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CECHY PRZEMYSŁU 4.0 I MECHANIZMY ZARZĄDZANIA PRZEMYSŁEM W OBECNEJ GLOBALNEJ SYTUACJI GOSPODARCZEJ

Streszczenie: Przemysł 4.0 zwiększa widoczność operacyjną, obniża koszty, przyspiesza czas produkcji, zapewnia wyjątkową obsługę klienta. Odporność operacyjna staje się kluczowym celem firmy. Analizowany jest trend przechodzenia od operacji „automatycznych" do „autonomicznych". Nakreślono kierunki polityki państwowej Ukrainy w celu stymulowania rozwoju Przemysłu 4.0.

Słowa kluczowe: Przemysł 4.0, systemy cyber-fizyczne, Internet Rzeczy, produkcja, odporność operacyjna, mechanizmy zarządzania państwem, standardy Przemysłu 4.0

FEATURES OF INDUSTRY 4.0 AND MECHANISMS OF STATE MANAGEMENT OF MANUFACTURING IN CURRENT GLOBAL ECONOMIC SITUATION

Summary: Industry 4.0 increases operational visibility, reduces costs, expedites production times, delivers exceptional customer support. Operational resilience becomes a key corporate objective. A trend of moving from "automated" to "autonomous" operations is analyzed. The directions of state policy of Ukraine to stimulate the development of Industry 4.0 are outlined.

Keywords: Industry 4.0, cyber-physical systems, Internet of Things, manufacturing, operational resilience, mechanisms of state management, standards of Industry 4.0

1. The meaning and advantages of Industry 4.0

The definition of Industrie 4.0 as proposed in 2011 was pretty lengthy. In a paper, entitled "Industrie 4.0 – Smart Manufacturing for the Future", GTAI *(Germany Trade and Invest)* looked at the questions what is smart industry *(a synonym of Industry 4.0)* and what Industrie 4.0 means [1].
An extract: Smart industry or "INDUSTRIE 4.0" refers to the technological evolution from embedded systems to cyber-physical systems…INDUSTRIE 4.0 represents the coming fourth industrial revolution on the way to an Internet of Things, Data

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and Services. Decentralized intelligence helps create intelligent object networking and independent process management, with the interaction of the real and virtual worlds representing a crucial new aspect of the manufacturing and production process" [2].

Despite its name, the concept of Industry 4.0, or the 4th Industrial Revolution, is not solely about manufacturing, even if manufacturing is the main sector involved today; its broader connotation includes concepts such as smart transportation and logistics, smart buildings, oil and gas, smart healthcare and smart cities.

Industry and policymakers alike recognise the huge opportunities for growth offered by digital transformation, interconnectedness and new manufacturing technologies related to Industry 4.0. Together, these phenomena are driving new business models, sustainable and efficient use of limited resources and the cost-effective production of highly customizable products, denoting an unprecedented transformation in industry, flexibility and agility.

Much has been said about Industry 4.0, and how it has revolutionized the manufacturing world by providing manufacturers with opportunities to utilize advanced tools and technologies throughout the product lifecycle. There's no doubt that Industry 4.0 has enabled manufacturers to increase operational visibility, reduce costs, expedite production times, and deliver exceptional customer support.

However, as 2021 rapidly approaches, it's time to turn our attention away from Industry 4.0 and toward Industry 5.0. Where the fourth industrial revolution focused on using technology to optimize the means of production, the fifth is all about connecting man and machine — that is, collaboration between humans and smart systems. Depending on who you ask, Industry 5.0 is either on the immediate horizon, or it's already here, its arrival accelerated by the onset of the COVID-19 pandemic.

Under smart systems could be meant the so called cyber physical systems which are created and function in different spheres (such as manufacturing, transport, smart grid, medicine etc.) [3].

2. Internet of Things technology as an integral component of Industry 4.0

IoT, which entails the interconnection of unique devices within an existing internet infrastructure, has enabled manufacturers to make informed, strategic decisions using real-time data and achieve a wide variety of goals, including cost reduction, enhanced efficiency, improved safety, product innovation, and more. According to a study from the MPI Group, nearly a third (31%) of production processes now incorporate smart devices and embedded intelligence. Additionally, 34% of manufacturers have plans to incorporate IoT technology into their processes, while 32% plan to embed IoT technology into their products.

Thus, it can be concluded that Internet of things (IoT) is one of significant technologies which is incorporated in the manufacturing processes in different industries and it is crucial for the operation of production lines on the basis of cost reduction, enhanced efficiency, improved safety, product innovation.

COVID-19 has brought renewed interest to IoT technology due to its remote monitoring and predictive maintenance capabilities. From a public safety perspective, it's impractical, if not impossible, for field service technicians to show up on job sites on a moment's notice; every work order must be meticulously planned well in advance. IoT-enabled devices make it possible for manufacturers to safely monitor

equipment performance at a distance and identify potential issues before a malfunction even occurs; they also enable technicians to gain a complete understanding of the problem at hand and come up with potential solutions before they arrive at the job site, so they can get in and get out that much faster [4].

3. Technology convergence becomes technology fusion

The convergence of information technology and operations technology (IT/OT convergence) is progressing rapidly as manufacturers realize it is key for successful digital transformation. Connectivity and/or convergence between OT and IT is essential for businesses to compete with the increasing demand for tighter integration and more information that leverages Industrial IoT, Industry 4.0, 5G, cloud, edge, additive manufacturing, advanced analytics, digital twin, AR/VR, AI, ML and other emerging technologies.

IT/OT convergence includes cybersecurity, which helps fill existing security gaps and ensures consistent security levels across the entire organization. Increasingly, convergence also includes the integration of power and automation, which involves converging information about electrical assets (such as in motor control centres) and the production process to help improve sustainability across the entire lifecycle of a manufacturing plant.

Convergence between power and automation also provides an integrated, digitalized approach that increases interoperability and flexibility, reduces capex and opex expenditures, increases production efficiencies, decreases unscheduled downtime and improves overall profitability. Rather than a trend, ARC (*author note: ARC Advisory Group*) believes that this convergence between IT and OT, *IT cybersecurity and OT cybersecurity*, and power and automation will become permanent, representing a true technology fusion.

4. Operational resilience becomes a key company objective

One of the objectives of a company's digital transformation journey is to ensure resilient operations, improving a manufacturer's capabilities against heightened business risks. These include increasing cybersecurity threats, *new regulatory compliance mandates*, and more strenuous plant and personnel safety requirements. Even before COVID-19, manufacturers faced numerous challenges such as market and commodity uncertainty, rapid fluctuations in demand, supply chain disruptions, and the need to become more agile, efficient and sustainable.

However, the current pandemic magnified those challenges, leading manufacturers to focus on operational resilience as a key corporate objective. Operational resilience means that companies are breaking physical and organizational boundaries to engage a real-time workforce, connecting teams and enhancing collaboration. It means supply chains *are being managed in real-time* to maintain their integrity, agility and flexibility to respond to market demand and material availability shifts.

Operational resilience means that new methodologies are being deployed for companies to protect against unscheduled downtime and asset failures, ensure product fulfillment, protect personnel and enhance security architectures. In 2021, manufacturers will look to increase their operational resilience, to reduce their supply

chain vulnerability, lower safety risks, improve remote operational performance and optimize production throughout the plant lifecycle.
A conclusion can be made that one of the key objectives of any manufacturing company is operational resilience and all management decisions concerning supplies, negotiations with partners, response to customer needs, operational resilience, cyber security measures, personnel management and safety are made in real time with close collaboration of all members of a team from the lowest level to the top management. Such approach in management of a company (for example a plant) is required also because of the current COVID-19 pandemic.
Industry 4.0 is a part of national economy of a developed state and it will develop rapidly and will transform into more innovative concepts in order to satisfy manufacturer and customer requirements. For this reason such state should take appropriate measures to support certain enterprises by means of tax optimization, licencing of certain types of economic activity, issue of standards in Industry 4.0, certification of products and services, training of public officials etc.
Also in order to optimize production throughout the plant lifecycle cyber physical systems should be created.
Cyber-physical systems integrate computation, communication, sensing, and actuation with physical systems to fulfill time-sensitive functions with varying degrees of interaction with the environment, including human interaction.
As could be seen from the above notion, cyber-physical systems play a significant role in the modern manufacturing processes management with integral interaction of sensors, physical objects, actuators, cloud computations, communication means. Such systems are already functioning in different spheres (industries) such as energy sector (smart grid), healthcare, traffic control as well as in smart manufacturing [6].

5. Automated operations become autonomous operations

One more issue that needs to be considered is that automated operations become autonomous operations.
Accelerated by the COVID-19 pandemic, industry urgently requires new modes of operation.
Thanks to advances in digitalization and new open process automation standards, IT/ OT convergence and digital transformation, manufacturers have an opportunity to move from “automated” to “autonomous” operations where appropriate. Not only do these advances present the opportunity to improve overall business value, they present an opportunity to further advance safe and flawless operations. The goal of moving from automation to autonomous operation is to improve the reliability and predictability of the operating plant.
Today, human operators decide what to do when something unpredictable happens. Tomorrow, the autonomous systems may be making those decisions, with the humans serving as observers and overseers. One concern often expressed is the aging workforce and how to pass on the knowledge gained over years of making decisions. This is often based on intuition and experience. While these human characteristics can be hard to replicate in systems, when trained with appropriate historical data and combined with adequate real-time data, artificial intelligence (AI)-based applications can enhance the human’s understanding of what is normal and abnormal in plant operations.

In 2021, manufacturers will continue to make inroads toward moving operations from automated to autonomous.

6. The state policy of Industry 4.0 implementation and regulation in Ukraine

Ukraine like other developed countries also implements Industry 4.0 in its economy. In order to define the peculiarities of Industry 4.0 implementation and regulation in Ukraine it is necessary to outline the mechanisms of state management of Industry 4.0 in the Ukrainian economy.

For the purpose of the Industry 4.0 regulation in Ukraine the Cabinet of ministers of Ukraine issued an Order dated 17 January 2018 "On the approval of the concept of digital economy and society development in 2018-2020 years and the plan for its realization". Actually it is still valid.

This order provides that Industry 4.0 is an updated concept of "smart manufacturing", which is identified with the "fourth industrial revolution" and the emergence of *cyberphysical systems*. Industry 4.0 is the next stage of digitalization of industry, in which the main role is played by technologies and concepts such as the Internet of Things, "big data", "predictive analytics", cloud computing, "machine learning", machine interaction, artificial intelligence, robotics, 3D printing, augmented reality.

The integration of digital technologies into production processes, or digitalization of industry, is a priority of state industrial policy. The state policy to stimulate the development of Industry 4.0 has three directions [5]:

- creation of the infrastructure of Industry 4.0 - *industrial parks*, branch centers of technologies, etc.;
- access to capital to create new innovative industries;
- development of digital skills to train personnel capable of working with Industry 4.0 technologies.

To use the potential of Industry 4.0 in Ukraine, it is important to implement the following initiatives [3]:

- targeting, i.e. analysis and research of industrial sectors in order to assess competitiveness and development prospects. Such work provides the involvement of research agencies, obtaining relevant insights, identifying growth drivers, organizing the communication of results, and so on. The results of the research should be used for further planning and risk reduction for potential investors;
- introduction of modern information technologies in industry, or a program of education and transfer of best practices from the IT sector and digital industries to industrial sectors. Today, industrial sectors lag far behind the trends, technologies and opportunities of the digital market. Lack of practices regarding technologies - drivers of Industry 4.0, as well as insufficient mastery of innovation and investment management, management methods itself are real obstacles on the way to Industry 4.0. The result of the introduction of modern information technology in industry should be the formation of joint competent groups - representatives of digital IT-industries, on the one hand, and industry, on the other, focused on cooperation and development of new products and services;
- engineering clusters. Powerful developers in industrial engineering have the opportunity to radically influence industrial innovations, scientific research and

development, export marketing. The activities of industrial engineering companies are aimed at finding and developing new industrial products, generating ideas, industrial design, prototyping. Such sectors of the economy as food and processing industry, metallurgical engineering, agriculture, are the most promising for the creation and development of the industrial engineering industry;

- sectoral "road maps" of digital transformation. The creation of roadmaps for digital transformation involves the search for, development and implementation of initiatives to digitize industries. For many sectors, it is a plan to recover, increase competitiveness, and in some cases return to the economic environment.

Other important tasks are the official recognition of international standards, which are the generally accepted basis of Industry 4.0 (about 100 standards), state support for technical committees involved in working on standards related to Industry 4.0; creation of mechanisms of technology transfer.

Based on the above it follows that the most efficient state mechanisms of Industry 4.0 implementation in Ukraine are the creation of industrial parks, branch centers of technologies, creation and development of engineering clusters, the official recognition of international standards, which are the generally accepted basis of Industry 4.0.

These solutions are required by the current global economic situation, the impact of COVID-19 pandemic, advances in digitalization and convergence of information technology and operations technology (IT/OT convergence), the need for resilient operation of manufacturing plants and other enterprises. Therefore, these solutions can be taken into account by other countries in order to efficiently implement and manage Industry 4.0 in different economic sectors.

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