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THE PROJECT OF HEATING SYSTEM BY MEANS OF HEAT PUMP TECHNOLOGY

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1. Introduction

At the present time there is a serious problem of exhaustion of existing kinds of energy sources, such as oil and gas. It is become actually researching and working out of practical method for reception of alternative cheap energy sources. One of such sources is the Earth heat.

2. Heat pump technology

Already about 25 years the Western countries: the USA, Germany, Sweden and some others use the Earth heat as energy for premise heating including using of rocks low potential heat (Fig. 1) [1].

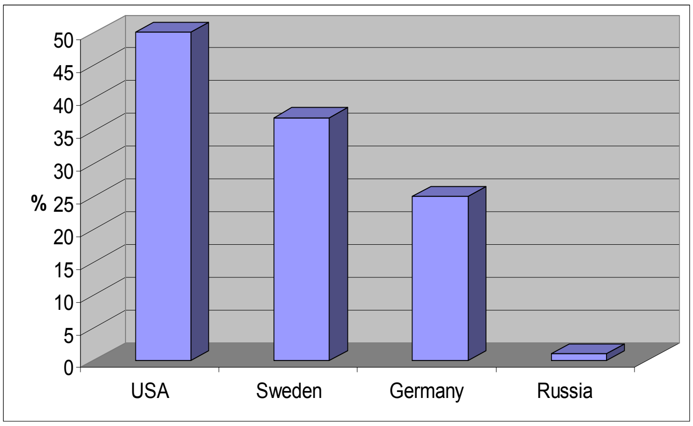

Fig. 1 *The diagram of the Earth heating energy using for heating in the different countries.*

It is required a small difference of temperature, about 3…8 ^{0}C, for using such technology as “heat pumps” [6]. The technology of “heat pumps” helps to get heating energy from low potential heat energy sources: air, water and rocks. But the most effective and the most universal way is the drilling of thermo technical bore holes. As it is known the temperature of the rocks as usually increased on 3 ^{0}C for each 100 m. This circumstance allows considering rocks as a source of low potential energy. So for practical use of low potential heat energy source such as rocks it is necessary to drill bore holes up to the depth 100…150 m [4].

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The principal of the heat pump technology is rather simple: the special pipes (Fig. 2) falls in a bore hole (or in the system of bore holes).

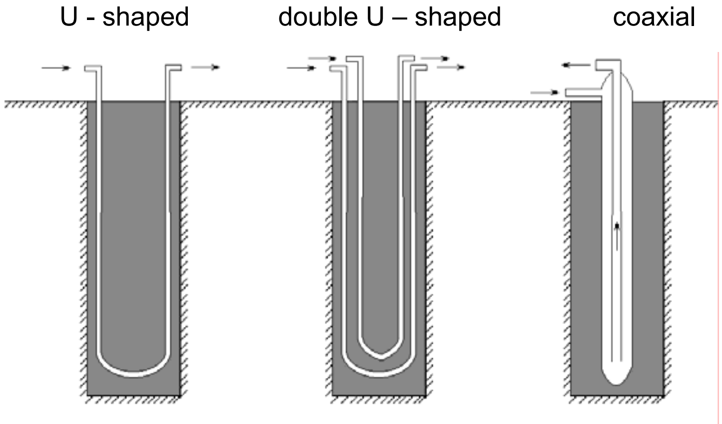

Fig. 2 *The existing types of the pipes for thermo technical boreholes.*

In these pipes the heat-carrier circulates getting heat energy from the rocks to the heat pump on the surface. Coaxial, U-shaped and double U-shaped pipes can be used. In the coaxial pipes heat-carrier falls down in the internal channel and rises up in the ring space between pipes. But these streams can be reversed. The space between bore hole and pipes is fills with the special materials which provide following conditions: the improvement thermo conduction between rock and the heat-carrier, the exception of contact between circulating liquid and underground waters that protects the last one from the pollution. The materials are the cement or clay-cement solutions [5].

Let's consider the basic scheme of the heat pump working. Falling downwards, the heat-carrier heats up from the rocks, then the warmer heat-carrier rises on the other knee of a pipe and arrives in the heat pump. The heat pump or the geothermal pump works by a principle «a refrigerator on the contrary». Then the heat-carrier passes through the evaporator and gives heat which was collected to a coolant which has very low temperature of boiling. The coolant, passing through the evaporator, passes from a liquid condition to the gas condition. Further this gas gets to the compressor where at high pressure forcing, gas becomes high-temperature. After the compressor hot gas arrives to the condenser where the heat transfers to the heat-carrier circulating in heating system. The cooled coolant, passing through special devices, reaches initial temperature and pressure, and then the cycle repeats again.

The heat pump, unlike traditional heating devices is compact enough and can be compared with the usual refrigerator that allows saving space in comparison, for example, with a boiler (Fig. 3).

Fig. 3 *The appearance of the heat pump.*

In special cases when the area is limited or it is requirement for more heat energy, it is possible a bivalent operating mode of the heat pump as well. The bivalent operating mode is the mode when the traditional heating device is connected in a heating line.

There are calculated two possible borehole systems in the given work: system with an U-shaped pipe and a coaxial. There was made a project of modeling a new heating system for researching center of the St. Petersburg Mining Institute. The center is situated in Ulyanovka in Leningradskaya region, it is 60 km to the south-east of St. Petersburg. The number of boreholes – 4 their depth are 150 m. The cross-section is presented by sedimentary adjournment (tab.1) with the average value of heat conductivity 1,58 w/(m·K).

Tab. 1. *Thermo physical properties of the rocks*

The rocks description	The density, ρ, kg/m^3	Heat conductivity, λ, w/(m·K)
Friable sand, sandy loams and loams with insignificant inclusion of a pebble (to 5 %)	1500… 1700	0,21…1,26
Limestone	1800… 2100	1,70
Sand and clay with a interlayer of diatomaceous slates	2000… 2200	1,32
Pink and white sand and fragile sandstone	1900… 2100	1,42
Thin layer Cambrian dark blue clay	2300… 2500	1,60
Medium-grained sandstone with rare interlayers grey clay	2300… 2500	1,81
Clay and clay stone	2400… 2600	1,60
The average value on depth	2000 ….2200	1,58

The distribution of the rocks temperature on depth is presented on the graph (Fig. 4).

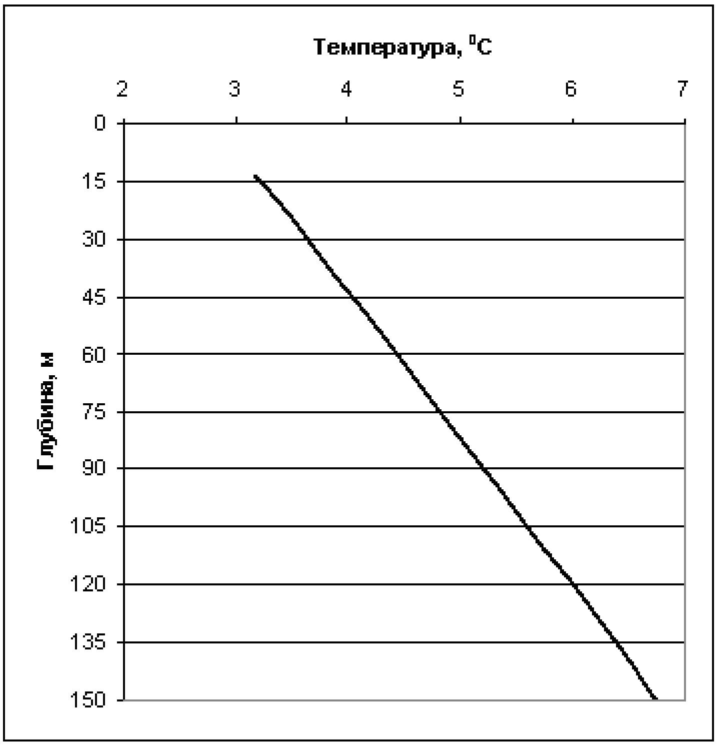

Fig. 4 *Natural temperature mode of the rocks.*

The depth of the season temperature fluctuation is approximately 14,5 m. In this paper we supposed there was no seasonal temperature fluctuation for calculating. The average geothermal factor is equal 0,023 K/m and the average thermal stream density is equal 0,042 w/m^2.

There was accepted following assumption for the modeling: the temperature of the pipes external walls equal to temperature of the rocks; the rocks thermo physical parameters were considered invariable; the geothermal factor was considered constant and equal to 0,023 K/m [2].

The first model with was the U-shaped pipes. This model was calculated as like as heat exchanger in the environment with the constant heat stream. The counting parameters were: the initial temperature of the heat-career (water) is 1^{0}C; expense of the heat-career 60 l/min; the external diameter of the U-shaped pipe is 20 mm; the internal diameter – 14 mm. So we got the effective temperature different approximately 3,3^{0}C (Fig. 5) [7].

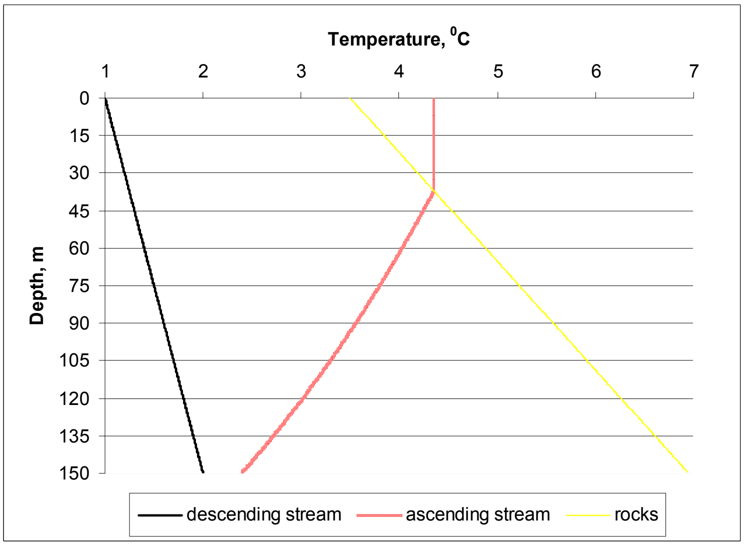

Fig. 5 *Temperature distribution on depth (U-shaped pipes).*

The second model was with the coaxial pipes. This model was calculated by means of formulas for thermal mode of the bore holes. The counting parameters were: the initial temperature of the heat-career (water) is 1^{0}C; expense of the heat-career 60 l/min; the external diameters of the pipes is 40 and 20 mm; the internal diameters – 34 and 14 mm. So we got the effective temperature different approximately 3,8^{0}C (Fig. 6).

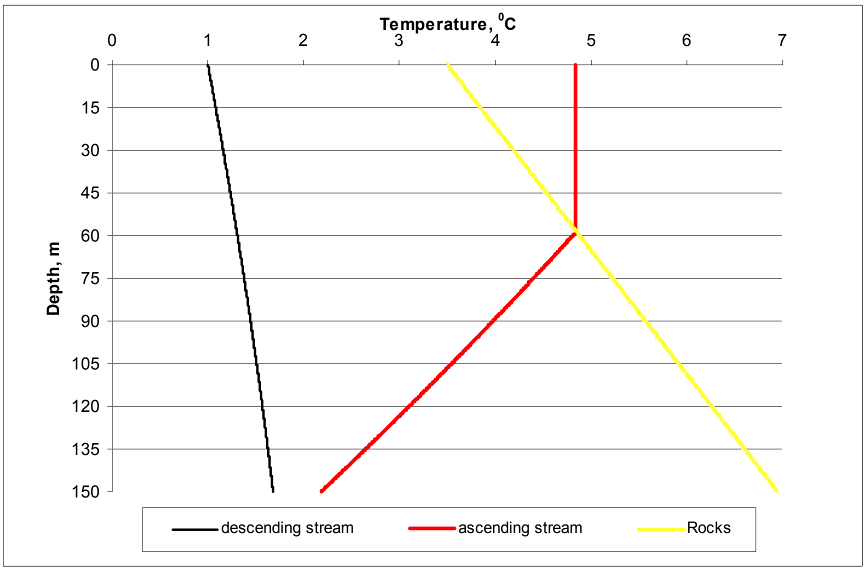

Fig. 6 *Temperature distribution on depth (coaxial pipes).*

The concept of the borehole thermo technical system efficiency is the relation between the different of received heat energy and spent energy for circulation on the one hand and received heat energy on the other (1) [3].

$$\eta = \frac{N_T - N_\Pi}{N_T} = 1 - \frac{\Delta P(Q;H)}{c\rho\Delta t(Q;H)}, \qquad (1)$$

where N_T - the received power, w;
$N_п$ - the power spent for overcoming of hydraulic resistance, w;
ΔP - pressure losses, Pa;
Q - the heat-carrier expense, m^3/sec;
H - depth, m; c - a heat-carrier thermal capacity, J / (kg·K);
ρ - heat-carrier density, kg/m^3;
Δt - difference of temperatures, K.

Let's compare two systems using (1). The results are in graph (Fig. 7).

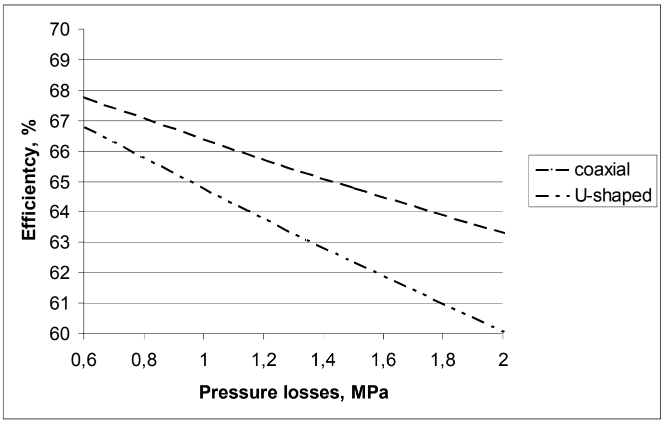

Fig. 7 *Comparison of efficiency.*

The coaxial systems show themselves more effective in the conditions of higher pressure losses, so we choose coaxial pipes for our heating system. According to our calculation it is theoretically possible to get 16 kw heat power from one borehole with the depth 150 m. So, we receive heat power about 64 kw from 4 boreholes that will suffice on area heating approximately 1280 m^2, from calculation 50 w/m^2. The area of the researching center building approximately 1100 m^2 it is enough power on its heating. The time of new system outlay recovery is 10 years and its profit 30 thousand euro (Fig. 8).

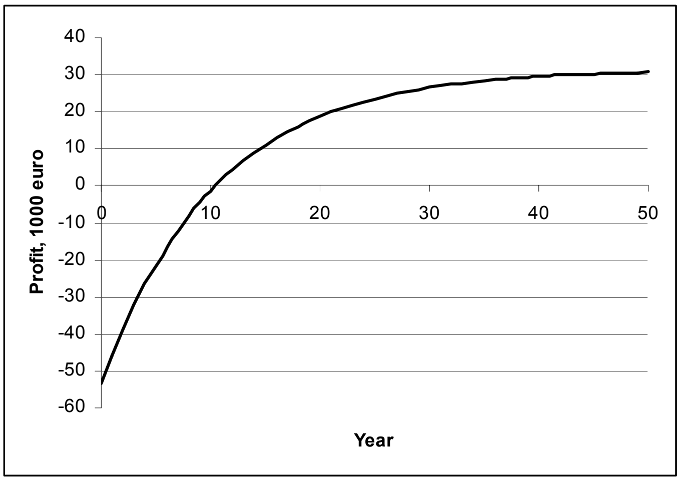

Fig. 8 *The profit from new system.*

3. Conclusion

The new heating system was designed for SPMI researching center. There were the proved of its efficiency. The next step of our researching will be the building of similar system and comparison of theoretical data with the practical.

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