Laboratory work No 1

Part 1. Arrangement and operating principle of an autonomous heating system

Purpose of work: Familiarization with the scheme, arrangement and technical characteristics of the laboratory model of an autonomous heating system. Familiarization with equipment, shut-off and control valves, measuring tools and possible configurations of heating systems.

To ensure standard comfort conditions in heated rooms in accordance with the requirements of the norms and their functional appointment, you need to have clear enough traditional methods and means of achieving comfort and the tendencies of their improvement and development.

The engineering task of creating comfortable conditions in heated can be formed as a requirement to achieve heat balance between the heat sources in the room (heating appliances, equipment, solar radiation) and heat losses through the enclosing structures, with the infiltration of air through the window openings and with ventilation air.

Comfort conditions include such parameters of the internal environment of the inhabited rooms (primarily, temperature) under which the internal regulation system of the body experience minimal stress.

A heating system is an engineering system that provides heat in heated room, balanced with its losses in the surrounding medium at comfortable values of internal temperatures.

The heating system includes heaters with connecting pipelines and shut-off valves, forming a certain standard configuration. Any configuration is formed by one of the possible mutual methods of connecting heaters. When parallel connection of heating devices, the heating system is called two-pipe, with a serial connection – single-pipe.

The operating conditions of the heaters in different schemes of connections will not be the same, and this circumstance is taken into account while designing the heating system, and subsequently installation and adjustment.

The main element of the heating system is the heater (convector, radiator, etc.). There is a nomenclature of heaters, which includes many different in constructive execution, design, specific and nominal technical characteristics of devices. This circumstance is important in that respect, that in the design process and in the subsequent setup process of heating system, the nomenclature list of heaters facilitates and ensures the adoption of a competent solution, in which the heater is the closing element.

To study the arrangement, operation modes and thermophysical processes in heating systems, an experimental installation is proposed that includes all the basic elements of a standard autonomous heating system.

As part of the experimental installation, the main elements are: heat generator **1** with temperature control device, expansion tank **2**, safety devices **3**, **4**, **5**, two heaters **12**, automatic temperature controller **6** of heat carrier at the entrance to the heating system, circulation pump **22**. Heating devices and equipment elements are connected by pipelines and shut-off valves to a circuit that allows to flexibly change the configuration of the system depending on the setting of the task of the laboratory experiment. Figure 1 shows the general schematic diagram of the experimental installation.

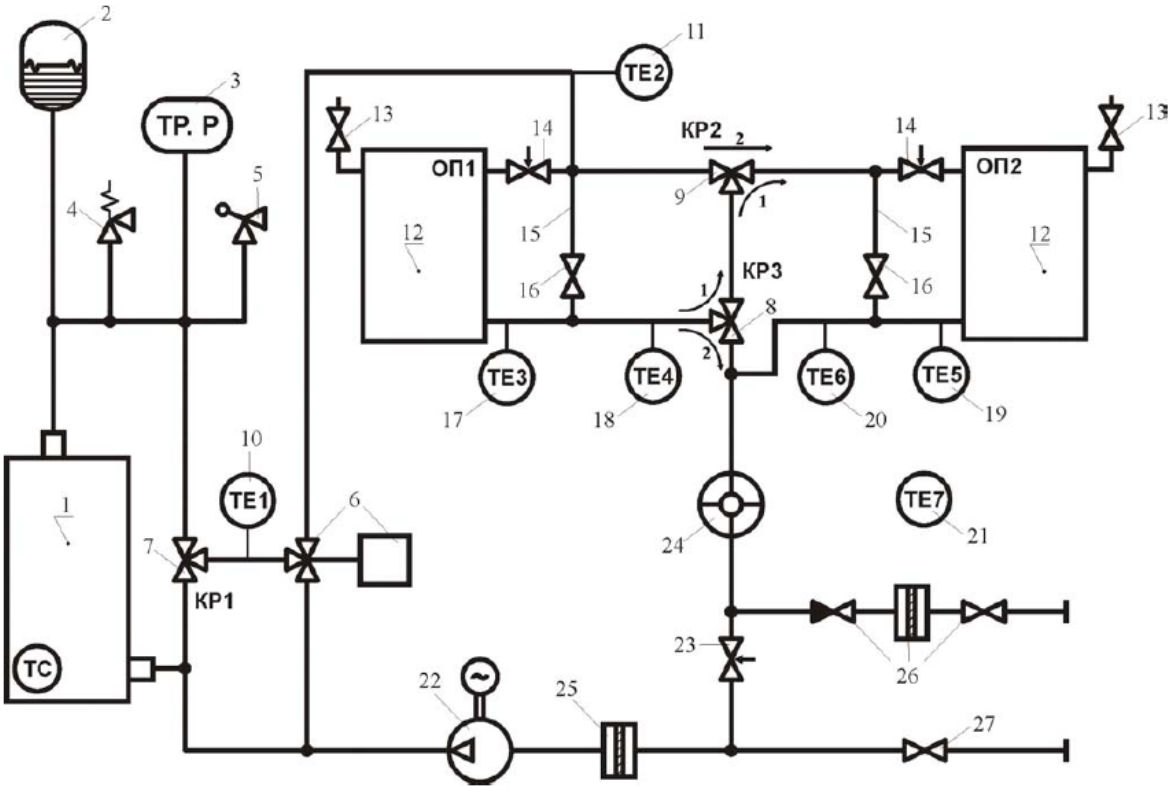

Fig.1. Hydraulic schematic diagram of the autonomous heating system.

1 - heat generator with a temperature control device;

2 - expansion tank;

3 - manometric thermometer and manometer for temperature measurement of heat carrier at the output of the heat generator and pressure in the system;

4 - safety valve for 1.5 gauge atmosphere (excess pressure), for emergency pressure relief from the system;

5 - automatic steam-air valve of float type for removing air from the system;

6 - automatic heat carrier temperature mixed-type controller at the inlet of heaters with electric drive;

7 - three-way mixing valve KP1 for manual installation of heat carrier temperature at the inlet of the automatic controller;

8 - three-way switching valve KP3, installing a heater ОП1 in the circuit of the serial (position 2) or single (position 1) connections;

9 - three-way switching valve KP 2, installing a heater ОП2 in the circuit of the serial (position 2) or single (position 1) connections;

10 - temperature sensor TE1 of the heat carrier at the input of automatic controller 6;

11 - temperature sensor TE2 of the heat carrier at the outlet of the automatic controller 6 and at the inlet of the heating device ОП1;

12 – heaters ОП1 and ОП2;

13 - Mayevsky tap (radiator air vent key) for removal of air from heaters;

14 - regulators of the flow of heaters ОП1 and ОП2;

15 - shunting bridges of heaters ОП1 and ОП2;

16 - disconnecting cranes of bridges of heaters ОП1 and ОП2;

17 - temperature sensor TE3 of the heat carrier at the outlet of the heater ОП1;

18 - temperature sensor TE4 of mixture of working and shunt flow of heat carrier at the output of the heater ОП1;

19 - temperature sensor TE5 of the heat carrier at the outlet of the heater ОП2;

20 - temperature sensor TE6 of mixture of working and shunt flow of heat carrier at the output of the heater ОП2;

21 - ambient temperature sensor TE7;

22 - circulating pump;

23 - regulator of the general heat carrier flow;

24 - flowmeter of the total flow of heat carrier;

25 - filter;

26 - filling unit of the system (filling valve, inverted valve, filter);

27 - drain tap with hose;

28 - temperature sensor TE8 at the heat generator output;

29 - temperature sensor TE9 at the output of the automatic temperature controller 6 of the heat carrier in the heating circuit.

The main characteristics of any heating system are the nominal heat output and temperature graph.

Working pressure, design features, the types of heating devices used, the operating volume of the heating system, the diagram of connection are derived parameters.

Depending on these characteristics, the requirements for individual elements of the system are formed. So, the required volume of the expansion tank is determined mainly by the working volume of the heating system. The required output of the circulation pump is determined by the nominal output of the heating system, the temperature graph of the system or its individual circuit and the specific heating capacity of the heat carrier.

The task:

1. Calculate the heat carrier flow rate for the following initial parameters:

• Nominal power 20 kW;

• Temperature graphs 95 – 70, 60 – 45 and 35 – 30 ºC;

• Specific heat capacity of the heat carrier $C_p \approx 4.11819$ [kJ/kg ºC].

2. Measure the performance of the circulation pump used in the installation at different pump speeds (3 speeds). Measurements can be made on a "cold" installation.

Procedure:

1. Switch on the installation without turning on the heat generator (automatons 1, 3, 4).

2. Turn on the PC and start the control program.

3. Set the valve KP1 in the position with the handle up.

4. Set the valve KP2 to position 1 and the crane KP3 to position 1.

5. As a result, the heater No. 1 will be connected.

6. Close disconnecting cranes of bridges 16

7. Set the regulators 14 on the radiators and the regulator of total flow 23 for full opening (counter-clockwise to stop).

8. Set the speed switch on the circulation pump in position 1.

9. Determine the flow rate of the heat carrier by the increment of the reading of flowmeter 24 in 5 minutes and calculate the second flow.

10. Record the second flow rate of the coolant from the monitor screen and compare the results.

11. Carry out these measurements for the remaining values of the rotation speed of circulation pump.

12. Compare the obtained values of flow with the calculated values for various temperature graphs and draw conclusions about the sufficient or insufficient performance of a specific circulation pump for the heating system specified above.

Part 2. Preparing for operation, filling the heating system with a heat carrier, starting the hydraulic circuit and measuring system

Purpose of work: Acquisition of knowledge and skills in preparation for work and maintenance of an autonomous heating system. Familiarization with the regime conditions of functioning of the installation and its separate units in the interaction with each other, preparing and bringing the installation and measuring devices in working condition.

The purpose of the heating system is to heat the rooms, i.e. creation and maintenance of comfort in the cold season. Sanitary norms prescribe switching of

heating system from summer to winter when the temperature of the outdoor air through the value of t_{out} = +8 ºC.

Preparation of the heating system for operation should include a number of preventive and, if necessary, repair measures for ensuring its reliable operation during the heating season. One of compulsory measures in the preparation of the system is to check it for density. The density test is performed by means of hydro-pressing system. Hydro-pressing is performed after filling system, if before it was empted. With centralized heat supply, filling is produced by deaerated water from the return line. When there is an individual heat generator, the system can be filled from the source of non-aerated water.

Modern autonomous heating systems are generally not connected to the atmosphere and operate at elevated pressure. During operation of the system the temperature of the heat carrier changes and hence its volume. To ensure normal working conditions in the autonomous systems an expansion tank with a gas cushion is used. It is able to absorb the expanded heat carrier, maintaining approximately constant pressure in the system.

When the circuit is filled with the heat carrier, air pushes out from the system. Further supply of heat carrier will lead to the movement of the membrane and the reduction in the volume of the air cushion that will lead to an increase in air cushion pressure and system. Initial air cushion pressure should be lower than working pressure in the heating system. In working condition the expansion tank must be partially filled with a heat carrier (in the range of 0.2-0.7 of the volume).

Filling should be done through the lowest point of hydraulic circuit. Before filling it is necessary to open air valves. Under normal filling conditions, all air from the system must be completely superseded. The filling process is considered to be completed when Mayevsky tap (radiator air vent key) start to flow water without air bubbles, after which the air valves are overlapped.

After filling the hydraulic circuit with water the overpressure must be created in the system by supplying a heat carrier in the expansion tank and air tank cushion compression. Consistency of pressure in the circuit is a sufficient sign of density of hydraulic circuit of the heating system.

After filling the heating system with a heat carrier, it is necessary to make control opening and closing shut-off fittings and verify by a pressure gage the density of hydraulic circuit (check the safety valve).

The task:

1. Prepare an autonomous heating system for operation and maintenance.
2. Fill the system with a heat carrier.

Procedure:

1. Untwist the steam-air valve for a couple of turns;
2. Open the filling valve 26 (the handle must be in the horizontal position);

3. Set the valves KP1 to the middle position, KP2 to position 1 and KP3 to position 2, which corresponds to a serial connection heating appliances;
4. By observing the safety valve 4 in the system, turn on the deep-water pump 28 by automatic 5;
5. Switch off the deep-water pump 28 when the safety valve turns on;
6. Untwist the safety valve (contraclockwise) in order to drain some water for decreasing the pressure;
7. turn on the circulation pump 22 to drive the bubbles air in the upper points of the system;
8. open Mayevsky taps (radiator air vent key) by screw-driver in order to remove air;
9. close Mayevsky taps and Switch off circulating pump;
10. Repeat the procedures 4-8;
11. The installation is ready for laboratory experiments.

Make a report on the results of the work done with the following content:

1. Title page
2. Purpose of the work
3. Description of the experimental setup
4. Task
5. Procedure
6. Results
7. Conclusion

Control questions

1. How to connect the heaters:
   a) in a single-pipe system;
   b) in a two-pipe system
2. Classification of heaters, their types.
3. Classification of heating systems.
4. By what ways is heat transferred from the heat carrier to the air in the room?
5. Why is air removed from the heaters?
6. For what purpose do regulation of the heat transfer of the heater?
7. How to calculate heat carrier flow rate?
8. How to calculate heat output of the heater by two ways?
9. Heat balance of the room.