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Expanding the functionality of a thermal power station and increasing its energy efficiency

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Abstract

The given article deals with the problem of functionality of the thermal power stations through the use of the energy potential of combined heat and power plants in the city's engineering infrastructure. This is due to the possibility of combined production of heat and electricity as well as products and services required in the city's utilities. The ways of increasing the energy efficiency of thermal power stations both by using an incineration plant or a stationary snow melting plant on the territory of thermal power plants are presented in this article.

Keywords: thermal power plant, functionality, an incineration plant, a snow melting plant, city engineering infrastructure, energy efficiency.

Increasing the energy efficiency of combined heat and power plants has always been a primary task for the development of the heat and power industry. However, the principles of functioning of the wholesale electricity and capacity market (WECM) which do not take into account the distance of electricity transmission from the power plant to the consumer complicate the ability of thermal power stations to compete with other sources of electricity such as nuclear power plants, hydroelectric power plants and state district power plants. This is due to the fact that despite the location of the thermal power stations in the load centre electricity tariffs include a transport component comparable to the cost of electricity generation. At the same time, there is a drop in heat supply from thermal power stations with hot water and process steam which leads to a reduction in electricity generation based on heat consumption and a decrease in thermal efficiency.

The solution of the problem is to expand the functionality of the thermal power stations through the use of the energy potential of combined heat and power plants in the city's engineering infrastructure. This is due to the possibility of combined production of heat and electricity as well as products and services required in the city's utilities.

Increasing the energy efficiency of thermal power stations is achieved through:

- increase in heat production by the use of low-potential sources of heat energy for the disposal of snow removed from the streets;
- increasing the power developed by the turbine unit for heat consumption when passing water from the centralized cold water supply system through the condenser to increase the efficiency of the drinking water treatment configuration;
- saving the fossil fuel consumed by the thermal power stations when the waste-incineration plants are included in the cycle of the station.

Increasing the energy efficiency of thermal power plants can be achieved by using the main condensate of the turbine, condensate from the turbine heaters or return heating water as a heating agent in a stationary snow melting plant located on the territory of the thermal power plants [1]. When this technology is implemented, the amount of steam taken off to low-pressure heaters or network heaters increases which leads to an increase in electricity generation based on heat consumption.

The location of a stationary snow melting plant on the territory of thermal power plants is also due to the presence of workshops for chemical water purification and relatively cleans effluents, for example, blowdown water from circulating technical water supply

systems, for organizing its mixing with contaminated melt water with subsequent discharge into the city sewage system.

In addition to the energy effect for thermal power plants, the proposed technology will reduce the cost of snow removal from the territory of cities due to the fact that thermal power plants are located within the city.

Evaluation of the technical and economic indicators of the thermal power plant when implementing new technologies for the disposal of snow removed from city streets showed that the most effective technology is the use of heat from the return heating water (Figure 1) which allows saving more than 3000 tons of equivalent fuel per year for a stationary snow melting plant with a capacity of 650 tons /h. The discounted payback period is 4 years [2].

Figure 1. Scheme of using the heat of return heating water
(RF patent No. 165483)

The advantage of this scheme should be attributed to a sufficiently high thermal efficiency associated with an increase in electricity generation based on heat consumption due to a decrease in the temperature of the return water supply before the network water heaters.

Another option for the joint use of the engineering infrastructure of centralized heat and water supply to consumers is the inclusion of the technological process of preparing drinking water for the centralized cold water supply system in the thermal power station cycle [3].

In order to organize the controlled water heating in the city water supply system, it is proposed to use the spent steam of heating turbines. To do this, it is necessary to turn on the condenser of the steam turbine of the thermal power station (mini- thermal power station) through the cooling medium into the pipeline of the source or purified drinking water before supplying it to the centralized cold water supply system. Thus, the source water heated before the water treatment plant or the temperature of cold drinking water rises before being supplied to consumers is provided. The use of crude or purified drinking water as a cooling medium in the condenser allows increasing the generation of electricity based on heat consumption and to full usage of the advantages of district heating.

Controlled (up to 20–30 °C) heating of drinking water of the centralized cold water supply system is carried out in the built-in condenser bungle of a given steam turbine (Fig. 2).

Figure 2. Use of a steam turbine condenser of an existing thermal power plant for heating water in a centralized cold water supply system

The result of such controlled heating of drinking water directed to consumers is a decrease in heat consumption for heating water in the hot water supply system of both open and closed heat supply systems. In closed heat supply systems a decrease in heat consumption is achieved due to the use of warmer source drinking water at consumers for preparing hot water as well as by mixing in circulating water intake. An increase in the efficiency of open heat supply systems is achieved only by reducing the amount of hot water used by consumers, when it is mixed in circulating water intake with warmer water of the cold water supply system. The systemic energy effect is achieved by replacing part of the heat load of the hot water supply which is covered by the heating extractions of the heating turbines with exhaust steam.

As a result of calculating the energy efficiency of the technology for using urban thermal power plants in the drinking water preparation scheme for a centralized cold water supply system by the example of Ulyanovsk it was revealed that the increase in the power developed by a turbine unit for heat consumption exceeds 3.3 MW per power unit with a turbine of the T-100 type – 130.

Increasing the energy efficiency of a thermal power plant can be achieved by using an incineration plant in this cycle. This solution has a number of advantages both for the combined heat and power plant itself and for the municipal sector:

- the presence of low-potential heat sources suitable for ‘soft’ drying of waste and increasing their caloric content;
- the possibility of using boilers of combined heat and power plants for afterburning gases from an incinerator;
- reduction of capital costs for the construction of an incineration plant;
- transport accessibility associated with the location of a thermal power plant within the city and the reduction of fuel consumption for waste disposal;
- the possibility of using boilers for thermal power plants for the thermal decomposition of toxic gases;

- the possibility of using the created infrastructure for round-the-clock energy-efficient and cost-effective waste disposal.

When implementing this solution it becomes possible to use solid domestic waste as a fuel (the lowest heat of combustion of SDW ranges from 1200 kcal / kg to 3950 kcal / kg).

When solid domestic waste is burned on special furnace grates and the heat of combustion products is used by waste heat boilers, several tasks are solved:

- saving of fossil fuel is achieved (combustion of 1 ton of solid waste replaces on average 450 kg);
- electrical and thermal energy is generated and is useful;
- using special equipment the content of harmful substances in the flue gases is brought to an acceptable level.

Thus, the expansion of the thermal power plant functionality by combining the generation of thermal and electric energy and technological processes required for the municipal economy allows the most efficient use of the existing infrastructure of the thermal power plant and increase its energy efficiency [4].

1. Zamaleev, M.M. The problem of snow utilization in large cities [Text] / M.M. Zamaleev, I.V. Gubin and V.I. Sharapov // Sat. scientific. works of scientific-issled. laboratories "Heat power systems and installations" UISTU "Heat power engineering and heat supply". Issue 11. - Ulyanovsk: UISTU, 2015. – pp. 141-152.
2. Patent 165483. Stationary snow-melting plant based on a thermal power plant [Text] / M.M. Zamaleev, V.I. Sharapov, I. V. Gubin et al. // Bulletin of inventions. – 2016. – No. 29.
3. Zamaleev, M.M. Energy-efficient solutions for joint use of urban infrastructure of centralized heat and water supply / M.M. Zamaleev, V.I. Sharapov, I. V. Gubin et al. // Energy saving in the urban economy, energy, industry: the Seventh International Scientific and Technical Conference (Ulyanovsk, April 21-22, 2017): collection of scientific papers. T. 1. - Ulyanovsk: UISTU, 2017. – pp. 122-127.
4. Zamaleev, M.M. Using the energy potential of the thermal power for the needs of the communal services [Text] / M.M. Zamaleev, V.I. Sharapov, I. V. Gubin, V.A. Pavlov // Proceedings of Academenergo. – 2016. – No. 2. – pp. 25-38.