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Improving the environmental efficiency of gaseous fuel combustion in hot water gas-fired boilers

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ABSTRACT: An analysis of the design features and operating modes of gas-fired boilers is carried out, their advantages and disadvantages are determined in relation to water-pipe boilers; analysis of existing methods of calculating heat transfer in boiler furnaces and combustion chambers; calculated properties of heat transfer in small boiler furnaces and theoretical conditions of its amplification are defined;

I. INTRODUCTION

Relevance of the study. At present, the consistent implementation of energy policy is important for the recovery and strengthening of the economy in Uzbekistan before the increase in energy production and production. resources need to increase environmental efficiency at the same time. Recently, block automated boilers based on small and medium-capacity gas-fired boilers are widely used in small energy and housing and communal services.

Due to differences in heat transfer in the furnaces of small furnace boilers, their small size and operating parameters affecting the physical conditions of the process, they differ significantly from similar processes in furnaces of power boilers, which leads to a decrease in thermal conductivity. The use of secondary radiators in boiler furnaces complicates the calculation of the heat transfer process. Unlike flue gases, as a result, it returns heat from them to the radiant surfaces of the furnace with greater intensity. The increase in heat transfer leads to a decrease in the maximum temperature in the core of the torch, which contributes to a decrease in the formation of thermal nitric oxide in the boiler furnace.

II. LITERATURE SURVEY

The works of others are of significant importance in the issues of theoretical justification and practical implementation of various types of design of contact devices for cooling outgoing flue gases [1].

The issues of theoretical substantiation and practical implementation of surface (condensation) flue gas coolers behind boilers are reflected in the works of other scientists. In these works, it is emphasized that the development of the design of such coolers through the use of modern highly developed 10 finned heating surfaces allows them to compete effectively with contact devices [2].

A characteristic feature of the introduction of energy-saving and environmental protection technologies at operating boilers of small and medium power is their severe limitation in terms of capital costs. In accordance with this, decisions are expedient that do not provide for the replacement of existing technological equipment with new ones, but for its maximum possible use, subject to the achievement of modern indicators in terms of fuel combustion efficiency and air protection. The only exceptions are minor improvements in some units of the burner during the introduction of any technological method. Therefore, such actions are energy-ecological rehabilitation of existing heat engineering equipment [3].

Taking into account the state of the existing fleet of heating and industrial boiler houses that have physically and morally obsolete, often inoperative automation systems

regulation, an integral part or the initial step of a comprehensive solution may be an improvement, in order to increase the efficiency of fuel combustion, regular automation systems or, in some cases - with significant wear, their complete

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replacement. The next step in energy saving is to reduce the consumption of electricity by draft machines of boiler units. [4].

The constant rise in energy prices in the short and long term makes us think about the modernization of existing units in order to increase efficiency (efficiency) and, consequently, reduce the consumption of gas and other energy resources. Today, the main sources of heat for residential buildings and structures are district boiler houses and thermal power plants operating on fossil fuels. Currently, the market situation is not the best due to the technical condition of the equipment and the high cost of natural gas and electricity. An important task is the development and implementation of low-cost and quick-return energy-saving technologies. In the production of thermal energy, as in any other production, you need to strive for the most efficient production. In boilers, one of the ways to reduce the cost of heat production is to increase the efficiency of the boiler. The efficiency of boilers operating on natural gas and fuel oil is 85–92% (calculated based on the net calorific value of fuel). In addition, due to wear and tear of equipment, boiler houses operate with low efficiency. As a result, the problem of increasing energy efficiency through the modernization of boiler equipment or energy saving measures becomes urgent. Boiler efficiency increase is one of the ways to reduce the cost of heat production [5].

III. MATERIAL AND METHODS

First, it is necessary to determine the volumes and enthalpy of air and combustion products.
1.Determine the theoretical volume of air, m^3/m^3, required for complete combustion of fuel:

$$V_{в}^{o} = 0{,}0478 \cdot \left[0{,}5CO + 0{,}5H_2 + 0{,}5H_2S + \sum\left(m + \frac{n}{4}\right)C_mH_n - O_2\right], \quad (1)$$

where m is the number of carbon atoms;
n is the number of hydrogen atoms.
We determine the enthalpy of the theoretical volume of combustion products for the entire selected temperature range, m^3 kJ:

$$I_{г}^{0} = V_{ro2}(c\nu)_{ro2} + V_{N2}^{o}(c\nu)_{N2} + V_{H2O}(c\nu)_{H2O}, \quad (2)$$

where cυ, $(c\upsilon)H_20$ are the enthalpy of 1 m3 of triatomic gases, the theoretical volume of nitrogen, the theoretical volume of water vapor, kJ/m^3; V_{RO2}, V^0_{N2}, V^0_{H2O} are the volumes of triatomic gases, the theoretical volume of nitrogen and water vapor, m^3/m^3.
We determine the enthalpy of excess air, m3 kJ:

$$I_{изб}^{в} = (\alpha_y - 1)I_{в}^{o}, \quad (3)$$

The heat received by the heated medium into the heat exchanger according to the balance is equal to the sum of the heat received by each heat carrier in each stage, m^3 kJ: [12].

$$Q_{б} = \frac{\sum_{i=l}^{i=n} G_i c_i \left(t_i^{"} - t_i^{'}\right)}{B_p} \quad (4)$$

where Gi , ci , t’’, t’ are respectively the flow rate, heat capacity, input and output temperatures of the coolant.
3. Enthalpy of gases excluding H2O condensation
- at the input I' = 3655.42 kJ/m^3
- - at the dew point Tr= 1080 kJ/m^3
The heat given off by flue gases in the heat exchanger according to the balance is calculated as the sum of the heat of physical cooling of gases to the dew point and the latent heat of condensation of water vapor during further cooling of combustion products to the temperature at the outlet of the heat exchanger, kJ/m^3:

$$Q_{б} = g_n \cdot \phi \cdot \left(I^{'} - I_p + \Delta I^{w}\right), \quad (5)$$

where φ is the coefficient of heat conservation, taking into account its losses to the environment, can be conditionally assumed to be the same as in the thermal calculation of the boiler unit;

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I' and I_p are the enthalpy of combustion products without taking into account the latent heat of vaporization (according to the lowest heat of combustion) at the temperature of gases at the inlet to the utilizer and at the dew point, kJ/m3.

Currently, the situation has changed significantly, and deep cooling of flue gases has become economically feasible due to a sharp increase in fuel and heat prices and the emergence of more advanced designs of metal heat exchangers, in particular bimetallic heat exchangers. With all the attractiveness of using contact heat exchangers when utilizing the heat of flue gases from boilers, the main disadvantage of the installations - the absorption of carbon dioxide and oxygen by water from the combustion products and the acquisition of corrosive properties by it - hinders the widespread use of such heat exchangers. For normal operation of installations, it is necessary to carry out decarbonization, deaeration of water, which in some cases complicates the use of irrigation water. In this regard, attention is paid to the use of condensation heating surfaces. The heat exchange surface of condensation heating surfaces is much more developed in comparison with conventional economizers. Condensing heat exchangers have the same high efficiency as contact heat exchangers, but they are more metal-intensive structures. At the same time, the absence of direct contact between the combustion products and the heated water makes them preferable from the point of view of the quality of the heated water.

IV. CONCLUSION

The proposed gas analytical instruments, fuel-air ratio correction systems and automation systems for boiler units make it possible to:
– to implement the concept of energy-saving operation of boiler units in continuous mode;
– save up to 6-10% of fuel during the year;
- reduce by 3-40% emissions of nitrogen oxides into the atmosphere;
- reduce by 20-55% the consumption of electricity by fans and smoke exhausters;
– increase the reliability of equipment operation by diagnosing and monitoring the operation of gas-air paths, sensors, actuators.

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