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IV.3.

EXPLOITATION OF GEOTHERMAL ENERGY FOR POOL MANAGEMENT

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INTRODUCTION

Geothermal energy in Slovak republic is utilized for centralized heat supply of rural agglomerations objects (heating of buildings and preparation of hot water), heat for greenhouses and for securing operation of holiday resorts.

Under the conditions of Slovakia geothermal energy is used utilized in 2/3 of total utilization of GE for operation of holiday resorts in 32 locations (Poprad, Vrbov, Liptovský Trnovec, Bešeňová, Oravice, Podhájska, Senec, Kráľová pri Senci, Dunajská Streda, Galanta, Veľký Meder, Lehnice, Diakovce, Topoľníky, Tvrdošovce, Nové Zámky, Šaľa, Poľný Kesov, Gabčíkovo, Štúrovo, Komárno, Patince, Bánovce nad Bebravou, Malé Bielice, Partizánske, Chalmová, Koplotovce, Kremnica, Sklené Teplice, Rajec, Dolná Strehová, Tornaľa).

Today in Slovakia there are 172 communal swimming pools with 404 pools. From the total number of the pools only 146 is operated with geothermal water and 258 with regular water. According to hygienic criteria geothermal recreational facility are facilities in which at least one swimming pool is operated from the geothermal source / water, which represents value more than 50% irrespective of consistent recirculation or not, eventually less than 50% if the permissible limit of mineralize, 5000 mg.l-1.

Mainly in recreational facilities are used (outside) flow swimming pools with controlled geothermal water. Today are also used circulatory swimming pools with heating pool water, GTW is primary source.

1. DEVIDING OF POOLS

In areas of thermal swimming pools are founded different types of pools, their operation is different according to utilization of GE. For feeling the pools are used various kinds of technological water (1). According of type of operation of the pool, pools distinguished in the direct implementation of the flow of swimming pools and water dilution and indirect use of GE:

a) **Direct feeling** of flow pools with liquid water dilution, which is generated by mixing GTV and potable water to reach the required temperature of regulated pool water. In this case, is more favorable balance of needs of GTV. Mixing ratio of GTV and cold water is calculated by using the calorimetric equations. For these pools is regulated exchange of pool water, it resulting of high demands on the source of GTV. Given that the GTV is diluted, demand of it is less. An example of such a pool management is shown in Fig. 1:

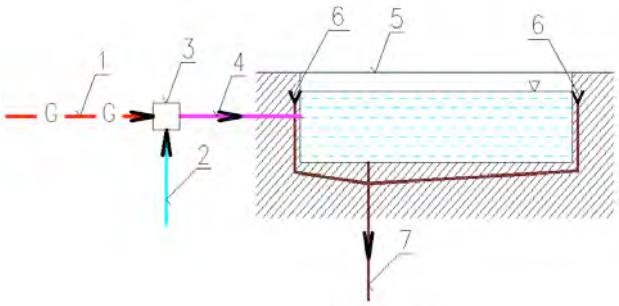

Fig.1 Flow pool filled up with diluted geothermal water
1 – inlet of geothermal water, 2 – inlet of cold water, 3 – mixing chamber,
4 – pool, 5 – spill troughs, 6 – pool drain

b) **Indirect use of GE**, where is prepared swimming pool water by using geothermal water (adjusted heating potable water). Swimming pool water circulates through the circulating system (filters, chemical treatment of water and circulation pump), where is achieved a very efficient use of primary energy contained in geothermal water. The total exchange of water content pool is made in large time intervals (4 to 6 months). By the pool management, is daily added about 5 to 10% water content of the pool, this water is heated by geothermal energy. Example circulating pool industry is in Fig. 2:

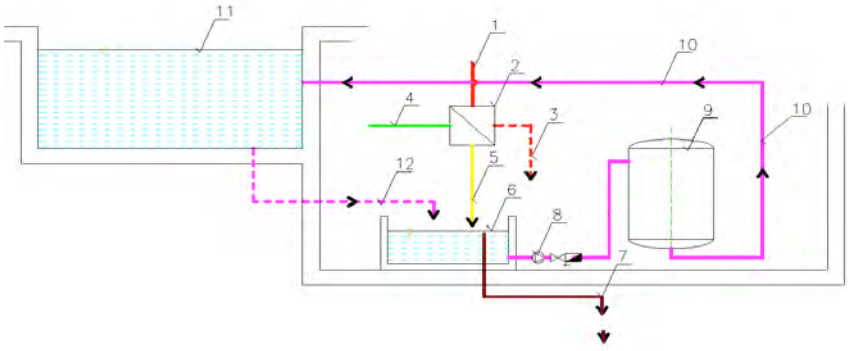

Fig.2 Example of circulation pool filled up with heated supply water
1 – inlet of geothermal water, 2 – heat exchanger, 3 – cooled geothermal water, 4 – inlet of cold water,
5 – heated pool water, 6 – equalizing tank,
7 – overflow into drainage, 8 – circular pump, 9 – sand filter, 10 – purified pool water, 11 – circulation pool, 12 – polluted circulation pool water

2. DESCRIPTION AND OPERATION OF SWIMMING POOLS

In the case "A" is a flow-type pool. For large pools are great demands on the flow rate, depending on the prescribed 1 to 10 - fold exchange of water per day, respectively. 24 hours. These pools have very negative economy of GV and thus with GE (waste water contains energy pool water temperature). The proportion of waste energy increases with the temperature of the pool. As an example, to compare these two uses, use the pool of standard size swimming pool 50 m x 21 m depth of 1.5 m to 2 m of water temperature 26 ° C. The source of heat for this pool is the geothermal well, its main energy parameters are: yield is 30 l / s and the temperature at the drill head is 57 ° C

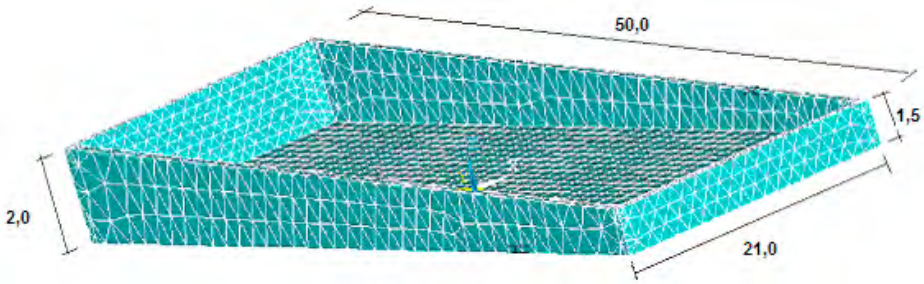

Figure 3 Swimming pool

The amount of pool water needed per month is calculated as follows**:**

$$m_B = n \cdot V/(3600 \cdot T) \quad (l/s) \quad (1)$$

where:

n - multiplicity of water exchange in the pool per day (-)

V – water capacity of the pool (l)

T – time of pool operation (usually T = 24 hours)

3600 – conversion of hours to seconds

Since swimming water is made up of GV and cold water, the amount of pool water is the sum of GV and the cold water:

$$m_B = m_{GTV} + m_s \quad (l/s) \quad (2)$$

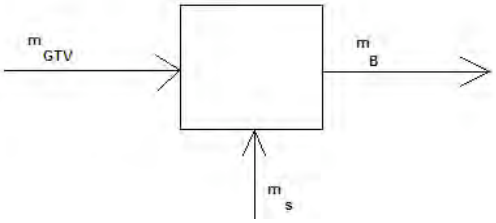

Figure 4. Mixing chamber

The mixing calorimetric equation will be:

$$m_B \cdot \theta_B = m_{GTV} \cdot \theta_{GTV} + m_s \cdot \theta_s \, (l/s) \, (3)$$

Converts flow pools is chosen so that once a certain time period (week), the pool season, the 6 days is traffic flow, and the seventh day is a hygienic cleansing pool.

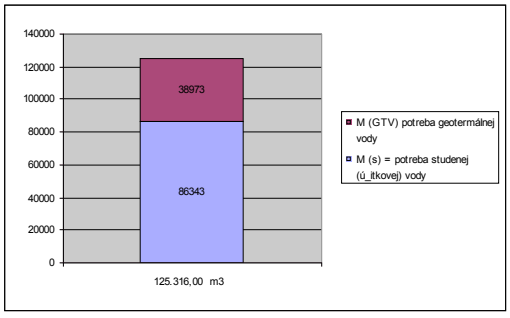

Chart 1 : Demand of pool water for flow pool.

Case "B" type of pool represents a solution that was launched in the future should be applied in recreational purposes. The advantage of this type of pool is that heated water represents 5 to 10% capacity of the pool. GV is the primary energy carrier and heated is the cold potable water.

In these systems, achieving satisfactory chilling of geothermal water, hence the rate of utilization of a renewable source of heat is satisfactory. The disadvantage of these systems is that they must solve complicated circulating system, which requires large energy inputs as well as sub-

stantial investment. In addition, increasing demands on the spatial arrangement in the vicinity of the swimming pool.

In the circulation swimming pool must be ensured at least once before the start-up purification of the entire volume of water in the pool circulation equipment. During operation, of the swimming pool is secured the circulation of water and disinfection. Intensity of water circulation and the amount of dilution water is determined by operator according to the number of visitors for one day so that they complied with the limit values of indicators of water quality.

In the pool with water circulation operator must ensure the disinfection of water and exchange of water in a quantity of 10% of the volume pool for one day so that they complied with the limit values of indicators of water quality.

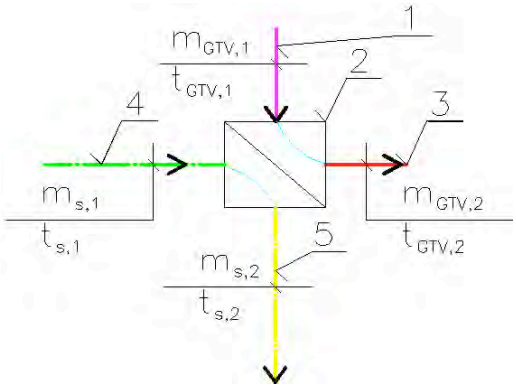

Fig. 5 Heat delivery in the recuperative heat exchanger
1 – inlet of geothermal water, 2 – heat exchanger, 3 – cooled geothermal water, 4 – inlet of cold water, 5 – heated pool water, m – volume flows (l/s), t – temperatures, index 1 – parameters at inlet into heat exchanger, index 2 – parameters at output of heat exchanger

Geothermal energy is the primary and the amount of heat given to the heat exchanger can be expressed:

$$\mathbf{Q_{GTV} = c_{GTV} \cdot m_{GTV} \cdot (\theta_{GTV,1} - \theta_{GTV,2})} \quad \mathbf{(kW)} \quad \mathbf{(4)}$$

where:
c_{GTV} is the specific heat of geothermal water (kJ/(kg.K)),
m_{GTV} – amount of geothermal water entering the heat exchanger (kg/s),
$\theta_{GTV,1}$ – temperature of geothermal water at the inlet into heat exchanger (°C),
$\theta_{GTV,2}$ – temperature of geothermal water at the outlet from heat exchanger (°C).

The amount of heat delivered to the secondary heat carrier, which is the pool water, can be expressed as:

$$\mathbf{Q_B = c_B \cdot m_B \cdot (\theta_{B,1} - \theta_{B,2})} \quad \mathbf{(kW)} \quad \mathbf{(5)}$$

where:
c_B is the specific heat of pool water (kJ/(kg.K)),
m_B – number of pools of the filled-in water entering the heat exchanger (kg/s),
$\theta_{B,1}$ – temperature of pool water at the inlet into heat exchanger (°C),
$\theta_{B,2}$ – temperature of pool water at the outlet from heat exchanger (°C).

In the recuperative counterflow heat exchanger, high-quality cooling GV is achieved on the primary side; on the secondary side, cold water is heated from the temperature $\theta_{B,1}$ =12 to 15 °C to the required pool temperature $\theta_{B,2}$ = 26 to 30 °C, possibly more. From the viewpoint of energy, the circulation system is most

appropriate, as the geothermal water is cooled to maximum extent and cooling to the temperature $\theta_{GTV,2}$ = 23 to 20 °C is achieved, which is already convenient also from the viewpoint of environmental protection (the requirement is + 25 °C). Better cooling can be achieved only by application of thermal pumps.

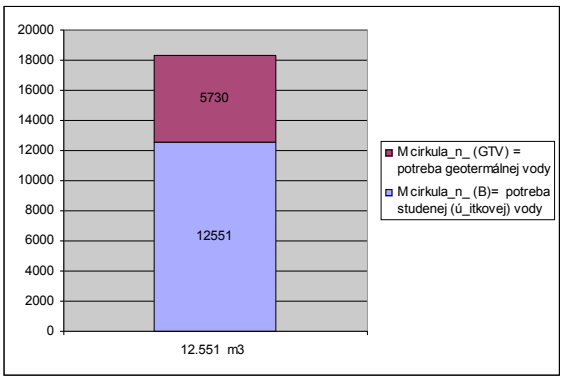

Chart 2 : Demand of pool water for the circulation pool

3 COMPARISON OF POOL WATER SUPPLIES IN INDIVIDUAL-BASED

It should be noted that, technically, example B is complex, is required buffer tank, filter, circulator pump, the connecting pipe (usually plastic), closing valves and measuring and registration equipment and unequivocally demanding capital construction. And if we compare these two operations, (Figure 3) that during the operation flow-way in each case whether or V_{GTV} or V_S cost for the total quantity of water (m3) higher than in the circulating pool operation. The difference makes the water needs of 10% in the circulation flow across the swimming pool.

It should not by forgeten to note a energy management , which means by using gothermal energy saving in the case of operation with flow-through pool system 59,342 m3 of natural gas and for the circulating pool 7,700 m3.

It depends on the number of pools operated in recreational facilities, and than we can quantify how much of the primary energy source and was not consumed and to the surroundings we not eliminate adequate amounts of CO2.

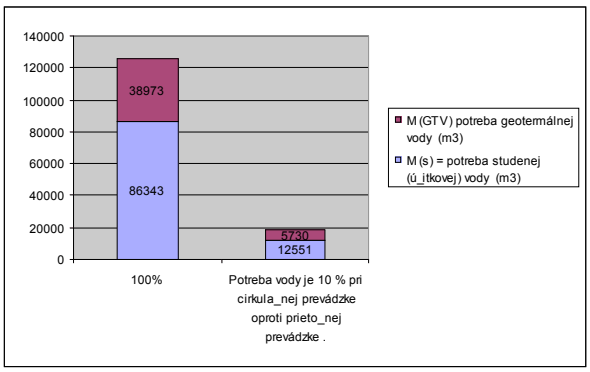

Chart 3 : comparison of demand of water for flow and circulation pool

5 CONCLUSION

The article was elaborated as a contribution to the theme Exploitation of geothermal energy for pool management.

Different energy intensity of operation of pools with flow mode and circular mode is demonstrated. Defined are here two types of pools with direct fill-up by diluted

water, which is provided by dilution of geothermal water with pool water. In the second case we focused on the pool type with indirect exploitation of GE. Both pool types have their advantages and disadvantages. In the first case, the essence is that the geothermal water is used uneconomically and literally spent wastefully; the problem of the second type of pools with circulating operation is the fact that it is technically more demanding in terms of investment into technologic equipment, such as the afore-mentioned equipment like equalizing tank, filter, circular pump...

From the viewpoint of energy, the circulation pool is a more expensive primary investment, e.g. the mechanical adjustment – pump with the filter, with skimmer and nozzles, plus additional equipment (exhauster), purchase of the filters alone, chemical treatment of water, circular pump. The individual calculations are together with the operating costs shortly mentioned in the work in individual chapters, as the stress was not laid upon the financial aspect.

In the final and global effect, it is more advantageous to operate the circulating system of pool management rather than a flow pool, especially for the reason of water consumption and energy costs.

The quality of water in public as well as in private pools requires considerably demanding care. The pool geothermal water must fulfill certain criteria from the chemical, bacteriological, biological and physical aspects. Each swimming person brings actually into the water thousands of diverse microorganisms which reproduce themselves in water and disseminate infections. Without treatment and due care, the pool water might become very dangerous for the swimming persons.o

Each pool needs care one must devote to it. Please keep in mind that the care dedicated to a pool with geothermal water will return in the shape of quality and enjoyment of swimming, leisure or therapy.

The purity of water depends not only on the mechanical and chemical protection; paramount is the selection of high-quality filtration.

As for energy, 88.2 % of energy is utilized and this an almost ideal indicator of the utilization rate. In other words, using geothermal energy for preparation of pool water in circular operation via recuperative heat exchanger is the most appropriate way of utilization, which is usually situated into the last stage of complex utilization of the geothermal energy system.

An important aspect pointed out by the authors, which cannot be neglected nowadays, is also the fact following from the equipment denomination, namely that using the circulation pool prolongs the lifetime of the geothermal source, since only 1/10 of water amount in comparison with the first afore-mentioned system is exploited. And this is the main reason of elaborating my contribution for this conference. We have to bear this in mind responsibly and take a while to think over this fact and this idea.

The amount of saved primary energetic resources and of the polluting substances not being discharged, thus saving the environment, are the facts also worth mentioning.

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