

ЖЫЛУ ФИЗИКАСЫ ЖӘНЕ ТЕОРИЯЛЫҚ ЖЫЛУ ТЕХНИКАСЫ ТЕПЛОФИЗИКА И ТЕОРЕТИЧЕСКАЯ ТЕПЛОТЕХНИКА

UDC 621.7

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Electro technology of heat exchange drilling in rocky soil

The aim of the study is to develop scientific and practical principles of implementation of energy saving heat pump technology for heat and cold supply to residential, public and industrial premises on the basis of alternative and renewable sources of energy. One of the effective methods to generate heat from groundwater by means of heat pump technology is the use of wells for consolidation of heat exchange elements produced by drilling. Fundamentally new innovative method of making wells is electro-hydraulic drilling. When electro-hydraulic drilling electrical energy directly in the bottomhole transforms into mechanical energy of shock waves that can break up rocks. This paper describes the results of studies of the impact of electro-hydraulic pulse on hard and superhard rock minerals.

Key words: heat pumps, heat exchangers, wells, electro hydraulic drilling.

One of the energy efficient method is the generation of thermal energy using heat pump technology which makes it possible by saving energy to use: ground heat, ground water, water reservoir, natural kill and etc. [1]. Environmental benefits from the use of this technology is that it completely avoids the local greenhouse gas emissions from fuel combustion. Therefore, the replacement of old boilers which use gas or liquid fuel for the systems in the basis of which there is heat pump considered to be a priority and urgent task. The solution of which will not only reduce the consumption of fossil fuels but also greatly reduce the emissions of carbon dioxide.

Heat pump is space-saving, efficient and environmentally friendly heating system, allowing to get heat for hot water supply and heating houses through the use of low grade heat source by carrying it to heat-transfer with higher temperature.

The benefits of heat pump include efficiency: it takes only 5 kWh per hour of electricity for equipment to transfer 1 kWh of thermal energy to the heating system. When using heat pump the fuel efficiency is increasing as the conversion of thermal energy to electricity in large power plants occurs with an efficiency of up to 50 %. Another advantage of heat pump is the ability to switch from heating mode in winter to conditioning mode in summer, just instead of radiators the fan coil units or the system of «cool ceiling» are connected to external collector.

The main heat exchanger element of low grade heat soil collection system is vertical ground heat exchanger of coaxial type which is located outside along the perimeter of the building. These heat exchangers are installed in wells to a depth from 32 to 35 m each arranged near structure.

Nowadays there are a lot of types of drilling equipment which are widely used on the territory of Kazakhstan [2, 3]. However, the process of drilling itself is quite difficult and labor consuming on the territory of Central Kazakhstan in particular when using small drilling equipment because of the complex geology of soil.

At a depth of 10 meters in the soil there are sand and loam, on up to 40–50 meters there are clay, the remains of rocks, residual soil, at a depth of 80–100 meters, on the level of water horizon, you can meet conglomerate, sandstone, siltstone with parting lignite. In many areas rocky slabs occur quite close to the surface.

Widely used today mechanical screw drilling technology is more effective in soft ground in the absence of hard rock and rocky slabs. Drilling to a depth of 35–50 meters with a diameter wells up to half a meter can be difficult if the above obstructions.

Electro-hydraulic drilling is a fundamentally new way of drilling and still has not yet found industrial application, the research task and practical intrusion of this technology to date remains relevant.

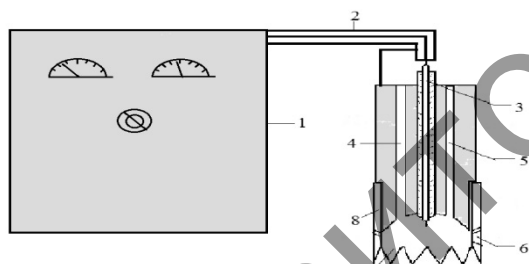
Unique advantages of this new technology include the followings:

- opportunity to carry out work in a limited spatial capacity (constructed buildings, covered accommodation, basement and etc.) which is almost impossible with conventional drilling methods because of unhandiness equipment;
- longstanding reliable operation due to the absence of friction and wearing part of equipment;
- ease of operation and maintenance, achieved by using as an active part the accessible cable-electrode which is considered to be consumable part;
- low energy consumption and environmentally friendliness of the work.

This technology compared to the conventional can destroy constraints as hard rocks more effectively and in the short time during drilling heat exchangers influenced by shock waves in the high voltage discharge within a fluid.

Electro-hydraulic effect represents high voltage discharge within a fluid. When the formation of an electrical discharge in a liquid the energy release occurs within a relatively short period of time. Powerful high voltage electric pulse with sharp rise-up portion causes a variety of physical phenomena. Such as the occurrence of super high hydraulic pulse pressure, electromagnetic radiation in a wide frequency range under certain conditions up to x-ray, cavitation phenomena [4, 5]. Electrohydropulse phenomena as the physical basis of various electro technology is well studied [6–9].

For generating short rise-up portion voltage pulse applied to discharge gap in a fluid the gas discharge gap — gas discharge was used, and as for certain energy pulse the electric storage capacitor was exploited. We have developed and practically implemented electro-hydraulic installation and operating cell for drilling (Fig. 1).



1 — electro-hydraulic installation; 2 — coaxial cable-electrode; 3 — central electrode; 4 and 5 — channels supplying cleaning fluid; 6 — hole in a crown drill for gas outlet; 7 — crown jag; 8 — crown drill

Figure 1. The scheme of electro-hydraulic drill



Figure 2. Appearance of electro-hydraulic drill

The installation consists of electro-hydraulic installation (power supply, high-voltage generator, impulse capacitor, discharge) (1), coaxial cable-electrode (2), and electro-hydraulic drill with central electrode in its construction (3), (4) and (5) channels supplying cleaning fluid, (6) — hole in a crown drill for gas outlet, (7) — crown jag, (8) — crown drill.

Appearance of electro-hydraulic drill is shown on the picture (Fig. 2).

Installation operates as follows. Impulse capacitor (3) is charged by a high-voltage generator (2), powered from the adjustable source of current (1). When the specified voltage a discharge (4) breakdown occurs and all the energy stored in the capacitor is transmitted to the working gap of electro-hydraulic drill through a cable-electrode. The impulse electrical discharge in a fluid occurs which is the source of powerful mechanical shock waves, reflected from the crown drill it affects the treated rock, thus breaking it into small pieces.

As a result of an experimental study the optimal values of time and the amount of electric sparks when electro-hydraulic drilling of rocks were determined, also the time at which stones and hard rocks were crushed during the drilling.

The objects of electrohydropulse treatment were solid rocks in the form of natural stones. Natural stones are very diverse in its structure material, often built of various minerals, frequently in the process of formation and subsequent occurrence in the earth's crust are subjected to considerable stress [10]. In the experiment natural stones whose hardness was 5–6 units by Mohs' scale were used.

Photos of samples of processed natural stones are shown in picture (Fig. 3).



Figure 3. Pictures of natural stone samples

As a result of the intensive electrohydropulse processing of natural stones the indicated samples had been broken into small pieces (Fig. 4).

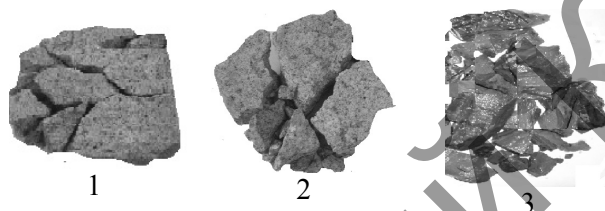


Figure 4. The photos of natural stone samples after electrohydropulse processing

During experiment electrical values of installation have been changed within the following limits:

$$U_{high} = 20 \div 35 \text{ kV}$$

$$C_{cap} = 1 \text{ mf.}$$

$$l_{disch} = 7 \div 12 \text{ mm}$$

$$L_{work} = 25 \div 35 \text{ mm.}$$

The energy of the discharge in the working gap varied $E = 250 \div 620 \text{ J}$

In experiment the treated natural stones had an average thickness from 42 mm to 80 mm.

The experiments were conducted as follows. The electro-hydraulic drill was installed on the surface of the stone put in a tank with water. The number of discharge to the fracture process was determined after switching the equipment.

Derived graph of the dependence of the discharge number on the stone thickness at different values of energy is shown on Fig. 5 a, b.

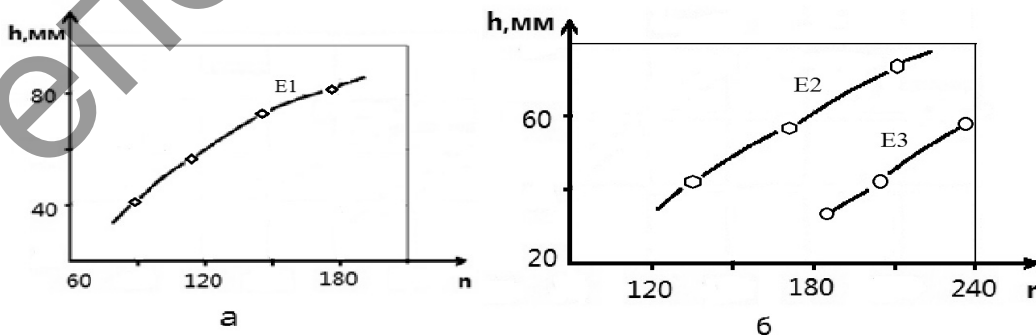


Figure 5. Graphs of the dependence of the fracture process of given thickness on the quality of electro-hydraulic pulses

It is shown that when the discharge energy is about 288 Joules (E3) the stone with thickness of 55–60 mm can be destroyed. The amount of impulses is 230. When discharge energy is growing (E2) the thickness

of destroyed stones increases, at the same time the amount of impulses necessary to destroy decreases. For instance, when discharge energy is about 612 J (E1) it is possible to destroy the stone with thickness of 80 mm. This requires less amount of impulses about 170.

Based on experimental studies the limits of electrical parameter method were established at which solid rocks — natural stones began to break.

The qualitative dependence were determined, characterizing the beginning of fracture process of rocks of different thickness depending on the number and energy discharges.

Experimental work demonstrated the possibility of achieving higher speed of drilling than on the commonly used equipment. Electropulse destruction is explosive, it does not require special pressure of electrodes to the bottom with considerable force and therefore deterioration of electrodes is relatively small during electrohydropulse drilling.

References

- 1 *Energy Strategy of the Republic of Kazakhstan for 2004–2015*, Astana, 2003.
- 2 Bondar E.S., Kalugin P.V. *Heat pump as an energy efficient component of air conditioning systems*, Electronic journal of energy service company «Ecosystems», 2008, (5).
- 3 Ray D., McMichael D. *Heat pumps*, Moscow: Energoizdat, 1982, 224.
- 4 Yutkin L.A. *Electro-hydraulic effect*, Moscow: Mashgiz, 1955, p. 51.
- 5 Yutkin L.A. *Electro-hydraulic effect and its application in industry*, Leningrad: Mashinostroenie, 1986, p. 253.
- 6 Kussainov K., Sakipova S.E., Nusupbekov B.R., Turdybekov K.M., Kuzhukhanova J.A. *Electric hydro-pulse development technology of heat exchangers production for using ground heat at shallow depths*. Industrial Heat Engineering, International Scientific and Applied Journal, 2012, vol. 34, (7), p. 32–33.
- 7 Kussainov K., Nusupbekov B.R., Shaimerdenova G.M., Bulkairova G.A. *Electroimpulse Grinding And Reduction Of Natural Minerals*, Eurasian Physical Technical Journal, 2009, vol. 6, No. 2 (12), p. 60–64.
- 8 Kussainov K., Baikenov M.I., Nusupbekov B.R., Satybalidin A.J. *Influence electrohydroimpulse impact on the physical and chemical properties of highly viscous hydrocarbons*, Chemistry and Chemical Engineering: Materials I-th International Conference of the Russian-Kazakhstan, (26–29, April, 2011) / NITPU, Tomsk, 2011, p. 534–537.
- 9 Kussainov K., Nusupbekov B.R., Shaimerdenova G.M., Bulkairova G.A. *Influence of electrical parameters electrohydropulse installation purification tubing* // Bull. Almaty University of Energy and Communications, 2011, No. 2 (13), p. 53–56.
- 10 *The Mohs Mineral Hardness Scale*, By Andrew Alden, About.com: Geology, Electronic resource, 2010.

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Тақты жердегі жылу алмасу ұңғыларды бұрғылаудың электротехнологиясы

Мақала мақсатына дәстүрлі емес және жаңартылған энергетика көздерін пайдаланып, қоғамдық және өндіріс орындарын, тұрғын үйлерді жылу және суытумен қамтамасыз етуде энергия үнемдегіш жылу сорғылары технологиясын ендірудің ғылыми-практикалық негіздерін жасау жатады. Жылу сорғылары технологиясы негізінде жер қойнауынан алынатын жылу мен жер асты суларын пайдаланудағы ең тиімді әдістердің бірі бұрғылау арқылы жылуалмастырғыш элементтерін бекітуге арналған ұңғымаларды қолдану болып табылады. Ұңғымаларды жасауда электрогидравликалық бұрғылау әдісі жаңа инновациялық әдіс деп есептеуге болады. Бұл кезде электр энергиясы бұрғылайтын жерде тікелей соққы толқындарының механикалық энергияға айналып, тау жыныстарын бұзуға қабілеттілігінде болып отыр. Қатты және өте қатты тау минералдарына электрогидроимпульстік әсердің қалай болатындығы туралы зерттеу нәтижелері келтірілген.