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DETERMINATION OF THE FORMATION OF HARMFUL SUBSTANCES WHEN BURNING HIGH-ASH COALS IN POWER BOILERS ALMATY TPP WITH RELEASE TO MINIMIZE OF HARMFUL SUBSTANCES INTO THE ATMOSPHERE

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The trend of development of the fuel and energy sector of the Republic of Kazakhstan at the present stage imposes strong requirements for using sources of energy. If in the past foreground stood only energy production, today's energy companies must keep to strict standards of emission of harmful substances and the most profitable to use the equipment. It is extremely important that the development process "clean" burning of coal with minimal emission of harmful substances, and therefore must be optimized all the design and operating parameters of the combustion process. Development of new methods to reduce emissions of harmful substances with the help of physical models is the high cost of physical experiment. Such a development can only give suggestions for the solution of partial problems, as the physical modeling of all parallel running processes in the combustion chamber and flues at reduced scale settings is fundamentally impossible. This problem can be solved only through systematic analysis of physical and chemical modeling. In this regard, numerical simulation becomes one of the most economical and convenient way for detailed analysis and better understanding of the complex physical and chemical phenomena taking place in the furnaces.
Keywords: combustion, combustion chamber, pulverized coal, reacting the mixture, a polyphase, coal particles, aerodynamic characteristics, thermal performance, numerical simulation, turbulence, chemical kinetics

Inroduction

Currently, the most common method of combating air pollution is to remove contaminants as far as possible from release. This is done by building high pipelines in factories and power plants. In the protection of the air of the cities and settlements of the important role of green plantings and green zones, located around dust, improves gas composition.

The actuality of this problem and growing attention it relate to the rising efficiency of using of energy, existing power plants, creating a new combustion chamber to optimize the combustion process of pulverized coal and the environmental problems associated with increasing the amount of pollutants released into the atmosphere.

In the cities of Kazakhstan, the atmospheric air is polluted by many harmful ingredients particularly acute problem for the city of Almaty, where a high level of pollution contributes to the total emissions of vehicles, industrial enterprises, as well as the unique geographical conditions of the city. Among the heat-energy sources the main share of emissions from major sources of Central heating: TPP, SDPS (state district power station) at different levels, district heating plants, etc.

Today in Kazakhstan, about 85% of electricity is produced in thermal power plants, the main fuel which is coal. More than 80% of the coal burned in these thermal power plants is low-grade high-ash coal (more than 40%), mainly Ekibastuz pool, where active mining of cheap coal by open method. In result to the adopted technology of production of high-ash coal from Ekibastuz field and use them without prior enrichment of the natural environment experiencing significant anthropogenic pressure [1-3].

Ash is a mixture of minerals in the free state or associated with the fuel. These non-combustible minerals are basicly composed of salts of alkali and alkaline earth metals, oxides of silicon, iron, aluminum, and sulfates of calcium and magnesium. Presence in fuel ash affects the quality of the fuel because it reduces the amount of heat per unit mass of fuel. Tiny solid particles of ash entrained flue gases flow and are entrained from the furnace, forming fly ash, which pollutes, and sometimes fills up the convection heating surface, reducing heat transfer. The ash content of domestic coal reaches 10-55%. Changes accordingly and the dust content of flue gases, reaching for high-ash coal of 60-70 g/m^3.

Over the past 20 years, global energy consumption increased by 30 % and this growth is likely to continue in view of the growing needs of rapidly developing countries in the Asian region. In developed countries over the same period has changed the structure of consumption — there was a replacement of the coal more environmentally friendly gas.

However, consequently to the large consumption and increasing prices for natural resources such as oil and natural gas, special attention is paid to solid fuel - coal. Coal is one of the most common and Kazakhstan natural resources. While its production is carried out mainly by open method, so this type of solid fuel is the cheapest in our country fuel, but it is a high-ash.

Ash is a mixture of minerals in the free state or associated with the fuel. Presence in fuel ash affects the quality of the fuel because it reduces the amount of heat per unit mass of fuel. Tiny solid particles of ash entrained stream of flue gas, polluting convection heating surface, which reduces heat transfer [4,5].

Of considerable interest to the energy industry in the region and reduce the human impact on the environment represent fundamental research in the field of combustion, the development of new and improvement of existing technological processes to improve the combustion of low-grade solid fuels and application of alternative fuels. This will allow to reduce emissions of pollutants and simultaneously to improve the main indicators of the TEC plant [6,7].

Thus, research in the field of advanced technologies for improving the combustion of pulverized coal and the use of alternative methods of organization of the combustion process of various fuels are currently the most relevant to the entire energy complex of Kazakhstan. The main direction of improvement of pulverized coal combustion and utilization of alternative fuels is the implementation of stringent environmental regulations in terms of specific emissions of harmful substances with exhaust gases, the standards are defined.

Using computer simulation in a short time to conduct an extensive analysis of all the parameters of the future of the boiler, which will provide savings of time and money, unlike the construction of the current model, it is possible to work out some technical solutions (configuration, layout and design of the burners), and also to solve the environmental problems of emissions of harmful combustion products.

Experimental part.

This part of the work dedicated to numerical simulation of combustion process in the combustion chamber of the boiler BKZ-420-140. The furnace is equipped with six vortex burners on two levels, located on the front wall.

As a study object was selected combustion chamber of the boiler BKZ-420, with steam capacity 420 t/h, located at the Almaty TEC-2. The boiler E-420-13,8-560 BT (BKZ-420-140-7) is designed to work at Ekibastuz coal for generation of superheated steam in thermal power plants with cogeneration turbines with high steam parameters.

The boiler is vertical-tube, single-drum with natural circulation, single-hulled, closed, U-shaped, gas-tight execution of the hole layout, designed for high steam parameters is designed to work under boost. Combustion chamber prismatic shape open type, with dimensions in terms of the axes of 14.46×12,052×29,102(m3) (figure 1). Blocks of the furnace and convective gas duct is suspended on rods to the ceiling frame of the boiler and freely expand downwards. The stiffness and strength of the walls of the furnace are provided with zones of stiffness [8-11].

Here, in the form of fuel used is low-grade, high-ash Ekibastuz coal: moisture 25%, volatiles of 24 %, the highest calorific value 16 750 [kJkg-1].

Side burners in each tier located at 8 degree angle relative to the Central burner. Each burner can burn 12 tons of Ekibastuz coal. The steam capacity of this machine is 420 t/h [12].

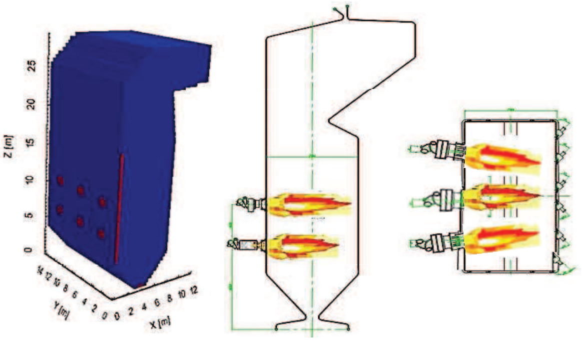

Fig.1. General view of the combustion chamber of the boiler of Almaty TEC BKZ-420

As can be seen from figure 2, the carbon monoxide is formed from inexpensive coal and it becomes more to the output of the furnace because the path to the exit temperature decreases. And this is due to the fact that in the area of the burners creates a vortex current.

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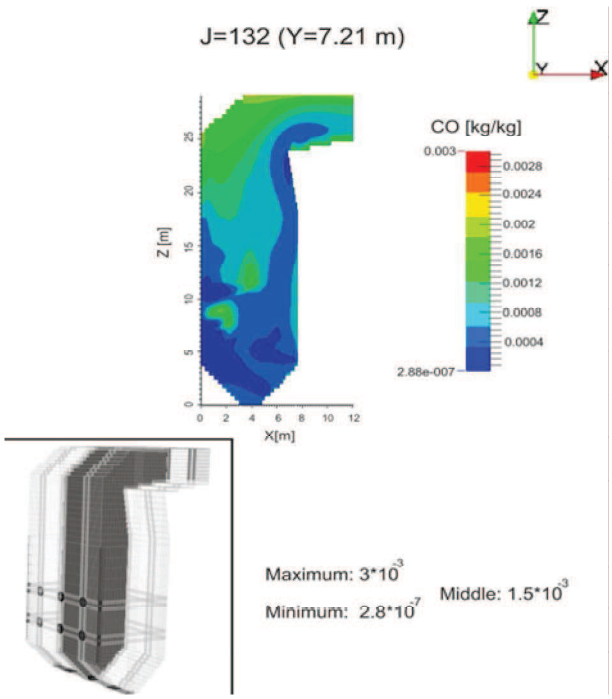

Figure 2. Longitudinal vertical section distribution CO carbon monoxide in the center of the boiler

As can be seen from figure 3 the distribution of CO carbon monoxide at the exit of furnace adopts the average and minimum value. But still it is not conform to world standards.

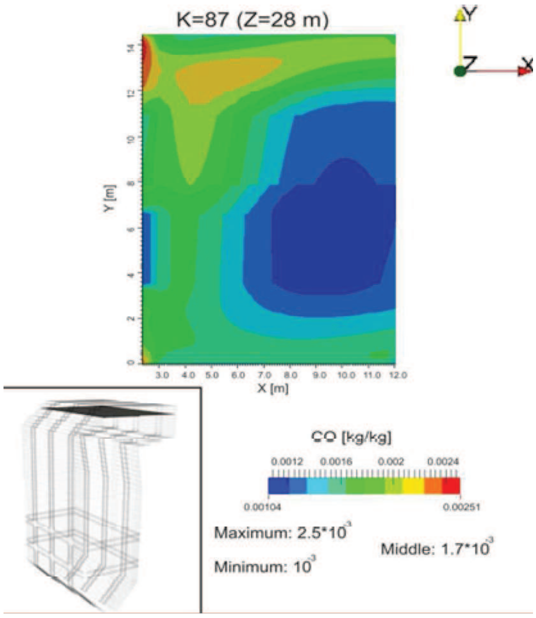

Figure 3.The distribution of CO carbon monoxide at the exit of the furnace

Nitrogen oxides are harmful impurity in exhaust gases. The combustion of fuels in boiler furnaces, the nitrogen contained in the air and the fuel, becomes reactive and, when combined with oxygen, forming oxides.

The reaction in the combustion chamber is formed mainly nitrogen oxide (≈90 %), the remainder of the oxides of nitrogen are nitrogen dioxide. The formation of nitrogen dioxide due to the oxide requires considerable time and occurs at lower temperatures. At the exit of the pipe, the composition of NO_x is almost constant compared to the combustion chamber, and only in the atmosphere the process of its gradual to oxidation. There are 3 sources of nitric oxide formation:

1) the formation of nitrogen oxide during the oxidation of air nitrogen at high temperatures - thermal;
2) oxidation of nitrogen that is included in the fuel composition – fuel nitric oxide;
3) formation of "quick" nitrogen oxides in the root of the torch.

The relatively greater impact of the fuel nitrogen oxides takes place in the boilers of small capacity, for which the temperature in the core of the torch is not high and the formation of "air" nitrogen oxides for this reason slightly.

The factors influencing the formation of nitrogen oxides when burning different fuels:

- the flame temperature;
- oxygen concentration in the combustion zone;
- the residence time of combustion products in high temperature zone;
- the nitrogen content in the fuel.

In turn, these factors depend on the air excess factor, from the design of burners, from the aerodynamic characteristics of the combustion process, the size and thermal stresses of furnaces, the conditions of heat exchange between gas flows and heating surfaces [13-17].

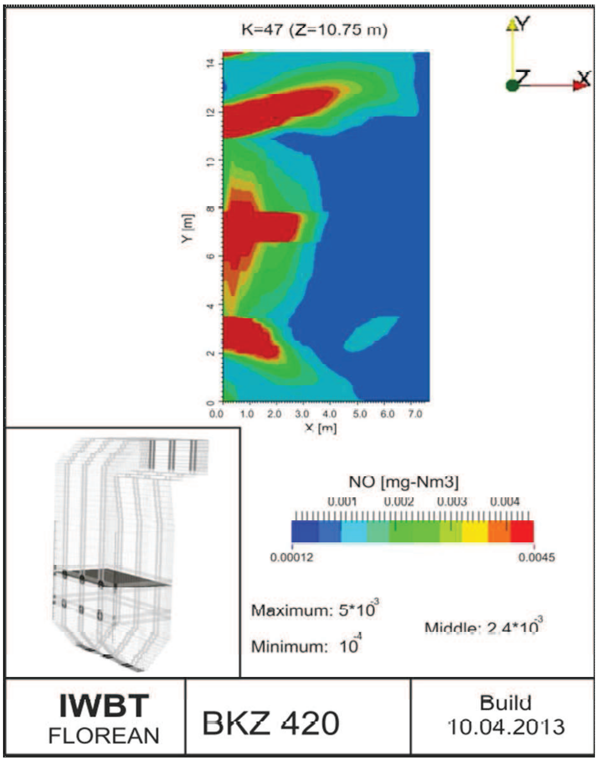

Figure 4. Cross-sectional distribution of nitric oxide in the area of the burner (z=10,75 m)

As can be seen from figure 4, the basic formation of oxides of nitrogen falls on the area about the burners. Because, there is a high temperature

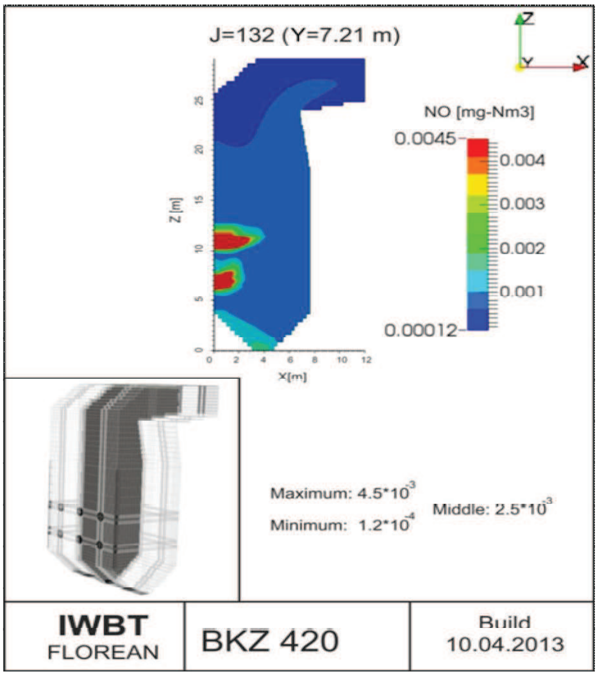

Figure 5. Longitudinal vertical section distribution of nitric oxide at the center of the boiler (z=7,21 m)

And here is the same as in the previous figure. The only difference in the directions of formation of nitric oxide.

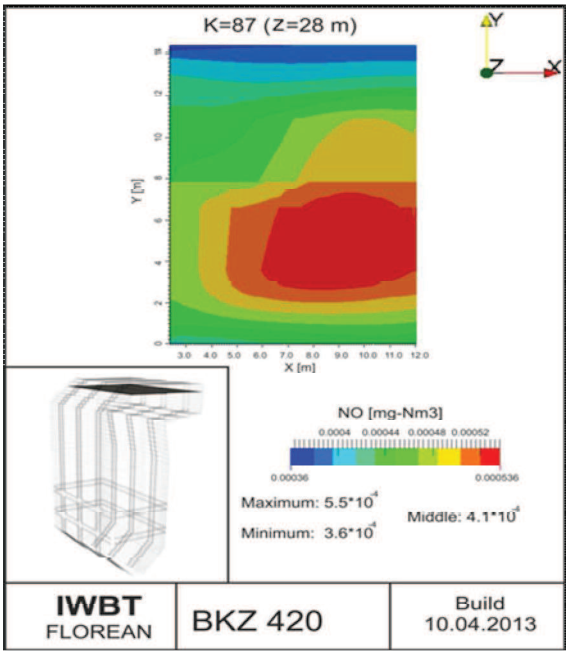

Figure 6. Distribution of nitrogen oxides at the exit of furnace (z=28m)

Here, distribution of nitrogen higher than in other sections. This is due to the fact that in this part of the furnace the temperature is high.

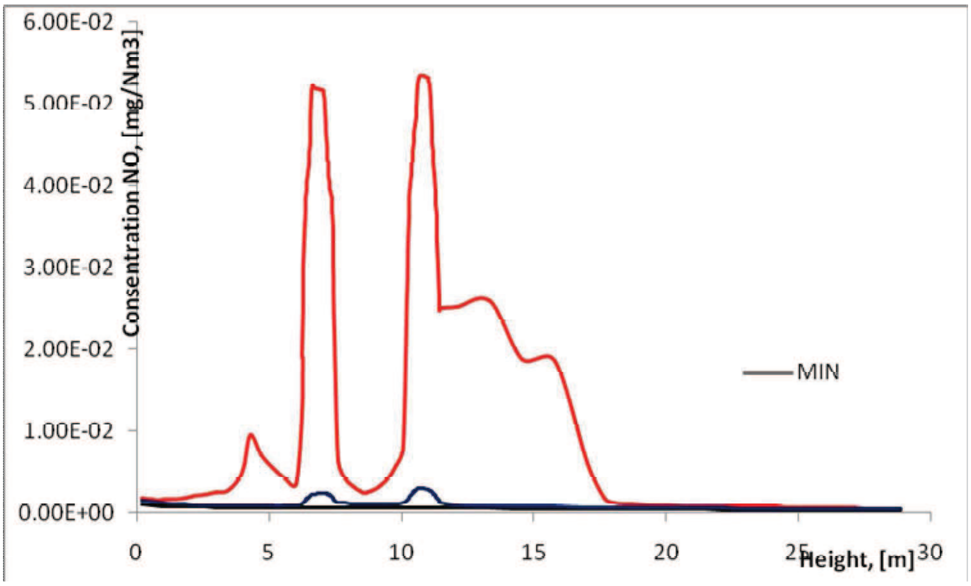

Figure 28. The average value of the distribution of nitric oxide throughout the volume of the furnace of the boiler.

Conclusion

The obtained results allow to conclude that the location area burners has a vortex flow caused by the location of burners and the vortex method of supplying pulverized coal flows into the combustion space. The presence of vortex motion provides more rapid ignition and flame stabilization[18,19]. Hot gases entrained in the torch, heat the fuel mixture and ignition intensifitsiruetsa. The active updrafts is also the busy area near the walls of the furnace, which in turn affects the convective component of heat transfer in the combustion chamber. Such computational experiments are original and new. at the same time, there is an urgent need for such studies from the thermal power plant in our Republic and abroad.

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