Varazdin Development and Entrepreneurship Agency and **University North**
in cooperation with
Faculty of Management University of Warsaw
Faculty of Law, Economics and Social Sciences Sale - Mohammed V University in Rabat
Polytechnic of Medimurje in Cakovec

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71st International Scientific Conference on Economic and Social Development Development

Book of Proceedings

Editors:
Iva Gregurec, Darko Dukic, Abdelhamid Nedzhad

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APPLICATION OF INDUSTRY 4.0 TECHNOLOGIES IN CREATION OF AUTOMATED INDUSTRIAL COMPLEXES

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ABSTRACT

The article deals with the development of automated industrial complexes using Industry 4.0 technologies. The main stages of the development of the concept of "Industry", the technology of the current stage of Industry 4.0 - technologies for the construction and use of "digital twins", BIM-technology for 3D-modeling of buildings and structures are described. The areas of application of these technologies, as well as their advantages and disadvantages are presented. An example of designing the elements of an automated process control system for the "Mine No. 12" processing plant using traditional methods and using Industry 4.0 technologies is given.

Keywords: *automated industrial complex (AIC), industrial revolution, Industry 4.0, digital twin, BIM-technologies, computer-aided design (CAD) systems, modeling, automated process control systems (APCS), EPLAN*

1. STAGES OF INDUSTRIAL REVOLUTIONS. MODERN INDUSTRY 4.0 TECHNOLOGIES

The creation of modern automated industrial complexes (AIC) is a complex task, both technically and organizationally. In conditions of limited resources, it is impossible to effectively solve the problems of creating an agro-industrial complex without the use of modern technologies, in particular, Industry 4.0 technologies. Now briefly consider the process of development and formation of the concept of the industrial revolution - "Industry" (Figure 1) [1], as well as the main technologies of the current stage of Industry 4.0 in the field of creating automated complexes.

The first industrial revolution (Industry 1.0) began in the second half of the 18th century after the appearance of steam engines, which made it possible to switch from manual labor to machine labor in almost all areas of production and caused a colossal rise in labor productivity.

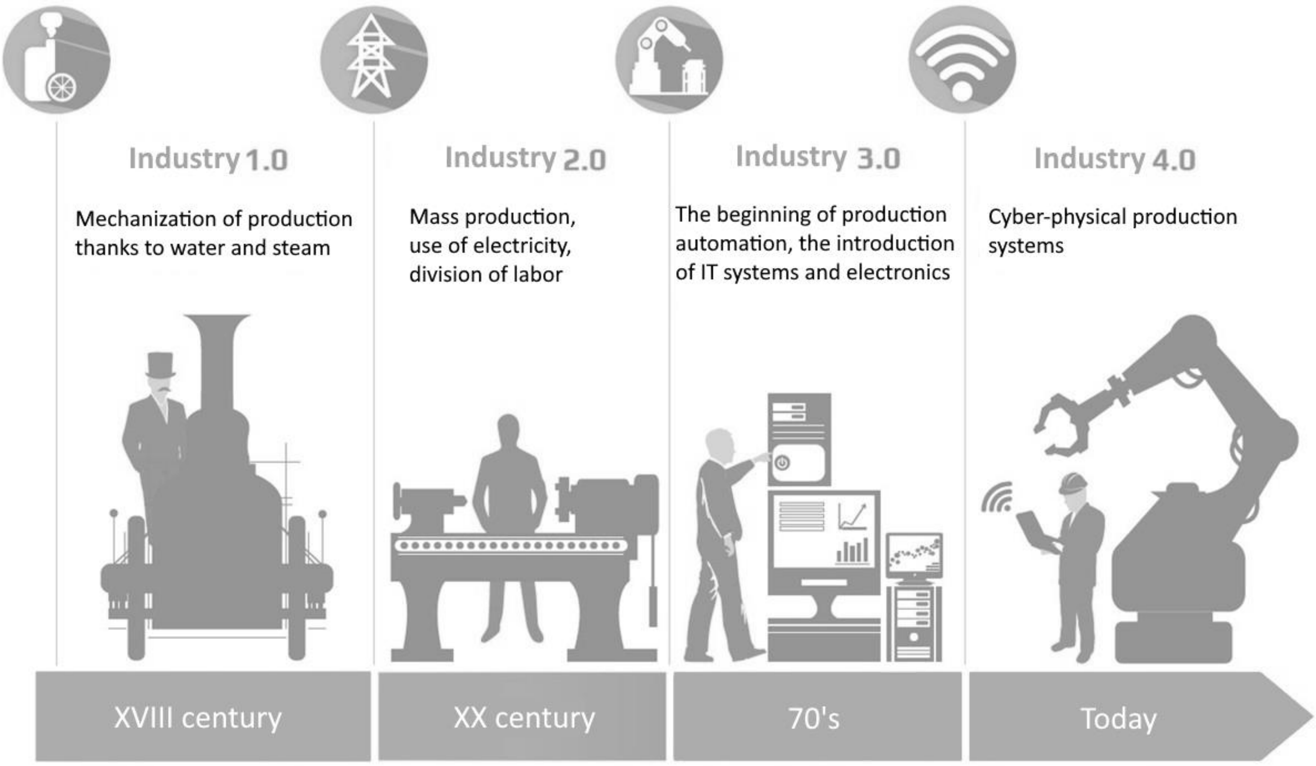

Figure 1: The process of development of the concept of "Industry" - industrial revolution

The second industrial revolution (Industry 2.0) came with the development of electricity and was characterized by the development of mass conveyor production. Its main "engine" was the development of science and the introduction of its results into production. The third industrial revolution (Industry 3.0), also called the digital revolution, began in the second half of the 20th century with the creation of digital computers and the subsequent evolution of information technology. The industrial revolution is currently entering the fourth stage (Industry 4.0), the features of which are the massive introduction of "cyber-physical systems" into production. The fourth industrial revolution began with a 2011 initiative led by academics, designers, manufacturing and policy makers who identified Industry 4.0 as a means of increasing the competitiveness of the manufacturing industry through the enhanced integration of “cyber-physical systems” into factory processes [2]. The main technologies developed in the framework of the fourth industrial revolution (Industry 4.0) are shown in Figure 2.

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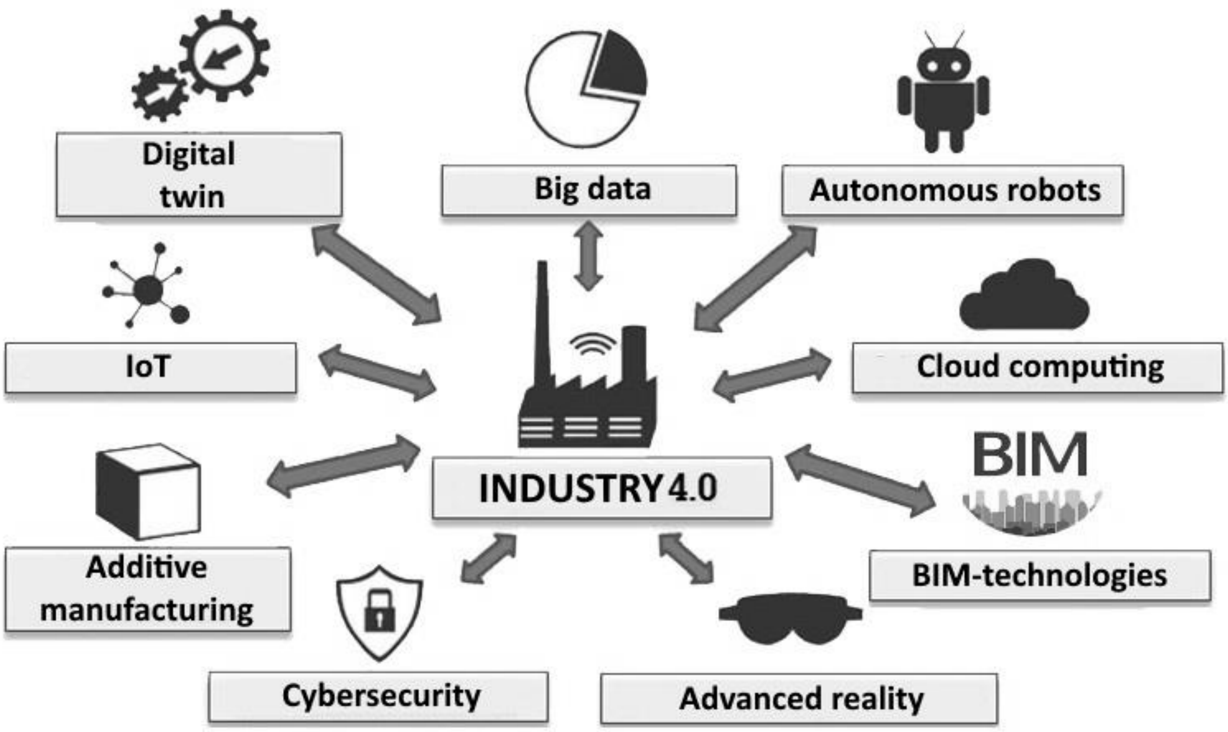

Figure 2: The main technologies of Industry 4.0

2. BUILDING INFORMATION MODELING TECHNOLOGIES

When creating automated industrial complexes, the most important and promising Industry 4.0 technologies are BIM (Building Information Model / Modeling) technologies - technologies for 3D-modeling of buildings and structures, as well as technologies for constructing and using “digital twins”. "Digital Twin" in Industry 4.0 is defined as a virtual representation of a physical object, system, complex throughout their life cycle using real-time data obtained from smart sensors [3]. Within the framework of the technology of "digital twins" a digital model is created for a physical object, piece of equipment or an entire industrial complex, which is used to analyze and predict the behavior of such an object or complex as a whole. The digital model is constantly updated in order to fully comply with the current operating mode of the real complex. This makes it possible to identify unforeseen changes in the processes, to optimize the operating modes of equipment, to prevent breakdowns and accidents, which ultimately makes it possible to significantly increase the reliability and efficiency of the agro-industrial complex. However, at the moment, the scientific and practical foundations for creating digital twins of the agro-industrial complex are poorly developed [4]. For some industries, digital twins of standard objects have been developed and debugged, for example, the oil and gas industry, mechanical engineering. However, it is impossible to completely transfer a ready-made debugged system to a new object, since even seemingly insignificant differences can cause significant deviations and errors. Even for seemingly similar productions, every time a significant revision is required. The main difficulty in creating an agro-industrial complex using digital twin technologies lies in the selection and further development of such methods for creating and researching digital twins, which allow, firstly, to reasonably transfer (recalculate) the results of model solutions to a full-scale control system, and, secondly, take into account the features and conditions of its functioning most fully. In our opinion, this is possible when using the methods of natural-mathematical modeling [5-6]. BIM in the framework of Industry 4.0 is defined as an information model / modeling of buildings and structures, which in a broad sense means any infrastructure objects [7]. The first BIM-technologies began to appear in the late XX - early XXI century.

As a separate direction of computer-aided design (CAD) systems associated with 3D-modeling of buildings and structures in the form of digital three-dimensional models (digital twins of buildings and structures), BIM was formed in the second decade of the 21st century (Figure 3).

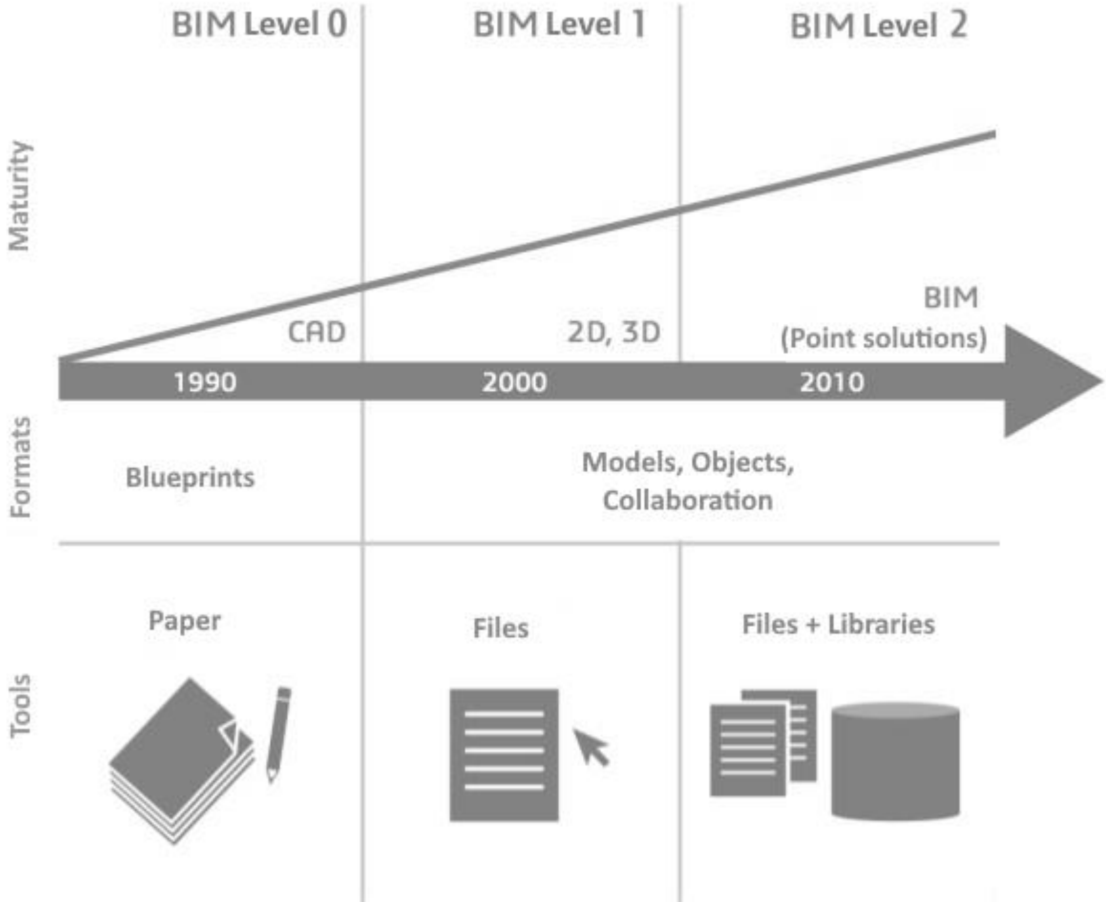

Figure 3: Evolution of BIM-technologies in the creation of automated industrial complexes

The design process is based on the creation and use of 3D-models of absolutely all elements of buildings and structures, as well as their utilities (Figure 4). Thus, BIM-technologies provide a single information platform for all participants in the creation of an automated industrial complex - designers, architects, engineers, builders, etc. BIM-technologies allow you to combine the work of many people in different directions into a single shell, allowing you to simplify and automate the design and development processes.

Figure following on the next page

Figure 4: 3D-model of a building constructed using BIM

It should be noted that BIM-technologies are not universal and comprehensive technologies for the design of automated industrial complexes in general. The areas of effective application of BIM-technologies are limited and are primarily associated with the tasks of constructing 3D-models of buildings and structures, their utilities, that is, with tasks of a spatial nature - the layout of building structures, technological equipment, utilities (water, gas, electrical, sewer, communication) etc. BIM-technologies do not solve the problems of developing software, algorithmic mathematical support for ACS TP - to solve these problems, the use of other design tools and technologies is required [8, 9]. The main advantage of using BIM technologies is the high speed of designing 3D-models, their clarity, the ability to quickly make changes at any stage of the design, the ease of organizing the joint work of many performers of one project. However, there are drawbacks when using BIM-technologies. First of all, this is the need for a transitional process to the use of BIM-technologies: it is required to restructure all participants in the creation of an automated industrial complex from traditional local design to 3D-modeling. The responsibility of specialists is growing, as well as the requirements for their knowledge and qualifications, both in the technical and informational parts [10, 11]. Also, one of the possible problems of using BIM-technologies in the design of automated industrial complexes can be a set of project documentation generated by BIM-tools and a form of document submission. The overwhelming majority of programs for building BIM-models are products of foreign production and, as a rule, are not fully adapted and localized to the design and construction standards of the Russian Federation. In 90 percent of cases, additional labor-intensive operations are required to localize project documentation to the norms and standards of a particular state. Despite all these shortcomings, the scope of application of BIM-technologies in the construction of 3D-models is quite wide, their use is economically feasible and effective. The use of digital twins of buildings and structures in the form of 3D-models built using BIM greatly simplifies the processes of their design, construction and operation.

3. BIM-SOFTWARE PRODUCTS - EPLAN ELECTRIC PACKAGE

At the moment, in the Russian design market in the field of civil engineering, there are many software products for BIM-solutions (Table 1).

Characteristic	BIM-package			
	Allplan	Revit	Renga	EPLAN
1. Development company	Nemetschek Allplan Systems GmbH (Germany)	Autodesk, Inc. (USA)	Renga Software (Russia)	EPLAN Software & Service GmbH & Co. KG (Germany)
2. Functionality	medium	high	low	high
3. Fields of application	architecture, structural elements architecture	architecture, structural elements, engineering architecture	architecture	automation, structural elements, engineering
4. Support for the Russian market	Russified software, lack of construction and documentation standards for the Russian market	partial Russification, lack of construction and documentation standards for the Russian market	full support of Russian requirements and design standards	support of Russian regulatory and technical standards GOST for working documentation
5. Compatibility of use with other software products	integration with open design systems of Russian software developers	integration with Autodesk applications	application of the created models in 1C solutions	compatibility of document formats with other CAD systems (for example, AutoCAD)

Table 1: BIM-packages presented on the Russian software market

When designing the control system cabinets of the coal-processing plant "Mine No. 12" (Kiselevsk), the EPLAN Electric BIM-package from EPLAN Software & Service GmbH & Co (Germany) was tested for the automatic generation of design documentation based on 3D-models of the components used in the data. cabinets. BIM-design made it possible to significantly, 5 times reduce the time for the development of the project of control cabinets for the automated process control system (Figure 5).

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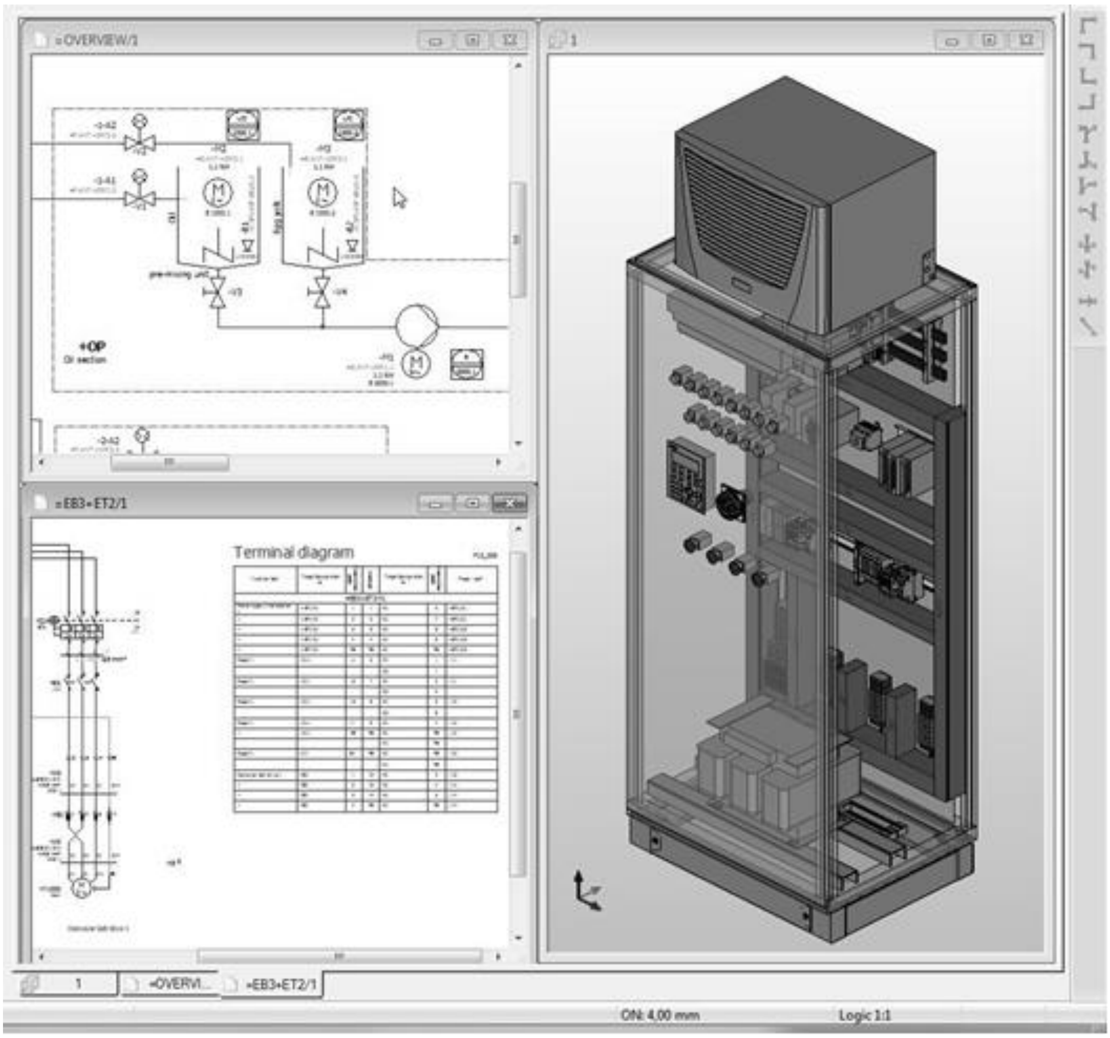

Figure 5: Control cabinet of the APCS of the Mine No. 12 PF, designed using the EPLAN Electric BIM-package

4. CONCLUSION

Technologies of the fourth industrial revolution Industry 4.0 are in many ways promising technologies for the creation of automated industrial complexes. The Industry 4.0 technologies considered in this article - technologies for building and using digital twins, BIM-technologies - are not universal tools for creating automated industrial complexes. They only in some part allow solving the problems of designing the agro-industrial complex, but they do not solve the problems of algorithmic control of complex technological processes, the problem of developing information, mathematical and software for the agro-industrial complex. However, with the development of these technologies in line with the natural-model approach, they can serve as the basis for the creation of modern automated industrial complexes.

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