

DETERMINATION OF THE DRILLING RIG CONDITION

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The algorithm of determination of condition of the rig is offered in the paper. The author demonstrates the interrelation between the well construction algorithm and the optimal control algorithm within the mechanical drilling process. The author offers the flowchart describing the determination of system conditions of the rig.

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The wells are constructed in order to perform the oil and gas mining. The basic process of wells construction is drilling and fastening.

Construction of wells includes a number of processes, which are conducted in sequence [1]: construction of ground-based facilities; driving the shaft hole; separation of layers; completion of the well and bringing it into operation.

Driving the shaft hole is possible in implementation of two parallel operations: face deepening of wells using the rock cutting tool performing a rotating motion, and face purification of the drilled rock.

Separation of layers is made by successive execution of two operations: securing the walls of the hole using the casing string, and sealing the annulus.

The basic process of construction of wells is the mechanical drilling which, regardless of the rock destruction method, is performed by executing the following sequence of operations [1]:

- descent of the drill pipe with the rock cutting tool;
- destruction of rocks on the bottom of the hole;
- lifting up the column of drill pipes to replace the worn-out chisels;
- well casing lining, and tamping using the grout.

Optimization of the well hole deepening is based primarily on the criterion of minimum cost of a meter of the borehole drilling:

$$q = \frac{c_{\sigma}(t_{\sigma} + t_{cn}) + d}{h(t_{\sigma})}, \quad (1)$$

where c_{σ} - cost of the drilling rig hour; t_{σ} - duration of current drilling; t_{cn} - duration of the round-lifting

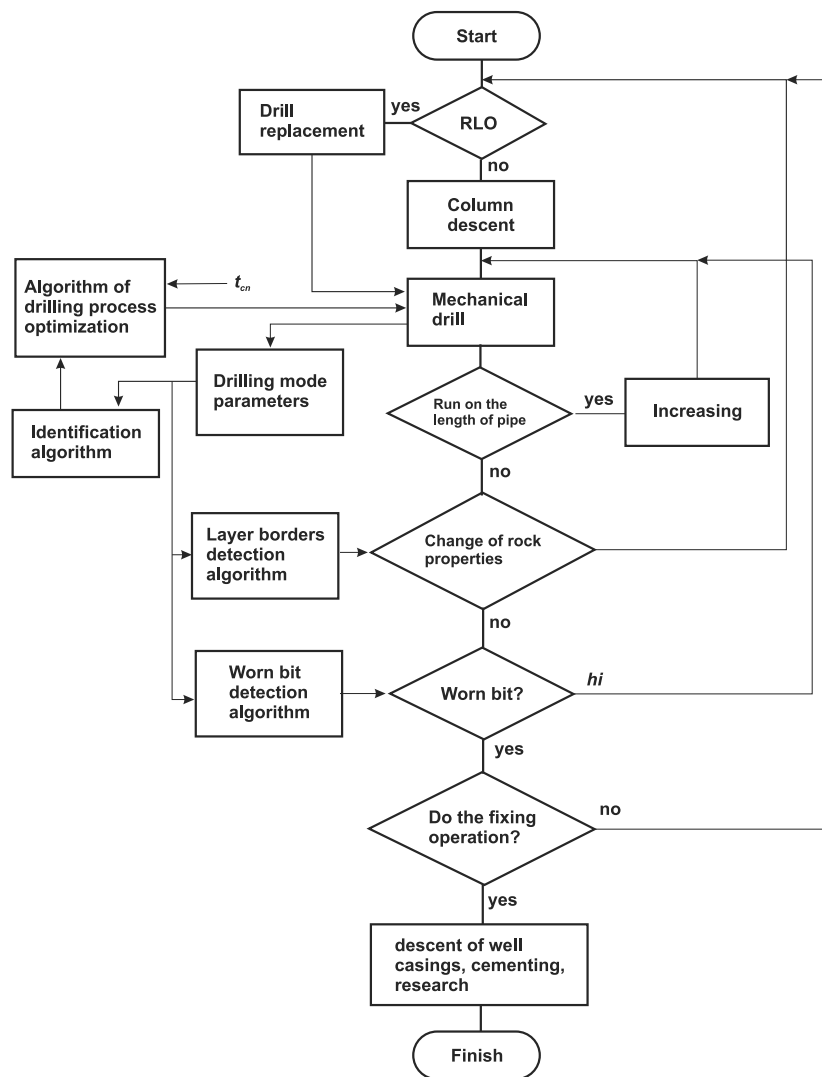


Fig. 1. Block diagram of the wells construction algorithm and its interaction with the algorithm of optimal control over the technological process of drilling

operation (RLO); d - cost of the rock cutting tool; $h(t_{\sigma})$ - driving on the bit per bit run.

As the drilling process involves a number of operations implemented in a specific sequence, the optimum

management criterion (1) provides that the task of determining the optimal control action must “run” at some point in time that corresponds to the beginning of production operations - mechanical drilling. ROL duration of each run is

Table 1.

Technological operations and controlled parameters

Technological process	Technological parameters	Is controlled	Information-measuring system
Hole deepening	axial load on the drill	+	
	rotor speed	+	
	torque on the rotor	+	
	flow of drilling fluid	+	
	load on the hook	+	
	casing block position		
Chisels operations	axial load on the drill	+	
	rotor speed	+	
	torque on the rotor	+	
	load on the hook	+	
	the pressure in the discharge line of drilling fluid	+	
	casing block position		
Circulation and flushing of the hole	load on the hook	+	
	flow of drilling fluid	+	
	the pressure in the discharge line of drilling fluid	+	
Grafting	load on the hook	+	
	torque to drilling keys		
	casing block position		

determined by the cost of time for such technological operations as descent and ascent of drill pipes, building the columns, replacement of chisels, circulation and flushing the hole [2].

When synthesising the optimal process management system of deepening the wells it is necessary to provide the automatic mode of input of values t_{cn} and launch the optimization problem at the moment which should synchronize with the beginning of the mechanical drilling.

Interaction of the well construction algorithm [2] with the algorithm of optimal control of the mechanical drilling process is shown on the Fig. 1.

Thus, the optimal control over the process of deepening the wells is necessary in recognizing the states of the rig.

Each state of the rig is characterized by a certain set of process parameters [3]. Table 1 shows the basic process of manufacturing operations and the construction of wells, as well as the controlled settings corresponding to the following activities.

Value t_{cn} is determined by the duration of a number of sub-operations, which are components of the RLO. These include [3] descending/ascending the drill string to replace the bit; bucket to lift the pipes; maintenance of pipes at the wellhead; twisting/untwisting the grooves; increasing the drill pipe; replacing the chisels.

In order to realize the optimal control algorithm process of deepening the wells it is important to determine the beginning and the end of the RLO. This will help to determine the length of round-lifting operations t_{cn} , which is a necessary condition for solving the optimization problem of a criterion (1).

In order to determine the duration of the RLO we set the initial timing as the time of lifting the bit for replacement; the end of RLO coincides with the moment of finishing the operation of a bit. We added the time needed to increase the column length to the received value $t_{cn}^{(1)}$. If there were n , increasing operations, then

$$t_{cn} = t_{cn}^{(1)} + \sum_{i=1}^n t_{n,i} + t_y, \quad (2)$$

where $t_{n,i}$ - time spent on increasing the drill string at i -th iteration; t_y - time spent on circulation washing and cleaning of wells.

Each rig state is characterized by a certain set of process parameters. There is no need to know their absolute physical values; it's enough to establish the fact of their presence. These controlled parameters are to be kept within certain limits based on technological regulations.

Formation of signals that will be featured in the problem of recognition of states of a rig is shown in the Fig. 2. When a certain technological parameter characterizing the corresponding technological operation is within the established limit, it is set to «one», otherwise - «zero».

The task of identifying the states of a rig we formulate as the task of pattern recognition.

Each state of the rig, identified with certain manufacturing operations (Table 1) will be the pattern. The set of states of the rig creates the space of patterns Ω . If ω is the pattern, then $\omega \in \Omega$. Each pattern (technological operations) had been assigned the serial number 1, 2, ..., m ; $M = \{1, 2, \dots, P\}$ - the classes set $\Omega_1, \Omega_2, \dots, \Omega_p$. Each pattern is characterized by a set of attributes that



Fig. 2. The process of formation of signs

Table 2.2.

Identification of main states of a rig

Rig condition	Technological parameters							
	load on the hook	axial load on the drilling tools	torque on the rotor	torque at machine keys	pressure in the discharge line of drilling fluid	casing block position	costs of drilling fluid inlet and outlet of the hole	rotor speed
Drilling	1	1	1	0	1	1	1	1
Chisels operations	1	1	1	0	1	1	0	1
Increasing	1	0	0	1	0	1	0	0
Circulation and flushing the hole	1	0	0	0	1	1	1	0
Lifting of the column	1	0	0	1	0	1	0	0

form a vector $\bar{x} = (x_1, x_2, \dots, x_n)^T$ in the feature space, built by the sequence of ones and zeros [4].

Since the physical parameters characterising a state of the rig are the positive values:

$$x_i = \text{sign}(p_i(t)), \quad i = \overline{1, n},$$

$$\text{where } p_i(t) = P_i(t) - P_{max,i}; \quad P_i(t),$$

$P_{max,i}$ - current and minimum value of the technological parameter;

$$\text{sign}(p_i(t)) = \begin{cases} 1 & \text{at } p_i(t) > 0, \\ 0 & \text{at } p_i(t) = 0. \end{cases}$$

Given the importance of $p_i(t)$, then

$$\text{sign}(p_i(t)) = \begin{cases} 1 & \text{at } P_i(t) > P_{min,i}, \\ 0 & \text{at } P_i(t) = P_{min,i}. \end{cases} \quad (3)$$

Now it's possible to form a pattern recognition problem related to identification of states of the rig.

Let's create the space of patterns Ω with classes Ω_1 (drilling), Ω_2 (chisels operations), Ω_3 (increasing) i Ω_4 (lifting of the bit). Each class is characterized by its vector \bar{x} , components of which take binary values «0» or «1». Obviously, each class contains only one pattern, which is determined by specific technological operations presented in Table 1.

The problem lies in the fact that upon presentation of the vector \bar{x} we include the object to one of the

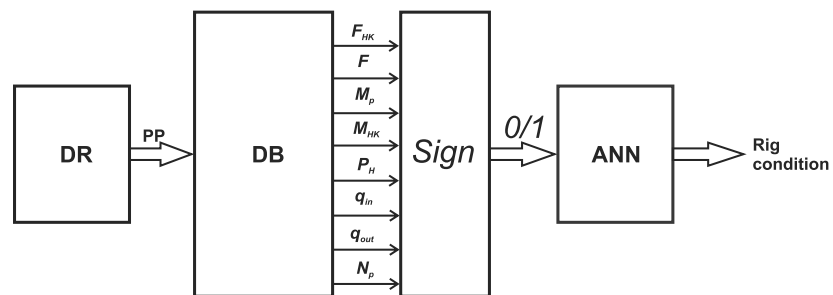


Fig. 3. Block diagram of determination of rig conditions

four classes. To solve this problem it is advisable to use neural network technology.

For successful implementation of an optimal process control system for deepening wells (Fig. 1) we need to know the current condition of the rig (to determine the start of the process of the mechanical drilling automatically) and, if necessary, identify the parameters of the mathematical model by the results of test drilling. Also information about the state of the drilling rig will allow automatically determining the time spent on round-lifting operations (RLO).

Block diagram of determination of rig conditions is shown on the Fig. 3.

The following indices are presented on the Figure 3:

F_{HK} - load on the hook;

F - axial load on the drill;

M_p - torque of the rotor;

P_H - pressure in the discharge line of the drilling fluid;

L_o - casing block position;

q_{in} - flow of the drilling fluid inlet of the hole;

q_{out} - flow of the drilling fluid outlet of the hole;

N_p - rotor speed.

Information about process parameters (PP), which comes from the rig (DR) is measured by the deliverers block (DB), and is converted into the digital form (Fig. 3). Sign unit plays the role of threshold in accordance with the formula (3). On the output of the Sign unit a combination of binary signals 0/1 is created, forming the input vector which is the input of artificial neural network (ANN).

In order to recognize patterns submitted in the form of binary sequences, one should use Hopfield and Hummer neural networks.

References:

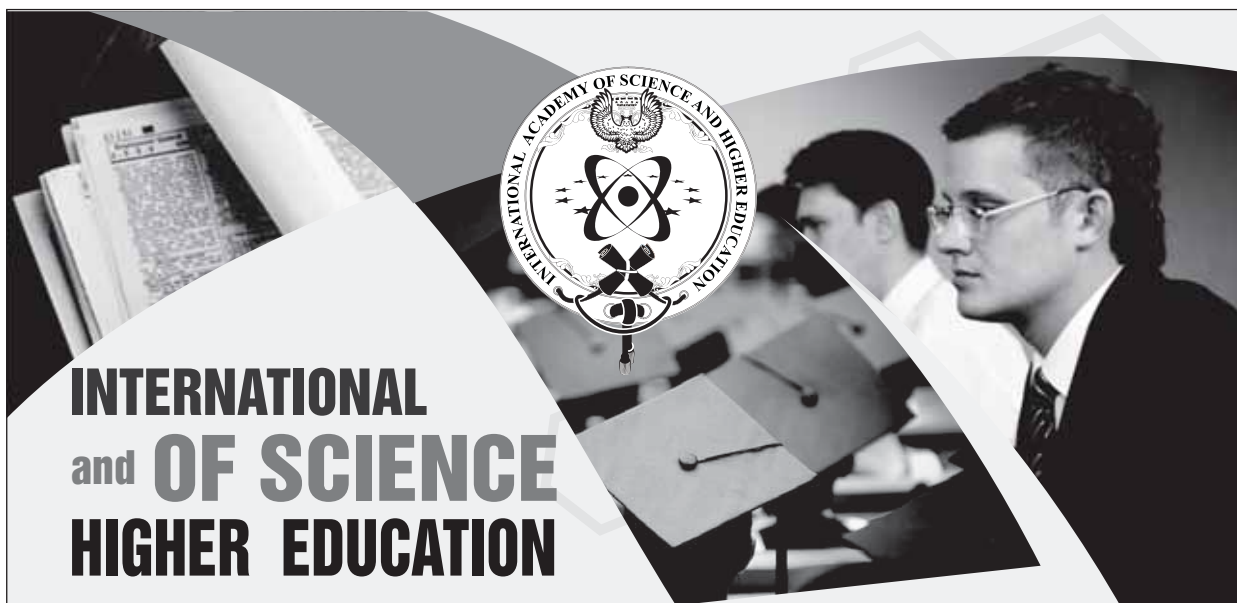
1. Bulatov A.I. Technique and technology of drilling oil and gas wells: Proc. for high schools., A.I. Bulatov, Y.M. Proselkov, S.A. Shamanov. - Moscow., "Nedra-businesscenter", 2003 – 1007 p.
2. Drilling facilities. Modern technologies and equipment. – Ekaterinburg., 2002. - 579 p.
3. Kropivnitska V.B. Method

of identifying the rig condition., V.B. Kropivnitska, T.V. Gumenyuk, D.O. Tkachivskyy., Bulletin of Khmelnytsky National University. - 2010., No. 1 (144)., pp. 94-97.

4. Kropivnitska V.B. Computer system of defining the rig condition., V.B. Kropivnitska, T.V. Gumenyuk, M.S. Svyryd., Progress in science. Collected Works of Buchach institute of management and auditing. - Buchach., 2009., No. 5., pp. 107-111.

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