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STUDY OF POLLUTANTS DISPERSION RESULTING FROM LIGNITE COMBUSTION IN POWER GENERATION

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ABSTRAC: The mitigation of power plants impact on environment generated through combustion of coal involves reducing pollutants emissions CO_2; SO_2, NO_x, airborne ash. The study of pollutants dispersion allows identifying of the areas affected by pollutants emissions as well as the areas in which concentrations of pollutants are beyond the legal limits.

ИЗСЛЕДВАНЕ РАЗПРОСТРАНЕНИЕТО НА ЗАМЪРСИТЕЛИ НА ОКОЛНАТА СРЕДА, ПОСЛЕДИЦА ОТ ИЗГАРЯНЕТО НА ЛИГНИТНИ ВЪГЛИЩА ПРИ ПРОИЗВОДСТВОТО НА ЕЛЕКТРОЕНЕРГИЯ

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РЕЗЮМЕ: Смекчаване опасното влияние на енергийните заводи върху околната среда от вредни емисии, причинени при изгарянето на въглищата включва намаляване на замърсяващи околната среда емисии: CO_2; SO_2, NO_x, пепели, носещи се във въздуха. Изследването позволяват да се установят засегнатите райони от замърсяващи въздуха емисии, както и районите, в които концентрацията на замърсяванията на въздуха от вредни емисии надвишава допустимите стойности.

Modelling of pollutants dispersion

The necessity of reducing atmosphere pollutions led the government institutions to issue air quality standards, which establish the values of average concentrations of pollutants, sampled over a precise interval of time – values which should not be exceeded.

The sampling interval is an important factor that must be considered when a pollutants control strategy is implemented; it must consider the fundamental mechanisms of transport and atmospheric dispersion.

The most important parameter which determines the transport, diffusion and dispersion of the pollutants is the general condition of the weather, or, in other words, the climate. The climate is characterized by physical properties of the air (temperature, density, temperature gradient) and pressure distribution, which determines the velocity and the direction of the wind.

These parameters influence the transport and distribution of the pollutants to different degrees. For example, at high values of wind velocity, one would expect the pollutants to be borne at high distances but the high velocity of wind enhances the internal turbulence of the effluent and intensifies the dispersion.

On the other hand, at low values of wind velocity, the effluent remains relatively compact, the height of the effluent is large and the dispersion is reduced, therefore the concentration of the pollutants it is likely to be higher than in the case of large values of wind velocity.

There are also complex feed-back mechanisms: the atmospheric turbulence depends on the air properties and especially on the temperature gradient; the temperature gradient determine the direction and the velocity of the wind velocity, the distribution of nebulosity and the level of nebulosity determines the extent to which solar radiation modifies the temperature gradient. The level of nebulosity determines the intensity of chemical reactions between various components of the atmosphere.

All these factors make difficult to develop a determinist model for the dispersion and the transport of the pollutants (an a priori computing strategy of the pollutants concentration in various points in space). Most models rely on simplifying assumptions, measured values and statistical theories.

The main problem that must be solved in the case of pollutant emissions is on the one hand the mitigation of their harmful potential and the amount emitted in the atmosphere and on the other hand to ensure the emission conditions in the atmosphere so that when the effluent comes back to soil its concentration remain below the values admitted. This last aspect involves the interaction of three factors: the recipient, the effluent and the emission conditions.

The transport and dispersion of the pollutants takes place in the atmospheric boundary layer, between 500 and 1000 m above the soil.

The values of various parameters which influence the turbulent movement in the atmosphere are not precisely known, on the one hand due to the difficulties and errors in their measurement and on the other hand due to their fast and random fluctuations.

The effluent consists of a mixture of solid, liquid and gaseous particles. Among gases, the sulfur, nitrogen and carbon compounds occur most frequently (SO_2, SO_3, NO, NO_2, CO). The presence in the effluent of more compounds in different phases makes difficult to dete mine the exact composition of the effluent and on the other hand makes possible for various chemical reactions subsequent to the emission to occur. Such chemical reactions introduce in the complete description of the effluent a supplementary number of chemical and physical variables.

The emission conditions are not generally speaking problematic since they are known for nominal regime of the installation. The emission conditions involve the geometrical characteristics of the chimney stack, the relief, the presence of natural or artificial obstacles in the vicinity of the source and the parameters of the effluent (temperature, velocity, composition).

The experimental installation

Fo the study of pollutants dispersion resulting from lignite combustion at Rovinari power plant the numerical modeling program ISC 3 View (Industrial Source Complex, version 3, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, S.U.A.). The model was developed on the basis of classic formulae of Gaussian dispersion described by Pasquill (The estimation of dispersion of windborne material, *Meteorological Magazine*).

Steady state conditions:

- emission is continuous and uniform
- the horizontal field of wind velocities is homogenous;
- no friction in vertical plane

The characteristics of the pollutant:

- the gas or the particulate are small enough so that the effect of gravity can be neglected;
- no chemical reactions
- total reflexion at the ground.

ISC3 is the latest version of ISC (Industrial Sources Complex). The models were evolutive in the sense of improving the user friendliness and easiness of introducing the input data concerning the spatial distribution of sources and meteorological data.

The program offer answers to the most frequent impact analysis for any type of source (stationary of mobile) any height and for any origin (industry, combustion installations, ventilation, intersections, parkings), for any size and for any location.

Through the options they offer the programs can compute average values for 30 minutes, daily, annual or over a prescribed interval of time.

The more representative the input data are, the more veridical conclusions. Regarding the emission concentrations (input data of the source) the online measurement method is recommended, under representative duration conditions or statistical processing of data, using the so called emission factors.

The dispersion model ISCST3 represents a steady state Gaussian model that can determine the concentrations of pollutants generated by a large number of sources. A few modeling capabilities of ISCST3 are:

1. Modeling of atmospheric dispersion of a large number of pollutants
2. The program can take into account a large number of punctual, surface or volume sources
3. The pollutants flow rates can be considered constant or variable over an hour, month or a season. These emission factors can be defined for one or for more sources
4. The positions of the receiving points can be defined in Cartesian or polar coordinates.
5. Complex topography terrains modeling
6. The program uses real meteorological data that determine the impact on atmospheric pollution.

Compared to the previous versions the program *ISC3 View* uses a new interface for the ISCST3 model. This interface was developed especially for operating system Microsoft Windows and operates as well under Windows 95, Windows NT, and Windows for Workgroups

The interface *ISC3 View* uses five different menus for defining the input data file for the model ISCST3:

1. Control menu (CO), which specifies a modeling scenario.
2. Sources menu (SO), which specifies the pollutants emissions;
3. The receivers menu (RE), which specifies the matrix of receivers
4. Meteorological conditions (ME), which specifies the meteorological data for the location considered
5. Complex terrain configuration (TE) – the option that takes into account the areas with complex topography
6. Output menu (OU), which specifies the output data for a complete analysis of impact on air

In the program ISC3 View each of the six options is represented by an icon (figure 1), which in its turn opens the first window of the menu. The rest of the options are specified in the lower corner of each window.

The program ISC3 View allows modeling of a maximum number of 300 sources using a matrix with maximum 1200 receivers and a maximum number of four groups of sources.
At the end of the data input process the program is run after a check of the data introduces in the modeling scenarios in the window titled Project status (figure 3).

In the upper side of window are specified the input and output files and in the lower side a confirmation message is displayed.

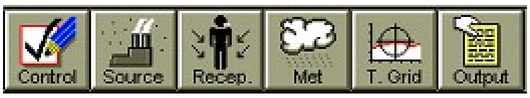


Fig. 1. General menus of ISC3

The check of the input data is achieved by a post processor ISC View Post that can draw the curves of equal concentration for the data defined in each scenario. The curves are drawn at the ground level taking into account the shape of the relief throughout the whole area analyzed. The parameter of the two-dimensional curves is the pollutant concentration.

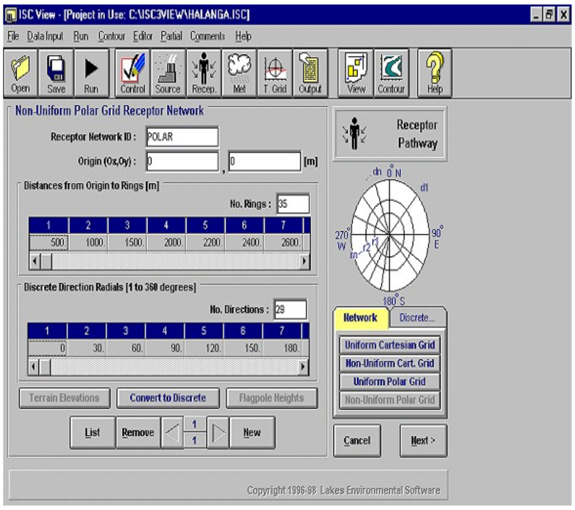


Fig. 2. The window for the receiver matrix

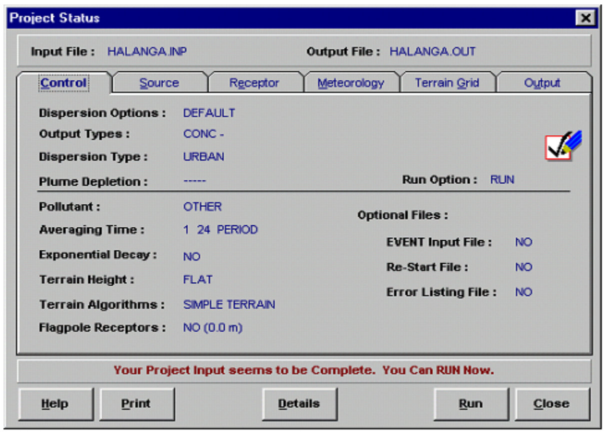


Fig. 3. The check window

Experimental results

In table 1 are presented the results of measurements carried out at Rovinari power plant in October 2005. The data was used for simulations with USC 3 View

Table 1. Results of measurements

Nr. crt.	Parameter	Symb	U.M.	Boiler C4 , chimney stack 2	Boilers C5;C6 , chimney stack 3
1	Temperature of flue gas at the chimney stack	t_{gc}	^0C	137	158
2	Height of the chimney stack	H_c	m	250	250
3	Diameter of the chimney stack	D_c	m	8	8
4	Velocity of flue gas	w_{gc}	m/s	16,4	14,1
5	Mass flow rate of carbon monoxide	M_{CO}	mg/s	9800	11230
6	Mass flow rate of nitrogen oxides	M_{NOx}	mg/s	143200	161400
7	Mass flow rate of sulfur oxides	M_{SO2}	mg/s	1030600	1222600
8	Mass flow rate of ash	m_p	mg/s	172900	71990

In table 2 are presented the values of concentrations measured at receivers, as evaluated by the simulation program (for carbon monoxide) as well as the limits specified by STAS 12574-87; in figures 4 and 5 are presented the hourly and daily average distributions of CO (expressed in □g/m^{3}N) generated by chimney stacks 2 and 3 at ground at 5 km distances measured from the center of the matrix.

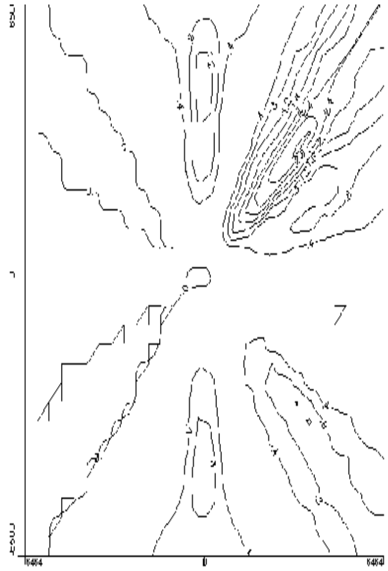
In table 3 are presented the hourly and daily distributions of nitrogen oxides (expressed in □g/m^{3}N) emitted by chimney stacks 2 and 3 at 5 km distances measured from the center of the matrix.

Table 2. Values of concentration measured at the receivers for carbon monoxide

$(CO_{max})_{30min}$	$(CO_{max})_{30min}$			$(CO_{max})_{24ore}$	$(CO_{max})_{24ore}$		
$(C_{max})_{STAS}$ [□g/m^3_N]	$C_{computed}$ [□g/m^3_N]	X [m]	Y [m]	$(C_{max})_{STAS}$ [□g/m^3_N]	$C_{computed}$ [□g/m^3_N]	X [m]	Y [m]
6000	3,41	2973	2676	2000	0,48	2973	2676

Table 3. Values of concentration measured at the receivers for nitrogen oxides

$(NOx_{max})_{30min}$	$(NOx_{max})_{30min}$			$(NOx_{max})_{24ore}$	$(NOx_{max})_{24ore}$		
$(C_{max})_{STAS}$ [□g/m^3_N]	$C_{computed}$ [□g/m^3_N]	X [m]	Y [m]	$(C_{max})_{STAS}$ [□g/m^3_N]	$C_{computed}$ [□g/m^3_N]	X [m]	Y [m]
300	24,97	0	3500	100	4,37	2973	2676



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Recc**Fig. 4. Hourly distribution of CO emitted by chimney stacks 2 and 3 at ground over distances of 5 km**

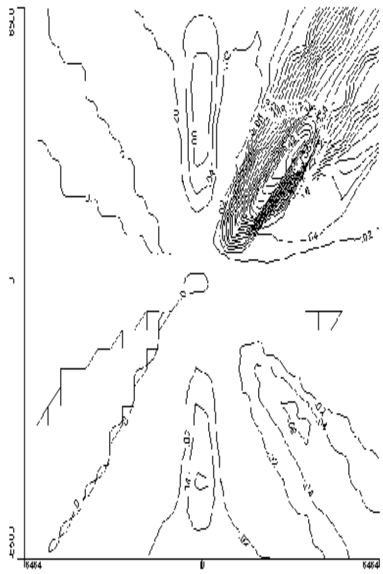

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Fig. 5. Daily distribution of CO emitted by chimney stacks 2 and 3 at ground over distances of 5 km