immediate decision making;
- *Service Orientation:* offering Internet services (Cyber-Physical Systems, people or Smart Factories);
- *Modularity:* refers to the production system, processes and products. The modular principle allows for a higher degree of flexibility and adaptability to the changing requirements of the market-production situation as well as the individual expectations of the customers.

These six core principles, which Industry 4.0 is subjected to, enable businesses to self-analyze and improve their degree of maturity to bring them into their business and to fit them into the highly competitive and complex environment, which they are forced to function in.

C. Characteristics of the Future Manufacturing

Typical for an Industry 4.0 manufacturing is the high degree of product capitalization in the context of highly flexible and adaptive production. Indeed, Industry 4.0 focuses on creating intelligent products and manufacturing processes. This drive is supported by new technological solutions such as artificial intelligence, machine self-learning, intelligent mobile applications, block technologies, digital platforms etc.

The impact of new technologies in Industry 4.0 on manufacturing processes is usually expressed in terms of:

- creation of new products and services with built-in intelligence;
- creation of innovative business models and capabilities for customization and adaptation to customer needs and requirements;
- digitizing the production cycle;
- accelerating development through digital and virtual production;
- automating routine and repetitive operations;
- building a flexible organization of the production process, in other words, building decentralized and digitized production networks whose components operate autonomously and are capable to effectively control their operations in response to changes in the environment [4].

III. TRAINING AND OPERATIONS MANAGEMENT COMPETENCES REQUIRED WITH RESPECT TO INDUSTRY 4.0

One of the biggest threats posed by process automation is replacing people with machines. Such fears have also occurred during the previous three industrial revolutions, which have also led to similar labor market shocks and to the emergence of new occupations and the need for re-training. Of course, at present, the manifestation of this threat is on a much larger scale, mainly because of the use of artificial intelligence. However, it should be noted that, in order to achieve desired efficiency, artificial intelligence itself needs to be combined with the appropriate industrial experience and physical models of the machinery as well. Given this, the role of the human factor must not be underestimated. Rather than embracing technology as a threat and substitute for the human labor, it should be seen as a means for helping employees focus on those operations that bring bigger added value, while at the same time offloading them from the routine ones. In fact, this idea lies at the heart of the Lean Thinking concept, which according to our opinion is not losing its relevance at all. The new manufacturing environment based on Industry 4.0 technology enables much more Lean Thinking principles to be implemented, as well as they contribute to a more effective and efficient running of the operations system of the enterprise. For the efficient management of the production, it is necessary for the

operations managers to have the skills to solve complex problems. In this sense, the potential of Value Stream Mapping and the application of the simulation modeling could be utilized and adapted.

Given that the individual approach to customers is one of the key features of Industry 4.0, the concepts for customer involvement/integration in the value creation process (Customer Order Decoupling Point, Co-Creation, Co-Development, etc.) are increasingly important for manufacturing operations managing.

Production managers must also have complex problem-solving, critical thinking and creativity skills. In this regard, they need to gain knowledge about methods and approaches that promote innovation in management and decision making. One such method is the so-called "Theory of Resolving of Invention-related Tasks" (TRIZ). TRIZ is one of the problem solving methods that depend on previous experience and logic/research rather than unpredictable thinking. TRIZ argues that we should stand on the shoulder of giants while solving problems. Years of research conducted by thousands of engineers to reach innovative solutions for repeated problems should be considered as one of the essential tools to solve problems. If a problem exists while a specific problem has been solved in another project, this experience can save time, effort, and cost instead of starting from scratch. Production managers need to be able to present complex concepts in realistic workflows and build the appropriate team for their implementation.

The authors of present publication advocate the opinion that above discussed concepts are of a vital importance for an efficient management of the production and operations system of the enterprise. It is crucial to integrate their application into the conditions of the new "Industry 4.0 manufacturing environment".

IV. CONCLUSION

Operations Management plays probably the most important role in the Industry 4.0 environment. Industrial enterprises can make the most of the benefits of Industry 4.0 only by combining digital technologies with human skills and knowledge in the field of Operations Management. This will require even moving from Industry 4.0 to a broader vision of digital transformation where the Industrial Internet connects people, data, assets and machines to create a truly connected digital world.

REFERENCES

[1] Achatz,D. et al. (2009) "Nationale Roadmap Embedded Systems," ZVEIZentralverband Elektrotechnik- und Elektronikindustrie e.V. Kompetenzzentrum Embedded Software & Systems.

[2] Bauernhansl, T., Hompel, M. and Vogel-Heuser, B. (2014) Industrie 4.0 in Produktion, Automatisierung und Logistik: Anwendung, Technologien und Migration.

[3] Einsiedler, I. (2013) Systeme für Industrie 4.0," Product. Manag., vol. 18, pp. 26–28.

[4] Erol, S., Jäger, A., Hold, P. and Ott, K. (2016) Tangible Industry 4.0: a scenario-based approach for the future of production, conference preceding "CIRP Conference on Learning Factories, pp.13-18.

[5] Hermann, M., Pentek, T. and Otto, B. (2015) Design Principles for Industry 4.0 Scenerious: A Literature Review, Working Paper, Technische Universität Dortmund.

[6] Kagermann, H., Wahlster and, W. and Helbig, J. (2013) Recommendations for implementing the strategic initiative Industrie 4.0: Final report of the Industrie 4.0 Working Group.

[7] Lee, E. (2008) Cyber Physical Systems: Design Challenges. *11th IEEE Symposium on Object Oriented Real-Time Distributed Computing (ISORC),* 363 – 369.

[8] Vyatkin, V., Roop, P. and Fitzgerald, J. (2007) "Now That's Smart!," Industrial Electronics Magazine, IEEE, vol. 1, no. 4. pp. 17–23.