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DIGITALIZATION OF ADJUSTMENT AND MAINTENANCE PROCESSES FOR OPTIMIZING ENERGY CONSUMPTION IN THE OIL AND GAS SECTOR

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ЦИФРОВИЗАЦИЯ ПРОЦЕССОВ НАЛАДКИ И ОБСЛУЖИВАНИЯ ДЛЯ ОПТИМИЗАЦИИ ЭНЕРГОПОТРЕБЛЕНИЯ В НЕФТЕГАЗОВОМ СЕКТОРЕ

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Abstract. This article examines the impact of digitalization on adjustment and maintenance processes in the oil and gas sector aimed at optimizing energy consumption. Modern technologies such as big data analysis, the Internet of Things (IoT), and Machine Learning (ML) algorithms are discussed, highlighting how they assist companies in reducing energy consumption and enhancing operational efficiency. Examples of the implementation of these solutions in major companies are provided, demonstrating significant reductions in energy costs and equipment downtime. The advantages of contemporary approaches over traditional adjustment and maintenance methods are emphasized.

Аннотация. В статье рассматривается влияние цифровизации на процессы наладки и обслуживания в нефтегазовом секторе с целью оптимизации энергопотребления. Обсуждаются современные технологии, такие как анализ больших данных, интернет вещей и алгоритмы машинного обучения, которые помогают компаниям снижать энергопотребление и повышать эффективность операций. Приведены примеры внедрения этих решений в крупных компаниях, демонстрирующие значительное сокращение энергозатрат и времени простоя оборудования. Подчеркиваются преимущества современного подхода перед традиционными методами наладки и обслуживания.

Keywords: digitalization, oil and gas sector, energy consumption, optimization, big data, maintenance, sustainable development.

Ключевые слова: цифровизация, нефтегазовый сектор, энергопотребление, оптимизация, большие данные, техническое обслуживание, устойчивое развитие.

Digitalization, as an important trend in contemporary development, profoundly influences all sectors of the economy, including the oil and gas sector. Amid global climate change, increased ecological demands, and the necessity for improved resource utilization, optimizing energy consumption has become a particularly relevant task.

The oil and gas sector are one of the most energy-intensive in the global economy. The processes of extraction, processing, and transportation of hydrocarbons require significant energy volumes, driven by the complexity of technological operations and the scale of production facilities. Optimizing energy consumption in this industry is directly linked to improving companies' economic performance, reducing operational costs, and minimizing environmental impact. In this

Т. 10. №11 2024
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context, digitalization plays a central role in modernizing and optimizing equipment adjustment and maintenance processes, allowing for a significant reduction in energy costs and an overall enhancement in production efficiency. The purpose of this article is to examine the current aspects of digitalization and analyze the impact of the implementation of modern technologies on energy consumption optimization.

Main part. Challenges of energy efficiency and process optimization in the oil and gas sector

The oil and gas sector are one of the largest consumers of energy in the world. According to the International Energy Agency (IEA), in 2022, the oil and gas industry accounted for over 30% of the total global primary energy consumption (Figure 1).

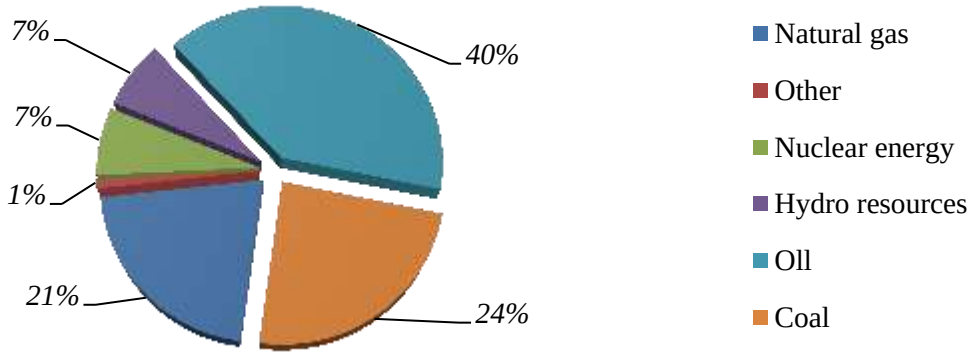

Figure. Global primary energy consumption, 2022 [1]

The primary energy costs are associated with the processes of extraction, processing, and transportation of hydrocarbons. A significant portion of energy expenditures occurs during the adjustment and maintenance of equipment, negatively impacting the overall efficiency and sustainable development of the sector. Traditional methods of equipment adjustment and maintenance in the oil and gas sector often prove ineffective. Many processes are performed manually, increasing the likelihood of errors and slowing response times to emerging issues. Without constant monitoring of equipment condition, it is challenging to quickly identify and rectify faults, potentially leading to prolonged downtimes and losses. Often, companies lack clear information on the status of their assets, complicating the planning of preventive work and increasing the risk of accidents. Fragmented management systems and the absence of a unified database hinder analysis and decision-making, further detracting from process efficiency.

Ineffective adjustment and maintenance processes in the oil and gas sector have serious implications for both the economy and the environment. From an ecological perspective, high energy consumption is linked to increased greenhouse gas emissions and other pollutants. The economic consequences of process inefficiencies are also significant. Rising energy costs amidst fluctuating oil and gas prices can lead to decreased profitability for companies. Thus, addressing issues related to the inefficiencies of adjustment and maintenance processes becomes not only an ecological but also an economic necessity for the oil and gas sector. In this situation, the introduction of digital technologies can be an important factor in improving aspects, significantly increasing efficiency and reducing the negative impact on the environment.

Digitalization of processes: the main aspects

Digitalization in the oil and gas sector involves the integration of advanced digital technologies into the processes of extraction, processing, and maintenance of hydrocarbons. This includes automation, data collection and analysis, as well as the use of intelligent systems to enhance efficiency and reduce costs. The goal of digitalization is not only to optimize production

Т. 10. №11 2024
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processes and reduce energy consumption but also to improve safety, service quality, and minimize environmental impact. Digitalization in the oil and gas sector covers a wide range of technologies, each of which makes a significant contribution to process optimization, efficiency improvement and safety. One of the main technologies is Internet of Things (IoT). This concept includes a network of interconnected devices equipped with sensors that collect and transmit data over the Internet. In the oil and gas industry, IoT allows continuous monitoring of equipment, which helps to quickly identify and eliminate malfunctions [2]. For example, sensors can monitor the operating parameters of pumps and compressors, transmitting information to a central control system, which ensures more efficient resource allocation and reduces downtime.

Another important technology is big data analysis. In the context of a constant increase in the volume of information produced in the process of extraction and processing, traditional methods of data processing are becoming insufficient. Big data analysis allows oil and gas companies not only to process huge amounts of information, but also to extract valuable insights from them. For example, you can analyze data on productivity, costs, and working conditions, which contributes to more accurate forecasting and planning.

Artificial intelligence also plays a significant role in the digitalization of the oil and gas sector. Using Machine Learning (ML) and deep learning algorithms, it can analyze data and identify patterns that are not visible in normal analysis. This allows you to automate many processes, such as inventory management, maintenance planning, and optimization of equipment operating parameters.

Cloud solutions provide flexibility and scalability, allowing companies to store and process large amounts of data without the need for significant capital investments in infrastructure. Cloud platforms allow teams to work together, share data and analytics in real time, which is especially important for international companies with distributed assets. This simplifies project management by providing access to the necessary information at any time and from any place.

Real-time analytics is becoming important for the oil and gas sector, as it allows for rapid response to changes in production processes. Thanks to this technology, companies can not only monitor the condition of equipment, but also instantly analyze data, which increases safety and reduces the risk of accidents. For example, if anomalies are detected in the operation of the equipment, you can immediately take measures to fix the problem [3].

Digital twins represent another cutting-edge technology in digitalization. These are virtual models of physical objects or processes that reflect their state and behavior. Digital twins allow engineers and operators to conduct simulations and analyze how changes in operating conditions can affect the performance and reliability of equipment. This helps in planning upgrades and optimizing maintenance, which in turn helps to increase efficiency and reduce costs.

According to the author, digitalization in the oil and gas sector is an important factor contributing to improving the efficiency and sustainability of the industry. The introduction of technologies allows companies to optimize processes, reduce costs and minimize risks. It also contributes to more accurate forecasting and rapid response to changes, and digital twins provide in-depth analysis of equipment performance. Together, these technologies help not only improve the financial performance of companies, but also reduce the negative impact on the environment, which makes digitalization an important step towards the sustainable development of the oil and gas industry.

The role of digitalization in adjustment and maintenance

Traditional methods of equipment adjustment and maintenance in industrial sectors, such as oil and gas, are based on manual processes and intuitive approaches. Maintenance is usually conducted according to predetermined schedules, which do not always correspond to the actual

Т. 10. №11 2024
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condition of the equipment. This includes regular checks performed by operators based on standard procedures, but such inspections are often limited to visual assessments and may not cover all possible defects. Documentation of inspections and maintenance is done manually, increasing the likelihood of errors and complicating access to historical data [4]. As a result, traditional adjustment and maintenance methods can be ineffective and do not always ensure reliable equipment operation, highlighting the need to transition to more modern and digital approaches.

Digitalization significantly changes the approach to adjustment and maintenance in the oil and gas sector. It brings improvements in productivity, reliability, and efficiency of processes, which in turn contributes to cost reduction and enhanced overall operational efficiency. In the adjustment process, digitalization helps optimize energy consumption through more precise and rapid analysis of equipment performance. The use of programmable logic controllers and automation systems allows for the adjustment of equipment based on its energy characteristics, minimizing excess energy consumption. Virtual testing and simulations help determine optimal operating parameters before the equipment is launched, preventing inefficient energy consumption during operation.

Real-time data analysis also plays an important role. Modern monitoring systems allow for tracking energy consumption at each stage of equipment operation and promptly adjusting settings to achieve optimal performance. This enables the identification and elimination of sources of excess energy consumption, such as inefficient operating modes or faults that could lead to additional costs. In the maintenance process, digitalization provides tools for predictive maintenance and remote monitoring. Predictive maintenance allows for planning maintenance and repairs based on data analysis, helping to prevent unexpected breakdowns and reduce inefficient energy consumption related to faults [5]. Remote monitoring enables the tracking of energy performance metrics in real-time and allows for optimization measures to be taken without the need for physical presence.

Intelligent support systems based on artificial intelligence can analyze large volumes of data on energy consumption and suggest solutions for optimization. These systems assist not only in the adjustment of equipment but also in planning long-term improvements aimed at reducing energy costs. Digitalization of adjustment and maintenance processes represents an important step toward increasing the efficiency and reliability of equipment operation in modern conditions. The implementation of digital technologies allows not only for the optimization of current processes but also for their transformation, making them more flexible and adaptive to changes in the production environment. The transition from traditional methods to digital solutions brings significant advantages (Table).

Digitalization of adjustment and maintenance processes offers significant advantages over traditional methods, including improved accuracy and speed of adjustments, more effective forecasting and prevention of failures, and optimization of energy consumption. These changes not only contribute to cost reduction and increased productivity but also create more sustainable and environmentally friendly processes. In an environment of increasing competition and demands for efficiency, the implementation of digital technologies has become an integral part of the successful development strategies of enterprises across various industries [8].

An example of successful implementation of digitalization in adjustment and maintenance processes for optimizing energy consumption in the oil and gas sector is ExxonMobil. The company actively utilizes digital technologies to optimize its energy processes. The introduction of big data analytics and IoT systems at its refineries enables the company to effectively collect and analyze data, allowing for prompt responses to potential issues, significantly reducing equipment downtime. As a result of these changes, ExxonMobil reported a 10-15% reduction in energy consumption at some of its production facilities, which translates to savings of up to $100 million per year. This is

Т. 10. №11 2024
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also associated with an overall productivity increase of 5-10%, ensuring not only cost savings but also increased production volumes [9].

Table

COMPARISON OF TRADITIONAL ADJUSTMENT AND MAINTENANCE METHODS WITH DIGITALIZATION [6, 7]

Advantages	*Digitalization*	*Traditional methods*
Accuracy and speed of adjustment	High accuracy thanks to automated systems. Fast setup using real-time data	Errors are possible due to the human factor. Long-term processes requiring manual intervention
Fault prediction and prevention	Data analysis and problem prediction. Prevention based on data analysis	The reaction to malfunctions only after they occur. Scheduled repairs, without taking into account the actual condition
Optimization of energy consumption	Intelligent control systems	No analysis, fixed operating modes
Data access	Centralized databases and cloud technologies	Limited access, information is scattered
Team coordination	Improved interaction through digital platforms	Difficulties in the exchange of information
Cost reduction	Saving on repairs and energy resources	Higher costs for emergency repairs
Big data analysis	The ability to perform deep analytics and identify trends	Limited analysis capabilities
Environmental sustainability	Reducing the carbon footprint through process optimization	Lack of focus on sustainable development

Another example is Chevron, which actively implements intelligent management systems. These systems analyze data in real-time, optimizing equipment performance and minimizing energy consumption. The adoption of these technologies has led to a 10-20% reduction in energy costs in certain operations due to optimized equipment performance. ML algorithms assist not only in forecasting but also in improving maintenance planning. This allows Chevron to identify potential issues in advance and minimize risks associated with failures. As a result, the company has been able to reduce maintenance costs by 25% [10]. Thus, digitalization not only contributes to significant energy savings but also enhances overall operational efficiency, marking an important step toward sustainable development for companies.

Conclusion

The digitalization of adjustment and maintenance processes in the oil and gas sector is becoming an essential tool for optimizing energy consumption and improving operational efficiency. The adoption of modern technologies such as big data analytics, the IoT, and ML algorithms enables companies to not only reduce costs but also enhance the resilience of their business processes. In light of global challenges related to climate change and resource depletion, digitalization is becoming not just a technological trend but a necessary condition for ensuring the sustainable development of the oil and gas sector. Investments in digital technologies and innovative solutions will open new horizons for process optimization, helping the industry adapt to changing conditions and demands of the modern world.

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