ANNALS OF THE FACULTY OF ENGINEERING HUNEDOARA
2005, Tome III, Fascicole 1

SOME ASPECTS REGARDING THE AIR QUALITY IN PETROSANI AREA

BOCIAT Maria Adriana, CIOLEA Daniela Ionela

UNIVERSITY OF PETROSANI,
ROMANIA

ABSTRACT

The dual relation between the environment protection and the economic development must create that equilibrium which can allow the accomplishment of the objectives for a sustainable development. The sustainable development of the human society needs to keep under control the effect of the anthropic activities on the environment, which leads to the necessity of environmental monitoring and assessment.

The ampleness and the danger of the pollutants emissions in the air can be explained through the fact that the smoke emission takes place at low height, so their dispersion is very reduced, and on the other hand, through the high content in heavy hydrocarbons and tars.

On ecologic point of view, the danger of atmosphere pollution has two aspects:

- *one direct, connected to the atmosphere composition which can suffer alterations;*
- *the other, indirect, connected to the „vehicle" role played by the atmosphere in the rapid transport of lots of harmful agents.*

The models used currently in Romania for the pollutants concentrations calculation are that based on the gaussian solutions for the diffusion equation.

KEYWORDS:

mathematical model, pollutant's emission, fossil combustibles, emission factors

1. THE ESTABLISHING OF A MATHEMATICAL MODEL FOR THE CALCULATION OF THE POLLUTANT'S EMISSION

In the first faze, was analyzed the dependence of the emission and imission of pollutants at the burn of the fossil combustible, specific to the burning process, like: the quality of the combustibles, the burning conditions, as well as the parameters concerning the environment, like the wind speed, atmospheric conditions, atmospheric pressure, dispersion quotient. From this analysis, was concluded which are the most relevant processes and factors for the description of the pollutants emission and imission, as well as the principal equations from the environment's thermo-fluidic-dynamics, which must be used in the mathematical modeling of the pollutants' emission and imission. From this study also resulted that the theory of the limit stratum from the fluids mechanics has an important role in the modeling of the pollutants' emissions on the smoke chimney, the differentiated equations from the theory of the limit stratum being the base of other, more simplified, models.

There are two approach methods: starting from the specific chemical reactions or starting from the emission factors [1] the emissions of pollutants in the atmosphere through the burning of fossil combustibles can be calculated.

Starting from the chemical reactions:

a) the carbon dioxide

The burning equation: $C + O_2 \rightarrow CO_2$

We note:

x – the quota from the carbon burned as carbon byoxide;

k – the report between the molecular mass of the CO_2 and the atomic mass of the carbon, which is the stoichiometric quotient (k=[12+(16*2)]/12=44/12=11/3);

a – the quantity (in kg.) of used coal is obtained from the product of the elementary analysis (%) of the coal (c);

q – the quantity (in kg) of coal used in a house.

This way, a = q[kg]*c[%], results: x= k*a.

Kipping in mind that we speak about the coal burning in stoves (for warming and cooking), we consider an incomplete burn and we take the rapport of 7:3, which is 70% CO_2 , 30% CO.

b) the sulfur dioxide

The burning equation: $S + O_2 \rightarrow SO_2$

We note:

x - the quota from the sulfur burned as sulfur dioxide;

k – the report between the molecular mass of the CO_2 and the atomic mass of the sulfur, which is the stoichiometric quotient (k=[32+(16*2)]/32=64/32=2);

a – the quantity (in kg.) of used coal is obtained from the product of the elementary analysis (%) of the coal (c);

q – the quantity (in kg) of coal used in a house.

This way, a = q[kg]*c[%], results: x= k*a.

c) the azote dioxide

The burning equation: $N + O_2 \rightarrow NO_2$

We note:

x – the quota from the azote burned as azote dioxide; k – the stoichiometric quotient of NO_2 (k=[14+(16*2)]/14=46/14=23/7); a – the quantity (in kg.) of used coal is obtained from the product of the elementary analysis (%) of the coal (c); q – the quantity (in kg) of coal used in a house.

This way, a = q[kg]*c[%], results: x= k*a.

Starting from the emission factors:

The emission (the quantity of pollutant exhausted in the atmosphere) is determined from the relation:

$$E = B*H_i^i*e \text{ [kg]}$$

where:

E – the quantity of pollutant exhausted in the atmosphere in a certain period of time, in kg; B – the quantity of combustible consumed in that same period, in kg; H_I^I – the calorifical inferior power of the initial combustible, in kJ/kg;

e – the emission factor, in kg/kJ, (represents the quantity of pollutant exhausted in the atmosphere, reported at the unit of heat produced at the same time as the combustible in the boiler) [1].

a) the CO_2 pollutant

The emission factor at CO2, for the coal combustible, adopted in all countries from the European Union is: $E = 98*10^{-6}$ kJ/kg , results:

$$E_{CO2} = B*H_i^i * e_{CO2} \text{ [kg]}.$$

Speaking about a thermal power station supplied with coal, and the burning performance being huge, we'll take a rapport of 9:1, (which means 90%CO_2 and 10%CO).

b) the SO_2 pollutant

The emission factor for the SO_2: $e_{SO2} = 1.77*10^{-6}$ kJ/kg, results:

$$E_{SO2} = B*H_i^i * e_{SO2} \text{ [kg]}.$$

c) the NO_2 pollutant

The emission factor for the NO_2, for the coal combustible, is:

$e_{NOx} = 2.2*10^{-6}$ kg/kJ, results: $E_{NO2} = B*H_i^i * e_{NO2}$ [kg].

TABEL 1: THE EMISSIONS OF POLLUTANTS (CO_2,SO_2,NO_2,CO) IN THE ATMOSPHERE THROUGH THE BURNING OF FOSSIL COMBUSTIBLES FOR 1 DAY, FOR B kg/home-coal.

E [kg]	B [kg]				e_P [kg/kJ]	H_i^i [kJ/kg]
	1	10	20	30		
E_{CO2}	1.5876	15.876	31.752	47.628	$98*10^{-6}$	
E_{SO2}	0.0318	0.318	0.637	0.956	$1.77*10^{-6}$	
E_{NO2}	0.0396	0.396	0.792	1.188	$2.2*10^{-6}$	
E_{CO}	0.1764	1.764	3.528	5.292		

2. THE ESTABLISHING OF A MATHEMATICAL MODEL FOR THE CALCULATION OF THE POLLUTANT'S IMISSION

After the model for the calculation of the pollutants' emissions was determined, was continued, according to the research plan, with the development of a mathematical model for the description of the pollutants dispersion in the atmosphere (imission), using the simplified eulerian model (Gauß) for the specified conditions for the considered region.

The value of the concentration for one pollutant (CO_2, SO_2, NO_2, CO) produced by a punctual momentary and continuous source, linear source or area source, having the height *h*, is given by the equation:

$$c_i(x, y, z) = \frac{Q}{2 \cdot \pi \cdot \bar{u} \cdot \sigma_y \cdot \sigma_z} \cdot e^{-\frac{y^2}{2\sigma_y^2}} \cdot \left(e^{-\frac{(z-h)^2}{2\sigma_z^2}} + e^{-\frac{(z+h)^2}{2\sigma_z^2}} \right)$$

where:

c_i – the noxe concentration (kg/m^3); Q – the emission of the pollution source (kg/s); h – the height of the source (m); u – the medium wind speed (m/s); σ_y , σ_z - diffusion parameters which are determined according to the distance x.

For the pollution sources in the Valley of the Jiu, we determine the value of the pollutants' concentration (CO_2, SO_2, NO_2, CO), from the relation:

$$c_i = \frac{10^6}{3600 \cdot 24 \cdot 2 \cdot \pi} \cdot \frac{Q_i}{\bar{u} \cdot \sigma_y \cdot \sigma_z} \cdot e^{-\frac{y^2}{2\sigma_y^2}} \cdot \left(e^{-\frac{(z-h)^2}{2\sigma_z^2}} + e^{-\frac{(z+h)^2}{2\sigma_z^2}} \right)$$

where:
c_i – the noxe concentration (mg/m ^{3});
Q_i – the emission of the pollution source (E – the total emission of the pollutant "i") (mg/s);
i - CO_2, SO_2, NO_2, CO;
h – the effective height of the source (the height of the smoke chimney) (m);
u – the medium speed of the wind (chosen on the predominant speed direction) (m/s);
σ_y , σ_z diffusion parameters, which are determined according to the distance x (m), [2], [3].

TABEL 2: THE POLLUTANTS DISPERSION IN THE ATMOSPHERE (EMISSION) (I.E. FOR THE COLONIE AREA)

Nr. crt.	x [m]	c [mg/m^3]			
		CO_2	CO	SO_2	NO_2
1	200	12.75	5.235	0.276	0. 260
2	300	6.03	2.574	0.137	0.127
3	400	6.03	1.558	0.085	0.077
4	500	2.6	1.083	0.056	0.054
5	600	1.83	0.768	0.041	0.038
6	700	1.39	0.587	0.031	0. 029
7	800	1.09	0.465	0.025	0.023
8	900	0.89	0.378	0.019	0.019
9	1000	0.73	0.315	0.018	0.016

3. CONCLUSION

- The mathematical model for the pollutants' emission calculation, as a result of the burning processes in the industrial and home activities is one based on the quantity of the fossil combustible burned in an hour and which considers medium content pollutant chemical substances from the fossil combustibles.
- There are two approach methods: starting from the specific chemical reactions or starting from the emission factors.
- Leaving from the emission factors, were obtained the results from the emission and emission factors tables. The difference comes because of the fact that the burning of the coal in the fireplaces is not so efficient as the burning in a thermo-central, where the burning is better; in the thermo-centrals was take the report of 9:1, having the 2,6% percent to the 7:3, which is the case of the home users.

4. REFERENCES:

[1.] Ioana Ionel, C. Ungureanu: *Termoenergetica şi mediul*, Editura Tehnică, Bucureşti, 1996

[2.] I.C.Tulbure: *Zustandsbeschreibung und Dynamic umweltrelevanter Systeme, Papierflieger, Nr. 25, Clausthal – Zellerfeld,* (Metode de modelare a stării şi dinamicii sistemelor de mediu, Teză de doctorat, U.T. Clausthal), 1997

[3.] I.C.Tulbure: *Curs de ingineria mediului*, U.T. Clausthal, Litografia ITM, 2002