environment

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ACCUMULATION OF LOW-POTENTIAL THERMAL ENERGY

MAGAZYNOWANIE NISKOTEMPERATUROWEJ ENERGII GEOTERMALNEJ

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Abstract
The article presents interpretation of accumulation of thermal energy in a vertical borehole. It describes measuring device and final graph of measurement. It studies mainly the influence of water on storage capacity of the vertical borehole.

Keywords: accumulation, termokinetic parameters, thermal conductivity, heat capacity

Streszczenie
Artykuł przedstawia zagadnienie magazynowania ciepła w pionowym odwiercie w gruncie. Przybliża on zastosowane urządzenia pomiarowe i schemat układu pomiarowego, a także analizuje wpływ wody na zdolności magazynowania ciepła w pionowym odwiercie.

Słowa kluczowe: akumulacja, parametry termokinetyczne, przewodność cieplna, pojemność cieplna

1. Introduction

Accumulation capacity of ground in the surrounding borehole is influenced by its termokinetic parameters, it is thermal conductivity, heat capacity and density. Thermal conductivity is so affected by water content, density soil, mineralogical elements and chemical property of water. Heat capacity of the ground have no strong influence of mineralogical and chemical structure, but the content of water is most important. We can state that the biggest influence on accumulation capacity of borehole has soil moisture, eventually underground water.

Appealing to Operational Program for Research and Development – Transfer of knowledge and technology from research and development into practice (ITMS-26220220057), whose strategic goal is "Device for the use of low-potential geotermal heat without forced circulation of the heat carier in deep boreholes", near the University of Zilina.

2. Accumulation of low-potential thermal energy

In rock with right termokinetic parameters it is possible to accumulate thermal energy over the system in the underground structure, for example sun's heat accumulation in summer and for later usage in winter. In our case this system consists of two bore by over 150 meter depth. In bore there are set thermal plastic U-tubes form polyethylene 4xDN32. In Figure 1 we can see technique placing and intrusion of U-tubes in the borehole. Borehole V_1 is connection parallel and in borehole V_2 are two U tubes connection into series. Water is applied as heat transfer fluid in accumulation in ground over earth heat-exchanger. Temperature in the axle borehole is measured with the help of thermoelements. Thermoelements are placed in depth 5, 50, 100, 150 for V_1 and in depth 2, 25, 50, 75, 100, 125, 150 for V_2. Aim charging of such little amount of borehole with solar energy in summer months raises its effectivity and operating life. The measuring will verify this aim as real realization and if realized borehole accumulation with low-potential thermal energy in summer months is possible.

In borehole distributed heating performance is 15 kW. This performance is generated with heating spirals placed in the tank. Spirals are connected to alternating electric source. Circulations of water insure circulating pump, which is measuring electric input power, feed on electric network individually. Sensing temperature of water is done at input

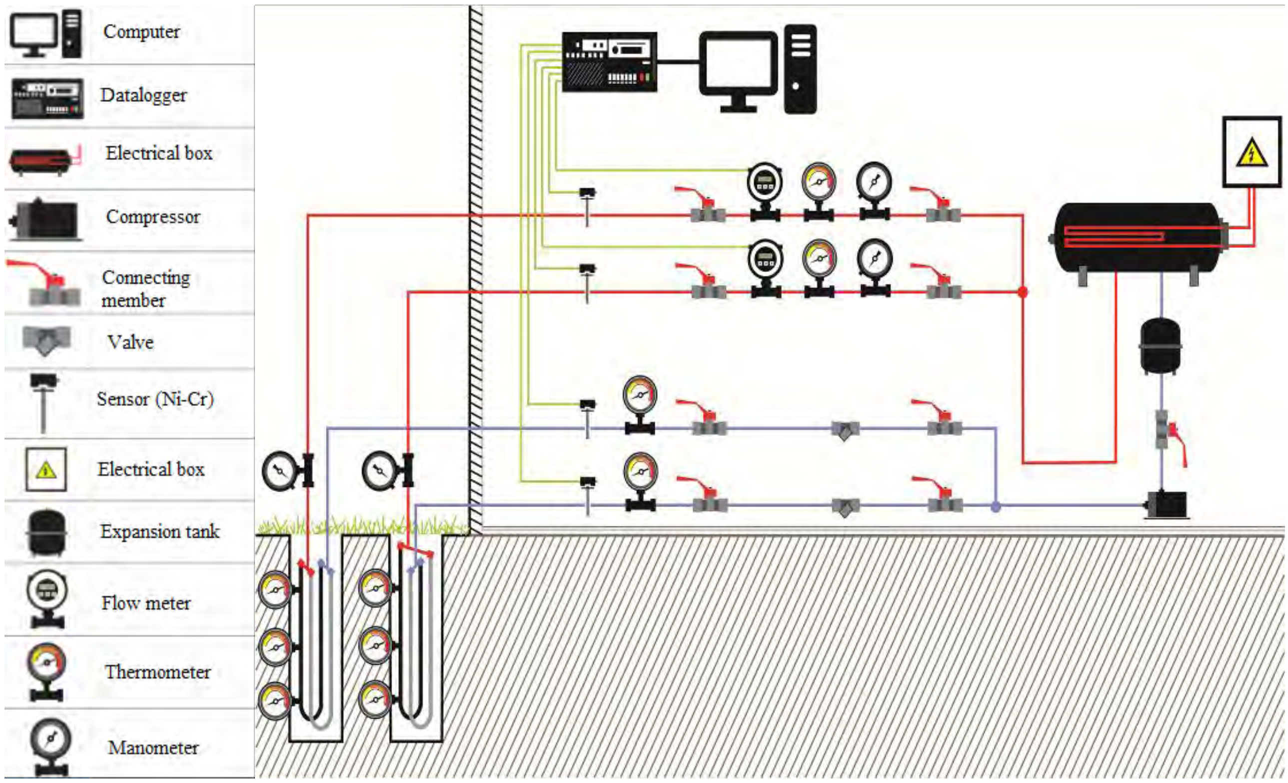

Fig. 1. Scheme of equipment

Fig. 2. Experimental device in laboratory

and at its output with temperature sensors PT100 DIN1/6. Temperature in borehole is scanned with thermoelements, which are placed throughout alee depth bore at distance every 25 meters. All monitored attributes are recorded on central measuring station and loaded to personal computer. Access tubes are located on ground and they are isolated with isolation TURBOLIT DG 20x42-DN32. Temperature sensing of atmospheric air is placed in exterior thermoelement.

In the borehole there was transported constant power 15 kW for duration of 56 hours. Over this time temperature of ground in the axis borehole go up in average by over 15°C.

3. Evaluation of accumulation heat

Storage capacity of borehole is most adversely affected with localization groundwater. So for comparison and evaluation of accumulation of heat to real bore it needs to simulate storing heat for ideal ground, so for ground without water. 2D simulation is made in program ANSYS. As input date is the thermokinetic parameters of dry claystone. In Figure 3 we can see cool dry rock from 25°C for the duration of 56 hour. As we can see on temperature area (Fig. 3), after elapsed time of simulation the temperature of rock surrounding borehole is 15.6°C.

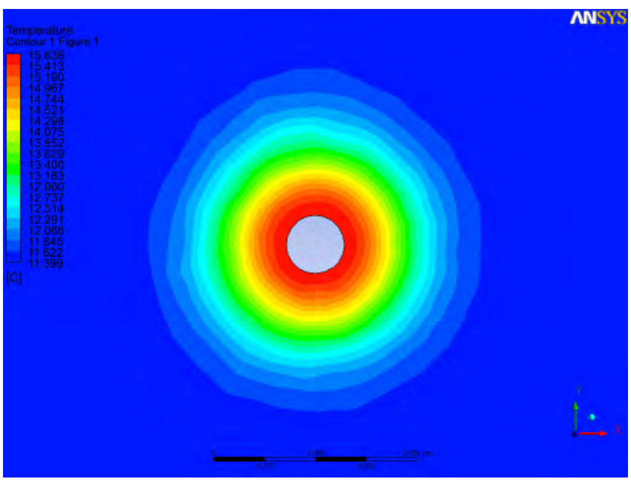

Fig. 3. The temperature field around the borehole for 56 hours

Following graphs (Figs. 4-9) illustrate temperature decrease in borehole V_2 (charging thermic input power is 7.7 kW) in individual depths bore after power off heating. Recording time is 56 hour. All over depth borehole occurred over measuring temperature decreased. On graphs on biggest depths we can see oscillation of measured temperatures. It is apparently caused by longer thermoelements, which is applied in biggest depths. These probably induce electrical signal from near electrical substation. For correction of this undesirable effect and for evaluation of results moving average measured temperature was applied.

On the first graph (Fig. 4) temperature drop is visible at a depth of 25 meters. As can see in the figure, neither after the recording time (56 o´clock), temperature in depth 25 m did not reach initial temperature. Over this time come temperature drop by about 10°C. Comparison process of cooling rock in the depth 25 meter with the simulation cooling dry rock, can be stated a little moisture and acceptable storage capacity.

At the depth of 50 meters, we can study expressive temperature drop. There gets the temperature of the rock to the initial temperature after 38 hours away from the shutdown of heating. During this time there was a decrease temperature of about 15°C. It's big assumption is contents of groundwater or gravitational moisture in claystone.

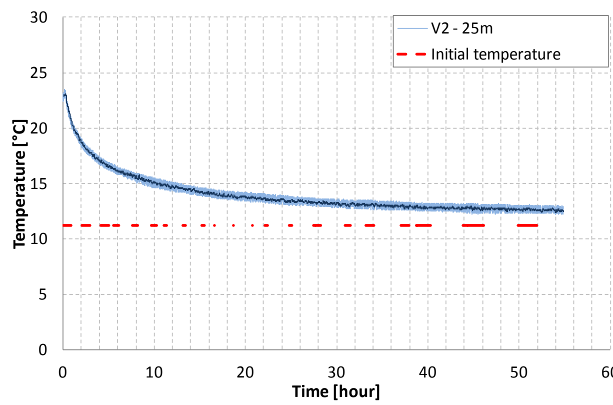

Fig. 4. Graph of temperature drop at a depth of 25 meters

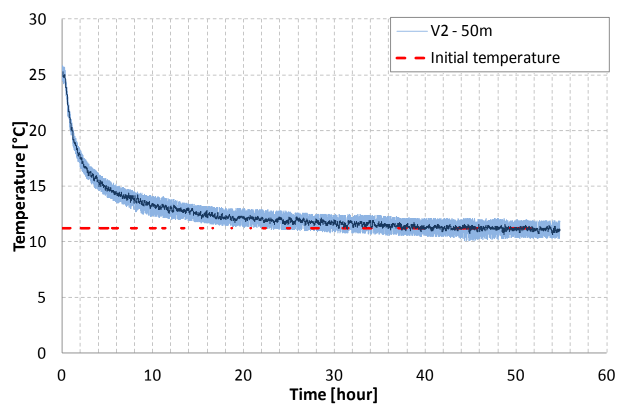

Fig. 5. Graph of temperature drop at a depth of 50 meters

On graph (Fig. 6) of temperature drop at a depth 75 meters occurs even faster cooling of the rock. It attests to contents of groundwater. Temperature attain the initial value after 22 hours away from the disconnection of heating and overall decrease is 15°C.

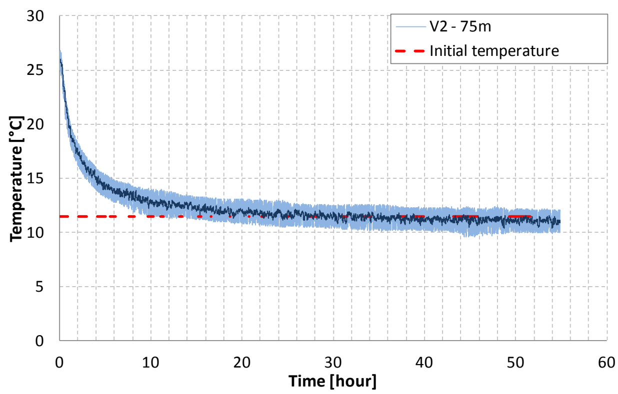

Fig. 6. Graph of temperature drop at a depth of 75 meters

Temperature measurement at a depth of 100 meters pointed to that in the direction of bigger depths are probably moving away from the watered layer. The initial temperature of the rock was attained after 40 hours.

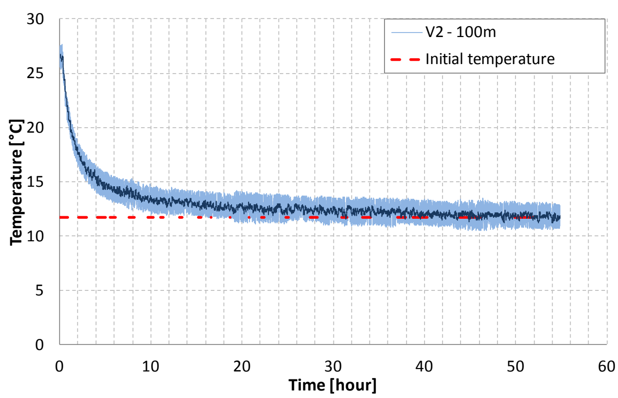

Fig. 7. Graph of temperature drop at a depth of 100 meters

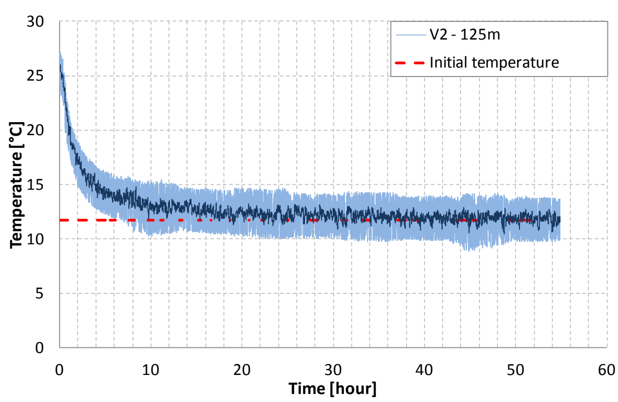

Fig. 8. Graph of temperature drop at a depth of 125 meters

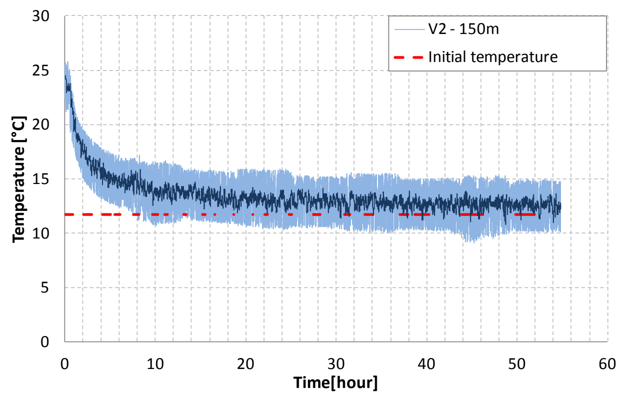

Fig. 9. Graph of temperature drop at a depth of 150 meters

The course of temperature decrease on the axis of the borehole to 125 m distance from the surface also indicates the volume of water bed. The fall of temperature occurs in 26 hours. Storage capacity of surrounding is reduced.

At the depth of 150 meters applicable conditions are present to store low-potential thermal energy. It is indicated by the fact that temperature have no initial value after elapsing of recording time.

In the same way borehole V_1 was evaluated. After examination processes cooling the temperature for depth 5, 50, 100, 150 meters have been determined, that the cooling of rocks at the initial temperature occurs on boundary of the 50 hours or far beyond it. This fact indicates the only little volume of groundwater or groundwater located in bigger distance from borehole. Borehole V_1 is more suitable for accumulation of low-potential energy.

From existent ends it is possible to deduce that on the borehole V_2 significantly more water than borehole V_1 is present. The correctness of our ideas is also backed by thermal response test and its comparison with graph of cooling rock. Interpretation test have given consequential attributes about effective thermal conductivity of the borehole. The borehole V_1 has value of 2.11 W/(mK) and borehole V_2 has value 2.8 W/(mK). As the borehole are away from each other just 10 meters on composite ground it is hardly likely, so different attributes of effective thermal conductivity indicate higher volume of water on the borehole V_2. This supports also ends from graphs of cooling ground.

4. Conclusion

In the case of applied borehole for accumulation of heat it is needed to perform main measuring process of cooling temperature after storage some thermal energy. These time dependences of temperature drop in the axis of the borehole after powering off heating, verily present applicability or impropriety of mine rock for accumulation of heat. After evaluation of graphs and detection, than in some parts of boreholes water is present. We can state than boreholes haven´t got applicable conditions for accumulation of heat. Deposit of underground water take away heat faster into surrounding borehole and by that make it impossible to effective accumulate heat. Bigger thermal conductivity of rock caused be water in the pore improves conduction of heat in surrounding borehole. The fact that water in the ground increases its heat capacity, is in the case of unlimited solid irrelevant.

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