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ELECTRO-PULSE TECHNOLOGY OF PRODUCTION HEAT EXCHANGERS FOR EXTRACTING THE HEAT FROM THE GROUND AT SHALLOW DEPTHS

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The aim of the study is to develop scientific and practical bases of introducing energy-saving heat pump technology to heat and cold supply of residential, public and industrial premises on the basis of alternative and renewable energy sources. The heat exchanger of the heat pump is installed in the wells for groundwater heat. A widely used method of getting well, canals - drilling. Electro drilling, in which electrical energy is directly in the slaughter goes into mechanical work, breaking the rock, is a fundamentally new way of drilling. For its implementation are electro drills of various types and modifications.

Keywords: electric pulse technology, heat pump, heat exchanger, drilling, heat from the ground at shallow depths.

Currently, search and active use of new alternative energy sources in many developed countries of the world are accepted as vital, strategic resources necessary to ensure the future development of their economies.

Modern development of power engineering in the Republic of Kazakhstan is characterized by a cardinal restructuring of the fuel and energy complex. This is due to the increase in the price of fossil fuel in the world market, the aggravation of environmental problems.

In these circumstances, the measures to save fuel and energy resources are a priority in the long-term energy policy.

In the CIS countries, large heat and power plants and district heating stations with a heating capacity of more than 50 Gcal/h are the sources of district heating for residential, public municipal buildings and public utilities. One of the energy saving alternatives is to obtain thermal energy using a heat pump, which makes it possible to use heat of the ground, underground water, water bodies, natural water flows, etc. [1]

For a small heat pump with a capacity of about 10 kW, which can be used for individual houses, the expense of an underground water flow of about 1-2 m^3/h is required. For this purpose a heat exchanger is used. Heat exchangers can be arranged horizontally or vertically [2].

A horizontal ground heat exchanger is usually arranged near the house at a shallow depth. The use of horizontal ground heat exchangers is limited by the size of available sites.

Vertical ground heat exchangers permit the use of low-potential heat energy of the ground mass lying below the "neutral zone" (10-20 m from the ground level). Vertical ground heat exchanger systems do not require large area sites and do not depend on the intensity of solar radiation incident on a surface. Vertical ground heat exchanger works effectively in virtually all types of geological environments, except for ground with low thermal conductivity, such as dry sand or dry gravel. Systems with vertical ground heat exchangers are widely spread.

Vertical ground heat exchanger systems can be used for heat and cold supply of buildings of different sizes. For a small building just one heat exchanger is enough; large buildings may require an entire unit of wells with vertical heat exchangers.

Coaxial vertical ground heat exchangers located outside the perimeter of the building are the main heat exchanger element in the collecting system of low potential heat of the ground.

These heat exchangers are 8 wells with the depth from 32 to 35 meters each, arranged near the house. [3]

To use the groundwater heat, the heat exchanger of the heat pump is installed in the wells. A widely used method to make wells and canals is drilling. Nowadays there are many types of drilling rigs widely used in Kazakhstan. The existing technologies for drilling wells of heat exchangers are efficient in case of soft ground in the absence of hard rocks and stone plates. Drilling a well with the diameter up to half a meter to the depth of 25 meters in the condition of the above mentioned constraints can be difficult. The proposed technology would make it easy to overcome such obstacles, destroying them by the impact of shock waves at high-voltage discharge in water. It involves crushing and grinding of hard rock that allows efficient drilling wells to the required depth in the short term.

The main advantages of this technology are: the uniqueness of the proposed innovative way of drilling hard rocks is the ability to work within limited space (covered premises, cellars, etc.), that is, in many cases, impossible with traditional mechanical methods of drilling hard formations due to the bulkiness of the equipment used.

The electrohydraulic drilling when the electrical energy turns into mechanical work directly in the bottom, thus destroying the rock, it is a fundamentally new way of drilling. For its implementation various types and modifications of electro-hydraulic drills are designed.

Depending on the design and purpose of a drill, it may have two or more electrodes, they can be fixed, rotating and perform vibration movement. The movement of the electrodes can be caused either by an external source (an engine), or due to the energy of flowing water, or action force of the electro-hydraulic shocks.

Suggested electro-hydraulic drills constructively are divided into four main groups.

First group: electro-hydraulic drills with a rotating central electrode – it is experimentally proved that the drills of the continuous face of this type at a voltage of 70-100 kW and capacity 0,7-1.0 mF can drill large wells with the diameter of up to 450-500mm. The rotation of the front edge of the central electrode is carried out in various ways (for example, by an electric engine, turbine, driven by drill water supported through the drill pipe, as well as by reaction of electro-hydraulic shocks) [4]

Second group: electro-hydraulic drills with fixed central electrode. In the course of investigation on the creation of a drill with a fixed central electrode dependence of breakdown voltage in a liquid on the mass content of any mechanical impurities in it was revealed. The method of the so-called "dirty face" was suggested, and drill of continuous face used for this technique was created as well.

The third group: linear drills. If, figuratively speaking, we "flatten" the continuous or circular face drill with a fixed central electrode, we will constructively obtain two types of linear drills. Linear drills with water supply through the central electrode with a length of cut equal to 1-2 m, at a voltage of 50-80 kV can form narrow slits and slots with the widths of up to 8-10 mm not only along direct, but also any curved lines.

Fourth group: drills of this type can drill all the rocks, frozen ground, ice, salt; they can cut wood, perform various underwater works - cut expansion gaps in concrete channels, holes for the groove at the bottom of dams and drill wells with any longitudinal curvature that is achieved by imparting the corresponding longitudinal curvature to the drill rod.

But they all are not brought to the industrial applications, only their principles are described.

All aforesaid made it necessary to carry out experiments to develop an electro-hydraulic technology of preparation of ground ditches for industrial use. For this purpose we used an experimental setup based on the electro-hydraulic effect.

Electro-hydraulic effect - is a transformation of the process of hydrodynamic vortex power to mechanical energy. Electro-hydraulic effect is a high voltage electrical discharge in a liquid medium. During the formation of an electric discharge in a liquid energy release occurs within a relatively short period of time. A powerful high-voltage electric pulse with a steep leading front causes a variety of physical phenomena. Such as the emergence of ultra-high hydraulic pulse pressure, electromagnetic radiation in a wide range of frequencies up, under certain conditions, to x-rays, the cavitations phenomenon. The electro-hydraulic discharge occurs upon the application of pulse voltage of sufficient amplitude and duration to a liquid, resulting in evolving of an electric breakdown [5].

To form the pulse with a short leading front voltage applied to the discharge gap in the liquid we used the discharge gap in a gas – a gas discharger, and in order to generate certain pulse energy an accumulating electrical capacitor was used. Once we developed and implemented into practice a scheme of constructing electro-hydraulic setup, figure 1.

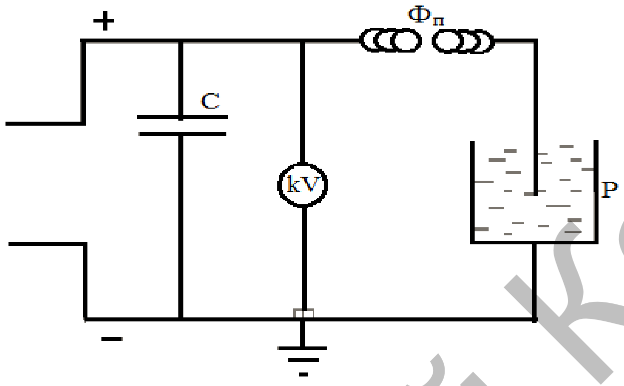

Fig.1. Scheme of electrohydraulic setup: kV - rectifier, Fg - forming a spark gap, W - working cell of the electrohydraulic drilling, C - capacitance of the capacitor.

The laboratory equipment consists of the following units: control panel, a system protective capacitor, an electric power supply, current limiter, automatic power off, a high voltage indicator, commutation generator, high voltage rectifier of the transformer, power storage devices, the protective system of the capacitor, residual voltage removing unit, protection system, a small discharger, an electrode system. To carry out experiments on the destruction of stones in the drilling process, a working cylindrical cell was made, the bottom of which has a hemispherical concave shape (its thickness together with the insulating material is 13mm). To hold the electrode in the cell body at the same position attachments are mounted. The negative electrode of the electro-hydraulic setup is placed at the bottom of the cylindrical cell. In Figure 2 and Figure 3 the working cell of the electro-hydraulic setup is shown.

Fig.2. Working cell for drilling.

Fig.3. Working cell, mounted on a stone.

The thickness of the stones used for the investigation in the laboratory of hydrodynamics and heat and mass exchange, was different (h = 30mm, h = 40mm, h = 70mm). The best results were obtained at a gap length of 9 mm in the discharger of the electro-hydraulic equipment.

As a result the experimental study, the optimal values of time and quantity of spark discharges during the electrohydraulic drilling of stones, as well as the time when the cracking of the stone took place in the drilling process were determined.

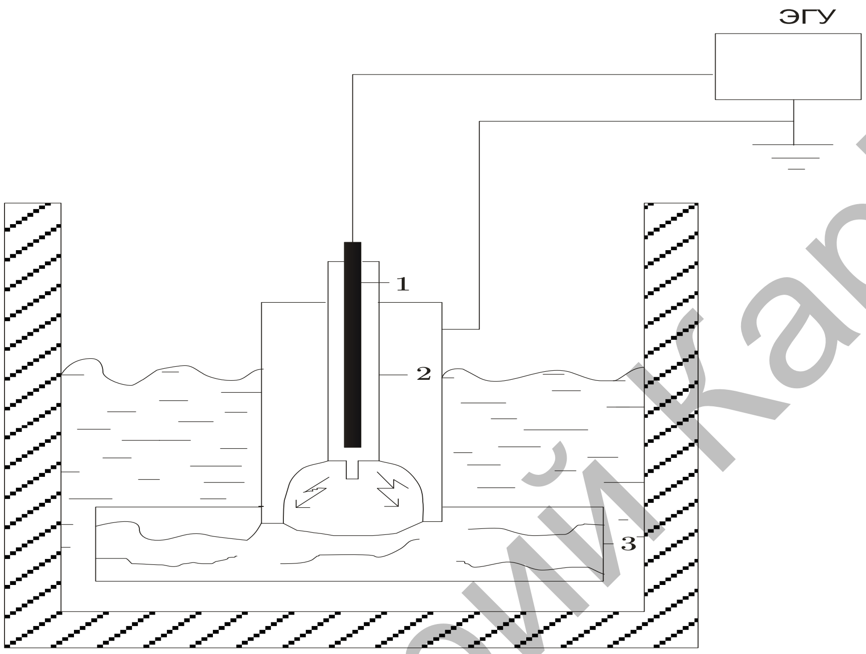

Fig. 4. Scheme of the electro-hydraulic drilling: 1– electrode, 2 – cell, 3 – stone.

The experimental results of electrohydraulic drilling of stones with h = 30 mm, h = 40 mm are shown in Figures 5 and 6.

Fig.5. Break of the stone after drilling for 3 minutes (h = 30mm)

Fig.6. Break of the stone after drilling for 5 minutes (h = 40mm)

Figure 7 shows that at the thickness of the of stone h = 30mm-40mm the number of discharges prior to crushing was 150-200 impacts and for h = 70 mm it was 400-450 impacts. Drilling depth depends on the number of impact discharges. At the maximum impact discharge, the rate of increase in drilling depth grows. The reason is that at the impact discharge an increase in pressure takes place, it causes the lump grinding on the surface of a stone. An increase in the impact of a discharge leads to pressure growth, so at the maximum impact of an electric discharge the depth of drilling is increased.

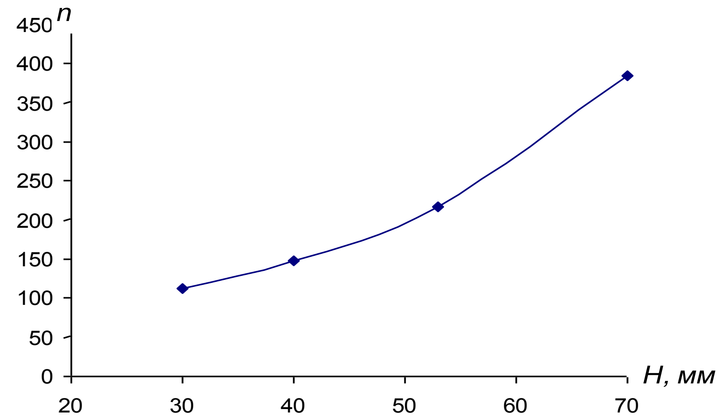

Fig.7. Dependence of the number of impact discharges on the thickness of a stone prior to crushing.

Figure 8 shows a graph of dependence of the impact discharges number on the length of time of the drilling process

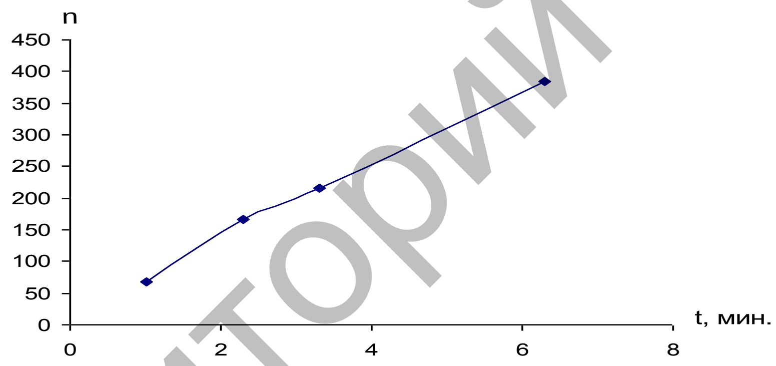

Fig.8. Dependence of the number of impact discharges on the time length at a electro-hydraulic effect.

The dependence of the number of impact discharges on the length of time at a electro-hydraulic effect was established. As it is shown in the graph, in the process of crushing of stone (h = 40 mm) the number of spark discharges amounts to 50 impacts per minute, 150 impacts in two minutes, 200 impacts in three minutes, 350 impacts in seven minutes. It was found out that during the process of drilling, the stone surface begins to grind and eventually the drilling depth increases, and consequently this increases the frequency of electrical discharges.

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