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Study On The Optimization of Heat Pumps With Ground Thermal Source

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Abstract

The paper is a synthesis of a topical bibliography with theoretical, experimental and applied results; Complex research program was based on analysis of data recorded by DDC for a period of more than two years, as the one in, Bucharest Romania; Detailed geotechnical study at both regional and local levels favored an efficient design of the entire system, cold and warm requirement is covered by the minimum monthly costs, much lower than what would have been required of a classical system; Maintenance equipment is easy and can be done for most situations via the DDC's, and moreover, the complex automation optimizes these systems, getting significant energy savings. In the case of the geoheat exchanger with boreholes with a single circuit, after the comparison between simulated data with software EED and recorded data it was shown that the average temperature values for carrier fluid are comparable allowing validation of the results. The main problem was to prove that this new type of GSC will not disturb, energy wise, the crossed geological formations. Finding a viable solution that is more efficient than the solution with vertical boreholes, closed, mounted in parallel with a single circuit; For greater efficiency hybridization system is a solution that deserves to be carefully analyzed

Keywords - component; formatting; style; styling; insert (key words)

1. Introduction

As each kind of system, the one based on geothermal heat pumps can be optimize. This can be done using a number of methods: choose a better solution for the geoheat exchanger, using a good automation solution, as DDC (Direct Digital Control) for example, using new, more efficient spare parts (from the latest generation of compressors).

Choosing one or another method depends of the stage in which the system is. If in the designing stage, choosing the type of geoheat exchanger depends on all the information about geological strata crossed by it, for energy needs. For a good selection, one must use a software for simulating the soil behavior. Also including an automation for controlling the inside parameters and their collaboration with external ones so that the energy is limited, while still providing the best iinterior comfort.

If the system is already functional, it is possible to hybridize it or to choose new generation equipment. For example, the new generation of compressors is more efficient and can be integrated in the heat pumps.

This paper contains the analyzes of an existing system, which provides data registrations for more than 2 years, in comparison to a new one, which in the same conditions will use 2 circuits/boreholes instead of just one.

2. The Influence of the Two Different Geoheat Exchanger Types in Energy Extraction

In the Fig. 1, one can see the comparison between the monthly evolution of energy extraction, including the one of the pick loads on the 25th year of operation, for a simple circuit and a double circuit, Vitan, Bucharest.

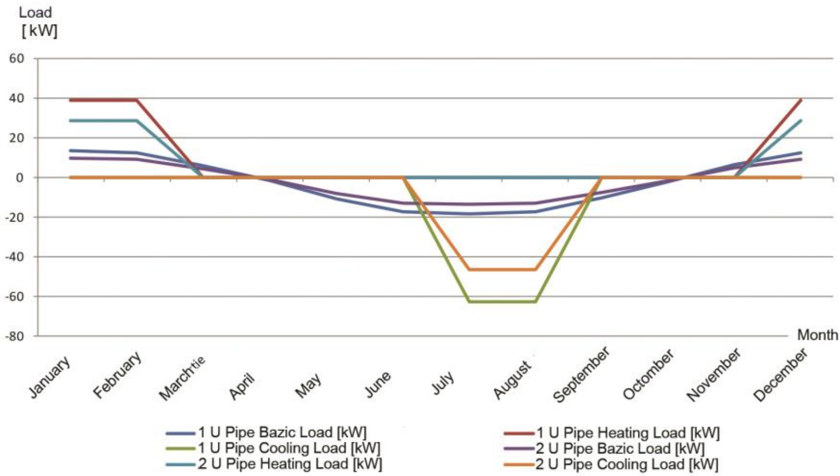

Fig. 1 Monthly evolution of energy extraction, including the one of the pick loads on the 25th year of operation, Vitan, Bucharest, simple circuit vs. double circuit

Analyzing the simulation results for the double loop system / borehole, one of the main findings is that the energy extraction increases by 26% and the reduction of the consumption of materials is similar.

This increased energy, extracted from the soil, is not reflected negatively in the ground conditions; no energy extraction higher than the one supported by the ground occurs and the extraction temperature does not drop below 0 °C in order to produce a freeze of the area immediately surrounding the contact rock/barrel. It is taken into consideration that the number of boreholes decreased from 112 (that is the actual situation of the simple circuit/borehole) to 84 (if the double circuit/borehole would be used), in the same available surface.

The distance between boreholes can be increased, fact which would make the process of thermal balancing of the soil faster. That would lead to a slightly increased price, because it would increase the need for a horizontal connection pipe for the collectors.

3. Optimal Method for Placing Pipes In The Boreholes

The location of the pipe system in the borehole is extremely important as it can influence the energy extraction from the soil with up to 35%. Maximum energy capture from the ground is reached using a larger area contact and a layer of rocks on top and geoclips (spacers), because they place the pipes in the right position, so that the maximum energy can be extracted from the borehole walls Fig. 2.

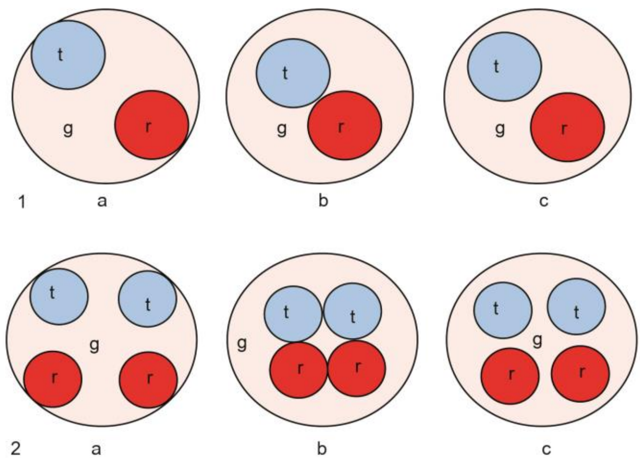

Fig. 2 Placing tubes in the borehole
1. Systems with simple circuit; 2. Double circuit systems;
a. Correct position; b., c. - Incorrect positions; g - grout - insulated cement, t – tour, r - return

The arch of the geoclip pushes the pipe in the borehole walls and increases the contact surface between them. That mean the ideal position of the pipes is as the one presented in Fig 3.

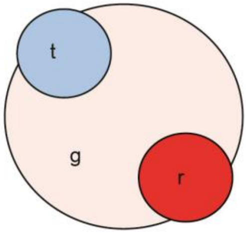

Fig. 3 Ideal position of the pipes
g - grout - insulated cement, t – tour, r - return

4. Performance Equipment

Also as a way of optimizing is to choose equipment that works most of the time on an average power or speed (ex the fan coils plants). If one chooses plants that satisfy the room requirements by running them on maximum speed and power, the energy consumption will be higher than using plants that works on average speed and capacity. Even if the purchasing price for more efficient equipment and with bigger capacity is higher, the investment will be paid off by paying less for consumption. The automation system will enable the operation in speed and / or optimizing power and costs.Using the Pack Calculation Pro, a dedicated software simulated the energy consumption for the existent compressor of the water – water heat pump and for the same one but using a new generation compressor (in reference to the same system from Vitan). The results are presented in table 1.

Table1. Annual energy consumption for simulated systems in comparison with existing systems

Soil - water pump	Existent heating	Optimized heating	Existent cooling	Optimized cooling
% of time:	94.50	90.00	100.00	100,00
% of energy:	99.80	88.60	100.00	100,00
COP				
average CoP [-]:	2.90	3.00	5.57	5,80
Energy consumption				
Pumps and fan coils [kWh]:	1331.00	1195.00	4499.00	4499.00
Compressor [kWh]:	70342.00	63042.00	32935.00	31493.00
Total [kWh]:	71673.00	64236.00	37435.00	35992.00
Economies				
Annual energy savings [kWh]:	-	7436.00	34238.00	35681.00
Annual energy savings [%]:	-	10.40	47.80	49.80

By optimizing the heat pump with a new generation compressor it results that the system becomes more efficient. This is revealed by the fact that the CoP respectively EER is better, even with lower power consumption.

As one can see in Table 1, the heating consumption drops to 37 307.7 kWh from 41 318.6 kWh, and for cooling from 15 903.0 kWh to 15

290.6 kWh kWh. Moreover if one takes into account that the system has 10 soil - water heat pumps resulting a 373 077 kWh saving on heating and 152 906 kWh on the cooling. CO_2 emissions are lower for the optimized system both for the cold and warm season.

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5. Conclusions

The number of boreholes dropped by 25% and the geoheat exchanger's length has decreased by 25.74% for the solution with 2 circuits / borehole related to the solution of only one circuit/borehole and shift costs drop by 25%, so the solution 2 circuits / borehole is the best solution to optimize systems for large buildings so that means the alternative choice is an efficient one.

The system can be optimized using the constructive solution, with double circuit/borehole. It was found that the system does not change the efficiency in time and that means that the soil, which is the primary energy provider, does not modify its properties as energy reservoir. This situation is mainly explained by the fact that the systems are reversible and the energy that is extracted during the cold season doesn't differ much from the amount of energy that is inserted into the soil during the warm season. This behavior emphasis the fact that this kind of exploitation balances the soil, and the difference between the energy input in the extracting season, even when it does exist, is balanced with the energy generated from the inside of the planet. The correct placement of the pipes in the borehole is important and can optimize the energy extraction. Also changing some existing equipment with new generation one can result in maximum energy economies.

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