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INFLUENCE OF PULSE ELECTRICAL DISCHARGES ON THE MICROSTRUCTURE OF THE ELECTRODE SYSTEM DRILL

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The paper is considered practicalities of the electro-hydraulic drilling. The basis of this method is a unique phenomenon - a method of directly transforms of electrical energy into mechanical energy of the shock waves that accompany electrical discharges in conditions a limited spatial volume of water in the bottom of the well. The power a shock wave is allows to effectively disruption is not only the solid rocks but also influences the condition of the drilling system. Study the structure and quality of the surface of the electrode system of the drill, and the character of the changes after the electrohydropulse of processing. Conducted spectral analysis of the microstructure of the melted portions of the surface drill electrodes resulting from the impact of underwater spark discharge. Experimentally are installed regularities of erosive of wear the metal electrode from the energy parameters and the number of electro-impulses.

Keywords: *electrode, electrohydraulic pulse, energy, discharge.*

Introduction

Electrohydraulic drilling is a basically new method that has not been used in industry as of yet. The electric-pulse treatment developed here is based on the Yutkin electrohydraulic effect [1–3]. The main advantage of the proposed technology is its reliability due to the absence of friction and wear parts in the equipment, as well as the simplicity in operation and maintenance. However, the wide implementation of this technology in practice is hampered by undesirable effects and consequences. The processes occurring on the surface of the electrodes subjected to erosion and action of high-power underwater spark discharges require additional investigations. In electrohydraulic well-drilling, the cable of the positive electrode is also subjected to wear (is consumable). Melted regions appear on the surfaces of the positive and negative electrodes; their effect on the strength of the electrode system has not been studied comprehensively. In this connection, this study aims at experimental investigation of the degree and rate of electrode wear depending on the energy parameters and the number of electro hydraulic pulses.

The electrohydraulic setup with a working cell for testing and studying various processes accompanying electrohydraulic drilling was designed and assembled at the Laboratory of Hydrodynamics and Heat Transfer of the Buketov State University (Karaganda). The operation principle of the electrohydraulic drill can be described as follows: first, the pulse capacitor is charged from a high-voltage generator. When a preset voltage is attained, the breakdown of the discharge gap occurs, and the entire energy stored in the pulse capacitor is transferred to the working gap via the cable-electrode. A pulsed electric discharge occurring in a fluid is a source of high-intensity mechanical shock waves, which are reflected from the bore bit and produce a focused action on the medium being processed, crushing it into small pieces [4–7].

In the system for well-drilling, RK-75-9-12 bared cable core connected to the positive terminal of the pulsed current source is used in the working cell for the central electrode, while the negative terminal is connected with the electrohydraulic bore bit. Such a design of the electrode is convenient in well-drilling for installing heat-exchange pipes. As a result of the redistribution of velocities, the forces emerging during the discharge due to a hydraulic shock and the hydrodynamic force facilitate self-centering of the cable-electrode. During prolonged operation, the central bared core of the cable-electrode becomes shorter due to erosion, and the insulation of its end part is damaged. The insulation is mainly cut along the central core, and efficiency of drill operation becomes lower. For this reason, after electrohydraulic crushing of hard rocks, it is necessary to replant insulation by baring the working end of the cable-electrode from the insulating layer.

1. Experimental technique

To form a pulse with a short front of the voltage applied to the discharge gap in a liquid the authors used a discharge gap in the air that is an air discharger; and to generate a pulse of certain energy they used energy storage electrical capacitor. In the laboratory the authors have developed and tested an electro-hydraulic plant and a working area for drilling (Fig. 1).

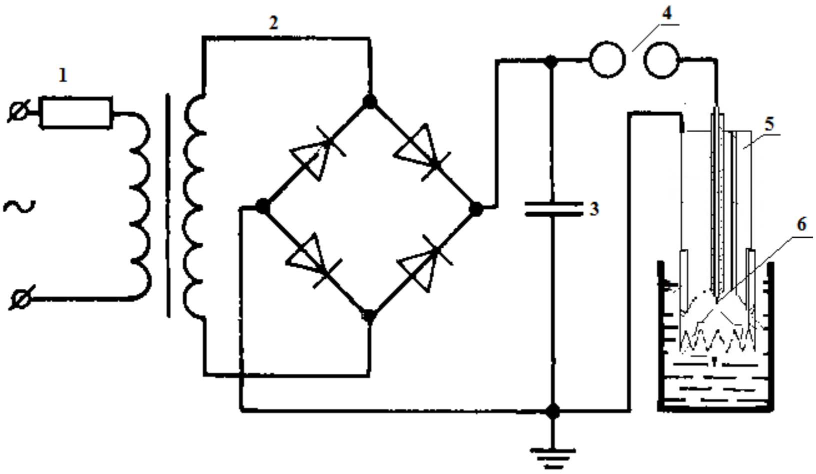


Fig.1. Scheme of electro-hydraulic apparatus and electro-hydraulic drill
1 – power supply, 2 – high-voltage generator, 3 – pulse capacitor, 4 – discharger, 5 – electrohydraulic drill, 6 – centre electrode

As a result of the experimental study the authors defined the optimal values of time and the number of spark discharges in electro-hydraulic drilling the stones, and determined the time at which destruction of stones and hard rock occurs during the drilling.

Forces caused by discharge due to hydraulic impact and flow force, as a result of redistribution of velocities, stimulate self-centering of the electrode cable. During continuous operation the central bare cord of the electrode cable is shortened due to erosion, and the insulator of its end breaks down. Insulation is basically breaks down along the central cord and the device loses its efficiency. In this case, after the solid rocks fracture it is necessary to periodically tinker the operating tip of the electrode cable giving it original shape.

2. Results and discussion

During operation, each discharge is accompanied with erosive wear of the electrodes, which depends on the voltage and energy per pulse, the electrode material, etc. As a result, the cable-electrode of the electrohydraulic drill fails.

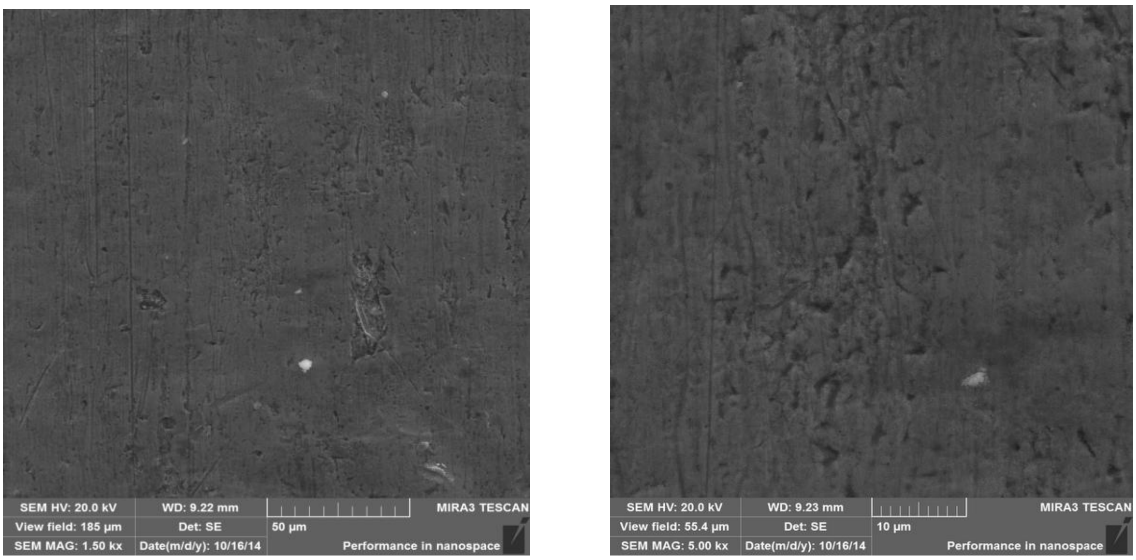
It is well known that during electrohydraulic drilling, spark eroding occurs, which is associated with emission of particles from the metal surface by the electric discharge pulse [8, 9]. If the distance between the electrodes immersed into a liquid medium is preset, the decrease in the spacing between the electrodes initiates the breakdown, and the electric discharge occurs with the formation of a high-temperature plasma in the discharge channel. This property is used in electroerosive processing of materials, which is usually carried out by electric pulses with a duration not exceeding 0.01 s so that the released heat has no time to propagate to the bulk of the material. In addition, the pressure of the plasma particles during their impacts against the electrode facilitates erosion of not only the melted, but also of the heated substance.

The electric breakdown always propagates via the shortest route; for this reason, the closest regions of the electrodes are first to erode. The nature of changes and the quality of the surface after the treatment depend on the duration, frequency, and energy of electric pulses. It was found from the results of experiments change of the length wear of the working electrode the depend on the number of pulses and various discharge energies (Table 1).

Table 1 - Change of the length wear of the working electrode at discharge energies from 600 J to 1350 J.

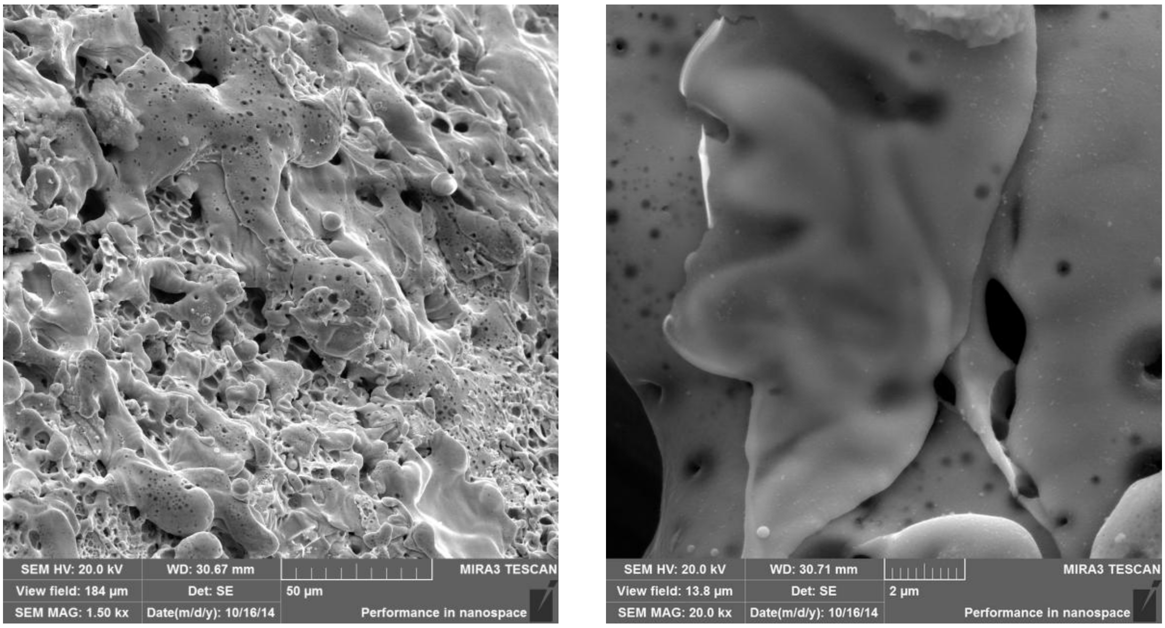
Voltage, kV	Energy, J	Change of electrode's length, mm	Number of electropulses
20	600	0.1	55
		0.5	98
		1.0	121
		1.5	225
25	938	0.5	50
		1.0	100
		1.5	150
		2.0	254
30	1350	1.0	50
		1.5	102
		2.0	154
		2.5	255

It can be seen from the curves that with increasing discharge energy, the working electrode is worn faster for the same number of pulses. Figure 2, 3 show the microphotographs of the central cable-electrode before and after electrohydraulic treatment, obtained using the MIRA3 TESCAN microscope.



× 1.50 kx × 5.00 kx

Fig. 2. Microphotograph of the central cable-electrode obtained with different magnifications before electrohydraulic treatment



× 1.50 kx × 20.0 kx

Fig.3. Microphotograph of the central cable-electrode obtained with different magnifications after electrohydraulic treatment

The photographs obtained with the help of the electron microscope with different magnifications help to trace in detail the changes in the microstructure of the positive electrode.

Analysis of the photographs of the surface of the cable-electrode obtained after electrohydraulic treatment shows that the microstructure of the entire surface changes significantly, and large melted regions including spots with different densities and structures as well as voids are observed. However, investigation of longitudinal and transverse metallographic sections using a microscope with 20000-fold magnification showed no traces of cracks in the metal.

Conclusion

In our experiments, we studied erosion in the metal part of the electrode system of the electrohydraulic drill. We investigated melted regions of the surface by analyzing the microstructural changes of the electrode surfaces before and after electrohydraulic action for various parameters of electric discharges. Analysis of characteristic changes in the cable-electrode during electrohydraulic well-drilling shows that erosive wear of metals occurs in different ways depending on the electric parameters, frequency, and duration of discharges.

The inner surface of the tubular shell of the electrohydraulic drill serving as the negative electrode is not torn and is not subjected to mechanical wear. Substantial wear occurs only in the central cable electrode, which is the only consumable material.

Thus, the electrohydraulic pulsed method of well-drilling for heat-exchangers makes it possible to attain high efficiency of crushing with low energy expenditures as compared to mechanical methods.

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