“INDUSTRY 4.0”—TOWARDS OPPORTUNITIES AND CHALLENGES OF IMPLEMENTATION

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Abstract
In the paper the concept of "Industry 4.0", which is based on self-organizing production systems, is shown. The attention is paid to the automation which is "an installation" that provides conditions for a human cooperating with the system as a client, service technician and programmer. The problem of competence understood as a competence of the person and as the power of position, and creating more and more independence of the system, independent from the human, way of his functioning, is also presented. Moreover, the comparison of the assumptions of automation and contemporary solutions is done.

Keywords:
Automation, Industry 4.0, IT, manufacturing.

1 INTRODUCTION
The process of technological changes has resulted in the possibility of a radical change from the computer integration manufacturing (CIM, ERP) to the concept of "Industry 4.0". The next industrial revolution based on the Internet of things and new technologies is not a continuation of current trends in automation. It results from the changes of the philosophy of creating systems responsible for the product or service [1]. It appears that it is the customer, his requirements for product quality, price and delivery time that provide are a pulse for initiating such system. In this way, the product becomes the axis of integration of socio-technical system formed ad-hoc, which should be included - as a subsystem – in the systems of higher degree of complexity. In the scale of the enterprise and the economy this phenomenon can be described as fractals which are not permanent creations. Therefore, it should be noticed that the implementation and integration of socio-technical systems, even those with a predominance of automated solutions, requires special preparation of adaptation processes, and gradual and flexible implementation. The specific technical and organizational conditions of production system with a high level of customization and those related to the readiness and preparation of personnel engaged in the product realization, should be also considered. Thus, the new situation associated with the fourth industrial revolution creates different implementation conditions. Moreover, this revolutionary change concerns creation of production systems that are more and more cyber-physical (Table 1).

<table>
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<th>18th/19th century</th>
<th>Beginning of 20th century</th>
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<td>1st industrial revolution</td>
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<td>Use of steam power machine</td>
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Table 1. Industrial revolutions timeline.

In the concept of cyber physical systems it is assumed that the products and manufacturing systems, which are necessary to their creation (factories, equipment, appliances, tools) will be firstly designed and tested during simulation, and virtual reality will be used to select solution variants and optimize the systems. The analyses of production systems are performed in reference to their validity, correctness of spatial layout, quality assurance, processing capacity, necessary and possible inputs, and environmental impact. Such a system is often an interim network created on the basis of declarations and information existing in the Internet. Such cyber physical systems appear on the basis of the principle of self-organization to realize a customized order where the conditions are defined in the customer specifications. Their different formations and actions - often possible without human participation - represent the revolutionary nature of the observed changes.

Contemporary industrial revolution is the answer to information age problems which are the consequence of the unreliableness of human resources (especially when data are enhancement) or individualization of customer expectations. It is also the result of new opportunities from the development of related technologies. There has been a made a shift in the foundations which were the basis for the IT sector - a leader - for many years [2]. Nowadays, "pure IT" is becoming more and more servile. The concurrent development of information systems and monitoring and maintenance systems of machines and devices, where the intention is to control the systems in real-time, has led to the appearance of messages originating both from system operators and from machines or devices themselves in the Internet (Figure 1).

Figure 1. Logic of IT and system solutions development towards fulfilling servient functions via Internet of Things.
“Industry 4.0” can be identified [8]:

hand, 5 topics that are rated for the implementation of Industry 4.0. This concept defines a broad spectrum of innovations in the areas of IT, awareness, ideas and further research on the universities, research institutes and industrial plants in Germany, announced a report on investment, development of local small-scale production [5]. The situation is similar to cloud computing, which is more and more advanced in comparison to the previous versions and still develops dynamically. It results from the fact that it is more and more significant and ubiquitous, however, on the other hand, it is also a source of many concerns, for both individual consumers and businesses.

In the management of modern manufacturing, information technologies support the deliberate creation of intelligent systemic (organizational, logistic) solutions that combine the concepts of lean, agile and quick response while preserving cognitive, anticipatory, realization and adaptability abilities [4]. Therefore, the purpose of this paper is to show the trends that are emerging in relation to the “4th generation industry” in the context of the consideration of its implementation to industrial enterprises.

2 IDEA OF INDUSTRY 4.0

Social, technological and environmental changes have led to the individualization of mass production. In this progressive social change the customer will be willing to pay 10-15% more for a unique product. At the same time, it will be required to deliver it rapidly what contributes to the development of local small-scale production [5]. The analysis of the industry show that there are conditions which allowed for revolutionary changes in manufacturing activities that will be based on the latest technologies and nano solutions.

In April 2013 at Hannover Messe, a consortium of universities, research institutes and industrial plants in Germany, announced a report on investment, development of local small-scale production [5]. The situation is similar to cloud computing, which is more and more advanced in comparison to the previous versions and still develops dynamically. It results from the the announcement of the Industrial Internet Consortium Testbeds, I4.0 Test Facilities (IIRA). They extend their cooperation in the areas of Industrial Internet Consortium Testbeds, I4.0 Test Facilities and Infrastructure to ensure interoperability on the technical level [10].

All these actions indicate that the industrialized countries noticed the unique and complementary effects in new manufacturing technologies and different production concepts [11] as global manufacturing trend is in a positive direction. Everyone wants to be a leader in the industrial revolution, which is supposed to help to return the industry to both Europe and North America [12]. For example, in the U.S. factory jobs are on the rise, and many of new jobs are coming back to North America from China. Since 2010, when manufacturing employment in the U.S. was 11.45 million jobs, nearly a million new factory positions have been created, mostly in the Southern states, particularly North Carolina, South Carolina, and Tennessee [13]. In such considerations natural environment plays a vital and crucial role. All the efforts should be concentrated on waste-free production, which should be realized efficiently. For example, it is suggested not to consume valuable fuel for unnecessary transportation of goods. Such assumptions lead to the return to local solutions and the provision of local products. Even Coca-Cola has committed to “water neutrality” at the local level across its globally distributed production facilities [14].

In one of the latest reports published by the European Parliament Industry 4.0 is defined as a change in organization and value creation where machines and devices communicate each other and choose the optimal pathway. The exchange of information, communication between participants leads to flexible changes in the implemented path what finally influences economy and social aspects. It is predicted that within 5-10 years the productivity of the economy of Germany will increase from 15 up to 25% [15].

After the fourth industrial revolution the factories will be able to self-organizing. In order to achieve it, it is very likely to use fractal models that allow even a description of chaotic processes occurring in dynamic systems [16]. The management concept based on the notion of “fractals” as self-organizing and self-optimizing, small and fast regulatory systems assume that production fractals communicate directly with the relevant supplier or recipient fractals. Due to self-organization, they choose each time methods, such as planning and control methods, and use machines and robots that are suitable for carrying out particular tasks. The management and creation of such a structure is becoming more and more difficult. The requirements towards individual employees or groups are getting more and more sophisticated. The creation and management of such information and communication networks is a personal, organizational and technical challenge for the future.

III. Dimension data security: active protecting confidential data from unauthorized access

IV. Middle class company’s policy dimension: innovative action of the middle class companies

V. The regulatory dimension: reference architectures and application in order to achieve competitive advantages.

At the same time the Smart Manufacturing Leadership Coalition (SMLC) in the USA, actively supports the development of intelligent manufacturing, which uses intelligent tools that operate in real-time at the level of all production processes, what was noticed at the SelectedUSA Summit in 2016 [9]. Moreover, the Plattform Industrie 4.0, and the Industrial Internet Consortium have also decided to explore the potential alignment of the Reference Architecture Model for Industrie 4.0 (RAMI4.0) and the Industrial Internet Reference Architecture (IIAR). They extend their cooperation in the areas of Industrial Internet Consortium Testbeds, I4.0 Test Facilities and Infrastructure to ensure interoperability on the technical level [10].

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In the organizational structure of an enterprise, fractals are self-contained units that operate on the principle of self-organization: at the operational level, self-organization refers to business processes, and tactical and strategic levels refer to the formulation of goals and the formation of internal and external relationships and interactions.

The products and machines will communicate with each other using integrated circuits with strict production instructions. It is predicted that more and more devices will be available online. However, this situation requires appropriate protection of the devices, information and communication systems, data processing and users applying intelligent industrial networks model and best cyber security practices [17]. It results from the fact that such systems generate, process, and exchange security-critical and privacy-sensitive data that are often targets of cyberattacks. Such attacks can be very dangerous as they may lead to physical damage of the system and even endanger human lives [18].

In Industry 4.0, infrastructure and technology overlays make it possible to better and faster use information, which results in a shift of the foundations of information transfer in production activities. The innovation initiative should not only refer to a new discovery in basic research and search for its applications, but primarily it should be focused on specific procurement, problems, or needs of society.

It is assumed that the product or service will be an integration axis around which an ad hoc system is ready to develop, produce and offer, and ultimately to provide service and finally dispose. A client’s order, which contains a specification of requirements, should be an inspiration to act - to design, configure, use the manufacturing system, and disintegrate it after performing the task.

However, a question arises what producers should do to be ready for Industry 4.0. The answer seems to be easy – such an enterprise should be flexible, use new technologies and processes, which can be adopted, and achieve significantly faster return on investment [5]. Furthermore, it should be prepared for the digitization of the manufacturing sector, driven by four disruptions: “the astonishing rise in data volumes, computational power, and connectivity, especially new low-power wide-area networks; the emergence of analytics and business-intelligence capabilities; new forms of human-machine interaction such as touch interfaces and augmented-reality systems; and improvements in transferring digital instructions to the physical world, such as advanced robotics and 3-D printing” [19]. On the other hand, the executives wonder which data will be the most important, which data leakage can lead to the biggest loss and which technologies would increase the return on investment for a company. In order to sort out these choices, Industry 4.0 levers perceived in the context of value drivers can be used (Figure 2).

![Figure 2. Value drivers and their Industry 4.0 levers (Adopted from [19]).](image)

As it can be noticed this compass consists of eight basic value drivers and 26 practical Industry 4.0 levers which should be taken into account by manufacturing leaders. It is supposed that cross-functional discussions can facilitate the companies to find the levers which are the best appropriate to solve their particular problems [19].

According to Mike James (a board member of the MESA International Board of Directors) organizations, which would like to adapt this idea and make changes to their production, should start from six basic steps [5]:

- create a team to study Industry 4.0,
- order the team to study what Industry 4.0 means and how it will affect the company,
- encourage the team to participate in events related to Industry 4.0 and discusses its issues at regular meeting,
- control and manage current investments,
- experiment with new technologies,
- be open to try new strategies even if they mean risk of losing money.

It appears that the greatest challenge for companies, which move their business to the digital model, is to change business processes and organizational structures in the enterprise related to migration [20]. There is often a need to radically reorganize sales department to meet the requirements of the digital model and connect new sales channels with the traditional ones. The best customer service procedures have to be developed as it is easy to change the provider of goods via the access to the Internet. However, the challenge is to broaden the access to the sources of data to external ones (e.g., social media), which results in more data and business processes to be processed and analyzed. It is also important to provide an
acceptable level of data security, which often requires substantial investment. It leads to the appearance of new roles in the company, for example such as a chief digital officer (CDO). It is possible to find some variations in the actual title of this job. However, the role of this person is to define the company’s digital strategy and execute its cross-functional transformation into a fully digital enterprise, but the question arises what such a digital leader is supposed to accomplish. In order to achieve it, it is possible to find five CDO “archetypes” — the progressive thinker, the creative disrupter, the customer advocate, the innovative technologist, and the universalist. The provided models are supposed to indicate the potential range of CDOs roles and responsibilities [21].

3 PROBLEM OF COMPETENCE

Competences consist of qualifications (formally confirmed), skills and experience, and attitude (in respect of duties, regulations, co-workers, supervisors, but also techniques or new concepts). New technology areas, related to the idea of Industry 4.0, require new skills from specialist staff. It should be underlined that there is a tendency is that mechanical, repetitive activities will be performed mainly by machines or robots. Thus, people should primarily develop such skills as creativity, experimenting, situational assessment, design, organization and reengineering. The 4.0 engineer must be able to process and analyze large amounts of data from multiple sources, assess the validity of the information, their credibility, and draw relevant conclusions. It will help him to get to know this information, including using electronic media and Big Data tools [22].

For example, the integration of control systems with IT systems, the programming of industrial robot assemblies, the integration of analytical systems in data clouds with local systems, cyber security and the application of artificial intelligence algorithms in automation systems can be mentioned among others.

Competence - the key is also openness - modern experts cannot be limited to their narrow specialization. They must have the ability to understand notions and concepts from other disciplines. They should be open to changes, both in the area of specialization and in the team in which they work. The more and more important is becoming the ability to communicate, intercultural one and using virtual tools.

Employers should completely change organizational structures, create systems managing talents, and use human resources strategies to keep up with the pace of technological revolution.

In 2017 the survey was carried out among more than 10 400 heads of companies and HR divisions from 140 countries, including 22% of the correspondents from large companies (employing over 10,000 employees), 29% from medium-sized companies (from 1 to 10 thousand employees) and 49% from small companies (less than 1 thousand employees). Its results show that 56% companies modify human resources programs to make it possible to use digital and mobile tools, while 33% already use various forms of artificial intelligence applications to solve HR problems. At present, the company’s personnel is not only full time employees, but also professional, seasonal, commissioned and “crowd” employees. The employers should also perceive robots, cognitive tools and artificial intelligence systems as new types of personnel. However, only 17 percent board members is ready to manage personnel, robots and artificial intelligence. This level is the lowest one observed for five years in the Global Human Capital Trends survey [23].

It is also indicated that by 2020, the European labour markets may be short of as much as 825 000 ICT professionals. This lack of employees can be particularly visible in advanced manufacturing settings where there is a need of analysis of big data and cybersecurity. In spite of the fact that various actions have been undertaken to boost the acquisition of eskills, the young generation is not particularly interested in the digitalization of the workplace. In the survey, conducted among young German, only 13% of the respondents definitely would like to work in ICT, in spite of the fact that they perceive this sector as the most prospectus [24].

4 READINESS OF ENTERPRISES TO IMPLEMENT IDEA OF INDUSTRY 4.0 IN POLAND

According to the Welcoming Innovation Report of the GE Global Innovation Barometer [25] 77% of Polish entrepreneurs are optimistic about the Industry 4.0 and 83% of the respondents are interested in its technologies. The global business optimism results from the fact of the dynamics of corporate investments in Big Data analysis tools. In the recent years, this indicator has grown at a two-digit rate. In Poland, the scale is much small and it increased from 49% in 2014 up to 68% in 2016.

Data-driven business is getting more and more tangible, and data do not only are important for the advertising industry or IT sector. Their benefits are also noticed in the fin-tech sector such as banks, telecoms, consulting and insurance companies. It results from the fact that the information coded in the Big Data allows to have a 360-degree view of the business situation and implement the effective strategy.

The companies, which refer to Big Data in their decision-making processes, are more flexible, respond faster to market trends, and have the ability to anticipate problems or threats that may appear in the future months. These data have also a positive influence on corporate revenue.

When implementing new concepts beyond the substantive one, it is important to have an application knowledge that allows you to creatively introduce new solutions, not just reactive to duplicate what has already been created somewhere.

5 CONCLUSIONS

In Poland many companies are not prepared for the 4.0 revolution. They are ready to improve their elements or departments, but not to do the overall integration. However, today at the stage of purchasing of new machinery it is important to know their possibilities, how they will work with other machines and even if they can be integrated in the future [26].

The level of the introduction of robots to carry out industrial tasks in Poland is growing much faster than on the matured markets (in the years 2010-2014 it increased by 20%). However, it should be emphasized that in Poland most of the enterprises are small and medium-sized which that are not “technological leaders in comparison to the enterprises located in Western European countries. The level of process automation is far from expected. In spite of the fact that Polish society is well educated, the degree of saturation of business with digital competence is not high. The investigations show that among 28 European Union countries of the European, Poland is in the 25th position. However, the interest to implement the Industry 4.0 concept can result from increasing labor costs. There is a need to search for new approaches to achieving the same efficiency with less engagement of human resources [27].

In Industry 4.0, IT is a driver of change and innovation in terms of process and technology, however, it is not a
prerequisite. The production system require digital models, simulations and analysis of large data sets to produce products that meet quality standards. At the design and construction stage, a mathematical approach and IT technology are needed. It is much cheaper than running a

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