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Energy saving technologies in the heat supply systems of Uzbekistan

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Abstract. The paper attempted to show the possibilities of improving the energy efficiency and reliability of heat supply services, as well as the quality of heating and hot water supply, by proposing the transition of heat supply systems to closed consumer connection schemes. The authors analyzed the results of experimental studies of elevator inputs that are not able to provide the required parameters in the heating system in time and schemes for connecting hot water to heating networks that have serious drawbacks, on the "Sergeli" and "Yunus-Obod" districts in Tashkent. As the analysis showed, the elevator connection of heating systems and the classical scheme for connecting open hot water supply systems do not provide stable heating modes and guaranteed water supply to places of water parsing with a temperature in the range of 60-70 °C. It is clear that it is necessary to reconsider decisions on connecting subscribers to the heat networks, to choose the best options that will normalize the supply of heating to consumers. In this regard, in the republic, it is proposed to use closed systems: heating the coolant through the heat exchange device of the house`s heating point from the boiler room.

1 Introduction

Uzbekistan is characterized by relatively low energy efficiency standards [1] compared to countries located in similar geographic areas. Heat and hot water in large cities of the republic are supplied through the district heating systems, at the level of distribution systems. In this case, as a rule, large energy losses occur due to the fact that consumers are practically unable to regulate the temperature inside the premises, only with the help of inefficient means, for example, by opening windows or connecting electric heaters. The presence of a large number of standard multi-family residential buildings and industrial buildings allows to use the same type of energy efficiency methods, which provides significant economies on the scale of objects. The strong traditions of centralized district heating in large cities are an excellent institutional technical basis for the organization of efficient heating and cooling of buildings in the country in the future.

The study [2] notes that the most serious barriers to improving energy efficiency in the residential sector are related to building standards, the behavior of the population and difficulties in organizing and financing measures to improve energy conservation in common areas. The sphere of housing and communal services most affects the quality of life of the

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population and it contains the prospects for sustainable development along the green path, primarily in increasing the employment of the population of the republic. As the experience of other successful countries in energy-saving policy shows, in Uzbekistan, reducing the electricity consumption in the heat supply of buildings will reduce the total consumption of primary energy resources by almost five times; reducing the consumption of thermal energy reduces the total consumption of primary energy resources by almost three times [2].

One of the main technological measures in the heat supply of residential and industrial facilities, the implementation of which is necessary in the republic, is the transition to closed heat supply schemes with the use of individual heating points (IHP), which are quite effective from an economic point of view. Low payback periods make it possible to attribute this method of energy saving to low-cost and fast-paying [3,4].

2 Materials and methods

The purpose of the work is to show opportunities to improve energy efficiency and reliability of heat supply services, as well as the quality of heating and hot water supply.

The object of the research is the elevator nodes of residential buildings on the "Sergeli" and "Yunus-Obod" districts of Tashkent.

2.1 The description of the problem (on the example of Tashkent city)

The centralized heating supply of Tashkent (similar throughout the republic) includes nine large heating plants (HP) of the “Tashteplocentral” enterprise (HP-1, 3-10) and the “TashTETS” combined heat and power plant, which generate 90% of all heat energy in the capital. Three large boiler houses (HP-2, "Vodnik" and "Sanoatenergo") and 200 local ones are also included in the list of heat sources "Toshissikkuvvati".

The installed capacity of all boiler houses in Tashkent is 6233.093 Gcal/h; the connected capacity is 3602.223 Gcal/h. About 9.67 million Gcal of thermal energy is sold annually.

There are 30.2 thousand units of shut-off valves, 4013 oil seals compensators, 11.1 thermal chambers and 24.1 thousand hatches on the heating networks. To maintain the hydraulic regime of heat consumers, 66 pumping stations have been installed on the networks, including 11 regime-pumping stations on the main heating networks. 13.226 buildings are connected to heating networks: 9.209 residential buildings, 586 medical organizations, 485 schools, 644 kindergartens, 659 higher and secondary specialized educational institutions and 1.643 other facilities. The total connected load is 3602.223 Gcal/hour, of which 67% are residential facilities, 22% are social and cultural facilities and 11% are other city infrastructure.

The reasons for the excess consumption of thermal energy are as follows:

- Unsatisfactory heat supply to individual thermal zones of the city is associated with the deplorable state of the main and distribution heating networks, which require timely and high-quality overhaul. 65% of heat networks in Tashkent are expired exploitation period.
- The poor condition of the in-house heating systems does not allow consumers to receive thermal energy from the source.

2.2 Assessment of connection schemes for heating systems

Here are the statistics of the state of elevator inputs in the examined individual heating points (IHP):

- 42 inputs on elevator connections are equipped with plugs, that is, the input node has been transferred to the scheme of direct connection of the heating systems (HS) to the heating network;
- None of the "unplugged" inputs had a calculated mixing coefficient. Only in four objects it reached a value of 1.15/1.32, while in the rest its average value was 0.403.

Significant differences between the objects connected to different heating plants were not found. As for the influence of remoteness from the heating plant, it manifests itself in the head consumers - the percentage of "plugged" inputs is much lower than in the end and middle ones. The results of the survey irrefutably demonstrate that there is practically no decrease in the temperature of the network water in the input nodes. Elevators are not used for their intended purpose. IHPs are not adapted to receive overheated water. The average mixing coefficient $И_{aver}$ = 0.198 makes it possible to keep a temperature graph in heating networks not higher than 100-70 ° C in order to ensure the calculated temperature on the surfaces of heating devices up to 95° C. This is the actual condition of elevator heating points in residential buildings in Tashkent.

The general conclusion based on the results of the analysis is the statement: elevator inputs are not able to consistently provide the required parameters in the HS over time.

It can be concluded that both the classical and the schemes used in Tashkent and in other cities of the republic for connecting heating and hot water systems to heating networks have serious drawbacks. In this connection, there is a need to improve the schemes of the heat supply system of the cities of the republic for the connection of heating and hot water systems.

2.3 General assessment and conclusions on IHP schemes

As the analysis of the research results showed, the elevator connection of HS (Heating Systems) and the classical scheme for connecting open hot water supply systems do not provide stable heating modes and guaranteed water supply to places of water parsing with a temperature in the range of 60-70 ° C. The inevitable consequence of the use of these schemes is the mass deregulation of the IHP and the operating modes of heating networks, which is also noted in the literature. The consumption of heat and network water absolutely ceases to correspond to the engineering data. When superheated water is supplied to the IHP, the safety of residents is violated in terms of the possibility of burn injuries. Of no small importance for the normal operation of heating networks and subscriber IHPs is the accounting for the consumption of network water to create circulation in the hot water supply systems of buildings. This consumption is not taken into account at all when calculating heat networks, but its value is significant and amounts to 28.2% of the coolant consumption. The greatest excess water consumption is observed in the HS. It is created intentionally by the residents in order to eliminate the unheated lagging premises due to the use of elevator units. The increase in water consumption compensates for the decrease in heat transfer of the end heaters, and then, after the deregulation of the heating network, and the decrease in the temperature graph of heat supply.

The data obtained on the excessive consumption of heat and network water by residential buildings in Tashkent indicate that the applied IHPs and the heat supply scheme with superheated water pipelines connected to them, not only do not meet the requirements of safe and stable heat supply, but also reduce the technical and economic characteristics of heating networks. The consumption of network water increases more than 2 times. The temperature of the return water rises accordingly Heat is significantly overspent with extreme unevenness of heat distribution. With the beginning of the heating season, the hydraulic and thermal regime of heat supply is rapidly destroyed, after which the situation becomes practically uncontrollable.

It is absolutely clear that it is necessary to reconsider decisions on connecting subscribers to the heat networks, to choose the best options that will normalize the supply of heating to consumers.

3 Solution

In open systems (compared to closed ones), there is a higher wear of pipelines and intensive scale deposits on pipes in consumer heating systems, which worsens heating in apartments. Low-cost during installation, but expensive to operate, such systems are characterized by short service life of the internal heating system and pipelines of heating networks, high operating costs in the production, transportation and consumption of heat, excessive consumption of network water and, accordingly, thermal energy.

Most of the main equipment in the field of heat production is physically and morally obsolete. The deterioration of boiler equipment is 70-100%, up to 65% of heating networks require major reconstruction, the efficiency of obsolete boilers is low (75%), and the actual efficiency reaches 68%, which leads to a significant waste of fuel and maintenance costs. In open heat supply systems, hot water is drawn for the needs of the consumer directly from the heating network. In this case, the water parsing can be partial or complete. The hot water remaining in the system is used for heating and ventilation. The water consumption in the heating network is compensated by the additional amount of water supplied to the heating network. The main advantage of the open heating system is its economic benefit. However, there are several disadvantages of such a system, and first of all, it is a low sanitary and hygienic quality of water. Heating devices, pipeline networks give water color, smell, various impurities and bacteria appear. Various methods are used to purify water in an open system, but their use reduces the economic effect [5,6].

In this regard, in the republic, the use of closed district heating systems is proposed: heating the coolant through the heat exchange device of the house`s heating point from the boiler room. With closed systems, corrosion control is easier due to higher water quality and lower volumes. The main effect of switching to closed DHW systems is an increase in the service life of the district heating system and related equipment, in this case, supply pipelines, distribution and pipelines inside the building. In addition, the quality of water in the DHW system is improved.

In the closed heat supply system, the heat supply is regulated centrally, while the amount of heat coolant (water) remains unchanged in the system, and the heat consumption depends on the temperature of the circulating coolant. They, as a rule, use the capabilities of thermal points. They receive the coolant from a source of thermal energy, and the central heating points of the districts regulate the temperature of the coolant to the required value for the needs of heating and hot water supply, and distribute it to the consumer. The advantages of a closed heat supply system are high quality hot water supply, energy saving effect. The disadvantage is the difficulties of water treatment due to the remoteness of heat points from each other [5,6].

It can be concluded that both the classical and the schemes used in Tashkent and in other cities of the republic for connecting heating and hot water systems to heating networks have serious drawbacks. In this connection, there is a need to improve the schemes of the heat supply system of the cities of the republic for the connection of heating and hot water systems.

Decree of the Cabinet of Ministers of the Republic of Uzbekistan № 306 “On measures to implement the project “Reconstruction of the district heating system and energy efficiency in the cities of Andijan, Chirchik, Bukhara, Samarkand and Tashkent (the main goal of the project is HP 8)” dated April 12, 2019 [7,8] during 2019-2024 in Uzbekistan, aimed at the phased transition of district heating to a closed system, taking into account the introduction of modern resource-saving technologies, was the most effective solution to the problem. The implementation of the project will improve the energy efficiency and reliability of heat supply services, as well as the quality of heating and hot water supply, and as a result, the modernization and reconstruction of central boiler houses, heat supply networks with the transition to a closed heat supply system. In general, it is proposed to modernize 181 boiler houses in the republic, install 28.000 heating points, reconstruct 841.1 km of existing networks and lay 575.6 km of new networks based on pipes with polymer insulation and a protective sheath.

3.1 Analysis of the heat supply project of a typical residential building (No. 157, Bukhara)

In this paper, the authors analyzed the implemented heat supply project of a typical residential building (№157 in Bukhara), in which the heating and hot water supply systems are connected according to a closed scheme, where the heating of the coolant occurs through the heat exchange device of the house`s heating point from the boiler room [9]. The calculation part is made in accordance with the following regulatory documents KMK 2-04-05-97 *, ShNK 2-08-01-05 and for the area with an outside air temperature of -12 ° C. Heat supply is made with the installation of the individual heat point. The IHP comes as a set and is installed in the basement of 2.4 m by 4.0 m of a residential building. The individual heating point consists of a heating heat exchanger, a single-stage DHW heat exchanger, a DHW system regulator, a heating system circulation pump, a DHW circulation pump, heating system heat meters, a DHW system flow meter (Figure 1).

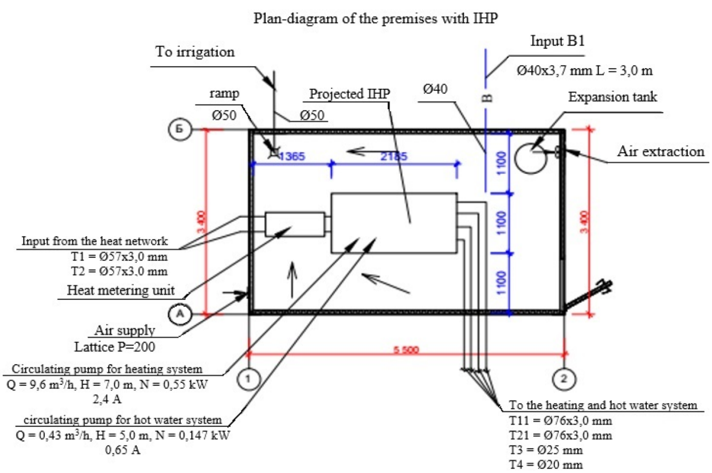

Fig. 1. Plan for placing an individual heat point in a residential building in the city of Bukhara.

Plate heat exchangers are used to connect buildings to centralized heating and hot water supply networks. A plate heat exchanger is one of the types of recuperative heat exchangers, the operation of which is based on heat exchange between two coolants through a contact plate without mixing (Figure 2). The plate heat exchanger consists of several sheets of thin corrugated metal (package of plates) forming channels. The gaskets are located between the plates and form a seal. The seal prevents fluids from mixing and leaking, but they also determine which channels each fluid can flow through. The principle of operation of all plate heat exchangers (HE) is the same: coolants are supplied to the HE, which move along the internal contour of the heat exchange unit, formed by the package of plates, in the process of movement, in contact with the surface of the plate, the hotter coolant gives off part of the heat to the heated coolant. At the outlet, coolants with a changed temperature enter the heating and hot water supply system.

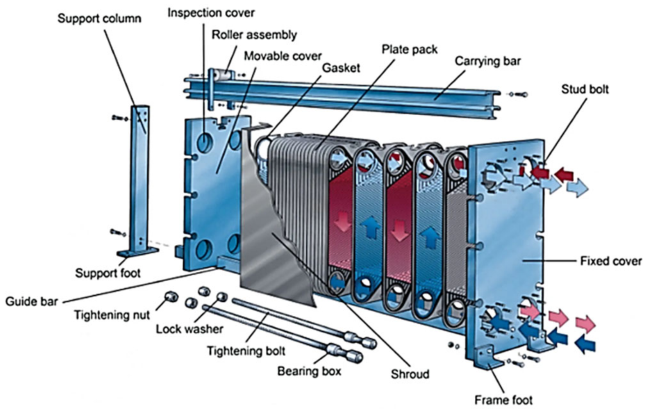

Fig. 2. Plate heat exchanger.

The biggest advantage of plate heat exchangers over other heat exchangers is their heat transfer efficiency. The plates separating two liquids are thinner compared to other materials. This increases the rate of heat transfer and thus reduces heat loss that may occur during transfer. Heat exchangers are invaluable because of these features that increase the life of the system. Plate heat exchangers can perform many functions such as heating element, cooling element, automatic switch or pressure switch.

During the reconstruction of heat supply systems at the facilities of the republic, heat exchangers of the CIPRIANI company were installed in the IHP of residential buildings (Figure 3). This plate heat exchanger has limited operating temperatures and pressures. Excessive temperature and its changes will cause damage to the seals and plates. Plate heat exchangers are very sensitive to pressure surges. All possible precautions should be taken and these limits should not be exceeded, as this heat exchanger his heat exchanger has a high sensitivity to sudden changes in operating parameters. It is necessary to install all the necessary safety devices. The plate heat exchanger is designed for heating and cooling liquids through indirect contact with another liquid [10].

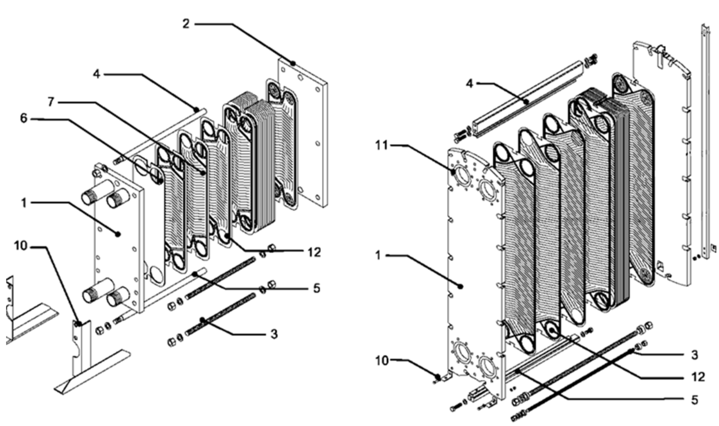

Fig. 3. Plate heat exchanger of CIPRIANI company: 1 - fixed (front) panel; 2 - movable (rear) panel; 3 - tightening bolts; 4 - guide / bearing crossbar; 5 - guide crossbar; 6 – plate pack; 7 - plates + gasket; 8 - support column; 9 - roller; 10 – frame foot; 11 - protective coating of the channel; 12 - channel.

3.2 General information about the scheme for connecting the heating and hot water supply to residential building № 157 in Bukhara

Parameters of the coolant of the heating network: winter mode - 120-70°C and summer mode - 70-30°C. Parameters of the coolant of the secondary circuit: heating systems - 60-80°C; hot water systems - 5-60°C [11].

The connection of the equipment of the individual heat point to heat networks is carried out through the heat energy-metering unit installed in the premises of the IHP. The components of the IHP may include additional equipment, depending on the scheme of automation of heat consumption systems, the characteristics of the facility and the conditions of the heat supply.

With an independent connection scheme (Figure 4), the heating temperature is controlled by changing the flow rate of the coolant along the primary circuit of the heat exchanger. Circulation in the heating system is provided by circulation pumps. In closed heat consumption systems, the regulation of the DHW temperature is carried out by changing the flow rate of the coolant along the primary circuit of the heat exchanger. The circulation in the DHW system is provided by DHW circulation pumps. To obtain the heating coolant with parameters of 80-60 °C in the individual heating point, the project provides for the installation of the plate heat exchanger with a pressure drop of not more than 20 kPa. To obtain hot water with a parameter of 60 °C, the plate heat exchanger is installed with a pressure drop of not more than 50 kPa, on the secondary circuit.

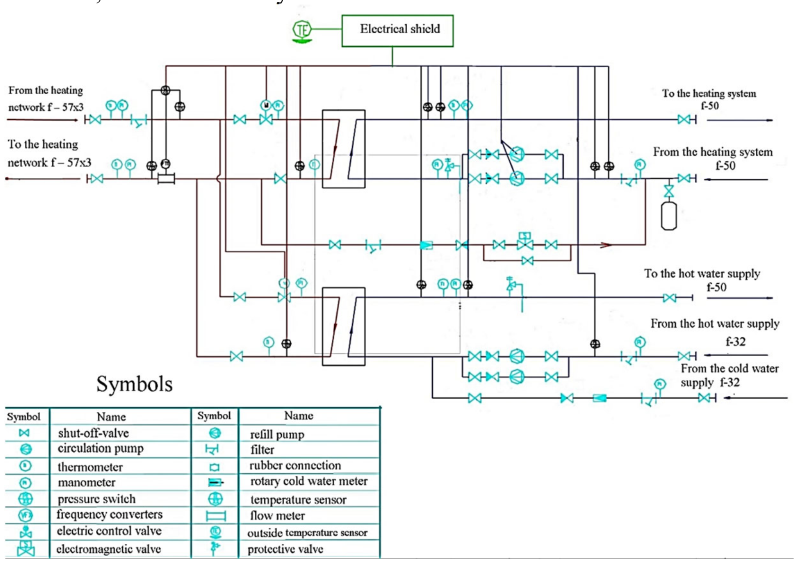

Fig. 4. Scheme for connecting residential building № 157 to heating networks through the individual heating point.

On the supply line to the heat exchangers for heating and hot water, control valves with a drive, a pressure gauge, a thermometer, a filter and a heat meter are installed. A pressure gauge, a safety valve and a water temperature sensor are also installed on the line going to the heating systems of heat consumers. A filter, a water temperature sensor and a contact pressure sensor are installed on the line coming from the heating systems of heat consumers. The project also provides for a double circulation pump on this line. Mesh filters are mounted in front of each pump, and non-return valves are installed after the pumps (for some types of pumps, non-return valves are built into the housing). Filling the heating system is carried out through the make-up water system and filling with pipelines Dy 25 from the return line of heating networks through the metering unit for thermal energy and coolant. Cold low-pressure water from the intra-quarter networks enters through the water meter unit into the DHW heat exchanger. Distribution pipes of heating and hot water systems are insulated.

4 Conclusions

The phased transition of district heating to a closed system will bring socio-economic benefits from investments in modern and efficient heat supply systems that will increase the reliability, safety and quality of services for the population in participating cities (accounts payable under the current heat supply system will decrease from 14.4 trillion Uzbek sums to 1.8 trillion Uzbek sums).

The plate heat exchanger is a modern type of heat exchangers that are actively replacing analogues of obsolete types, such as shell-and-tube units. This is facilitated by their compactness, low price and high technical characteristics.

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