The Influence of Highly Efficient Environmentally Friendly Plasma-chemical Technology on the Characteristics of Combustion Processes of Power Boilers

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Introduction

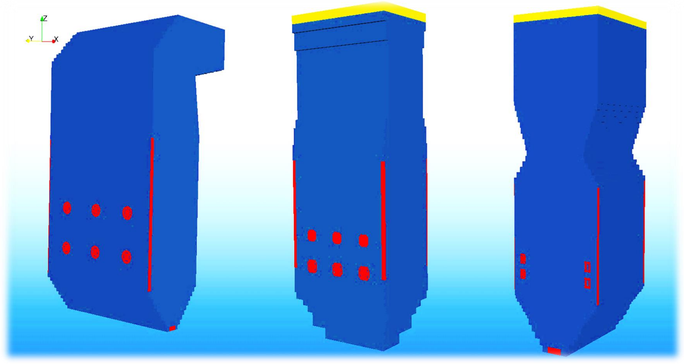
Scientific research in the field of developing new and improving existing technologies to improve the combustion of low-grade fuels, which reduce emissions of pollutants into the atmosphere and at the same time improve the main indicators of energy complexes, are of significant interest for the heat and power industry of the Republic of Kazakhstan.

The development of such methods and improvement of coal combustion processes, along with the use of alternative methods for organizing the combustion process (plasma thermochemical preparation, using acute blast technology and technology using a mechanism for selective and non-catalytic reduction of nitrogen oxide emissions) is currently the most relevant for the entire energy complex.

Motivation: a study of a new way of organizing the process combustion of high-ash coal in combustion chambers of operating thermal power plants using plasma-fuel systems (PFS).

The object of study

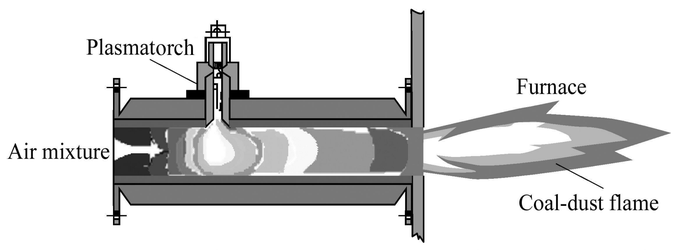
Figure 1 shows a general view of the combustion chambers of the boilers BKZ-420 (a), PK-39 (b) and BKZ-160 (c), equipped with plasma fuel systems.



(a) (b) (c)

Figure 1

These boilers differ in power, in the geometry of the combustion chambers, in their sizes, in the method of supplying fuel and oxidizer, in the layout of burner devices and plasma torches.



Thermochemical preparation of pulverized coal fuel for combustion is carried out by installing plasmatrons [1] on the lined channel of the burner air mixture, which is thereby converted into a plasma fuel system (Fig. 2).

The mathematical model

To study the processes of heat and mass transfer in high-temperature environments of the furnace space, used the physical, mathematical and chemical models, including a system of three-dimensional Navier–Stokes equations and equations, heat and mass transfer, taking into account the source terms, which are determined by the chemical kinetics of the process, nonlinear effects of thermal radiation, interphase interaction, as well as the multistage chemical reactions.

The basic equations used in this work can be written in a generalized form as follows [2-3]:

$$\frac{\partial \rho \phi}{\partial t} = -\frac{\partial \rho u_i \phi}{\partial x_i} + \frac{\partial}{\partial x_i}\left(\Gamma_\phi \frac{\partial \phi}{\partial x_i}\right) + S_\phi$$

Here ϕ – generalized transport variable,

Γ_ϕ – generalized exchange coefficient,

S_ϕ – source term.

The system of equations can be solved numerically using the control volume method, described in detail in [19-20, 26-27] and was used in computational experiments on the combustion of high-ash coal at Kazakhstan thermal power plants.

Results

For the BKZ-420 boiler three regimes of furnace operation were investigated: 1 is traditional combustion, when the furnace operates with standard coal-dust burners; 2 regime, three plasma torches are installed and they act on the flow of pulverized coal in three burners: in two extreme burners of the lower tier and in the central burner of the upper tier; in 3 regime, the plasmatorches are installed in all six burners of two tiers.

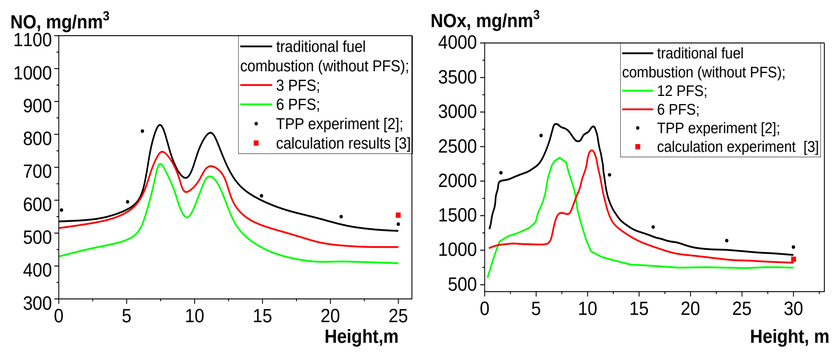
The furnace chamber of the BKZ-160 boiler, two cases were investigated: traditional combustion of pulverized coal and combustion of coal with PFSs installed in two opposite burners of the lower tier.

For the PK-39 boiler four regimes were investigated: one with traditional burners and three, when low-temperature plasma acts on the pulverized coal flow: in four vortex burners of the lower tier; in six burners of the lower tier and in all twelve burners of two tiers.

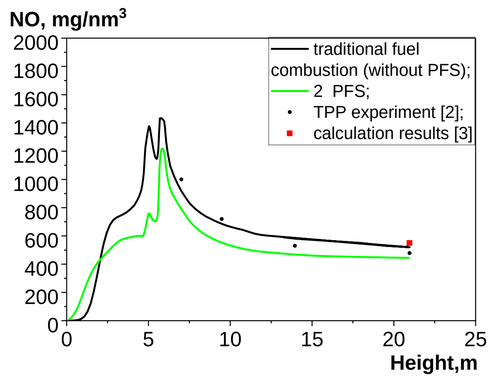
Figure 3 shows the concentration fields of nitrogen oxides NO along the height of the combustion chambers of the boilers under study.

Results

We see that the installation of plasma fuel systems (PFS) in combustion chambers significantly improves the environmental performance of thermal power plants. As a result of the implementation of our proposals to improve the technology of burning low-grade coal, it is expected to reduce nitrogen oxide emissions by 30-40%.



a) boiler BKZ-420 b) boiler PK-39



c) boiler BKZ-160

Figure 3

Conclusions

Plasma activation technology, universal software products, methods for calculating the characteristics of combustion processes can be used when burning all types of coal at any energy enterprises in the fuel industry, not only in Kazakhstan, but in other countries with

Acknowledge

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