

ENERGY SAVING MODEL OF THE HEATING CYLINDRICAL WARMLY EXCHANGE MODULE TOM – 1

For effective burning of low-grade Kuznetsk coal, according to Voronov E.N. proposal the heating cylindrical heat exchange module TOM-1 is developed and approved. Which distinctive feature is the cone-shaped fire chamber with a grid-iron motionless not failure lattice and a loading ring for burning in a layer of polyfractional coal in the dense clamped bed. And also a design of heat exchange sections of heating trumpet elements with modular distributive water collectors in a look of «a water shirt», carrying out as well a role of a brickwork envelope of a copper. As thermal isolation the thin layer of corundum is used. This design is the representative of energy saving technology.

Keywords: energy saving, cylindrical heat exchange module, polyfractional coal, cone-shaped fire chamber, heating trumpet element, a water shirt

The solution of problem power - and the cost-effective use of resources of housing and communal services and industrial sector with introduction of economic scientific and technical development at all times was actual. Achievement of economic benefits of burning of low-grade coals, taking into account social, financial restrictions, requirements for environmental protection, health and safety, should be directed on creation of energy saving designs of heating coppers with higher of efficiency and effective technologies of burning of local firm fuel.

For effective burning of low-grade Kuznetsk coal, and also borlinsk, kuuchek, shubarkol coals, according to Voronov E.N. proposal. the heating cylindrical heat exchange module TOM – 1 [1], presented on fig. 1 is developed and approved.

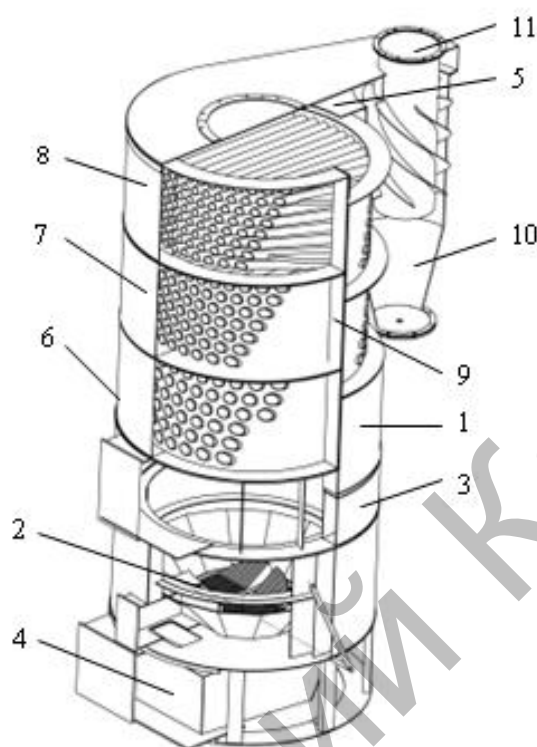
Profitability and reliability of work of heating coppers can be estimated to quantitative and qualitative characteristics which depend on type of the furnace device, brand and a grade of fuel and a way of its burning. The thermal capacity of the furnace device, thermal capacity of volume of a copper and visible thermal capacity of a grid-iron lattice or a burning mirror belong to quantitative characteristics. The amount of losses of warmth belongs to qualitative characteristics chemical and mechanical under burning fuels, value of factor of excess of air in the furnace device and efficiency of a heating copper.

The capacity of layered fire chambers depends on the active area of a grid-iron lattice, i.e. a part of a surface of a layer on a lattice, and intensity of its work defines visible thermal capacity of a grid-iron lattice and thermal capacity of furnace volume. Thermal tension of a lattice depends on its design and a grade of burned fuel.

Distinctive feature of the heat exchange TOM-1 module is the cone-shaped fire chamber with a grid-iron motionless not failure lattice and a loading ring for layered burning of multi fractional coal in the dense clamped bed and a design of heat exchange modules of heating trumpet elements with modular distributive water collectors in a look of «a water shirt», carrying out as well a role of a brickwork envelope of a copper. As thermal isolation corundum in thickness 15mm instead of a fireclay brick is used.

Coal of the Kuznetsk field is characterized by quite high exit of flying substances therefore it is carried to brand CC, and on the size of a piece to brand P – the private soldier, i.e. multi fractional structure - the size of a piece from a coal dust to a block therefore the pulverulent method of burning of coal of such brand as practice showed, is the most economic [2]. Constructional features

of a fire chamber of Voronov E.N. and improvement the organization of furnace process of layered burning allow to burn multi fractional coal as well in a layer.



1–case; 2–cone-shaped furnace device; 3–loading ring; 4–under the furnace device; 5–collector of smoke gases; 6–the bottom module of heating elements with diameter of tubes of $d_{tr}=60 \times 4,5\text{mm}$; 7–the average module of heating elements with diameter of tubes of $d_{tr}=52 \times 3,5\text{mm}$; 8–the top module of heating elements with diameter of tubes of $d_{tr}=42 \times 3,5\text{mm}$; 9–modular distributive water collectors («a water shirt»); 10–gas purification cyclone; 11–exit of smoke gases.

Fig. 1 General view of the heat exchange module of Voronov E.N.

The analysis of the actual heat technical characteristics of Kuznetsk coal showed considerable changes, humidity on working weight changes within $W_p - 5,5 - 7,0 \%$; an ash-content on dry weight the Expert $A^c - 44-49 \%$ and an exit of flying V_g to combustible mass of $V^c - 27-31 \%$. Kuznetsk coal has high warmth of combustion of fuel, but owing to considerable fluctuations of an ash-content caloric content on working weight also changes in a wide limit. Enough with high precision warmth of combustion of working weight of Kuznetsk coal can be determined by an empirical formula:

$$Q_h^p = 7886 - 83A^p - 85W^p, \quad (1)$$

where - Q_h^p the lowest warmth of combustion of fuel, kcal/kg (at calculation of the boiler equipment it is used Q_h^p as leaving smoke gases have temperature above temperature of condensation of water vapor); A^p - an ash-content on working weight, %. For kuznetsk coal the lowest warmth of combustion in heat technical calculations is accepted by equal 3910 kcal/kg. Factor of caloric content of Kuznetsk coal 0,56 (is defined by the relation of the lowest warmth of combustion of fuel to conditional warmth of combustion).

For ensuring completeness of combustion when burning coal with a big exit of flying substances of one supply of primary air from fire chamber sweat insufficiently, it is necessary to submit over a bulk burning layer air of secondary blasting (fig. 2) with providing a constant of a bulk layer.

The height of a bulk layer depends on the sizes of pieces and humidity of fuel, than pieces and more humidity of fuel are larger, the bulk layer should be thicker. At layered burning the height of a bulk layer of fuel not a by cycle and usually doesn't exceed height of an oxygen zone and for cylindrical fire chambers makes 1,0 – 1,2m, in Voronov E.N. cone-shaped fire chamber the height of a bulk layer makes 0,6m at equal heat productivity.

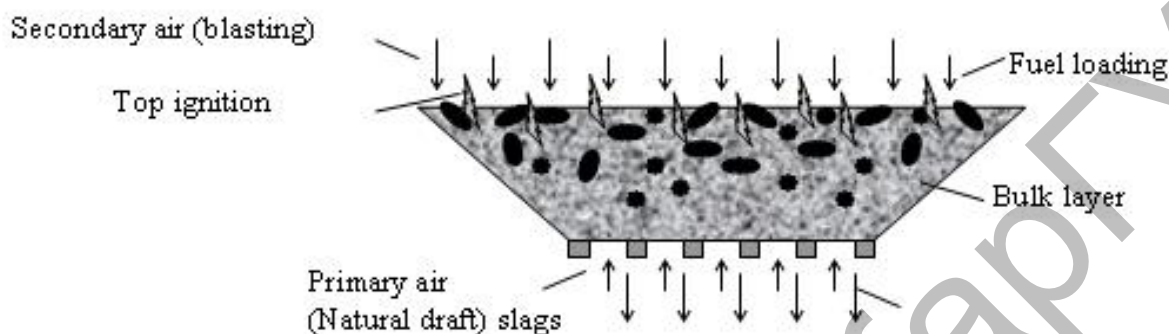


Fig. 2 Voronov E.N. Cone-shaped fire chamber.

In layered devices it is usually burned rather large pieces of coal. The high adiabatic of layered processes promotes development in a layer of high temperatures, and burning proceeds in diffusive area that distinctly proves to be true strong dependence of speed of burning out on intensity of a supply of blasting. Reduction of diffusive resistance of a layer and transfer to kinetic area intensifies burning. Layered process at the compressed layer with giving of secondary blasting on the one hand presses fuel to a grid-iron lattice not only under the influence of weight of a bulk layer, but also blast air, and the grid-iron lattice interferes with violation by aerodynamic stability at increase in secondary blasting. Therefore the cone-shaped fire chamber reduces the area of a grid-iron lattice, in comparison with cylindrical, thereby promotes aerodynamic stability of a layer. The relation of the areas of a grid-iron lattice and mirror of burning of a cylindrical fire chamber equally 1, optimum value of the relation of the areas for Voronov E.N. cone-shaped fire chamber. certain experimentally for heat exchange modules of different productivity it is equal 0,5. The live section of a lattice, that is the relation of all gaps in a grid-iron lattice through which primary air in a layer arrives, to all area of the lattice, expressed as a percentage, equals 12-18 %.

At the clamped dense bed on a grid-iron lattice, under the influence of a body weight increase of a forcing of burning of the top layer increases an air filtration in inside layer and to carrying out from a layer of larger pieces which completely don't manage to burn through. It leads to sharp increase mechanical under burning and complicates burning of multi fractional fuels of small particles containing a significant amount, interfere with increase of a mirror of burning most fully to use layered burning. Such mode is characterized by sharp decrease in profitability of burning of multi fractional fuels at the expense of ablation increase, in order to avoid this mode, in a design of the heat exchange module «the top ignition» bulk layer and a loading ring is offered.

At «the top ignition», the loaded fuel is lit from above under the influence of heat of a radiated flame of flying substances burning in furnace space, fuel is lit under the influence of heat transferred by heat conductivity from the top layers to the bottom. Having got on a layer surface, pieces of fuel start to get warm intensively with support of intensive exudation of moisture, and in process of increase of temperature disintegration of unstable organic connections with allocation of flying substances begins. For fuels having a big exit flying this stage leads to change of physical properties and structures of the coke rest, pieces become porous, their internal surface and the size of a time changes. The stream of flying substances actively enters interaction with oxygen of air of a counter flow of secondary blasting that interferes with oxygen interaction with the coke rest, for

this purpose in a design of the furnace device hand-operated weedier for a periodic backwashing are provided. Warming up by a piece to temperature 1050-1100s leads to complete allocation of flying substances and completion of process of coking.

As humidity of Kuznetsk coal is insignificant, at its layered burning «dry gasification» coke rest with a set of the chemical reactions defining process of burning out on zones proceeds, in an oxygen zone:



in a regenerative zone:



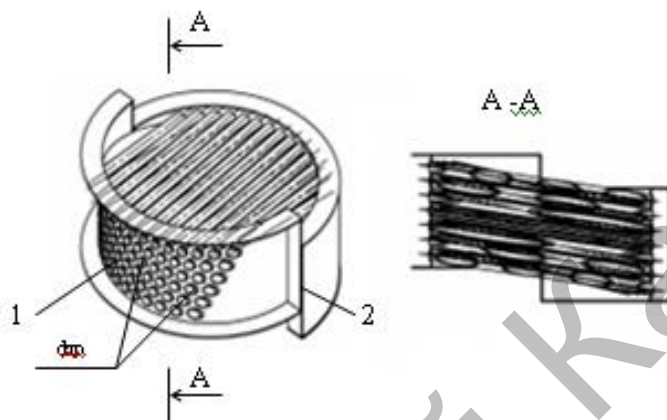
Oxygen is continuously brought from environment of a loading ring and will be spent on an interface of a coke particle. Burning of the coke rest of small coal slices occurs to «not burning interface». «The top ignition» doesn't demand cooling of a grid-iron lattice as at the bottom giving of blasting and «the bottom ignition» elements of a grid-iron lattice are in a zone of high temperatures.

Water-heating coppers distinguish on heat productivity and temperature of received water. Unit of thermal capacity is 1кВт which is equivalent to thermal energy 860ккал/h. Heat productivity of heat exchange TOM-1 modules when burning coals of kuznetsk, borlinsk, shubarkol, kuuchek pools with the secondary blasting, started in production 81, 105 and 160кВт, without secondary blasting 61, 79 and 120кВт. The major factors providing profitability of burning of fuel are, first of all, the type of burned fuel, and also a temperature mode and concentration of oxygen in a torch. The temperature of burning is influenced by heat productivity, excess of air in a fire chamber and temperature of received hot water and thermal tension of a mirror of burning. Numerical size of a mirror of burning of the module 96÷106кВт/сm.м.

Intensity warm mass transfer at layered burning is much higher than at pulverulent burning of firm fuel in a torch, it is promoted by rather high speeds of a stream of products of burning, turbulence influence of a bulk layer and an exception of process of a scaling on trumpet heating elements. At a food of coppers by hard water there is a gradual accumulation of mineral impurity and after approach of a condition of saturation start to drop out in the form of crystals. As the centers of crystallization rough nesses on surfaces of heating tubes, and also the weighed and colloidal particles being in boiler water serve. Substances which crystallize on surfaces of tubes in the form of dense deposits, form scum, and substances which crystallize in volume of boiler water, form the weighed substances – sludge. To prevent formation of scums on surfaces of tubes and to exclude threat of damage of tubes, and also to prevent corrosion processes of metal of pipes, besides, each millimeter of adjournment of a scum gives to 1,5-2 % of an excessive consumption of fuel because of decrease in factor of a heat transfer of a metal wall therefore at operation of water-heating coppers will organize a special water mode. For heating coppers before the boiler processing with application of a cation method or inside the boiler, with a periodic sludge purge, that is installation of the additional equipment demanding considerable capital investments is required. A solution of the problem of scale educational in Voronov V. E. thermal module it is carried out at the expense of sectioning of heating trumpet elements with a horizontal arrangement of trumpet elements with a bias of 12-13 degrees and the decreasing diameter of trumpet elements in sections (fig. 3).

At normal operation of the module of adjournment of a scum on an internal surface of tubes shouldn't reach the size causing essential thermal resistance. In order to avoid this phenomenon, the bottom section of the module which perceives the warmth received at burning of fuel by semi-radiation, are executed with diameter of tubes of $d_{tr}=60 \times 4,5\text{mm}$.

Water circulation in the module direct-flow, temperature at an exit from the module 90°C and an entrance 35°C (individual coppers pay off on temperature at an exit from a copper 95°C and an entrance 70°C with a vertical arrangement of pipes). In coppers with slightly inclined pipes at direct-flow circulation in the conditions of development of convective heat perception go on fall of diameters of tubes for the purpose of increase of speed of movement of water in tubes therefore average and top sections convective are executed with diameter of tubes in average section – $d_{tr}=52\times 3,5\text{MM}$ and top – $d_{tr}=42\times 3,5\text{MM}$.



1 – heating trumpet element; 2 – distribution manifold mountable.

Fig. 3 Type of the heat exchange module of heating trumpet elements

Warmth perceived by the bottom module is defined as a difference between a radiant stream of a mirror of burning and a reradiating stream in the average module. Direct radiation from a mirror of burning of a fire chamber provides intensive pollution of forward ranks of tubes of the bottom module, increases temperature of pollution and can bring to *пережогу* tubes. In order to avoid it, in a design of the heat exchange module the loading ring is provided.

At manual service of fire chambers seldom it is possible to sustain settlement values. The fire chamber with manual service is characterized by periodicity of operating modes, difficulty of regulation of supply of air, existence of break of primary air during the periods of loading of fresh fuel. At the beginning of loading of fuel and at its warming up warmth practically isn't allocated. In fuel reburning warmth is allocated in the minimum quantity, in burning of flying substances and the coke rest the maximum thermal emission is observed. Such periodicity of process of burning of fuel in a hand-operated fire chamber involves change of thermal capacity of a copper and its profitability. After giving on a burning-down layer of fresh fuel, its warming up and a drying there comes the period of intensive allocation of flying substances at what complete combustion needs a large amount of air.

At constant productivity of the blast fan, at consolidation of a layer of the burning-down coke rest and a gradual burn-out of a layer in the furnace device starts to arrive actively to 20-30 % of primary air from fire chamber sweat while need for it to become ever less because of allocation and burning of bulk of flying substances. Therefore the factor of excess of air of secondary air should be minimum.

The size of factor of excess of air is defined by temperature of smoke gases which should be in the established limit. The bottom limit is defined from stability conditions of process of burning. Excessively low temperature of smoke gases reduces the general level of temperature in the heat exchange module, complicates a firing, and at minor casual changes of a mode of burning will lead to a extinction. The top limit is limited to need of prevention of a slag of forward ranks of tubes of

section of the heat exchange module the melted ash particles. Therefore in a heating copper of such design the temperature of leaving gases is much lower, than in existing and makes 190-210 °C.

Design features of the heat exchange TOM-1 module allow to use it as independent installation and very convenient possibility of creation of the heating system, including network from consistently connected modules. Service, connection of the module doesn't demand big labor costs. The design of the furnace device is developed so that as much as possible to facilitate its cleaning of ashes and slag.

Uniqueness and simplicity of a design of the TOM-1 module allows to let out them various heat productivity, changing diameter of the module at equal height. Installation of heating modules is made on sections according to the standards accepted for installation of the heating equipment. The fulfilled technology, modern tools, qualification and experience of the assembly organizations allows to make this operation quickly, qualitatively and safely.

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