UDC 334.7; JEL Classification: D29

The smart technologies application for the product life-cycle management in modern manufacturing systems

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Abstract. Perspective directions of development of information technologies in the field of improvement of programs of universal artificial intelligence for tasks of the organization of production are Considered. Modern trends of application in production are considered and advantages to companies are analyzed. The concept of building a production process using smart technologies and other artificial intelligence approaches is proposed.
Keywords: production organization, artificial intelligence, process informatization, machine learning, production process management, digital intelligent technologies.

Introduction

The production process at the most enterprises in Russia and all over the world today is mostly automated. At all its stages, most of the work is done by mechanisms, machines, software for comprehensive data analysis. And yet, in most industries, any management decisions of even the lowest level are carried out by specialists and managers. At the same time, one of the fastest growing innovative areas of technological development is artificial intelligence. It enters gradually into all aspects of the business from working with clients to the strategic planning [1].

Many experts say that, unlike Internet companies such as Google or Amazon being flagships for the implementation and development of AI solutions, as well as banks and service market companies that successfully implement it in their operations, artificial intelligence in manufacturing has not yet received such wide distribution. Therefore, it is difficult to talk about the real competition of manufacturing companies in terms of its effectiveness. But there is no doubt that the future of production largely depends on its ability to adapt high-tech to its needs. Already, companies that use AI technology are amongst the market leaders [2-6].

Digitalization of production

Over the years, companies have invested in digitalizing production. ERP, MES, SCADA systems receive information from sensors in production and visualize information for analysts and engineers. CRM systems analyze the customer base, financial departments work with 1C and other financial instruments. Each part of the process is recorded and calculated using computers, but more often it happens that these systems are not integrated amongst themselves. Big Data is neatly collected and stored in different databases for the usage by department employees, while this information could work daily for the company [7-9].

Unlike humans, AI has no specialization, but there are ample opportunities for learning and creating patterns, for making optimal decisions after analyzing the full picture of the enterprise. Let us consider the most developed areas of AI work at the moment.

1. Generative design. Today, the best designs are created by programs in which engineers and designers enter the desired parameters and a possible sketch at the input, but it is the software that creates the models, which go then into mass production. The accuracy of calculations performed by machines is higher in many times, and the final models are better suited for further assembly on automated conveyors [5].

2.Digital Twin. An exact virtual copy of the production process in real time. The system monitors the entire process in general, conducts performance and quality analyses, analyses the operation of the system and indicates to the user all possible errors, malfunctions or simply process flaws. Companies that use Digital Twins typically build their processes on the basis of modern foresight. The principle of Predictive maintenance is to anticipate problems and crashes and resolve them in advance. AI analyses data from sensors and, while tracking the slightest changes in work, gives recommendations for changing the plan of logistics supplies. As a result, the accuracy of the project, the continuity of production and maintaining a high efficiency of the system, product quality surpasses key figures before the application of AI solutions [2-4].

Let us consider the construction of the production process using artificial intelligence: at the initial stage, managers, engineers and technologists work out the product parameters, using generative design technologies, determine the necessary dimensions, materials, properties. The search for production parameters is based on existing information about the product model, budget, location logistics and the necessary supplies. The sensor system and all the necessary AI solutions are installed and interconnected at the very first stage in order to run machine learning algorithms as early as possible [4].

The implementation of the process involves dividing it into four segments, interconnected by the strategic goals of the enterprise. Since production and sales are integrated in the system, the transition from one stage to another in all life stages of products is recorded by programs and directly affects production volumes and delivery times. Therefore, the change management algorithm is kicked into gear, which receives information from the sales unit and the digital twin system.

3. Machine learning. The technology works in two directions: obtaining, processing the current information flow and finding solutions for future optimization in the databases of best knowledge and previous experience. The program analyses the economic efficiency, production capacity, flexibility, timing and marketing component of the current position of the product and predicts changes within the process and on the market.

The following segments of automation of production processes, in which smart technologies are actively used, are distinguished:

The “Sales Segment” actively uses the second line of work of the machine learning algorithm, i.e., based on Live data and the best practice databases, it analyses the market situation and builds a sales strategy. In the same block, the information about customers is

processed, about sales logistics, about costs, which are associated with sales. Processes and costs are programmed, automated and optimized.

"Quality segment" is related directly to the production. Quality depends often on proper standardization, and thanks to the artificial intelligence, the probability of error approaches zero. The production process, which is based on anticipation, transmits information to the change management algorithm and determines the reliability and characteristics of the process with the frequency, which is necessary for a particular production.

"Production management segment" is a unit for direct management of systems by a manager. Despite the visible successes in the development of artificial intelligence in almost all areas of activity, we can confidently say that in the next ten to twenty years, a very small percentage of processes managers will be able to completely transfer to the implementation of AI. For this, there are many reasons that are individual for each industry, from the general ones we can name the existing percentage of errors, the influence of the human factor in most markets, the insufficient degree of integration of most companies into the IoT (Internet of things) network.

The introduction of technology is a multi-level process. The machine learning algorithm is improved and accumulates knowledge throughout the entire time of functioning. The period of complete training of machines in production processes depends on the complexity and number of operations. The connection between the production and management of an organization in each segment is a complex process and it must be managed by company managers [7]. To teach the algorithms to see the moments of transition between the stages of the process, we need information about previous iterations of key business processes that machine learning can derive from the data of SCADA and MES systems of the company [3].

Speaking about the benefits that AI can give to the business, it could be said that changing the situation in today's markets does not leave any space for manoeuvres for companies, which are operating according to old standards. The loss of time in marketing management and production improvements will not allow companies to compete with more tech market leaders. Thanks to the digital twin, standards achieved through optimization and improvement, based on the knowledge collected by data mining algorithms, are maintained and improved.

Modern AI applications, much better than people do with figures and statistics. The monitoring of the status of processes of production is necessary for efficiency, frequent reports are necessary for progress, and if they are made by artificial intelligence, then managers have free time for development and strategic planning based on the information received. Machine learning-based software solution will be a support for managers, engineers, logisticians, architects. Analysis and optimization of the initial process, tracking the position of the company on the market and in comparison with its results over the past periods, tips on managing time and finances based on the best practices and experience of artificial intelligence, full statistics reports and analyses at the request of the manager, systematization and optimization all processes to achieve common goals will become more achievable and understandable for managers and employees, thanks to visualization [5].

Smart Technologies (Digital Intelligent Technologies)

For the formation of a single system of smart manufacturing, the integration with manufacturing smart technologies is required, which is a complex of software, hardware, information and communication and cyber-physical solutions that combine all the elements of the production system [8]. A key feature of smart manufacturing is the deep transformation and digitalization of the organization's business processes for the full automation and algorithmization of industrial enterprises. Production technologies are based on the creation of a physical and virtual infrastructure for communication and interaction of various elements

of production processes. Formation of a single smart production system is a difficult task to integrate disparate information of various forms, therefore, for these purposes, it is expected to use smart technologies, a group of approaches to production based on the use of artificial intelligence technologies. An integrated production system includes broad tasks: designing a corporate technological architecture, reconfiguring business processes, consolidating information between objects and business entities, creating an organizational production strategy. The interactions occur in real and virtual space at all stages of the life cycle. First of all, the phases of design, production and implementation are digitized. Thus, the enterprise needs to develop a unified digitalization methodology, since different departments, services and divisions must "communicate" in one technological language, with the help of which documentation is made out, databases are formed, software is compiled and equipment is configured. The choice of a common communication language allows one to move on to the step of constructing a model of digital transformation and enterprise development into an integrated production system with a single information communication space.

The digital form of the economy makes a unified system of data, knowledge, methods of their processing and transfer. In paper [11], the term "intelligent digital technologies" (IDT) is used to refer to this system. In foreign literature, the term "smart technology" is used. They include Artificial Intelligence (AI) [12], machine learning (Machine Learning, ML), the Internet of things and cyberphysical and sensory systems (Internet of Things, IoT), digital data management technologies (Data Science, DS) and knowledge (Knowledge management, KM), big data technologies (Big data technologies, BDT), data mining technologies (Data Mining, DM) and talent management using digital technologies (Educational Technologies, EdT).

Artificial intelligence is a cross-cutting super technology: a complex of models, techniques, approaches, algorithms, technologies and tools for managing information. It also includes various cognitive, neuromorphic, and bio-morphic technologies that consolidate the achievements of all branches of knowledge in imitation of the neurobiological and psycho-emotional processes of natural intelligence. First of all, these are the distinctive mechanisms of human mental activity: learning, abstraction, and pattern recognition [18].

The next step is to create a full-fledged digital model of production - a virtual, fully interactive twin of the entire production system. This allows one to interact with a realistic virtual copy of the production system and thereby manage production processes in reality; have quantitative models of the effectiveness of the functioning of the entire system and reasonably plan the results of its development.

Algorithmization of production processes is done on the basis of machine and deep learning approaches and their integration into the general organization of production system, which forms the integrated network space of an industrial enterprise in the form of a structure of key functioning parameters represented by high-quality data. Formalization and analysis of production operations allows us to formulate a strict vision of production processes and the entire global network of value formation, analyze the presence of problem situations and quickly take adequate measures, optimize the process of making managerial decisions, objectively evaluate the performance of an organization.

The use of smart technologies in production allows us to create smart manufacturing complexes and systems, to design interactively a holistic picture of an industrial organization, and create the future architecture of a smart production organization. The single structural model allows all production participants to represent clearly the functions performed and problem areas at different levels of the organization's activity review (socio-economic level, production and technological level, information and telecommunication level, etc.). Also, the development of production smart technologies seems to be a promising direction for the development and application of artificial intelligence to solve economic problems and the development of integrated production complexes

Conclusions

ADT is a key trend of the present time [19]: for the year of 2016, the global market for artificial intelligence technologies was estimated at 33 billion rubles. (The amount is converted into rubles at the historical exchange rate), and together with the observed tenfold investment increase, this market will reach the monetization of 330 billion rubles by 2020 year. Moreover, significant commercial application of ADT is observed not only in the field of financial and commercial services, but also in more conservative sectors, such as engineering, metallurgy and chemical production (according to the TAdviser analytical center and company "Jet Infosystems").

More detailed ICT market segmentation was proposed by company Tractica and it was based on the analysis of several hundred real cases. Six fundamental technologies were identified. They include: machine and deep learning, technical vision, natural language processing, machine argumentation and machine conclusion of reasoning, as well as 21 niche technologies. The forecast of this company on the growth of the global ADT market is: from 40 billion of rubles in the 2016 year, up to 2.5 trillion of rubles in the 2025 year.

Areas of change with the help of ADT: cost reduction, improving product quality, increasing the soundness of decision making, increasing labor productivity, improving security and reducing the negative impact of the human factor, developing competitive potential, and increasing the effectiveness of interaction with customers [19]. The local ADT market is represented by more modest investment values (0.7 billion rubles in the 2017 year and up to 28 billion rubles by the 2020 year) [20].

The current status of the domestic market reflects global trends in the multiple annual growth of interest and penetration into the most diverse areas of activity: services, advertising, medicine, information security, transport, algorithmic trading and various forms of industrial production [20].

Nevertheless, local experts emphasize the general lag of the domestic ADT market from global trends, justifying this by the low level of automation and digitalization of the economy, the moral and technical deterioration of the main computing power, as well as the practice of domestic companies using ADT as a know-how, information on the content and results of which do not disclose publicly.

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