THE UNIQUE BENEFITS OF ELECTRO-HYDRAULIC PULSE TECHNOLOGY OF DRILLING WELLS

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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. According this method an electrical energy transformed into mechanical energy of shock waves that can break up rocks directly in the bottom hole. This paper describes the results of a study of the electric hydro-pulse effect on hard and super hard rock minerals.

Keywords: heat pump, heat exchanger, *renewable sources of energy*, *groundwater*, well, electro-hydraulic drilling.

Introduction

One of the energy efficient methods is to obtain thermal energy is a heat pump technology which makes it possible to save energy using heat of the ground, underground water, water bodies, natural water flows, etc. [1]. The environmental benefit from the use of this technology is that it enables to completely avoid local greenhouse gas emissions from fuel combustion. Therefore, a priority and urgent task is to replace old boilers that use gas or liquid fuel by the systems based on a heat pump. This replacement would not only reduce the consumption of fossil fuels, but also substantially reduce emissions of carbon dioxide.

Heat pumps are compact, economical and environmentally friendly heating facilities for hot water supply and heating houses that use low-grade heat source by transferring it to a heating agent with a higher temperature.

The benefit of heat pumps is their efficient performance: to transfer 1 kWh of thermal energy to heating system a plant needs to spend only 0.2-0.35 kWh of electric power. Since the efficiency factor of conversion of thermal energy into electric power at large power stations is up to 50%, fuel efficiency when applying heat pumps rises. Another benefit of heat pump is the convenience of changeover from heating supply in winter to air-conditioning duty in summer, for that instead of radiator units fan coils or "cool ceiling" facilities are connected to an external collector.

The main heat exchanger element in the collecting system of low potential heat of the ground are coaxial vertical ground heat exchangers located outside the perimeter of the building. These heat exchangers are installed in wells with depth ranging from 32 to 35 m each, arranged around the building [2].

Nowadays there are many types of drilling rigs widely used in Kazakhstan [3, 4]. Widely used nowadays mechanical auger drilling methods are more efficient in case of soft ground without solid rock and stone slabs. Drilling to the depth of 25 meters at well diameters up to half a meter with the above mentioned inconveniences can be difficult. Electro-hydraulic drilling is a fundamentally new method that has not yet been applied in industry; the task of research and the practical use of this technology remains relevant to this day.

The unique benefits of this new technology are the following:

- opportunity to perform work in confined working space conditions (inside of constructed buildings, premises, basements, etc.) where it is almost impossible to use conventional drilling methods due to bulky equipment;
- long term reliable operation due to the absence of rubbing and wearing parts of the equipment;
- ease of operation and maintenance, that is achieved by the use as an active part a widely available cable electrode that is a consumable product.
- low power consumption and environmental friendliness of performed work.

This technology, as compared to conventional ones, makes it possible to demolish such obstacles as solid rocks more efficiently and in a short time when drilling wells for heat exchangers by impact of shock waves at high-voltage discharges in aqueous media.

Experiment technique

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, cavitations phenomena [5-7].

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

Figure1. Photograph of the general form of an electro-hydraulic plant for well drilling

The installation consists of a power supply, a high-voltage generator, a pulse capacitor, a discharger, a coaxial cable-electrode and an electro-hydraulic drill having in its design a central electrode, channels for supplying a drilling fluid, a hole in the drill crown for gas outlet, cogs of the crown and a crown of the drill. A picture of the cell for drilling is shown in Figure 2.

The electro-hydraulic drill works as follows. The pulse capacitor is charged by the high-voltage generator powered from an adjustable current source. When gaining the preset voltage, a breakdown of discharger takes place and all the stored energy in the capacitor through a cable-electrode is transferred to the working clearance.

Fig. 2. The appearance of the electr-hydraulic drill

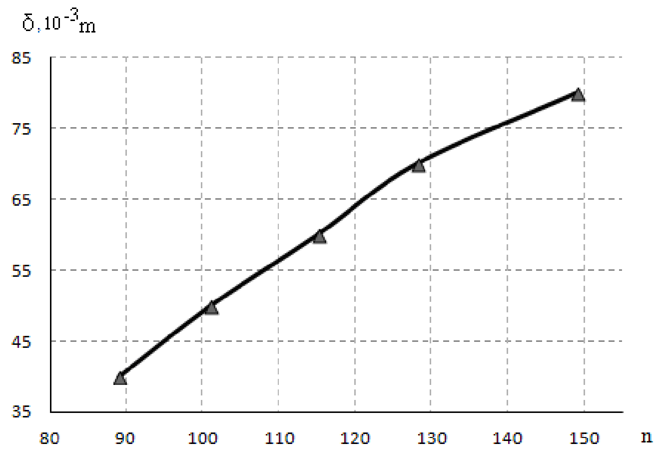
A pulsed electrical discharge occurs in a liquid. The discharge causes powerful mechanical shock waves, which being reflected from the drill crown affect the processed rock, thus destructing it into small pieces.

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

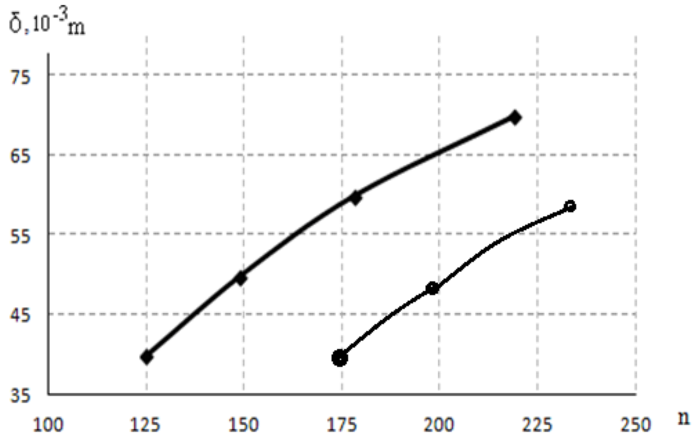
The objects of electric hydro-impulse processing were solid rocks in the form of natural stones. Natural stone is very diverse in structure material, in many cases made of various minerals, often in the process of formation and subsequent bedding in the Earth crust, which is subjected to considerable stresses. The experiments were performed as follows. We put stones of specified thickness into the bottom of a cylindrical vessel, modeling a bottom-hole of a real heat exchange well with a diameter of about 30 cm. The cylindrical vessel was filled with water and the electro-hydraulic drill was plunged into it so as to reach the surface of the stone. Upon actuation of the plant we determined the number of discharges up to the destruction process began.

Results of experiment

The resulting dependence graph of the discharges number on the thickness of the stone at different energy values is presented in Figure 3.



a)



b)

Fig. 3. The dependency of the destruction process of stone of specified thickness on characteristics of electro-hydraulic pulses.

You can see that at the discharge energy level around 288 Joules destruction of a stone to the thickness of 55-60 mm is possible. The number of pulses is 230. When discharge energy rises, the thickness of destructed stones increases while the number of pulses required for destruction decreases. For example, at the discharge energy level around 612 J it is possible to destruct stones of 80 mm thickness. This requires less number of pulses of about 170.

Conclusion

On the basis of experimental research the limits of electro-physical parameters of method, when the intensive destruction of solid rocks – natural stones begins were determined.

The quantitative dependency, characterizing the beginning of the process of destruction of rocks of various thickness depending on the number and energy of discharges was defined.

The experimental work proved the possibility of achieving higher drilling speeds compared to those at conventionally used plants. The electric pulse destruction is implemented without using a drilling bit, it does not require special tightness of electrodes to bottomhole surface with considerable force; therefore, the wear of the electrodes at electrohydraulic pulse drilling is relatively minor.

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Article accepted for publication 17.03.2014