AN AUTOMATED AIR QUALITY CONTROL SYSTEM IN INDUSTRIAL ZONE OF PANCEVO

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INTRODUCTION

Pancevo is a large industrial center of oil, chemical and petrochemical industry in Serbia. Its industrial zone is only 20 km away from the center of Belgrade, the capital of Serbia and Montenegro. In the industrial zone of Pancevo, only 3.5 km from the center of the city there are three factories, which emit air pollutants (SO2, NOx, NH3, Cl, CO2…) to the atmosphere from 57 chimneys and vents of the physical heights in the range from 10 to150 meters and from numerous of undeclared small sources.

Industrial zone was hardly bombed for the several times in 1999. Atmosphere then was abnormally polluted; inhabitants felt it mostly with the help of its senses of sight and smell. Medical doctors now support such statements due to rise of number of patients with cancer at the territory of Pancevo in the last time, which they relate with air pollution as a consequence of bombing factories in industrial zone. From the point of view of air pollution protection, extremely negative moment was absence of any relevant quantitative information about the air pollution concentration during bombing and about local meteorological conditions, because there was not established appropriate air quality monitoring system at the territory of Pancevo and because there was not appropriate meteorological station in operation. Reason for that is bad federal and republic of Serbia legislative relating to the environmental protection, then very bad economic situation in the country before bombing and at the end relatively low level of ecological education of the employees and especially of the leaders of the factories.

Experiences from the period of bombing, with every day events of the worst chemical accidental scenarios and some peace time chemical accident at the territory of the city Pancevo, resulted in defining the project of the title:" Automation existed meteorological station established during bombing and realization of a fully automated system for continual air pollution control in routinely and accidentally situations".

Description of automated air quality system

Main goal of the project was establishing of an automated system for air quality assessment at the whole territory of municipal Pancevo, related to air pollutants emission from sources in factories of industrial zone of the city. In the industrial zone there are three factories: oil refinery, petrochemical complex and fertilizer factory. They emit air pollutants to the atmosphere as was mentioned, from chimneys, vents and numbers of undefined sources.
Central part of the system is PC located in control room in City Hall to which are connected automated meteorological station, three PCs from factories in industrial zone and one PC from municipal department of ecology.

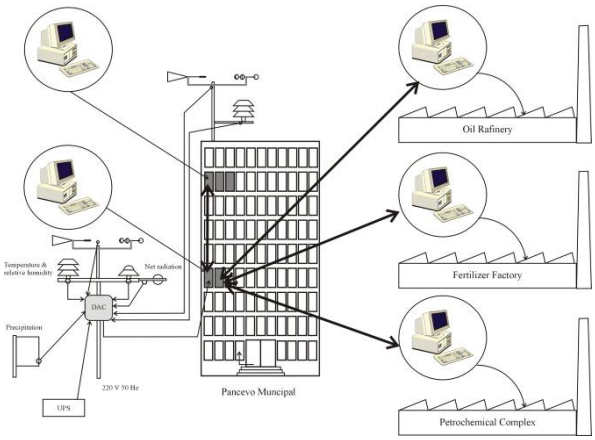

Fig. 1: Scheme of automated system in Pancevo

Central PC operates like server which processes meteorological data, saves and checks emission inventory of every factory and on dependence of type of air pollution emission runs accidental or routine atmospheric dispersion models. Task of local PCs is to inform central PC about changing in air pollutants emission from any source and to transfer all relevant data in the case of an accident.

Hardware

Through realization of the mentioned project meteorological measurements which support atmospheric dispersion models were fully automated, so that data from the sensors for wind speed and direction, one wind speed sensor, two air temperature sensors, global and net radiation sensor, air pressure and rain gage are getting in real time. The acquisition system of the meteorological station, capable of receiving sixteen analogue signals simultaneously, is controlled by a micro controller which packs received signals into a message and sends them using a direct connection to the central PC.

Software

Software is consisted of three parts: software for processing data coming from sensors and exchanging information between central and local PCs (system software), atmospheric dispersion software, graphical user interface (GUI).

The software developed for the System enables user to: receive data from data acquisition system which acquires data from meteorological sensors, memorize and display these data in numerical and graphical form, transfer these data to all factories, update the data related to the pollution sources, receive air pollution sources data located in factories, display dispersion of air pollution on the map of city or alternatively on the map of municipal territory, graphically display degree of air pollution with corresponding colors; clicking at some point user obtains numerical value of air pollution in that point, control performances of the entire automated system and especially state of the interconnections, display at the monitor and to print out air pollution fields for a specified date with appropriate meteorological conditions Software uses the Windows operating system enabling simple and easy communication with the System. Entire automated system behaves like LAN and it is based on the TCP/IP protocol.

Constitutive part of presented systems is software of atmospheric dispersion modeling based on the straight line Gaussian dispersion model for routine air pollutants release and puff dispersion model of the Gaussian type for instantaneous releases.

Diffusion equation for routine releases:

$$C(x,y,z)=\frac{Q}{2\pi\sigma_y\sigma_z u}\exp\left(-\frac{1}{2}\frac{y^2}{\sigma_y^2}\right)$$
$$\left\{\exp\left[-\frac{1}{2}\frac{(z-H)^2}{\sigma_z^2}\right]+\exp\left[-\frac{1}{2}\frac{(z+H)^2}{\sigma_z^2}\right]\right\} \quad (1)$$

Diffusion equation for instant releases:

$$C(x,y,z,t)=\frac{q}{\sqrt{(2\pi)^3}\sigma_x\sigma_y\sigma_z}\exp\left\{-\left[\frac{(x-ut)^2}{2\sigma_x^2}+\frac{y^2}{2\sigma_y^2}\right]\right\}$$
$$\times\left\{\exp\left[-\frac{(z-H)^2}{2\sigma_z^2}\right]+\exp\left[\frac{(z+H)^2}{2\sigma_z^2}\right]\right\} \quad (2)$$

where variables in both equations have usual meaning.

From wind speed data, solar radiation-day and net radiation-night or temperature vertical gradients stability is derived, which lead to the standard deviations of concentration distribution in accordance with some empirical set of σ curves.

Both models are constitutive part of the automated meteorological station that supplies them with appropriate meteorological data. Input source parameters are: time of integration, coordinates and height of the sources, its diameters, source strength (Q,q), temperature of pollutants and level above ground for concentration calculation, effective source/puff heights and appropriate physical dimensions of the sources. They can operate in the prognostic mode or in the diagnostic mode. Further, plume/puff rise and effective stack height are calculated using the Briggs model and wind power low, respectively. Models take into consideration topography, dry and wet deposition.

Operators in factories control rooms need as simple as possible tools for fast receiving information of air quality at the controlled territory. Task of GUI is to prepare such information. This software is user friendly with next communication options: basic window with minute's and ten minute's meteorological data in graphical and digital form (wind speed and direction, maximum, minimum and average values atmospheric pressure, relative humidity, global and balance radiation, air temperature at two levels, precipitation), graphical presentation of average hourly air pollution concentration in routine releases, chemical database, sources database, daily report of historical meteorological data, report of historical hourly air pollution concentration, review of realized accidents, simulation of hypothetical accidents, system working regime, fulfilling archive with missing data, instant alarm of current accident.

Input data
Automated meteorological station supply models with appropriate meteorological input data for generating wind fields and turbulence conditions in mixing layer.

Input data concerning air pollutants routine emission and characteristics of its sources are coming from the factories data bases, which originate from the project documentation and from the temporary, very rare control of chimneys gas emissions. Duty of every operator is to enter promptly any changing of emission characteristics. After establishing continual air pollution control in industrial hot spots in Serbia, in accordance with the newest environmental protection act of Serbia from the past year, air pollution emission data will directly enter the atmospheric dispersion models.

In accidental situations an operator enter location of an accident (clicking on the screen on the reported location of the accident), type of air pollutant, assessment of its released amount, height of the puff and its initial dimension.
If polluted clouds are invisible and previous scenario of the accident does not exist, this procedure may be unusable. To avoid such situations in this phase of the project two possibilities are opened:
operator defines only location of some accident and enters type of air pollutant, after that software prepares all the other input data
operator enter amount of air pollutant which send him operator on duty in section of a factory, and after that like previously software prepares all the other input data
In both cases operator closely describe accident, for example if in some tank there is only gas phase of air pollutant, gas and liquid phase or only liquid phase etc.

System output
Generally speaking there are two basic outputs from the system: numerical and graphical presentation of meteorological parameters and fields of air pollution distribution, dry and wet deposition also in digital and graphical form.

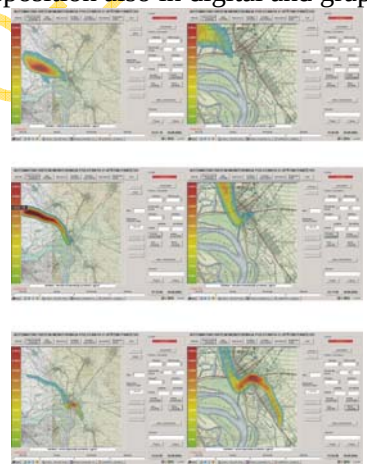

Fig.2. Two scale graphical presentation of air pollution, dry and wet deposition fields in an accidental situation

Conclusion
Output from this project is an automated air quality control system in industrial zone of Pancevo, which purpose is to give information to operators in control rooms of the factories, civil informing center of Pancevo and municipal department of environment in Pancevo for starting countermeasures. In agreement with subsequent requirements

of employees in mentioned institutions, lots of functions of the system are defined during realization of the project, more or less raised on the experiences during bombing.

Main next step in realization of the project is its harmonization with European praxis are validations of atmospheric dispersion models and procedures in air quality control.

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