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Analysis of Fuel Consumption of Fuel Burning Devices in Boiler Rooms

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Annotation: Based on the type of solid fuel, the hydraulic and aerodynamic calculations of the device of the small boiler room, the optimal speeds of the dust-air mixture and secondary air at the exit from the burner were considered, and direct flow burners were compared with stacked burners.

Keywords: small boilers, solid fuel, hydraulic calculation, aerodynamic calculation, dust air mixture, secondary air, direct flow burner, optimal speed.

The preparation of the fuel mixture for the required combustion speed of the fuel dust is achieved in the combustor, which is called the combustor . Fuel dust obtained after grinding and drying at a temperature of 70-130 $^{0\ C}$ is blown into the fuel chamber through the primary air flow. Secondary air enters here through the burner at a temperature of 250-420 $^{0\ C.}$ So, the burners deliver 2 types of flow to the firebox - dust-air mixture and secondary air flow. The formation of the fuel mixture is completed in the combustion chamber.

Burners are the main element of the combustion device, the formation of the mixture depends on its location in the firebox, the speed of combustion is determined by the aerodynamic combustion chamber, the speed and complete combustion give heat power and efficiency to the firebox.

Dust burners are stacked and direct flow. Powder-gas mixture burners are used for burning fuel in powder form and natural gas. Mixed burners are used for burning three types of fuel (solid, gas, fuel oil). Through stacked burners, a mixture of dust and secondary air is supplied in the form of a stacked flow, and a conical spread flame is formed in the size of the firebox. Burners of this type are made in a circular section.

Direct- flow combustors often transfer combustion chamber parallel-flow aerodust and secondary air. First of all, the mutual arrangement of the burners on the firebox wall of the mixed flow and the required volume of the firebox creates an aerodynamic flow. These burners can be of two types : circular and rectangular.

Stacked burners are divided into the following types :

- secondary air is circulated in the apparatus with two shells and two shells ;
- direct flow - shell, air dust falls into the direct flow channel and is transferred to the sprinkler, and secondary air circulates in the shell device;
- the first one rotates the air-blade-air dust flow in a cone, and the secondary air with the help of an axial rotor.
- two-bladed - secondary air and aerodust rotates with the help of axial and tangential blades.

Stacked burners determine the production efficiency of conventional fuels from 1 to 3.8 kg, thermal power from 25 to 1000 MW. The most common are double-shell and shell-blade burners, used for large heat capacity (75-1000 MW).

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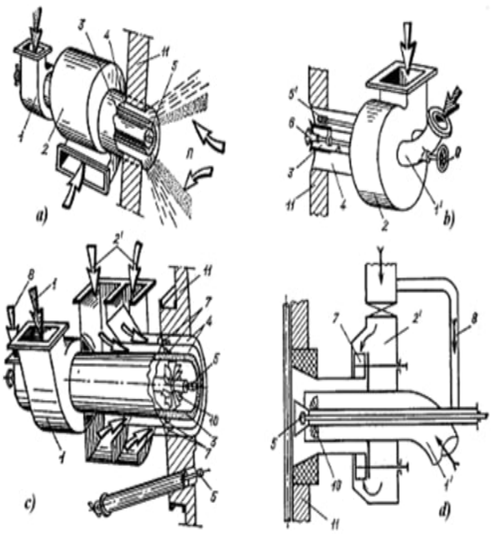

Figure 1. Types of pile burners:

a - a double-shell burner; b – direct flow shell burner; s – shovel burner with shell; d - burner with two shovels; 1 – dust-air mixture shell; 1 – dust-air mixture inlet pipe; 2 – secondary air shell; 2 – secondary air inlet box; 3 – a channel for transferring the dust-air mixture to the furnace; 4 – the same for secondary air; 5 – main fuel oil injector; 5 – fuel oil nozzle; 6 - the dust-air mixture is cut and distributed at the outlet; 7 – secondary air shovel rotor; 8 – central air tertiary transmission channel; 9 - adjusting the status of the distributor; 10 – air flow converter; 11 – fireplace cover; P – suction of gases from the firebox into the flame vessel.

Stacked up burners his own _ strong ejection Hot the bathroom _ of gas the dust to the mixture come fall with separate it's worth it as a result fast to heat up and ignite up to temperature take will come .

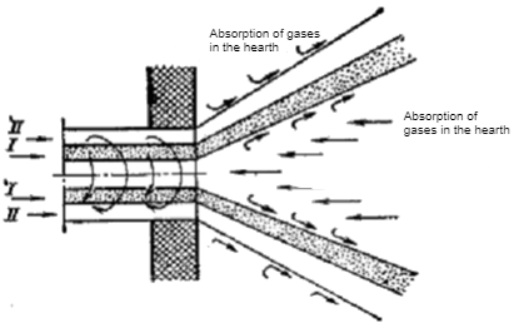

Figure 2. Formation of a mixture at the exit from the pile burner : I-dust-air mixture; II-secondary air

The dust-air mixture and the secondary air at the exit from the burner form two scattered truncated cones, which are additionally formed in the combustion core of high-temperature gas in the absorption zone in two parts . The more hot gases in the firebox are introduced into this process, the more gas will catch fire and fuel will burn .

Direct current burners. Due to the relatively low flow turbulence , straight-flow combustors produce a long-range directed flow that loosely mixes the primary and secondary flows with small expansion angles. Therefore, in the successful burning of fuel , the flow of mutual movement is achieved in the combustion chamber of various burners. They can be installed in the camera with a fixed or screw operation and facilitate the work of adjusting the mode of the furnace (Fig. 3).

A type of burner with a right angle, extending to the top in height. It has lateral flow of the surrounding gas due to its high ejection . Therefore, this type of burners creates a pre-ignition of the internal dust transfer in the external aerodust transfer (Fig. 4). Direct current burners are used as units in large capacity steam boilers because of their relatively low efficiency.

direct flow burners, highly reactive fuels are mainly used for burning: lignite, peat, shale and hard coal with high (reactive) volatile matter. The speed of the dust-air mixture at the exit from the burner is as follows: w_1 =20¸28 m/s, the optimal speed of secondary air w_2 =(1.5¸1.7)w_1 .

Location of burners. The burners on the wall of the furnace chamber are distributed in such a way that in order to ensure the maximum complete combustion of fuel in the nuclear flame, to provide favorable conditions for the removal of solid or liquid slag from the furnace, and to prevent slag formation on the walls of the furnace chamber. . The same working description is taken into account when choosing the types of burners and their optimal location.

Therefore, when comparing direct flow burners with stacked burners, it can be seen that stacked burners produce a shorter flame length and a wider angle opening. Violent mixing of the primary and secondary air flow is formed due to the accumulated kinetic energy , which ensures complete combustion of the fuel in the flame core (up to 90-95%). In this sense, stacked burners belong to "individual" burners, each of which provides its own fuel burning . Figure 2.10 shows the location diagram of stacked charcoal burners.

can be frontal and double-frontal (a, b in Fig. 2.10) with one or two tiers in height . When located along one front, the back wall of the screen receives strong heat absorption (10-20% higher than the average), and the depth of the furnace should be $B = (6 \text{ ¸ } 7) \cdot D_{a}$ to eliminate slag on the wall ,

where: D_a is the embrasure diameter of the burner.

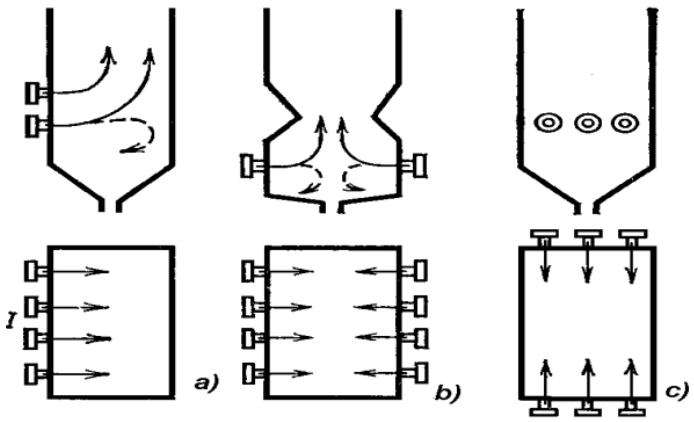

Figure 5. Placement of heap dust - coal burners on the walls of the firehouse:

a - front two-tiered; b - frontal two-sided one-tier; c – one-story with one side.

large-capacity steam boilers, if it is not possible to place the necessary burners on one frontal wall, it is important to place the burners on opposite sides.

Efficiency of fuel use in boiler installations

The mutual equality of the amount of heat released from the fuel and the heat spent on the working body and losses is called the heat balance of the boiler.

kg of solid and liquid fuel or 1 m ^{3} of gas burned in the boiler can be expressed as follows:

$$Q_{T}^{И} = Q_1 + Q_2 + Q_3 + Q_4 + Q_5 + Q_6, \quad (7)$$

where: $Q_{T}^{И}$ - the amount of heat generated from 1 kg (or 1 m ^{3}) of fuel in the furnace, MJ (kg) or MJ (m ^{3}); Q_1 - the amount of useful heat 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 content of the working fuel can be determined from the following expression:

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$Q_к^и = Q_{T..Q} + Q_{or} + Q_b$, (8)

Here: $Q_к^и$ - heat of lower combustion of fuel ; $Q_{T..Q}$ - heat entering the furnace with air from outside (if the air is heated from outside the boiler); Q_{yo} - physical heat of fuel; Q_b - heat input with steam (when fuel oil is used).

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

$$Q_1 = \frac{Д_{кб}}{B}(h_{кб} - h_{ic}) + \frac{Д_к}{B}\left(h''_к - h'_к + \frac{Д_х}{B}\right)h_х - h_{T.C}$$, (9)

where: $D_{k.b}$, D_i - consumption of primary and secondary superheated steam, kg/s; Dx - consumption of water driven from the drum, kg /s; $h_{k.b}$, $h_{T.S}$, h_k ,- enthalpies of superheated steam, supply water and water at the saturation line, kJ/kg;

$h''_к$, $h'_к$ - enthalpy of secondary superheated steam leaving and entering the intermediate superheater, kJ/kg; V - consumption of burned fuel, kg/c or m ^{3} /s.

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

$Q_1 = Q_{o'} + Q_q + Q_i + Q_{ek}$ (10)

where: Q_O ' is 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 steam superheaters and the economizer, kJ/kg.

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

$100 = Q_1 + Q_2 + Q_3 + Q_4 + Q_5 + Q_6$. (11)

This heat balance shows the percentage distribution of the heat of 1 kg or 1 m 3 of ^{fuel} .

The heat lost by the smoke leaving the steam boiler is determined by the following formula:

$$Q_2 = H_T^0 + (\alpha_ч - 1)H_х^0 - H_х \quad (12)$$

In this formula H_T^0=J ^0_T·S $_T$ ·Q $_ч$ is the enthalpy of the exhaust smoke (when the coefficient of excess air is a=1) ; (a $_ч$ -1) $H_х^0$-J enthalpy $_{of}$ increased air at temperature; N $_x$ is the enthalpy of atmospheric air.

chemical combustion is determined by the following formula:

$$Q_3 = V_{CO} \cdot Q_{CO} + V_{H_2} \cdot Q_{H_2} + V_{CH_4} \cdot Q_{CH_4}, \quad (15)$$

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

Taking into account the above formula, the relative value of the lost heat ($Q_T^и$ in percent) can be determined from the following formula:

$$q_3 = 126{,}4V_{CO} + 108V_{H_2} + 358{,}2V_{CH_4}. \quad (13)$$

Gas volumes V_{CO}, V_{H_2}, V_{CH_4} the numbers shown in front are 100 times reduced combustion heats of gases corresponding to 1 m^3.

lost as a result of mechanical combustion depends on the type of furnace of the boiler and the type of fuel used. This indicator is determined with the help of "Calculation of heat of boiler devices (normative method)".

lost from the surface of the boiler to the surrounding environment is determined by the following formula:

$$Q_5 = q_{T.C} \frac{F_c}{B}, \quad (14)$$

where: B - fuel consumption in the boiler, kg/s; F_S - outer surface of boiler walls, m^2; $q_{T.S}$ q0.2 - 0.3 kW/m^2 - heat flow from the outer surfaces.

ejected waste (slag) can be determined using the following formula:

$$q_6 = \frac{\alpha_{шл} (ct)_{шл} \cdot A^{н}}{Q^{н}_{т}}, \quad (15)$$

here: a_{shl} q1-a_U - part of the slag removed from the furnace chamber ; s_{shl} t_{shl} - heat capacity and temperature of the released slag.

Useful work coefficient (FIK) is the total heat energy in the boiler $Q^{н}_{T}$ shows how much of it was effectively used (Q_I) :

$$\eta_k = \frac{Q_1}{Q^{н}_{т}} 100 \quad (16)$$

This method of determining FIK is called the correct balance method.

Knowing the sum of the lost heat of the steam boiler , the gross FIK is determined by the reverse balance method:

$$\eta_k = 100 - (q_2 + q_3 + q_4 + q_5 + q_6) \quad (17)$$

By determining the FIK of ozone, the effectively used heat can be determined according to the following formula :

$$Q_1 = Q^{н}_{T} \cdot \eta_x \quad (18)$$

of fuel used in the boiler can be determined from the following formula, kg/s:

$$B = \frac{Д_{к.б}(h_{к.б} - h_{т.с}) + Д_{ш}(h''_{ш} - h'_{ш}) + Д_{х}(h_{х} - h_{т.с})}{Q^{н}_{T} \cdot \eta_k} \quad (19)$$

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

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

$$E_{o'.e} = E_V + E_{T.S} + E_{Ch} + E_{T.EN} + E_{M.B} \qquad (20)$$

where: E_V , $E_{T.S}$, E_{Ch} , $E_{T.EN}$, $E_{M.B}$, - respectively compressed air transfer fan, smoke extractor, dust preparation mechanisms, supply electric pumps and remote control electric energy consumed by cars.

The part of energy spent for own needs is determined by the following formula, % :

$$\Delta \eta_{ў.э} = \frac{Э_{ў.э}}{BQ_r^н \cdot \eta_{э.с} \cdot \tau_н} 10^4 , \qquad (21)$$

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

$h_{e.s}$ - - FIK i, % of electric energy production at IES;

t_i - boiler operation time, hours.

If h_k ,. if the part of the energy spent on itself is subtracted from, the net FIK of the cauldron is determined :

$$\eta_к^{нт} = \eta_к - \Delta \eta_{у.э} . \qquad (22)$$

Summary

fuel type of the small boiler room, hydraulic and aerodynamic calculations were carried out, and comparing straight-flow burners with stacked burners, it can be seen that stacked burners produce a shorter flame length and a wider angle opening. does. Violent mixing of the primary and secondary air flow is formed due to the accumulated kinetic energy , which ensures complete combustion of the fuel in the flame core.

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