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Using the heat pumps as a renewable source of energy

SIMONA DUICU
Department of Manufacturing Engineering
Transylvania University of Brasov
500036 B-dul Eroilor, nr.29, Brasov
ROMANIA

Abstract: In the paper are shown some advantages of using heat pumps as a renewable source of energy. Also it is make a short presentation of cooling and heating systems together with the main sources of thermal energy.

Keywords: heat pump, renewable energy, and thermal energy.

1 Principle of cooling systems

Cooling systems and heat pumps are thermal machines, which has the role to take warmth from environment with a lower temperature and to yield it to other environment with upper temperature as it shown in Fig.1. This can be considerate the simplest model cooling system.

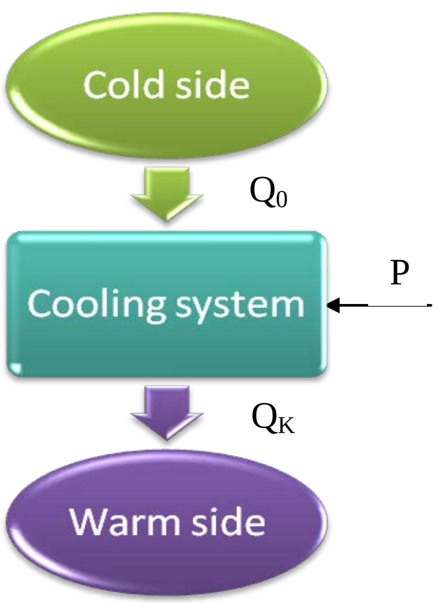

Fig.1 Principle of cooling system.

Because warm and cold source has an infinite thermal capacity, their temperatures remain constant even they are changing heat. The warm flow, which is absorbed from the cold source, is Q0 and the warmth flow yielded to warm source is Q_k.

According with the second low of Thermodynamics, named Increase of Entropy, which it states that heat cannot of itself pass from a colder to a warmer body, for warmth transportation is necessary a energy consumption P.

To can take warmth from the cold source, the cooling medium must have a lower temperature than it.

During this process, the cooling medium can have two types of behavior:

- increase its temperature (Fig.2a);
- maintaining its temperature (Fig.2b).

where:

S is warmth changing surface, t_r is cold source temperature.

To can maintain unchanging the coolant temperature, during the process of taking heat is necessary to transform its state, called *vaporization.*

The absorbed heat Q_0 in both situations is given by [2]:

$$Q_0 = m_1 \cdot c_p \cdot \Delta t \text{ [kJ] (see Fig.2)} \quad (1)$$

or

$$Q_0 = m_2 \cdot r, \text{ [kJ] (see Fig.3)} \quad (2)$$

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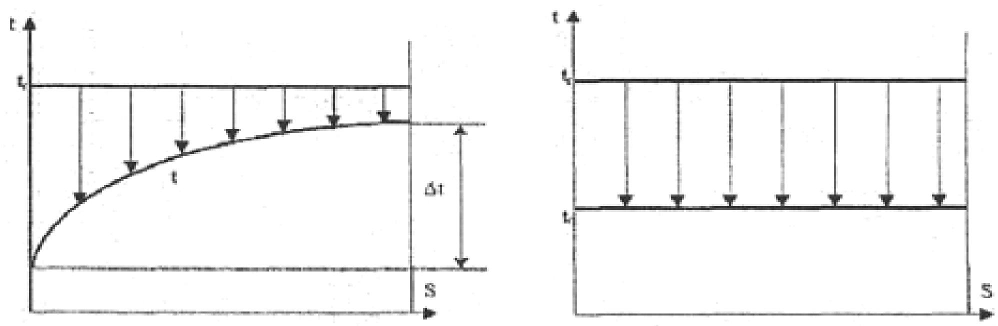


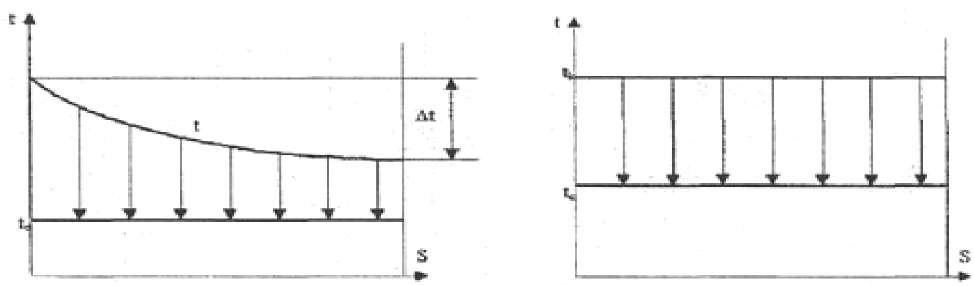
a) b)

Fig.2 Types of cooling medium behavior.

where:
m1 = quantity of coolant which is heated [kg], Cp =
specific warmth [kJ.kg^{-1}.K],
Δt = coolant temperature variation between two stages [°C],
m_2 = quantity of coolant which vaporized [kg],
r = latent vaporization heat of coolant at temperature t_0.

To make an efficient thermal transfer, Δt is limited at a few degrees. To can yield heat to warm source the coolant must have a higher temperature that it. During the process of transfer the heat to the warm source the coolant can have two states of behavior:

- decrease its temperature (Fig.3a);
- maintaining constant its temperature (Fig.3b).



a) b)

Fig.3 States of behavior of coolant during transfer to warm.

The yield heat Q_k is given by [2]:

$Q_k = m_1 \cdot c_p \cdot \Delta t$, *[kJ]*, (Fig.3a) (3)

$Q_k = m_2 \cdot r$ *[kJ]*, (Fig.3b) (4)

where:
m_2 = quantity of coolant which condenses.

To maintain constant coolant temperature during the yield heat process is necessary changing its state, called *condensation.*

2 The main elements of a cooling system

The condensation pressure is higher than that of vaporization. For this reason in this system is consuming energy to increase vapor pressures from *vaporizer* taking heat from cold source till the pressure from condenser where will give heat to warm source. This process is achieved in *compressor.*

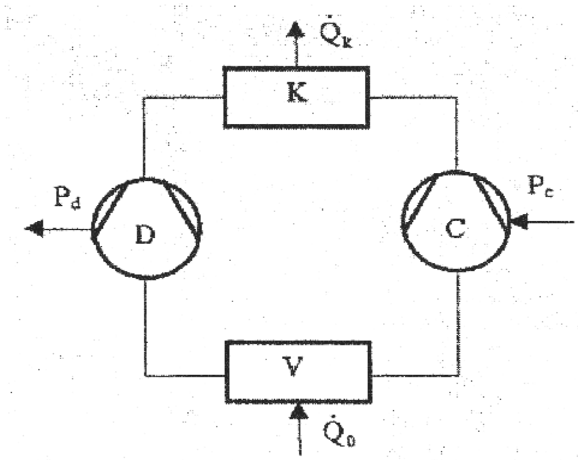


Fig.4 Elements of cooling system.

After compression, the coolant vapors give the heat in *condenser* to cold source and condense when it becomes liquid. From energetic viewing, coolant relaxation is made by *detentor*, that has the advantage of producing mechanical energy and power, which compensates some quantity, needed to compressor. Cooling systems and heat pumps have four main elements: vaporizer (V), compressor (C), condenser (K), and detentor (D), (Fig.4).

3 Comparison between cooling systems and heat pumps

In principle the inverted cycle of function for these two systems is identical. The difference is only temperature heat sources level from that of environment, t_a [°C], respectively T_a [K]. In Fig.5 are shown three schemes of installations, which are working with inverted thermodynamic cycles.

a) Cooling installations with cold source temperature t_r [°C] or T_r [K], equal with vaporization temperature t_0 [°C] or T_0[K], lower than environment temperature t_a [°C] or T_a [K].

b) Heat pump with warm source temperature t_c [°C] or T_c [K], equal with condensation temperature t_k [°C] or T_k[K], higher than environment temperature t_a [°C] or T_a [K].

c) Combined systems, with cold source temperature equal with vaporization temperature, lower than environment temperature.

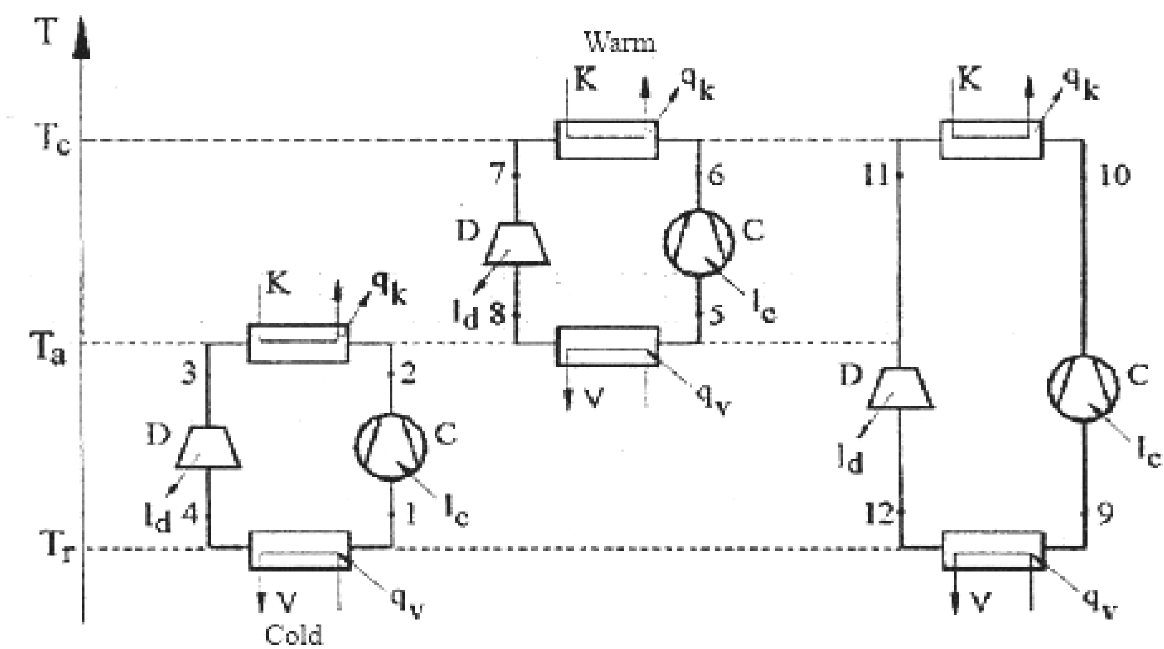


Fig.5 Schemes of installations.

4 Energy sources of heat pumps

Modern electric heat pumps obtain approx. three quarters of the heat required for heating from the environment, the remaining quarter is drawn as electrical power for driving the compressor
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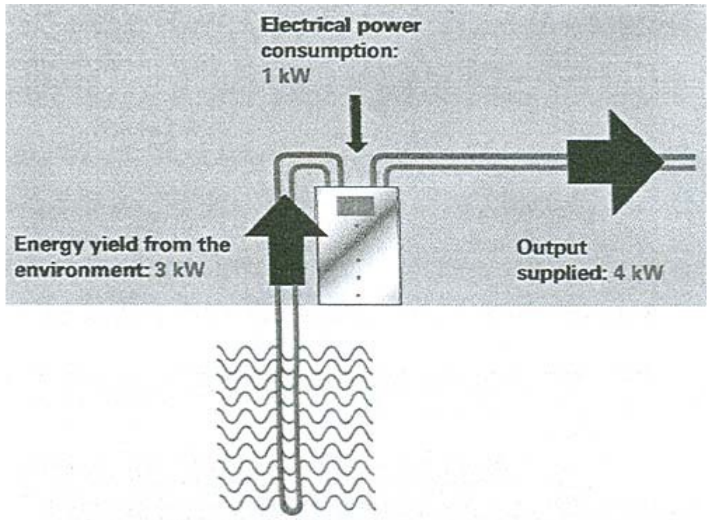

Fig.6 The effectiveness of the heat pump

The performance factor is a result of the ratio between the transferred heating energy (including the compressor heat generated by the electrical power consumption) and the energy used (power supplied to the equipment), which describes the effectiveness of the heat pump (Fig.6).
Irrespective of their type, heat pumps can be viewed as equipment which raises the temperature of a process medium from a low to a higher temperature level using additional energy,
There by making the heat content of the medium useful. The main sources of energy which are used by heat pumps are:

1. Water. The most efficient source for an ecologic heating is underground water, if is to a suitable depth. A constant temperature of 8^0C- 12^0C makes water to be a thermal energy for entire year and a small price. Its efficiency is high and will be transported from the well to heat pump and to drain well situated at 15-m distance (Fig.7).

a) b)

Fig.7 The most efficient source for an ecologic heating.

2. Ground. The ground is a good energy store, as underground temperatures ranging from 7 to 13 °C are relatively even all the year round. The thermal energy can be captured by horizontal collectors or with a probes set vertically into the ground at a depth of 15 m.

(Fig.8). They are efficient even in the night and in wintertime. Ground has the function of heat capture. The pipes which deliver this stored energy via a mixture of water and anti-freeze (brine) to the evaporator of the so-called brine/water heat pump are buried under ground at a depth of between 1.2 m and 1.5 m. These ground collectors are made by copper with thick wall.

a) b)

Fig.8 Capturing the energy from the ground..

3. Air. Outside air offers the least expensive option for exploiting an energy source. Air is supplied via a duct, it is cooled down in the heat pump evaporator and then it is returned to the ambience
(Fig.9). Modern air/water heat pumps can provide heating energy down to an outside temperature of minus 20 °C. However, given optimum sizing at such low outside air temperatures it can no longer meet the central heating demand completely. On very cold days, an electric heater inside the calorific heats the heating water, which was pre-heated by the heat pump, to the selected flow temperature.

a) b)

Fig.9 Exploiting air as energy source.

Growing environmental awareness has focused attention on the utilization of renewable energies. As a consequence, heat pumps are experiencing their own renaissance.

Today, heat pumps provide a reliable, cost-effective and future-proof heating system, which operates with particular environmental responsibility.

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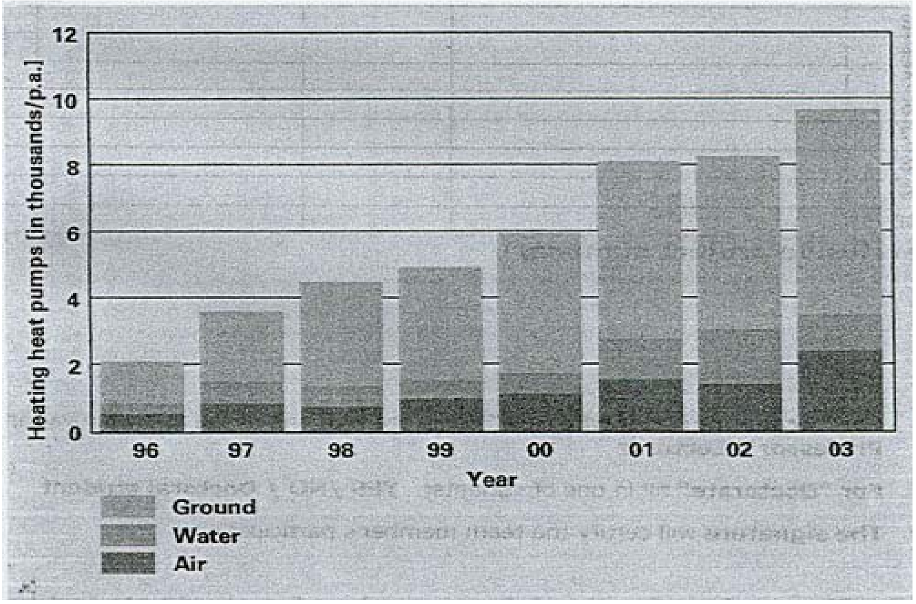

Fig.10 Growth rates for the German market.

In Switzerland today, every third new building is equipped with an electrically operated heat pump; in Sweden 7 out of 10 new buildings rely on a heat pump. Growth rates for the German market, too, are substantial, as shown in Fig.12.

References:
[1] Linden, D – *Handbook of Batteries.* McGraw-Hill, new York, 1995.
[2] Vlisidis, A – *A review of hybrid energy systems for buildings*. Doctoral thessis referate 1, 2006.
[3] Fragiadakis, G – *Photovoltaic systems.* Greek edition, 2004.
[4] Patel, M. – *Wind and solar power systems*. Florida, CRC Press, 1999.
[5] Mochammad Zakir, and ot. – *Stand alone system modeling*. WREC 2002.
[6] Rodolfo, P. – *Parametric analysis of wind sitting efficiency*. Wind engineering, 2003.
[7] Lun, I.Y.F – *A study of Weinbull parameters using long-term wind observations*. Renewable energy 20 (2000).