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TÍTULO: Suministros de la Industria de Extracción de Petróleo y Gas, y Sistema de Apoyo a la Decisión Inteligente.

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RESUMEN: El sistema de soporte de decisiones está diseñado para garantizar la minimización del riesgo de falla asociada con la perforación y las pérdidas. El desarrollo de un sistema automatizado inteligente para respaldar las actividades del operador de la plataforma permitirá la detección proactiva de las causas que conducen a situaciones de emergencia y brindará la oportunidad de tomar decisiones informadas. Para resolver este problema, es necesario llevar a cabo la elección de un aparato matemático para el reconocimiento de situaciones de pre-emergencia en el proceso de perforación, y desarrollar y capacitar al clasificador basado en redes neuronales artificiales.

PALABRAS CLAVES: reconocimiento de patrones, vocabulario funcional de funciones, redes neuronales artificiales, situaciones anormales, detección previa a choques.

TITLE: Supplies of Oil and Gas Extracting Industry and Intelligent Decision Support System.

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ABSTRACT: The decision support system is designed to ensure the minimization of risk of failure associated with drilling, and losses. The development of intelligent automated system to support the activities of the operator of the rig will allow proactive detection of causes that lead to emergency situations and provide opportunity for informed decision-making. To solve this problem, it is necessary to carry out the choice of mathematical apparatus for recog-nition of pre-emergency situations in the drilling process, and developing and training the classifi-er based on artificial neural network.

KEY WORDS: pattern recognition, working vocabularies of features, artificial neural networks, abnormal situations, pre-crash sensing.

INTRODUCTION.

The oil and gas industry play a key role in the Russian economy. To date, the Russian Federation is one of the world's largest producers of oil and gas.

A year in Russia produces about 490 million tons of oil and about 580 billion cubic meters of "blue fuel". The strategic tasks of the industry development are to ensure the necessary structure of reserves, smooth and gradual increase in production with stabilization of its level in the long term.

Ensuring the planned production levels and increasing the efficiency of oil and gas production will be based on scientific and technical progress in the industry, improving drilling methods, impact on the formation, increasing the depth of extraction of stocks and introducing other advanced technologies for oil and gas production that will make it economically feasible to use hard-to-recover oil reserves and gas.

The main directions of scientific and technical progress in oil and gas production are:

- Creation and development of technologies and equipment that ensure highly efficient development of various types of oil and gas fields;
- Development and development of technological complexes for drilling and production on the shelf of the Arctic, Far Eastern and southern seas;

- Improvement and development of technologies for the construction and operation of oil and gas facilities in complex natural and climatic conditions;
- Development of computer-aided design and modeling technologies for the development of deposits.

Long-term state policy in the field of oil and gas production is aimed at creating stable conditions that ensure sustainable development of the industry.

One of the criteria characterizing the full use of the resources of an industrial facility is its failure-free operation.

This is due to the fact that such economic indicators as the length of downtime of equipment, the amount of expenses for searching for and eliminating the causes of pre-emergency and emergency situations, the number of fines for violations of environmental safety, etc., are indirectly related to accident-free operation.

The increase in efficiency with increasing accident-free use of equipment is caused by the following factors:

- Reduction of the total duration of downtime of production or its individual sections, which provides the enterprise with additional income;
- A general increase in the actual physical resource of the equipment;
- Reduction of general damage caused by violations of the flow of production.

At the same time, in Russia since 2004 the share of equipment exploited beyond the time frames for its development is increasing (Churkin, 2015; Moradi et al, 2014; Azad & Motlagh, 2014). The high degree of wear and tear of such equipment requires, at its operation, to take into account the various information related to ensuring trouble-free production. All this fully applies to the oil and gas industry.

DEVELOPMENT.

Analytical part.

At present, production safety systems rely, as a rule, on monitoring the process state parameters in the permissible range. This approach does not allow to take into account pre-emergency situations, determined by combinations of permissible values of several parameters. As a consequence, the operation of the industrial facility is characterized by insufficient accident-free operation and is associated with violations of environmental safety (Gel'man and Marganiya, 2010). Therefore, for complex industrial facilities, it is necessary to recognize pre-emergency situations (PES), which allows predicting the emergence of an emergency mode, and then prevent the shutdown of the process or reduce losses from the occurrence of an accident (Abu-Abed, 2017).

Existing methods used in modern industry do not provide sufficient information support for PES recognition, so identification of the latter is carried out with the mandatory participation of plant personnel. However, the efficiency of the operator's PES recognition also depends on his skill, the complexity of the installation, and the characteristics of the equipment and may not be sufficient, which leads to accidents at the industrial site.

The lack of effective methods for recognizing the PES causes a lack of failure of industrial facilities. Since losses associated with stoppages due to pre-emergency situations at industrial facilities are quite large, the creation of such a method will allow to obtain significant economic benefit due to the shortening of equipment downtime and increase in the physical resource of its operation (Hausamann, 2002).

Elimination of failures of complex engineering systems is a key task in the development of new deposits and requires comprehensive measures to ensure their performance and trouble-free operation.

Thus, the development of a software module for an automated information system for the supply of an industrial object for spare parts, which allows to increase its trouble-free operation, and the introduction of new models and methods for improving maintenance processes of downhole oilfield systems is an actual scientific and practical task (Misnikov, 2017).

The work done is to increase the efficiency of drilling rigs operation by reducing idle time by developing new algorithmic and software tools for detecting pre-emergency situations using image recognition methods.

Research part.

To solve the tasks and during the research methods of system analysis, neuroinformatic, pattern recognition, simulation modeling, object-oriented programming was used.

The practical importance of the work follows from its focus on developing means to ensure timely recognition of PES at drilling rigs and its practical implementation in the form of a software package (Lebedev and Puhova, 2017).

The state of the drilling process is monitored and analyzed based on the values of a number of parameters that are automatically measured by sensors and recorded by the geological and technological information during the entire time of the well's drilling.

Based on the analysis of modern methods and systems for detecting pre-emergency situations, the methods of pattern recognition have been chosen to solve the problem of recognition of AS at drilling rigs when drilling wells (Abu-Abed and Khabarov, 2017). Therefore, as a mathematical device for solving the problem of recognizing the PES, it is proposed to use artificial neural networks of direct propagation, trained using the method of back propagation of the error.

A modification of the basic learning algorithm aimed at finding this global minimum is proposed, as well as a general structure of the neural network classifier PES consisting of one hidden layer with the number of neurons equal to the number of inputs of the classifier. The possibility of obtaining an additional effect from the use of the neural network classifier PES on the drilling is achieved by using the results of the PES recognition to increase the efficiency of the system of supplying spare parts for drilling rigs by estimating the remaining life of the components.

To do this, it is necessary to develop a model of a spare parts supply system for a group of drilling rigs within a single field and to conduct model studies for four different strategies for operating equipment.

Description of the model of the maintenance system for oilfield well systems.

As a rule, supply systems operate in conditions of environmental uncertainty. When managing material flows, factors, many of which are of an accidental nature, must be taken into account. In these conditions, the creation of an analytical model that establishes clear quantitative relationships between the various components of logistical processes can be either impossible or too expensive.

Under the system of provision of spare parts, tools and accessories (spare parts) of drilling rigs is meant a multilevel system consisting of a set of single, group sets of operating spare parts and supplies of the replenishment source. The components of the system are interconnected and have certain characteristics. The spare parts system is designed to restore the operation of the drilling rigs after failures during operation. Let's consider a two-level system of stocks of elements with periodic replenishment, emergency deliveries and repair of the failed elements in repair bodies (Makhutov and Baecher, 2011).

Simulation modeling involves two main processes: the first is the construction of a model of a real system, the second is the setting up of experiments on this model. The following objectives can be pursued: a) understand the behavior of the logistics system; b) choose the strategy that ensures the most efficient functioning of the logistics system.

The systems of drilling rigs and their spare parts stores are dynamic, that is, their parameters vary with time (Singh, et al. 2017). Therefore, the state of the system, the properties of the object and the number of active objects, parameters, actions and delays are all functions of time and are constantly changing during the modeling process.

When modeling the maintenance and repair work of drilling rigs, the use of the network queue systems device is advisable in the event that the repair work is carried out by teams located in the storage of spare parts. Two cases can be distinguished:

1. Each drilling rig has its own fixed point of the group spare parts, which is responsible for its replenishment. At the same time, each item of a group of spare parts has a fixed number of drilling rigs, which it supplies. In this case, the queue systems network degenerates into a set of closed subnets.
2. Each drilling rig can refer to several items of spare parts (in the limit - to any such item), which can either accept or reject the application for the component.

The choice of one or another method of formalizing the existing supply network for drilling rigs depends on the actual topology of the service network. The second case is the most common.

Experimental part.

The work (Misnikov, 2016) is devoted to the development of the hierarchy of classes of the simulation model and the estimation of the economic effect.

Based on the previously developed structure of the neural network analyzer (Abu-Abed, 2017) designed to identify pre-emergency states of the drilling rig, an algorithm was developed to determine the structure and composition of the inventory of property and accessories to restore the rig's operational capability after the components fail. To study the effect of the use of the neuronet classifier for the state of drilling, a comparison of simulation results for all four of the above-mentioned strategies for operating equipment was conducted. The results of the simulation are presented in Tables 1 and 2. The economic effect was estimated as a quotient from dividing the effect obtained by modeling a strategy to the basic economic effect obtained by modeling the most inefficient strategy-operation before failure as a result of failure or breakdown.

Table 1. The average waiting time for the beginning of repair for different operating modes of equipment (hour).

Place of Birth	Strategy			
	1	2	3	4
Mine-1	18.46	20.43	22.34	15.25
Mine-2	20.37	19.29	24.53	18.42
Mine-3	23.18	25.87	30.21	20.34
Mine-4	22.82	24.54	27.58	19.78

Table 2. The total economic effect for different modes of operation of equipment.

Place of Birth	Strategy			
	1	2	3	4
Mine-1	1.05	1.12	1	1.27
Mine-2	1.02	1.08	1	1.21
Mine-3	1.06	1.08	1	1.23
Mine-4	1.08	1.11	1	1.25

From the data obtained, it can be concluded that the application of the neural network classifier PES allows to reduce the average waiting time for the beginning of repairs by 12% and to increase the economic efficiency by an average of 11% compared to the maximum value obtained using other strategies. The last estimate is approximate, because when assessing the economic effect, not all its components were taken into account (Misnikov, 2017; Manso, et al. 2018). Analysis of simulation results allows us to conclude that it is advisable to use a neural network classifier for the state of a drilling rig when organizing a system for supplying drilling spare parts.

For all considered strategies of equipment operation, the specific costs for the supply of drilling spare parts can be reduced by using information about the state of the drilling produced by the neural network classifier. At the same time, a minimal decrease is observed when using the strategy "before failure", which is rarely used in real practice.

The information system for monitoring the state of drilling and supply of spare parts.

Based on the developed algorithmic and software, the structure of a system for monitoring the state of drilling and supply of spare parts is proposed (figure 1).

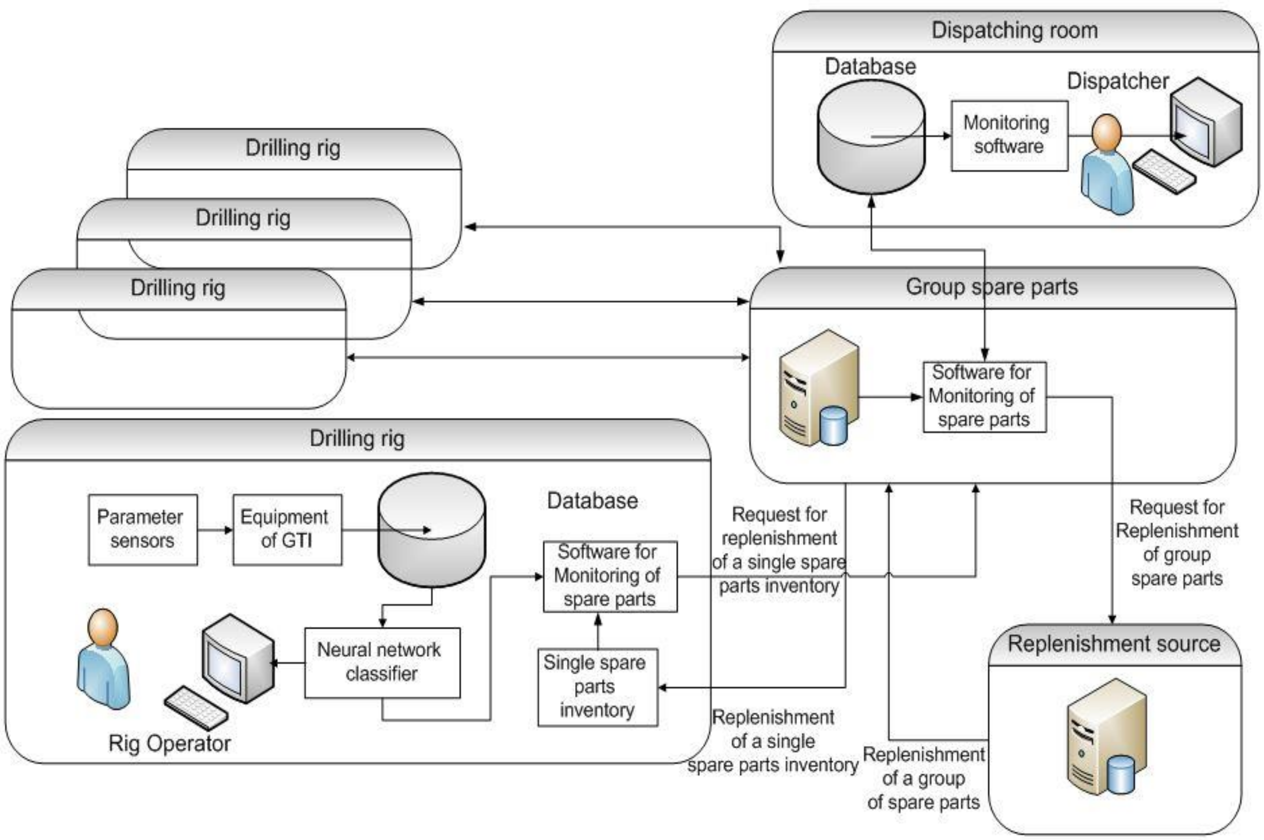

Fig. 1. Structure of the monitoring system for the state of drilling and supply of spare parts.

It is composed:

- Stations geological and technological information on drilling rigs, processing information coming from sensors and storing it in the database;

- A neural network classifier that processes data from the geological and technological information database and performs recognition of pre-emergency situations occurring during the drilling process and issues appropriate warnings to the operator of the drilling rig;
- Software for management of the spare parts system (the client part), based on the results obtained by the classifier, evaluating the remaining life of the components used on the drilling rig and issuing a request to the group spare parts for the delivery of components whose resource has fallen below a specified threshold value;
- Software for management of the spare parts system (server part), functioning as part of a group spare parts inventory and ensuring the collection and processing of requests for replenishment of single spare parts located on drilling rigs;
- Software for monitoring the status of the spare parts supply system, providing on the basis of data received from the software management and monitoring of spare parts, as well as its own database, real-time display of the state of the drilling rigs in the region (including emergency and pre-emergency conditions), the state of the spare parts inventory (range and number of stored components), as well as the process of delivery of the requested components to the drilling and replenishment of the group spare parts.

Thus, the developed class library was used to create the following software tools:

- The software of simulation modeling, allowing to carry out an estimation of efficiency of use of the neural network classifier of PES;
- Software for monitoring the state of drilling and supply of spare parts.

A significant difference between these two software tools is the input source. In the development of simulation tools, a drilling process is imitated, in which random disturbances are introduced that can lead to the occurrence of a pre-emergency situation and the failure of some components. The composition of a single spare parts inventory is considered to be specified in accordance with the technical regulations, the composition of the group spare parts inventory can be formed and replenished in various ways, which will allow to "lose" different strategies of inventory management.

When developing the monitoring system, the program processes the real data of the geological and technological information, while the occurrence of emergency and pre-emergency situations is documented. Further in both programs, requests for replenishment of spare parts are generated, which in the case of a model run are satisfied by the modeling system itself, based on the availability of appropriate components in the spare parts inventory of various levels, and in the case of the monitoring system, they are transferred to the appropriate level for execution.

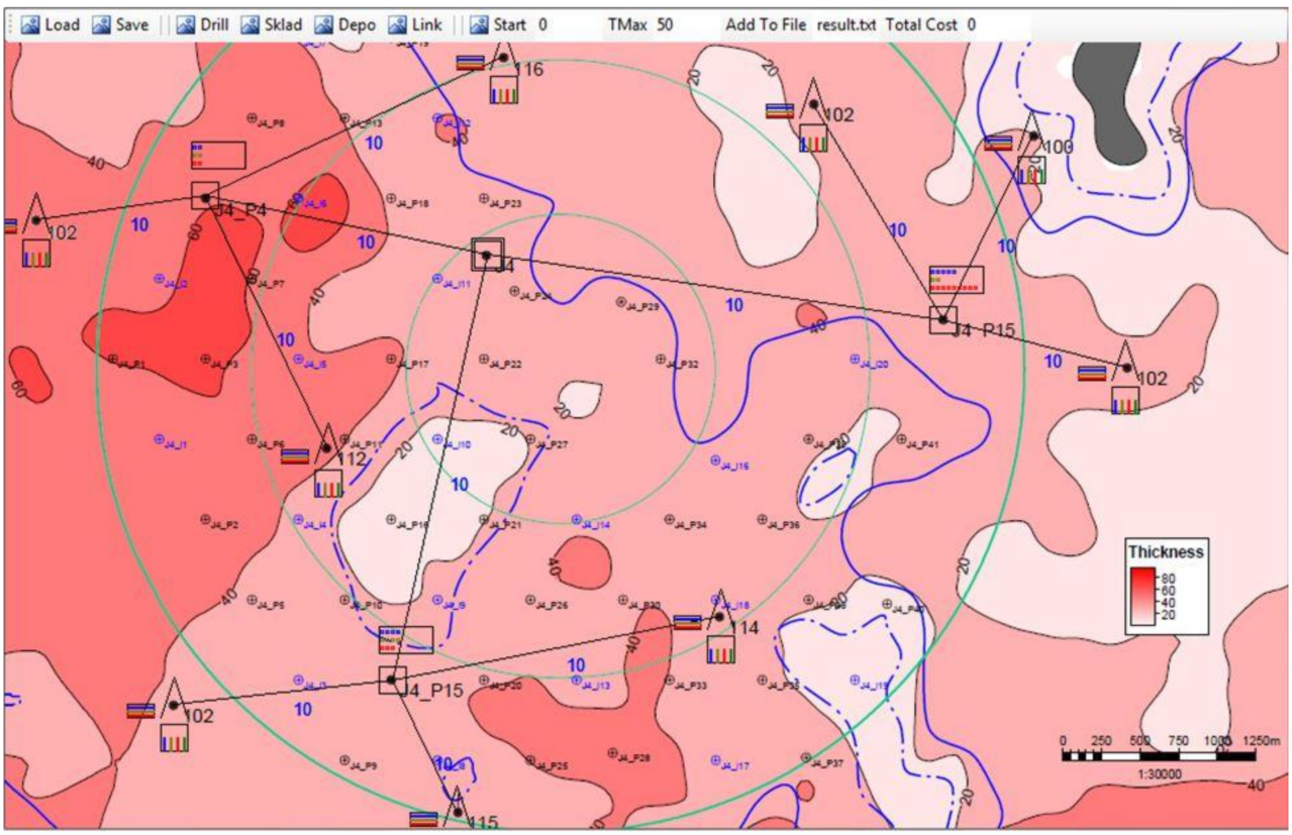

Fig. 2. Interface of the program for modelling the supply system of spare parts.

On the interface of the developed classifier, a signal is displayed on the recognition of the PAC, the moment of detection of the PES and is offered to the operator of the rig to either confirm the occurrence of the PES or to refute it.

The information received from the operator in the process of work can be used for the further training of the classifier. The interface of the developed software for displaying the results of monitoring the state of drilling and supply of spare parts is shown in Figure 2.

CONCLUSIONS.

This monitoring system will simplify the adoption of decisions on the management of spare parts and improve the economic performance of the drilling complex as a whole. Using in practice developed in this project facilities allows to reduce the probability of emergency situations due to the use of special decision support tools into the work of drill master.

The main results of the work are:

1. In the organization of a supply system for drilling spare parts, a simulation model based on a non-grid classifier was developed, which is a closed queuing network.
2. The structure of the system for monitoring the state of drilling and supply of spare parts is proposed, which makes it possible to provide on-line monitoring of the state of drilling rigs and improve the economic performance of the drilling complex as a whole.

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