The Closing Wells as Heat Source

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Abstract

The Turaszówka crude oil field is situated within the borders of Krosno town. The oil resources are nearly depleted. Many of the boreholes have already been liquidated. Currently, only 22 boreholes are being exploited. Eight of them are watered and exploiting oil along with the reservoir water.

The boreholes were submitted for producing the geothermal energy, because of their location. They are situated within the urban area. The suggested solution allows for gaining the pure energy and also does not require additional expenditure for mining researches connected with closing of the abandoned boreholes of the field.

The paper points to the suggestion and preliminary analysis for wells of Turaszówka oil field adaptation for borehole heat exchangers. There is also presentation of using the heat for Complex of Upper Grammar School heating system and the swimming pool which are both placed close to the oil field.

Key words *: wells, geothermal energy, environmental protection*

Introduction

Geothermal energy of the rock and the filling geothermal waters are an immense source of heat. It can be applied in various branches, depending on the state of recovered energy. Geothermal heat can be exploited in a number of ways, mainly depending on the conditions of places where energy occurs [5] and way in which it can be managed. It should be stressed that thermal energy should be managed in situ. Heat transport significantly reduces the profitability of geothermal sources use, although the most expensive part of the installment is drilling of production and injection wells. Hence, the most favorable factor increasing the geothermal heat applications is the existing depleted wells and heat networks with local customers of heat at a given temperature.

An outline of geological conditions of Turaszówka oil field

Turaszówka oil field was discovered in 1892 [4]. Four tectonic units can be distinguished in this area, i.e. east and west block (Ciężkowice II sandstone is productive), south block (Ciężkowice I sandstone is productive) and north block (oil is produced from Ciężkowice I sandstone). Owing to its conditions, collector character and reservoir conditions, Turaszówka field belongs to lithologically and tectonically confined structural fields.

All boreholes drilled on the Turaszówka field are located in favorable landscape conditions. This area is not diversified morphologically, and the well datums range from 250 to 267 m asl [2].

Groundwaters in the Turaszówka oil field are present in Ciężkowice I and II sandstone beds as contours of edge waters. Apart from this, upper waters from infiltration of surface and intradeposit waters (having a great share in oil-and-water production) have been found in Ciężkowice I and II sandstone strata.

It follows from the analyses of groundwaters, that they are alkaline, chloride-sodium brines, with dry residue content 15.0 to 33.5 g/dm3 [2].

At present, Turaszówka oil field is hydrated to a great extent. For 22 active wells only 13 wells produce pure oil, 8 produce oil with reservoir water, and one is an injection well for reservoir water. Two productive horizons are exploited. Reservoir water exploited with oil is injected to Ciężkowice II sandstone bed.

All wells were drilled with a percussion method. The casing was sealed with clay [2].

Basic information about potential geothermal users

In the neighborhood of Turaszówka oil fields, a few potential geothermal energy users exist. The energy can be produced through the existing boreholes. It follows from the preliminary analysis that the heating system in the Complex of Upper Grammar School no. 5 in Krosno would be the best candidate.

The complex consists of 6 objects (school, dorm, indoor swimming pool and workshops) totaling to 73005 m3 [1]. It is located in the north-east part of the field, close to the active wells of the Turaszówka wells.Total

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heat demand is 2742.6 kW. Central heating load at ambient temperature 253 K is 1926.5 kW [1]. For useful water production 584.2 kW is needed. The indoor swimming pool technological needs amount to 231.9 kW. The average annual gas consumption is ca. 500 000 m3/a.

Having assumed that the calorific value of gas is 35 MJ/m3, the cumulated capacity of the system (boiler capacity, transport and regulation) is 0.75 and the cost of gas 1.10 PLN/m3, the yearly production of primary energy is expected to be 17500 GJ, the useful energy demand - 13125 GJ, cost of heating - 550 000 PLN, which gives the unit cost of useful energy equal to 41.90 PLN/GJ.

The analysis of heat system characteristics shows that the low-temperature heat of Turaszówka field can be best utilized for the needs of hot useful water production and heating of the indoor swimming pool (heating water for the pool and floor heating).

Analysis of energy production through reservoir water

One of the methods of recovering the heat of the crust is reservoir waters production. They have temperature of the reservoir and great heat capacity (specific heat of water is ca. 4.2 kJ·kg-1·K-1). In favorable reservoir conditions, this method of geothermal exploitation is most efficient.

At present, there are eight watered wells in the Turaszówka oil field, daily producing 1300 kg reservoir water, except regular oil production (table 1).

The quantity of energy recoverable from the by-product water from oil extraction was determined on the assumption that it was chilled a temperature of 276 K. The temperature of extracted water was determined as a weighted average temperature of reservoir water produced by the wells. The mass of the exploited water was assumed to be the weigh. The temperature of reservoir water from a given well was calculated on the assumption that the average yearly ambient temperature was 279 K, the depth of heat penetration from the surface 15 m and geothermal gradient 0.03 K/m. On this basis, the temperature of reservoir water from the watered wells was 13.85oC.

With such assumptions, the quantity of thus recovered energy could be assessed to only 21.5 GJ.

Tab. 1. Daily reservoir water extraction from Turaszówka field [2].

No.	Well	Average depth of productive interval, m	Temperature of produced reservoir water, oC	Water extraction, kg/d
1	Ewa 7	329.0	15.42	130
2	Ewa 13	286.5	14.145	300
3	Ewa 15	280.0	13.95	50
4	Kościuszko 4	285.5	14.115	320
5	Kościuszko 7	260.5	13.365	260
6	Amelia 10	341.5	15.795	50
7	Amelia 12	186.0	11.13	140
8	Amelia 14	292.5	14.325	50
Total				**1300**

Only on the assumption that with the depletion of oil resources reservoir water production will increase, this kind of geothermal energy recovery can be considered. The remaining wells will be gradually hydrated, and this be used either as production or injection wells. When the whole field is hydrated, enhancement methods can be applied to increase the water production.

Such a solution is advantageous because the existing oil pipelines (after prior insulation) can take on the function of a water network supplying a heat pump with water. After heat recuperation, water would be re-injected to the formation strata.

Analysis of energy exploitation with BHE

The construction and principle of BHE are described in a number of publications. The concept of adaptation of the existing boreholes to BHE is discussed in [3]. There are a lot of advantages of recuperation of the heat of the earth through BHE, e.g.

- no risk accompanying drilling and geothermal waters exploitation;
- no mass exchange (water) – no impact on mass equilibrium; the borehole constitutes a closed system, therefore no environmental hazard is expected;
- high durability, practically no replacements in the borehole are necessary;
- maintenance not needed, unless the surface equipment;
- easy and safe control of the heat source;
- high reliability;
- accessibility all year long (highly coherent source);

- storeability.

After completing oil extraction operations, wells are usually closed. Another option is that they may be partly closed, i.e. part of the productive interval is cut off so that the existing boreholes have no hydraulic connection with the rock mass, and BHE can be installed.

The total depth of active wells used in Turaszówka field is 5317.6 m. After adaptation to BHE, the total depth of the boreholes will be 4355 m. The analysis of the average yields of the operational foreign BHE and heat exchangers, whose capacity was established through mathematical modeling, the accessible heat capacity can be assessed to about 220 kW. In the case of the full load, which is possible after modernization of the existing customer's heating system, 6938 GJ of thermal energy can be produced each year.

A number of wells in the Turaszówka field are not operational any longer or closed. After restoring these wells to operation, the accessible capacity and quantity of produced energy can be increased. This, however, requires additional investments.

Adaptation of pipeline systems may be a problem. When a borehole starts operation as a BHE, additional pipe has to be disposed to each of the wells. The circulation system is a closed system, therefore each BHE has to be supplied with two pipes – supply and recuperation pipes The ground may be the preliminary source of heating for the pipes with the chilled heat carrier (disposed in the ground). Pre-heated fluid should be thermally insulated. Earth works on the pipeline network supplying the customer with heat will cause additional costs, much smaller if the distance between the well and the user is small.

Conclusions

1. Turaszówka oil field is at the final stage of exploitation and can be adapted to BHE.
2. Complex of Upper Grammar School No.5 with the existing objects is a potential geothermal energy user, owing to its heat demand and closeness to the about-to-closed boreholes.
3. At the present stage of exploitation of the Turaszówka oil field, the heat can be recuperated from reservoir water, exploited from 8 oil wells. With the hydration of the field, the geothermal resources will gradually increase.
4. There are real possibilities for adapting closed, in-operational and operational boreholes to BHE.
5. Wells can be closed, exploitation and management method for geothermal energy in Turaszówka oil field chosen after prior detailed technical and economic analysis of the undertaking .

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