Improving the energy efficiency of the boiler house of the city of Syzran, Samara region by introducing equipment with improved technical characteristics

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Abstract. The work is devoted to improving the energy efficiency of the boiler house by introducing more modern equipment with improved technical and economic characteristics. A drawing of this equipment is presented. The heat engineering calculation of the heat exchanger is performed. The problems of concession agreements of heat supply organizations are formulated. The mechanism of interaction of public-private regulation is described. The paper outlines how important it is to have a rational energy saving mechanism. The advantages and disadvantages of concessions are noted. An example of foreign experience in the use of concession agreements is given. This article touches on the topic of reducing energy consumption, including due to the transition to a different type of coolant in the boiler room. Based on the specifics of the object of heat consumption of the boiler house, the most rational heat carrier instead of water vapor is hot water, as can be seen from the above calculations. The principle of operation and the feasibility of using a water-water heat exchanger are described. In the work, the author transfers the heat exchanger to another type of coolant, as well as to another design of the heat exchanger. The advantages and disadvantages of the equipment are given. The work carried out a constructive heat engineering calculation. An assessment is made of the contribution to the modernization of heat supply systems, due to the effective interaction of heat supply organizations with specialized heat supply companies. Keywords: energy efficiency, boiler room, heat exchanger, energy saving, hot coolant.

1 Introduction

Heat supply facilities in Russia are regulated by Federal legislation (Law on Heat Supply No. 190 of 27.07.2010; Rules of Technical Operation of Thermal Power Plants approved by Order of the Ministry of Energy No. 115 of 24.03.2003; Resolution on Approval of Investment programs No. 1079 of 23.12.2020; Law on Energy Conservation No. 261 of 23.11.2009; Law on Concession Agreements No. 115 of 21.07.2005). The participants of the

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concession agreements are the concedent (the municipality that owns the heat supply facilities), the concessionaire (carries out the reconstruction and operation of heat supply facilities). The obligations of the concedent are the transfer of heat supply facilities to the possession and use of the concessionaire. The concedent also coordinates the concessionaire's investment program developed by energy service companies and monitors the progress of its implementation. The regional authority sets tariffs for the provision of services by the concessionaire and approves the investment program. The obligations of the concessionaire relate to the implementation of investments at the expense of own and borrowed funds in the reconstruction of the object of the concession agreement. The terms of concession agreements should take into account the interests of all participants.

Russian researchers note the advantages of public-private partnership as one of the ways to develop public infrastructure based on the immutability of long-term tariffs. At the same time, the private party participates not only in the construction and reconstruction of the object of the concession agreement, but also in its subsequent operation (provision of services at the created object and maintenance).

The disadvantages of the concession include the underestimation of economically justified expenses and lost income, accounts payable and receivables of the concessionaire, high losses of coolant due to the deterioration of municipal infrastructure. The use of international experience makes it possible to solve the problems of concessions in Russia. Foreign researchers note the need to use project financing of concessions (Soka and Zhaoxia, 2014). Banerjee, Duigun, Noe, Shaban (2019) believe that the state's share should not exceed half of the total financing of the concession agreement.

The important role of budget financing in public-private partnership is noted. It is important to develop a mechanism for technical modernization of heat generation facilities within the framework of a concession agreement. The object of the study is steam and hot water boiler house No. 4, located in the Samara region, Syzran.

2 Problem statement

The absence of an energy saving mechanism for heat supply organizations;

Unauthorized removal of the coolant by the consumer;

Losses in the heat supply system;

Inefficient thermal energy analysis system;

Lack of a system for monitoring the consumption of thermal energy and fuel and energy resources, modernization projects.

3 The purpose of the study

Selection of the optimal coolant and heat exchanger in boiler room No. 4 of Syzran, Samara region.

4 Research questions

What are the criteria for choosing a coolant?

What are the parameters of the heat exchanger?

5 The main part

In boiler room No. 4 of Syzran, Samara region, a heat exchanger with a capacity of 158 gcal /year with a steam type of coolant is installed. The boiler room is designed for heating residential buildings and industrial buildings (warehouses, educational buildings, workshops, access, storage for equipment, residential buildings, etc.).

The author proposes to replace the steam heat exchanger in the boiler room with a water one and perform a thermal calculation showing its energy efficiency.

The proposed heat exchange equipment is a 2–pipe register made of smooth steel electro-welded pipes of DN80 mm, reconnected to a water heating system operating in the heat supply mode of 95-70 ° C. Pipelines with a heat carrier steam – turn off.

The calculation of the heat load of the heat exchanger is presented below:

Initial data for the calculation:

Heating system: water, independent with a temperature schedule of 95-70 °C.

Heat exchanger: 2-row register mounted horizontally, made of electric-welded steel pipe GOST 10704-91 Dn = 80 mm, Length (L) –3800 mm;

t_{1p}=95 °C – the calculated value of the water temperature at the outlet of the heat exchanger;

t_{2p}=70 °C – the calculated value of the water temperature at the inlet to the heat exchanger;

t_{vn}=18 ° C - the calculated value of indoor air;

k=°-27 C – estimated outdoor air temperature in Syzran;

pts.o.p.= -4.7 °C – average outdoor air temperature for the billing period (year);

24 hours – the duration of the heating system operation per day;

Zo= 196 days. the duration of the heating system for the billing period (year).

Calculation.

The annual heat load for the heating period is determined by the formula:

$$Q_o = Q_{o.\max} \cdot [t_{vn} - t_{av.}] / (t_{vn} - t_o) \cdot 24 \cdot Z_o \cdot 10^{-6} (\text{gcal / year}) \quad (1)$$

In the absence of design data, the value of the maximum hourly heat load should be calculated according to the heat exchange surface area of the installed heating devices of the heating system.

The maximum heat flow from the heat exchanger is determined by the formula:

$$Q_{o\max} = K_p \cdot F_p \cdot \Delta t \text{ (kcal / h)} \quad (2)$$

where Kr is the coefficient of thermal conductivity of steel;

Q is the heat transfer coefficient, W

FP – the area of the outer surface of the pipe section for which the calculation is made, m2

ΔT is the value of the temperature pressure (the sum of the primary and final temperatures, taking into account room temperature), °C.

Heat exchanger area:

Dn80mm Pipe – Dn = 89 mm=0.089 m, h=3.8 m;

$$F = \pi \cdot D_н \cdot L = 3{,}14 \cdot 0{,}089 \cdot 3{,}8 = 1{,}062 \, (metr^2) \quad (3)$$

The value of the temperature pressure:

$$\Delta t = (t_{1p} + t_{2p}) / 2 - t_{vn} = (95 + 70) / 2 - 18 = 64{,}5°C \quad (4)$$

Heat transfer coefficient of the heat exchanger:

The heat transfer coefficient of the Kr depends on the diameter of the pipes, the number of threads applied in the premises and the temperature flow. On average, the coefficient value ranges from 8 to 12.5 Kcal / (m^2 hour · ° C)

The heat transfer coefficient of the heat exchanger is taken as for one thread (see Table No. 1), because it is located horizontally.

K=10.5 (Kcal/ m^2 ·°C) – for pipes of DN80 mm and ΔT=64.5 °C

$Q = 10{,}5 \cdot 1{,}062 \cdot 64{,}5 \cdot 10^{-3} = 0{,}72$ (gcal / day)

Annual heat load:

$$Q_o = 720 \cdot \left[\left(18-(-4.7)\right) / \left(18-(-27)\right) \right] \cdot 24 \cdot 196 = 171\,(gcal\,/\,year)$$

Table 1. Determination of the heat transfer coefficient.

Connection type	For pipes with internal diameter. mm	Δt. °C			
		50-60	60-70	70-80	80-100
In one thread	Before 40	11.5	12	12.5	12.5
	50-100	10	10.5	11	11.5
	Above 125	10	10.5	10.5	10.5
In several threads	Before 40	10	11	11.5	11.5
	Above 50	8	9	9	9

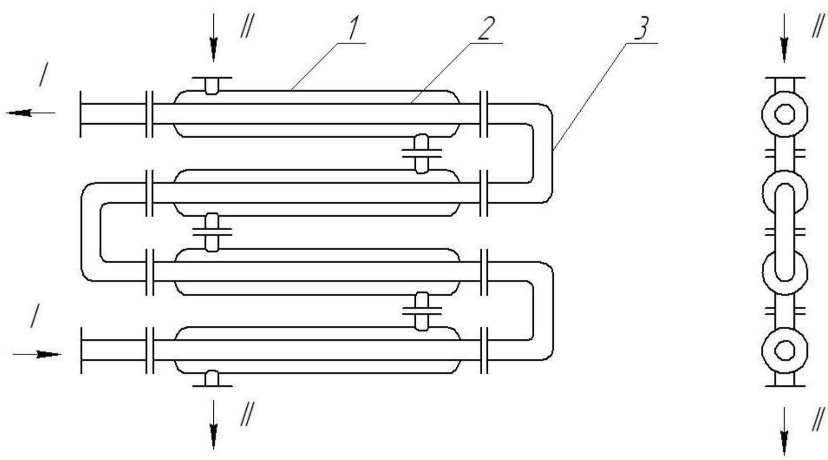

Fig. 1. Water-to-water heat exchanger of the "Pipe in pipe" type. Where: 1 - outer pipe; 2 - inner pipe; 3 - kalach; I, II - heat carriers.

Figure 1 shows the proposed article of the heat exchanger. Below is the principle of its operation.

The heat from the hot coolant to the cold is transferred through the impenetrable wall separating them. In this case, the heat from the hot coolant to the cold coolant is transferred in three stages: by convection, by radiation from the hot coolant to the wall, by thermal conductivity inside the wall and from the wall to the cold coolant by convection.

One coolant passes in the annular gap between the large and small pipes, and the other coolant flows through the inner pipes, while the heat exchange between the heat carriers occurs by heat transfer through the surface of the inner pipes.

Two-pipe devices, or "pipe-in-pipe" devices, are very simple in design. They are several elements located one above the other, each of which consists of two pipes: an outer larger diameter and an inner pipe concentrically located in it. The elements are connected to each other in series with the help of removable connecting knees (kalachi).

Due to the small cross section in these devices, it is possible to create high heat carrier velocities, both in the pipe and in the annular section, even at low heat carrier flow rates,

With significant flow rates of coolants, several parallel sections of two-pipe devices are installed, operating from a common collector.

The methods of intensifying the operation of recuperative heat exchangers include the use of various types of longitudinal and transverse finning of pipe surfaces, which increases the heat transfer surface and enhances flow turbulence, which contributes to an increase in heat transfer coefficients. Often, the surface is ribbed only on one side, on the one where the heat transfer coefficient is lower (during the movement of gases, viscous liquids, etc.).

The transverse ribs are made in the form of round or rectangular metal washers mounted on the pipe. Longitudinal ribs run along the pipes and can be of rectangular or trapezoidal section. Often pipes are supplied not with continuous longitudinal ribs, but notched at a certain distance and bent in different directions, which enhances the turbulence of the flow. Ribbed heat exchangers with ribs in the form of a multi-threaded spiral work intensively.

To intensify the process of heat transfer inside the pipes, they are also filled with various nozzles, the use of pipes of variable cross section, and the creation of artificial roughness on the inner surface.

Advantages of two-pipe devices:

1) ease of manufacture;

2) reliable operation at low heat carrier flow rates

Flaws:

1) small heat transfer surface (surface of the inner tube) per unit volume and, consequently, the bulkiness of the apparatus;

2) difficulty in cleaning the annulus.

6 Conclusion

The annual heating capacity of the calculated heat exchanger was 171 Gcal/year, which is 12 Gcal/year higher than that of the original heat exchanger.

The expediency of using a water-water heat exchanger in a heat supply system instead of a steam one is due to lower costs for fuel and energy resources of the boiler house, since more fuel is required to produce steam, as well as the absence of a need for steam from the consumer. Since the cross sections of the inner surface of the pipe and the annular gap are small, significant speeds of movement of heat carriers (up to 3 m / s) are achieved in such a heat exchanger, which leads to an increase in heat transfer coefficients and thermal loads, slowing down the deposition of scale and dirt on the walls of pipes.

The interaction of heat supply organizations with specialized energy service companies makes it possible to develop an effective investment program, an energy saving program and a plan for the modernization of boiler houses and heating networks.

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