Investigation of turbulence characteristics of burning process of the solid fuel in BKZ 420 combustion chamber

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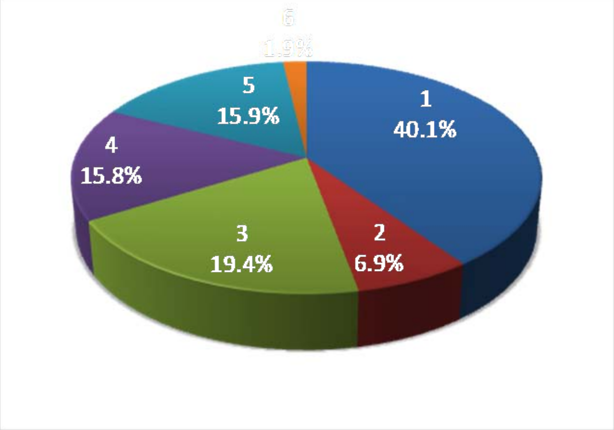
Abstract: - In this paper the results obtained by the numerical method of modelling of Ekibastuz coal burning in BKZ-420 combustion chamber of Kazakhstan Power Plant. There are devoted to the numerical simulation of combustion processes in the furnace boiler BKZ-420. Boiler's steam generating capacity equal 420 T/h. Boiler (Fig.2) has six vertical pulverized coal burners arranged in two levels with three burners on the front wall of the boiler. High ash, low-grade coal from Ekibastuz burned in the furnace. Its ash content is 40 %, volatile – 24 %, humidity – 5 %, highest calorific value is 16 750 kJ/kg. Milling dispersity of coal was equal to R_{90} = 15 %. It this research was shown that the most intense burning is observed in the central part of the chamber where the flow temperature reaches about 980 °C and it is seen the temperature reaches a peak in the cross sections of the location of the burners. There combustion reaction occurs more intensively.

Key-Words: - BKZ-420, combustion, Ekibastuz coal, heat and mass transfer, modeling, pulverized coal, turbulence, two–phase, flow

1 Introduction

The study of convective heat problems in turbulent flows in the presence of chemical reactions is an important task of thermal physics and hydrodynamics; as such, flows are widespread in nature and play an important role in many technical devices. Knowledge of the laws of such flows is important in constructing a theory of physics of combustion, creating a new physical-chemical technology, as well as problem solving power engineering and ecology. In studies of complex combustion process should be analyzed depending on the influence of numerous physical and chemical parameters of the combustion reaction [1]. The development of theory of heat and mass transfer, development on this basis manufacturing processes and systems with the rational use of energy resources is an actual task.

At the moment the world energy in the foreseeable future based on the use of fossil fuels, mainly low-grade coal. It should be noted that the deterioration of steam coal is widespread, and not only in the CIS countries, but also in the developed capitalist countries. Today the world's thermal power plants (TPP) produce more than 40 % of electricity and heat. Although generally coal had several 'ups and downs' during its utilization history, it is still one of the most important fuels for generation of primary energy, especially of electric energy (Fig.1). According to International energy Agency (IEA) statistics issued in 2003, coal supplies around 24 % of primary energy needs and generates some 40 % of produced global electricity, while further increase in utilization of coal is expected in the future [2].



1 – coal, 2 – liquid fuel (fuel oil, diesel fuel), 3 – gas, 4 – nuclear energy, 5 – hydro, 6 – other (solar, wind, geothermal, waste, including vegetable origin)
Fig.1 Total world electricity generation by fuel

Energy Industry of Kazakhstan Republic is aimed at the use of coal as an energy fuel. According to the "Statistical Review of World Energy» (Statistical Review of World Energy), prepared by the British company, at the beginning of 2013, Kazakhstan is one of the leading countries in coal reserves, second only to China, USA, Russia, Australia, South Africa and India and ranked 8th place that divides our country with Ukraine [3]. Kazakhstan holds about 3.9 % of global coal reserves. Today in Kazakhstan coal reserves constitute 33.6 billion tons. Ekibastuz coal field is the main source of raw materials to be used in the energy industry due to obtaining it by open way. But because of the characteristics of this fuel special importance is got fundamental researches with practical relevance and aimed at improving the combustion efficiency of energy consumption and minimize emissions of harmful dust and gas emissions in Kazakhstan.

2 Problem Formulation

Investigation of turbulent combustion of solid fuels, coal-fired and problem solving of modern thermal physics, power engineering and ecology is the urgent need not only for our country, but also a problem of global proportions. This is evidenced by similar studies that are conducted in the CIS countries, the European Union and the United States [4]-[7].

Solution of many technical tasks impossible without using of CFD software packages [8], [9], allows modeling of difficult particular process in practice. In this article investigated numerical study of physical characteristics and aerodynamic properties of pulverized fuel combustion in thermal power plant with Florean program complex [10].

Investigation of problems of convective heat and turbulent flows in the presence of chemical reactions is an actual problem of thermo-physics and hydro aerodynamics, because such flows are widely distributed in nature and take importance in many technical devices. Knowledge of laws of such flows important when constructing combustion physics theory, at creation new physical-chemical technologies, and also at the decision of problems of power system. In researches difficult combustion process should be analysed according to the influence of physical and chemical parameters of the combustion reaction.

2.1 Physical formulation of the problem

There are devoted to the numerical simulation of BKZ-420 combustion chamber. Its steam capacity equal 420 T/h. Boiler equipped with six vortex dust burner, arranged in two levels with three burners on the front wall of the boiler as shown in Figure 1. Low-grade high-ash coal dust from Ekibastuz has burnt in the boiler, it has ash content of 40 %, volatile – 24 %, moisture content – 5 % and the highest calorific value 16 700 kJ/kg (see Table1). The fineness of coal milling is equal to R_{90} = 15 %. All numerical calculations were performed on above characteristics.

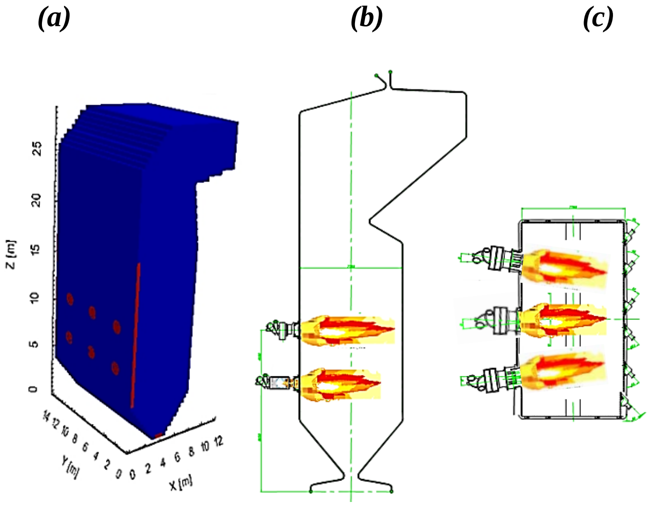
On the front wall of the combustion chamber six double-flow vortex of dust and gas burners in two stages (three per stage) are established. The last burner turned to the center of burner by 8 degrees. The capacity of each burner is 12 T/h (Fig.2).

Industrial implementation of any new technology is not possible without preliminary analysis of advantages and disadvantages suggested method. The rapid development in computer sciences gives the advance to computational techniques to be used for simulation of complex combustion processes in industrial furnaces.

Products of combustion contain different harmful substances and the emission of these components grows into a great problem. Industrial development causes an increase in hydro carbonaceous fuels' consumption. These fuels contain harmful and poisonous components such as carbonic oxide (CO), nitric oxide (NO), sulphur dioxide, acid sulphate, lead combinations and different hydrocarbons, etc.

To decrease emissions of harmful substances various methods are applied, including special fire regimes (organization of combustion process), which suppresses the formation of harmful substances in flame and two-stage burning, when the burners work with low air surplus. In this way numerical experiments became one of the most effective and suitable means for detail analysis and in-depth study of physical and chemical phenomena.

In this paper software package FLOREAN [11], [12] for 3D modeling of coal-dust combustion in furnaces of real-sized boilers was used. This program enables to calculate velocity components *u*, *v*, *w*, temperature *T*, pressure *P*, concentration of combustion products and other turbulence characteristics of combustion process all over the combustion space and at its exit. Pressure is determined through the connection between the continuity equation and the equation of motion by means of Patankar's Simple-method [13].



(a) – 3D view of BK-420 boiler and its breakdown into control volumes
(b) – Burners establish arranged on two levels
(c) – Top view on the cross section (h = 10.75m)
Fig.2 General view of the industrial boiler BKZ-420 of the Almaty TPP-2

Complex physical and chemical processes include the conservation equations of mass, conservation of angular momentum and energy for the gas and solid phases. The gas flow is considered in the Euler system, the dynamics of a solid phase is considered in the Lagrangian system. The turbulent structure of the flow is described by a two-parameter model of turbulence. The radiation heat transfer is determined on six stream model. The mathematical description of the physical and chemical processes are based on the solution of the balance equation. In general, all of these equations contain four components: changes in the value of time, component describing convective transport, component describing diffusive transport, component describing the source or flow.

Table 1
Source data of coal and BKZ-420 combustion chamber for numerical calculation

Characteristic	Quantity
Coal type	Ekibastuz
Density of particles	1300 kg/m^3
$C_{daf,}$ %	82.0
$H_{daf,}$ %	5.0
$N_{daf,}$ %	1.5
$O_{daf,}$ %	11.5
Ash , %	40.0
Humidity , %	5.0
Volatile content, %	24-28
Coal consumption in the boiler	72 000 kg/h
Consumption of coal to the burner through two channels	12 000 kg/h
Primary air flow to the boiler	107 035 kg/h
Secondary air flow rate to the boiler	402 656 kg/h
The temperature the secondary air	280 °C
Temperature of aeromixture	88.85 °C
The average particle size of coal	64 mcm
The lower heating value of coal	16 750 kJ/kg
The amount of computation (control volumes)	671 113

2.1.1 Mathematical model

Among the methods of modeling the combustion of pulverized fuel most widely used method based on the Euler, an approach to describe the motion and heat transfer of the gas phase. This method uses the spatial balance equations for mass, momentum, the concentrations of gaseous components and energies for the gas mixture. To describe the motion of single particles and heat mass transfer of fuel along their trajectories used Lagrange approach. Turbulent flow structure is described by a two-parameter of k-ε model of turbulence, where k – the kinetic energy of turbulence, ε – turbulent energy of dissipation.

The mathematical description of physical and chemical processes based on the solution of balance equations. In general, these equations contain four terms describing:

- change in the value of time;
- convective transfer;
- diffusive transfer;
- source or sink.

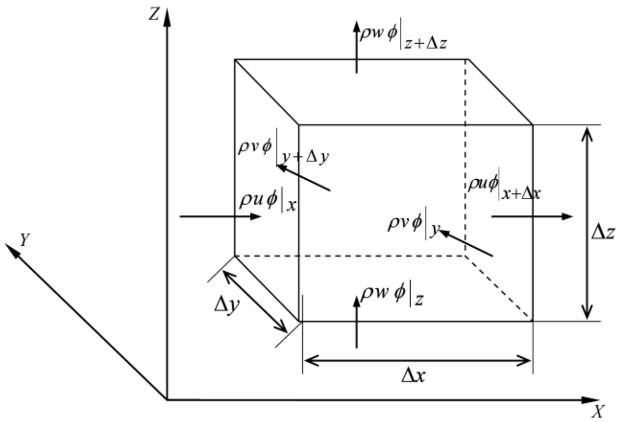


Fig.3 Control volume for the generalized transport equation

In figure 3 shown generalized model of control volume, where $\rho u\phi|_{i,i+\Delta i}$ – describes the convective transfer across the borders of the variable control volume in Cartesian coordinates. For derive the balanced ratios selected stationary control volume element or control element of mass (Fig. 3). It is supposed that the center of gravity of the selected element moves with the velocity of flow. This corresponds to a stationary control volume sound approach for the Euler flow. Change the value of the transport is described in a single fluid element. The value of this quantity determined at each point of the domain.

By converting from a finite limit to the infinitesimal volume element obtained by controlling the differential equation describing the conservation of the transport variable ϕ:

$$\frac{\partial(\rho\phi)}{\partial t} = -\frac{\partial(\rho u_1\phi)}{\partial x_1} - \frac{\partial(\rho u_2\phi)}{\partial x_2} - \frac{\partial(\rho u_3\phi)}{\partial x_3} + \frac{\partial}{\partial x_1}\left[\Gamma_\phi \frac{\partial\phi}{\partial x_1}\right] + \\ + \frac{\partial}{\partial x_2}\left[\Gamma_\phi \frac{\partial\phi}{\partial x_2}\right] + \frac{\partial}{\partial x_3}\left[\Gamma_\phi \frac{\partial\phi}{\partial x_3}\right] + S_\phi \tag{1}$$

Where, ρ – density; u_i – flow speed in the direction x, y, z; ϕ – variable transfer, Γ – diffusion coefficient.

Changing in eq.(1) the convective and diffusive transfer of flux density, cross-border control volume, we obtain a flux density:

$$\Phi_{(K),j} = \rho u_j\phi$$ – Convective component;

$$\Phi_{(D),j} = \Gamma_\phi \frac{\partial\phi}{\partial x_j}$$ – Diffusive component.

Then, taking into account eq.(1), written as:

$$\frac{\partial(\rho\phi)}{\partial t} = -\frac{\partial\Phi_{(K),j}}{\partial x_j} + \frac{\partial\Phi_{(K),j}}{\partial x_j} + S_\phi \tag{2}$$

We write eq.(2) in vector form:

$$\frac{\partial(\rho\phi)}{\partial t} = \mathrm{div}\Big((-\rho u\phi) + \Gamma_\phi \mathrm{grad}\phi\Big) + S_\phi ,$$

and in tensor form, equation (2) takes the form:

$$\frac{\partial(\rho\phi)}{\partial t} = -\frac{\partial(\rho u_j\phi)}{\partial x_j} + \frac{\partial}{\partial x_j}\left[\Gamma_\phi \frac{\partial\phi}{\partial x_j}\right] + S_\phi \tag{3}$$

To calculate the gas flow solid-phase with the input of all transport quantities in the control volume are determined by the generalized equation (3). In this equation S_ϕ – is source (sink) term for the quantity ϕ, other terms describes the variation of ϕ:

$$\frac{\partial(\rho\phi)}{\partial\tau}$$ – Time component;

$$\frac{\partial(\rho u_j\phi)}{\partial x_j}$$ – Convective transfer;

$$\frac{\partial}{\partial x_j}\left[\Gamma_\phi \frac{\partial\Phi}{\partial x_j}\right]$$ – Molecular transfer.

In mathematical model of gas, flow or liquids used equations of conservation of mass and momentum. For flows in which taken place processes of heat transfer, as well as for compressible media we have to solve the equation of energy conservation. In flows with the processes of mixing of different components, with the reactions of combustion, etc. must be added the equation of conservation of the mixture components or the conservation equation for mixture fraction and its changes. For turbulent flow the system of equations is complemented by transport equations for turbulent characteristics.

Thus, to solve this problem we consider the equations describing the flow and which are derived from the generalized equation (3). This system has no analytical solution and can only be solved by numerical methods.

In general, for numerical solution the whole computational domain is divided into discrete difference grid point, or volume, continuous field variables is replaced by discrete values at the nodes of the grid, and derivatives in the differential equations are replaced by their approximate expressions in terms of the difference of function values at grid points. In the present study for the problem is solved using the method of control volume. The system of algebraic equations for the differential equation of control volume for each balanced value is as follows:

$$a_P\phi_P = \sum_n a_n\phi_n + S_\phi .$$

Coefficients are determining the contribution of convective and diffusive flow in all directions at each point of control volume. As a result of approximation of equation (2) were obtained algebraic equation (3) for each control volume and for each unknown variable ϕ_n.For each cell in the computational domain used physical laws of conservation and differential equations describing these laws (transfer equation), integrated over the volume of each cell.

FLOREAN is based on the numerical solution of the Reynolds averaged balance equations for mass, species, energy and momentum. It predicts gas flows, species concentrations, temperature fields due to combustion, radiation and convective heat transfer and the pollutant formation and destruction in furnace chambers. The mean flow equations are investigated by the *k*-*ε* turbulence model.

The changes of the concentrations of flue gas components and the fuel due to the combustion are taken into account in the source sink terms by appropriate sub models.

In addition, in the source sink term the heat balance takes into account the energy release due to the combustion reactions and the significant heat transfer due to radiation using a six flux radiation model. Equation for conservation of thermal energy is written in terms of the enthalpy *h*. Radiation heat transfer is determined by 6 flux radiation models by Lockwood, etc. [14].

Pulverized coal flames are turbulent reacting two-phase flows. Particle presence is approximated as continuum and the mean particle velocity is assumed to be approximately equal to the gas phase velocity.

In the standard *k*-*ε* model written basic transport equation of turbulent kinetic energy *k*:

$$\frac{\partial(\overline{\rho}k)}{\partial t} = -\frac{\partial(\overline{\rho}\,\overline{u_j}k)}{\partial x_j} + \frac{\partial}{\partial x_j}\left[\frac{\mu_{eff}}{\sigma_k}\frac{\partial k}{\partial x_j}\right] + P - \overline{\rho}\cdot\varepsilon \tag{4}$$

Where, P - production of turbulent kinetic energy, which is defined by the following equation:

$$P = \left[\mu_{turb}\cdot\left(\frac{\partial\overline{u_i}}{\partial x_j} + \frac{\partial\overline{u_j}}{\partial x_i}\right) - \frac{2}{3}\cdot\rho\cdot k\cdot\delta_{ij}\right]\cdot\frac{\partial\overline{u_i}}{\partial x_j} \tag{5}$$

The equation for the turbulent kinetic energy dissipation *ε* was written as:

$$\frac{\partial(\overline{\rho}\varepsilon)}{\partial t} = -\frac{\partial(\overline{\rho}\,\overline{u_j}\varepsilon)}{\partial x_j} + \frac{\partial}{\partial x_j}\left[\frac{\mu_{eff}}{\sigma_\varepsilon}\frac{\partial\varepsilon}{\partial x_j}\right] + C_{\varepsilon,1}\cdot\frac{\varepsilon}{k}\cdot P - C_{\varepsilon,2}\cdot\frac{\varepsilon^2}{k}\cdot\overline{\rho} \tag{6}$$

The turbulent viscosity is determined by the equation of Prandtl - Kolmogorov:

$$\mu_t = C_\mu\cdot\rho\cdot\frac{k^2}{\varepsilon}$$

Where these are empirical constants:

$C_\mu = 0.09$;

$\sigma_k = 1.00$;

$\sigma_\varepsilon = 1.30$;

$C_{1\varepsilon} = 1.44$;

$C_{2\varepsilon} = 1.92$

The boundary conditions for the turbulence model are defined as follows (kinetic energy of turbulence at the inlet):

$$k_{in} = 1.5(u_{i,in}Tu)^2$$

It should be noted that the modeling of flows in the presence of turbulence, which are taken as a basis for solving the equations for the turbulent characteristics (kinetic energy of turbulence and its dissipation), allows to obtain the desired accuracy of the solution, while excluding non-useful machine costs associated with obtaining it.

3 Results of CFD research

The present paper provides an overview of the current capabilities of the CFD-computer code FLOREAN (acronym for **FLO**w and **REA**ctio**N**) developed at the Institute for Fuel and Heat Technology in Technical University of Braunschweig (Germany).

Simulation tool FLOREAN allows to get detailed information about furnace performance including velocities, temperature, thermal radiation and concentration distributions, etc. within the furnace and along the walls. The efficient combustion of solid fuel in combustion chambers and the efficient heat transfer to water and steam in steam generators are essential for the economical operation of power plants. This information is useful to evaluate the combustion process and to design optimal furnaces. FLOREAN will also be very useful in improving combustion process of different fuels in industrial boilers, optimizing operation and minimizing pollutant emission [15]-[17].

Consequently, the FLOREAN – code was used to predict thermal and hydrodynamic aspects of flue gases mixing in the near wall region and inside the furnace. In the case of Over Fire Air (OFA) technology of simulations show that effective mixing between flue gases and over-fire air is of essential importance for CO re-burning and low NO_x emissions.

Florean solves a number of transport equations depending on the user's specific problem setup. It's given the (general) continuity, momentum, energy species and turbulence equations. Figures below shows the vector field full speed $V = \sqrt{u^2 + v^2 + w^2}$ throughout the volume of the combustion chamber by means of which one can characterize the behavior of pulverized coal flow within the combustion chamber. One can clearly see the area of the fuel mixture through the burner.

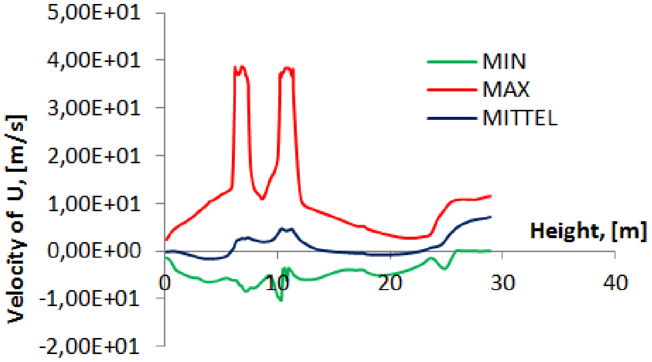


Fig.4 Distribution of the velocity vector direction of the *x* axis height of the combustion chamber of the boiler BKZ-420

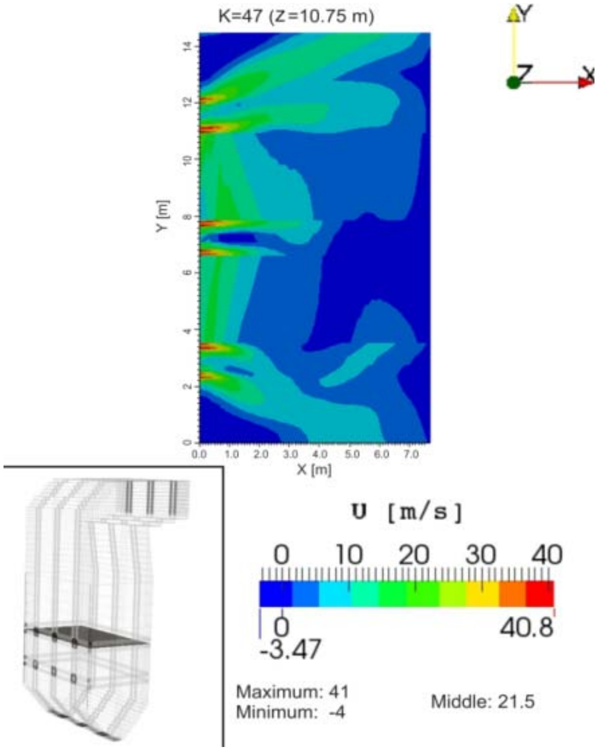


Fig.5 Velocity profile on the cross section of the combustion chamber of the boiler BKZ-420 (K=47, Z = 10.75m)

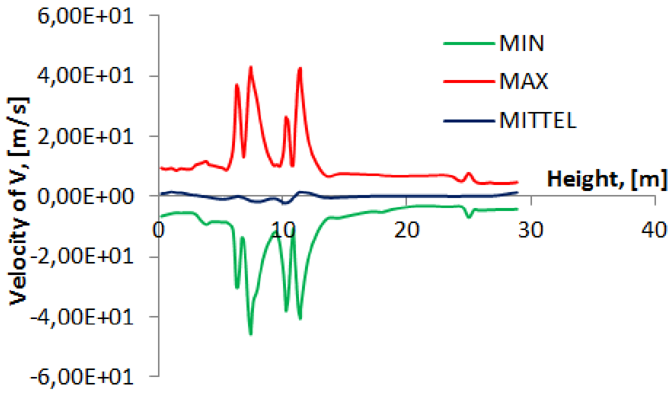


Fig.6 Distribution of the velocity vector direction of the *y* axis height of the combustion chamber of the boiler BKZ-420

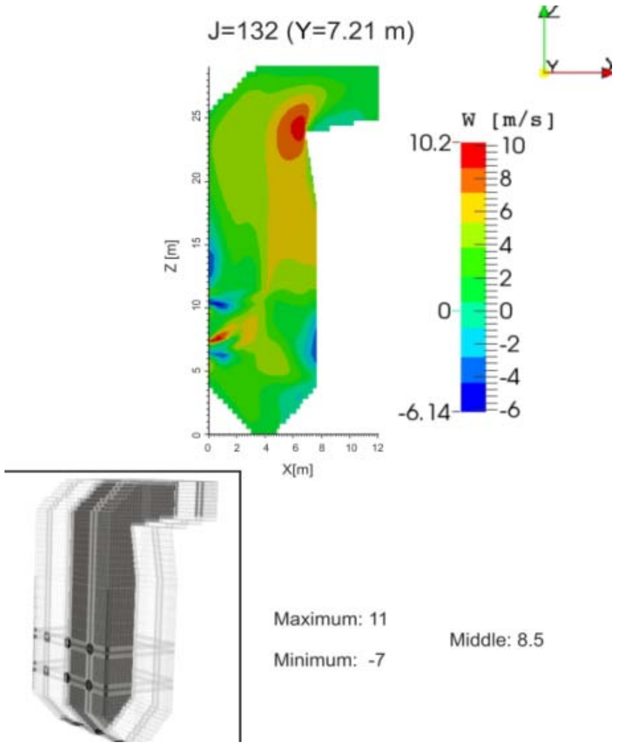


Fig.7 Velocity profile on the cross section of the combustion chamber of the boiler BKZ-420 (J=132, Y = 10.75m)

Figure 5 - in the cross section, which accounts for the lower tier of burners (K=47, h = 10.75m) has *max* speed on the inlet, it equal 40 m/s. Figure 4 shows the distribution of the velocity vector direction of the *x* axis height of the combustion chamber of the boiler BKZ-420, there we can see two peaks, its mean that speed of

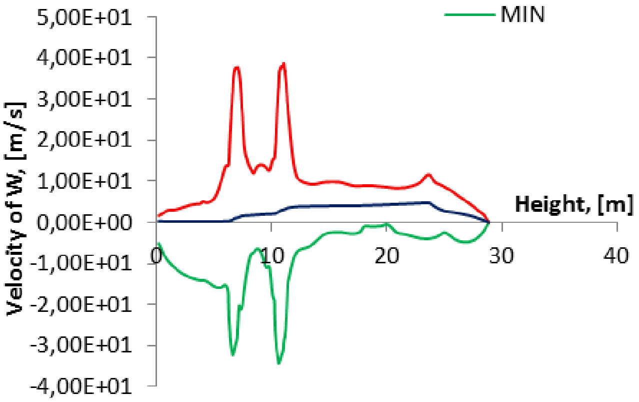


Fig.8 Distribution of the vector velocity direction of the *Z* axis height of the combustion chamber of the boiler BKZ-420

pulverized coal particles *max* on the inlet of burner. Figure 6-8 shows the velocity profile on the cross section of the combustion chamber of the boiler BKZ-420 (J=132, Y = 7.2 m) by *Z* axis. There *max* speed equal to *W*=11 m/s.

Speed vector fields in the figure 9 is shown as arrows vectors of length gives a value of full speed, their direction connected with the direction of the full-speed at the selected point of the combustion chamber. Presented on figure 9 model able to obtain whole velocity profile in the BKZ-420 chamber including three different levels by *Y* axis: Y_1 = 2.85 m, Y_2 = 7.2 m, Y_3 = 11.69 m.

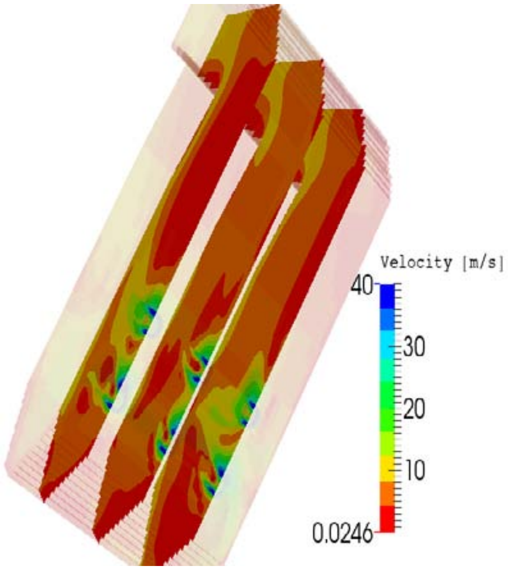
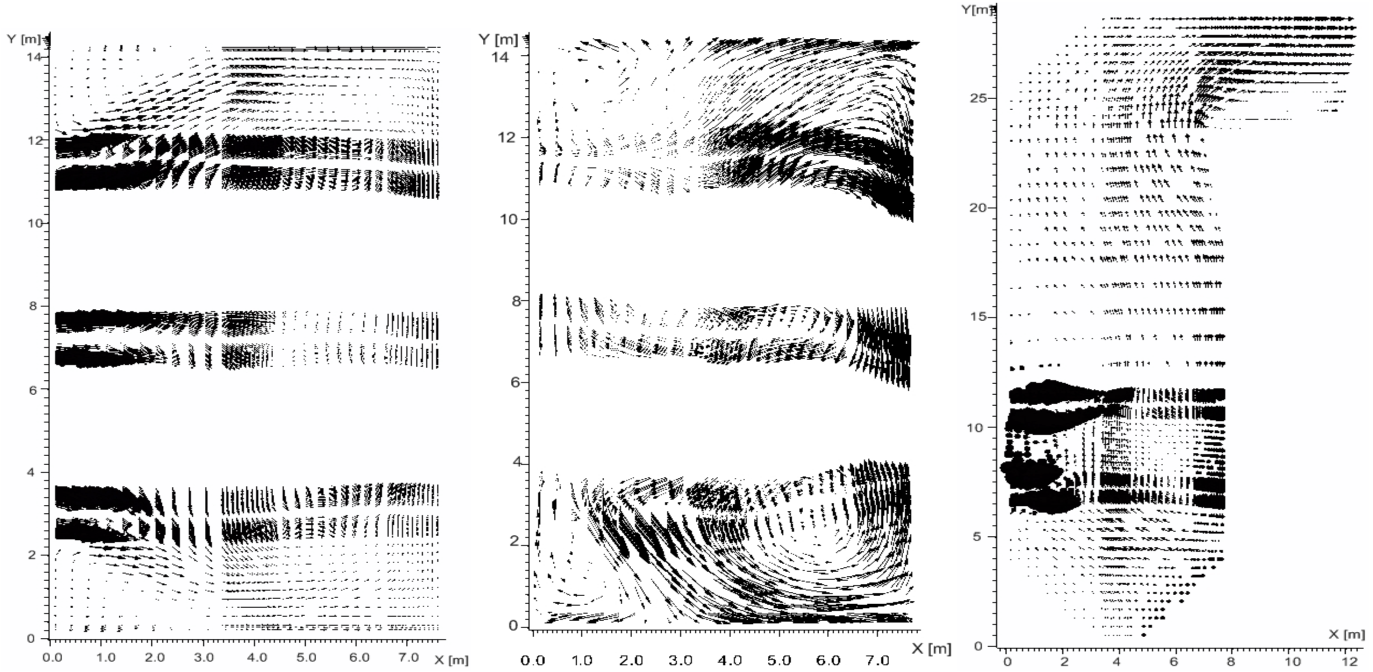


Fig.9 Velocity profile on the different levels of the combustion chamber Y_1 = 2.85 m, $Y2$ = 7.2 m, Y_3 = 11.69 m on the *Y* axis for two long lines (z_1 = 6.2 m) and (z_2 = 10.75 m)



(a)-Z_1=10.75 m, (b)-Z_2=6.2 m, (c)-Y=7.2 m

Fig.10 Velocity vector profile by the height of combustion chamber

Figure 10 illustrates velocity distribution in the combustion chamber by means of which one can characterize the behaviour of pulverized coal flow within the combustion chamber. One can clearly see the area of the fuel mixture through the burner. According to all of the figures above we can see *max* velocity on the inlet of burner, also on the cross section by Z axis (Z_2=6.2 m). Right and left side of burner exist turbulence flow of combustion.

On the basis of mathematical models and 3D computer modelling had conducted the study of complex of heat exchange processes taking place during combustion of low-grade coal fuel (Ekibastuz coal) on real energetic facility of the Republic of Kazakhstan (the combustion chamber of the boiler BKZ-420 of TPP-2). It is shown that the most intense burning is observed in the central part of the chamber where the flow temperature reaches about 980 °C. Due to the fact that coal particles in this area have a more intense radiation and have higher concentration and the total surface, it is seen that the temperature reaches a peak in the cross sections of the location of the burners. This is an area of combustion reaction occurs more intensively. As you approach the exit from the combustion chamber temperature profile is stabilized, and the differences between the minimum and maximum values decreases. Pressure field on the figure 11 shows that maximum pressure on the below opposite side of burner. Figure 12 presented 3D view of turbulence combustion profile by the height of combustion chamber.

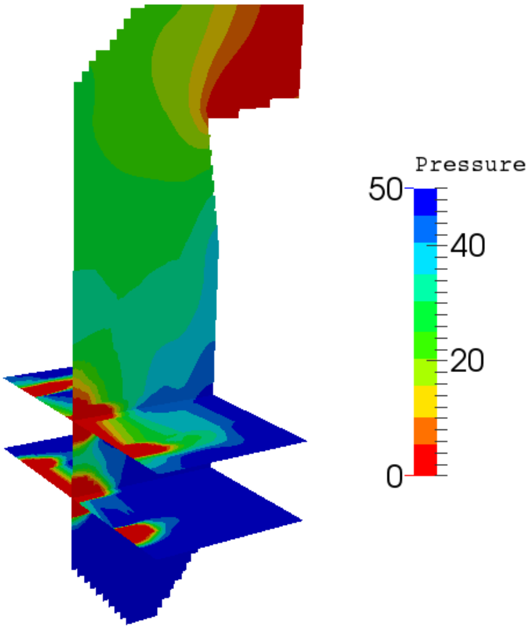


Fig.11 Pressure profile by the height of combustion chamber

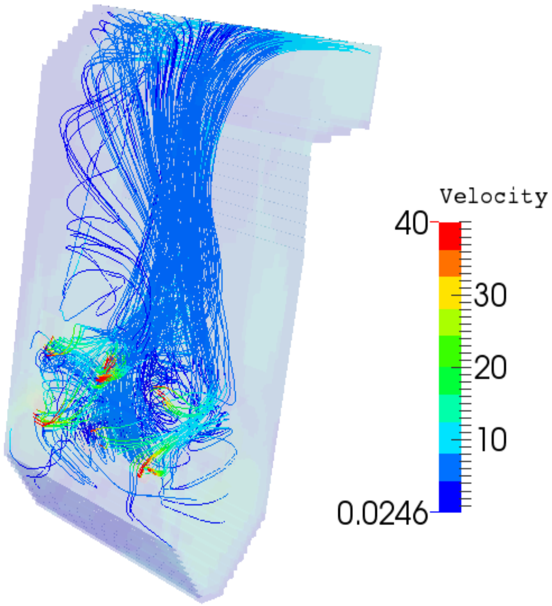


Fig.12 3D view of turbulence combustion profile by the height of combustion chamber

As seen in Figure 13, the temperature at the outlet of the combustion chamber is more than 1000 ^{0}C. The temperature values in the upper and lower tiers are much smaller. One reason for this - the fuel supplied to the furnace and the air that it contains interact with each other not immediately the process is slow. Consequently, the torch on the flame front burns intensely at 3-7 meters.

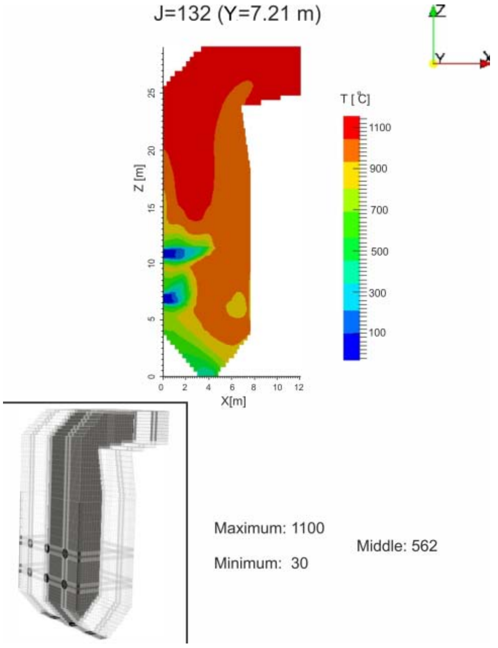


Fig.13 The temperature distribution in the longitudinal section (y = 7.21 m) of the combustion chamber of the boiler BKZ-420

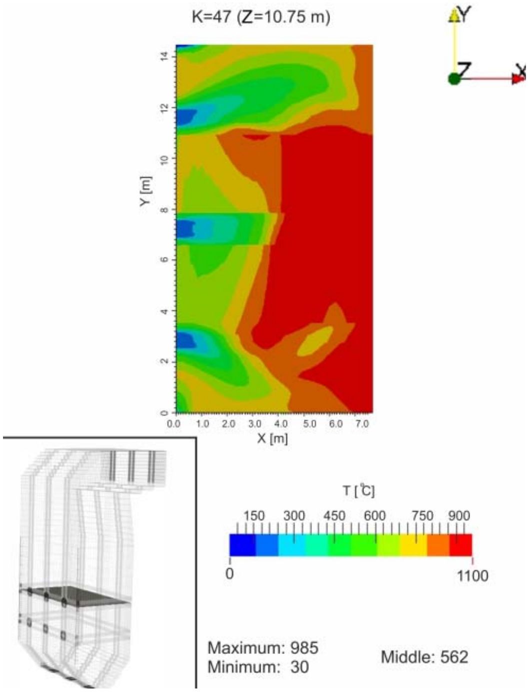


Fig.14 The temperature distribution in the cross section (z = 10.75 m) of the upper tier of the combustion chamber of the boiler BKZ-420

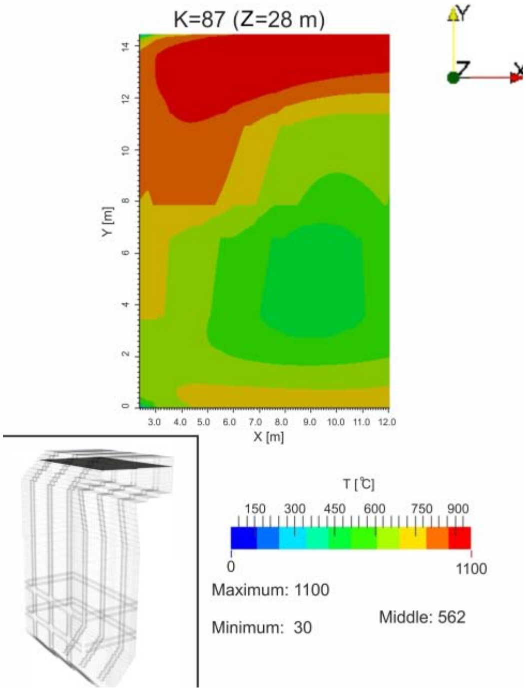


Fig.15 The temperature distribution at the outlet of the combustion chamber of the boiler BKZ-420

As seen from Figures 14 and 15 while burning coal four torch forming in the central area of the combustion chamber the common core with temperature of about 1100 ^{o}C, because coal particles in this region have more intense radiation and have a higher concentration, and the total surface. Reflected in the figures corresponds to the real picture of the process in the combustion chamber BKZ-420, Almaty CHP-2.

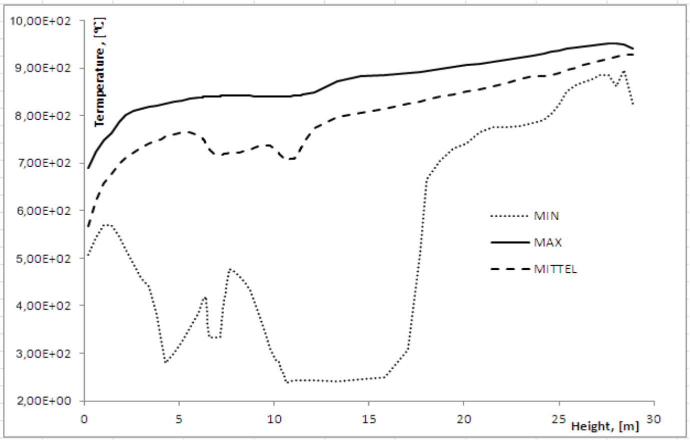


Fig.16 The temperature distribution in a longitudinal section along the height of the combustion chamber

Analysis of the figures 15 and 16 shows that in the zone of burners at the height of 28 meters the temperature is set equal to 500 ^{0}C. As we move toward the exit of the combustion chamber temperature rises and at the outlet reaches its maximum value equal to 1100 ^{0}C.

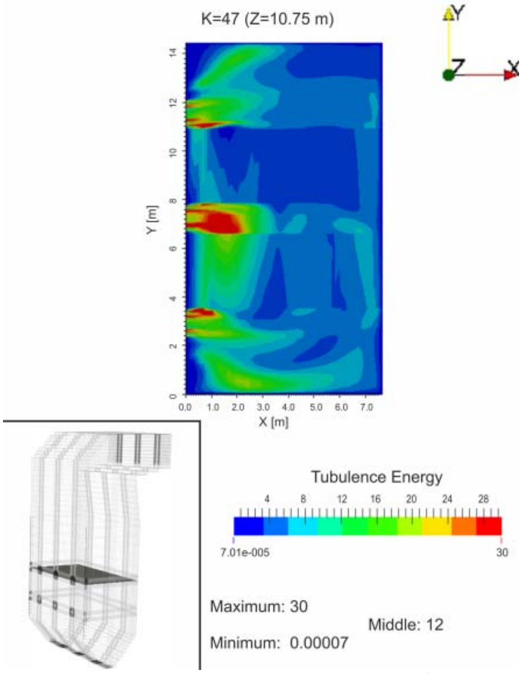


Fig.17 The energy distribution of turbulence in the longitudinal section (z = 10.75 m) of the upper tier of the combustion chamber BKZ-420

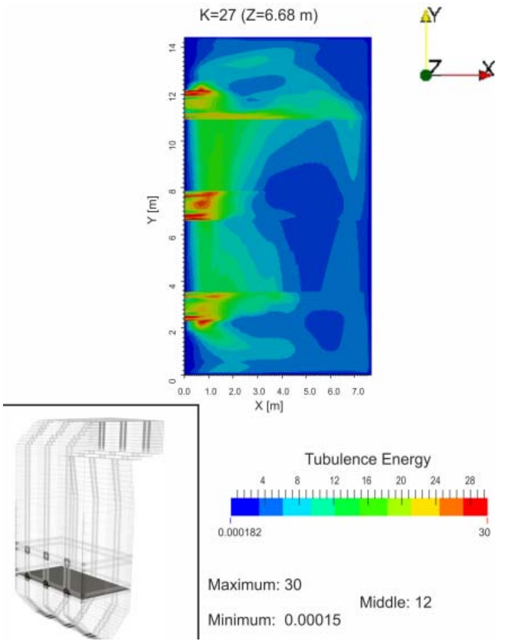


Fig.18 The energy distribution of turbulence in the longitudinal section (z = 6.68 m) of the upper tier of the combustion chamber BKZ-420

Figure 17 and 18 shows the distribution of the turbulent energy in two tiers of the combustion chamber of the boiler BKZ-420.

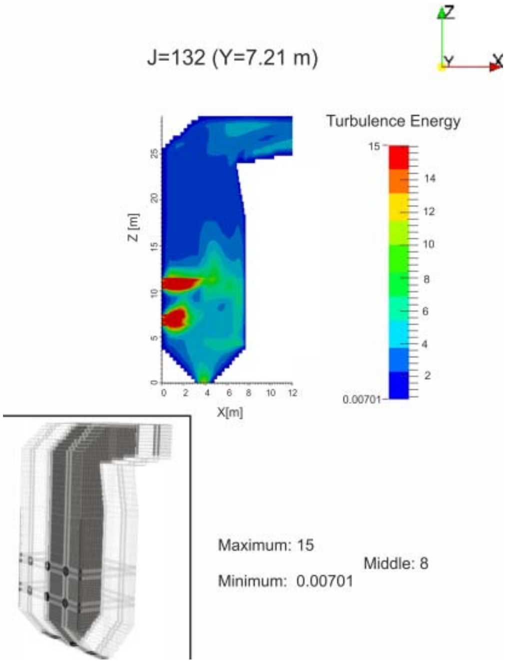


Fig.19 The energy distribution of turbulence in cross-section (y = 7.21 m) of the combustion chamber of the boiler BKZ-420

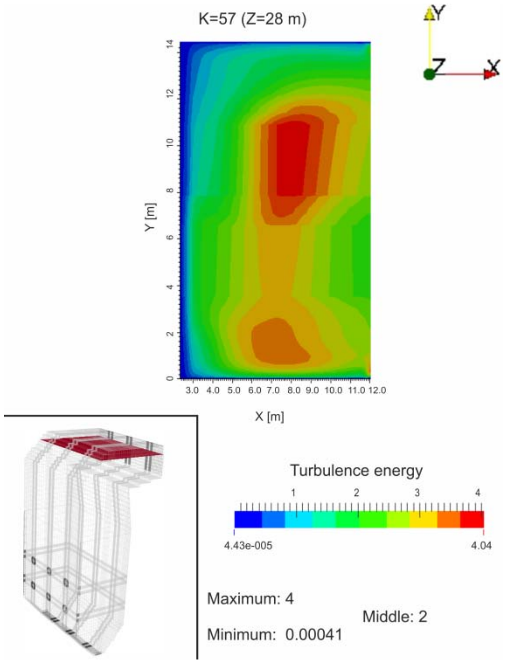


Fig.20 Distribution of turbulence energy at the output of the combustion chamber of the boiler BKZ-420

Energy of turbulence in the upper tier is much more than in the lower. Maximum turbulence energy corresponds to the region near the central burner of the upper tier. Combustion process in the top tier is complete, as the fuel burns with minimal residues.

As shown in Figure 19, the maximum turbulence energy levels corresponds to the lower and upper burners tiers. Elsewhere the turbulence energy is minimal. Figure 20 shows the distribution of turbulent energy from the center of the combustion chamber to the outlet. Since the temperature in the central part of the chamber takes the maximum value, this implies that also the turbulence energy is maximal in the center of the chamber.

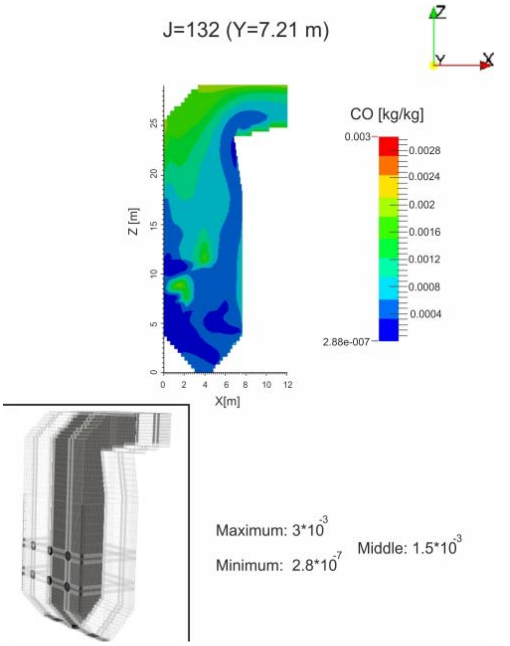


Fig.21 The distribution of the concentration of CO in the longitudinal section (y = 7.21 m) of the combustion chamber of the boiler BKZ-420

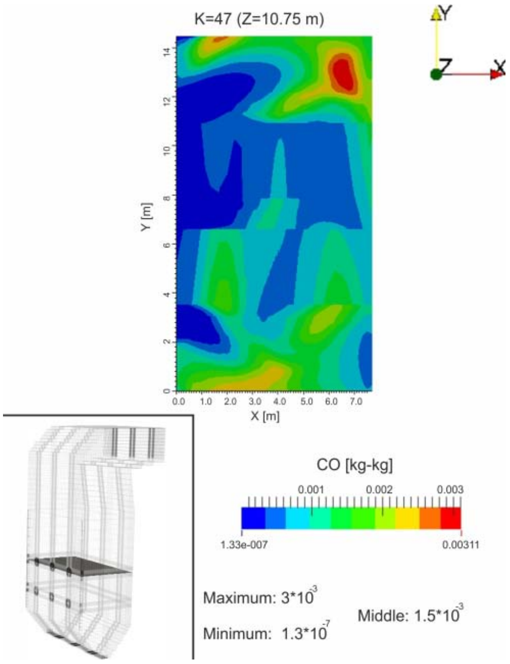


Fig.22 The distribution of CO concentration at the upper burner (z = 10.75 m) of the combustion chamber of the boiler BKZ-420

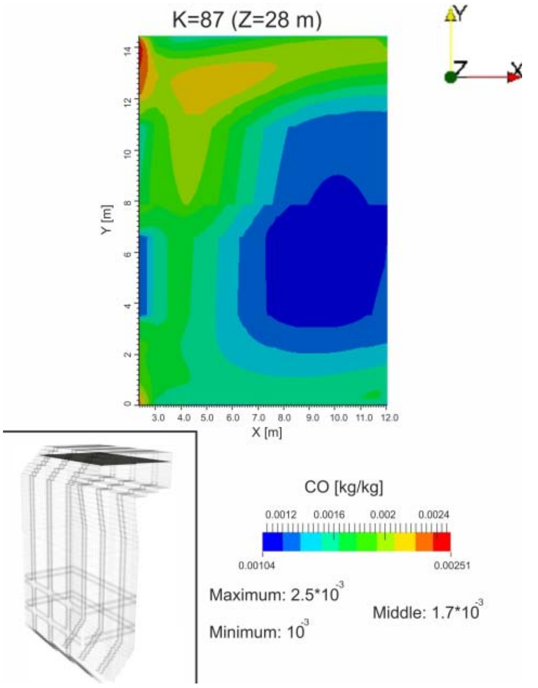


Fig.23 The distribution of CO concentration at the outlet (z = 28 m) from the furnace combustion boiler BKZ-420

Analysis of figures 21-23 shows that the maximum carbon monoxide CO takes $3 \cdot 10^{-3}$ kg/kg. In the field of burner CO concentration is set to equal $1.7 \cdot 10^{-3}$ kg/kg. As we move toward the exit of the combustion chamber CO concentration falls, since that decreases the concentration of carbon and oxygen, meaning it here $1.5 \cdot 10^{-3}$ kg/kg, and through a chemical reaction of CO reacts with oxygen oxidizes and forms CO2.

4 Conclusion

Results obtained by means of computer modelling of gas flows behaviour, velocity fields due to combustion, radiation and convective heat transfer and the pollutant formation and destruction in furnace of real boiler BKZ-420 can be used to predict main characteristic of combustion process and to provide recommendations for effective boiler performance. Results from CFD simulation can be useful for engineers to choose an appropriate boiler performance for successful furnace and overall combustion process optimization [18]-[19].

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