INDUSTRY 4.0's OPPORTUNITIES AND CHALLENGES FOR PRODUCTION ENGINEERING AND MANAGEMNET

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Abstract: *Today Industrial Enterprises are facing the challenge of the 4th Industrial Revolution. Steam Power, Henry Ford's Assembly Line, and Proliferation of Coal-based energy etc. – each of these developments in the evolution of manufacturing fundamentally changed the way products were manufactured and the way manufacturers moved products from factory to the customers. The present paper discusses the term "Industry 4.0" and its main characteristics, as well. Furthermore, a theoretical framework for evaluation the key technologies and concepts with respect to their impact on the production engineering and management. Also this paper discusses and some given arguments why manufacturers need to make changes in their traditional view of the functioning of the production system in term of "Industry 4.0".*
***KEYWORDS**: INDUSTRY 4.0, SMART FACTORY, INTERNET OF THINGS, PRODUCTION/OPERATIONS MANAGEMENT, INDUSTRIAL ENTERPRISE*

1. Introduction

Each industrial revolution raises new requirements and challenges for business and determines new approaches inside the organizations, as well [6]. A retrospective analysis of economic growth shows (Figure 1) how the impact of a set of logically related factors, conditions and events has changed the way of life and necessities of society and how this has affected production environment. The techniques for management of the production system, as well as the enterprise as a whole, are constantly evolving – from Craft Manufacturing through Mass Production to arrive at today's tendency for Mass Customization. At the same time, approaches/methods, with the help of which the production system is tuned to the requirements of the environment, also undergoes its own development.

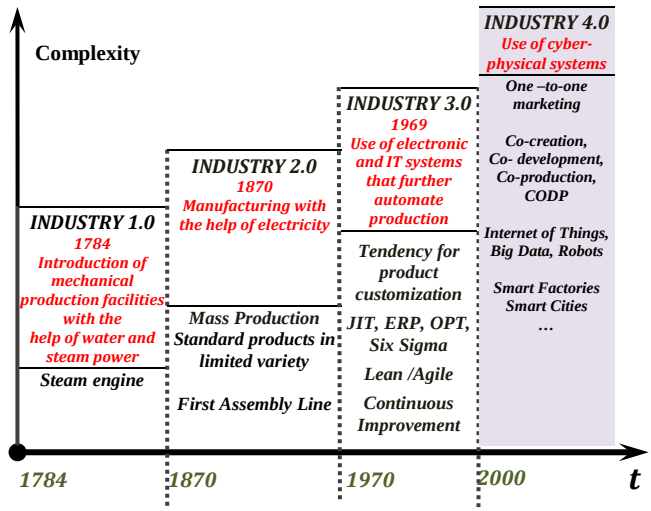

***Fig.1.** Form Industry 1.0 to Industry 4.0*

In recent years, the efforts of the manufacturers have increasingly focused on building up the so-called "open" production systems which are characterizes with high degree of flexibility and agility to the dynamically changing and complex market environment. These production systems have "self-regulation" effect, which is based on the customer feedback, or generally on the better communication and „synchronization" between all actors in the value chain. Here, the role and importance of information and communication technologies, which have seen a significant development over the last three decades, are increasingly decisive. And so comes the next stage of improvement - the Fourth Industrial Revolution (Industry 4.0), which requires and creates the conditions for building a new paradigm for business management and production processes.

Markets seek for high customization. Manufacture and operations require different methods. This includes more agility, less human factor in routine activities, high interconnectivity among others.

The aim of the article is to analyze the main characteristics of Forth Industrial Revolution/Industry 4.0 and to discuss its impact on the production engineering and management.

2. What is INDUSTRY 4.0?

The 4th Industrial Revolution – „Industry 4.0" can be described as an collective term, referring to a set of connected digital technology solutions that support the development of automation, integration and real-time data exchange in manufacturing processes. In essence, this reflects an industrial and technological transformation process that naturally follows the development of scientific and production practices.

In [7] are presented two aspects about the key drivers for the 4th Industrial Revolution. The first one is a combination of todays' rapidly growing technological development, which includes Internet of Things (IoT), Internet of Services (IoS), Cyber-Physical Systems (CPS) smart objects and big data, which are expected to lead to a paradigm shift in industrial production [8]. This can be described as a technology push that enables significant advances for industry. The second aspect is a result from the industrial actors' efforts, which are focusing on the use of new technologies as a good opportunity to become independent of the high labor costs.

However, the main ideas about Industry 4.0 were published for the first time in 2011 [2]. In the same year it become a strategic initiative of the German government and was included in the "High-Tech Strategy 2020 Action Plan" [4].

Similar strategies have also been proposed in other industrial countries, e.g., on a European level, the corresponding catch word are "Factories of the Future", "Industrial Internet" in USA and "Internet+" in China.

Despite the great interest in the Industry 4.0 has no single accepted and established definition for it. In [11] it is defined as *„the integration of complex physical machinery and devices with networked sensors and software, use to predict, control and plan for better business and societal outcomes*", or in [3] "*A new level of value chain organization and management across the products lifecycle*" or [1] "*a collective term for technologies and concepts of value chain organization*". These definitions reveal the main features of the Fourth Industrial Revolution [9]:

- The ***vertical networking*** of smart production systems (smart cities, smart factories, smart products) and the networking of smart production and smart services, with strong needs-oriented, customized production operations.
- ***Horizontal integration*** that is being considered to develop a new generation of global value-creation network, which includes integration of partners and customers.

- ***Through-engineering*** throughout the entire value chain, taking in not only the production process but also the end product – that is the entire product life cycle.
- ***Acceleration through exponential technologies*** (e. g. sensor technology).

In summary, 4th Industrial Revolution embodies the achievements of genetics, artificial intelligence, robotics, nano-technology, biotechnology, and 3D printing. It combines the real world of production with the digital world of computer science, creating an "ecosystem" in which both man and machine work together to achieve complete optimization. One of the main issues that the fourth industrial revolution raises is how to integrate the artificial intelligence into the production system, how to orient different business sectors to change. Industry 4.0 combines the development of technology with the production process, creating an entirely new reality in which the most adaptable can be preserved and competitive in the market where they operate. An important prerequisite for successful business dealing with the challenges of Industry 4.0 is the need for a complete change in thinking and attitude and developing a new concept of production engineering and management.

3. *The New Challenges and Opportunities for Manufacturing in terms of Industry 4.0*

The Fourth Industrial Revolution has the potential to fundamentally change the structure of the economy as a whole. As has been pointed out, Industry 4.0 is focused on digitization and the replacement of older analog technologies. Efforts need to be made to integrate the so-called Cyber-Physical Systems into the overall organization of the production system, which will make it more dynamic. The production process will rely on automation, with high-tech robotic machines taking the lead. Interaction between the different units in the industrial enterprises will undergo a radical change because of the increasingly diminishing role of the man in favor of the machinery. Of course, this does not mean that work done by human recourse will surely be unnecessary. People are still better at creating unique and innovative products. Human spirit, resourcefulness and entrepreneurship should play a major role in the industries of the future. In general, the urge is for machines to replace the human factor in performing routine and repetitive production activities. Also interaction between the different production units in the industrial enterprise will undergo a radical change because of the increasingly diminishing role of the man in favor of the machines.

Industry 4.0 will make the most of software resources in the field of resource planning. This means getting better programs, better predictive algorithms that will produce more and more quality analyzes. This will allow the production process to be even more optimized, cost-effective and easy to manage, control and maintain. Thus, losses in production such as technology waste, process defects etc. will be minimized. In this respect, it is particularly important for manufacturing companies to build an efficient IT infrastructure that will require serious investment.

Production methods and technologies are expected to undergo substantial change. For example 3D printing technology largely displaces conventional production. This will lead to the need for a new design and a complete new organization of the production performance.

The digital transformation to Industry 4.0 brings new opportunities for a more flexible customer integration. Customization is a global trend and it is likely to spread even more rapidly across manufacturing industry in the future. Customers increasingly want to determine how their products are designed and made, and will be having an increasing input into the production processes development and at an early stage /Engineer-to-Order/.[9,10]

It is very important to note that the "Internet of Things", services, date and people also opens up new avenues for data theft, industrial espionage and attacks by hashers.

4. *Conclusion*

Even though complexity of Industry 4.0 production system is growing, it has a huge potential which is in the following areas [9]:

- specialized industry-specific solutions ("pull from the customer") and individualized understanding of customers' needs even in a case of manufacturing one-off items, having very low production volumes (batch size of 1) and still gaining a profit
- increased competitiveness and flexibility resulting from dynamic structure of business processes (i.e. quality, time, risk, robustness, price and eco-friendliness),
- optimized decision making due to end-to-end visibility in real time
- increasing resource productivity;
- work-life-balance,
- high-wage economy with tied-up capital cost, cut energy costs and reduced personal costs.

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