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FEATURES OF INCREASING THE EFFICIENCY OF FUEL COMBUSTION WHEN DESIGNING BOILER EQUIPMENT.

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Annotation: The article presents small boiler combustion devices and fuel efficiency. Based on the analysis of the boiler device flow chart, the article examines the issues of increasing energy efficiency and provides recommendations.

Keywords: Boiler device, fuel, energy efficiency, combustion efficiency, combustion chamber, burner, nuclear flame.

ОСОБЕННОСТИ ПОВЫШЕНИЯ ЭФФЕКТИВНОСТИ СЖИГАНИЯ ТОПЛИВА ПРИ ПРОЕКТИРОВАНИИ КОТЕЛЬНОГО ОБОРУДОВАНИЯ.

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Аннотация: Представлены топочные устройства малых котлов и эффективность использования топлива. На основе анализа технологической схемы устройства котла рассмотрены вопросы повышения эффективности использования энергии и даны рекомендации.

Ключевые слова: Котельное устройство, топливо, энергетическая эффективность, полнота сгорания, топочная камера, горелка, ядерное пламя.

Relevance of the topic: Energy saving and production of energy-saving technologies are considered one of the priority areas in the global economy. In this regard, research on thermal energy systems and technologies is important. Today, 80% of the energy consumed by humanity comes from natural organic fuel. 90% of the energy balance of Uzbekistan is gas and only 4% is coal, and 6% are hydroelectric power plants and other types of alternative energy sources.

The main objective reasons for the low use of coal in our republic are:

- High ash content of Angren coal, i.e. a large amount of ash released during combustion.
- Virtual absence of modern technologies for the use of high-ash brown coal.
- High impact of coal combustion on the environment.

Today, the creation of favorable microclimate conditions for the population is considered an urgent task.

The decision of the President of the Republic of Uzbekistan “On the program for the development of the heat supply system for 2018-2022” was adopted, aimed at improving the quality and uninterrupted supply of thermal energy to consumers, modernizing the heat supply system with the aim of updating and modernizing it based on the introduction of efficient and low-energy technologies, and consistently implementing measures for the efficient and rational use of fuel and energy resources [1].

The industry has faced serious problems for years and is currently waiting for its solution.

Among them are a radical change in heat supply, the use of alternative sources of fuel and energy, in particular solar energy, a gradual transition to local heat supply and hot water supply systems, outdated fuel issues, such as replacing energy-intensive boilers with natural gas. Of particular importance from the point of view of modern energy-efficient equipment, control equipment and the transition to new technologies are energy-saving equipment, heating, ventilation and air conditioning systems of buildings and structures [2].

Design solution for boiler heaters. Burners on the combustion chamber wall are placed in such a way as to ensure the most complete combustion of fuel in the nuclear torch, create favorable conditions for removing solid or liquid slag from the combustion chamber, and prevent slag formation on the combustion chamber walls. When selecting burner types and their optimal placement, the same operating characteristic is taken into account [3].

Thus, when comparing direct-flow burners with multi-tier burners, it is clear that multi-tier burners provide a shorter flame length and a wider opening angle. Due to the accumulated kinetic energy, a violent mixing of the primary and secondary air flows is formed, ensuring complete combustion of the fuel in the flame core (up to 90-95%). In this sense, multi-tier burners are classified as "individual" burners, each of which ensures the combustion of its own fuel. Fig. 1 shows the layout of stacked coal burners.

In the drawing, the burners can be frontal and double-frontal (a, b in Fig. 1) with one or two tiers in height. When located along one front, the rear wall of the screen receives strong heat absorption (10-20% higher than average), and the depth of the firebox should be B = (6 ÷ 7) Da to eliminate slag on the wall.

where: Da is the diameter of the burner embrasure.

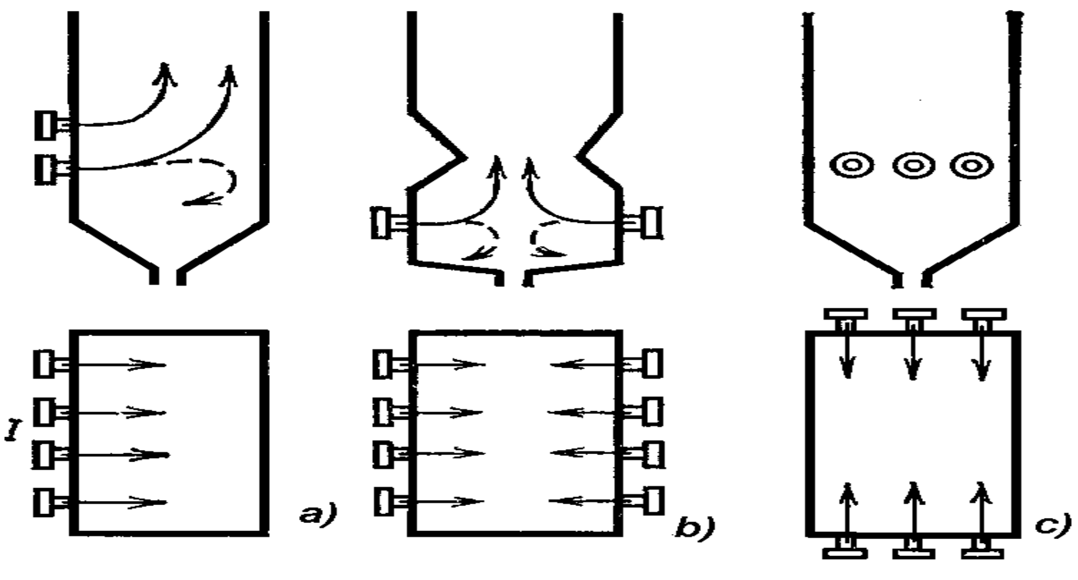

Figure 1. Arrangement of stacked powder-coal burners on the walls of the furnace:

a - front two-tier; b - frontal double-sided single-tier; c - single-tier on one side.

In high-power steam boilers, if it is not possible to place the required burners on one front wall, it is important to place the burners on opposite sides with two fronts [4].

Theoretical part: Mutual equality of the amount of heat released from the fuel and the heat spent on the working fluid and losses is called the heat balance of the boiler.

The heat balance for 1 kg of solid and liquid fuel or 1 m3 of gas burned in the boiler can be expressed as follows:

$$Q_T^u = Q_1 + Q_2 + Q_3 + Q_4 + Q_5 + Q_6 , (1)$$

where: Q_T^u - the amount of heat released by 1 kg (or 1 m^3) of fuel in the furnace, MJ (kg) or MJ (m^3); Q_1 - the amount of heat usefully used in the boiler; Q_2, Q_3, Q_4, Q_5, Q_6 - the amount of heat lost with smoke, due to chemical and mechanical incomplete combustion of fuel, cooling of the boiler surface and ejected slag. The total heat capacity of the working fuel can be determined from the following expression:

$$Q_к^u = Q_{T..Q} + Q_{yo} + Q_b , \qquad (2)$$

Here: $Q_к^u$ - heat of lower combustion of fuel; $Q_{T.Q}$ - heat entering the furnace with air from outside (if the air is heated outside the boiler); Q_{yo} - physical heat of fuel; $Q_в$ - linear heat with steam (when using fuel oil) [5].

Efficiently used heat in a steam boiler is determined by the following formula:

$$Q_1 = \frac{Д_{к.б}}{B}\left(h_{к.б} - h_{T.C}\right) + \frac{Д_u}{B}\left(h_u^{''} - h_u^{'} + \frac{Д_x}{B}\right) h_к - h_{T.C} , (3)$$

where: $D_{k.b}$, D_i - primary and secondary superheated steam consumption, kg/s; D_x - water consumption expelled from the drum, kg/s; $h_{k.b}$, $h_{t.s}$, h_k, - enthalpies of superheated steam, feed water and water on the saturation line, kJ/kg;

$h_u^{''}$, $h_u^{'}$ - enthalpy of secondary superheated steam at the outlet and at the inlet of the intermediate superheater, kJ/kg; V - fuel consumption, kg/s or m^3/s.

The amount of heat effectively used in the boiler can be determined by the following formula:

$$Q_1 = Q_{o'} + Q_q + Q_i + Q_{ek} \qquad (4)$$

where: $Q_{O'}$ - the amount of heat received by the furnace surfaces, kJ/kg;

Q_q, Q_i, Q_{ek} - the amount of heat received by the main, intermediate superheaters and economizer, kJ/kg.

The above heat balance formula can be expressed in relative terms:

$$100 = Q_1 + Q_2 + Q_3 + Q_4 + Q_5 + Q_6. \qquad (5)$$

This heat balance shows the percentage distribution of heat of 1 kg or 1 m^3 of fuel [6].

Heat loss with smoke coming out of the steam boiler is determined by the following formula:

$$Q_2 = H_T^0 + (\alpha_ч - 1)\, H_x^0 - H_x \quad (6)$$

In this formula $H_T^0 = \vartheta_T^0 \cdot S_T \cdot Q_{ch}$ – enthalpy of outgoing smoke (with excess air coefficient α=1); $(\alpha_{ch}-1) H_x^0 \cdot \vartheta_{ch}$ – enthalpy of elevated air at temperature N_x - enthalpy of atmospheric air.

The amount of heat lost due to chemical misfires is determined by the following formula:

$$Q_3 = V_{CO} \cdot Q_{CO} + V_{H_2} \cdot Q_{H_2} + V_{CH_4} \cdot Q_{CH_4}, \quad (7)$$

Here: V_{CO}, V_{H_2}, V_{CH_4} - is the volume of combustible gases in combustion products, m^3/kg of fuel, Q_{CO}, Q_{H_2}, Q_{CH_4} - is the volumetric heat of combustion of combustible gases, MJ/m^3.

Taking into account the above formula, the relative value of heat loss ((Q_T^u in percent) can be determined by the following formula:

$$q_3 = 126{,}4 V_{CO} + 108 V_{H_2} + 358{,}2 V_{CH_4}. \quad (8)$$

The numbers before the gas volumes V_{CO}, V_{H_2}, V_{CH_4}, represent the heat of combustion of gases reduced by 100 times, corresponding to 1 m^3.

Heat losses due to mechanical combustion depend on the type of boiler furnace and the type of fuel used. This indicator is determined using the "Calculation of the heat of boiler units (normative method)".

The amount of heat lost from the surface of the boiler to the environment is determined by the following formula:

$$Q_5 = q_{T.C} \frac{F_c}{B}, \quad (9)$$

where: B- is the fuel consumption in the boiler, kg/s; FS- is the outer surface of the boiler walls, m^2; $q_{T.S}$ $q_{0.2}$ - 0.3 kW/m^2 is the heat flow from the outer surfaces.

Heat losses with emitted waste (slag) can be determined using the following formula:

$$q_6 = \frac{\alpha_{шл} (ct)\, шл \cdot A^u}{Q_T^u}, \quad (10)$$

here: α_{shl}q1-α_U - fraction of slag removed from the combustion chamber;

s_{shl} t_{shl} - heat capacity and temperature of the released slag.

The useful efficiency coefficient (COP) shows what part of the total thermal energy is effectively used (Q_I) in the boiler:

$$\eta_к = \frac{Q_1}{Q_T^и} 100 \quad (11)$$

This method of determining efficiency is called the right balance method.

Knowing the sum of the heat losses of the steam boiler, the gross efficiency is determined by the inverse balance method: [7].

$$\eta_к = 100 - (q_2 + q_3 + q_4 + q_5 + q_6) \quad (12)$$

By determining the efficiency of ozone, the effectively used heat can be determined using the following formula:

$$Q_1 = Q_T^и \cdot \eta_к \quad (13)$$

As a result, the fuel consumption used in the boiler can be determined by the following formula, kg/s:

$$B = \frac{Д_{к.б}(h_{к.б} - h_{Т.С}) + Д_и(h_и^{''} - h_и^{'}) + Д_х(h_к - h_{Т.С})}{Q_T^и \cdot \eta_к} \quad (14)$$

The overall efficiency shows the efficiency of the boiler. But its normal operation is ensured by various auxiliary mechanisms and devices. The energy spent on them is called the consumption required for the operation of the boiler.

Energy consumption for the needs of the boiler is determined by the following formula, kWh:

$$E_{o'.e} = E_V + E_{T.S} + E_{CH} + E_{T.EN} + E_{M.B} \quad (15)$$

where E_V, $E_{T.S}$, E_{CH}, $E_{T.EN}$, $E_{M.B}$, are respectively the energy consumed by the compressed air pumping fan, smoke exhauster, dust preparation mechanisms, feeding electric pumps and remote control electric machines.

The share of energy spent on own needs is determined by the following formula, %:

$$\Delta\eta_{ў.э} = \frac{Э_{ў.э}}{BQ_T^и \cdot \eta_{э.с} \cdot \tau_и} 10^4, \quad (16)$$

Here: V- is the fuel consumption in the boiler, kg/s;

$\eta_{e.s}$ - is the efficiency of i, % of the electricity generated at the central power plant;

τ_i - is the operating time of the boiler, h.

If η_k,. if we subtract the part of the energy spent on itself, then the net efficiency of the boiler is determined:

$$\eta_{к}^{НТ} = \eta_{к} - \Delta\eta_{у.э}. \qquad (17)$$

Conclusion and recommendations:

1 Direct-flow burners mainly use highly reactive fuels for combustion: brown coal, peat, shale and hard coal with high (reactive) volatile matter. The speed of the dust-air mixture at the burner outlet is: ω_1=20÷28 m/s, the optimal speed of secondary air is determined as ω_2=(1.5÷1.7)ω_1.

2. Thus, comparing direct-flow burners with multi-tier burners, it can be seen that multi-tier burners provide a shorter flame length and a wider opening angle. Due to the accumulated kinetic energy, a violent mixing of the primary and secondary air flows is formed, which ensures complete combustion of the fuel in the flame core..

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