Reduction Harmful Emissions at the Pulverized Fuel Combustion in the Furnace Chamber

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Introduction

Coal in Kazakhstan has several advantages: low sulphur content, high volatile content, on a dry ash less mass and low price, because the coal is mined in open cast mainly. It is characterized by its low rating due to the high ash content in its composition (more than 40%) [1-2]. As a result, the use of such fuel in the power system leads to problems in flame stabilization and combustion in general, in slagging of convective heating surfaces (furnace walls) and air pollution from fly ash, carbon monoxide, nitrogen oxides and other combustion products. Using low-grade coals increases the consumption of fuel oil or natural gas used to melt the boiler, pick up and stabilize the burning of the dust torch, and the environmental situation worsens.

In this work, a computer package of applications of Florean [3-4] applied programs was used as a basis for the conduct of computational experiments on thermal transfer processes using 3D modeling in the combustion chamber of the thermal power plant. Studies have been conducted to determine the effect of a forced partial stop of the supply of coal dust through the burner devices on the main characteristics of the combustion chamber of the BKZ-75 boiler of the Shakhtinskaya thermal power plant (TPP, Kazakhstan).

INITIAL DATA FOR COMPUTATIONAL EXPERIMENTS

The BKZ-75 boiler of the Shakhtinskaya TPP (Kazakhstan) was chosen as the object of the study. The boiler is equipped with four pulverized coal burners which installed in two on the front and back walls in one tier. The boiler burns the dust of Karaganda ordinary coal, with an ash content of 35.1%, a yield of volatile 22% and a calorific value of 18.55 MJ/kg.

For carrying out of computing experiments the geometry of investigated object according to the real scheme (Fig. 1).The finite difference grid has steps along the X, Y, Z axes of: 59×32×67, which is 138 355 control volumes. Two modes of fuel supply were investigated: a direct-flow method of delivering the air mixture, when two direct-flow burners are working, two are in emergency mode and a vortex method of delivering the air mixture - two vortex burners with an angle of swirl of the air mixture and their inclination to the boiler symmetry center by 30 degrees; two are in emergency mode.

Fig. 1 shows the design of the burners of the furnace chamber of the boiler BKZ-75 in **emergency mode** (off burners are marked in red).

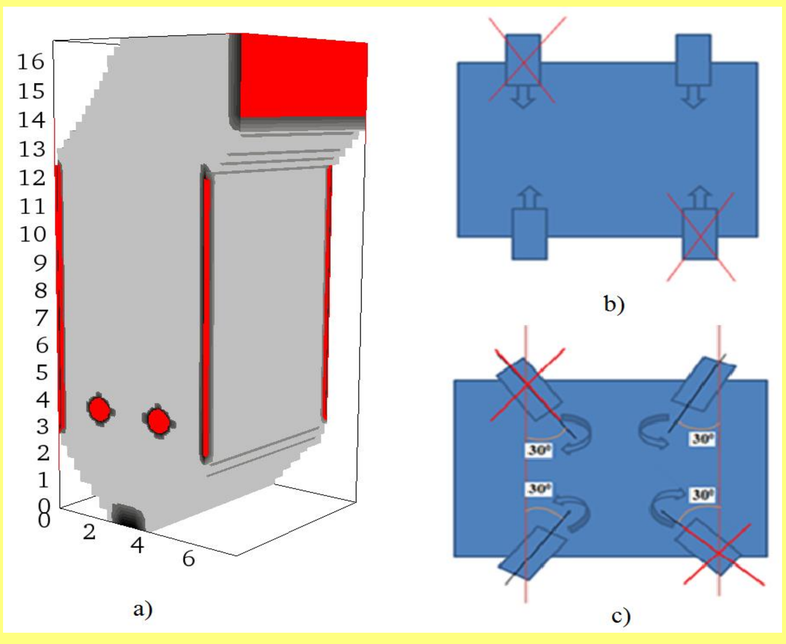

Fig.1. General view (a) and designs of the burners of the furnace chamber of the BKZ-75 boiler in emergency mode: (b) direct-flow method of supplying air mixture; (c) vortex method of supplying air mixture

RESULTS AND DISCUSSION

Fig. 2 shows three-dimensional temperature distributions characterizing the thermal behavior of the pulverized-coal flow in the combustion chamber for the two studied modes of supply of air mixture (direct-flow and vortex). Compared to using the direct-flow method of supplying the air mixture, the average temperature of the furnace chamber of the BKZ-75 boiler during the vortex method of supplying the air mixture increases both the central section 991.6°C. This is due to the vortex nature of the flow, providing maximum convective transport and an increase in the residence time of coal particles in the furnace chamber of the BKZ-75 boiler.

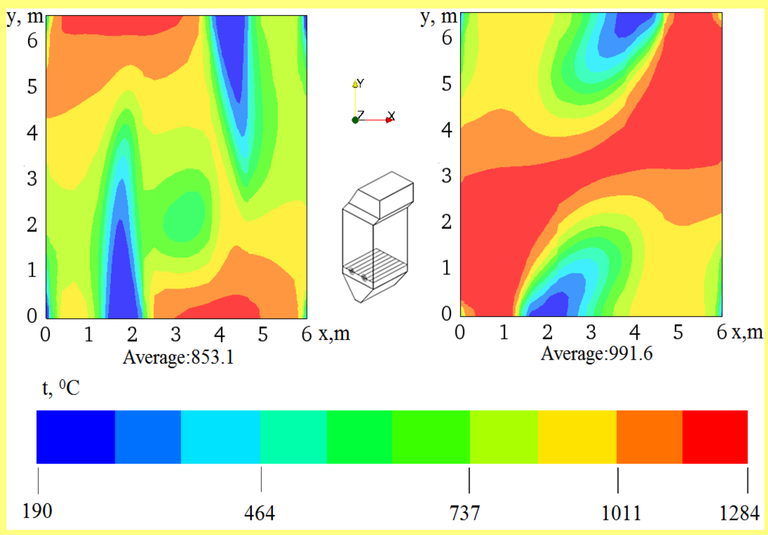

Fig. 2. Distribution of the temperature in in the burner section (z=4) of the combustion chamber of the boiler BKZ-75 during emergency mode:
a) direct-flow method of supplying air mixture;
b) the vortex method of supplying air mixture

Fig. 3 presents a comparative analysis of the distribution of the average temperature along the height of the combustion chamber for the two studied modes. We observe an increase in the zone of maximum temperatures (curve 1) with the vortex method of supplying the air mixture (curve 2). The temperature at the outlet of the combustion chamber in this case is less than with the direct-flow method of supplying the air mixture and its value is 836^{0}C versus 847^{0}C. The temperature at the outlet of the combustion chamber (base version) is confirmed by experimental data at TPPs and theoretical value calculated by the method of CBTI (Central Boiler-and-Turbine Institute) for direct-flow supplying of air mixture [5-6].

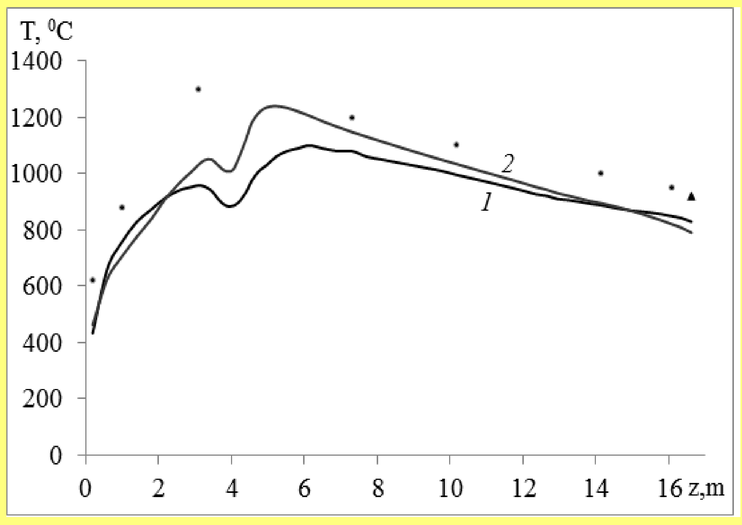

Fig. 3. –Distribution of the temperature T along the height of the combustion chamber of the BKZ-75 boiler in emergency mode:1- direct-flow method of supplying air mixture; 2-vortex method of supplying air mixture; ● - experimental data at TPPs; ▲ - is theoretical values obtained by method of thermal calculation.

Fig. 4 illustrates the distribution of concentrations carbon monoxide *CO* and nitrogen dioxide NO_2 in different sections of the combustion chamber of the BKZ-75 boiler.

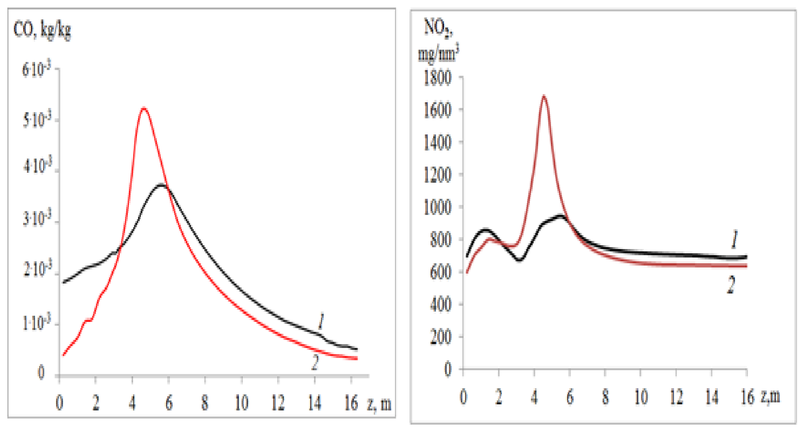

Fig. 4. Distribution of concentration carbon monoxide *CO* (a) and nitrogen dioxide NO_2 (b) along the height of the combustion chamber of the BKZ-75 boiler in emergency mode: 1 - direct-flow method of supplying air mixture; 2 - vortex method of supplying air mixture

We see that the use of the vortex method of supplying air mixture leads to a decrease in the total concentration of carbon monoxide *CO* and nitrogen dioxide NO_2 at the exit from the furnace space. The concentration carbon monoxide *CO* at the outlet of the combustion chamber is $5.2* 10^{-4}$ kg/kg for direct-flow method of supplying air mixture, and $3.4* 10^{-4}$ kg/kg for the vortex method of supplying the mixture. The total concentration of nitrogen dioxide NO_2 at the exit from the furnace space and amounts to 636.58 mg/Nm3 (Fig. 4, curve 1), and for the direct-flow method of supplying air mixture 688.50 mg/Nm3 (Fig. 4, curve 2).

Conclusions

The results of computational experiments are presented: temperature fields T, concentration fields of carbon oxides CO and nitrogen dioxide NO_2 over the entire volume of the combustion chamber and their comparative analysis for the two studied modes of supply of air mixture (direct-flow and vortex). Based on the results of studies on **emergency mode** of burner devices, the following conclusions can be drawn:

The use of vortex burners in the combustion chambers of coal-fired TPPs can significantly optimize the combustion process of low-grade high-ash coals and significantly reduce emissions of harmful substances (NO_2 and CO) into the environment.

The vortex method of supplying air mixture into the burner devices of the combustion chamber leads to a decrease in temperature T, the concentration of carbon oxides CO and nitrogen oxides NO at the outlet of the combustion chamber.

At the outlet carbon monoxide CO and nitrogen dioxide NO_2 concentrations are less than the maximum permissible concentration (MPC) accepted in Kazakhstan. Thus, we can conclude that the vortex method of supplying air mixtures in the combustion chambers of energy boilers significantly improves the environmental performance of thermal power plants.

References

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