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APPLICATION OF ARTIFICIAL INTELLIGENCE AND AUTOMATION IN THE OIL AND GAS SECTOR

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In recent years, artificial intelligence (AI) and automation have become integral parts of the oil and gas industry, unlocking new opportunities to enhance efficiency, safety, and process resilience. AI technologies significantly improve exploration, extraction, processing, and transportation of hydrocarbons, while also enhancing forecasting accuracy and risk management. Automation optimizes production processes, reduces costs, and minimizes human error.

This paper explores the key applications of AI and automation in the oil and gas sector, such as prediction and optimization of extraction, safety improvement, risk management, as well as the use of robotic systems and digital twins. Special attention is given to the implementation of intelligent data analytics systems, market trend forecasting, and the industry's sustainable development.

The adoption of these technologies allows oil and gas companies to increase competitiveness, improve environmental sustainability, and minimize operational risks. The paper also presents examples of successful implementations and the challenges faced by companies during their digital transformation.

KEYWORDS: artificial intelligence, automation, oil and gas industry, digitalization, safety, optimization, digital twins.

ПРИМЕНЕНИЕ ИСКУССТВЕННОГО ИНТЕЛЛЕКТА И АВТОМАТИЗАЦИИ В НЕФТЕГАЗОВОМ СЕКТОРЕ

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В последние годы искусственный интеллект (ИИ) и автоматизация становятся не-отъемлемой частью нефтегазового сектора, открывая новые возможности для повыше-ния эффективности, безопасности и устойчивости процессов. Технологии ИИ позволяют значительно улучшить процессы добычи, переработки и транспортировки углеводородов, а также повысить точность прогнозирования и управления рисками. Автоматизация, в

свою очередь, оптимизирует производственные процессы, снижая затраты и минимизируя влияние человеческого фактора.

В статье рассматриваются ключевые направления применения ИИ и автоматизации в нефтегазовой отрасли, такие как предсказание и оптимизация добычи, повышение безопасности, управление рисками, а также использование роботизированных систем и цифровых двойников. Особое внимание уделяется внедрению интеллектуальных систем для анализа данных, прогнозирования рыночных трендов и устойчивого развития отрасли.

Применение этих технологий позволяет нефтегазовым компаниям повысить конкурентоспособность, улучшить экологическую устойчивость и минимизировать эксплуатационные риски. В статье также представлены примеры успешных внедрений и вызовы, с которыми сталкиваются компании в процессе цифровизации.

КЛЮЧЕВЫЕ СЛОВА: *искусственный интеллект, автоматизация, нефтегазовый сектор, цифровизация, безопасность, оптимизация, цифровые двойники.*

МҰНАЙ-ГАЗ СЕКТОРЫНДА ЖАСАНДЫ ИНТЕЛЛЕКТ ПЕН АВТОМАТТАНДЫРУДЫ ҚОЛДАНУ

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Соңғы жылдары жасанды интеллект (ЖИ) және автоматтандыру мұнай-газ секторының ажырамас бөлігіне айналып, процестердің тиімділігін, қауіпсіздігін және тұрақтылығын арттыруға жаңа мүмкіндіктер ашты. Жасанды интеллект технологиялары көмірсутектерді өндіру, өңдеу және тасымалдау процестерін едәуір жақсартуға, сондай-ақ болжау мен тәуекелдерді басқарудың дәлдігін арттыруға мүмкіндік береді. Автоматтандыру өз кезегінде өндіріс процестерін оңтайландырады, шығындарды азайтады және адам факторының әсерін азайтады.

Мақалада мұнай-газ саласында өндірісті болжау және оңтайландыру, қауіпсіздікті арттыру, тәуекелдерді басқару, роботтық жүйелер мен цифрлық егіздерді пайдалану сияқты ЖИ және автоматтандыруды қолданудың негізгі бағыттары қарастырылады. Деректерді талдау, нарықтық трендтерді болжау және саланың тұрақты дамуы үшін зияткерлік жүйелерді енгізуге ерекше назар аударылады.

Бұл технологияларды қолдану мұнай-газ компанияларына бәсекеге қабілеттілік-

ті арттыруға, экологиялық тұрақтылықты жақсартуға және пайдалану тәуекелдерін азайтуға мүмкіндік береді. Мақалада сонымен қатар табысты іске асырудың мысалдары және цифрландыру процесінде компаниялардың алдында тұрған қиындықтар келтірілген.

ТҮЙІН СӨЗДЕР: *жасанды интеллект, автоматтандыру, мұнай-газ секторы, цифр-ландыру, қауіпсіздік, оңтайландыру, цифрлық егіздер.*

Introduction. In recent decades, the oil and gas industry has been undergoing a transformation due to the introduction of advanced technologies, including artificial intelligence (AI) and automation. These technologies can significantly improve the efficiency, safety and sustainability of production processes, as well as reduce operating costs. In this article, we will look at how AI and automation are changing the oil and gas sector, as well as their impact on various stages of the production cycle.

1. Optimization of exploration and production

One of the key applications of artificial intelligence and automation in the oil and gas industry is the optimization of hydrocarbon exploration and production processes. With the help of AI, it is possible to improve the quality of exploration work, reduce the time and cost of field development.

Application of AI in exploration:

• Analysis of geophysical data. Artificial intelligence helps to process and analyze data from seismic surveys, which makes it possible to more accurately model the geological structure and predict the location of deposits.

• Reservoir modeling. AI systems can analyze data on the behavior of formations and reservoirs, which helps optimize production strategies and increase the oil recovery rate.

• Resource forecasting. Modern AI algorithms are able to more accurately predict the volume of hydrocarbon reserves, which minimizes risks and increases profits.

Automation at the production stages:

• Well automation. The use of automatic systems for monitoring and adjusting well parameters can significantly reduce human interference in the process, increasing safety and accuracy.

• Robotic systems. The use of robots to perform operations in hard-to-reach and dangerous areas (for example, in deep-sea or underground installations) significantly reduces risks for workers [1].

2. Intelligent process management systems

In the oil and gas industry, the management of technological processes at various stages of production, from drilling to processing, plays an important role. The implementation of intelligent control systems using AI and automation allows you to:

• Manage flows. AI can analyze sensor data and predict changes in oil and gas flow parameters, which helps to respond quickly to changes and prevent emergencies.

• Optimization of production processes. Automatic control systems can adjust the process in such a way as to maximize the efficient use of resources, minimizing energy costs and increasing productivity.

• Monitoring the condition of the equipment. With the help of AI, it is possible to predict equipment malfunctions and automatically initiate maintenance procedures, which significantly reduces the risks of accidents and downtime.

3. Prediction and risk management

One of the most important aspects of AI application in the oil and gas industry is forecasting and risk management. This applies to both environmental and operational and financial risks.

• Forecasting accidents and incidents. AI systems can analyze data from multiple sensors installed at production facilities and predict possible emergencies such as oil leaks, gas emissions, or equipment overloads.

• Environmental risk management. Artificial intelligence is used to monitor environmental impacts, for example, to detect leaks of hydrocarbons and other harmful substances in real time. This allows us to quickly take measures to minimize environmental damage.

4. Smart factories and production automation

Automation plays a key role in the petrochemical and refining industries, which are also part of the oil and gas sector. Modern factories and processing plants are becoming "smart" due to the integration of AI into control, management and diagnostic processes.

• Automation of recycling processes. AI helps optimize production cycles, manage product quality, and minimize losses. For example, control systems can adapt processing processes on the fly depending on the characteristics of the raw material.

• Intelligent logistics. Modern AI-based management systems help optimize logistics at production facilities, manage inventory, and minimize transportation costs.

5. Remote control and monitoring

The introduction of AI and automation significantly changes the approach to remote monitoring and management of facilities, which is especially important for work in remote or dangerous areas.

• The use of drones. Drones with sensors and cameras can carry out inspections of facilities such as pipelines, drilling rigs or gas rigs, transmitting real-time data. This allows you to avoid dangerous field trips of employees with potential threats.

• Centralized management. With the help of automated systems, it is possible to centrally manage the entire process of extraction and processing of hydrocarbons, including remote facilities, which increases efficiency and reduces management costs [2].

6. Economic and environmental benefits

The use of artificial intelligence and automation can significantly reduce costs and increase profitability, which is especially important in conditions of instability in the global oil and gas markets.

• Reduced operating costs. Automation allows you to optimize work processes, reduce errors, improve cost control, and increase productivity.

• Environmental efficiency. AI helps to minimize pollutant emissions and control environmental risks, which contributes to compliance with environmental standards and improves the sustainability of the industry in the long term.

7. The future of AI applications in the oil and gas sector

The future of the oil and gas industry is inextricably linked to the development of artificial intelligence and automation. As machine learning algorithms and deep analytics improve, the opportunities for process optimization will only expand. We can expect:

• Improve the accuracy of predictions. With the help of AI, it will be possible to predict production even more accurately, as well as the behavior of the oil and gas market.

• Development of smart object technologies. More smart wells, automated drilling rigs, and integrated plants that will operate with minimal human intervention are expected to be introduced.

• Development of new eco-technologies. AI will help in the development of technologies aimed at more environmentally friendly extraction and processing of hydrocarbons.

Materials and research methods. The use of artificial intelligence and automation in the oil and gas industry opens up new horizons for improving efficiency and safety at all stages of the production process. From exploration and production to processing and logistics, these technologies can optimize operations, reduce costs, and improve environmental sustainability. In the future, artificial intelligence and automation will become even more integrated in the oil and gas sector, offering new opportunities for innovation and industry growth [3].

Analysis of the application of artificial intelligence and automation in the oil and gas sector.

In recent decades, the oil and gas sector has faced increasing challenges related to the need to improve the efficiency, safety and sustainability of production processes. In response to these challenges, as well as to optimize costs and minimize risks, the industry is actively implementing advanced technologies such as artificial intelligence (AI) and automation. Let's look at the impact of these technologies on various aspects of the oil and gas industry, their advantages and possible challenges.

Optimization of hydrocarbon exploration and production processes

Advantages:

• Artificial intelligence significantly improves the exploration and production processes, allowing for more accurate prediction of the location of hydrocarbon deposits, as well as improving the quality of seismic and geophysical research. This reduces exploration time and costs, increasing the efficiency of field development.

• Production automation allows you to create systems that can adjust the parameters of wells in real time, minimizing errors, increasing accuracy and safety. This is especially true in difficult and hard-to-reach areas, such as offshore and deepwater fields.

Challenges:

• The high cost of initial investments in AI and automation technologies, as well as the complexity of implementation in existing production processes.

• The need for highly qualified specialists to develop and support these technologies.

Intelligent process management systems

Advantages:

• AI in production process management allows analyzing data from various sensors in real time, predicting changes in parameters, which helps to respond to possible problems in a timely manner and prevent accidents.

• Automation of control over technological processes, including flow, temperature and pressure control, reduces the human factor and minimizes the risks of operational errors.

Challenges:

• The inability to fully automate in some cases — there are many factors that may require human intervention, especially in complex and unusual situations.

• The need for high-quality data collection for training AI systems, which may require upgrading existing infrastructures.

Prediction and risk management

Advantages:

• Predicting emergency situations using AI allows you to identify potential threats in advance and take timely measures to prevent accidents, such as oil leaks, gas emissions or equipment overload.

• Environmental risks, such as pollution, can also be effectively controlled using AI systems that analyze data on possible leaks and emissions in real time.

Challenges:

• The reliability and accuracy of AI models may vary depending on the quality of the data being fed into the system. If the data is incomplete or distorted, this can reduce the accuracy of forecasts and increase risks.

• Ethical and legal issues related to automated risk management, especially if the AI system makes decisions without human involvement.

Development of smart factories and production automation

Advantages:

• In the petrochemical industry, automation of processing and production increases efficiency, improves product quality, and reduces operating costs. AI systems, for example, can set up equipment for more precise processing of raw materials, which contributes to more efficient processing and reduced losses.

• Intelligent AI-based logistics helps optimize inventory management and minimize transportation and distribution costs.

Challenges:

• Problems with the integration of existing technologies and automated systems. The implementation of new solutions requires significant investments in equipment modernization and staff training.

• Cyber threats related to digitalization of processes. As the level of automation increases, the risk of cyber attacks and data leaks increases [4].

Remote control and monitoring

Advantages:

• Remote monitoring and control using AI and automation significantly improves security by allowing remote facilities to be monitored without physical presence on site. This is especially important in extreme and dangerous working conditions (for example, on offshore platforms).

• The use of drones and robots for inspections and equipment checks reduces risks to human resources and increases the accuracy of inspections.

Challenges:

• Dependence on high-speed and reliable communication networks, which can be a problem in remote regions.

• Difficulties in regulation and legislation, as remote control technologies may require new safety standards and legal regulation.

Economic and environmental benefits

Advantages:

• Reduction of operating costs due to automation of many processes and optimization

of staff work. This leads to significant savings on labor resources, as well as reduces the likelihood of errors that can lead to accidents.

• Environmental sustainability: AI helps to minimize pollutant emissions, control leakage risks and environmental impacts, which contributes to compliance with environmental norms and standards [5].

Challenges:

• Significant initial investments in the development and implementation of technologies that many companies may not be able to afford, especially in conditions of instability in the oil market.

• Difficulties in the transition to new technologies and staff training to work with high-tech systems.

The future of AI and automation applications in the oil and gas sector

Advantages:

• It is expected that with the development of AI technologies in the future, the oil and gas industry will be able to make more accurate forecasts, optimize production processes and manage risks.

• The introduction of new environmentally friendly technologies in the extraction and processing of hydrocarbons using AI, which will help significantly reduce the negative impact on nature.

Challenges:

• Technological barriers: At the moment, many oil and gas companies are still using outdated equipment and technologies, which makes it difficult to implement new solutions.

• Moral and ethical aspects: Issues related to the autonomy of systems may raise concerns among employees and the public, especially if AI systems begin to make decisions without human involvement.

Conclusion. The use of artificial intelligence and automation in the oil and gas industry opens up significant opportunities to increase efficiency and safety, improve environmental sustainability and reduce operating costs. However, despite the obvious
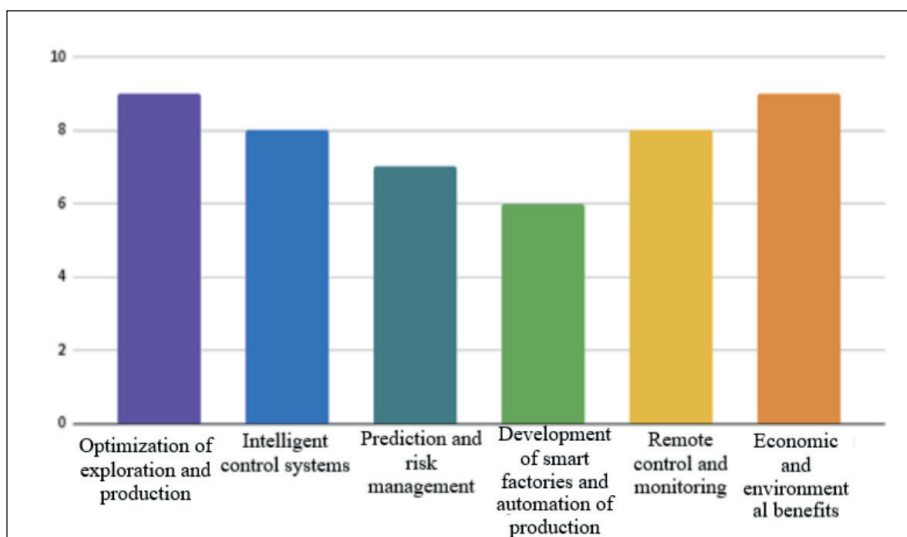
advantages, technology requires significant initial investments and may face various technical, economic, and legal challenges. It is important that companies carefully analyze the risks and benefits of implementing AI and automation, carefully choose technologies and take into account all aspects, including staff training and data security [6,7].

The study shows that this graph illustrates the application areas of artificial intelligence (AI) and automation, as well as their importance (score from 1 to 10). The horizontal axis lists the areas of application, and the vertical axis shows the percentage of importance.

All directions have high humidity levels close to 100%. Among them:

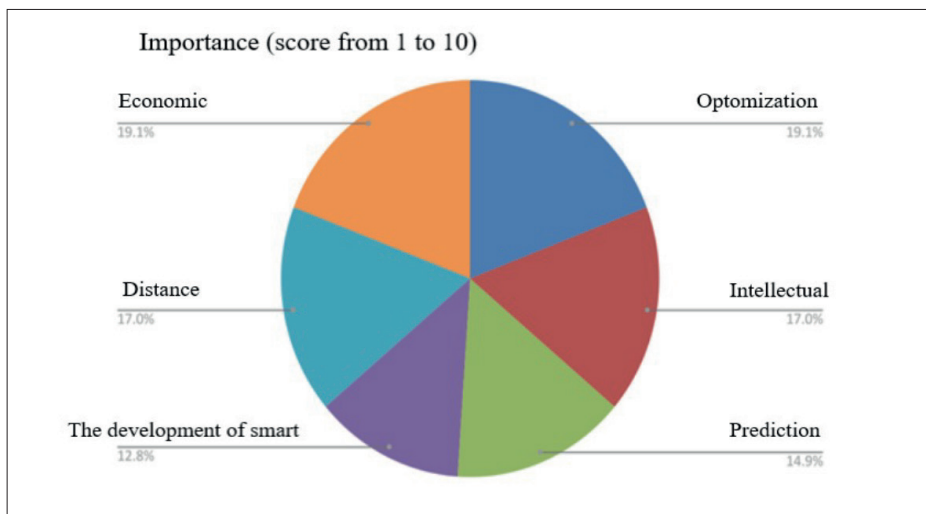Optimization of exploration and production.
Intelligent control systems.
Prediction and risk management.
The development of smart factories and automation of production.
Remote control and monitoring.
Economic and environmental benefits.

Each category has almost the same score, which indicates their equal importance in the analysis.

The study shows that this circular graph represents the distribution of importance of various applications of artificial intelligence (AI) and automation (score from 1 to 10) as a percentage.

The sectors of the chart correspond to the following areas:

Optimization of exploration and production — 19.1%.
Economic and environmental benefits — 19.1%.
Intelligent control systems — 17.0%.
Remote control and monitoring — 17.0%.
Prediction and risk management — 14.9%.
Development of smart factories and production automation — 12.8%.

The graph shows that more importance is given to areas related to process optimization and economic efficiency, while the development of smart factories is relatively less important.

REFERENCES

1   Волкова Д.С. Использование искусственного интеллекта в нефтегазовой отрасли: возможности и перспективы // Современные научные исследования и инновации. 2024. [Volkova D.S. Ispol'zovanie iskusstvennogo intellekta v neftegazovoy otrasli: vozmozhnosti i perspektivy // Sovremennye nauchnye issledovaniya i innovatsii. 2024] URL: https://web.snauka.ru/issues/2024/01/101227.

2   Подольский А.К. Применение методов искусственного интеллекта в нефтегазовой промышленности // Современная наука. 2016. № 3. С. 33–36. [Podol'skiy A.K. Primenenie metodov iskusstvennogo intellekta v neftegazovoy promyshlennosti // Sovremennaya nauka. 2016. № 3. S. 33–36.]

3   Тчаро Х., Воробьев А.Е., Воробьев К.А. Цифровизация нефтяной промышленности: базовые подходы и обоснование "интеллектуальных" технологий // Вестник Евразийской науки. 2018. Т. 10, № 2. С. 77. [Tcharo Kh., Vorob'yev A.E., Vorob'yev K.A. Tsifrovizatsiya neftyanoi promyshlennosti: bazovye podkhody i obosnovanie "intellektual'nykh" tekhnologiy // Vestnik Evraziyskoy nauki. 2018. T. 10, № 2. S. 77.]

4   Ghahramani, Z. (2015). Probabilistic machine learning and artificial intelligence. Nature, 521(7553), 452–459. [Ghahramani, Z. (2015). Probabilistic machine learning and artificial intelligence. Nature, 521(7553), 452–459.]

5   Mohamed, A. H. H., & Hasan, A. R. (2019). Artificial Intelligence in Oil and Gas Industry: Applications and Trends. Journal of Petroleum Science and Engineering, 179, 672–690. [Mohamed, A. H. H., & Hasan, A. R. (2019). Artificial Intelligence in Oil and Gas Industry: Applications and Trends. Journal of Petroleum Science and Engineering, 179, 672–690.]

6   Samuel, A. L. (1959). Some Studies in Machine Learning Using the Game of Checkers. IBM Journal of Research and Development, 3(3), 210–229. [Samuel, A. L. (1959). Some Studies in Machine Learning Using the Game of Checkers. IBM Journal of Research and Development, 3(3), 210–229.]

7   Guo, B., Wang, S., & Su, J. (2020). Big Data and AI in the Petroleum Industry: A Review. Energies, 13(15), 3782. [Guo, B., Wang, S., & Su, J. (2020). Big Data and AI in the Petroleum Industry: A Review. Energies, 13(15), 3782.]