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[1]V. M. Sineglazov,
[2]M. O. Heleveria

COMPUTER-AIDED DESIGN OF DISTRICT HEATING SYSTEMS BASED ON HEAT PUMP

Aviation Computer-Integrated Complexes Department, National Aviation University, Kiev, Ukraine
E-mails: [1]svm@nau.edu.ua, [2]yaizkieva@gmail.com

Abstract—*The basic heating problem. A review of computer-aided design. Possible universal computer-aided design of heating system based on heat pump.*

Index Terms—Heating system; heat pump; computer-aided design.

I. INTRODUCTION

The heat pump is a multifunctional device that combines the functions of the boiler, hot water springs and air conditioning. The main difference from all other sources of heat is an exceptional opportunity to use renewable energy to low-temperature environment for heating and hot water. Projected World Energy Committee in 2020 in the developed world will be heating using heat pumps. The heat pump uses the heat dissipated in the environment of land, water, air. Spending 1 kW of electricity to drive the pump, you can get 3.4 kW of heat energy. Heat pump installations, making reverse thermodynamic cycle in low-labor matter, revolving low potential draw heat from the environment, increase its capacity to the level required for heating, spending 1.2 ... 2.3 times less primary energy than the direct combustion of fuel. The use of heat pump installations – this non-renewable energy savings and environmental protection, including by reducing CO_2 emissions (greenhouse gas) into the atmosphere. Heat pumps came from the depths of refrigeration and are usually created and produced by the plant refrigeration engineering. This is one of the most important intersections of technology of low temperature energy. The most important feature of heat pump systems – flexibility with respect to the type of energy used (electrical, thermal). This allows you to optimize the fuel balance of energy sources by substituting a scarce energy resources less scarce. Relatively few heat pumps are currently installed in industry. However, as environmental regulations become stricter, industrial heat pumps can become an important technology to reduce emissions, improve efficiency, and limit the use of ground water for cooling. The source of low-grade thermal energy can be heat, both natural and artificial origin. As natural sources of low-grade heat can be used:

– heat of the earth (ground heat);
– ground water (groundwater, artesian, thermal);
– outside air.

As an artificial low-grade heat sources may be:

– ventilation air;
– sewage (wastewater);
– Industrial discharges;
– heat processes;
– household heat.

Heat pump technology is already familiar with the example of a conventional refrigerator. In the closed heat pump circuit heat is transferred and transported by the refrigerant. You may wonder where the real heat gain takes place which is so typical for heat pumps? The answer is simple: in the evaporator! Evaporator brings the liquid refrigerant even at low temperatures to a boil, evaporating and stores the gained energy. The refrigerant is no longer liquid, but in gas form. What happens now? The refrigerant volume is reduced in the compressor downstream where the pressure is increased and hence also the refrigerant's temperature. The hot refrigerant then flows on to the condenser, or heat exchanger in which the environmental gained heat is transferred to the heating system. The refrigerant has now cooled down. After temperature and pressure loss it can again pass through the expansion valve, taking up new heat from the environment. So the cycle begins all over again.

Heat pump technology can be considered in the following diagram (Fig. 1).

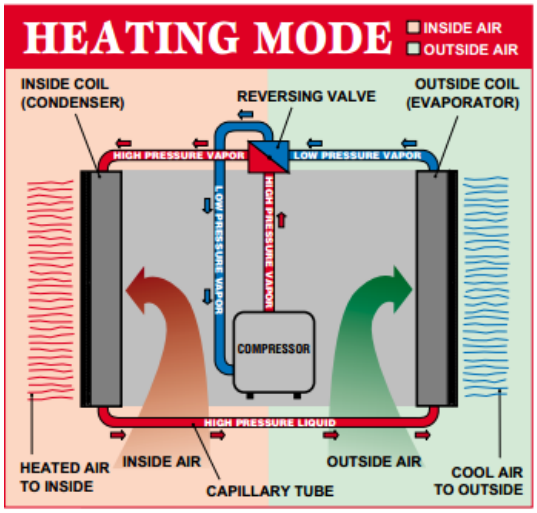

Fig. 1. Diagram of the heat pump

The main components of the inner loop heat pumps are: condenser, capillary, evaporator, compressor that derives its power from the electrical grid. In addition, the internal circuit contains thermostat that controls the heat pump and coolant that circulate in the system (gas with certain physical characteristics).

II. THE STATEMENT OF THE TASK

Analyze the structure of the heat pump and its components, purpose and properties, develop a heating system of computer-aided design system based on heat pump and create software for the calculation of heat pump systems.

III. CALCULATION OF HEAT PUMP INSTALLATION

Removing heat from every meter of pipe depends on many parameters: depth styling, the availability of groundwater, soil quality, etc. Tentatively we can assume that for horizontal collectors, he is 20 W/m More specifically: dry sand – 10 dry clay – 20 wet Clay – 25 clay with a high water content – 35 W/m.

The difference in temperature of the coolant in the direct and reverse loops in the calculation is usually equal to 3 °C. The area of the collector should not build buildings to heat the earth replenished by solar radiation.

The minimum distance between the pipes should be laid 0.7–0.8 m. Dovzhyna a trench is typically from 30 to 120 m

As the primary circuit coolant recommended 25 percent glycol solution. The calculations should take into account that its heat at a temperature of 0 °C is 3.7 kJ / (kg · K), density – 1.05 g/cm^3.

When using antifreeze pressure loss in pipes is 1.5 times more than the water circulation. To calculate the parameters of the primary circuit heat pump installations will be required to determine the cost of antifreeze

$$Vs = Q_0 \cdot 3600 / (1{,}05 \cdot 3{,}7 \cdot .t), \quad (1)$$

where t is the temperature difference between the incident and the return line, which is often mistaken for 3 K and Q_0 is the thermal power derived from low-grade sources (soil).

The latter value is calculated as the difference between the full capacity of the heat pump and electric power Q_{wp} spent on heating Freon P, kW:

$$Q_0 = Q_{wp} - P. \quad (2)$$

Total length of pipe manifold L and the total land area under his A calculated as follows:

$$L = Q_0 / q, \quad (3)$$

$$A = L \cdot d_a. \quad (4)$$

here q is the specific (from 1m pipe) heat removal; d_a is the distance between the pipes (step stacking).

IV. SOFTWARE AND COMPUTER-AIDED DESIGN STRUCTURE

The program for the calculation of the heat pump allows the user to select the appropriate data for his building, namely: the region; degree of insulation of the building; the ratio of the area of wall openings (doors, windows, etc.); number of residents in this building; building area in square meters. Below it is posible to see the structure of computer-aided design system (Fig. 2).

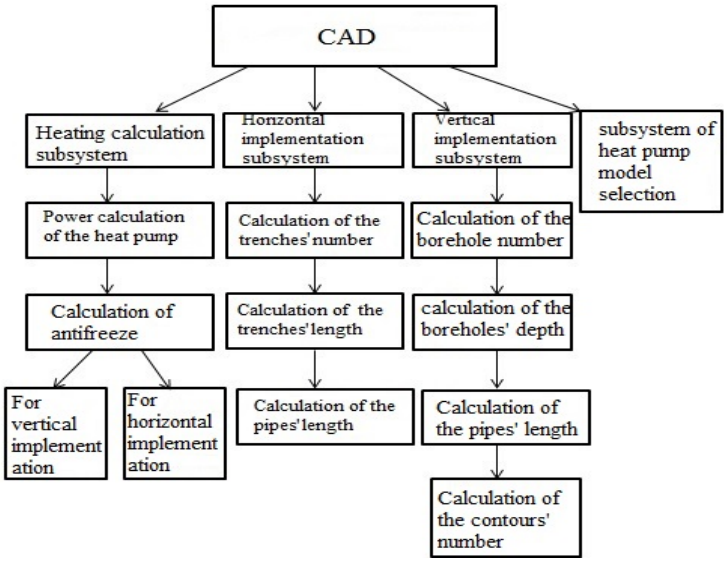

Fig. 2. Computer-aided design structure

V. DESCRIPTION OF USER INTERFACE

To get started with the program, the user must now open html file in your browser.

Scheme of the user interface is shown in the figure below (Fig. 3).

Region. The user can select a region of Ukraine,

where there is a building in which you want to calculate the heat pump.

Insulation of the building. You can choose the level of insulation of the building (old building without insulation / insulation of old buildings / new building insulation standard / high insulation factor).

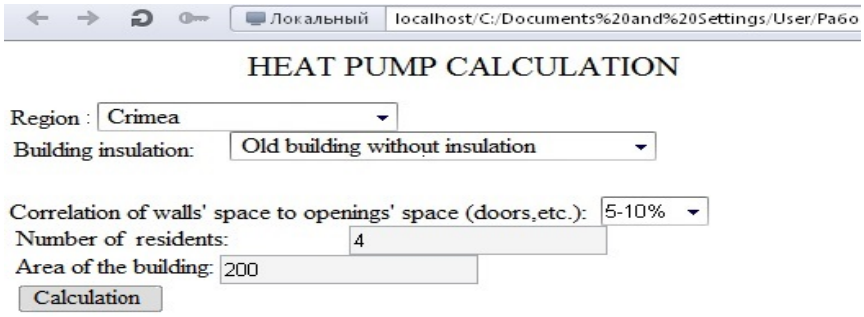

Fig. 3. User interface

Value space of walls and openings (windows, doors, ...). The user has to select the percentage of walls and openings of the building (5–10 % / 10–20 % / > 20 %).

Number of residents, people. The user program can enter the number of people living in the building.

Building area, m^2. The user has to enter a building area in square meters.

Calculation. To start the calculation of the heat pump must press this button.

Next, the program will automatically show the calculations to the user.

VI. CONTROL EXAMPLE

Calculate the heat pump for the following data.

Location: Kyiv and Kyiv region.

Insulation of buildings: old building without insulation.

Value space of walls and openings (windows, doors, ...): 5 – 10 %.

Number of residents, people, 3.

Building area, m^2: 150.

The program calculated the heat pump for this building:

Power Pump = 13.32 kW.

Number of antifreeze:

– horizontal contour: 4114;

– vertical probe: 2469.

Horizontal implementation:

Soil type dry sand will need 27 trenches, length 50 m and 1350 m tube.

Soil type dry clay need 13 trenches, length 50 m and 650 m tube.

Soil type moist clay will need 11 trenches, length 50 m and 550 m tube.

Soil type clay with a high water content will need 8 trenches, length 50 m and 400 m tube.

Vertical implementation:

For the type of soil dry sediment will need 20 wells, depth 34 m and 2720 m tubes for 40 circuits.

For the type of rocky soil and water saturated sediments will need 8 holes, depth 34 m and 1088 m tubes for 16 circuits.

For the type of stony rocks with highest thermal conductivity will need 6 wells, depth 32 m and 768 m tubes for 12 circuits.

For the type of soil, underground water will need 5 wells, depth 34 m and the 680 m tubes for 10 circuits.

VII. CONCLUSIONS

While working on the theme of the study examined the theoretical aspects of the structure and operation of heat pumps are considered the basic purpose and benefits of their use, and the characteristic of each type of heat pump. The heat pump uses the heat dissipated in the environment of land, water, air. Spending 1 kW of electricity to drive the pump, you can get 3.4 kW of heat energy. Given these circumstances, this paper is rather urgent. The most important feature of heat pump systems – flexibility with respect to the type of energy used (electrical, thermal). The heat pump will not only save money but also saves health tenants and their heirs. The unit does not burn fuel, and therefore not harmful formed oxides. Therefore, on the ground around the house is no trace of sulfur, nitrogen, phosphoric acid and benzene compounds. And for the use of heat pumps planet – good. The practical part of this work contains a thermal software calculation of the heat pump. For writing this program were analyzed methods of calculating the heat pump system. The program allows the user to select the appropriate data for its buildings, namely the region where the building is located; degree of insulation of the building; the ratio of the area of wall openings (doors, windows, etc.); number of residents in this building people; building area in square meters and provides an accurate calculation of the heat pump for a specific user. The results of this study can be used by Ukrainian enterprises during their projects using heat pumps.

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Sineglazov Viktor. Doctor of Engineering. Professor.
Aviation Computer-Integrated Complexes Department, National Aviation University, Kyiv, Ukraine.
Education: Kiev Polytechnic Institute, Kyiv, Ukraine (1973).
Research area: Air Navigation, Air Traffic Control, Identification of Complex Systems, Wind/Solar power plant.
Publications: 464.
E-mail: svm@nau.edu.ua

Heleveria Mariia. Student. Bachelor.
Aviation Computer-Integrated Complexes Department, National Aviation University, Kyiv, Ukraine.
Education: National Aviation University, Kyiv, Ukraine (2013).
Research area: Energy, heat pumps, computer-aided design systems.
Publications: 1.
E-mail: yaizkieva@gmail,com

В. М. Синєглазов, М. О. Гелеверя. Система автоматизованого проектування системи теплопостачання на базі теплового насоса

Розглянуто системи автоматизованого проектування системи контролю теплового насоса.

Ключові слова: система контролю; тепловий насос; автоматизоване проектування.

Синєглазов Віктор Михайлович. Доктор технічних наук. Професор.
Кафедра авіаційних комп’ютерно-інтегрованих комплексів, Національний авіаційний університет, Київ, Україна.
Освіта: Київський політехнічний інститут, Київ, Україна (1973).
Напрям наукової діяльності: аеронавігація, управління повітряним рухом, ідентифікація складних систем, вітроенергетичні установки.
Кількість публікацій: 464.
E-mail: svm@nau.edu.ua

Гелеверя Марія Олександрівна. Студентка. Бакалавр.
Кафедра авіаційних комп’ютерно-інтегрованих комплексів, Національний авіаційний університет, Київ, Україна.
Освіта: Національний авіаційний університет, Київ, Україна (2013).
Напрям наукової діяльності: енергетика, теплонасосні установки, системи автоматизованого проектування.
Кількість публікацій: 1.
E-mail: yaizkieva@gmail.com

В. М. Синеглазов, М. А. Гелеверя. Система автоматизированного проектирования системы теплоснабжения на базе теплового насоса

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Синеглазов Виктор Михайлович. Доктор технических наук. Профессор.
Кафедра авиационных компьютерно-интегрированных комплексов, Национальный авиационный университет, Киев, Украина.
Образование: Киевский политехнический институт, Киев, Украина (1973).
Направление научной деятельности: аэронавигация, управление воздушным движением, идентификация сложных систем, ветроэнергетические установки.
Количество публикаций: 464.
E-mail: svm@nau.edu.ua

Гелеверя Мария Александровна. Студентка. Бакалавр.
Кафедра авиационных компьютерно-интегрированных комплексов, Национальный авиационный университет, Киев, Украина.
Образование: Национальный авиационный университет, Киев, Украина (2013).
Направление научной деятельности: энергетика, теплонасосные установки, системы автоматизированного проектирования.
Количество публикаций: 1.
E-mail: yaizkieva@gmail.com