HEAT-TECHNICAL CHARACTERISTICS OF HEAT PUMP DEVICE FOR HEAT SUPPLY SYSTEMS

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ABSTRACT

This article analyzes the main energy parameters of steam-compressor heat pumps. In this case, the process of dependence of the heating coefficient of the heat pump on the boiling and condensing temperature of the refrigerant is studied and graphs are given. In addition, as a result of exergetic analysis of heat pumps analyzed the state of exergetic efficiency in creating a comfortable environment with high efficiency in the building

Keywords:*heat pump, energy balance, heating coefficient, exergetic profitability ratio, compressor, condenser, evaporator,regulating valve, evaporator temperature, in real device, in ideal device*

One of the most pressing issues is the production of energy using renewable, alternative energy sources and the utilization of secondary energy resources, as well as saving fuel and energy resources.

It is envisaged that the economy will be provided with energy resources by solving two tasks. First, diversify the fuel balance through extensive use of renewable energy resources. This will reduce their contribution to the production of electricity and heat by replacing traditional fuels with renewable energy sources. Second, the implementation of a long-term program to reduce the energy capacity of production in sectors of the economy will be achieved by improving the environmental condition of industrial areas.

One of the modern devices used in energy saving is heat pumps (HP), which simultaneously operate on the basis of energy-efficient and environmentally friendly technology.

According to the International Energy Agency, research on the development of heat pumping devices is currently underway in 15 countries. It is scientifically estimated that the use of heat pumps can reduce the consumption of liquid fuel in the heat supply by up to 70% in the future. Scientific observations and analysis show that the use of heat pumps in air conditioning systems in dry-hot climates provides great energy and economic efficiency. Therefore, the use of heat pumps in order to save energy in the heat and cold supply of buildings is a matter of scientific and technical importance.

Their energy parameters are important in evaluating the efficiency of heat pumps. This article analyzes the main energy parameters of steam-compressor heat pumps. Compressor heat pump produces from 2.5 to 5 kW of heat per 1 kW of electricity. It is known from practice that the high temperature regime of the heat pump in the heat supply system is around 40 ÷ 55 0S. Studies show that the use of heat pumps in heat and cold supply can save up to 70% of primary energy resources. The dynamics of changes in the heating coefficient of heat pumps are determined and analyzed below.

The energy balance of the heat pump is determined as follows:

$$Q_{kond} = Q_{bug'} + L_{kom};$$

In this Q_{kond}, - the heat received in the condenser (condensing heat of the working fluid), kW; $Q_{bug'}$- heat from a low-potential medium in the evaporator (heat received by the working body when it boils in the evaporator), kW; - work consumed in the compressor (power) kW.L_{kom}

The heating coefficient of the heat pump is calculated by the following formula:

$$\varphi = \frac{Q_{kond}}{L_{kom}} = \frac{\alpha \cdot T_{kond}}{T_{kond} - T_{bug'}};$$

There T_{kond} - is the condensing temperature of the working fluid, K; $T_{bug'}$ - boiling point of the working fluid, K; α - is the coefficient taking into account the energy losses occurring in the heat pump.

Based on the above equations of the heating coefficient T_{kond} and $T_{bug'}$ temperature dependence were determined and shown in Figure 1. The results of the calculation show that an increase in T_{kond} leads to a decrease in the φ coefficient. It can be determined that the ideal heating coefficient of heat pumps is $\varphi = 2.5 \div 10$. In a real device, the φ is around $1.8 \div 6.0$.

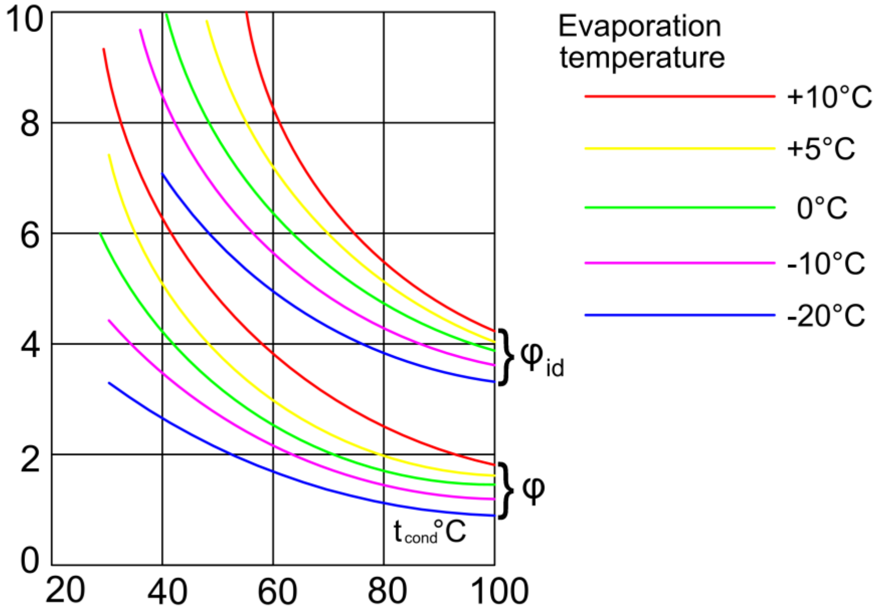

Figure 1. The dependence of the heating coefficient of the heat pump on the boiling and condensing temperature of the refrigerant.

The computational analysis performed shows that the greater the heat released during condensation of the working fluid and transferred to the environment, the higher the heating coefficient of the heat pump unit. Based on the observations, it can be concluded that in summer mode, ie in air conditioning mode, when the ambient temperature reaches +40 - +50 °C, the heat exchange between the working fluid vapor (freon) and air is greatly reduced and stopped. Therefore, in the condenser section of the heat pump there is a problem of creating an environment of 20-30℃ in summer. This situation is observed in the winter mode of the heat pump (heating mode) when the outside air temperature is -10 ℃ and below.

The energy efficiency of a compressor heat pump is evaluated by the heating coefficient (φ). also referred to as the φ -heating coefficient or heat transfer coefficient.

$$\varphi = \frac{q_n}{l} = \frac{q_{C_0} + l}{l} = \varepsilon + 1$$

Here ε -reverse is the cooling coefficient of the Carnot cycle

If we express by temperatures:

$$\varphi_F = \frac{T_k}{T_k - T_{C_o}} \alpha;$$

α - the coefficient takes into account all the losses of the cooling cycle. α = 0.3-0.4.

The exergetic **profitability ratio** of the heat pump is calculated by the following formula.

$$\eta_e = \frac{l_{qk}}{l} = \frac{q_k \tau_e}{l} = \varphi \tau_e$$

$$q = l_q + a_q;$$

l_q-exergy, a_q-a energy

$$l_q = \frac{q(T - T_0)}{T} = q\tau_e;$$

$$l_q = \frac{qT_0}{T} = q(1 - \tau_e);$$

In this case, l_{qk} is the specific exergy of the heat flux in the condenser. φ -heat pump conversion factor.

For the ideal cycle of HP, $T_k = T$ and $T_{C_o} = T$ = To $\eta_e = 1$. The exergetic profitability ratio of any real device, including a heat pump, is suddenly smaller and is an indicator of its perfection.

The **main elements** of the heat pump include:

1) compressor.

2) capacitor.

3) evaporator.

4) adjusting valve.

These devices are interconnected by a system of hermetic pipes in which the working fluid circulates.

The difference in the evaporator increases in return:

$$q_{cd} = i_4 - i_5 = i_1 - i_7;$$

$$q_{co} = i_7 - i_6;$$

q_{co}- heat received by the evaporator working body;

The heat released in the condenser is the useful heat of the heat pump, which is equal to the following

$$q_n = i_2 - i_3;$$

The heat released by the condensate in the refrigerator

$$q_{ck} = i_3 - i_4;$$

Internal specific work performed on the compressor:

$$l_i = i_2 - i_1 = (i_2^1 - i_1)/\eta_i;$$

Comparative performance of electric compressor drive:

$$l = \frac{l_i}{\eta_{em}} = \frac{(i_2^1 - i_1)}{\eta_i \eta_{em}};$$

η_i-internal profitability ratio of the compressor .

We find the change coefficient (**heating coefficient**) of the heat pump:

$$\varphi_F = \frac{q_k + q_{cu}}{l};$$

or

$$\varphi = \frac{Q}{N};$$

In this case, the total heat released from the Q -heat pump, heat capacity, kW.

N - Heat pump compressor drive power, kW,

Mass consumption of the working fluid circulating in IN [26]:

$$G_a = \frac{3.6Q}{q_k + q_{cu}};$$

The operation of the heat pump is evaluated by the exergetic method.

To do this, the exergetic balance equation of the device is constructed.

The exergetic balance equation of the heat pump is as follows:

$$l + l_{q_{co}} = l_{q_u} + l_{cu} + \sum d_e$$

Exergic balances are the exergys that are transferred to and from the cycle in all elements of the device using the equation. Based on the results of exergetic analysis, it will be necessary to carry out improvements to increase the energy efficiency of the heat pump.

Exergetic profitability ratio of the heat pump.

$$\eta_{enn} = \frac{(q_u + q_{cu})\tau_{eco}}{l + q_{co}\tau_{eco}};$$

Exergetic analysis of heat pumps shows that exergetic profitability ratio gives high efficiency because it is larger than 1.

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