APPLICATION OF HEAT PUMPS IN COMBINED SYSTEM IN RESIDENTIAL BUILDINGS FOR HEATING, HOT WATER SUPPLY, AIR CONDITIONING AND VENTILATION

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Abstract

This article discusses one of the effective ways to save fuel and energy resources is the use of environmentally friendly non-traditional renewable energy sources, and first of all, solar energy accumulated in the soil, water bodies, air. However, the frequency of action and the low temperature potential of these sources do not allow using their energy for heating buildings directly, without conversion. Heat pumps are used as converters of thermal energy from an energy carrier with a low temperature to an energy carrier with a higher temperature.

Keywords: Heat supply, economy, fuel, energy, resource, non-traditional, pollution, periodicity, accumulated, boiler and individual, furnace, unit.

Introduction

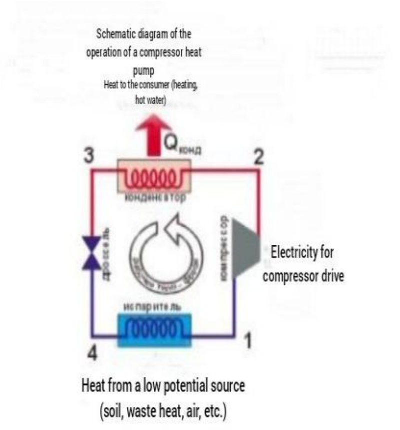
At present, our republics, as well as the whole world, are facing two interrelated problems: saving fuel and energy resources and reducing environmental pollution. In the context of the depletion of fossil fuel reserves and a sharp increase in the cost of developing new deposits, it is becoming more and more irrational to burn coal, gas and oil products in millions of low-power boiler houses and individual furnace units, causing a large amount of harmful emissions into the atmosphere and a significant deterioration in the environmental situation in cities and the world. [L.1;,2;,3;,4;].

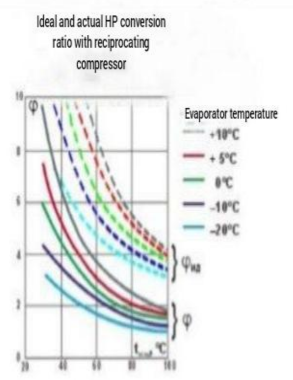
Goals and objectives. One of the effective ways to save fuel and energy resources is the use of environmentally friendly non-traditional renewable energy sources, and first of all, solar energy accumulated in the soil, water bodies, and air. However, the frequency of action and the low temperature potential of these sources do not allow using their energy for heating buildings directly, without conversion. Heat pumps are used as converters of thermal energy from an energy carrier with a low temperature to an energy carrier with a higher temperature. The heat pump is an inverted refrigeration machine and allows you to generate heat energy using low-grade heat from secondary energy resources and non-traditional renewable energy sources. The use of heat pumps allows saving up to 70% of traditional energy resources.

Scientific novelty. Currently, heating and hot water supply of urban facilities is carried out, as a rule, from centralized heat supply systems. The source of thermal energy in such systems is urban CHPPs, which carry out combined generation of electricity and heat, or district boiler houses. The benefits of district heating are widely recognized. From a thermodynamic point of view, the combined production of electricity and heat in CHP plants is much more efficient than the separate production of electricity in condensing thermal power plants and heat in boiler houses. Russia is a recognized leader in terms of the scale of use of centralized power and heat supply systems. In many countries, the construction of thermal power plants, following the example of Russia, is considered as an effective means of saving energy and reducing the negative impact of energy facilities on the environment.

The practical significance of the work. However, the use of district heating systems has its drawbacks and limitations. The construction of extended heating mains to remote facilities, as well as to facilities in areas with low building density, is associated with significant capital investments and large heat losses along the route. Their operation subsequently also requires high costs. Serious problems also arise in the reconstruction of existing facilities and the construction of new ones in populated urban areas with dense buildings. In these cases, an increase in heat loads creates often insurmountable difficulties for the developer, including financial ones, in obtaining and implementing technical conditions for connection to the district heating network.

Object of study. The current tariffs for thermal energy, combined with the costs of connecting to city heating networks, make it increasingly necessary to think about alternative methods of heat supply. Heat pump systems of heat supply seem to be one of the most effective alternative means of solving the problem. From a thermodynamic point of view, heat supply schemes based on heat pumps are in most cases even more efficient than from CHPs and individual boiler houses. Heat pumps are widely used for heating residential and office buildings in the USA, Sweden, Canada and other countries with similar climatic conditions to Russia. According to the forecast of the World Energy Committee, by 2020 in the advanced countries the share of heating and hot water supply with the help of heat pumps will be 75%. The experience of using heat pumps in Russia is also expanding. Heat and cold supply with the help of heat pumps belongs to the field of energy-saving environmentally friendly technologies. This technology, according to the conclusion of a number of authoritative international organizations, along with other energy-saving technologies, belongs to the technologies of the 21st century [L.3;,4;].





A schematic diagram of a compression heat pump is shown in fig. 1. The essence of his work is as follows. In the heat pump evaporator, heat of a low temperature potential is taken from some source of low-grade heat and transferred to the low-boiling working fluid of the heat pump (freon). The resulting steam is compressed by a compressor. At the same time, the steam temperature rises, and the heat at the desired temperature level in the condenser is transferred to the heating and hot water supply system. In order to close the cycle performed by the working fluid, after the condenser it is throttled to the initial pressure, cooled to a temperature below the source of low-grade heat, and again fed into the evaporator. Thus, the heat pump carries out the transformation

of thermal energy from a low temperature level to a higher level required by the consumer. At the same time, mechanical (electrical) energy is expended on the compressor drive. [L.3;,4;,5;]
If there is a source of low-grade heat with a more or less high temperature, the amount of heat supplied to the consumer is several times higher than the energy consumption for the compressor drive. The ratio of useful heat to the work expended on driving the compressor is called the conversion factor of the heat pump, and in the most common heat pump systems it reaches 3 or more. Typical dependences of the ideal and real heat pump conversion factors on the temperature of the condenser and evaporator are shown in fig. 2. It can be seen that, for example, at an evaporator temperature of 0°C and a condenser temperature of 60°C, the conversion factor of a real installation reaches 3. With an increase in the temperature of the low-potential heat source or with a decrease in the temperature required by the consumer, the conversion factor increases and can reach 4, 5 and greater values.

Obviously, the use of heat pumps is especially effective in the case of using air systems or underfloor water heating systems, for which the temperature of the heat carrier does not exceed 35-40 ° C. Recently, heating systems using modern heat exchangers with high heat transfer coefficients and, accordingly, allowing the use of coolant with low temperatures have been increasingly used.

The key issue on which the efficiency of heat pumps largely depends is the question of the source of low-potential heat. As low potential sources of heat can be used:
a) secondary energy resources
- heat of ventilation emissions;
- heat of gray sewer drains;
- waste heat of technological processes.
b) non-traditional renewable energy sources:
- heat of the surrounding air;
- heat of groundwater;
- heat of reservoirs and natural water flows;
- heat of solar energy;
- is the heat of the surface layers of the soil.

An ideal option for heat pumps is the presence of a source of waste heat from an industrial or municipal enterprise close to the consumer. In our business environment, such cases are not uncommon. However, these cases should be considered as special cases. [L.3;].

Soil heat can be used as a fairly universal source of low-potential heat. It is known that at a depth of 4-5 m or more, the soil temperature is practically constant throughout the year and corresponds to the average annual temperature of atmospheric air. In the climatic conditions of central Russia, this temperature is + 5–8 ° C., which is quite good for use in heat pumps. The surface layers of the soil (up to 50 - 60 m) are a fairly versatile and widely available source of low potential heat. Wells-heat exchangers can be built under the foundation of the building or in close proximity to it. At the same time, such systems do not require a noticeable alienation of land.

The thermal modes of operation of ground heat exchangers can be significantly improved by using, along with the heat of the ground, the heat recovered from ventilation emissions, the heat of liquid effluents, and, in some cases, solar energy. [L.4;].

In the designs of new buildings, the fulfillment of the requirements for increasing the thermal insulation of enclosing structures (walls, windows) leads to the fact that the main source of heat loss is ventilation emissions, and increasing the tightness of buildings due to the use of double-glazed windows requires the introduction of new technical solutions for organizing controlled air exchange in rooms . This means that supply and exhaust ventilation systems are increasingly being used. Consequently, technical possibilities are being created for organizing the utilization of thermal emissions and returning heat to the building. Compared to the well-known air heat exchangers and heat recovery units, heat pump installations allow for a deeper and, most importantly, year-round utilization of the heat of the air leaving the building, since heat recovery in this case is carried out by a heat carrier with a lower temperature.

The utilized heat of ventilation emissions, liquid effluents and the heat obtained in the simplest solar collectors should be sent to the ground to replenish the heat intensively “pumped out” from the ground in winter, thereby restoring or even increasing its temperature potential.

The accumulated long-term experience in the design, creation and practical operation of heat pump heat supply systems, feasibility and design justifications for their implementation in real small and large construction projects located both in dense urban areas and in rural areas, testify to the wide possibilities effective application of heat pump systems and providing with their help noticeable economic, energy-saving and environmental effects. [L.2; 4;, 5;].

For example: a heat pump with a SEER of 3.0, compared to a boiler with an annual efficiency factor of 90% (an extremely high and difficult level to achieve), emits 40% less CO2 into the atmosphere than a boiler of the same capacity over a similar time period .

The introduction of heat pumps also leads to a decrease in other harmful compounds (table 1.1)
Table 1.1.
Comparative assessment of harmful emissions for the heating season (5448 hours) from various heat sources with a thermal power of 1.16 MW

Type of harmful emissions, t/year	Boiler house on coal	Electric heating	Heat pump, with an average annual factor of 3.6
SOx	21,77	38,02	10,56
NOx	7,62	13,31	3,70
solid particles	5,8	8,89	2,46
Fluorine compounds	0,182	0,313	0,087
Total	34,65	60,53	16,81

Thus, the use of systems based on heat pumps is in many cases an economically justified solution, leading both to saving non-renewable energy resources and protecting the environment, including by reducing CO2 emissions into the atmosphere. [L.5;6;].

Conclusions

An additional potential for increasing the efficiency of using heat pumps also lies in the possibility of their implementation not only for heating and hot water supply, but also for air conditioning, including control and management of indoor air humidity and in a number of technological processes. This is done with the help of reversible heat pumps, in which the direction of the heat flow can be changed.

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