Technical sciences

UDC 621.036.7

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ANALYSIS OF EXERGETIC LOSSES IN A COMBINED HEAT RECOVERY SYSTEM OF A BOILER PLANT

Summary. *The results of the analysis of exergy losses in the combined heat recovery system of the boiler plant are presented. To study exergy losses in this system, a complex technique has been developed based on the use of exergy analysis methods in combination with methods for representing exergy balances in matrix form. Using a complex technique, exergy losses were calculated in a combined heat recovery system and in its various elements. The relative*

contribution of each element of the system to the total exergy loss was determined. It has been established that the optimal operating mode of the installation is carried out at the boiler power, which is 50 ... 60% of its installed power.

Key words: *exergy losses, boiler plant, exergy analysis, heat recovery system, energy efficiency.*

Introduction. Improving the efficiency of power plants of various types, in particular, heat recovery systems of boiler plants, involves reducing exergy losses in them. When developing, researching and implementing highly efficient heat recovery systems, it is advisable to use modern integrated research methods. Therefore, the analysis of exergy losses in the combined heat recovery system of a boiler plant using methods based on the exergy approach is an urgent scientific problem.

Statement of the problem and research method. In the world practice of researching the efficiency of energy systems, more and more attention is paid to the use of exergy methods of analysis [1-5]. When evaluating the performance of power plants, it is advisable for research to use complex methods based on the exergy approach. Works [6-11] are devoted to the application of such techniques to the study of exergy losses in heat recovery systems of various types. Further research in this direction contributes to an increase in the efficiency of power plants and the development of exergy analysis methods. The purpose of the work is to reduce exergy losses in the combined heat recovery system of a boiler plant designed to heat water and blast air.

To achieve the goal, you must complete the following tasks:

- for a combined heat recovery system, develop a comprehensive methodology based on the use of exergy analysis methods in combination with methods for presenting exergy balances in matrix form;
- using an integrated methodology to calculate the exergy losses in various elements of the combined heat recovery system;

- to determine the relative contribution of each element of the heat recovery system to the total value of exergy losses under different operating modes of the boiler.

Research results. The exergy losses in the combined heat recovery system of a boiler plant designed for heating water and blast air have been studied. Exergy losses are an indicator of the efficiency of heat recovery and its individual elements. An increase in exergy losses corresponds to a decrease in their efficiency. To determine exergy losses, a technique was used that combines elements of exergy analysis with methods for presenting exergy balances in matrix form. Using the developed technique, a comparative analysis of exergy losses in the elements of the installation was carried out and the relative contribution of each of its elements to the total value of exergy losses under various operating modes of the boiler was determined. The installation under study includes a boiler, a hot water heat exchanger, an air heat exchanger, a gas heater, a smoke exhauster, a fan, pumps, a piping system connecting the main elements of the heat recovery system. Calculations of exergy losses in the installation were carried out for various operating modes of the boiler. The relative contribution of each element to the total exergy losses of the combined heat recovery system was determined (Fig. 1, Table 1).

As can be seen from the figures, the exergy losses for all elements of the combined heat recovery system increase with increasing boiler power. At the same time, the smallest exergy losses are observed in the hot air heat exchanger and in the gas heater. Exergy losses in pumps are comparable to exergy losses in a smoke exhauster.

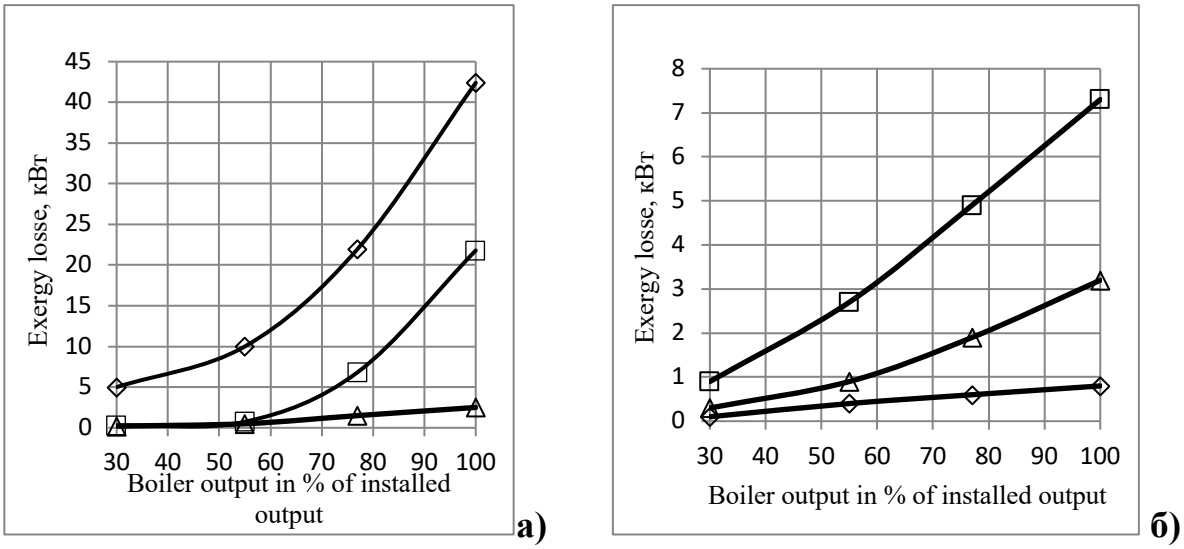

Fig. 1. Exergy losses in the combined heat recovery system: a) ◇– heat recovery system; □ - hot water heat exchanger; △ – hot air heat exchanger; b) ◇– gas heater; □ - smoke exhauster; △ – fan;

The relative contribution of exergy losses in the hot water heat exchanger to the total exergy losses of the heat recovery system increases with increasing boiler power. The total contribution of the pumping system and the piping system connecting the main elements of the heat recovery system to the total exergy losses is quite significant for all boiler power values. It decreases from 89.2% to 40.7% when the boiler capacity increases from 30% to 100% of the installed capacity.

Table 1

Relative contribution of the exergy losses of the elements of the combined heat recovery system to the total exergy losses

№	Elements heat recovery tional system	Relative contribution of individual elements to the total exergy losses in the heat recovery system, %			
		30% of installed boiler capacity	50% of installed boiler capacity	70% of installed boiler capacity	90% of installed boiler capacity
1	Hot water heat exchanger	16	11,8	26,4	45,4
2	Hot air heat exchange	14	11,8	8,8	6,7
3	Gas heater	2	4,7	2,9	2,1
4	Smoke exhauster	20	25,9	23,	18,5
5	Fan	6	8,2	8,8	7,9

6	Pump 1	14	15,3	12,4	8,2
7	Pump 2	20	21,2	14,7	9,7
8	Piping system	2	1,2	24	1,5

Graphs illustrating the exergy losses in the heat recovery system and in the hot water heat recovery unit depending on the boiler power have two pronounced sections. In the first section, when the boiler power changes to 50...60% of the installed power, there is a slight increase in exergy losses, approximately by 7 kW. In this section, the main exergy losses are in the pumping system and in the pipeline system. In the second section, exergy losses in the heat recovery system begin to increase more significantly, increasing by approximately 30 kW. In this case, the main exergy losses fall on the hot water heat exchanger. Taking into account the possibility of regulating exergy losses in the pumping system and the pipeline system, it can be concluded that the optimal mode of operation of the plant is carried out at a boiler capacity of 50 ... 60% of its installed capacity.

Conclusions

1. A comprehensive methodology has been developed for the analysis of exergy losses in the combined heat recovery system of a boiler plant, based on the use of exergy analysis methods in combination with methods for presenting exergy balances in matrix form.

2. Using a complex methodology, the exergy losses in various elements of the combined heat recovery system were calculated and the relative contribution of each of its elements to the total exergy losses was determined.

3. It has been established that the optimal mode of operation of the installation is carried out at the boiler power, which is 50 ... 60% of its installed power.

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