GEOTHERMAL WATERS IN POLAND
Ģeotermālie ūdeņi Polijā

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Abstract
This study presents the role of the geothermal waters mainly for the municipal heating, greenhouses, swimming pools, etc. Presently, two types of geothermal waters are used in the world. Waters of the temperatures higher than 130°C (steam) used mostly to drive turbines in geothermal power plants. Waters of low temperatures (20°C to 100°C) are used as a direct energy carrier for the municipal heating systems.
The geothermal waters in Poland are presented in this paper.
Keywords: *geothermal water, geothermal energy.*

Introduction

The industrial development of the geothermal resources began only in the 20th century and controlled technologies of development of geothermal deposits appeared only in the second half of the 20th century. The following basic stages of the development of the utilization of the geothermal resources can be discerned:
a) market popularisation of the new resource – heating of the interiors,
b) estimation, division into districts and geological maps of geothermal resources,
c) development of technology and definition of the technical and economic parameters of mining and utilization of the geothermal energy,
d) development of scientific bases needed to design and operate a plant pumping the geothermal waters to the surface.

Advantages of the energy of geothermal waters

By comparison with traditional sources of energy the following advantages of geothermal water are obvious:
a) The geothermal resources are inexhaustible and widely accessible. The geothermal resources for a heat supply extend over the most of the territory of Poland.
b) Proximity of the consumers.
The geothermal waters are located in a close proximity to its potential consumers. That greatly reduces the expenses related to the transport and raises the reliability of the operation [1-3].
c) Comprehensive power supply for local consumers. A plant processing the geothermal waters can provide the heat and electric power [1-3]. It solves the problem with the supply of the electric power to the remote and difficult to access areas.
d) Automation, safety and absence of miners.
e) Environmental safety.
A closed circulation technology provides the operation without creation of wastes or emission into the atmosphere.
f) Competitiveness.
According to the data of the foreign and domestic firms the utilisation of the geothermal waters for the production of heat and electric power is competitive as compared to other sources of energy.

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The specification of geothermal resources also includes the following disadvantages:
a) Low temperature. The temperature of the heat carrier at an output from the water raising depends on the geothermal conditions of the area. The cost of extraction of heat depends on the temperature of the water. An increase in the temperature is possible due to supplementary heating in the fuel boilers and thermal transformation.
b) Non-transportable. The extracted heat should be used or transformed into electric power near the developed deposit, since the cost of construction of the pipelines increases rapidly with the growth of the distance to the final consumers.
c) Distance between the structures. The distances between pairs and lines of bores of geothermal circulating system (GCS) with natural collectors are from 0.5 km to 1.5 km. The rigs and heating lines if the industrial geothermal plants can be dispersed on the long distances.

In Poland, works one GCS installation in Pyrzyce. It is used to popularise that technology among people and government administration.

The geothermal waters were discovered in various parts of Poland. Mot often they are brines of the mineral content of 2% to 30%. With the growth of depth increases the temperature of rocks and the temperature of the water located their reaches the same temperature.

The resources of heat contained inside the Earth are huge. The geothermal waters are located within the areas of large seismic activity, as the final product of the volcanic activity, for example in Island and inside the continental plates. In Poland, they are located in the south within the Silesian Coal Basin and in Russia on the Russian Plateau.

Geothermal energy

The geothermal energy is divided, depending of the temperature of the water, into two types:

- Energy contained in the overheated water steam of the temperature above 130^{o}. That steam serves to drive the geothermal turbines producing the electric power.
- Energy contained in the geothermal waters:

a) low temperature: $20 – 30^{o}C$
b) medium temperature: $35 – 80^{o}C$
c) high temperature: $80 – 100^{o}C$.

The geothermal waters of that kind are used as the direct carriers of energy in the heating systems.

Presently, in about 40 countries, the geothermal energy is used directly for the municipal heating, in greenhouses, fish plants, bathing places in the cities, balneology, etc.
In 1999, the world production of the electric power form the geothermal steam and the energy of the geothermal waters used directly was [Sokołowski J. 2001]

Continent	Production of the electric power [GWh/year]	Direct application (GWh/year]
Africa	397	492
America	23 342	7 266
Asia	17 509	22 532
Europe	5 745	19 090
Oceania	2 269	2 049
Total	49 262	51 429

The cost of the production of the electric power does not exceed \$0.05 for 1 KWh, and in a direct use, the cost of 1 KWh is \$0.02. Some 47% of the world electric power form the

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geothermal waters is produced in America and only 12% in Europe. The directly used geothermal energy constitutes for Europe 37% of the world's usage, and for America, only 14%. That also shows the temperature of the geothermal waters within those continents.

The geothermal waters in Poland

In Poland, exist the hydro-geological conditions needed for the development of the power industry based on the geothermal waters.

Within the Carpathian province, of the area of 13 000 km^2, there are the geothermal waters of the total capacity of 100 km^3.

In the Pre-Carpathian province, of the area of 16 000 km^3, there are the geothermal waters of the total capacity of 362 km^3.

In the north-eastern Poland and in the mid part of the Polish Lowland, of the area of 250 000 km^2, there are the geothermal waters of the total capacity of 6 224 km^3.

But there is a lack of government programmes concerning the development of the production of energy from the geothermal waters (at least till 2020).

The area of 5 500 km^2 of the Upper Silesia Coal Basin (LSCB) is one of the best explored areas of Poland (as regards the geothermal conditions). While searching for the coal the drilling in that area reached the depths of 1000 m to 2000 m. The Sosnowiec drilling, in Cambrian deposits with the temperature of 111^{o}C, reached the depth of 3443 m. The geothermal gradient in the boreholes within LSCB varies within broad limits from 2.0^{o}C/100 m to over 4.5^{o}C/100 m. The geometry of the surface distribution of the vertical geothermal gradient shows a zoning pattern of isolines. The positive anomalies characterised by a gradient value > 3.5^{o}C/100 m are observed south of Żory – Jawiszowice fault zone and in the northern part of that area. However, there is the possibility of heat extraction from water stored in post-mining excavations. The water in the post-mining excavations quickly gains the temperature of surrounding rocks because of relatively high value of the flow of the terrestrial heat. The heat installations used to deice the roads are costly but beneficial in terms of safety. If plants utilising the mine waters are close to the road, the thermal energy for the de-icing can be obtained at a very low cost.

Geothermal installations

The geothermal waters can be utilised in district heating networks as a sole heat source or in combination with other sources of energy. The first solution is justified in the event when a sufficient amount of geothermal waters is available with their temperature exceeding 100^{o}C. When the geothermal waters have lower temperatures, the geothermal power station should usually be enhanced by an additional heat source. In such case used can be various combinations of systems, selection of which depends on several factors.

Practical possibilities of utilisation of geothermal resources in Polish conditions, constrained by temperatures of extracted water, are brought down to the construction of installations enhanced by conventional heat sources. The effectiveness of the operation of such heat plant depends on the rational utilisation of the geothermal resources. On of the conditions of rationalisation of the geothermal waters is to enable the most efficient transfer of heat between the geothermal water and municipal water. In district heating networks, in utilising the geothermal heat, it is important to bring the return water temperature from the heat installations of recipients to the lowest level, so that it could determine the temperature of the pumped geothermal waters. In order to fulfil that condition it is advised to use predominantly low-temperature heat receivers.

In extraction of geothermal energy most often used are two basic systems: a single- and two-borehole. The two-borehole systems are used primarily in exploitation of highly

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mineralised waters. On the other hand, one-borehole systems can be used in the case of the waters of high and low mineral content.

With respect to the temperature of extracted geothermal water and value of the return temperature of municipal water, independently from the system of geothermal energy extraction, there are two designs of installations on the geothermal waterside used in the geothermal power stations, namely:

- heat exchangers working with peak-load boilers,
- heat exchangers with absorption heat pump and peak-load boilers

The first solution is used for higher temperatures of geothermal waters and the second one is used in the case of lower temperatures of extracted waters.

The principal element of the geothermal power station is a counter-current heat exchanger, where the heat contained in geothermal water is transferred to the municipal water. Supplementary to that, in the installation, is a peak-load boiler that is activated in the case when the heat carried away by the municipal water in a geothermal heat exchanger does not cover the amount of heat required by the recipients and when the temperature of the municipal water, beyond the exchanger, is lower than the required temperature of the municipal water delivered to the recipients.

Conclusions

1) The geothermal waters in Poland have a low temperature and that's why they can be used directly as a source of heat (heating of buildings, hot tap water, swimming pools and greenhouses).

2) The Polish universities do not graduate yet the specialists who would be able to develop and supervise the geothermal installations despite the fact that the EU assumes the increase of the energy from the renewable energy sources in 2010 up to 12% of the total production of the electric power.

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