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Research on Influence of the Furnace Chamber Aerodynamics on Ecological Indicators of Boiler Plants (Part 2: Results of a Low-temperature Swirl Combustion Practical Implementation and their Analysis)

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Abstract

Results of solid fuel burning process calculations on low-temperature swirl technology are given at this work. The developed calculation procedure is based on the diffusion and kinetic theory of burning, considers generation and decomposition of nitrogen oxides, allows carrying out quantitative estimates of emissions of NO_x during the work of boilers. The results of calculations showed that the organization of coal and peat combustion for low-temperature swirl technology allows improving ignition and burning of fuel, and considerably reduce emissions of nitrogen oxides. The received results are used at reconstruction of copper of BKZ-210-13,8 of the Kirov CHPP-4.

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Keywords: boiler plant; emissions of pollutants; nitrogen oxide.

1. Results of calculation, their analysis and discussion

Based on the methods of mathematical modeling [1-3], using modern approaches of the diffusion and kinetic theory of burning [4] and the analysis of physical and chemical processes of transition of chmically connected energy of fuel in thermal [5], the model, algorithm, technique and mathematical program [6-9] of calculation of process of generation and nitrogen oxides transformation during solid fuel burning on low-temperature swirl technology [10-14] are developed and verified with experimental data. The technique considers generation and

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decomposition of nitrogen oxides [15,16], allows to carry out quantitative estimates of emissions of NOx during the work of boilers.Calculations of process of burning to furnace are carried out to LTS in relation to the boiler BKZ-210-13,8 planned for modernization for LTS technology of combustion of the Kuznetsk coal of brands G and D and milling peat. Characteristics of rated fuels are provided in Table 1.

Table 1. Estimated characteristics of the Kuznetskii stone coal of brands G, D and milling peat

Name	Symbol	Dimension	Estimated characteristics	
			Kuznetskii coal	Milling peat
Moisture	W^t	%	11,2–22,3	55,1
Ash	A^r	%	13,2–22,3	6,6
Sulfur	S^r	%	0,2–0,4	0,1
Carbon	C^r	%	43,3–59,4	21,7
Hydrogen	H^r	%	3,1–4,3	2,3
Nitrogen	N^r	%	1,4–1,9	1,0
Oxygen	O^r	%	7,2–9,8	13,2
Net calorific value	Q^r_i	kcal/kg	4119–5643	1750
		kJ/kg	17245–23626	7327
Ash (on dry weight)	A^d	%	14,9–28,7	14,7

The sizes of fuel particles, their number on 1 kg of estimated fuel, weight within each fraction and the area of initial surface of reaction, were by processing of granulometric characteristics of initial fuels (see Fig. 1): Kuznetskii coal (R_{100} = 30 %, R_{500} = 1 %), milling peat (R_{100} = 50 %, R_{1000} = 15 %). The estimated size of the finest particle of the Kuznetsk coal made d_{min} = 40,6 of micron, the most coarse particle $d_{\max}$ = 780 of micron; for milling peat respectively: d_{min} = 380 of micron and $d_{\max}$ = 7,6 of mm.

The analysis of granulometric characteristics of estimated fuels showed that for the Kuznetskii coal, due to its low reaction capacity, fine dust with uniform grinding is provided to burning: indicator of polydispersion *n* (0,8–1,6) is 0,834, and *b* coefficient characterizing grinding subtlety (changes from 0,004 (rough dust) to 0,04 (fine dust)) makes 0,026. In case of combustion of highly reactive milling peat, the project provides extremely uneven and coarse grinding of fuel (n = 0,437; b = 0,093), which is not dust.

For calculations the furnace camera has been divided into elementary cells (see Fig. 2 (a)) in which nodal points were based velocity vectors of air-gas flows (see Fig. 2 (b)). The calculated aerodynamic picture of flows (see Fig. 2 (c)) was used for finding trajectories and calculations of burning out reacting fuel particles (see Fig. 2 (d)) with simultaneous definition of the resulting concentration of the nitrogen oxides formed during burning and dissipating on the surface of the burning carbon in the course of repeated circulation in the lower swirl zone of LTS of furnace.

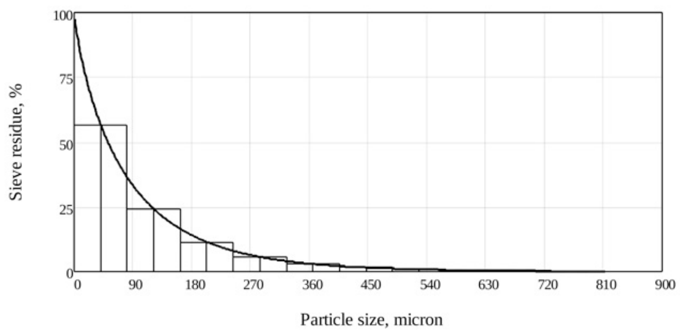

Fig. 1. Processing of grain size distribution curve of the Kuznetskii coal (W^r=12 of %, A^r=13,2 of %, R_{100}=30%, R_{500}=1%) per 1 kg.