Reserves for improving the efficiency of petrochemical production on the basis of "Industry 4.0"

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Abstract. One of the current problems in the industrial complex is the issue of resource saving and energy efficiency, which is confirmed by the relevant government programs, strategies, regulatory documents. The solution of the problem of increasing the efficiency of the organization of production systems requires the definition and development of the necessary mechanisms, in particular, by automating production processes. The article analyses the key trends in the development of the concept of "industry 4.0" in the petrochemical industry. The factors influencing efficiency of the organization of production systems are revealed. The main directions promoting development and improvement of the organization of production are defined. It considers the basic tools of process improvements, process automation, petrochemical plants: work on the system of just-in-time, 5S system of rationalization of the workplace, different information systems, particularly ERP systems, CALS-technologies. Advantages of automation of production processes at the enterprises of petrochemical complex are defined.

1 Introduction

The problem of resource saving and energy efficiency in the industrial complex of Russia today is one of the most urgent, which is enshrined in the relevant policy documents and development strategies of Russian enterprises. As part of the Energy strategy of Russia for the period up to 2030, one of the important tasks is "to achieve sustainable results in the field of fuel and energy complex in the context of increasing global competition for resources and markets; rational reduction of the share of fuel and energy resources in the structure of Russian exports, the transition from the sale of primary raw materials and energy resources abroad to the sale of products of their deep processing, as well as the development of the sale of petroleum products produced at foreign refineries owned by Russian oil companies" [1].

In modern conditions of technological modernization, industrial production is focused on innovative technological systems that can provide high economic efficiency, resource conservation, quality improvement. Solving the issue of improving the efficiency of petrochemical production requires the definition and development of the necessary mechanisms.

The production system is a resource-forming system with its characteristic features of functioning, which include the nature of the relationships between the elements of the system, the degree of variability of the composition and components of the production system, the nature of production processes, the type of relationships with the environment, etc. [2, 3].

Currently, the main drivers of digitization of petrochemical enterprises are the following:

- optimization of production process management system based on cloud servers;
- preventive maintenance and repair;
- business processes of subsidiary units;
- integrated planning and implementation;
- logistics: supply, production, distribution, transportation, inventory and warehouse infrastructure management [4].

2 Modern trends in the development of industrial enterprises in the transition to the digital economy

Issues of resource saving and energy efficiency are of particular importance for those sectors of industry where the share of manufactured industrial products is high – these include the petrochemical complex. The petrochemical industry, along with the chemical complex, has a significant impact on the main industries, construction, agriculture, being the basis for the production of various types of products, materials; and from other sectors of industry, this sector has a high level of automation of labor and technological development. This is due to the fact that petrochemical products are intensively used by all sectors of the economy.

In the conditions of continuous development and improvement of the organization of production, new concepts are implemented, which are aimed at improving the efficiency and productivity, reducing production

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costs, accelerating the entry of new products to the market, meeting the needs of the population, as well as increasing the competitiveness of production.

In industry, digitalization is based on the concept of "industry 4.0", which provides for the end-to-end digitalization of all processes and their integration into an intelligent technology platform [5, 6]. This emphasizes the undoubted relevance and practical importance of the issues of digital transformation, justification and formation of the image of digital systems and infrastructure of the digital economy.

One of the conditions for the effective functioning of the production sector of the domestic economy is the use of fuel and energy resources. Rationally organized production, processing and use of fuel and energy resources form the basis for the stable and efficient functioning of the economic system of the region and the country as a whole. Currently, the expansion of the use of decentralized energy sources, reduction of energy and material intensity of production are the main trend in energy consumption in the development of the world fuel and energy complex (figure 1).

The production system of a stable functioning enterprise is subject to constant quantitative and qualitative changes caused by market demands and technological development. In this regard, the mechanism for improving the efficiency of the organization of production systems should implement the functions of development, selection and implementation of measures that will ensure the effectiveness of systems, using the means and methods of organizing production through its automation.

Implementation of complex programs of automation of production processes at the largest oil companies contributes [8, 9]:

- increase the productivity of the technological process;
- improvement of product quality;
- reduction of transition time;

- increase the time to maintain the optimal technological regime;
- reduction of energy consumption;
- improving the efficiency of working processes and operational readiness of oil refineries (refineries);
- reduction of operating costs and development of the level of automation of production.

3 Areas of use of digital technologies in petrochemical enterprises

The petrochemical industry, with its significant production and investment potential, is designed to become the engine of modernization of the entire industrial complex during the deployment of the fourth industrial revolution and digitalization. The preservation of competitiveness, the introduction of open models of innovation in the petrochemical sector necessitate the active automation of management processes of the petrochemical industry. Here, one of the directions is the implementation of the principle of "digital plant", carrying out continuous monitoring of the state of each asset, each item of equipment in conjunction with each stage of the production process. The digital plant assumes connection to the information space where equipment manufacturers and service companies are connected [10, 11]. This interaction environment provides instant information exchange between the participants, which has a direct impact on the quality of decision-making, and therefore ensures the absence of accidents and downtime. Thus, the digital factory involves the connection of processes, assets and people for the continuous maintenance of the efficiency of production (figure 2).

Carrying out industrial modernization projects, oil refineries and petrochemical enterprises pursue the following goals:

Fig. 1. Current state of development of the world fuel and energy complex (created by author based on [7]).

Fig. 2. The value chain in the digital factory of the petrochemical industry (created by author based on [12]).

- increase productivity by minimizing work interruptions, downtime of equipment and personnel;
- achievement of high industrial safety and protection against cyber-attacks;
- reduction of production costs by increasing the manufacturability of production and the introduction of resource and energy-saving technologies.

At the same time, the digitalization and automation of production processes in petrochemical enterprises should be comprehensive and cover the entire value chain of the product – supply, production, distribution, maintenance and repair, after-sales service.

In the IT infrastructure of a petrochemical enterprise, it is possible to distinguish the structural levels of the pyramid of digitalization, at the base of which automated process control processes are located, then information systems for automation, synchronization, coordination, analysis and optimization of production at the enterprise are located [13, 14]. Integration of supply, production and distribution processes is carried out within ERP systems, integrating production and all operations for production management, human resources, Finance and asset management, to achieve their optimal use. Solving problems, Analytics of big data accumulated in the corporate information system of the enterprise is implemented in such a digital product, located at the top level of the pyramid hierarchy, as SAP-BI.

The systems of advanced process control (APC – Advance Process Control), which are gaining popularity in Russia at petrochemical enterprises, help to follow the set parameters of oil production and production of petrochemical products and in case of deviation from the target targets promptly inform the control center of the main and auxiliary processes. The use of flow analyzers allows you to control the physical and chemical characteristics of raw materials, semi-finished products, intermediate consumption and finished products. Adjacent installations are combined into complexes, which allows you to synchronize processes, manage them from a single center.

Projects on digitalization of petrochemical enterprises are successfully implemented in the Republic of Tatarstan. One example of a digital plant of petrochemical industry is JSC "TANECO", integrating into a single enterprise management system such processes as oil production, personnel training, technological regime according to the regulations,

visualization of internal management processes and their tracking.

At the Federal level, an example of the implementation of digital solutions in the petrochemical industry is the experience of Lukoil, which is currently implementing 14 digital projects in the corporate center, 28 in geological exploration and oil production, 10 in the electric power industry, 16 in processing and 12 in sales. Directions of development of digitalization of the petrochemical industry on the basis of distributed control systems (DCS) and emergency protection (DSP) are systematized in the following areas: digital worker, predictive maintenance and repair, integrated operations center, intelligent monitoring systems, information management on production facilities, software robots (RPA), optimization of production processes, 3D printing of spare parts, digital double.

Adaptation and implementation of standards for digital industries on the example of the Republic of Tatarstan are shown in figure 3 (figure 3).

Priorities for anticipatory standardization are [15]:

- additive manufacturing (additive manufacturing, 3D printing);
- end-to-end digital modeling of projects at all stages of the project life cycle (BIM);
- digital end-to-end life cycle management systems for industrial facilities and products, as well as end-to-end process control systems (MES);
- end - to-end digital design modeling (Dynamic3D Modelling, Simulation-Based Design, CAE, CAD);
- industrial Internet of things (IIoT), including IoT end device architecture standards, industrial IoT data transfer standards (NB-IOT, LoRaWAN and LPWAN);
- compatible target architectures, ontologies and smart city platforms.

For the development of digitalization in the industries of the Republic of Tatarstan it seems appropriate to carry out the following infrastructure initiatives and projects:

1. Together with network companies, the launch of a program to upgrade the equipment of transformer substations of the Republic of Tatarstan, including high-voltage substations, in order to introduce digital ACS TP (project "Digital substation") and replace analog equipment in the energy distribution management system based on IEC 61850 and other modern standards of digital energy.

Fig. 3. Advanced adaptation and implementation of standards for digital industries of the Republic of Tatarstan (created by author based on [12]).

2. Development of recommendations and direction for the implementation of common standards of wireless data transmission for industrial M2M communications (industrial Internet of things) – LoRaWAN, LPWAN, NB-IO with the participation of the Ministry of communications and information of the Republic of Tatarstan.

3. Provision of the "green light" mode for the introduction of wireless networks for M2M data transmission based on such protocols by Telecom operators (Rostelecom, Big3, etc.) on the territory of the Republic of Tatarstan; organization of interaction in the triangle format "Telecom operators – enterprises – regulators".

4 Conclusions

In modern conditions the optimization of control systems is reduced to the automation of logistics processes, which play an important role corporate information system ERP (enterprise resource planning), MRP (material requirements planning materials), SCM (supply chain management), CRM (customer relationship management), CALS-technologies and other software systems to automate production and management processes.

The nature of modernization of industrial enterprises in the transition to the digital economy can be considered in the framework of logistics, information, management and production subsystems aimed at reducing transaction and transformation costs. Modernization of the production subsystem of industrial enterprises can be carried out in several ways: improving their own

development of products and services and the organization of its production; orientation of production on Assembly operations based on the transfer of products from the customer; focus of production only on the production of components.

The introduction of logistics and information systems in industrial enterprises allows to achieve accuracy in the planning of economic activities and to maintain an adequate factual account of all major resources: material, financial, personnel, etc. Their use makes it possible to easily standardize typical business processes, while applying the best industry practices. Such systems create a single information space covering all enterprises of the group for production, processing and sales of products, unifies management processes, accounting policies and directories.

Thus, in order to increase the competitiveness of industrial enterprises, labor productivity, product quality, accelerate the process of new products entering the market, the key condition is the use of digital technologies and the implementation of strategic tasks facing the country in the context of economic transformation.

References

- [1] *On approval of the Energy strategy of Russia for the period up to 2030* [Electronic resource] // Order of the Government of the Russian Federation, November 13, 2009 1715-r.
- [2] O.G. Turovets, T.A. Chasovskikh, Bases of the organization of resource-saving production system of

the industrial enterprise. Bulletin of the Voronezh state technical University, **11-3**, 43-46 (2011)

[3] V.T. Malysheva, A.I. Shinkevich, S.Sh. Ostanina, E.L. Vodolazhskaya, V.O. Moiseyev Perspective Directions of Improving Energy Efficiency on the Meso and Micro Levels of the Economy. Journal of Advanced Research in Law and Economics, **1**, 75-83 (2016)

[4] *On approval of the program "Digital economy of the Russian Federation"* [Electronic resource] // Order of the Government of the Russian Federation, July 28, 2017 1632

[5] N.V. Barsegyan Open innovations as a resource for management of high-tech enterprises. Bulletin of Belgorod University of cooperation, Economics and law, **5**, 118-127 (2018)

[6] S.S. Kudryavtseva, F.F. Galimulina, I.A. Zaraychenko, N.V. Barsegyan Modeling The Management System Of Open Innovation In The Transition To E-Economy. Modern Journal of Language Teaching Methods, **8(10)**, 163-171 (2018)

[7] V.P. Meshalkin Methods of logistics of resource and energy saving as organizational and management tools of modernization of petrochemical complex. Integrated energy saving technologies, **2**, 4-20 (2011)

[8] A.I. Shinkevich, S.S. Kudryavtseva, M.V. Shinkevich, I.G. Salimianova, I.I. Ishmuradova Improving the efficiency of production process organization in the resource saving system of petrochemical enterprises. International journal of energy economics and policy, **9(4)**, 233-239 (2019)

[9] M.V. Shinkevich, N.V. Barsegyan The role of entrepreneurial initiatives in improving the organization of production of petrochemical enterprises. Bulletin of the Belgorod University of cooperation, Economics and law, **2 (75)**, 358-369 (2019)

[10] A.I. Shinkevich, S.S. Kudryavtseva, Increase of innovative activity in the sphere of energy saving on the basis of the concept of open innovations. Bulletin of Kazan technological University, **17**, 15, 495-499 (2014)

[11] S.K. Sahu, K. Narayanan, Environmental Certification and Technical Efficiency: A Study of Manufacturing Firms in India. Journal of Industry Competition and Trade, **16(2)**, 191-207 (2016).

[12] *State information system in the field of energy saving and energy efficiency: reference and information center* [Electronic resource] // Access Mode: <https://gisee.ru/articles/analytics/64098/>

[13] A.I. Shinkevich, A.A. Lubnina, N.M. Chikisheva, L.M. Simonova, E.E. Alenina, B.B. Khrustalev, R.Sh. Sadykova, R.R. Kharisova Innovative Forms of Production Organization in the Context of High-Tech Meso-Economic Systems Sustainable Development. International Review of Management and Marketing, **6(2)**, 219-224 (2016)

[14] S.S. Kudryavtseva Trends in the development of the digital economy in Russia. Sustainable development Management, **2 (15)**, 21-27 (2018)

[15] A.A. Lubnina, A.I. Shinkevich, V.V. Avilova, G.M. Kharisova, E.L. Vodolazhskaya, A.A. Novikov, E.V. Novikova Innovative Forms of Industrial

Enterprises' Cooperation International. Journal of Environmental and Science Education, **12(1)**, 69-77 (2017)