The simulation with the Finite Element Method of the velocity and temperature fields for a nonturbionar jet burner of 35MW feeding with pulverized coal

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Abstract: This paper presents the analysis of coal particle combustion in nonturbionar jet burner of 35MW used the Finite Element Method made with aid of the FLUENT programme.The pulverized coal combustion simulation involves modeling a continuous gas phase flow field and its interaction with a discrete phase. The particles traveling through the gas, will devolatilize and undergro char combustion creating a source of fuel for reaction in the gas phase.

Key-Words: coal-air mixture, combustion, nonturbionar jet, injection coal., Finite Element Method, FLUENT.

1 Introduction

In this paper is presented the results obtained with aid of the element finite method, concerning the variation of the values fields of physical sizes involving in the burning proces of nonturbionar burner with coal and black oil for 35MW, with long flame, in case of exclusive work with coal.

The constructive sizes of the burner is given in Fig.1 and the aerodynamic characteristics on Table 1, [14]. These were established as result of colaboration between T.K.T.I. company and the Boilers Factory from Taganorog (Russia)

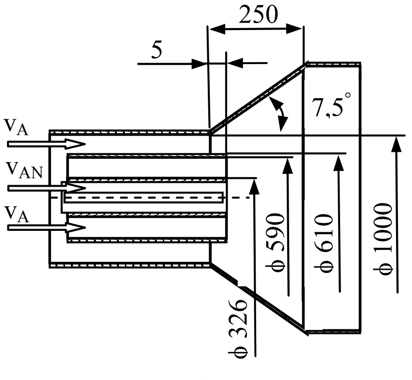

Fig.1

Table 1.

v_{AP}	m/s	20
v_{AS}	m/s	30,3
T_{AS}, T_{AP}	°K	645

In Table 1 are put note with v_{AP}, the velocity of the primary mixture (air and coal); v_{AS}, the velocity of the secondary air; T_{AP}, T_{AS}, the temperature of the primary mixture and the temperature of the secondary air.

The flow regime of mixture fuel is turbulent accompaning simultaneous from the internal and external recirculations. The internal recirculation is strong influencing by the central pipe and the external recirculation by the conical shape of external pipe of burner (made with $\alpha = 7.5°$) Fig.1.

Into the central pipe is finding the ignition device and the injector of black oil.

If we used the black oil, through this pipe is made the injection of air with $v_{AN} \neq 0$.

2 The analysis using F.E.M.

Because the flow through the burner is made with axial symmetry, the model of study is plane (the section from Fig.2). The modei is made with aid of the Gambit 2.2.30 programme, [20].

The element finite analysis is achieving with the Fluent 6.2.16. programme, [19].

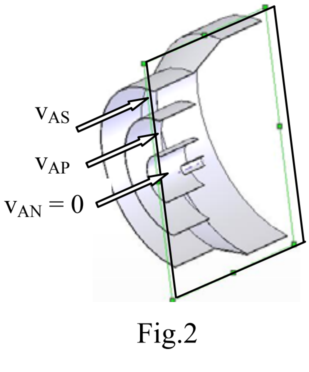

Fig.2

The simulation concerning the combustion of the pulverized coal dust from the injection with a flow volume of Q_{coal} =5,68 kg/s into a flow current of air from primary mixture.

The fuel considered on simulation consists from the following elements 64% char, 28% volatiles and 8% ash.

The inner wall of burning chamber have a temperature equal with T_p = 1100°K and the length L = 10000 mm. The gas resulting from burning procss of fuel is send directly to atmosphere.

The mathematical models used in analysis by the Fluent programme are: Solver (Segregaded), Energy, Viscous (" k-ε "), Radiation (P1), Model, Species Transports & Reactions (Non-Premixed Combustion), Discrete Phase and Injections, [19].

In Fig.3 to Fig.6 are given the distribution of fields for pressure (p), velocity (v), temperature (T) and density (ρ) of the combustible mixture finding into the furnace of burning installation.

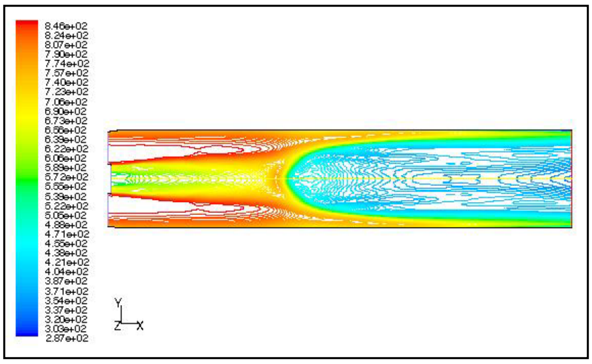

Fig.3

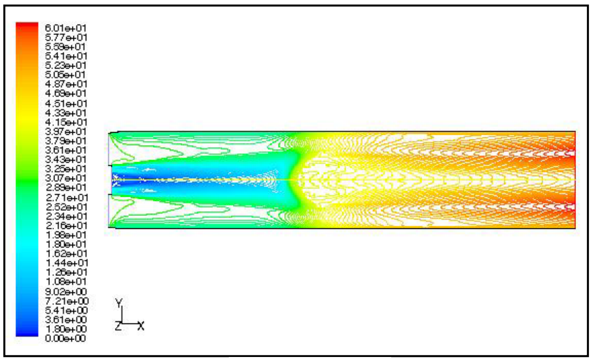

Fig.4

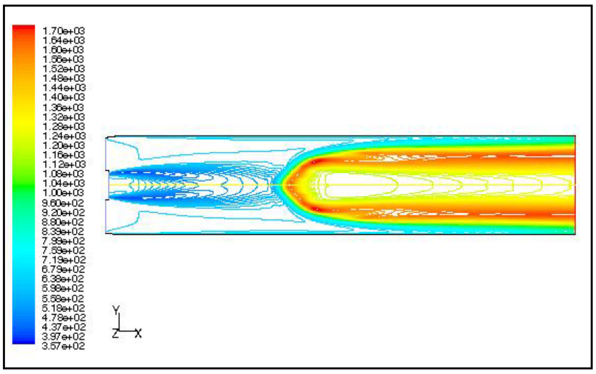

Fig.5

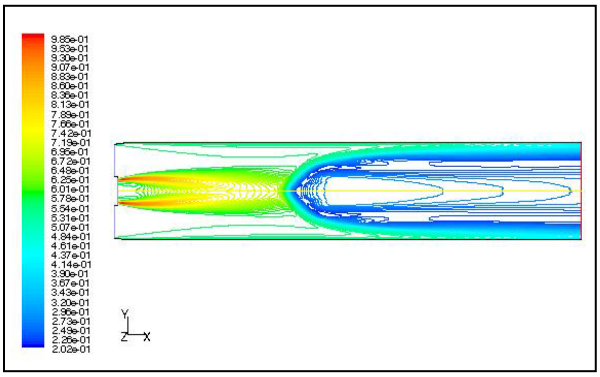

Fig.6

Also the analysis have in view the study of variation for p, v, T and ρ on the surface of the interior wall of burning chamber on direction of the symmetry axis of furnace and on the output cross section of the burning installation.

The medium and the maximum values of pressure, density, total temperature and velocity computed on the interior wall and on the symmetry axis are given in Table 2.

Table 2

interior wall		
size	medium	maximum
p [N/m^2]	538,63	707,89
ρ [Kg/m^3]	0,4643	0,5608
v [m/s]	0	0
T [K]	761,60	901,29
symmetry axis		
p [N/m^2]	472,86	759,54
ρ [Kg/m^3]	0,4126	0,7217
v [m/s]	29,98	50,75
T [K]	958,98	1627,41

The plots of variations for the sizes pressure, magnitude velocity, total temperature and density, on the furnace axis are made with a continue line.

Same sizes but for the interior wall of burner are made with a discontinue line Fig.7 to Fig.10.

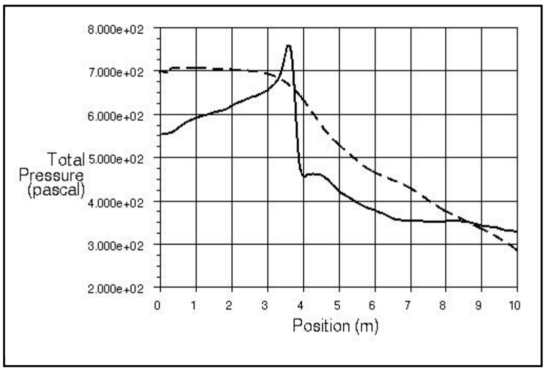

Fig. 7

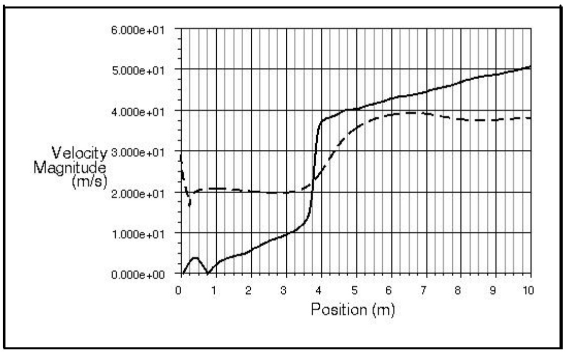

Fig. 8

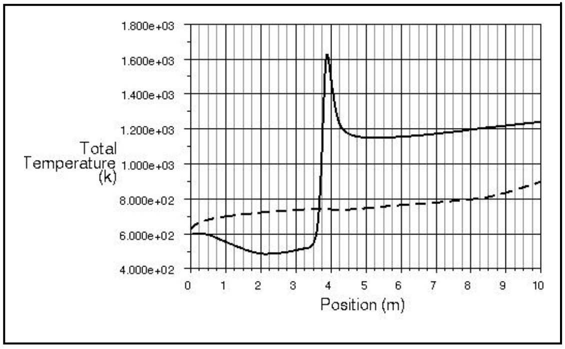

Fig. 9

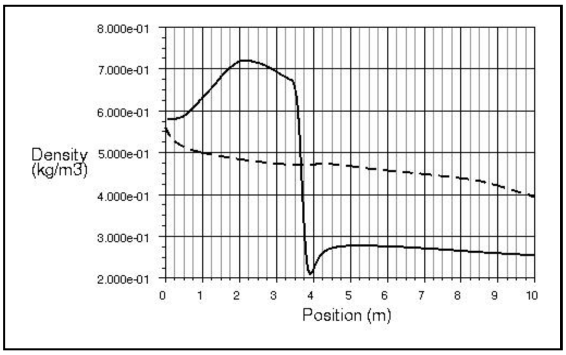

Fig. 10

For the output section the same sizes given for the interior wall p, v, T and ρ, are ploted in Fig.11 to Fig.14.

The medium value and maximum value for same sizes are given in Table 3.

Table 3

size	u.m.	output section	
	value	medium	maximum
p	[N/m^2]	398,34	579,22
ρ	[Kg/m^3	0,26841	0,4199
v	[m/s]	54,633	60,116
T	[K]	1311,29	1652,55

It's interesting to present the evolution in time of the parameters which characterize the combustible particles of coal in their traveling into furnance on the flow trajectorys.

These are the residence time, diameter, density, mass, velocity and temperature of particles.

The results of the simulation with the finite element methode are ploted in Fig.15 to Fig.20.

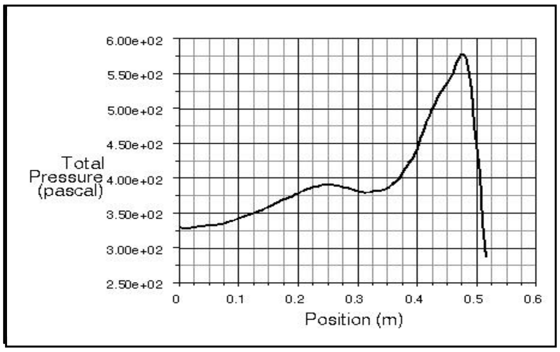

Fig. 11

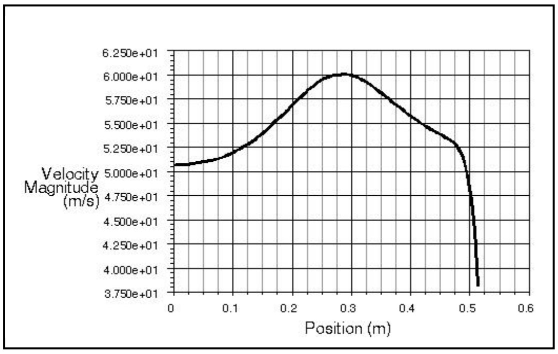

Fig. 12

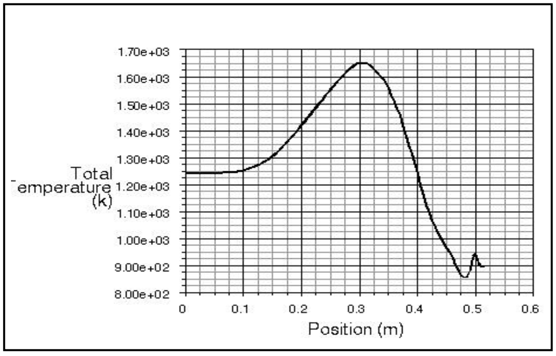

Fig. 13

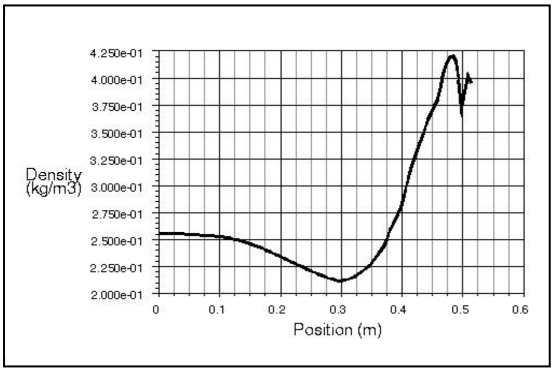

Fig. 14

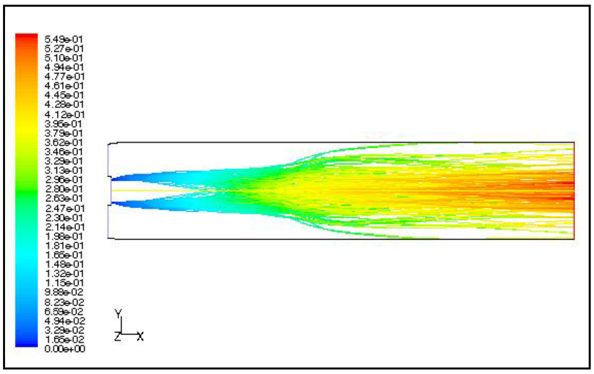

Fig. 15

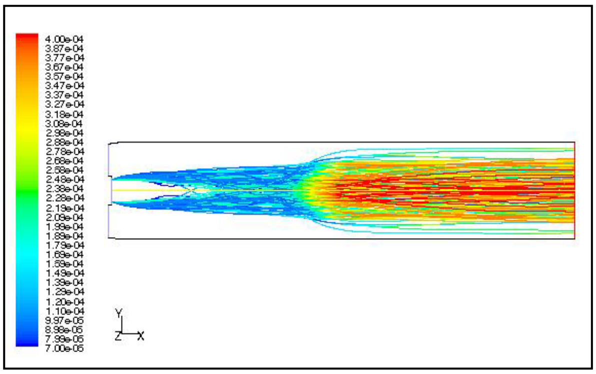

Fig. 16

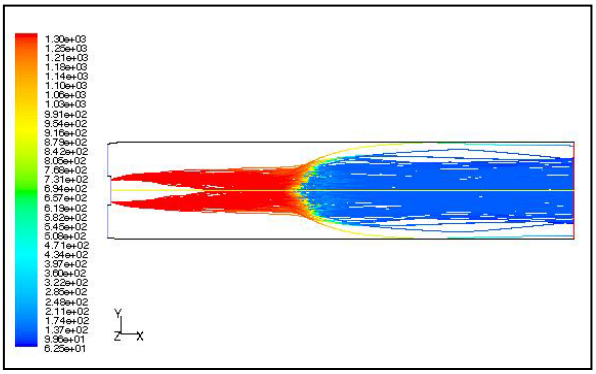

Fig. 17

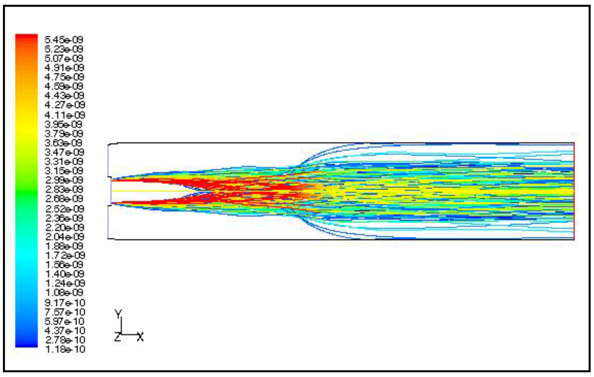

Fig. 18

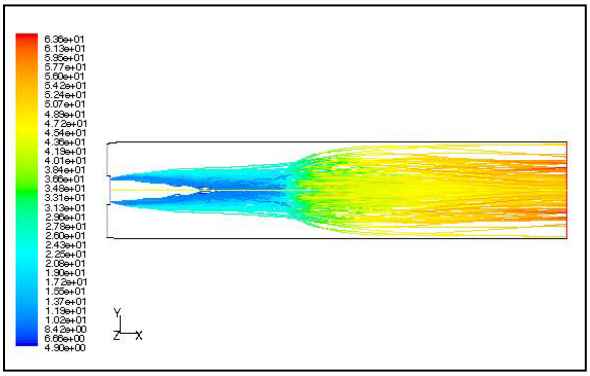

Fig. 19

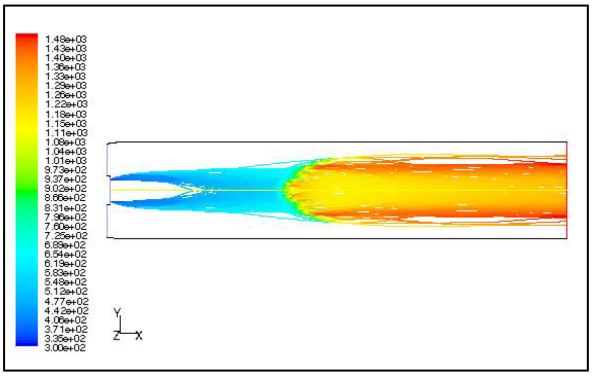

Fig. 20

3 Conclusion

The analysis with the finit element method made evident the turbulent character of flow for fuel into the furnance.

In proximity of the symmetry axis and on the exterior surface of jet become visibile the recirculation zones (both internal and external) with a velocity equal with (0,25 .. 0,4)·v_{AP}. Between these zones is developing the main motion, Fig.4.

The internal recirculation zone have the maximum width placed to distance (0,7÷ 0,80)·D_a in front of burner and the length of penetration of jet is approximate equal to 1,85D_a. With D_a, is put note the maximum diameter of burner.

In same time it has been ascertained a high stability of burning process base on a high field of temperature, Fig.5 and Fig.20.

In the first phase is made a premixture of dust coal with enough air with scope to burning the volatiles materials of coal and then the stability process of burning is provide by the supply of heat of burnt gas cycling into the flame, Fig. 4 and Fig.5.

In referince to burning evolution the analysis point out the existence of three zones along the furnance axis:

- the first zone (zone I) with a length equal with $\Delta L_I \approx 30\%$ L, where L = 10000 mm;
- the second zone (zone II), with a small length equal with $\Delta L_{II} \approx 10\%$ L;

- the third zone (zone III), with large length equal with $\Delta L_I \approx 70\%$ L;

The following observations made referinces to: for p (to Fig.3 and Fig.7); for v (to Fig.4 and Fig.8); for T (to Fig.5 and Fig.9); for ρ (to Fig.6 and Fig.10). The first zone is characterize for a slow evolution of burning process with a great turbulent intensity and moderate temperature.

The physical size: T, p and v have moderate gradients of increasing.

In the second zone because of the hight value of turbulent intensity, releasing an intense burning, the flame filling approximate 80% from section of jet, appears the large gradients of variation for sizes T, p, v, (which increasing) and for ρ (which decreasing). In this zone are the maximum value of T, p, v and the minimum value of ρ, see Table 2.

In the third zone, the burning process filling approximate in totality the section of jet.

Appears the moderate gradients of variation to p and ρ (which increasing) and to v and T (which decreasing). The variations of sizes p, v, T and ρ on symmetry axis are more bigger then their evolution on the interior wall of furnace.

With reference to evolution of the p, v, T and ρ on the output section of burning installation, from this point the observations make referinces to: for p to fig.11; for v to fig.12; for T to fig.13 and for ρ to fig.14.

In this case the analysis with the finite element method point out the existence of three zones:

- the fourth zone (zone IV), on vicinity of the symmetry axes with thickness equal to $\Delta h \approx 68\%$ R, where R = 515mm;
- the fifth zone (zone V, an intermediate zone) with thickness equal to $\Delta h \approx 14\%$ R;
- the sixth zone (zone VI), on vecinity of the furnace wall, with thickness equal to $\Delta h \approx 18\%$ R;

In the fourth zone with increasing the radius R, all the sizes p, v, T and ρ have a continuous evolution increasing finishing to the maximum value at R = 300 mm.

In the fifth zone, with the increasing of radius, the sizes v and T decreasing but p and ρ increasing.

In the last zone, adjacent to the wall, appear the maximum values of p and ρ and the minimum value of T. These values are given in Table 3.

Referring to parameters which characterize the coal particles injected into furnace in their motion on the trajectorys.

The next observations make referinces to residence time t_r to Fig.15; diameter φ to Fig.16; density ρ to Fig.17; mass m to Fig.18; velocity v to Fig.19 and temperature T to Fig.20.

In the first zone the particles have a small value for t_r and φ and large the values for ρ. The sizes T and v are small.

In the second zone arriving the particles with medium value of t_r , φ and ρ. The sizes T and v are in continuous increasing.

In the third zone arriving only particles with large values of t_r and φ. Also in this zone the v and T have large values.

In conclusion the analysis with the finite element method presents in mode detalied the informations from interior of furnace concerning the variation of physical sizes involving in burning process as pressure, velocity, temperature and density, which can be used to estimate the efficiency of burner.

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