

Numerical study of Pavlovskiy coal pulverized combustion in the furnace of BKZ-210-140 steam boiler

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Abstract. In this paper pulverized combustion of insufficiently investigated low-grade Pavlovskiy coal is simulated using the modern engineering software FIRE 3D. The object of study is a widespread in Russia BKZ-210-140 steam boiler. The results of computer simulation are represented with average temperatures in horizontal sections and oxygen concentration. Curves are plotted for three steam generating capacity loads of the boiler: 100 %, 70 % and 50 %.

Introduction

Different modifications of BKZ-210-140 steam boiler units are widespread in different regions of Russia. For example, the Vladivostok Central Heating and Power (CHP) Plant-2 has 14 boilers of this type. It's a drum-boiler with a U-shaped layout and dry ash removal. The combustion chamber with a volume of 1093 m³ is furnished with four tangentially mounted straight-flow burners and four pulverizing fans. The steam generating capacity is 210 tons per hour; the superheated steam pressure is 14 MPa and its temperature is 570 °C; boiler's efficiency (gross) is 90.3 %.

BKZ-210-140 steam boiler is produced since 1959, but nowadays there is a decreasing of performance, especially that at modes with low load conditions, resulting from the used coals quality reduction.

The boilers at the Vladivostok CHP Plant-2 are designed for burning the Chikhezhskiy lignite with the following characteristics: moisture = 41 %; ash content = 8.9 %; calorific value = 12260 kJ/kg. But presently, coals of the Pavlovskiy Deposit with a moisture of = 41.5 %; ash content = 19.6 %; calorific value = 91260 kJ/kg are used [1].

Quality reduction of combustible fuel increases the loads on the fuel-preparation system, decreases the stability of combustion process, and adversely affects the efficiency of power engineering equipment operation.

Because the used direct-fired pulverized-fuel system, the increased load on the pulverizing fans leads to a fuel and air flow reallocation along the burner devices which later affects the tangentially swirling flame formation. Flame displacement or non-intensive vortex formation leads to slagging of the heating surfaces and incomplete fuel burning. These processes reduce reliability and efficiency of the steam generating unit, especially at lowered loads.

Principles of study

Currently, the development of computer simulations has reached a level where it is possible to construct physical and mathematical models of processes occurring in the combustion chamber with accuracy sufficient for engineering practice. Models of multi-



component vortex motion, non-isothermal medium with polydisperse dust, radiation transfer, combustion and chemical reactions of gases, coal dust drying and pyrolysis processes and other physical and mathematical models allow to simulate the operation of real equipment. Modern computation equipment has enabled to implement these models in the form of engineering software available for personal computers.

The Euler-Lagrange method for describing aerothermal and chemical processes in gas-dispersion atmosphere based on the application package FIRE 3D [2] has been employed in this paper. Turbulent characteristics of gas are calculated with a $k-\epsilon$ turbulence model that also considers the effect of particle motion. Radiation heat transfer in the two-phase flow is represented within the framework of the P1 approximation of the spherical harmonics method [3] which displays positive results when used for pulverized-coal furnace.

The task of boundary conditions for equation systems is determined by the border type. For input boundaries homogeneous characteristic distributions are used. Mild boundary conditions are provided at outflow boundaries. Such output boundary position must be extensively moved far from the areas of possible flow recirculation. The furnace surfaces boundary conditions are used: conditions of attachment for velocity, boundary conditions of the first type for gas temperature, zero equality in the normal derivative of concentrations, gas component.

Calculation results

Fig. 1 presents numerical simulation results of average temperatures in horizontal sections and oxygen concentration at the three loads of 100 %, 70 % and 50 % of boiler steam generating capacity. It should also be noted that at load of 70% equipment operates with a single switched off burner.

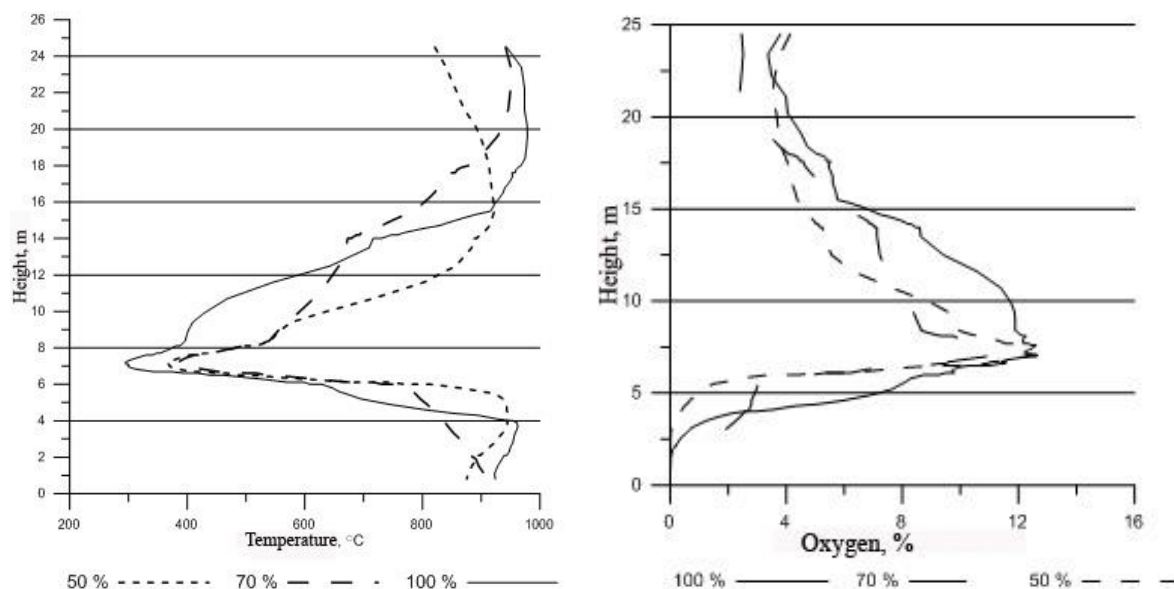


Figure 1. Average temperature and oxygen concentration variations along the combustion chamber height

Curve profiles are similar in all three cases. Comparing the numerical simulation results, it must be mentioned that temperature distributed more uniformly over the combustion chamber volume occurs when the boiler is operated at loads of 100 % and 50 % since flow movement

is symmetric in relation to heating surfaces. Temperature values at a height of 7 m are minimal in all cases due to fuel combustion in straight-flow burners and fuel drying by recirculation gases. Temperatures of outflow from the combustion chamber are as follows: at 100 % – 970 °C, at 70 % – 940 °C, at 50 % – 850 °C.

Oxygen concentration in all researched variants has similar values, whereas the curve profile corresponds to the combustion process in the furnace chamber (see Fig. 1). The concentration value of the outflow from the combustion chamber is 3-4 %.

The concentration of volatiles is rather low at all operation modes and its average value equals 1% (see Fig. 2). Variations of the CO concentration correspond to changes of the temperature level in the combustion chamber and are minimal at its outflow.

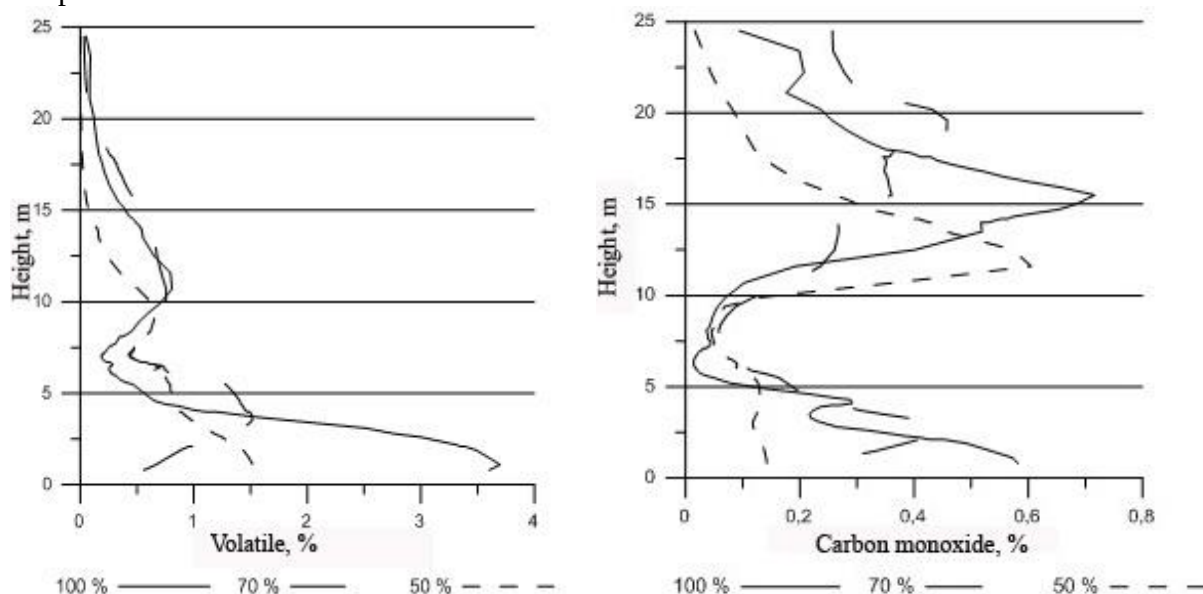


Figure 2. Variations of the concentration of volatiles and CO along the combustion chamber height

Summary

1. Wood wastes and the Kandinsky peat can be considered promising raw material for thermal technological processing both into fuel gas and peat briquettes.
2. The Sukhovskiy peat may be used for power generation only after conducting a thorough investigation and feasibility study of its use in certain conditions.
3. Using the Karasevskiy sapropel and Arkadevskiy peat is considered unpromising due to low ash content of raw material and final products of thermal technological processing.

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References

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