36. SIMPOZIJ AKTUALNI ZADACI MEHANIZACIJE POLJOPRIVREDE

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Expert paper

STUDY CONCERNING THE INFLUENCE OF SOME WORKING CONDITIONS, ON THE HEAT PUMPS PERFORMANCES

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Abstract

The paper presents relevant information about the working principle of the geothermal heat pumps and a study, based on an original computer simulation, analysing the influences of the working conditions on the heat pump performances. After presenting some basic considerations about the geothermal energy and about the heat pumps working principle, there are included some relevant considerations about the environmental conditions of Romania and the potential of the geothermal energy, as important renewable energy, to be used in the field of domestic heating with heat pumps. In domestic heating applications, the only available type of equipment able to use the geothermal energy is the heat pumps. Only these type of equipment can increase the temperature level of the at the Earth surface available geothermal energy, to the needed temperature level of the useful thermal energy. The original software used to analyse the influence of some working conditions, on the heat pumps performances, was written in Engineering Equation Solver language, using an academic licence available at the Technical University of Cluj Napoca. This software environment allows creating software adapted for the evaluation of the influence of many important parameters on the heat pumps performances. Between the relevant studied parameters can be mentioned: heat pump location, heat pump type, quality of the house insulation, type of heat pump application.

Key words: *Heat Pump, Geothermal Energy, Renewable Energy, Heating, Simulation, Software, Study*

Introduction

From the thermal potential point of view, the geothermal energy can be classified in two categories:

÷ of high thermal potential;
÷ of low thermal potential.

In fact 99% of the Earth interior is at over 1000° C and 99% of the rest is situated at over 100° C.

In domestic heating applications, is used the geothermal energy of the Earth surface available at lower and variable temperatures. In figure 1 is presented a typical diagram of temperature variation of the Earth surface.

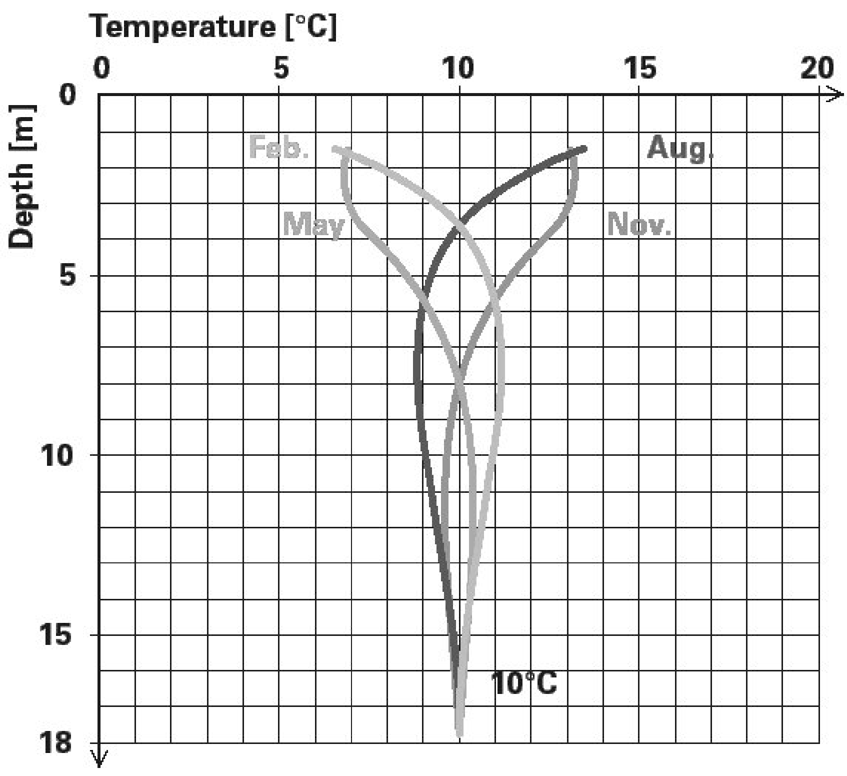

Fig. 1. Typical temperature variation at the Earth surface

In order to increase the temperature level of the geothermal energy available at the Earth surface, are commonly used the heat pumps with the main components and with the working principle scheme represented in figure 2.

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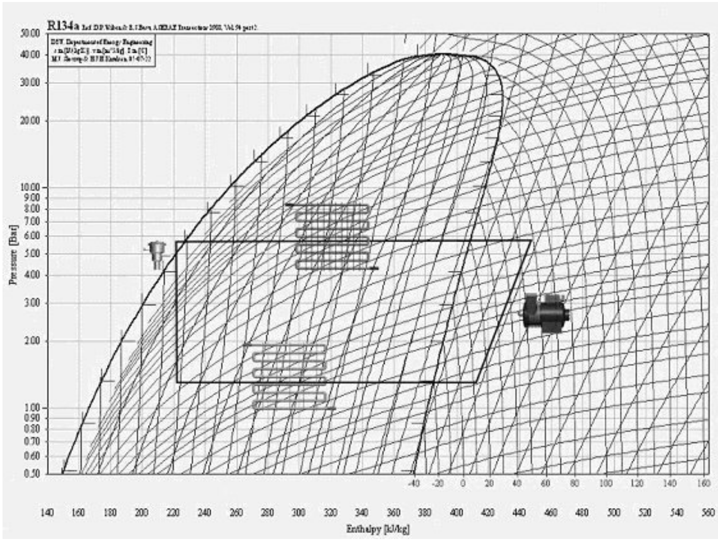

Fig. 2. Main components and the working principle of a heat pump in a lgp-h diagram

Typical heat pumps are using as cold source the geothermal energy of ground, water or air and are delivering the heat in the warm source represented by water or air. In this context the thermal energy of all the cold sources, including water and air, is also considered geothermal energy.

The temperatures of the available geothermal energy are different in each location of the heat pumps influencing the performances of these equipments.

In table 1 are presented the average temperatures in different locations in Romania.

Table 1. Average temperatures in some major cities of Romania

	Bistrita	**Bucharest**	**Cluj Napoca**	**Constanta**	**Iasi**	**Timisoara**
jan	-5	-2	-3	1	-4	-2
feb	-2	0	-2	2	-2	1
mar	3	5	4	5	3	6
apr	9	11	9	10	10	11
may	14	17	14	16	16	16
jun	17	20	17	20	19	19
jul	18	22	18	22	21	21
aug	18	21	18	22	20	20
sep	14	17	15	18	16	17
oct	8	11	9	13	10	11
nov	3	5	3	8	4	6
dec	-2	0	-1	3	-1	1

The data mentioned in table 1, are implemented in the dimensioning software of the companies Copeland [6] (citing the Meteosat databse) and Weishaupt [7].

The indicated tempearture are directly influencing the evaporating temperature of the air-air and air-water heat pumps. The earth and underground water temperature are less dependent of the heat pump location, but also important.

The heat pump destination is setting up the temperature value of the useful thermal energy delivered by the heat pump. In table 2 are indicated some typical temperature values of delivered useful thermal energy for different type of heat pump destination.

Table 2. Temperatures of heat pumps delivered usfull thermal energy

Destination	**Temperatures [°C]**
Radiant floor heating	25…29
Convective radiator heating	32…35
Warm water	≈ 45
Swimming pool	25…29

The condensing temperature of the heat pumps is influenced by the heat pump destination.

In principle, the performances of the heat pumps are determined by the difference between the condensing and the evaporating temperature.

Another important parameter of the heat pump, mainly in the domestic applications is the heat pump thermal power. This parameter is determinant for the heating system investment.

In order to reduce the heat pump thermal power, a determinant influence is presented by the building thermal insulation.

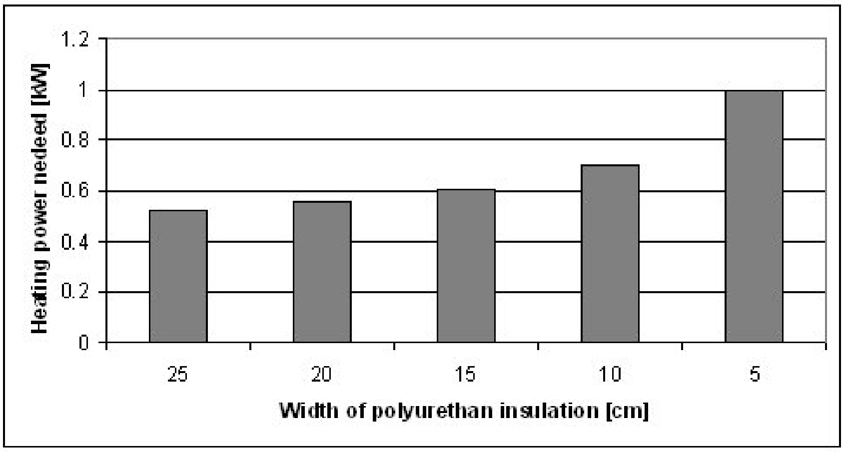

Fig. 3 Influence of insulation depth on the heating power

Figure 3 presents only the results obtained in the case of a typical 150m^2 residence realized from Sandwich panels of different width between 5…25cm.

The main characteristics of the considered residence are presented in table 3.

Table 3. Main characteristics of the residence

Parameter	**Value**
Inside temperature	25°C
Outside temperature	-5°C
No. of persons	4
Period of time for hot water preparation	8h
Length	10m
Width	6m
Height	7.5m
Base surface	80m^2
Windows surface	36m^2
Windows type	Float-Float

Methods

In order to study the influence of some important parameters, on the heat pump performances, an original software tool was written using Engineering Equation Solver (EES), dedicated and world leader software for thermal calculations.

The main functions realised by the original software are:

- Selection of the heat pump information
    - Destination
    - Type
    - Location
- Calculations
    - Heat pump working cycle
    - Heat pump efficiency

It was studied the influence of the following parameters:

- heat pump type;
- heat pump destination;
- refrigerant.

It was considered the following heat pump types:

- ground-water with horizontal collectors;
- ground-water with vertical collectors;

- ground-water with direct evaporation;
- water-water;
- air-water.

It was considered the following heat pump destinations:

- radiant floor heating;
- convective radiators heating;
- hot water preparation in winter;
- hot water preparation in summer.

It was considered the following type of refrigerants:

- R407C;
- R290 (propane);
- R404A.

Results and discussion

The single analyzed parameter of performance was the heat pump efficiency, calculated as the report between the useful thermal power and the absorbed electrical power. Figure 4 presents the influence of the heat pump type to the heat pump efficiency for radiant floor heating with R407C.

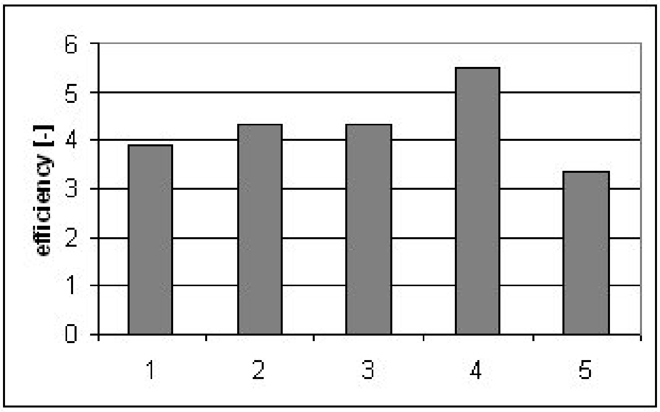

Fig. 4. Influence of the heat pump type to the heat pump efficiency
1 - ground-water with horizontal collectors; 2 - ground-water with vertical collectors;
3 - ground-water with direct evaporation; 4 – water-water; 5 – air-water

It can be observed that the water – water heat pump is working with the higher efficiency. The ground-water with vertical collectors heat pump and the ground-water with direct evaporation heat pump present similar values of the efficiencies. Between the two types of heat pumps, the first one presents the advantage of an easier maintenance, and the second one the advantage of a lower cost mounting.

Figure 5 presents the influence of the heat pump destination to the heat pump efficiency, for ground-water with horizontal collectors heat pumps with R407C.

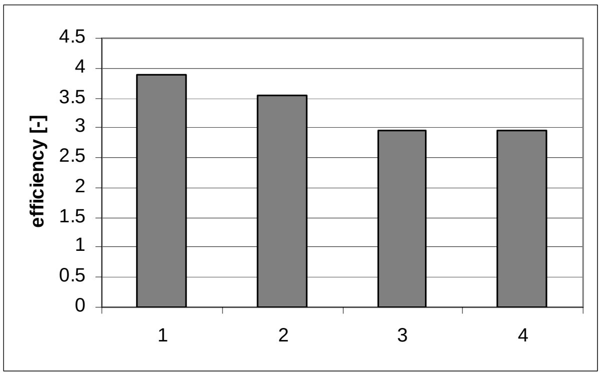

Fig. 5. Influence of the heat pump destination to the heat pump efficiency
1 - radiant floor heating; 2 - convective radiators heating;
3 - hot water preparation in winter; 4 - hot water preparation in summer

The higher efficiency is obtained for the radiant floor heating, similar from the working conditions and from the efficiency point of view with the swimming pool heating, as it can be observed in table 2. This means that the swimming pool heating is one of the most interesting heat pumps applications, mainly for the air-water heat pumps during summer, characterized with really high efficiency.

Figure 6 presents the influence of the refrigerant to the heat pump efficiency, for ground-water with horizontal collectors used at radiant floor heating.

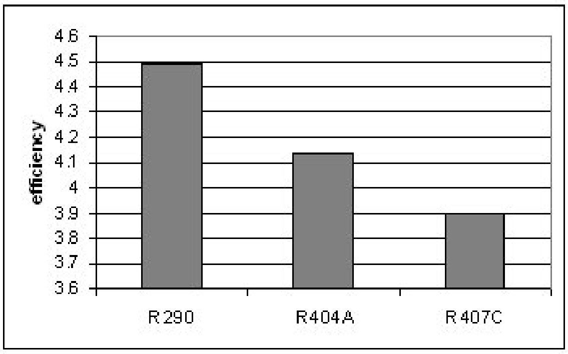

Fig 6 Influence of the refrigerant to the heat pump efficiency

Even if R290 (propane) assure the highest efficiency, this refrigerant is very inflammable and in many EU countries, but not in USA, the equipment with significant quantity of propane, such as in the case of heat pumps, can't be placed inside the buildings.

Figure 7 presents the combined influence of the heat pump destination and heat pump type, on the efficiency.

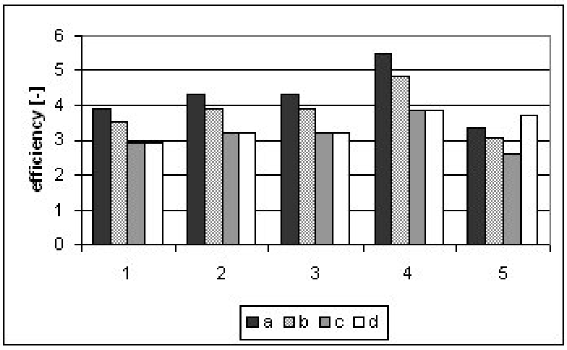

Fig. 7. Influence of the heat pump destination and type to the heat pump efficiency 1 - ground-water with horizontal collectors; 2 - ground-water with vertical collectors; 3 - ground-water with direct evaporation; 4 – water – water; 5 – air – water a - radiant floor heating; b - convective radiators heating; c - hot water preparation in winter; d - hot water preparation in summer

Figure 8 presents the influence of the heat pump destination for three types of heat pumps, on the efficiency. It can be observed that in the case of air-water heat pump, the efficiency is higher for the water preparation in summer than in winter. In the other types of heat pumps, there is no difference in the case of the hot water preparation because the ground and underground water temperatures are assumed to be constant during the year.

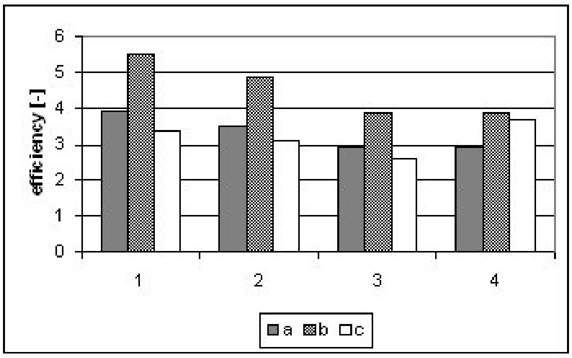

Fig. 8. Influence of the heat pump destination to the heat pump efficiency for some heat pump types 1 - radiant floor heating; 2 - convective radiators heating; 3 - hot water preparation in winter; 4 - hot water preparation in summer a – ground - water with horizontal collectors; b - water - water; c - air - water

Figure 9 presents the influence of the refrigerant to the heat pump efficiency for some heat pump types.

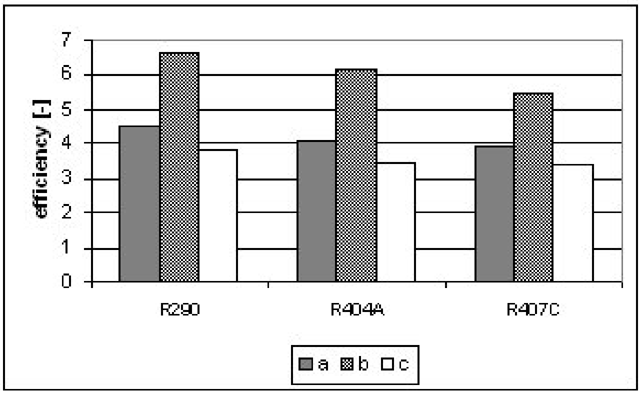

Fig. 9. Influence of the refrigerant to the heat pump efficiency for some heat pump types
a - ground-water with horizontal collectors; b – water-water; c – air-water

Conclusions

The location of the heat pump, the destination, the type and the refrigerant are some very important parameters that influence the heat pump efficiency.

The refrigerant is selected by the producer, but the other parameters are representing the working conditions of the heat pump, and there influence is determinant on the efficiency use of the geothermal energy in heat pumps.

In these conditions the choice of a technical solution must be the object of a very deep technical and economical analysis that can be based on the heat pump efficiency.

The R290 (propane) presents the highest efficiency, but this refrigerant is very inflammable and it is possible to use it only in very restrictive conditions (for instance the heat pump can’t be placed inside the house).

The water-water and ground-water with direct evaporation heat pumps present the higher values of the efficiency but it is difficult to find underground water with the required flow rates and chemical quality.

Even if air-water heat pumps present the lower values of efficiency, this type of heat pumps are the cheapest and equally the most efficient solution for heating the swimming pool during the summer

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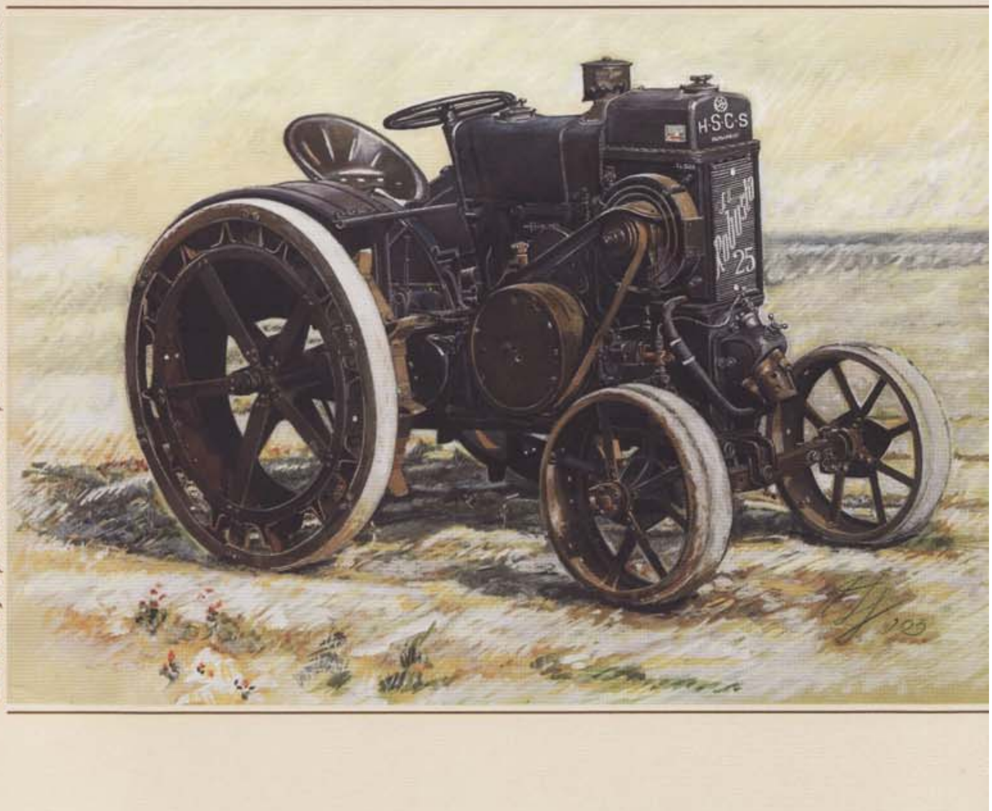

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