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Application of the integrated well-surface facility production system for selecting the optimal operating mode of equipment

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ANNOTATION
This work is dedicated to the analysis and development of an integrated production system that combines wells and surface facilities to select the optimal operating mode for equipment. The main focus is on studying data analysis methods, as well as collecting and processing information, which ensures high accuracy in process control and optimal use of technological capabilities. The integration of data from various levels of the production chain, from the well to the surface facilities, opens up new opportunities for optimizing equipment performance and improving resource management quality. Integration of wells and surface facilities – The effective integration of wells and surface facilities is crucial for optimizing production processes, minimizing operational costs, and reducing environmental impact. Integrated management systems allow the automation of many processes, providing continuous monitoring of operating parameters, automatic adjustment of settings, and supplying data for quick decision-making. This includes real-time data collection, analysis, and the use of the obtained information to select optimal operating modes, which helps improve both overall efficiency and safety in production processes. In the modern oil and gas industry, the efficient use of equipment at all stages of hydrocarbon production is of particular importance. Optimizing the operation of wells and surface facilities is a key aspect for increasing economic efficiency and reducing environmental impact. In this regard, the development and application of integrated systems that enable real-time control and adaptation of equipment operating modes has become a relevant and significant task.

Keywords: integrated system, surface facilities, integration of wells and surface facilities, geotechnology, geotechnological methods, well, filtration.

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Introduction

Modern technological and economic conditions in the oil and gas industry require increased efficiency and reliability of equipment [[1], [2]]. The contemporary oil and gas sector faces the need to enhance the efficiency and sustainability of its operations. One promising direction is the use of integrated production systems that combine wells and surface facilities [3]. These systems allow for the optimization of equipment operating modes, which contributes to increased productivity and reduced operating costs. This article examines various aspects of the application of such systems and optimization methods, as well as examples of successful implementation and development prospects. Integration of processes at the well-surface facility level not only optimizes operational parameters but also significantly reduces environmental impact, making this study relevant and important for the further development of the industry.

When servicing wells, the operator follows an established route and inspects the condition of surface equipment. The operator records instrument readings, inspects wellhead equipment, and collects fluid samples. As instructed by the supervisor, dynamograms are recorded. The operator participates in well depourification operations [4], transmits information from the sites to the dispatcher, and prepares wells for repair.

A well workover team replaces downhole equipment. More complex repairs, such as formation work, retrieval of stuck equipment, or transitioning to different horizons, are carried out by the well major repair teams.

Automation and Digitalization - Integrated Digital Platforms: Discussion of the role of IT solutions in production management, including real-time monitoring, automatic well control, and predictive equipment maintenance [5].

Robotics and Drone Technologies: The use of automated systems and unmanned aerial vehicles (UAVs) for monitoring, inspection, and even repairs at oilfields.

Computer-Integrated Manufacturing (CIM) is a manufacturing approach where computers control the entire production process. Such integration allows individual processes to share information with each other and initiate actions. Through computer integration, production can become faster and less prone to errors, with the primary benefit being the ability to create automated production processes. CIM typically relies on feedback control processes based on real-time sensor input, also known as flexible design and manufacturing.

A recognized model for a company managing information, responsible for the current level of automation, is the hierarchical model of computer-integrated manufacturing (CIM). According to this model, upper-level systems operate with aggregated data over relatively long periods of time, while lower-level systems work with real-time data streams.

SCADA systems are highly distributed systems used to manage geographically dispersed assets, often spread over thousands of square kilometers, where centralized data collection and control are critical for system operation. They are used in distribution systems such as water supply and wastewater collection systems, oil and gas pipelines, electrical grids, and railway transport systems.

SCADA systems consist of both hardware and software. Typical hardware includes a Master Terminal Unit (MTU) located in a control center, communication equipment (such as radio, telephone lines, cables, or satellites), and one or more geographically distributed field devices consisting of Remote Terminal Units (RTUs) or Programmable Logic Controllers (PLCs), which control actuators and/or monitor sensors.

Research methods

Lower-level models represent elements of data collection (sensors), device control (e.g., controllers, CNC machines), and the automated SCADA system (Supervisory Control and Data Acquisition), interacting with hardware. An overview of integration approaches is shown in Figure 1.

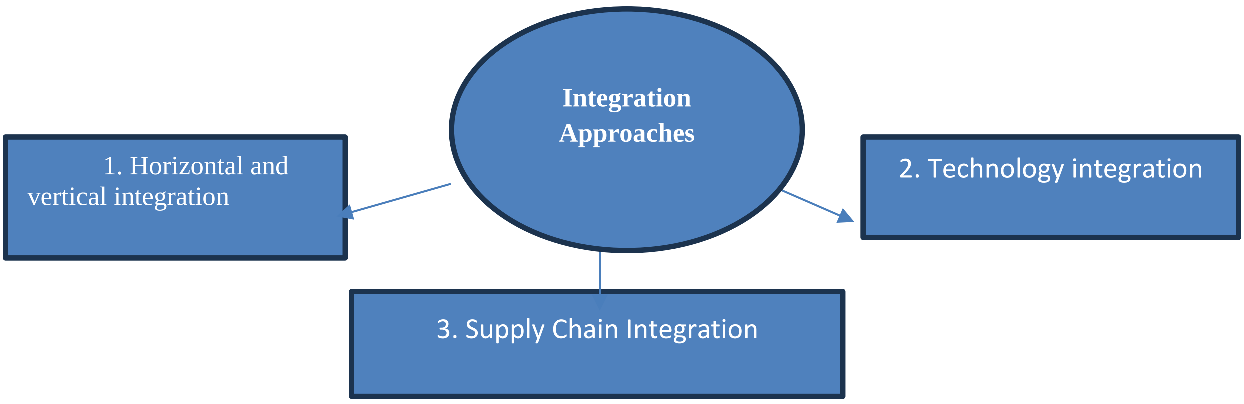

Figure 1 - Overview of Integration Approaches

Providing examples from the practices of large oil and gas companies that have successfully implemented integration approaches. These could be cases from various countries and regions, demonstrating how technological and managerial innovations have helped improve productivity and reduce costs. Summarizing the analysis, highlighting key findings and recommendations for oil and gas companies seeking to enhance their competitiveness and operational efficiency.

The Internet of Things (IoT) is a network of connected devices that collect and exchange data in real-time. In the oil and gas industry, IoT is used to create "smart" wells and surface facilities where all system elements are interconnected and centrally managed [6]. The digitalization of extraction processes enables the creation of digital twins of wells and surface facilities, which assist in simulating and analyzing various operational scenarios. These digital models allow for testing different parameters and conditions without risking real equipment, improving the accuracy and reliability of decisions.

The flow in the water supply pump group is first forecasted using an LSTM network for 24 hours. Then, the water intake pump group's flow is planned for 24 hours, along with the water level in the clean water tank, based on the water supply pump group's flow and engineering expertise. Secondly, nonlinear models of the operating pumps are configured based on historical data. Finally, intelligent joint optimal planning tasks are set, allowing for the minimization of pump consumption and the number of switch-ons, using flow constraints in the intake and supply pump groups, pressure in the main pipe, and water levels in the pump system's clean water tank. The optimal operating schedule for the intake-supply pump groups, setting the pumps' operating configurations at each moment in time, can be obtained using the DP algorithm.

Modern integrated production systems include complex control and monitoring systems that use software and hardware tools to collect, analyze, and visualize data. These systems ensure continuous control over all production stages, from well conditions to the transportation of finished products. Information technologies, such as SCADA (Supervisory Control and Data Acquisition) and DCS (Distributed Control System), play a crucial role in this [7].

One of the main advantages of an integrated system is the ability to enhance hydrocarbon extraction efficiency. By integrating all system components and using modern monitoring and control technologies, operators can optimize extraction processes, reducing losses and increasing productivity. For example, precise control of pumps and valves allows maintaining optimal conditions for oil and gas extraction.

Forecasting the flow in the water supply pump group: Based on historical data analysis, water temperature and pressure in the main clean water pipe are important factors influencing the flow in the water supply pump group. Since the LSTM network can remember and learn long-term data characteristics, a forecasting model is created to predict the water supply pump group's flow using the LSTM network. The forecasted flow in the supply pump group for the next 24 hours is adjusted for the difference between the predicted and actual flow in the supply pump group over the past 24 hours. The output variable is the supply pump group's flow for the next 24 hours.

An LSTM network consists of an input layer, a hidden layer, and an output layer. The LSTM network differs from RNNs by adding a forget gate f_t, input gate i_t, output gate o_t, and memory cell C_t to meet the needs of time series data. These gates can open or close depending on the memory state of the network (the previous network state) [[8], [9], [10]].

Developing an integrated system for optimal equipment operation in the oil and gas industry is a complex project that requires a deep understanding of both technical aspects and management processes. It is crucial to create a system that not only enhances operational efficiency but also takes into account environmental and economic factors. Adaptive control systems enable quick responses to changing extraction conditions and adjustments to equipment operation modes in real time. Such systems use data from sensors to automatically adjust the operating parameters of pumps, valves, and compressors. This allows for maintaining optimal conditions for hydrocarbon extraction and processing, minimizing losses, and increasing productivity.

Production and technological processes have made significant progress. The key is not only to create new equipment components but also to increase the degree of automation in managing production and technological modes at facilities and across utility industries. In this context, it is worth noting that fundamentally new forms of operation have emerged for current and future management systems.

Modern automated control systems can memorize [[11], [12], [13], [14], [15]], compare, and even find optimal modes for controlled processes. They select the best modes based on preprogrammed data, data obtained during the system's operation, as well as process simulations, all of which are implemented with minimal investments. Integrated systems significantly reduce operating costs by more effectively utilizing resources and minimizing equipment downtime. Modern monitoring systems enable quick identification and elimination of malfunctions, reducing repair and maintenance time. Equipment wear is also reduced, extending its service life and decreasing the frequency of replacements. Thanks to optimized operation modes and timely maintenance, the equipment operates longer and more reliably. Integrated systems enable regular equipment condition checks and forecast potential breakdowns, allowing for pre-planned maintenance and the replacement of worn-out components.

Dynamic well modeling involves analyzing well behavior at various production levels, pressure changes, and temperature conditions. Using specialized software suites, such as ECLIPSE and Petrel [[3], [4]], engineers can simulate different well operation scenarios and select the optimal parameters for maximum productivity and extraction stability.

Pipeline flow modeling allows for the evaluation of a system's hydraulic characteristics and the selection of optimal conditions for hydrocarbon transportation. Software packages such as OLGA and PIPESIM are used to conduct hydrodynamic calculations, which help prevent overloads and pressure losses, as well as optimize the operation of pumps and compressors.

The complete system of governing equations that describe the processes in the asynchronous electric drive of centrifugal pumps consists of four groups: electromagnetic equilibrium equations (Kirchhoff's laws) describing the electromagnetic processes in the motor, electromechanical energy conversion equations, equations describing the mechanical load on the motor shaft, and equations representing the output parameters and properties of the energy sources.

The first step was the analytical method, based on the classical definition of the optimal cross-sectional value, which allowed us to determine the qualitative characteristics, laws, and methods to reduce costs in the frequency-controlled electric drive operating under centrifugal load.

The main distinction from known methods is the use of refined mechanical characteristics of the central pump, which we obtained earlier [2].

$$(\omega) = \sqrt[4]{К_э \frac{\left(\frac{C_Н H_С + \omega^2}{\omega \eta_{ЦН}(\omega, H_С)}\right)^2 \omega \quad \frac{Н}{Н_0}}{К_0 + К_{СТ}\omega^{\frac{3}{2}}}}$$

Where

k_0 - relative losses in coils, steel and no-load current.

The accuracy of the method is determined by the accuracy of the approximation of the magnetization curve.

Figure 2 shows the dependence of the optimal values of the magnetic flux on the back pressure at the outlet of the pumping unit. The "kink" of curves 2 and 3 indicates a decrease in the operating range of pump wheel speed adjustment with an increase in the value of the static back pressure of the pipeline. The calculation was carried out using the same values of weight loss coefficients [[13], [14], [15], [16]].

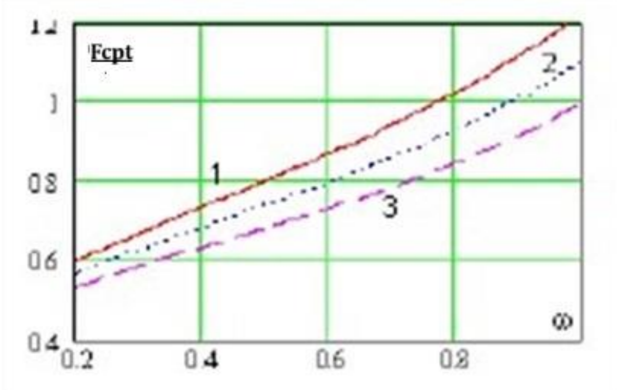

Figure 2 – Fopt Curves(w) for different values of relative pressure losses (w)

When selecting motors and designing the optimal automatic control system (ACS) for the central pump drive, the influence of induction motor (IM) parameters on the variation of optimal magnetic flux across the impeller's speed control range is of particular interest. Specifically, the value of F_{opt} often depends on the distribution of costs based on baseline arterial pressure. Figure 4b shows the results of calculating the optimal magnetic flux value based on inherent cost values common to mass-produced asynchronous motors.

The next phase of research involved the harmonic method, which takes into account the non-sinusoidal distribution of magnetic induction in the machine. In this case, the steel's magnetization curve is approximated by a hyperbolic sine, and the magnetic forces are represented by a series using Bessel functions.

The analytical studies conducted allowed us to establish the main patterns of the frequency-controlled electric drive for a centrifugal pump. The evaluation of real numerical relationships was based on the digital harmonic method of optimal calculation in terms of minimizing costs, accounting for system nonlinearity, precise core geometry, high-frequency control, and other factors. An algorithm was developed to solve this problem.

All processes in the induction motor are described by a system of linear equations of magnetomotive force (MMF) F, electromotive force (EMF) E, and torque M, which are fuzzy functions of the harmonic magnetic induction amplitude along the longitudinal and transverse axes.

Based on the harmonic method, a mathematical model of the "frequency-controlled induction motor – centrifugal pump" system was created, taking into account the technological parameters of the central pump, the geometric parameters of the motor core, and the actual distribution of magnetic induction. The model includes the entire set of electrical parameters, core structural parameters, and, most importantly, accurately considers the nonlinearity of the magnetic circuit.

Numerical studies conducted on the developed model determined the main patterns and methods for reducing motor energy consumption. Optimal laws and frequency control for the central pump drive were calculated for different core options, ensuring minimal motor costs. The obtained IM characteristics confirm the effectiveness of the proposed control algorithms and the high level of energy efficiency.

The created mathematical model can be directly used as an element of the automatic control system for the electric drive according to the "PC-IM" scheme for centrifugal units optimized for energy consumption.

Figure 3 shows the operating characteristics of the system: torque, useful power, consumed power, and power consumption. Using the proposed optimal cost-minimizing frequency control law, the efficiency of the central pump remains high and equal to the nominal value across the entire flow control range.

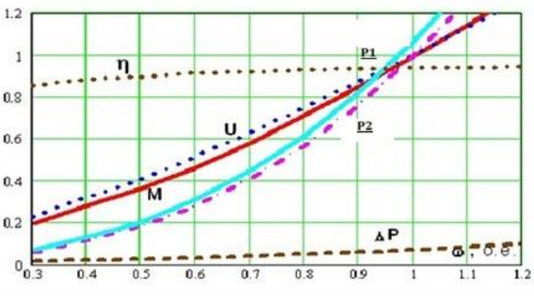

Figure 3 – Operating characteristics of blood pressure in the control range of the central pump with optimal frequency control

The calculation of energy consumption and energy performance of the torque-controlled drive (TCD) has several features compared to other induction motor (IM) control schemes (Figure 4). In the TCD, the rotor speed of the induction motor is adjusted by introducing an additional voltage $\boldsymbol{U_2}$ into the rotor circuit. This voltage can be controlled in terms of magnitude, frequency, and phase.

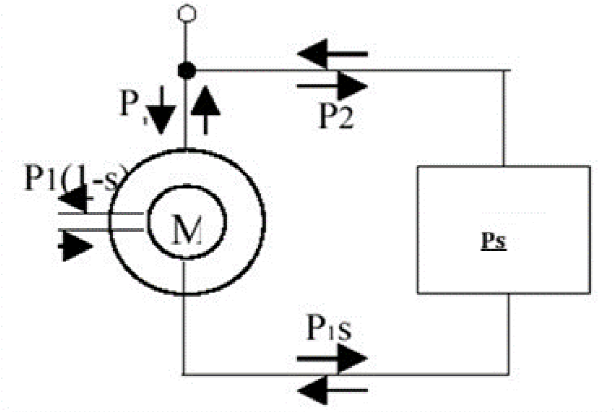

Figure 4 – Two-speed machine

The calculation of the static modes of operation of the DCS is reduced to determining the values of U_2 and δ from a joint solution of the electrical balance and electromechanical balances necessary to ensure the operating mode. Thus, we have obtained a mathematical model of the electric drive of a centrifugal pump according to the scheme of two feeding machines.

The power part of the SCH500 station is made according to a two-transformer circuit with a low-voltage frequency converter of the SM500 series with a voltage of 690 V.

There are many standard sizes for a power of 250 kW and 320 kW. Depending on the output power of the CM500, up to four HTM modules can be installed.

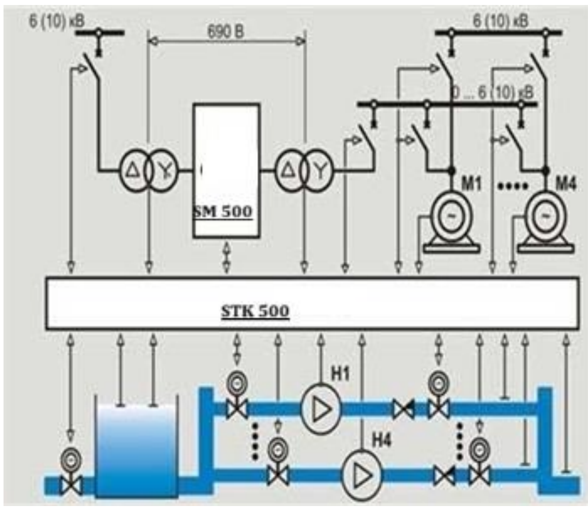

Figure 5 – Description of the station

All HTM modules are identical, with one being the master and the rest as slaves. Synchronization of the parallel operation of the modules is carried out at the "PMO" level. Power transformers can be used in standard configurations, either oil-filled or dry-type.

The KSO cells include switching equipment for group control. Structurally, the CM500 frequency converter (Figure 5) is a set of floor-standing cabinets.

The process controller is based on an industrial computer with a TFT monitor. The controller manages the electrical circuit of the SN500 station and the equipment of the main technological chain of the pumping station.

The power section of the SN500 station is designed using a dual-transformer scheme with a low-voltage frequency converter of the CM500 series, operating at 690V.

There are multiple size options with capacities of 250 kW and 320 kW. Depending on the output power, up to four HTM modules can be installed in the CM500.

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Information is displayed graphically in three main user windows:

Process window (displaying current information in a technological flowchart);

Control window (setting the operating mode and main control parameters);

Archiving window (access to two main archives: alarm archive and event archive).

Additionally, the controller can expand telemetry functions.

Advantages of using a variable frequency drive (VFD):

Smooth regulation of the motor speed in most cases eliminates the need for additional control equipment, significantly simplifying the technological system, increasing its reliability, and reducing operating costs. A frequency-regulated motor start ensures smooth acceleration without inrush currents or mechanical shocks, reducing stress on the motor and associated transmission mechanisms, thereby increasing their service life. In this case, the power of the drive motors for loaded mechanisms can be reduced according to startup conditions. The built-in microprocessor-based PID controller allows for speed regulation of controlled motors and associated technological processes.

Using feedback from the system to the frequency converter guarantees high-quality speed maintenance of the motor or the controlled process parameter under variable loads and other disturbances.

The frequency converter, paired with an asynchronous motor, can replace DC drive systems.

A frequency converter, supplemented by a programmable microprocessor controller, can be used to create multifunctional drive control systems, including systems with backup mechanical units.

Using a variable-frequency drive (VFD) allows for energy savings by eliminating unnecessary energy consumption. Significant efficiency is achieved by using frequency converters to regulate the operation of pumping units, which were traditionally controlled by throttle mechanisms in pump discharge pipes.

Throttle regulation involves energy losses due to local resistance created by control devices. These losses are eliminated when the pump's performance is controlled by regulating the motor speed. Energy savings from using VFDs in pumps typically amount to 10-30% of the power consumed by pumps under throttle control.

The implementation of variable-frequency drives (VFDs) at water supply and sewage pumping stations allows for optimizing the hydraulic regime of the water distribution network, addressing energy-saving objectives, reducing operating costs, and minimizing pipeline damage by maintaining optimal pressure in the network.

The automation of production processes was carried out in stages. Initially, an automated control system for technological processes was created and put into operation at two sewage pumping stations (SPS). Control over the operation of these stations was provided from the workstation of the dispatcher at the SPS workshop. A central database (CDB) was created on the dispatcher server in the workshop.

Automated operation requires complete monitoring of all parameters and the ability to make correct decisions in any situation. To ensure high equipment reliability, more than a hundred variable indicators characterizing the operation of the equipment, as well as the primary and secondary technological processes, are recorded. At the same time, the number of control actions set by the automated control system reaches twenty types. Almost complete control over the station's operation allowed for the development of control actions for all situations, eliminating the need for manual management from the dispatch room. This provided full protection against unauthorized or accidental access to the automated control system. The high reliability of the specialized controllers ensured monitoring and registration of all parameters characterizing the equipment's operation and the technological process.

Despite the high reliability of the automated control system, the transition to operating the pumping equipment without service personnel was limited by several external factors. The SPS workshop's automated control system was built on its own computer radio network operating at a frequency of 450 MHz. The rapid development of the city, the appearance of new high-rise buildings, and the significant distance between the SPS facilities made it difficult to use the computer radio network at some sites.

Thus, the requirements for the creation of the automated control system at the NDS workshop (Figure 6) expanded, necessitating the use of mobile communication channels and telephone connections (GSM, CDMA modems) due to objective difficulties in data transmission within the computer network.

The PTC PNO allows solving the following tasks (Figure 7):

Continuous monitoring of pumping stations, obtaining key indicators (energy consumption, volume of waste pumped, specific energy consumption);

Obtaining objective and reliable data to justify the selection of pumping equipment during reconstruction;

Processing data on system expenditures and identifying issues in pressure pipelines;

Comparing the operating time of pumping equipment with the standard adjustment interval and optimizing maintenance [[16], [17], [18], [19], [20], [21]].

When creating the control and automation system for KNS, the primary task was to solve the issue of data transmission and to choose the main communication channel between local dispatch centers. Existing power lines were tested. As a result, a data transmission network was created between the local dispatch centers based on existing communication networks, using SHDSL modems.

According to the technological scheme of the NDS, variable indicators characterizing the equipment operation at all stages of the technological process were determined. The selected variables are used for automating the work and/or managing the facilities of the store, taking into account the technological and administrative division. Part of the information received from the communication nodes of local dispatch centers is transmitted to the central dispatch center of the USC for evaluating the technological process, the operation of workshops, their facilities, and the enterprise as a whole. Based on variable indicators, the technical characteristics of local dispatch points and the devices of the central dispatch point have been determined.

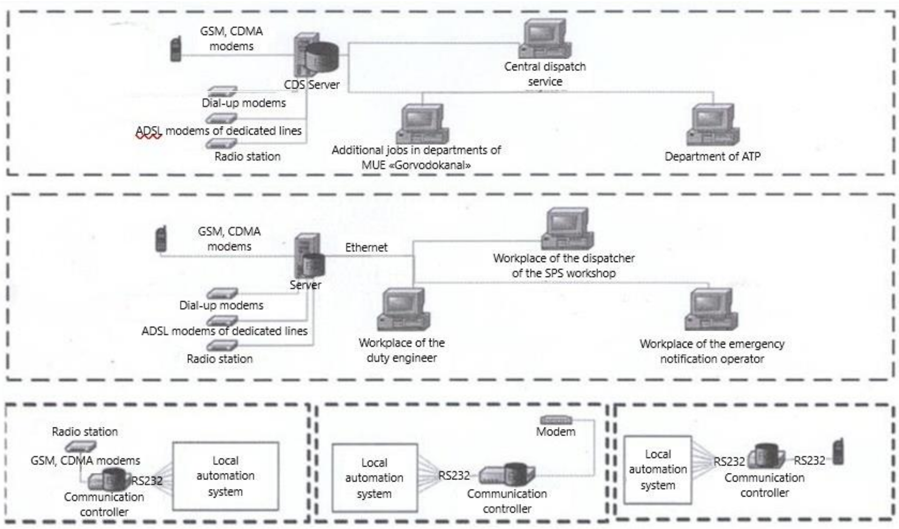

Figure 6 – Block diagram of automation of technological processes in the pumping station workshop

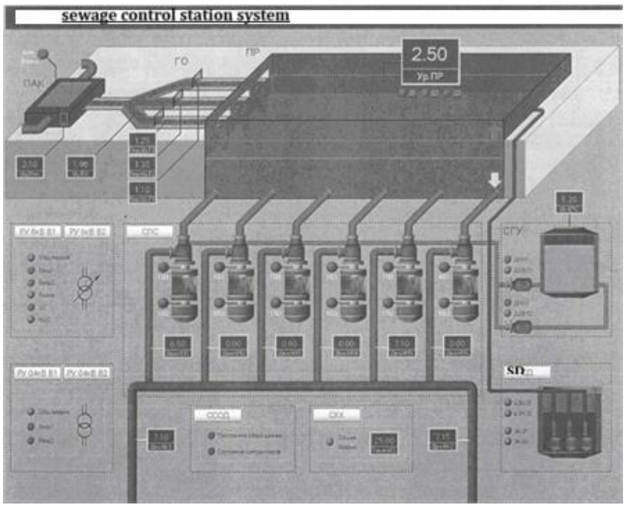

Figure 7 - A fragment of the mnemonic diagram of the dispatching control of a sewage pumping station (6 kV)

The information from the aforementioned facilities is transmitted to SHDSL modems via Wi-Fi wireless data transmission modems (the communication center of the local dispatch point of the corresponding workshop) and then transmitted via special lines to the central dispatch center (CIC) and displayed on the monitor.

The system's performance results showed that:

Low costs for installing special data transmission lines, high noise immunity, reliability, and data transmission speed;

Wireless data transmission networks using Wi-Fi technology are characterized by high mobility of data collection points, reliability, noise immunity, high data reception speed, low installation costs, and short implementation time;

In general, a local computer network has been created for the system, providing information from control measuring instruments and equipment control systems in local control centers for all workshops and in the Central Dispatch Center (CIC).

It is worth noting the possibility of dual use of the technical and software solutions included in the APKS (Automated Process Control System) for related tasks. For example, the technical and software tools of the SPC shop's APCS (Automated Process Control System) are used for analyzing pressure in water supply lines at control points. Information received from the water supply system pressure sensors is sent to the local automation system and transmitted to the central database of the pumping station, from where it is further transmitted to the central dispatch point. Measurement results, after processing, are displayed in the water supply service work centers and in the central control point.

The design solutions adopted are based on the experience of existing automation systems and are aimed at maximizing the coverage of technological process parameters on a unified information platform "Wander-ware," ensuring both the length of parameters and their interconnection in the technological chain and information flows.

Based on the design solutions, in 2009, the automatic filter washing systems of NFS-1 and NFS-5 are planned to be commissioned, and the internal pressure monitoring system expanded to 45 control points in the water supply network.

At present, plans are underway to equip the relevant divisions with new control and measuring equipment to use objective results for the implementation of APCS capabilities, enabling the acquisition of comprehensive characteristics of technological processes in automatic mode. Predicting equipment conditions and performing preventive maintenance are important aspects of optimizing operational modes. The use of predictive analytics and machine learning technologies allows predicting possible failures and planning maintenance in advance. This reduces the likelihood of emergency situations and helps maintain equipment in optimal condition.

Equipment required for automation: The SIMATIC S7-1200 PLC is a new family of Siemens microcontrollers designed for various low-level automation tasks. These controllers are modular and versatile. They can operate in real-time and can be used to create relatively simple local automation blocks or units supporting complex automatic control systems.

This algorithm is designed to control the main and backup pumps operating alternately in the same network. It is used for controlling circulation pumps in heating and hot water supply systems. In combination with a shutoff and control valve, the controller can be connected to a system using water from a tank. In this device modification, two inputs are used: the first can be connected to a switch, closing which initiates the algorithm, and the fourth input is connected to a pressure sensor. This could be a flow sensor that closes the output contact when the required pressure is achieved in the network or modern pressure sensors with a single current output. A pressure relay is used to control the main and backup pumps. A third relay can be connected to an alarm system or a third pump.

The automatic control system ensures even use of the main and backup pumps by alternating their operation. The pump operation time is programmed by the user (the maximum possible pump operation time is 63 days). In case one of the pumps fails, the device switches to the other, triggering an LED alarm indicator. If all pumps fail during operation, the third relay is activated, triggering an alarm or switching on backup pumps (without pressure control in the main line).

In the algorithm based on pressure sensor use, during pump start-up, the pressure sensor readings are not monitored for the user-specified time period (30 seconds by default). Additionally, the controller ignores short-term (2 seconds by default) drops in pressure sensor readings.

System efficiency analysis

Integrated well-surface facility systems and operational mode modeling open up new opportunities for improving the efficiency and reliability of the oil and gas industry. Implementing such technologies requires significant investments and a highly skilled workforce, but the long-term benefits—such as reduced costs and increased productivity—justify these efforts. Modern technologies and approaches to production process management allow for achieving high results and ensuring sustainable development of the industry.

A specific model corresponds to the basic scheme of the Integrated Production Planning (IPP). The main task of particular modifications is to fully declare all temperatures and losses at any given time and in each region of the GIS. Key information for modifications includes the selection of heat exchangers for heating, ventilation, and hot water supply systems; the choice of the standard forecasting interval, up to one calendar month, which is analyzed in full; and brief details about the modeling area, including temperature diagrams of the heat carrier. Depending on the external atmospheric temperature, the heat carrier temperature, and the heat source, the thermosensitive heat carrier at the IPP inlet and the predicted heat recovery vary. The controllers' resources are linked to temperature and temperature changes incorporated into heat theory, which are connected to the changes in natural products. Based on the properties of the control valve, it causes changes in the flow rate within the sleeve element and the valves.

The effect of incoming heat on the temperature Ti(t) can be determined by the gain factor k and a first-order system with a time constant τ. The influence of ambient temperature can be represented as a first-order system with a gain factor and time constant. The water temperature Tu(t), supplied to the heat exchanger loop, is regulated by a PI controller. The PI controller is one of the most versatile controllers. Essentially, it is a proportional controller (P-controller) with an additional integrated component. This integrated component, as the name implies, is added primarily to eliminate the static error inherent to the proportional controller. The integral part acts as an accumulator, accounting for the history of the current input variable to the PI controller (1) (Figures 8-10).

$$W(S) = \frac{1}{30s+1} + \frac{1}{2s+1}) \times \frac{1}{20s+1} = \frac{(30s+1)(2s+1)}{(30s+1)(2s+1)(20s+1)} \quad (1)$$

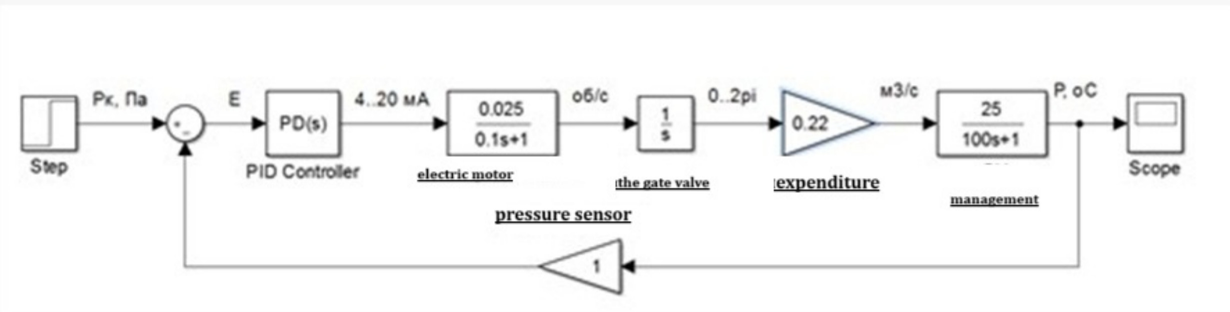

Figure 8 — Mathematical model in the Matlab environment

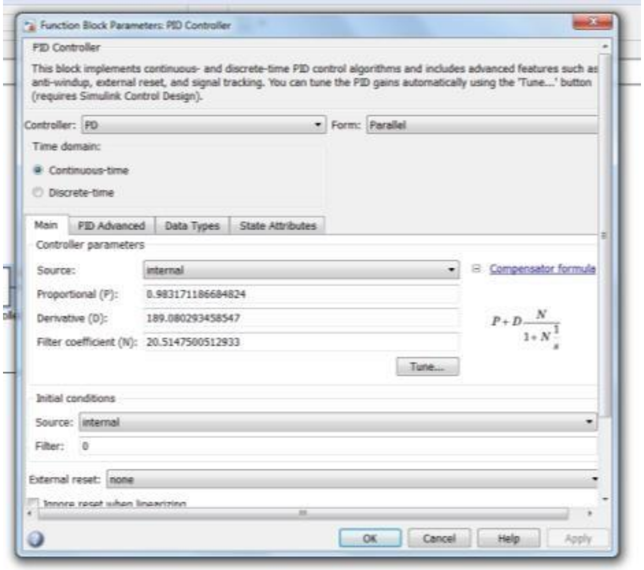

Figure 9 – Parameters of the PI controller

The following parameters of the PI controller are set in the Matlab environment

Conclusions

This study emphasizes the critical importance of developing and applying integrated management systems in the oil and gas industry to enhance efficiency and reduce environmental impact. Automation and optimization of processes at all levels of hydrocarbon production, from the well to surface facilities, are key elements for achieving these goals. The implementation of developed algorithms and software, as well as their successful testing and adaptation in real-world conditions, demonstrate the potential for significant improvements in operational efficiency and economic benefits.

The research also revealed that integrating modern technological solutions and analytical methodologies can lead to a deeper understanding and better management of production processes, which will inevitably reduce environmental impact and improve the safety of operations. These findings represent a valuable contribution to the scientific community and provide practical guidelines for application in the industry.

In the future, based on the data obtained and the methods developed, the scope of integrated systems application will be expanded, along with the investigation of their adaptability to different conditions and the specifics of various fields. The prospects for further research include the development of advanced models for adaptation and optimization, which will promote the broader adoption of these technologies in the industry.

The shift toward more sustainable and economically efficient production methods is becoming an integral part of the oil and gas industry's development. The implementation of integrated management systems not only increases overall productivity but also enables companies to comply with stringent international environmental safety standards. This, in turn, enhances the companies' reputation in the global market, boosts their competitiveness, and opens up new investment opportunities and market access.

Focusing on the use of advanced technological solutions and analytical tools makes the industry more adaptive to market changes and better prepared to respond to challenges such as fluctuations in hydrocarbon prices and regulatory changes. This approach not only optimizes current processes but also helps predict future changes in production parameters, ensuring stability and resilience in operations.

Additionally, the development and application of integrated systems create a foundation for continuous learning and skill improvement among employees. The adoption of the latest technologies requires ongoing professional development and training, which leads to an increase in internal expertise and improves the quality of work at all levels. This, in turn, fosters a culture of innovation and a drive for continuous process and performance improvement.

Based on the research conducted, the following recommendations can be formulated for the development of integrated production management systems in the oil and gas industry:

Digitization and data integration: Expand the use of digital technologies for data collection, storage, and analysis. This will improve process understanding at all levels and enable more effective resource management and response to changes in the production environment.

Development of adaptive systems: Design systems that can adapt to changing operating conditions and market demands. Adaptive management systems will help maintain optimal operating parameters under various conditions and reduce the risk of losses due to unforeseen circumstances.

Conflict of interest. The corresponding author declares that there is no conflict of interest.

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Жабдықтың оңтайлы жұмыс режимін таңдау үшін ұңғыманы және жер үсті өндірісін басқарудың біріктірілген жүйесін қолдану

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ТҮЙІНДЕМЕ

Бұл жұмыс жабдықтың оңтайлы жұмыс режимін таңдау үшін және жер үсті құрылымдарын біріктіретін интеграцияланған өндірістік жүйені талдау мен әзірлеуге арналған. Негізгі назар деректерді талдау әдістерін зерттеуге, ақпаратты жинау мен өңдеуге бөлінген, бұл процестерді басқарудың жоғары дәлдігін және технологиялық мүмкіндіктерді тиімді пайдалануды қамтамасыз етеді. Ұңғымадан жер үсті нысандарына дейінгі өндіріс тізбегінің әртүрлі деңгейлерінен деректерді біріктіру жабдық жұмысын оңтайландыру үшін және ресурстарды басқару сапасын арттыру үшін жаңа мүмкіндіктер ашады. Ұңғымалық және жер үсті қондырғыларын тиімді біріктіру өндірістік процестерді оңтайландыру және пайдалану шығындары мен қоршаған ортаға әсерді азайту үшін өте маңызды. Интеграцияланған басқару жүйелері көптеген процестерді автоматтандыруға, жұмыс параметрлерін үздіксіз бақылауға, баптауларды автоматты түрде түзетуге және жедел шешім қабылдау үшін деректер ұсынуға мүмкіндік береді. Бұл нақты уақытта деректерді жинауды, талдауды және алынған мәліметтерді пайдалана отырып, оңтайлы жұмыс режимдерін таңдауды қамтиды, бұл өз кезегінде өндірістік процестердің жалпы тиімділігін және қауіпсіздігін арттыруға көмектеседі. Қазіргі заманғы мұнай-газ өнеркәсібінде барлық өндіру кезеңдерінде жабдықты тиімді пайдалану мәселесі ерекше маңызға ие. Ұңғымалар мен жер үсті құрылымдарының пайдалану процестерін оңтайландыру экономикалық тиімділікті арттыру және экологиялық әсерді азайту үшін маңызды аспект болып табылады. Осыған байланысты жабдықтың жұмыс режимдерін нақты уақыт режимінде бақылауға және бейімдеуге мүмкіндік беретін интеграцияланған жүйелерді әзірлеу және қолдану өзекті әрі маңызды міндетке айналуда.

Түйін сөздер: интеграцияланған жүйе, жер үсті жабдықтары, ұңғыма мен жер үсті жабдықтарын интеграциялау, геотехнология, геотехнологиялық әдістер, ұңғыма, сүзу.

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Применение интегрированной системы добычи скважина-поверхностное сооружения для подбора оптимального режима работы оборудования

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АННОТАЦИЯ

Данная работа посвящена анализу и разработке интегрированной системы добычи, объединяющей в себе скважину и поверхностные сооружения, для подбора оптимального режима работы оборудования. Основное внимание уделено исследованию методов анализа данных, сбору и обработке информации, что позволяет обеспечить высокую точность управления процессами и оптимальное использование технологических возможностей. Интеграция данных с различных уровней производственной цепочки, начиная от скважины и заканчивая поверхностными сооружениями, открывает новые возможности для оптимизации работы оборудования и улучшения качества управления ресурсами. Эффективная интеграция скважинных и поверхностных сооружений крайне важна для оптимизации процессов добычи и минимизации операционных затрат и экологического воздействия. Интегрированные системы управления позволяют автоматизировать множество процессов, обеспечивая непрерывный мониторинг параметров работы, автоматическую коррекцию настроек и предоставление данных для принятия оперативных решений. Это включает в себя сбор данных в реальном времени, их анализ и использование полученных сведений для подбора оптимальных режимов работы, что помогает повысить как общую эффективность, так и безопасность производственных процессов. В современной нефтегазовой промышленности особое значение приобретает вопрос эффективного использования оборудования на всех этапах добычи углеводородов. Оптимизация процессов эксплуатации скважин и поверхностных сооружений является ключевым аспектом для повышения экономической эффективности и уменьшения экологического воздействия. В этой связи, разработка и применение интегрированных систем, позволяющих контролировать и адаптировать режимы работы оборудования в реальном времени, становится актуальной и значимой задачей.

Ключевые слова: интегрированная система, поверхностные сооружения, интеграция скважины и поверхностных сооружений, геотехнология, геотехнологические методы, скважина, фильтрация.

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