COMPARATIVE ANALYSIS OF MODELS KINETIC SCHEME OF THE NUMERICAL CALCULATIONS OF NITROGEN OXIDE AT PULVERIZED SOLID FUEL

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1. Introduction

Protection from harmful air emissions is one of the most acute problems of our time. The rapid growth in energy consumption is accompanied, as is well known, the increase in emissions that pollute the environment.

Thermal power plants, consuming large amounts of fossil fuels, emit combustion products containing particulate matter, sulfur oxides, nitrogen and carbon.

Each year, the environmental safety requirements more stringent. According to GOST 50831-95 [1] emissions of nitrogen oxides for thermal power plants, which will work after 2016 should not exceed 200 mg / m3 for solid fuels (with a power> 300 MW). In this regard, one of the major challenges for designers is to ensure health authorities set maximum permissible concentrations of gaseous impurities (primarily - NOx) in the air for input again, as already operated for thermal power plants.

In order to determine more effective ways to combat NO_x emissions for each unit of the boiler should be carried out field experiments. However, such experiments are not always possible.

In order to optimize the design process and reduce the cost of the experiment using numerical simulation. This will analyze the emissions of nitrogen oxide already in the design phase for the newly commissioned capacities and work out several options for the reconstruction of a boiler operating with the selection of optimal solutions to this problem.

To introduce effective methods of nitrogen oxide suppression is necessary to develop methods of mathematical modeling of the combustion of nitrogen-containing fuels in furnaces and combustion chambers. When you create a numerical model that describes the formation of nitrogen oxides, it is important to take into account all the peculiarities of the processes occurring in the combustion chamber: complex spatial aerodynamics, combustion of coal dust, etc.

To date, the mechanism of formation of thermal NOx is well studied and satisfactorily described circuit YB Zel'dovich [2]. More complicated is the simulation of the formation of fuel and fast nitrogen oxides. As a rule, the proposed kinetic models require the calculations to take into account a significant number of chemical reactions that accompany this phenomenon. This greatly limits their application in numerical research to full-scale facilities.

2. Description models

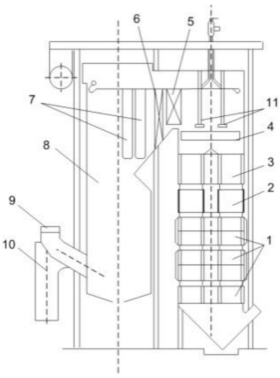
In this paper mathematical modeling of formation of nitrogen oxides when burning dust-like nitrogen-containing fuel in fire chambers of industrial package boilers is carried out based on the NO developed by Mitchell and Terbell [3] kinetic models of education, and also with use of model developed by Gusev, Zaychik and Kudryavtsev [4].

Mitchell-Terbella's model is rather convenient in use, its kinetic scheme consists of only 13 reactions. The kinetic scheme of this model is described by system from seven equations which model chemical reactions of burning of hydrocarbons, burning of coke, an exit and burning flying, formations of thermal nitrogen oxides, heterogeneous reaction of conversion of nitrogen oxides as a result of their interaction with carbon of coke [3, 5].

In the model of Guseva-Zaychik-Kudryavtsev it is supposed that all fuel nitrogen oxides are formed of nitrogen of the fuel which passed together with flying into a gaseous phase, and nitrogen influence remained in coke neglect. Formation of fuel nitrogen oxides is calculated in the assumption that during an exit and burning of the flying there is a decomposition of nitrogen-containing components of fuel to active atomic nitrogen N or cyanide of HCN hydrogen. Further it is considered that process proceeds in two directions: oxidation of nitrogen to nitrogen oxide and formation of molecular nitrogen owing to a recombination of atomic nitrogen or as a result of recovery of an oxide of nitrogen. The settlement scheme of generation of fuel oxides is described by system from three equations [4, 5].

3. Results and discussion

The numerical models of generation of NO_x described above were applied to operating BKZ-220-100ZhSh which configuration is provided in fig. 1. In fig. 2 distribution of concentration of nitrogen oxides on BKZ-220-100ZhSh copper fire chamber height is provided in case of from excess of air α = 1,2.



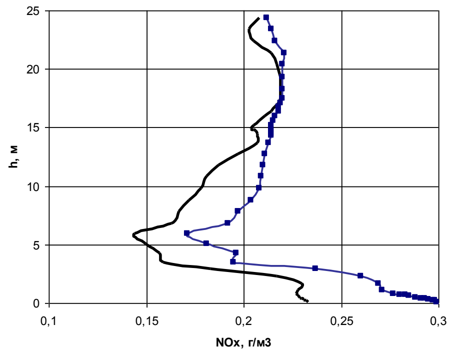


Fig. 1 Scheme of boiler BKZ-220-100ZhSh
1, 3 steps of an airheater; 2, 4 steps of the economizer; 5-convective step; 6, 7-output and furnace screens; 8-furnace camera; 9 nozzle of secondary air; 10 separator of a mill; 11-shot cleaning system

Fig. 2 Formation of nitrogen oxides on BKZ-220-100ZhSh boiler fire chamber height:————— – model [3],
–■–■–■–■– *– – model [4],*

The boiler BKZ-220-100ZhSh has the prismatic furnace camera. Height of the boiler is 24,9 m, width of a fire chamber is 8,64 m, depth of a fire chamber is 7,74 m. The furnace camera is completely screened pipes diameter 60mm. Poorly inclined symmetric under (α = 15z), formed by pipes of front and back screens, corresponds to system with a liquid slag removal, and the lower part of a fire chamber up to the height of 5,750 m is studded and is covered with chrome plastic. On side walls on a mark of 9,6 m there are lighting-up burners which are built in special torches with an organized supply of secondary air [6] are established.

From fig. 2 it is visible that the chosen mathematical models for research of an exit of nitrogen oxides yield close results. In fig. 3 nature of distribution of concentration of NO_x, typical for all models [3, 4], in the vertical section of a fire chamber passing between direct-flow torches and a 3D projection is provided.

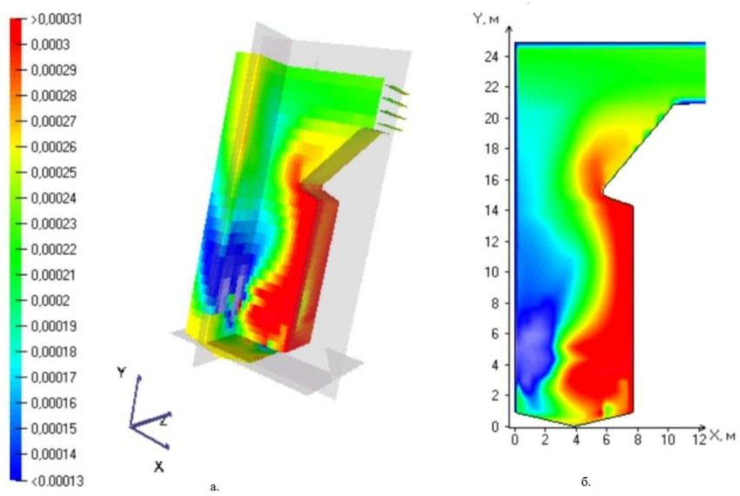


Fig. 3 Distribution of mass concentration of NO_x *in BKZ-220-100ZhSh boiler fire chamber: and – 3-D model; – in vertical section*

As can be seen from fig. 3, the maximum quantity of NO_x nitrogen oxides is formed in the upper and lower part of the zone of active burning which is characterized by the increased values of temperature of a flow. On a site from 10 to 25 m on the furnace height, where burning is already complete, concentration of NO_x changes poorly. The area of the maximum values of temperatures (to 1900 K) is in part of the furnace camera, opposite to torches. At the exit from a furnace temperature matters 1250 K.

4. Conclusions

1. The forecast accuracy of formation of NO_x substantially depends on a share of nitrogen of the fuel leaving together with flying or when burning a coke remaining balance.

2. The model [3] represents more exact and complete picture of process of formation of nitrogen oxides because of accounting of after-burning of a coke remaining balance, turbulent diffusion and transfer of components of the furnace environment average movement.

References

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