Geothermal Waters in Recreational Facilities of Slovakia

Jozef Kriš

Abstract: Geothermal resources represent that part of geothermal energy of solid, liquid and gaseous phases of the Earth’s crust, which can be economically exploited from the Earth’s surface and used by available technologies for purposes of power engineering, industry, agriculture, recreation and rehabilitation. The source of this energy is a residual heat of the Earth as well as heat releasing in radioactive decay of rocks and during the movement of lithospheric plates accompanied by volcanic activity and earthquakes. From this point of view, the geothermal energy is considered as renewable resource of energy. It mostly occurs in a form of hydro-geothermal resources such as geothermal water and steam. In addition, the heat of dry rocks is also included in to the geothermal energy resources. All of these energy resources are classified among the non-traditional alternative sources of energy.

Heat from the inside of the Earth is transferred to the surface and permanently emitted into the space. The mean value of surface heat flux density is \( q = 70 \text{mW/m}^2 \). Concerning that the Earth’s surface area is \( 5,1 \times 10^{14} \text{m}^2 \), heat losses represent about \( 42 \times 406 \text{MWt} \).

Keywords: Geothermal water, recreational facilities, technical problems

1. Introduction

The use of mineral, but especially geothermal waters for recreational and sport purposes is now based also on scientific knowledge. The construction of bathing facilities is inevitable with regard to worsening natural conditions for bathing, swimming and recreation near water.

It is important to fully utilize natural conditions for the accumulation of geothermal waters on the Slovak territory and use their higher natural temperature and evident healing effects on human organism for the construction of swimming pools at locations of such reservoirs. Another indisputable advantage is a possibility to extent bathing seasons of summer swimming pools together with more effective return on investments.
2. Present state of geothermal water use

At the present time there are 172 public swimming pools with the total number of 404 pools in Slovakia, including 146 pools with thermal water and 258 without thermal water. According to valid hygienic criteria, thermal swimming pool is defined as swimming pool comprising at least one pool filled by geothermal mineral water of portion higher than 50 %, regardless of whether there is successive circulation of water or not. Eventually the portion of geothermal water might be lower than 50 % in a case of exceeding the mineralization limit, i.e. 5000 mg.l\(^{-1}\). Mineral or thermal water can be used in public swimming pools only if water temperature does not exceed temperature of 28 °C in swimming pools (recreational swimming), 25 °C in sport swimming pools and 37 °C in relax pools (for sitting). The total mineralization is allowed to limit of 5000 mg.l\(^{-1}\) and strictly without H\(_2\)S content. The content of CO\(_2\) is determined by the maximum value of 500 mg.l\(^{-1}\).

The main criterion for assessment of existing and proposed thermal swimming pools is an extension of bathing season length or their year-round availability from 280 to 360 days, respectively. Exploitation of geothermal energy is a cost demanding process and that is why the cost-effectiveness plays significant role in this issue. Suitability criteria for utilization of such resources for recreational purposes and tourism are as follows:

- Water temperature; depends on swimming pool type
- Yield of geothermal resource; they are suitable with regard to construction of swimming pools, for particular attendance categories, allow required water replacement in pools and assure hygiene of bathing
- Content of mineral substances dissolved in water; they have healing effects. On the contrary, they give rise to incrustation and corrosion of equipment and have adverse effect on environment.
- Area location; to existing or planned settlements, transport options, attractiveness, etc.

Based on mentioned facts, the following resources of geothermal energy intended for purposes of recreational swimming pools are economically profitable (Franko):

- with minimum water temperature of 35–40 °C
- with minimum yield of well over 10 l.s\(^{-1}\)
- specific capacity of well by uncontrolled spillway from wells over 0,1 l.s\(^{-1}\)
- maximum mineralization to 10 g.l\(^{-1}\) and with appropriate composition of salts and gases
- depth of well ranged from 3000 to 4000 m
- geothermal gradient with value more than 30 °C.km\(^{-1}\)
- heat flux over 60mW.m\(^{2}\)

Present knowledge on construction and operation of thermal swimming pools indicate significant capacities in a comprehensive use of energy from geothermal water. Despite
positive results, unsolved problems related to construction, comprehensive use of geothermal energy, exploitation, transport, treatment and disposal of geothermal water still remain. The non-uniform approach to solution of such problems prevails in practice and usually leads to unsatisfactory results. The major reasons of this state can be summarized as follows:

- appropriate localization of well with regard to yield of well, temperature, mineralization, receiving body (suitable method for geothermal water disposal), capacities for construction of recreational area including operational-technical facilities for catering, regeneration and year-round accommodation, etc. Nowadays, the complex large bathing areas so-called “AQUAPARKS” are built all over the world. They comprises systems of pools for sitting (35–37 °C), recreation (24–28°C), swimming (24-26 °C) and children’s pools (28–30 °C) with waves, as well as pools with toboggans, slides and other attractions such as waterfalls, fountains, etc.,
- timely urban and water management conception based on capacity and real possibilities of region
- using the thermal water for heating of year-round operations (heat exchangers, heat pumps and recuperators – regenerative air heaters), improvement of calorific balance by covering of swimming pools out of recreational seasons,
- application of solar collectors near cold thermal water, etc.

<table>
<thead>
<tr>
<th>Region</th>
<th>Number of public swimming pools</th>
<th>number of pools</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>of which :</td>
<td>In operation</td>
</tr>
<tr>
<td></td>
<td>thermal</td>
<td>Non-thermal</td>
</tr>
<tr>
<td>1 Bratislava</td>
<td>13</td>
<td>0</td>
</tr>
<tr>
<td>2 Trnava</td>
<td>23</td>
<td>33</td>
</tr>
<tr>
<td>3 Trenčín</td>
<td>23</td>
<td>13</td>
</tr>
<tr>
<td>4 Nitra</td>
<td>25</td>
<td>39</td>
</tr>
<tr>
<td>5 Žilina</td>
<td>19</td>
<td>33</td>
</tr>
<tr>
<td>6 Banská Bystrica</td>
<td>29</td>
<td>27</td>
</tr>
<tr>
<td>7 Prešov</td>
<td>18</td>
<td>15</td>
</tr>
<tr>
<td>8 Košice</td>
<td>28</td>
<td>0</td>
</tr>
<tr>
<td>Slovakia total</td>
<td>178</td>
<td>160</td>
</tr>
</tbody>
</table>
Thermal swimming pools have been classified into the three categories with regard to water temperature, yield of well, content of mineral substances and location.

Following the studies of the Geodetic Institute of Ľudovít Štúr and other surveys, further recreational localities with prospect for use of geothermal water are considered: Bratislava, Piešťany-Trenčín, Malá Fatra, Low Tatras, High Tatras, Slovenký Raj, Štiavnica-Kremnica, Orava, Turčiansky Region, Vihorlat, Danube Region, Žilina, Poľana, Košice, Spiš, Prešov, Upper Nitra, Senica, Levice, South Slovakia and other.

List of swimming pools using geothermal waters for recreational purposes based on data from public health institutes is shown in the table 1.

3. Water management - technical problems related to use of geothermal water for recreational purposes.

Exploitation of geothermal water gives rise to the three major water management – technical problems.

- Incrustation in wells and distribution systems of used equipment (profile fouling and decrease in operational thermal capacity). Release of CO₂ disturbs the carbonate balance what results in CaCO₃ separation from a solution. The presence of air oxygen gives rise to oxidation of some compounds such as Fe²⁺ to Fe³⁺ and consequential separation from water. Oxidation of other compounds may result from using a disinfection preparation in pool thermal waters.
- Corrosion depends mostly on consistence of geothermal water, presence of O₂, CO₂, H₂S, Cl₂, total content of salt, etc. Corrosion occurs rapidly in an environment of various types of the geothermal water and under the different thermodynamic conditions. It is necessary to monitor corrosion because it is important factor that affects a service life of particular devices required for geothermal water use.
• Impact of geothermal water on environment has important role in its heat utilization. From known methods of geothermal water disposal we can use following:
  – discharge into surface stream (receiving body)
  – dilution and discharge into receiving body
  – partial demineralization and discharge into receiving body or use for irrigation
  – discharge into public sewerage and subsequent treatment
  – reinjection

Discharge of used geothermal water into the receiving body is regulated pursuant to the Act No. 184/2002 Coll. on waters and the Regulation No. 491/2002 Coll. of the Government of the Slovak Republic.

Considering the river system of Slovakia as well as water bearing of streams and asymmetric location of geothermal resources, the mentioned methods are very expensive and cost-ineffective.

The reinjection appears to be the most appropriate method for geothermal water disposal, although it is very expensive procedure. The production well is used for abstraction of geothermal water, which is cooled after heat withdrawal to a temperature of 30–40 °C and then returned through the reinjection well back to the aquifer.

A production well requires sufficient distance from reinjection well in order to eliminate effect of reinjected water on the temperature of pumped water. The distance is usually ranged from 1000 to 1500 m. Temperature in aquifer decreases by 1–2 °C every five years what provides constant temperature production over a 20–30 year period. This method of disposal is very demanding on technical equipment and it requires good knowledge of environment where reinjection is to be carried out, such as evaluation of harmful effects on a geothermal field and its lifetime.

The used wastewater from swimming pools is still discharged into the surface streams, except for two reinjection stations (used for heating of buildings) and such discharge has adverse effect on ecology. More detailed information on conditions and options for disposal of used geothermal water for particular basins of Slovakia as well as technical properties of geothermal waters are listed in the Atlas of Geothermal Waters in Slovakia (1995).

4. Conclusion

Regarding its geothermal energy resources, Slovakia is one of the perspective European regions. Effective use of this renewable energy resource might have economic significance for the Slovak Republic, considering traditional energy sources conservation and opportunity to enhance tourism and recreational capacities in more Slovak regions. Construction of another bathing areas/swimming pools with geothermal water and reconstruction of existing ones may lead to increased attractiveness of Slovakia as well as interest of foreign investors in this field of business. In many cases, the reinjection of abundant geothermal waters into the soil
horizons seems to be the most efficient method (ecological point of view). However, it requires perfect knowledge of environment and techniques in order to eliminate all adverse effects of geothermal water use on human environment, which may appear also after several years.

Acknowledgement
The article was prepared with support of the Grant Research Task 1/0342/03 and KEGA 3/1140/03 dealt in the Department of Sanitary Engineering of the Faculty of Civil Engineering of the Slovak University of Technology, Radlinského 11, 813 68 Bratislava.

References
Bím, M., Fendek, M.:The Position of geothermal energy within the power engineering conception of the Slovak republic, Proceedings from the II Slovak Conference on Geothermal Waters in Industry, Agriculture and Recreation
Fendek, M., Franko, O., Remšík, A., (1990): Map of thermal energy potential of geothermal waters
Franko, O., Hazdrová, M., Bodíš, D., Fendek, M., Remšík, A., Mateovič, L. (1990): Legend to the Geothermal Map of Czechoslovakia 1 : 500 000, Manuscript, Geofond, Bratislava
Fendek, M. a kol. (1999): Geothermal energy, Faculty of Natural Sciences UK, Bratislava 1999, pp. 122
Franko, O. (1985): Occurrence of geothermal waters as sources of energy in SSR, Diakovce 1985, s. 67 - 86
Kriš, J.: Conception for development of recreational capacities near geothermal waters, Chap. 8.7.5. of upcoming General Plan for Use and Protection of waters in Slovakia

Author
Prof. Ing. Jozef Kriš, PhD.: Faculty of Civil Engineering of the Slovak University of Technology, Radlinského 11, 813 68 Bratislava, Slovakia, Tel.: +421259274615 Fax: +421252921184, kris@svf.stuba.sk