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V.3.

PROPOSAL CONCEPT AND USAGE OF GEOTHERMAL ENERGY IN GEOTHERMAL ENERGETIC SYSTEM FROM ENERGETIC VIEW

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1. INTRODUCTION

Slovakia is one of the countries with rich and plentiful sources of geothermal energy. Utilization of geothermal energy (GE) is miscellaneous; among others, as alternatives for systems of centralized heat supply (CHS). The utilization of this unconventional source asks for maximal usage of accessible energetic potential. In accordance with GE utilization, it is necessary to project such captation devices or geothermal energetic system (GES), which will enable consistent – gradual, cascade – utilization of energy with maximum efficiency considering maximum protection of surrounding environment.

The actual utilization of GE depends on one hand on physiochemical attributes of GTW source, and on the other hand the policies, regulations, and norms, as well as technical abilities of GE utilization apply, in both: proposed captation devices as well as by classic heat sources.

Every geothermal source has its own specific features, which have to be known thoroughly, in order to design a device for its exploitation. From the energetic point of view, the temperature on the drill head as well as its richness are important, since they are the base for defining of the usable energy potential Q´ (heat rate) of GE source and usable heat energy Q (quantity of energy for a specific time period). Furthermore, it is necessary to know the physical, chemical, biological, and bacteriological characteristic of GTW. These properties influence the choice of GES substantially as well as own GE utilization and choice of materials for pipes and armatures, pumps, technological equipments, etc. [1]

2. CONCEPTION OF USAGE OF GEOTERMAL ENERGY

According to that proposed captation devices will serve in defined conditions which are limited by the regulations and technological norms, at the beginning of the customer proposal for example heating system we must synchronized proposal and calculation of this equipments with regulations and norm about attributes of heating source.

By the process of heat exchange from primary heating working medium – GTW to secondary heating working medium in form of heating water is running on the same physical laws and theories as by the usage of traditional heat resource. We should consider also the adverse conditions which will affect for example flow capacity of heat exchange area in the heat exchangers are stressed by incrustation and corrosion.

The heating balance of energetic need must be calculated by the proposal of all captation devices exactly according to the instantaneous usage of heat when it is delivered to more customers. Balance of heat needs and energy we can execute by very easy form and to put into consumption curve. At the calculation we are proceeding from higher temperature level to the lowest.

After selected conception of complex usage of GE there will be proposal of block schema of usage which is converted into a technological schema after calculation.

From that point the distribution of GTW is apparent from the source to the last capitation devices and removal of used waste GTW

3. ENEREGETICAL BALANCE

In order to optimally propose geothermal energetic system is needed to define possibility of heat source it means primary side GES. This part creates primary part of energy system which will be discussed in part 3.1. Secondary part of GES creates captation device which will be more specified in part 3.2.

3.1 Main energetic parameter of geothermal energy source

Basic parameters of geothermal energy source – geothermal drill are:

- drill head temperature $\mathbf{t_o}$,
- number of days in exploitation period **n,**
- reference temperature of the cooled geothermal water $\mathbf{t_r}$.

This parameters creates edge conditions for estimation of usage effectiveness for this non traditional reneweble source.. By means of these predefined quantities we shall calculate the usable energy potential **Q´,** usable heat energy **Q** and usable mass of geothermal water **M**, per selected exploitation period **n**..
Depending on this latter quantity, an algorithm of daily, weekly, monthly, seasonal or permanent utilization of the heat source.

The usable energy potential **Q´** is calculated from the formula:

$$\mathbf{Q' = m.c_v.\square.(t_o - t_r)} \quad \mathbf{(kW)} \qquad (1)$$

The usable heat energy **Q** is calculated from the formula:

$$\mathbf{Q = 24.\ Q'.\ n.\ 10^{-3}} \quad \mathbf{(MWh)} \qquad (2)$$

The usable mass of geothermal water **M** is calculated from the formula:

$$\mathbf{M = 24.\ n.\ m_o.\ 3\ 600.\ 10^{-3}} \quad \mathbf{(m^3)} \qquad (3)$$

where:

n number of days in expoitation period.

$\mathbf{m_o}$ – geothermal source output expressed in $[l.s^{-1}] = [kg.s^{-1}]$,

v – specific capacity of geothermal water (m^3/kg),

□ – specific density (kg. m^{-3}),

$\mathbf{c_v}$ – specific calorific content of geothermal water in $[kJ.kg^{-1}.K^{-1}]$,

$\mathbf{t_o}$ – the temperature of geothermal water at the drill head in [°C],

$\mathbf{t_r}$ – reference temperature of cooled geothermal water equal to +15°C,

3.2 Captation devices

Under the meaning of captation devices we mean technological equipment which are assigned for usage of energy of renewable sources directly or indirectly as it was written above. Between captation devices we include:

- heating of buildings,
- ventilation and AC,
- preparation of hot water,
- agriculture ,
- recreational purposes,
- Technologies.

4. BLOCK SCHEMA OF GEOTERMAL ENERGETIC SYSTEM

Following the features of geothermal source, suitable captation devices will be proposed as shown on Figure 1 depicting block schema (need of completion parameters needed – flow and temperature). At the same time, we assume consistent multi-usage and aplication of numberous heat exchangers arranged consecutively.

At the captation device, the quantity of used energy will be calculated by the formula:

$$\mathbf{Q_1' = m_1.c_v.(t_1 - t_2)} \quad \mathbf{(kW)} \qquad (4)$$

where:

m_o - geothermal source output expressed in $[l.s^{-1}] = [kg.s^{-1}]$,

c_v - specific calorific content of geothermal water in $[kJ.kg^{-1}.K^{-1}]$,

t_o - the temperature of geothermal water at the drill head in [°C],

t_v - reference temperature of cooled geothermal water equal to +15°C,

n - number of days in expoitation period.

According to formula 4 we will calculate also the need of heat for the other captation devices. By entering of required period (day, week, month, summer period) we will calculate the need of energy for individual captation devices and the need of energy for entered period; following the formula:

$$\mathbf{Q_1 = 24.\ Q_1'.\ n.\ 10^{-3}} \quad \mathbf{(MWh)} \qquad (5)$$

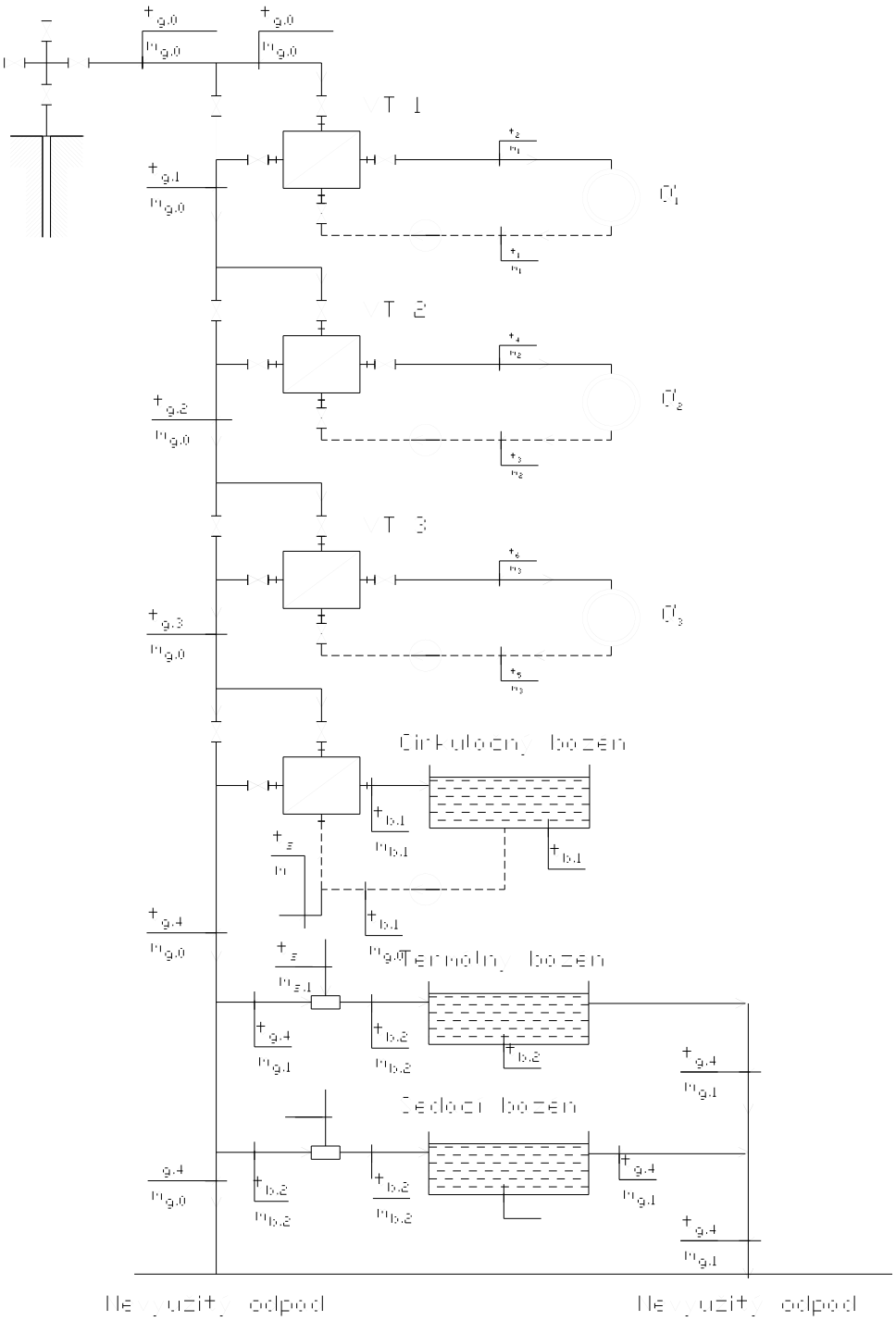

Figure 1: Schema of geotermal energetic systemu connection

In the recuperative heat exchanger, the heat is being transfered from the primary cooling medium – geothermal water through heat exchange areas to secondary cooling medium, as shown on Figure 2. These actions could be described by the following formula.

$$\mathbf{Q'_{GTV} = c_{GTV} \cdot m_{g,0} \cdot (t_{g,0} - t_{g,1})} \quad \mathbf{(kW)} \quad \mathbf{(4)}$$

where:

$\mathbf{m_0}$ - geothermal source output expressed in $[l.s^{-1}] = [kg.s^{-1}]$,

$\mathbf{c_v}$ - specific calorific content of geothermal water in $[kJ.kg^{-1}.K^{-1}]$,

$\mathbf{t_o}$ - the temperature of geothermal water at the drill head in [°C],

$\mathbf{t_v}$ - reference temperature of cooled geothermal water equal to +15°C,

n - number of days in expoitation period.

The quantity of heat which is transfered to secondary cooling medium, such as the pool water, can be formulate as follows:

$$\mathbf{Q_{VYK} = c_v \cdot m_1 \cdot (t_1 - t_2)} \quad \mathbf{(kW)} \quad \mathbf{(5)}$$

where:

c_v - specific heat of cooling medium of heating water (kJ/(kg.K)),

m_1 – mass flow of cooling medium – heating water entering the heat exchange (kg/s),

t_1 – temperature of cooling medium – heating water at the heat exchanger output (°C),

t_2 – temperature of cooling medium – heating water entering the heat exchange (°C).

In the recuperative heat exchanger, on the primary side, the geothermal water will drop of temperature, and on the secondary side, the temperature of cooling medium will increase. Thus, the cooling medium will be warmed for the heating system from its lower temperature t_2 to the desired temperature for supplying of the heating system. According to the heat source features, it is possible to operate in this manner number of heat exchangers consecutively (please refer to Figure 1).

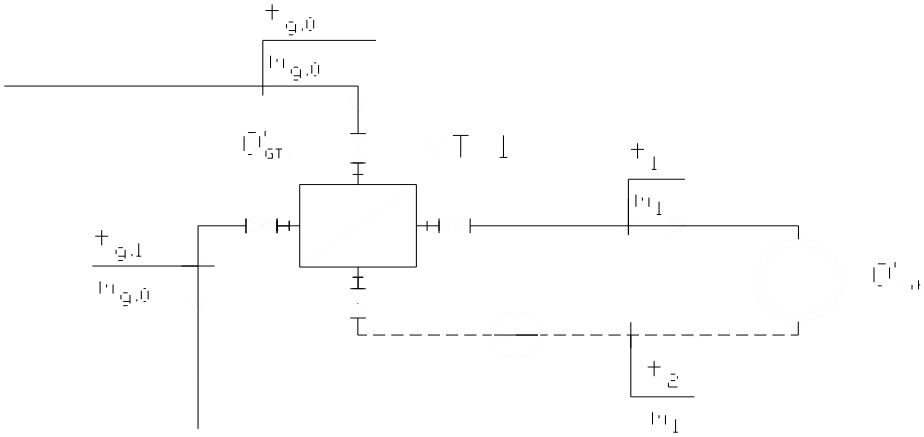

Figure 2: Heat transfer in the recuperative heat exchanger

VT 1 – recuperative heat exchanger, Q'_{GTV} – quantity of heat transfered by geothermal energy, Q'_{VZK} – quantity of heat supplied into heating system

5. EFFICIENCY EVALUATION OF GEOTHERMAL ENERGY

For the calculation of quantity GTW and elective heat slope on the captation device are calculated energetic bilances and as a result we have useful respectivaly nonuseful wasted capacity of energy where we are coming from teoretical useful quantity of energy Q_{1ic} for all captation devices:

$$\mathbf{Q_{1ic} = M_{1i} \cdot c_v \cdot (t_o - t_r) \cdot 3600^{-1}} \quad \mathbf{(MWh)} \quad (6)$$

where:

$\mathbf{M_{1i}}$) is the geothermal water volume for the all off-take point $[m^3]$,

$\mathbf{c_v}$ - specific calorific content of geothermal water in $[kJ.kg^{-1}.K^{-1}]$,

$\mathbf{t_o}$ - the temperature of geothermal water at the drill head in [°C],

$\mathbf{t_v}$ - reference temperature of cooled geothermal water equal to +15°C,

The usefullly utilized quantity of heat energy can be calculated from the formula:

$$Q_{1iu} = M_{1i}.\ c_{v.}\ (t_o - t_1).\ 3600^{-1}\ \textbf{(MWh)} \qquad (7)$$

Idle (wasted) quantity of heat energy can be calculated from the formula:

$$Q_{1io} = M_{1i}.\ c_{v}.\ (t_1 - t_r).\ 3600^{-1}$$

(MWh) (8)

At the same time, the following equation applies:

$$Q_{ic} = Q_{iu} + Q_{io}$$

(MWh) (9)

where:

Q_{iu} - total quantity of geothermal energy (GE) for the selected period [MWh]

Q_{iO} - total quantity of GE for hot air drying in [MWh],

If the temperature of outgoing, cooled GTW from heat exchanger higher than 30 °C, we need to think for another useful usage for example for preparation of hot water or for preparation technological water for the swimming pools, fish farm or for another technology – melting of snow etc.

Usefulness of geothermal energy is evaluated on the base of processed energy analyses effectiveness nontraditional renewable heat source. Mathematically is the usefulness of geothermal energy as a ratio usefully used heat by the total theoretical used heat:

$$ç = \frac{\sum_{i=1}^{n} (Q_u)}{Q_{teo}}.100$$

(%) (10)

Kde:

$\sum_{i=1}^{n} (Q_u)$ is sum of utilization of used energy by the captation devices (MWh) for the tracking time period,

$Q_{teor.}$ – theoretical used quantity of energy by the captation devices (MWh) for the tracking time period.

Practical sample of used usefullnes nontraditional energy in geothermal energetic system for the tracking time period is shown in Picture 3 as a graphical view.

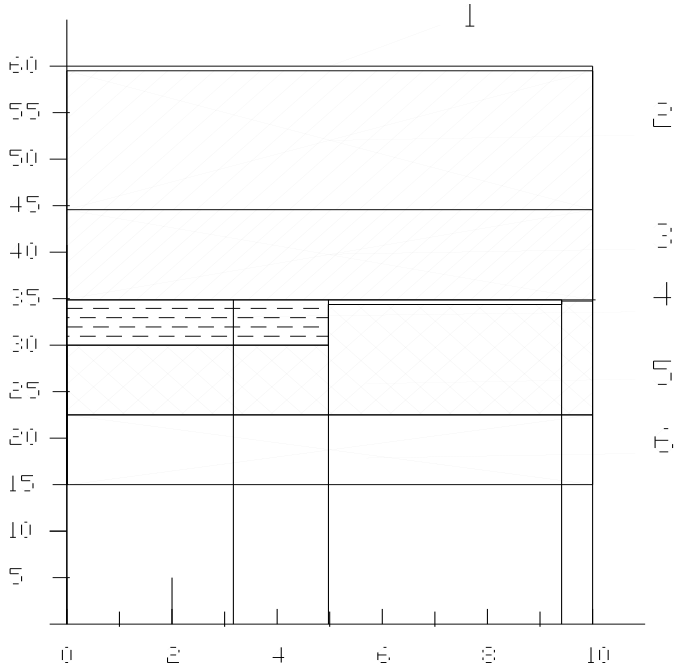

Figure Nr.3:Grafical evaluation of used utilization of geotermall energy in GES
1 – heat loss in piping, 2 – warmwater heated system, 3 – lowtemperature heated system, 4 – flow pool filled up with diluted, 5 – waste heat from pool, 6 – non used energy - waste

6. CONCLUSION

At the evaluation of energetic efficiency of usefulness geothermal energy at the captation devices must be observe some known knowledge and recommendations which are listed in these points:

1. Basic bases are geothermal energy source – geothermal drill hole. Basic parameters are quantity of geothermal water, which are

characterized efficiency in l/s (free overflow or fill), temperature on the drill head and chemical structure.

2. Exploitation geothermal energy is to be implicated in base loading (preparation of WW, heating system, ventilation and AC, or technology). Top energy is delivered from supplementary so called top source for noble medium (natural gas, biomass).

3. To develop exact heat balance of future supply objects (determine need of heat and energy for controlled time period). According to this point we design the transition of needed piping system which will supply captation devices. Determinations of the electrical system in kW and heat slope of heat exchangers.

4. For designed geothermal energy system will be proposed important monitoring points where they will monitor the flows of the heat carrying medium and continues temperature. We choose the right controlling and monitoring system which will control the energy import and monitor direct the need of energy and also will be modify parameters according to previously set up priorities and will make the regulation of the system.

5. Control and monitoring system will regularly observe and evaluate efficiency of utilization of unconventional energy source on the basis of geothermal water, while interfering into system in order to achieve maximum utilization.

6. Through a control and monitoring system implemented into GES we will be able to achieve highly thrifty acquisition of GTW which might considerably increase the working-life of the whole projekt.

7. Utilized waste geothermal water will be disposed so that they will least pollute the surrounding environment.

8. By utilizing of GE we will be able to safe a significant quantity of conventional energetic sources, coal, and especially natural gas. The environment will not be harmed by pollutants which would be incured by burning of conventional primary energetic sources.

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