BASING THE EFFECTIVENESS OF UTILIZATION OF SEWAGE WATER HEAT BASED ON HEAT PUMP DEVICES IN AUTONOMOUS HEAT SUPPLY

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Abstract. In the world, there are strong trends in the use of renewable energy sources in the creation of energy-efficient systems of management of heat and fuel-energy resources.

In this article, the authors used traditional methods such as technological parameters of heat pumps, experimental research, thermal engineering and calculation of the amount of sewage water and heat capacity to calculate the efficiency of utilization of sewage heat and its use in heat supply systems. As a result, it was determined that the overall efficiency of the system when heat pumps are used in autonomous heat supply systems is 4.

Key words: heat supply systems, energy efficiency, technological parameters, heat pumps, autonomous heat supply systems.

Introduction. Taking into account the picture of population growth, providing the population with quality and reliable energy units is a problem of human development. The use of energy is a sign of the strength of the scientific, technical, and economic management of society, which allows it to realize the level of its ventilation [1-5].

The energy needs of the countries of the world are increasing year by year.

Currently, the development of energy supply and meeting the need for energy resources is mainly carried out at the expense of coal, oil, gas, and nuclear energy. The lack of relative reserves of organic resources (except for coal) now creates the problem of a stable, high-quality, and reliable supply of energy units to consumers. In particular, there are serious problems related to heating and hot water supply systems of objects in rural areas heating of residents' homes, stable and reliable supply of natural organic fuels (natural gas, coal), and their savings. It is known that 40-45 percent of the energy produced in our Republic is spent on heating and lighting buildings. According to experts in the field, 360-450 kWh of energy is used on average for heating 1 m^2 of buildings in Uzbekistan, where the climatic conditions are suitable for us, and 160-240 kWh of energy is used in developed countries. indicators increase with the improvement of the lifestyle of the population. Therefore, in several decrees and decisions of the President of the Republic of Uzbekistan, the introduction of modern energy-efficient and energy-saving technologies, the development of renewable energy sources, and the provision of environmental stability are priorities and tasks defined [6-10].

Energy efficiency in heat supply systems through the use of geothermal, underground heat, and heat pumps in heat supply systems is one of the most promising innovations and is receiving great attention worldwide.

Methods and materials. In this article, the authors determined the heat of sewage water and the technological parameters, quantities and heat capacities of heat pump devices using traditional methods such as experimental research, thermal engineering and calculation.

An autonomous heat supply is a system that provides heat for heating and hot water supply in buildings and structures without connection to centralized heat sources. The main principles and elements of autonomous heat supply include the following aspects:

Autonomous energy supply systems for consumers are becoming popular today.

In autonomous heat and hot water supply systems, the following sources are the main sources of heat:

Gas boilers: The most common heat source in stand-alone systems. They can be either wall-mounted or floor-standing.

Solid fuel boilers: Use wood, coal, pellets and other solid fuels. They require more frequent maintenance, but can be more economical in some cases.

Electric boilers: Easy to install and operate, but can be expensive to operate when electricity rates are high.

Heat pumps: Use heat from the environment (air, ground, water) for heating. They have high energy efficiency, but the initial cost can be high. Heat pumps are devices that transfer heat from one source to another using the principle of thermal movement. They can effectively heat buildings and hot water by extracting heat from the environment (air, ground, or water) and transferring it to the heating system.

Heating systems.

Radiator systems: Radiators transfer heat to the rooms. They can be made of various materials, such as steel, aluminum or cast iron.

Underfloor heating: Systems that provide an even distribution of heat over the floor surface. Can be water or electric.

Convectors and infrared heaters: Offer alternative heating methods that can be used depending on the requirements and characteristics of the room.

Due to the decrease in the reserves of traditional energy sources all over the world, it is possible to achieve energy resource savings by using renewable energy sources and utilizing secondary energy resources, underground heat [10-15].

Geothermal energy source temperature is 40÷50°C, and low-potential energy sources (underground heat, soil, sewage water heat) cannot be used as the main heat source in heat supply systems when it drops below 10÷25°C. Heat pump devices can be used to transfer heat from a low-temperature source to a high-temperature source, which allows to provide the high temperature required for the heat supply system.

Over the past decade, the installation and use of geothermal energy sources and geothermal heat pumps in heat supply systems have grown significantly worldwide, with an annual growth rate of almost 10%. While most of this growth has occurred in the United States and Europe, interest is increasing in other countries such as Japan and Turkey [16].

The system of installation of geothermal energy sources and geothermal heat pumps and their use in heat supply systems is divided into the following three systems according to the purpose or method of obtaining heat [17-23].

Calculating the energy efficiency of an autonomous heating system that uses wastewater heat with a heat pump involves several key steps. These steps help determine how efficiently the system uses wastewater heat for heating and hot water supply. Here's how to approach the calculation and algorithm development:

Results. Calculation of potential thermal energy of wastewater. The energy that can be extracted from wastewater is calculated using the formula:

$$Q_{ww} = V_{ww} \cdot \rho_{ww} \cdot c_p \cdot \Delta t, kW \qquad (1)$$

V_{ww}— volumetric flow of wastewater (m^3/h); ρ_{ww}— density of wastewater (kg/m^3, for water usually about 1000 kg/m^3); c_p— specific heat capacity of wastewater (kJ/(kg °C), for water about 4.18 kJ/(kg °C)); Δt — temperature difference between wastewater and the environment (°C).

Calculation of energy obtained from a heat pump.

The energy obtained from a heat pump is determined by the formula:

$$Q_{out} = \eta_{COP} \cdot N \qquad (2)$$

η_{COP} –heat pump efficiency; N –electric energy consumed by the heat pump (kWh).

The electrical energy consumed by the heat pump can be found from the equation:

$$N = \frac{Q_{out}}{\eta_{COP}} \qquad (3)$$

We calculate the total heat balance of the system as follows:

We can calculate the total heat balance according to the following equation:

$$Q_{tot} = Q_{ww} \qquad (4)$$

We calculate the energy efficiency of the system using the following formula:

$$\eta_{sys} = \frac{Q_{out}}{N+N_{aux}} \qquad (5)$$

here, N_{aux} – auxiliary energy costs (e.g. for pumps or auxiliary systems).

The overall energy efficiency of the system depends on the ambient temperature, sewage water temperature, COP of the heat pump, and the temperature difference. The calculation results are shown in Table 1.

Table 1.

Energy efficiency of the system

No	Wastewater temperature, °C	Outside air temperature, °C	Volume of wastewater, m³/hours	Q_{ww}, kW	N (η_{COP} = 4), kW	N (η_{COP} = 5), kW	η_{sys}
1	20	10	25,6	1070,08	267,52	214,016	4
2	22	10	25,6	1284,096	321,024	256,8192	4
3	23	10	25,6	1391,104	347,776	278,2208	4
4	24	10	25,6	1498,112	374,528	299,6224	4
5	25	10	25,6	1605,12	401,28	321,024	4
6	26	10	25,6	1712,128	428,032	342,4256	4
7	27	10	25,6	1819,136	454,784	363,8272	4
8	28	10	25,6	1926,144	481,536	385,2288	4
9	29	10	25,6	2033,152	508,288	406,6304	4
10	30	10	25,6	2140,16	535,04	428,032	4
11	31	10	25,6	2247,168	561,792	449,4336	4
12	32	10	25,6	2354,176	588,544	470,8352	4
13	33	10	25,6	2461,184	615,296	492,2368	4
14	34	10	25,6	2568,192	642,048	513,6384	4
15	35	10	25,6	2675,2	668,8	535,04	4

Conclusion. This algorithm and calculations will help you understand how efficiently the system uses wastewater heat and evaluate its potential capabilities and economic benefits.

The ambient temperature is 10 °C, the amount of sewage water is 25.6 m³/hours, Q_{ww} and N change due to the temperature change of the sewage water. In any case sets $\eta_{sys} = 4$.

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