Geothermal energy in mining water in the North Bohemian Brown Coal Basin

V Davidkova

Jan Evangelista Purkyně University, Faculty of Health Studies, Velká Hradební 424/13, 40096 Ústí nad Labem, Czech Republic

Abstract. This article is focused on utilization of geothermal potential of mining water in the North Bohemian brown Coal Basin. Using of geothermal energy reduce CO$_2$ which is one from interest for protecting of the environment and with sustainable development. Other benefit is that geothermal energy is that cost effective. Although geothermal energy has many advantages is not so much utilized. In terms of geothermal energy, the site, as part of the Krušnohorské and Podkrušnohorské area, and these are to the most promising areas in the Czech Republic sections characterized by high heat flow. In article is presented the case study at Bílina mine. The field research covered water temperature measurement and the abundance of four hydro-geological boreholes and results showed that although the geothermal potential of the mine water is not significant, there will be great potential in low-temperature energy source use for heat pumps.

1. Introduction

The intention to explore geothermal potential in this area of interest based on consideration to use of this type of the Earth’s heat, such an alternative source of energy. Using of the geothermal energy leads to the production of green energy. Geothermal energy is cost effective, reliable, sustainable and environmentally friendly. In terms of geothermal energy, the use belongs to the area of interest, as part of the Krušnohorské and Podkrušnohorské area, to the most promising areas in the Czech Republic sections characterized by high heat flow [1, 6].

The research of geothermal energy will be conducted within terrain surveys at Bílina mine, where the temperature of mining water and its water yield (Figure 1) will be monitored.

The vision of utilizing the Earth’s internal heat to benefit the world is not new. It has long been recognized that energy, in the form of heat, is constantly radiating from the Earth’s surface into space. Some of that energy is solar energy that has been absorbed by soil and rock and reradiated as infrared radiation. But on average about 1% of that energy radiating into space is from the Earth itself. Although it may seem insignificant, in fact the amount of heat energy the Earth contains is staggering – there is enough heat energy in the subsurface to satisfy the energy needs of every nation of the world many times over [2]. Geothermal energy is natural heat of the Earth, which is accessible from the surface. Economically recoverable only in places its accumulation in the anomalies [3].
2. Case study: North Bohemian Brown Coal Basin – The Bílina mines
The North Bohemian Brown Coal Basin is a relict of a Tertiary sedimentary basin, filled with sedimentary material mostly during the Miocene era. At that period, 22 to 17 million years ago, more than 500 meters of clays, sands and organic material was gathered in the basin. A brown coal seam developed in most parts of the basin, formed from layers of peat deposited in a Tertiary swamp. The Bílina open cast mine site with a depth of over 200 m (the deepest point is practically the same level as the Baltic sea and the top level of the highest overburden bench has an elevation of between 220 and 280 m a.m.s.l.) is the deepest mine site in the North Bohemian Brown Coal Basin. The bottom of Bílina mine site is practically the lowest open point which can be reached in the Czech Republic [3].

3. Field research and methods
This particular field research was conducted in the Bílina Mines. The field research covered water temperature measurement and the abundance of four hydro-geological boreholes no. H9, H10, H11 (Figures 2 and 3) and RH-13 in 2009 – 2010 and 2011 – 2012 and 2018. As it has been already mentioned, in the context of the field research water temperature and abundance of four hydro-geological boreholes were monitored. Each borehole had its own label. The location where boreholes are located is near the village Braňany. In 2010 there were only two boreholes where there was the opportunity to conduct measuring. In 2012 there were four boreholes. These hydro-geological boreholes are used for dewatering the overburden of a coal seam. Deep boreholes are about 100 – 130 m and they have a diameter of about 0.5 meters. These boreholes are almost in operation all the time before the area had been mined (about 4 – 15 years). Plastic which is resistant to the destruction of the excavator is used for the borehole construction. Previously it was constructed from steel [7].
Over 200 000 m$^3$ of water is dewatered from The Mines Bílina annually. These boreholes are used for water monitoring from the mine. Hygienic water analysis should be done because this water flows to the recipient. Although, the water has good geothermal potential it is not utilized now [1, 6, 7].
The water temperature from the hydro-geological boreholes no. H9, H10, H11 and RH-13 was measured by the water thermometer. Water spreading was measured using the stopwatch and a one-liter container. The water temperatures were monitored in 2009 – 2010, 2011 to 2012 and 2018 (only verification measurements for the purposes of the current situation). All measured values are shown in the Figure 4. With the help of outdoor thermometer air temperatures were also measured in this area. Results showed that air temperatures had no significant effect on the water temperature.

Theoretical calculations of the thermal power transferred by the water were made using the following formula:

\[ Q = m \cdot c \cdot \Delta t \]
The meaning of the variables indicating the physical units:

- $Q \,[\text{kJ}]$: thermal power/capacity when taken from the borehole
- $m \,[\text{kg/s}]$: temperature potential (abundance)
- $c = 4,186 \, \text{kJ} \cdot \text{kg}^{-1} \cdot \text{K}^{-1}$: water specific heat capacity
- $\Delta t = 5 \,[\text{°C}]$: suitable temperature for a heat pump

4. Results and discussion

The average temperatures of the water from these boreholes are very similar. Only borehole no. RH-13 slightly differs since a lower average temperature was measured. An assumption is that this is due to the borehole distance (300 meters) from the estuary of the borehole. This distance is the longest of all the boreholes. For each borehole the thermal loss affected by this distance is indicated. The test of thermal loss (the water temperature in a few meters from the estuary of the borehole) has been conducted. The thermal loss was among the all boreholes 1 – 2 °C. The thermal heat at the estuary of the borehole is in the range of 3 – 5 °C. According to the average temperature of water (Figure 4.) the water temperature at the bottom of the borehole was measured at about 20 °C. The authors Bejšovec [4] and Blažková [3] noted that in the central region of the North Bohemian Brown Coal Basin had the largest quantity of hot water in the range of 20 – 25 °C. The research also shows the presence of hot water amount in the range of 20 – 25 °C.

The hydro-geological boreholes no. H11 and RH-13 are more spreading (0.73 l/s, 0.43 l/s). The observed results enabled theoretical geothermal potential calculation of the hydro-geological (pumping) boreholes: the complete theoretical calculation of the thermal power transferred by the water relating to the value of 5° C, which is the temperature suitable for a heat pump.

After deducting the average air temperature in region Podkrušnohorská (8.5 °C) the average water temperature reaches the level over 5°C in Figure 4.

The author Myslíl [8] noted that high-temperature hydrothermal sources (>150 °C) and medium-temperature hydrothermal sources (90 – 150 °C) are missing in the Czech Republic. However, there are many low-temperature hydrothermal sources (<90 °C) called thermal water with a temperature of approximately 25 – 72 °C [6].

5. Conclusion

The research shows the presence of low-temperature hydrothermal sources in the area of interest. Because of the measured results it was possible to calculate the theoretical potential of the analyzed geothermal boreholes. The highest average geothermal potential was measured at the borehole H11 of about 15.28 kW. Although the geothermal potential of the mine water is not so significant, there will be great potential in low-temperature energy source use for heat pumps.

Heat pump technology is one of the most sophisticated engineering accomplishments to come out the twentieth century. Heat pumps are simple devices that operate at the highest efficiency levels accomplished by heat-transporting systems. They transfer heat in ways that can accomplish both heating and cooling, while consuming a small fraction of the amount of energy they move. Their great advantage comes from the fact that they move heat that already exists, using basic thermodynamic principles, and thus do not require that heat be generated. In this sense they provide the ideal means to satisfy energy demands for heating and cooling buildings and spaces [2]. Heat pumps are less expensive, they do not drill deep and their installation is easier. For our case study is recommended use water-to-water heat pumps. Water-to-water heat pumps are among the most versatile of the geothermal product lines [10]. This system uses a low-potential heat energy which develops naturally in groundwater aquifers deeper or warmer wherein the heat pump increases the temperature to the values suitable for the hot water system in the building. This system is used both for heating and hot water. The principle of this system is to remove the heat from the water pump from the water extracted from the borehole. After cooling the water in the heat pump the water seeps back into the underground circulation drill hole or recipient (case study) [1, 6].
References
[1] Davídková V 2015 The Utilization of Geothermal Potential of Mining Water in the North Bohemian Brown Coal Basin (Košice: Technical University of Košice)
[2] Glassley E W 2010 Geothermal Energy: Renewable Energy and the Environment (Boca Raton: CRC Press)
[3] Blažková M 2010 Metodika k hodnocení geotermálního potenciálu v modelovém území Podkrušnohoří – doplněk: Praktická rozvaha využití geotermálního potenciálu (Ústí nad Labem: Univerzita J. E. Purkyně v Ústí nad Labem)
[4] Severočeské doly a.s.: Geology (online)
[5] Bejšovec Z 1994 Zhodnocení změn režimu podzemních vod vyvolaných báňskou činností v SHP a orientační stanovení zdrojů a zásob podzemních vod a možnosti jejich využití – centrální oblast (Most: Výzkumný ústav pro hnědé uhlí Most)
[6] Mertová V 2012 Využití geotermálního potenciálu v okolí Horního Jiřetína (Ústí nad Labem: Univerzita J. E. Purkyně v Ústí nad Labem)
[7] Mertová V 2010 Geotermální potenciál důlních vod v Severočeské hnědouhelné pánvi (Ústí nad Labem: Univerzita J. E Purkyně v Ústí nad Labem)
[8] Myslíl V 1986 Využití tepla podzemních vod (Praha: ASGI Genofond Praha)
[9] Lutgens F K and Tarbuck E J 1989 Essentials of Geology (Columbus: Merrill Pub. Co.)
[10] Egg J and Howard B C 2011 Geothermal HVAC: Green heating and Cooling (New York: McGraw-Hill Companies)
[11] Edwards L M, Fertl W H, Chilingar, G V and Rieke H H 1982 Handbook of Geothermal Energy (New York: Gulf Publishing Company)
[12] Muffler L J P and Rybach L 1986 Geothermal Systems: Principles and Case Histories (Chichester: J Wiley)