ORADEA UNIVERSITY GEOTHERMAL HEATING SYSTEM MODERNISING PROCESS

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ABSTRACT

The paper present an optimisation method for the Oradea University geothermal water heating system, the steps followed during this process and the practical results obtained. At the beginning of this application the authors collaborated with the Geothermal Research Institute from Reykjavik, Island.

KEYWORDS: heating station, district heating, domestic water, geothermal water.

1. GEOTHERMAL SYSTEM FROM UNIVERSITY OF ORADEA.

Geothermal well nr. 4796 from Romania is situated in the University of Oradea campus. In the drill is placed, at 90 m deep, a pump drived by a 65 kW electric machine (made by General Motors, USA). The electric machine is situated at ground level, above the pump (the type of the pump is "with axle"). The temperature of geothermal water is around 85°C and the artesian flow is 30 l/s. If the needs of system require a bigger flow, the deep pump increase the flow from 30 l/s to around 50 l/s. The production diagram of the well nr. 4796 from Romania is presented in figure 1. If we consider that, the geothermal water with 30°C temperature is thermal worn out, this geothermal well has a 7 MW installed capacity with the normal artesian flow and 10 MW installed capacity using the deep pump.

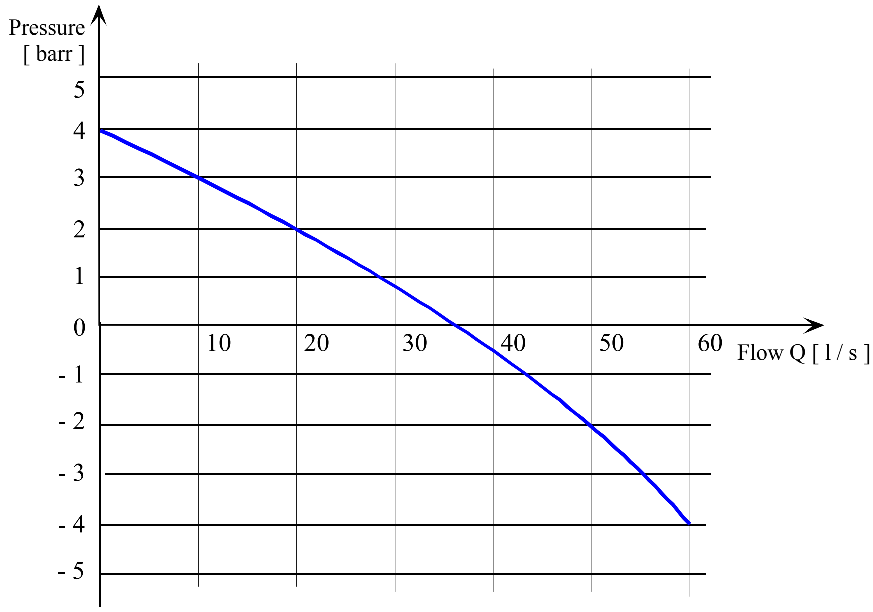

Figure 1. The production diagram of the well nr. 4796.

The geothermal system (figure 2) content a tank (300 m^3) for storage and degassing. To avoid corrosion, the pressure in the storage and degassing tank is higher than the atmospheric pressure to prevent oxygen entering into the water. This situation, also avoid calcite scaling by keeping part of the carbon dioxide in solution.

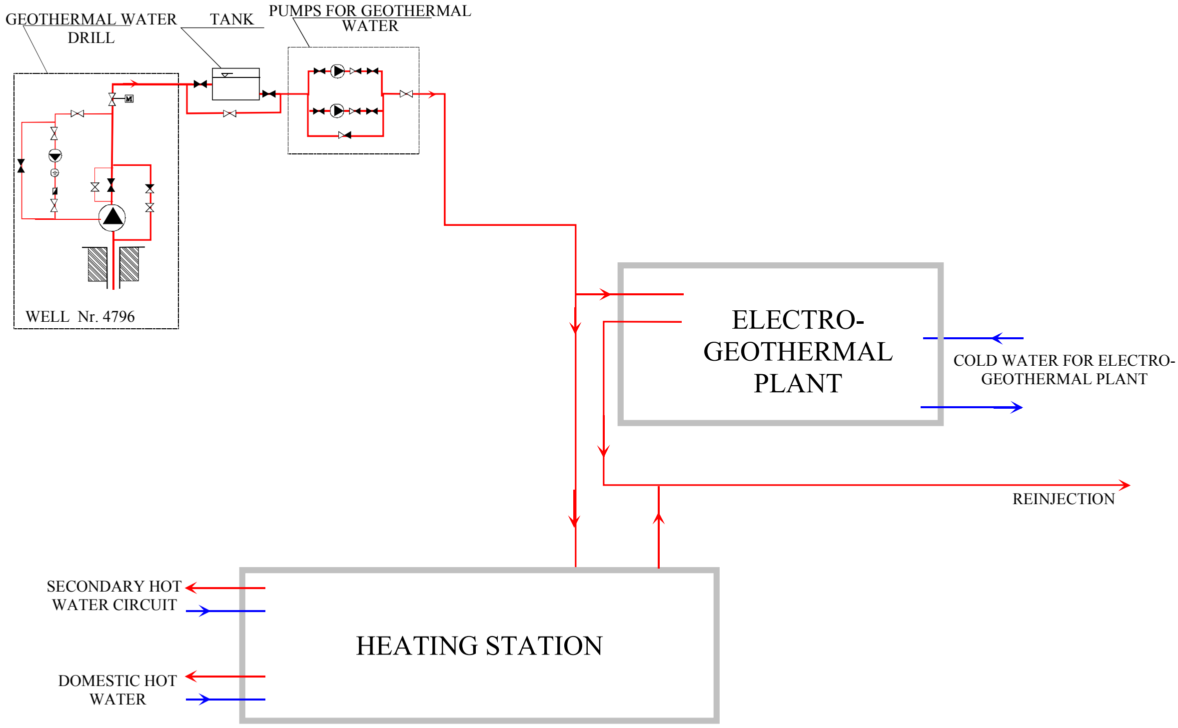

Figure 2. The basic scheme of the geothermal system from the University of Oradea.

The heating station is placed near the geothermal well and in the station there are two Grundfos pumps and auxiliary equipment. This heating station prepare the flow and pressure of geothermal water at the necessary value for the next part of the system. The geothermal system is working both in “the artesian regime” and in “the pump regime”. In the first case, the well station distributes geothermal water directly in the principal distribute pipes system and in the second case, the well station distributes the geothermal water to the tank. The pumps station sends the water from the tank to the principal pipes and it will be distributes to the different consumers.

The University campus has buildings with around 70.000 m^2 heating area (total built volume V_{bt} = 155.000 m^3). This include teaching amphitheatres and seminar rooms, laboratories, administration offices, two students hostels, a small library, a cantina, etc.

In next future it will be built an important library (total heating area = 5.900 m^2 and the built volume V_{bl} = 32.000 m^3), a students hostel with 400 places (heating area = 9.900 m^2, the built volume V_{bsh} = 30.000 m^3), a swimming pool with geothermal water and a glass house for the Horticulture Faculty.

2. THE HEATING STATION.

It is placed at 280 m distance from the geothermal well station, near the electro-geothermal plant. The old schema of the heating station is presented in figure 3. This station prepare hot water for district heating (DH) and domestic hot water (DHW). These two heating processes are developed indirectly: the geothermal water is used in the plate heat exchangers where the geothermal water energy is transferred to the heating fluid, usual water, which is circulated in the heating system. The usual water it is obtained from 11 cold water wells (CW).

The DH network is a closed system and is directly connected to the heating elements from the buildings. The heating period is about 172 days per year, between 15/10 and 15/04. The heating principle is the so called “constant flow principle with variable temperature”. The circulating pumps are working all the time at constant rotation, in order to maintain the same

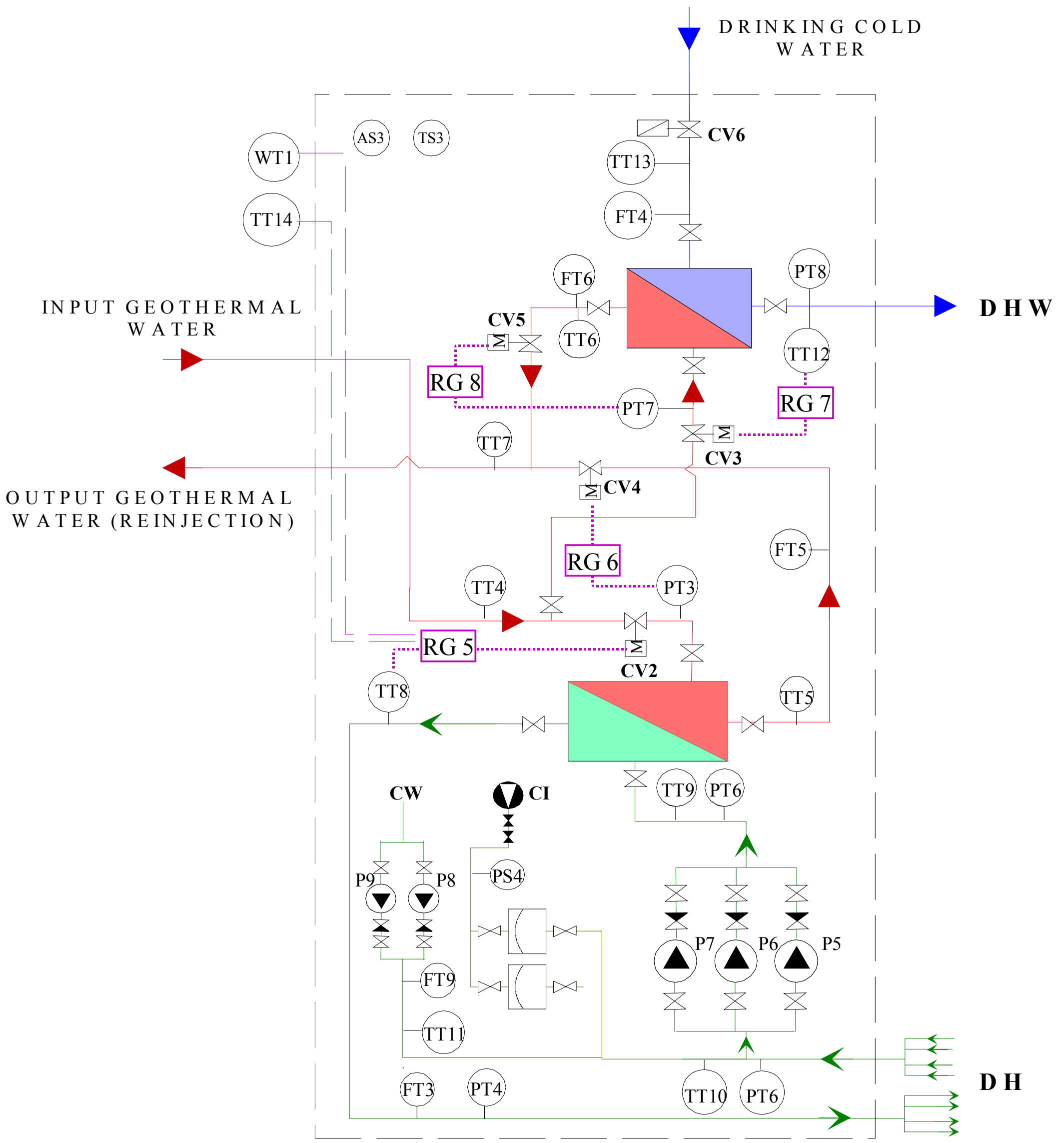

Figure 3. The old schema of the heating station.

flow in the heating system.

The DHW network is a subsystem with drinking water, from the water springs of the University, which is heated in the heat exchangers and it is used for domestic purposes. This subsystem is working the whole year.

To optimise the heating station working process, we compute the total necessary energy for the specific forecast conditions, from Oradea area (outside temperature, wind speed, humidity, etc.)

The purpose of the calculus was to determine the energy consume for district heating and domestic hot water. The calculus was made for a representative year. We used statistical informations for the outside temperature from Oradea geographic area. We concluded that for Oradea area, the outside standard temperature for calculations is $-12^{o}C$. (figure 4).

We analysed the results from past years, until 2001. For an optimum working process of the heating station, we obtained the next results:

a. for district heating:
   - the secondary agent: hot water;
      - flow = 160 m^3/h, temperatures (input/output) = $70^o/40^oC$, pressures

(input/output) = 3,5/1,5 barr.

- the primary agent: geothermal water;
  - flow = 140 m^3/h (39 l/s), temperatures (input/output) = $85^o/50^oC$, pressures (input/output) = 2,5/0,8 barr.

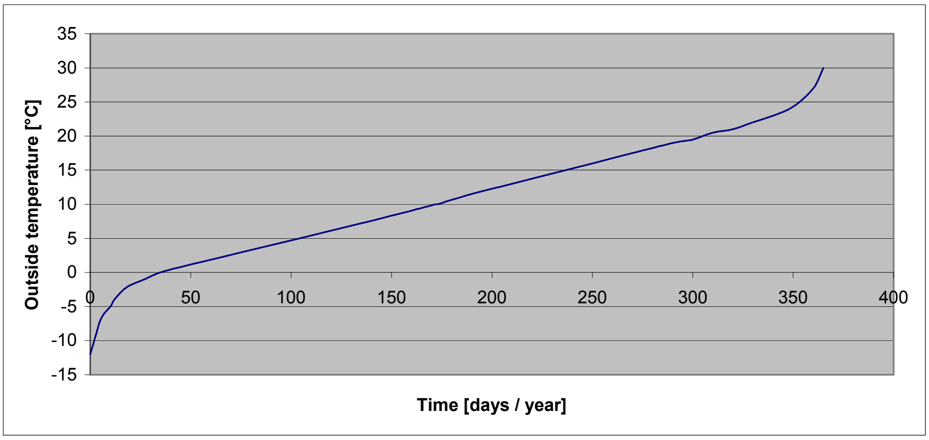

Figure 4. The yearly sort diagram of the outside temperature for the Oradea area.

b. for domestic hot water:
- the secondary agent: hot water;
  - flow = 15 m^3/h (4 l/s), temperatures (input/output) = $60^o/10^oC$, pressures (input) = 4 barr.
- the primary agent: geothermal water;
  - flow = 20 m^3/h (6 l/s), temperatures (input/output) = $85^o/50^oC$, pressures (input) = 2,5/1,6 barr.

The total flow of the geothermal water, necessary for district water and domestic hot water is (for the require conditions) around 160 – 165 m^3/h (≈ 45 l/s).

The yearly sort diagram for the geothermal water consumption is shown in figure 5. ($M_{geo\ inc}$ = the flow for district heating, $M_{geo\ acm}$ = the flow for domestic hot water and

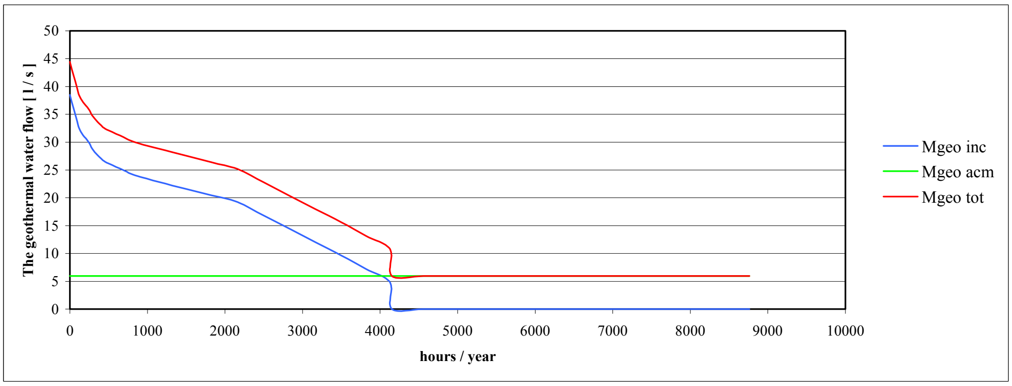

Figure 5. The yearly sort diagram for the geothermal water consumption at the University of Oradea.

$M_{geo\ tot}$ = the total flow of the geothermal water).

We analysed the obtained results and we selected the solution for the heating station: the cascade working system for the energy of the geothermal water.

The cascade working system consist in using the thermal worn out geothermal water from primary users, by the another consumers, called secondary users (figure 6).

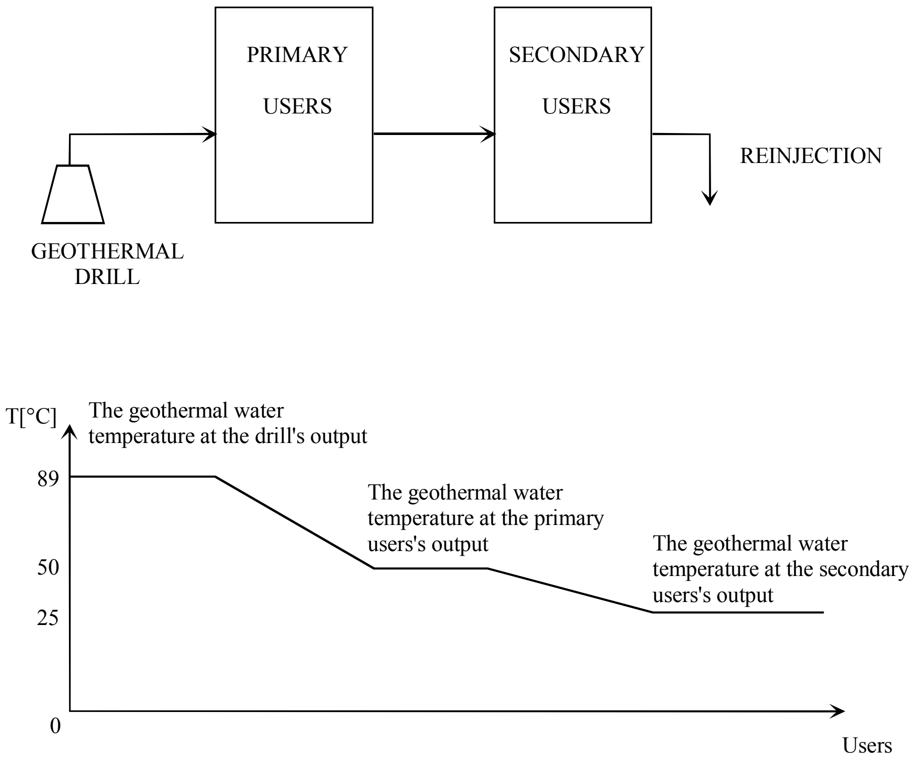

Figure 6. The cascade working system for the energy of the geothermal water.

We have recovered a part of the thermal energy of the thermal worn out geothermal water by:

- the floor heating system;
- the airing heating system;
- the heat pumps system;

The basic schema is shown in figure 7. The basic constructive-functionally schema for the cascade system of using the geothermal energy, for the heating system of the Oradea University is presented in figure 8 (DH 1 = District heating with static elements; DHW = Domestic hot water; FT = Flow transducer; TT = temperature transducer; PT = pressure transducer; WT = speed wind transducer; TS, PS, AS = warning for temperature, pressure and humidity; VT_{acm}= Domestic hot water tank).

The yearly sort diagram of the total heat consumed in the campus of the University of Oradea is shown in figure 9.

The route towards an increased productivity of a heating station is based on the automation of the processes and machines. This automation may be required to directly increase output quantities or to improve product quality and precision.

To achieve the process automation the operator must be replaced by a control system, which has the ability to start, regulate and stop a process as a response to measured variables within the process, in order to obtain the desired output. These objectives are solved using a control system based on a PLC microcontroller and using SCADA (Supervisory Control And Data Acquisition) man-machine interface.

Connecting a PLC to the heating station is how we achieve the automatic control of the plant. But, a PLC also has to be connected to the human operators, in order to accept commands from them and to display the status of the plant in a form that can be easy to read and understand. This is called the man-machine interface or MMI. Using SCADA MMI

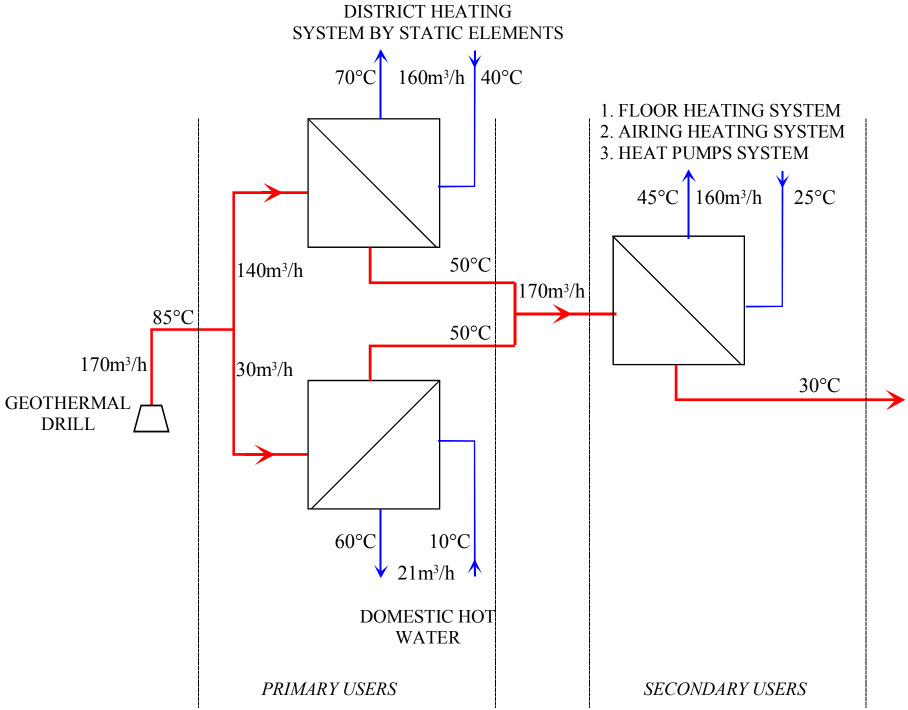

Figure 7. The basic schema of the cascade working system from the University of Oradea.

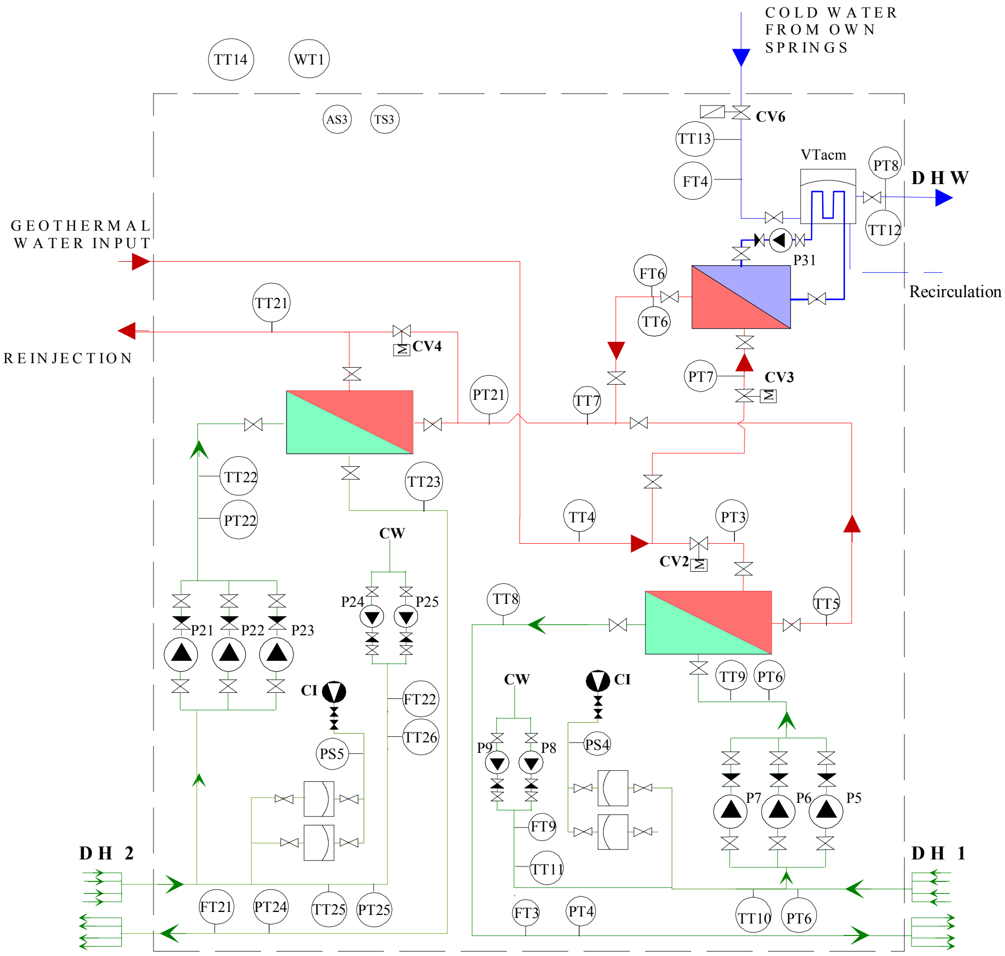

Figure 8. The basic constructive-functionally schema of the heating station.

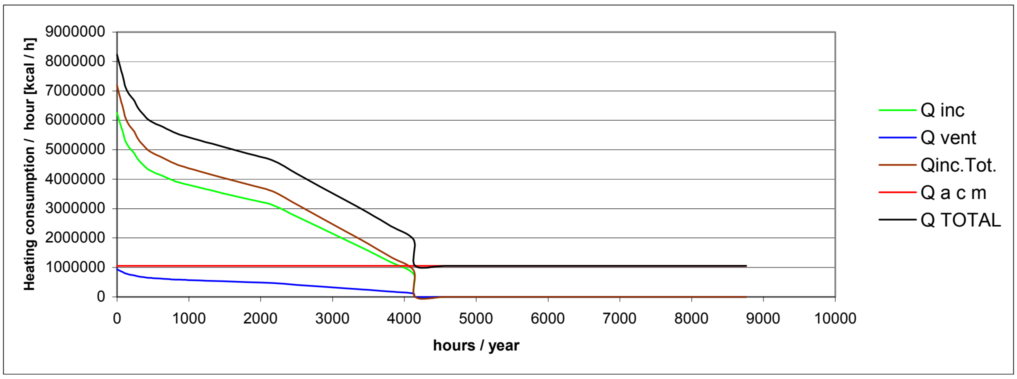

Figure 9. The yearly sort diagram of the total heat consumed in the campus of the University of Oradea.

provides a very useful graphical interface which is friendly to the human operator allowing him to perform his duty efficiently.

Although, PLCs are similar to conventional computers, in terms of hardware technology, they have specific features suited for industrial control: they are designed to survive in an industrial environment with all the implications for temperature, dirt and poor-quality supplies: they have a modular plug in construction, allowing easy replacement or addition of input and output units. These units are easy to be programmed and reprogrammed in a constantly changing plant. Finally, but maybe the most important characteristic is that they are fast enough to operate in real time, as most of the industrial processes need.

Allen Bradley PLC consists of three basic functional areas: processing, memory and input/output (and eventually communication units or special function for re-mote control or networking, if necessary). The controller operates by examining the input signals from process and carrying out logic instructions (which have been programmed into its memory) on these input signals, producing output signals to drive process equipment or machinery. This process of reading inputs, executing the program and controlling the outputs is done on a continuous basis called scanning.

The Allen Bradley programmable logic controller is constructed on a modular basis with function modules slotted into the back-plane connectors of the mounting rack. This allows the simple expansion of the system when necessary. The individual circuit boards are easily removed and replaced, facilitating rapid repair of the system and easy further development. The CPU controls and supervises all the operations within the PLC, carrying out programmed instructions stored in the memory. An internal communications bus system carries information to and from the CPU, memory and I/O units, under the control of CPU.

To obtain a higher efficiency of the thermal station, starting from the analyse we have developed, the PLC was programmed again and were created new automation cycles. Also, we have used the PLC to simulate the thermal station functioning process for new conditions.

3. CONCLUSION

By cascade using of the geothermal water energy can be obtained a supplementary heating for a 63000 m^3 area, using the same geothermal water flow.

By developing this system, between Oktober 2002- January 2003, the experimental results obtained are very close to those given by the simulation process in the same conditions.

So, the constructive-functionally dimensioning of the thermal station and the process control are correct. This way, is permitted an efficient energy resources exploitation and the optimum process control in safe conditions.

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