разрядтық арнада ток пен кернеудің осциллограммасы судағы электр разряды өшетін тербелістер режимінде де ағып өте алатынын көрсетеді.

Сонымен қатар, каналда плазма күйінің құрамы өзгеретіні анықталып, оны сипаттайтың теңдеулер мен термодинамикалық функциялар анықталды.

Разрядтық тізбектің реактивті элементтерінде жинақталған түрлендіруші электр энергиясы қатты диэлектриктерді бұзуға жұмсалған энергияға –аралық күй -ойық каналдағы заттың ішкі энергиясы Е арқылы айналады.

Мұндағы ішкі энергия айналу процесінде маңызды орын алып, ойық каналдың кеңеюіне байланысты қоршап тұрған диэлектрик жұмысына А түрленеді. $A = \int_0^{V_1} pdV$. Конденсатталған диэлектрик затының ойығына қолданылатын калориялық теңдеу қолданылған $E=\frac{\rho V}{\gamma-1}$. Сілтілік галлоидты канал үлгісімен термодинамикалық функциясының , құрамы мен канал плазмасының теңдеуіне аналитикалық есептеулер жүргізуге болады. Бұл аналитикалық есептеулер ойық каналдың геометриялық өлшемдері мен берілген энергия мөлшері экспериментaлдық-есептеу шамасына $y_э$ (t) сәйкестік береді[7].

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Study of heat exchange processes on soil heat exchangers of a heat pump

Currently, people are faced with the problem of serious deterioration of the state of natural resources and the environment for all the most important environmental indicators. Environmental pollution has a serious negative effect on human health. According to international studies, about 40 thousand children under 10 years old have neurological disorders as a result of excessive exposure to lead. Kazakhstan is in second place in terms of total environmental pollution by organic substances among the countries of Central and Eastern Europe and Central Asia. In cities, there is a high level of air pollution; the level of concentration of particulate matter is ten times higher than similar indicators in the European Union. According to estimates, air pollution causes up to 6 thousand premature deaths per year.

Today, the world economy depends on the export of raw materials and is therefore largely affected by external sharp fluctuations in prices on commodity markets. For example, Kazakhstan will reach the maximum level of oil production and export between 2030 and 2040. In addition, there is high uncertainty in the level of hydrocarbon prices. According to estimates by the International Energy Agency and the US Energy Information Agency, hydrocarbon prices may reach historic lows by 2035 [1].

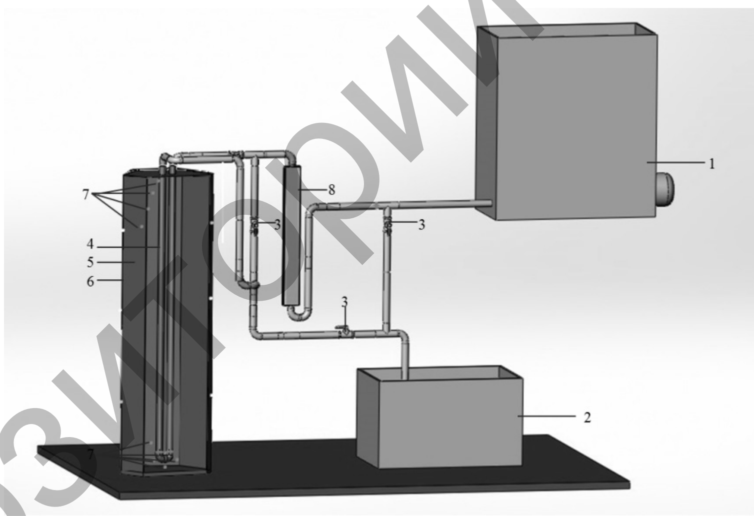
In this regard, the research and implementation of new technologies based on non-traditional energy sources is particularly relevant, since it is this type of energy that contributes to the solution of the above problems.

An intensively developing area of energy is the use of low-grade heat in heat supply systems, the sources of which can be secondary energy resources of low potential (water from cooling systems, waste water, exhaust air from ventilation systems, etc.) or the environment (atmospheric air, soil, water resources).

Use of low-potential warmth of soil is of special interest. The advantage of such a source of low potential heat is the widespread availability and relatively constant temperature.

The aim of this work is to study the heat transfer processes occurring in a soil heat exchanger.

For developing a methodology of calculating heat transfer processes in soil heat exchangers, a simulation research unit was created in the laboratory of the Department of Engineering Thermophysics (Figure 1), which allows modeling the operating conditions of a U-shaped soil heat exchanger. During the study of the heat transfer of U-shaped soil heat exchangers, the dependences of the temperature distribution in the soil around the pipe and the temperature change over time in dry and wet soils are determined.

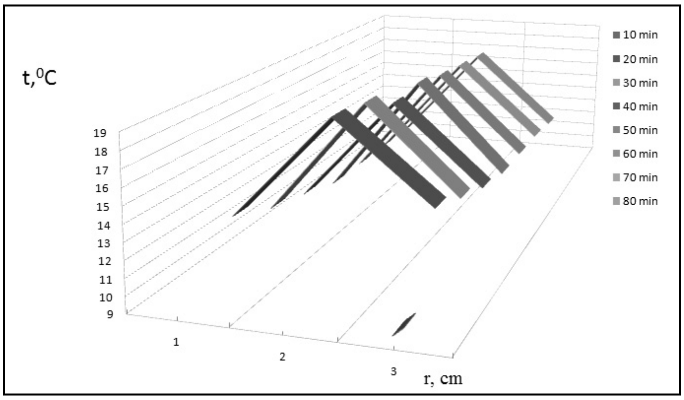


1 - water tank, 2 - measuring tank, 3 - valves, 4 - U-shaped vertical soil heat exchanger, 5 - soil, 6 - case, 7 - temperature sensors, 8 - flow meter

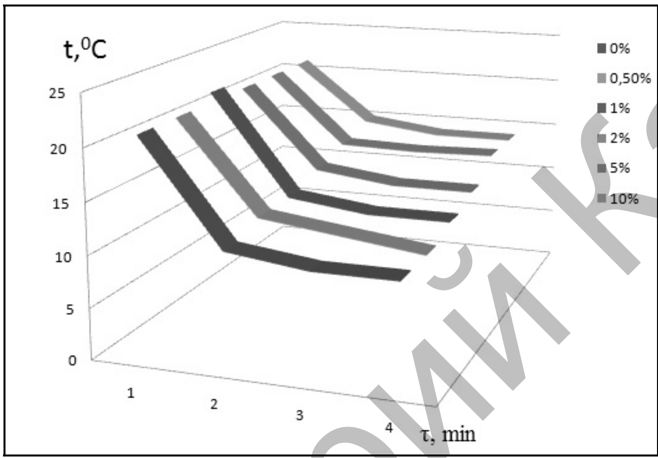
Figure 1 - Schematic diagram of the experimental stand for the study of heat transfer processes of soil heat exchangers

The experiments were carried out with different soil parameters to better approximate the natural conditions of the soil heat exchanger. During the experiment, temperature sensors measured temperature in several places, in particular, at different distances from the U-shaped pipe, at the outlet, and at the U-shaped pipe connection.

First, a change in temperature was determined at different radial distances in dry soil. When flowing through a U-shaped pipe of cold water at a speed of 0.098 m/s every 10 minutes, the readings of temperature sensors located at different distances were taken. They show the temperature changes around the pipe in the ground. According to the data obtained during the tests, dependency graphs were built. Figure 2 showsthetemperaturechangesovertime.



a



b

a - the connection area of the pipes; b - exit area of the pipes

Figure 2 - Change in temperature distribution over time (dry soil)

The temperature of the soil around the pipe over time decreases relatively faster than the temperature of the soil at a distance from the pipe. The temperature at the outlet of the pipe is higher than the temperature at the inlet, this is due to heat transfer from the soil to the pipe.

Temperature changes around the pipe of the soil heat exchanger located in the soil with different mass moisture concentrations are shown in Figures 2-3.

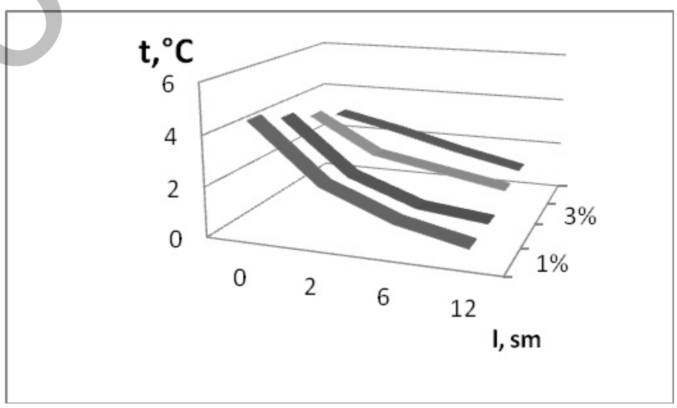


Figure 3 - Change in the temperature difference around the pipe depending on the distance at different soil moisture

According to the results of the research work, the sand temperature difference decreases with increasing humidity. Also, the heat exchange process in soil heat exchangers used for geothermal heat pumps has been investigated. At the research facility created by the authors, experiments were carried out and calculations were carried out confirming the best thermophysical parameters of wet sand. The regularities of the temperature distribution in the vicinity of a U - shaped soil heat exchanger are experimentally determined.

Since currently there are no standard heat exchangers for extracting heat from the soil, such systems must be designed for each specific object separately. It should be noted that from the point of view of thermophysics, soil is a rather complex system. Through experimental studies at the stands, the authors of the work obtained the time dependence of the temperature of dry and wet sands and the temperature distribution in the sand in the vicinity of the polyethylene pipe. The experiments carried out have confirmed that in dry soil the temperature change will be greater than in wet soil.

Thus, in capillary-porous systems, which is the soil mass of the heat collection system, the presence of moisture in the pore space has a noticeable effect on the process of heat distribution. The value of the equivalent thermal conductivity of moistened sand is higher than that of moistened clay, and increases with increasing humidity from 1 to 7%. The thermal conductivity of clays varies from 2 to 4 W / (m · °C), while in sand it ranges from 5 W / (m · °C) and more. The wetter the sand, the higher the thermal conductivity.

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