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ANALYSIS OF THE ENERGY PARAMETERS OF THE HEAT PUMP HEAT SUPPLY SYSTEM OF ENERGY EFFICIENT BUILDING

Abstract: *In order to further increase the energy efficiency of the experimental building, field experiments were conducted to maintain the proper thermal regime of its premises when using a heat pump heating system. The paper presents the results of experimental studies of the operating parameters of the heat pump heat supply system of an energy-efficient building of the Institute of Engineering Thermophysics of the National Academy of Sciences of Ukraine. The given analysis of the energy efficiency of the operation of the "soil-water" type heat pump in the nominal mode with the maximum load showed a high value of the energy conversion coefficient.*

Keywords*: heat pump, heat supply, coefficient of performance (COP).*

Introduction

Increasing the energy efficiency of heat supply systems using renewable energy sources [1] is a priority direction in the development of modern construction sector. The overall energy efficiency of the buildings is inextricably linked to its infrastructural support systems for supporting of the comfort human life. At the same time, the air conditioning of the premises in accordance with the proper sanitary and hygienic requirements is the main requirement for the possibility of a person's long-term stay inside premises of the building.

Literature review

The object of experimental research is the heat pump system of heat supply of an energy-efficient house [2-6], which simply consists of ground and heating circuits, as well as an intermediate circuit connecting the heat pump and the heat storage tank.

Problem formulation

The main aim of the article is to demonstrate the possibility of integration of the energy-efficient heat pump heat supply system into new construction sites and during thermal modernization of existing buildings of various types and purposes.

Object, subject, and methods of research

The energy-efficient building is a three-story building with a basement located on the territory of the Institute of Engineering Thermophysics of the National Academy of Sciences of Ukraine in Kyiv with a heating area of 306 m² and an estimated specific energy consumption for heating and hot water supply of approximately 14.8 kWh/(m²·year) [7-10]. At the same time, the heat pump has a capacity of 6.1 kW.

The soil circuit consists of a horizontal soil heat exchanger – a group of multi-pass and coil heat exchangers connected in parallel, made of polyethylene pipes 40x3.2 mm and 32x2 mm, located next to the house at a depth of 2.2 m. The site of their location has a surface area of about 180 m². The heat carrier in the soil circuit is a 30% aqueous solution of propylene glycol.

The intermediate circuit is made of a polypropylene pipe 40x6.7 mm filled with treated water. The tank-accumulator is designed for hydraulic decoupling of circuits of heat sources and consumers. It is a heat-insulated cylindrical container with a volume of 300 liters with coil heat exchangers inside.

The heating circuit consists of a set of heating devices connected in parallel, which includes water-heated floors of various configurations (including the so-called capillary floor heating device), coils in the walls of the house, as well as water-air heating devices (fan coils). The heat carrier used is prepared water.

The circulation of heat carrier in each of the above-described circuits is made by pumps with the possibility of adjusting their pressure-flow characteristics. Hourly measurements during the day in each of the circuits of the amount of heat, the volume of the heat carrier, as well as its temperature values in the supply and return pipelines were carried out by Sharky 773 heat meters (optionally every 10 minutes). For further analysis, recalculation of thermal power and volume flow was carried out, taking into account the dependence of the thermophysical properties of the heat carrier on changes in its temperature.

Study results and their discussion

The values of the heat carrier parameters in each of the circuits in one of the operating modes (nominal heat load) are shown below.

In Figure 1 shows the operating parameters of the soil heat exchanger circuit.

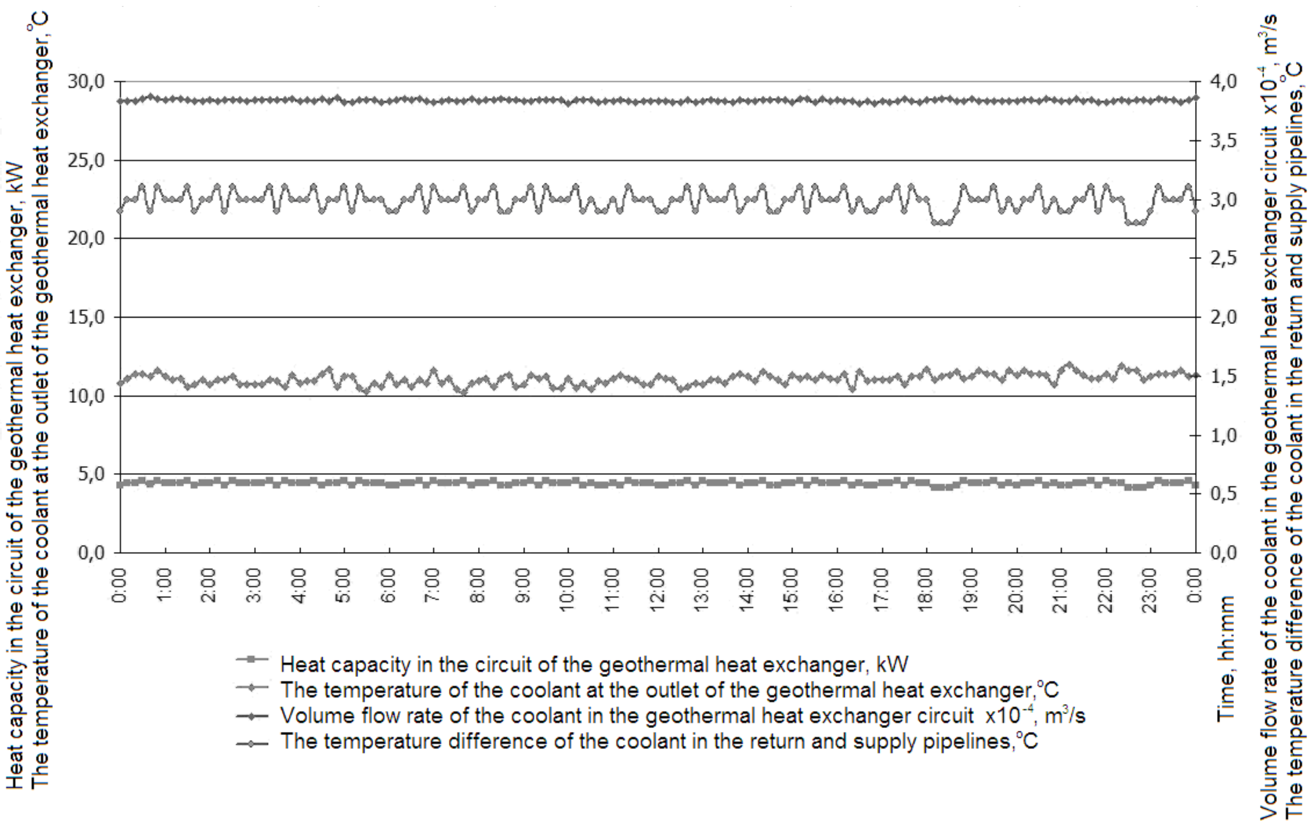

Figure 1. *Operating parameters of the soil heat exchanger circuit*

In Figure 2 illustrated operating parameters of the circuit heat pump – heat storage tank.

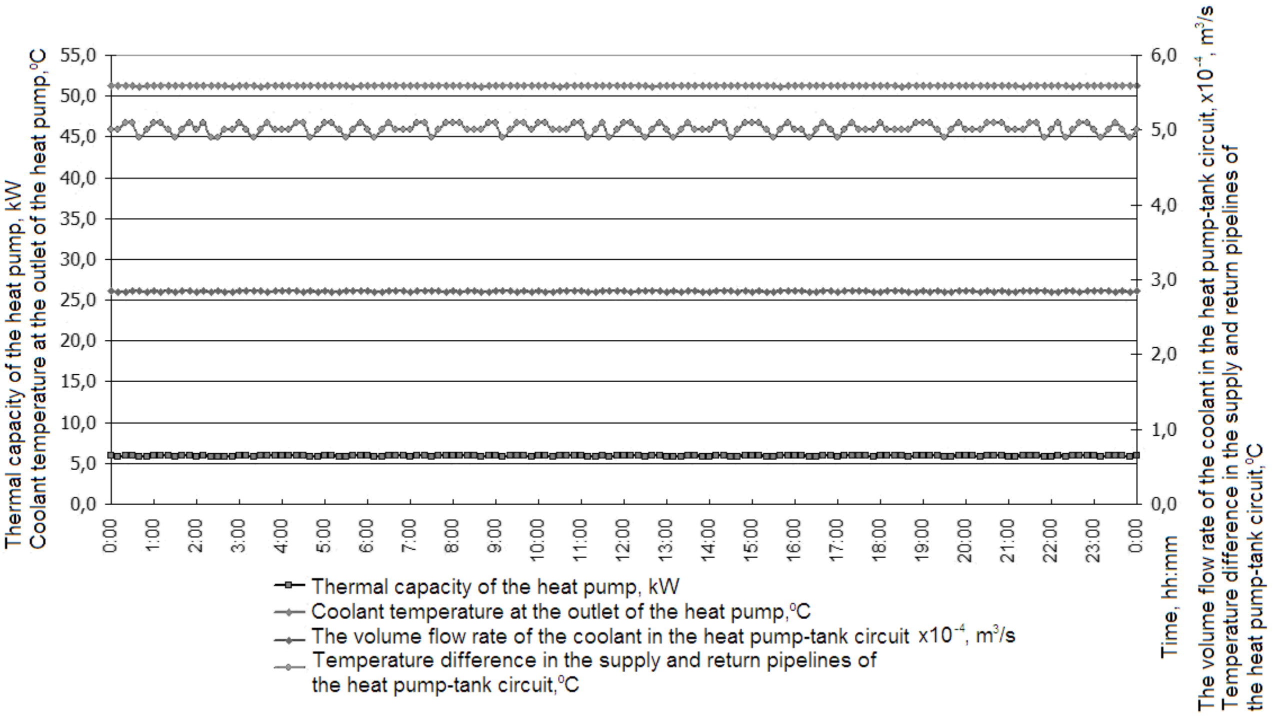

Figure 2. *Operating parameters of the circuit heat pump – heat storage tank*

In Figure 3 shows the operating parameters of the heating circuit.

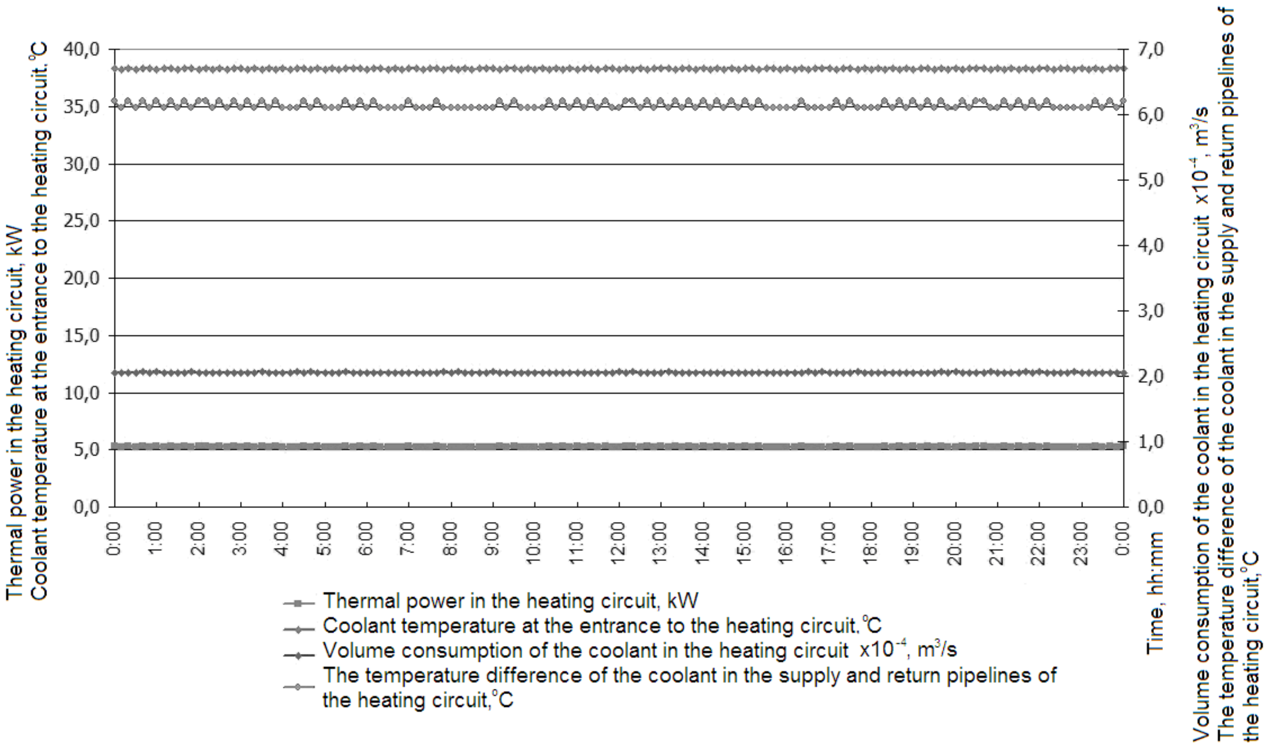

Figure 3. *Operating parameters of the heating circuit*

The calculation of the coefficient of heat transformation of the heat pump (COP – Coefficient of Performance) in the mode of its constant full load based on the balance of the amount of transferred heat

$$\mathrm{COP} = Q_1/(Q_1 - Q_2) = 5.90/(5.90 - 4.42) = 3.98$$

where:
Q_1 – the average daily value of the thermal power of the heat pump-tank circuit, kW;
Q_2 – the average daily value of thermal power of the geothermal circuit, kW.

At the same time, by definition, based on the law of energy preservation

$$COP = Q_1/N_{el} = 5.90/1.66 = 3.55$$

where:
N – the total average daily electric power consumtion by the heat pump, kW.

The amount of electricity consumed by the heat pump and circulation pumps was measured using an electric power inverter with its own meter.

Conclusion

A short analysis of the operation of the heat pump in the nominal mode showed its high energy efficiency due to its use as a source of low-potential heat of the soil massif, and as consumers – low-temperature heating systems.

The thermal regime with appropriate characteristics, which was created in the laboratory premises of an energy-efficient building with the help of heat pump technology, made it possible to conduct a number of experimental studies of the thermal parameters of various types of double-glazed windows and window profiles within the framework of the implementation of project No. 208/0172 of the National Research Foundation of Ukraine of the competition "Science for the Recovery of Ukraine in the War and Post-War Periods".

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