



PROBLEMS OF UTILIZATION OF HEAT PUMPS

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ABSTRACT

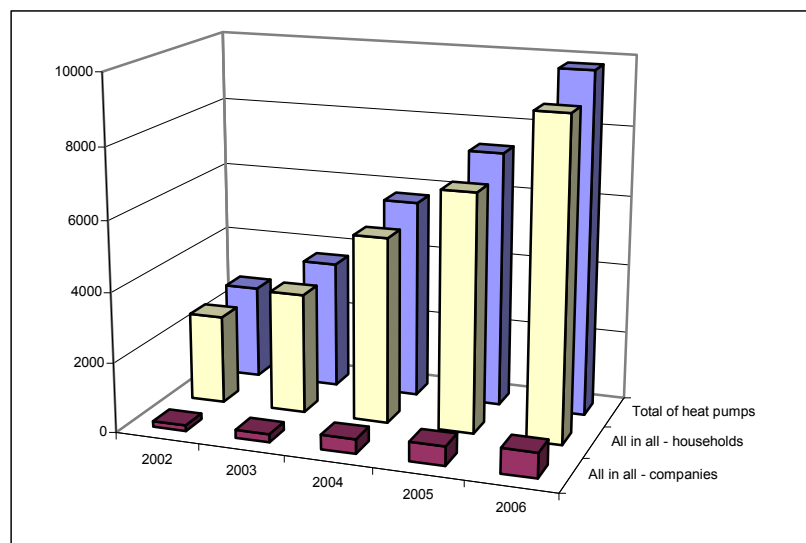
This paper is focused on problematic of the utilization of the heat pumps. Its first part is dedicated to this method of the heating generally. The principle of the heat pumps, their basic part and their division are presented here. Then the heat pump market in the Czech Republic is analyzed very shortly in the second part. Because great number of the companies is engaged in this source of the heat, I focused only on the organizations which deal with this heating. The next part of the work is concerned with the individual installations or the operation evaluation of heat pumps in the Plzeň region and the region of Karlovy Vary. This is the subject of the third part in which I worked out the overview of ascertained heat pump installations in the commercial buildings in these two regions and of the fourth part where I evaluated the heat pump operation in one selected building. Problems of the heating using heat pumps becomes more and more topical in the connection with the increasing prices of the energies and thus in the last part of the work I deal with some of the heat pumps of the future and their utilization.

KEYWORDS

Heat pump, low-potential energy, vapor compression cycle, COP, heat sources

1. INTRODUCTION

If you looking for some ways to reduce increasing energy bills or searching the profitable heating and cooling options for your new house, you may be considering the heat pump. While the heat pumps may have lower fuel costs than the conventional heating and cooling systems, they are more expensive to buy. The cost is the biggest problem in the sphere of the heat pumps. But the advantages of these devices predominate. For this reason the heat pumps are used more and more across the world. The situation in the Czech Republic is presented in Graph 1. Graph 1 – Trends in number of heat pumps in the CZR in years 2002 – 2006



What exactly are the heat pumps? The heat pump is the device that transfers heat from the natural heat sources in the surroundings (e.g. ground, water and air) or from the man-made heat sources (e.g. domestic and industrial waste) to the building or the industrial application. The heat of the natural sources is marked as the low-potential energy.

At this time the heat pumps are very progressive – they can also be used for cooling. Because the heat pumps consume less primary energy than the conventional heating systems, they are very important technology to reducing of gas emissions that harm the environment, such as the carbon dioxide, the nitrogen oxides or the sulphur dioxide.

2. HOW DO HEAT PUMPS WORK?

2.1. Components of heat pump systems

The heat pumps currently in operation are based on two principles – the vapor compression or the absorption cycle. Most of the heat pumps used the principle of the vapor compression cycle. The main components in this system are the compressor, the expansion valve, two coils (the evaporator and the condenser). The volatile liquid, known as the working fluid or refrigerant (see Table 1), circulates through these components and absorbing, transporting and releasing the heat.

What are the functions of the components in the heating systems? The compressor squeezes the molecules of the refrigerant gas together (increasing temperature of the working fluid). The expansion valve lowers the pressure created by the mentioned compressor. This cause the temperature to drop and the working fluid becomes the low-temperature vapor/liquid mixture. The evaporator is the coil in which the refrigerant absorbs heat from the natural heat sources from the surroundings and boils to become the low-temperature vapor. The condenser is the second coil in which the working fluid gives off the heat to its surroundings and becomes the liquid.

R10 – R50	group of refrigerants methane-base
R216 – R290	propane group
R400 – R411B	zoetrope mixture
R500 – R509	unzoetrope mixture
R630 – R631	nitrogen compounds
R702 – R764	inorganic refrigerants

Table 1 – Examples of refrigerants and their devising into groups

2.2. Principle of vapor compression cycle

The heat pumps transfer the heat by the circulating the refrigerant through the cycle of the evaporation and the condensation (see Figure 1). The compressor pumps this working liquid between mentioned coils.

The refrigerant is evaporated at the low pressure and absorbs the low-potential energy from the surroundings in the first coil so called the evaporator. Then the refrigerant is compressed en route to the other coil – so called the condenser – where it condenses at the high pressure. At this point, it releases the heat it absorbed earlier in the cycle.

The heat pumps cycles are fully reversible. This machine can be used yearly – for heating in winter and for cooling and dehumidifying in the summer days. It is the big advantage of the heat pumps.

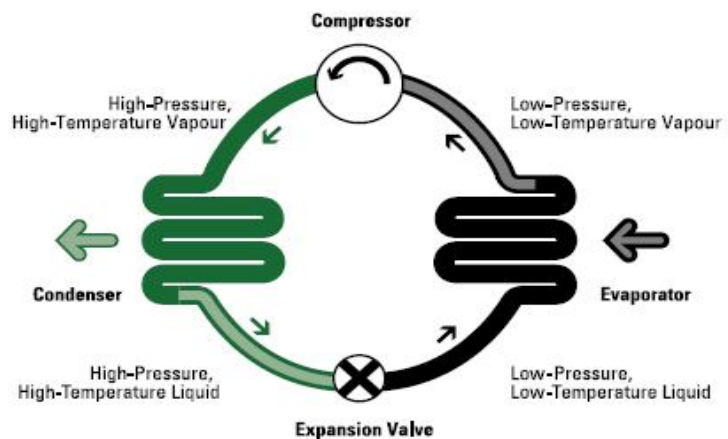


Figure 1 – Basic heat pumps cycle

What about the efficiency of these machines? So called COP (Coefficient of Performance) is the measured of the efficiency. It is determined by dividing the output energy of the device by the electric energy which is needed to run of its compressor. E.g. the ground sources heat pumps have COP from 3.6 to 5.2. What does e.g. COP 4.4 mean? It means that 4.4 kilowatt hours of heat are transferred for every kilowatt hours of electricity supplied to the heat pumps.

2.3. Heat pumps division, heat sources

We can dissociate the heat pumps in the accordance with the heat sources. The ideal heat sources should have the high and stable temperature during the heating time, the low investment and operational costs and the favorable thermo physical properties. It would have been available, not corrosive or polluted.

The most common sources of the low-potential energy are ground, water and air. The ground source heat pumps which are more widely used today have two parts – the circuit of underground piping and heat pump unit. The first part is outside the house and the second is inside the house. It is similar as by the water source heat pumps. Unlike the air sources heat pump is located only outside the house.

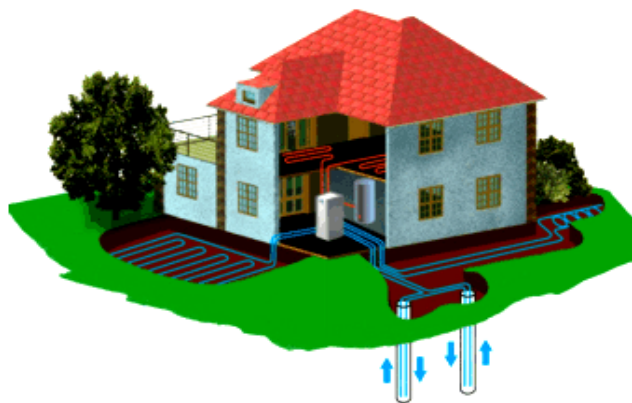


Figure 2 – Arrangements of pipe

Mentioned piping system of the ground source heat pump is either vertical or horizontal what Figure 2 illustrates.

3. HEAT PUMP MARKET IN THE CZECH REPUBLIC

It is very difficult to orient on heat pump market in the CZR. At this time the large numbers of the companies which deal with the problems of the heat pumps are in our republic. The biggest of these companies are associated in two organizations – the Czech Heat Pump Association (see Figure 3) and second is the Alliance heating and cooling tech – section Heat pumps.

These organizations have many ambitions, e.g. the advertising of this heating system, the ordering of the excursions and training, the designing in the field of the heat pumps, consultant activity, and the activities in the sphere of legislature, the cooperation with the governance and with international organization occurring in this area.

The biggest company which is the member of the Czech Heat Pump Association is the company IVT. IVT was established more than thirty years ago. In the Czech Republic it installed first heat pump in 1991.



Figure 3 – Logo of Czech Heat Pump Association

4. HEAT PUMP INSTALLATION IN REGION PLZEŇ AND REGION KARLOVY VARY

The number of the heat pumps increases in connection with the rising prices of the energy. The West Bohemia is not exception to this trend.

Via e-mails I addressed 588 villages (91,73% from sum total villages) in region Plzeň and region Karlovy to find out the number of the heat pumps in the commercial buildings. I got answer from 376 villages. I elicited 34 heat pumps in the commercial buildings from this research (see Table 2).

	Number of villages in region	Number of addressed Villages	Number of villages which answered	Number of villages which answered positive	Number of located heat pumps
Domažlice	84	74	42	2	2
Klatovy	94	84	53	7	9
Plzeň-jih	90	86	52	2	3
Tachovsko	51	48	30	1	1
Plzeň-město	24	19	10	0	0
Plzeň-sever	98	93	61	3	3
Rokycany	68	63	44	1	1
Cheb	40	33	24	3	4
Karlovy Vary	54	52	34	4	11
Sokolov	38	36	26	0	0
Total sum [-]	641	588	376	23	34
Total sum [%]	–	91,73%	63,95%	6,12%	–

Table 2 – Survey of research in agreement with regions

Via web pages I found out other 22 installing the heat pumps. So I learnt about total of 56 installation of the heat pumps in the commercial buildings in the West Bohemia. Most of the heat pumps works in Karlovy Vary and Klatovy region. We can find them e.g. in the Ecocentrum in Boží Dar, in the water preparing plants in Žlutice, in the pension Staré Srní in the homonymic village, in the hotel Ostrý in Železná Ruda, in the municipal office in Červené Poříčí or in Švihov, etc.

5. EVALUATION OF HEAT PUMP OPERATION

For the evaluation I chose the most interesting installation of all above mentioned – the heat pump which works in the water castle of Švihov (see Figure 4). This heat pump is single device in the CZR which works in the listed building.



Figure 4 – Water castle of Švihov

The office building of this castle was heated up through the electric boiler in the past. The bills for the electricity increased that is why Institution for listed buildings decided on the installing the heat pump. The water from the moat which is imminent by the castle is the heat source. The piping system about length of 454 meters was set in the moat when it was emptied. The pipes transpierce the castle wall right to the heat pump (see Figure 5). There is the heat pump IVT Greenline 11 about the power of 10.8 kilowatts.



Figure 5 – Piping system in moat

5.1. Choice of way of heating

The heat pump was only feasible resolution at the time when it was decided about the heating in this building – the electricity was too expensive, the village wasn't in the gas service area, the biomass was too expensive and none too extensive and the solar devices could't locate for the architectural reasons.

5.2. Choice of heat pump sources

At first sight (see Figures 4 and 5) it is unmistakable that the best source is water; let us say horizontal piping system.

Why not use the air source? The reasons are simple. First reason: the unstable temperature of the air within the year and consequently fluctuation in the COP. And second reason: the air source heat pump is located outside the buildings. It was non-permissible in the light of architectonic.

What about the ground sources? We look first in the horizontal piping system. We can count what big space would be need. We start from the assesment of the cooling factor. It equates to division between the power of heat pump and their input. For this heat pump it is:

$$Q_{cooling\ factor} = 10500 - 3600 = 6900\ W \quad (1)$$

The cooling factor is divided by the specific power of the accumulation for the type of the ground in the locality in question (for horizontal system). The result of this dividing is the space:

$$S = \frac{6900}{20} = 345\ m^2 \quad (2)$$

The biggest problem by the horizontal piping system would be also the absence of the space imminent by the castle.

Analogous to this count we can establish the deep of the vertical system – we divide the power of the heat pump by the specific power of the accumulation (for vertical system):

$$h = \frac{10500}{55} = 191\ m \quad (3)$$

The price for the design of the wells is the big problem in the case of the vertical system. One meter of the well costs to the tune of 1000 Czech crowns.

The water source heat pump is the better possibility for these reasons.

5.3. Environmental and economical aspect of heat pump heating

The environmental and economical aspect is important in the context of the evaluation of the heat pump operation.

The heat pumps consume far fewer energy than the traditional heating systems that is why they are fundamental to the reducing of the gas emissions, e.g. the carbon dioxide and the nitrogen oxides. The heat pump heating is also one of the most environmental acceptable.

The economical evaluation was saw through computer program which I got from the Centrum for renewable source and energy reduction. This program operates with host of the parameters – e.g. the prices and heat values of the particular fuels, the reading electrometer, the efficiencies of the devices in the building, etc.

The Table 3 is the program output. It stands to reason that the heat pump is the second best way of the heating for this building.

	Costs [Czech crowns/year]
Light fuel oil	104 869,-
Propane	102 944,-
Electric energy	96 592,-
Remote heat	83 455,-
Coke	83 381,-
Black coal	79 264,-
Wood briquette	77 952,-
Wood pellets	61 226,-
Natural gas	55 685,-
Brown coal	54 485,-
Wood	44 836,-
Heat pump	36 835,-
Biomass	29 610,-

Table 3 – Costs of various heat sources

6. HEAT PUMPS OF FUTURE

The past 10 years have brought the numerous and significant improvements in the performance of the heat pumps. Will the next years bring other increases of these performances? Today we can't say for a certainty what the heat pump of the future will look like and what performances will have. But we can take in that they use in more and more quantities. They will operate not only in the small buildings (family houses) but also in the industry halls, in the hospitals, in the schools, in the zoos, etc. The heat pumps have the future as the parts of the household equipment, e.g. in the clothes dryer.

The newer heat pumps which were developed recently are IVT 495 Twin, MACH IN and the heat pump named CHAMELEON (see Figure 6).

First named heat pump is the new resolution in the sphere of the heating, cooling and warming supply water which will used especially in the low-energy houses. This device will combine the exploitation of the heat of the foul air from the buildings and the ground source.

The heat pump is the “sci-fi” heat pump. We can take control of it at the distance – e.g. via the web pages or via the mobile phones.

The last mentioned heat pump – CAMELEON – is the multifunction machine which is able to heat, cool, operate of the sun blind, regulate of the temperature in the hothouse, etc.



Figure 6 – Heat pump CHAMELEON

7. CONCLUSIONS

This paper deals with the more and more actual and topical problems of utilization of the heat pumps. There are two reasons why this sphere is so important – the increase prices of the energies and the worsening quality of the environment. If we already have the oil or electric heating system, the installing of the heat pump may be very effective way to reduce the energy costs.

At this time the mostly heat pumps is installed in the Norse countries but their number increases also in the Czech Republic which Graph 1 envides.

May be suppose that the most modern heat pumps will developed and that they will extend into more buildings.

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