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LOW-TEMPERATURE HEATING SURFACE MODE OF THE BOILER

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Abstract: This article analyzes low-temperature heating skirts made from boilers and aims to explore the practical application of these technologies. It serves to explore energy efficiency by explaining the production process and the environmental impact of this energy production method.

Key words: boiler, low-temperature heating surfaces, economizer, air heater, heat exchanger, temperature distribution, gas consumption, thermal efficiency, stage arrangement.

Аннотация. В данной статье рассмотрен анализ низкотемпературных нагревательных юбок из котла и поставлена цель изучить применение технологий на практике. Статья служит для изучения энергоэффективности путем объяснения производственного процесса и воздействия этого метода получения энергии на окружающую среду.

Ключевые слова: котел, низкотемпературные поверхности нагрева, экономайзер, воздухоподогреватель, теплообменник, распределение температуры, расход газа, тепловая эффективность, расположение ступеней.

There are two main schemes for the relative positioning of the economizer and air heater:
1) sequential placement, when the economizer is located first in the direction of combustion products, followed by the air heater;
2) a two-stage arrangement, in which the combustion products first pass through the upper part of the air heater and then through their lower parts.
The two-stage arrangement of the tail heating surfaces somewhat complicates the boiler design. Long air bypass ducts are required. With a two-stage design, the air preheater and economizer are split into two stages.
The last heating surface along the gas flow is still the air heater.
The change in temperature of the gases and working fluid along the low-temperature heating surfaces is shown in Figure 1. As the air heats up, its temperature approaches the temperature of the gases; the opposite is true for water. As can be seen from Figure 1, the minimum temperature difference between the heating and heated fluids is observed at the "hot" end of the air heater Δt_m^{vp} and the "cold" end of the economizer Δt_m^{ek}. This behavior of the temperature curves follows directly from the heat balance equations.
In particular, for the first stage of the air heater, the heat balance equation has the following form:

$$(t_{\text{г.в.}} - t_{\text{х.в.}})\omega_{\text{в}} = (\vartheta_{\text{г}} - \vartheta_{\text{ух}})\omega_{\text{г}} \qquad (1)$$

Where $t_{\text{х.в.}}$; $t_{\text{г.в.}}$— air temperature at the inlet and outlet of the air heater, °C; $\vartheta_{\text{г}}$, $\vartheta_{\text{ух}}$— temperature at the inlet and outlet of the first stage of the air heater, °C; $\omega_{\text{в}}$, $\omega_{\text{г}}$— water equivalents of the volumes of air and gases, related to 1 kg of fuel, kJ/(kg • deg).

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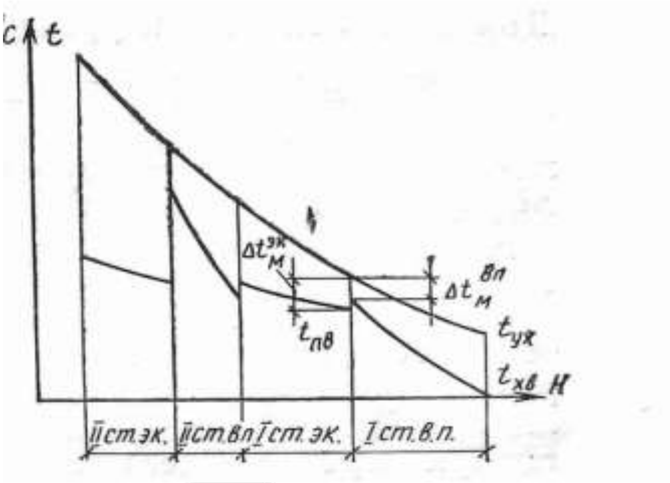

Fig. 1. Change in temperature of gas and working fluid along low-temperature heating surfaces

The values of water equivalents of air and gases are respectively equal to: for air

$$\omega_{\text{в}} = (\alpha_{\text{т}} - \Delta\alpha_{\text{т}} - \Delta\alpha_{\text{пл.у}})V_{\text{в}}^{0}c_{\text{в}}(2)$$

for gas

$$\omega_{\text{г}} = V_{RO_2}c_{RO_2} + V_{N_2}c_{N_2} + (\alpha_{\text{ух}} - 1)V_{\text{в}}^{0}c_{\text{в}} + V_{H_2O}c_{H_2O}(3)$$

The volume of gases is greater than the volume of air due to the presence of water vapor obtained from the fuel moisture and during the combustion of hydrogen, and the suction of air into the furnace and flues of the boiler. In addition, the heat capacity of gases is greater than that of air. Therefore, as can be seen from equations (2) and (3), the water equivalent of gases is always greater than that of air. From equation (1) it follows that the $\omega_{\text{в}} < \omega_{\text{г}}$increase in air temperature is greater than the corresponding decrease in gas temperature. The water equivalent of water, referred to 1 kg of fuel and equal to

$$\omega_{\text{вод}} = (D/B)c_{\text{р}} \quad [kJ/(kg \cdot deg)],$$

gases have a higher water equivalent, so the temperature curves in the economizer region diverge (see Fig. 1).

If in equation (1) the temperature of the gases before the first stage of the air heater and the temperature of the hot air are expressed through $\Delta t_{\text{м}}^{\text{вп}}$ and $\Delta t_{\text{м}}^{\text{эк}}$, then we obtain:

$$v_r = t_{\text{пв}} + \Delta t_{\text{м}}^{\text{эк}};$$

$$t_{\text{гв}} = v_r - \Delta t_{\text{м}}^{\text{вп}}.$$

The optimum temperature of the hot air behind the first stage of the air heater can be obtained from equations (1) and (3):

$$\Delta t_{\text{гв}} = t_{\text{пв}} + \Delta t_{\text{м}}^{\text{эк}} - \Delta t_{\text{м}}^{\text{вп}}.$$

If we substitute the values of the minimum temperature differences obtained above into this equation, we will have:

$$t_{\text{гв}} = t_{\text{пв}} + (10 - 15)\ ^\circ\text{C}.$$

This recommendation is often used when breaking down the heat drop between the stages of an air heater.

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