INDUSTRY 4.0 - TECHNICAL-ECONOMIC DEVELOPMENT PERSPECTIVE FOR THE METALLURGICAL PRODUCTION

SANIUK Sebastian[1], SANIUK Anna [2]

[1] *University of Zielona Góra, Faculty of Economics and Management, Zielona Góra, Poland, EU, s.saniuk@wez.uz.zgora.pl*
[2] *University of Zielona Góra, Faculty of Mechanical Engineering, Zielona Góra, Poland, EU, a.saniuk@iizp.uz.zgora.pl*

Abstract

The globalization process which manifested primarily by the growing share of developing countries in the world's manufacturing industry, forces Western European economies to take steps to improve the competitiveness of local metallurgical production. The ongoing process of relocating companies across Europe is threatening to deepen the decline of industrialization. Fears of Europe's marginalization in world production have prompted German experts to develop a new Industry 4.0 program that will help regain the status of a leader in the industrialization of highly developed countries. As part of the proposed concept, which is to underpin the Fourth Industrial Revolution, a close integration of physical facilities with the information network is planned. The emergence of sophisticated corporate networks, combined smart resources communicating over the Internet. This means that today's businesses face the next challenge of building and collaborating on cyber-physical systems.

The paper attempts to identify key problems related to the functioning of enterprises within the metal logistics network (steel production, distribution, metalworking, etc.), especially in the face of the challenges of the fourth industrial revolution.

Keywords: Industry 4.0, metallurgical production, technical-economic development

1. INTRODUCTION

As a result of globalization, the share of developing countries in the world's manufacturing industries such as China and India has increased significantly. The ongoing process of relocating businesses outside Europe is threatening to deepen the decline in industrialization and the marginalization of Europe in global production, as indicated by economic forecasts [1]. This fact forces the European countries to take steps to significantly improve the competitiveness of their enterprises, which will allow them the status of a leader in the industrialization of highly developed countries to be regained.

One of the proposed solutions, which is to revolutionize modern industry, is the new Industry 4.0 platform developed by German experts. The proposed concept is to combine physical objects with the information network and form the basis of the Fourth Industrial Revolution. It plans to set up sophisticated business networks linked by intelligent resources that communicate by the Internet. This means that today's businesses face the next challenge of building and collaborating on cyber-physical systems.

The concept of the Industry 4.0 is oriented towards high productivity of industrial systems and high profitability of realized projects. It points to a number of benefits that can flow from its use. It is worth noting the increase in production flexibility and organization of production of more personalized products. This means the ability to meet the needs of the customer which is the user of the product without detriment to the profitability of the production process by dynamically aligning the autonomous modules of the entire process of preparing, producing and delivering the product to the customer using Internet of Things and information stored in Big Data and Cloud Computing [2]. In addition, it is possible to significantly improve production efficiency through

the use of material, manufacturing, labor resources of network partners working together with unused production capacities. This intensifies the need for research into the problems of developing networked forms of co-operative corporations to operate in the era of the concept of Industry 4.0 [3], [4].

The article seeks to answer the question of what the Fourth Industrial Revolution in the Polish metallurgical industry is likely to succeed and what problems will have to face. The main aim of the paper is to identify key problems related to the functioning of enterprises within the metal logistics networks (steel production, distribution, metalworking, etc.), especially in the face of the challenges of the Fourth Industrial Revolution.

2. THEORETICAL FRAMEWORK OF THE INDUSTRY 4.0

The concept of the Industry 4.0 means to increase digitization of the entire value chain and interconnection of people, objects, systems through real time data exchange. The most important foundation of the Industry 4.0 is smart technology and creation of the Cyber-Physical Production Systems (CPPS). These systems must be flexible and self-controlling. A concept of a smart factory should be oriented towards high profitability of production plants and value added of industries. Companies have to change from existing forms of business activity to the new platform. This task requires a total transformation of organizations and their processes. The process should be managed in a new way where a significant element of a success is a digital thinking and collecting and analyzing data. All production areas should be fully integrated and controlled using advanced IT technologies [11]. Production organization is aiming for much greater efficiency, flexibility and speed. Main elements of Industry 4.0 development in **Figure 1** are shown.

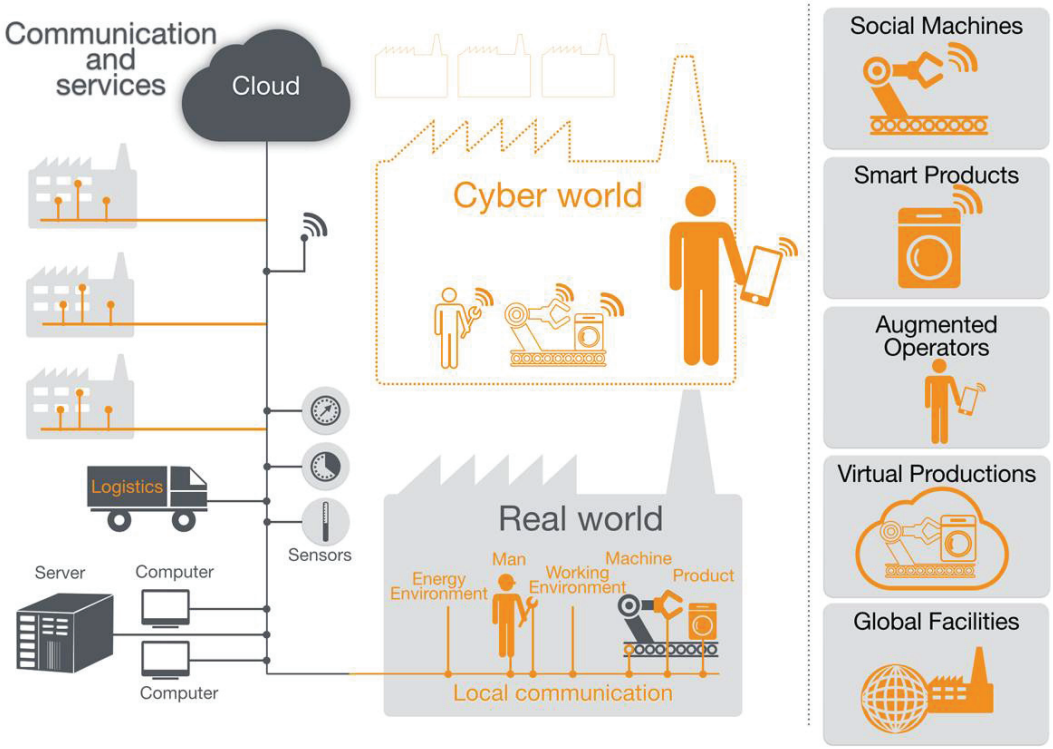

Figure 1 Elements of Industry 4.0 development [5]

The main goal of the Industry 4.0 is to increase competitiveness through first of all smart equipment, making use of information about high-wage locations, resources, energetic efficiency and also urban production [6]. As a result of this concept developing is to create fully automated and Internet-based smart factories.

It means progress in three significant areas [7], [8], [9]:

- digitalization of production (information systems for production planning and management);
- automation (systems for data acquisition from machines and production lines);
- Automatic Data Interchange (linking manufacturing sites in a comprehensive supply chain).

In smart factories the priority is a mass customization (MC). This is a combination of the advantages of unit and mass production. Unit production is done according to the preferences and tastes of customers on their special order, so it takes a long time and is associated with high costs of design, production preparation, etc. Mass production involves the rapid production of the repeatable or often the same products in large quantities.

In mass customization, the customer determines the characteristics of the product that he wants to purchase and automatically, very fast is manufactured such a personalized product. This solution is very attractive to the customer, but it is a real challenge for the manufacturer, who must prepare the procurement system and production system to automatically and quickly produce customized products [10]. The expectations and needs of every client are fulfillment, but it is connected with an increase of design and manufacturing costs. Products meets customer's needs the best with almost mass production efficiency. MC is possible when enterprise has flexible manufacturing system, can also rapid design and implement new products and processes. The design process must be accelerated by the use of simulation and analytics in such a way that the first sample produced is efficient and fulfills customer expectations. Using simulation and 3D printing will enable rapid prototyping, which will greatly increase the cost savings of materials and energy [12].

The mass customization brings many benefits such as: increased customer satisfaction, reduced cost of capital, reduced cash flow variability, increased brand equity, reduced price sensitivity, increased chances to cross sell and up-sell, increased customer loyalty, increased share of wallet, increased purchases, reduced promotion costs, ease of launching new products.

3. BARRIERS AND BENEFITS OF INDUSTRY 4.0 DEVELOPMENT IN METALLURGICAL PRODUCTION

The main barrier to the development of the concept of the Industry 4.0 is limited investment opportunities what means a lack of capital needed to develop a technical infrastructure and automation and communication of machinery and equipment. In the metallurgical industry, small businesses dominate, so this factor significantly impedes the implementation of this concept. In addition, a significant barrier is low labor costs, which do not mobilize to implement fully automated production lines [12].

Introducing the 4.0 concept in practice can help in the very dynamic development of the metallurgical industry, but it involves overcoming many important barriers and making many changes. The most important technological solutions and the resulting benefits of the introduction of the Industry 4.0 concept in the metallurgical industry are shown in **Table 1**.

The Industry 4.0 will allow analysis and data collection by devices enabling faster, more flexible and efficient production of higher quality goods at lower cost. The use of robots will allow for very quick re-assembly, will reduce the cost of operating the production line, and shorten the time from receipt of the order to deliver the product to the customer. Simulations will allow operators to test and optimize device settings before changes are made in the real world. As a result, the device configuration time may decrease by up to 80% and product quality will improve [12].

The introduction of vertical and/or horizontal software integration will allow for full integration of IT systems with suppliers, customers, and all phases from design to implementation and full operations of the production line. On the other hand, the Internet of Things will bring significant growth in built-in sensors and processors in the device, and even in the workflow components, which will improve their communication and interaction overall. It will also affect more centralized control and real-time decision making. Currently used electronic

RFID which are integrated into the components make the workplace equipment aware of what to do in order to complete the product and how to adapt the production line to the task [2], [12].

Table 1 The most important technological solutions and the resulting benefits of the introduction of the Industry 4.0 concept in the metallurgical industry

Implemented solution	Main benefits
Autonomous robots	• quick (few seconds) customization of the production line to produce the next item of the product • reduce costs associated with operating the production lines • shorten time between ordering and delivering the product to the customer
Simulations	• dramatic reduction time of device configuration • improve product quality
Vertical/horizontal software integration	• full integration of all IT systems • fully automated value chain
Internet of Things	• improve communication and interaction between devices and elements in progress • more centralized control • real-time decision-making
Additive manufacturing	• reducing the cost of materials used in production • reduction of machine downtime • weight reduction of components
Cybersecurity	• increased communication reliability • advanced user identification systems that provide access to devices
Cloud	• extensive data exchange • increased cloud efficiency • drastic decrease in response time (up to several milliseconds)
Big data and analytics	• real-time decision-making • increase energy efficiency • optimizing product quality • improved maintenance and service
Augmented reality	• supporting different activities • accelerate decision-making processes

Applying Industry 4.0 solutions requires the use of key systems and production lines to protect against cyber-attacks. As a result, the reliability of communication and use of advanced user identification systems that provide access to the devices increases. In turn, the use of 3D printers that are currently used to build prototypes and produce individual components will be expanded to produce full series of products that have complex shapes and lightness [12].

Using cloud-based software allows for extensive data exchange. In Industry 4.0, cloud performance will improve considerably and their response time will drop to the order of several milliseconds. So the use of clouds will increase. Process monitoring and control systems can also rely on cloud. Big Data based analytics will primarily enable real-time decision-making and extended reality systems support a variety of activities (such as identifying a particular part in a warehouse, sending repair instructions through mobile devices, etc.). In the future, they will help to make decisions faster [4], [12].

4. CONCLUSION

Introducing the Industry 4.0 concept in the metallurgical industry is a huge challenge, primarily due to the lack of sufficient capital to introduce the necessary new solutions, especially in the small businesses dominating in this industry. However, these new solutions are necessary because they change the approach and technology of production and help to gain competitive advantage in the market. Existence in the market in the near future will certainly be seriously threatened for companies that can become completely unattractive to customers without introducing concept 4.0.

The Industry 4.0 concept involves the creation of smart factories based on the mainly nine technological solutions described in the article, which revolutionize product manufacturing and enterprise management. The demonstrated benefits indicate that the preparation of metalworking companies into the Fourth Industrial Revolution is necessary.

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