THE AIR CONTAMINATION NEAR THE BUILDINGS AND THE VENTILATION EFFECTIVENESS

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The ventilation processes and systems of a building are carefully designed and built accordingly. However, indoor air quality is not always that it should be. The laboratory and field studies of ventilation design problems enable engineers to determine the correct location of the building air inlets and exhaust stacks. It is important for the ventilation and air conditioning systems to provide the indoor air quality standards with minimum energy needs.

There is no doubt that efficiency of ventilation, indoor air quality and air pollution in the vicinity of the buildings are closely connected. We believe that indoor and outdoor air of a building should be considered as a whole dynamic system (WDS) . Studying the interaction processes of indoor and outdoor air of a building within a whole dynamic system is possible by wind tunnel experiment with tracer-technique. It is true that the method of a system analysis may be used for optimization of the processes of heat-mass transfer within WDS. On account of that it is possible to limit an outdoor contamination penetrating in the building and energy consumption for ventilation systems. We assume, that such studies should be a basis for the development of scientific design principles of the ecological residential areas and "healthy" buildings.

The high levels of pollution in the vicinity of buildings are usually produced by low emissions. The flow near the buildings and their groups is very complex. In the immediate lee of building there is a "cavity" region where recirculation occurs, mean velocities are reduced and the air flow is highly turbulent. The flow in the building wake farther downstream is also characterized by a high turbulence and mean velocity deficit. The entrainment of plumes emitted from short stacks into the wake of buildings can result in maximum ground-level concentrations that are more significant than those found for similar sources in the absence of buildings.

The dispersion of the short stack plumes into a building wake is not uniform and strongly depends on the shape and arrangement of obstacles and the location of the sources. The maximum concentrations close to buildings are often more than average values [1,2]. It should be noted that the location of air inlets in the zone of maximum concentrations causes the unsatisfactory indoor air quality. To understand the details of the dispersion of low emissions within the "cavity" of buildings and their groups is very important for some practical problems. In particular, outlets should be located so that the emitted plume is likely to be drawn in by an inlet, the concentrations of the pollutants will accumulate to level which may cause harm to people's health. In addition, it is necessary to provide maximum dilution of exhaust gases and dispersion into the atmosphere with minimum re-entry into a building and minimum air pollution of adjacent areas. Dilution of these emissions with surrounding air along with the application of control devices is necessary in order to meet indoor and outdoor air quality standards. Besides the outdoor contamination penetrate into a building through natural ventilation and infiltration

To determine and analyse the indoor air quality it is important for the information about concentration fields near buildings to be accurate. Because the model studies in wind tunnel with the tracer-technique (^{85}Kr, SH_6) are considered as controllable and economical means for the detailed investigations of the processes of heat-mass transfer within WDS. Although experimental studies are very useful, there is a need for mathematical, empirical or combined models which can be used for solving these ventilation design problems. A large number of different numerical and empirical models for simulating the characteristics of plume released from point, line area or volume sources are known [3]. But some of them are based on the Gaussian plume models, which are only acceptable as the first approximation to estimating the outdoor concentrations close to buildings in zones of inlet location. More detailed investigations in wind tunnel or 3D modeling with advanced numerical models become necessary.

To study the above problems the wind tunnel investigations with ^{85}Kr [2], as a tracer, have been made. In the tests described here, the passive emission of ^{85}Kr in the different points of the wake has been realized. For all the points of the passive emission locations within the "cavity" not uniform distribution of concentrations has been obtained. The worst conditions for the case of wind blowing normal to the building length have been found. In the case of the gas emitted in the zone of horseshoe vortex, the strong asymmetry of the ^{85}Kr dispersion near the building models has been observed [2].

The stable zone of the "cavity" exists only for a limited range of wind directions. When wind direction yawed at the angle $\alpha > 20^0$, the "cavity" at the lee edge of building was not observed.

The results of the passive gas dispersion within the "cavity" may be used for estimating the indoor air quality. The coefficient of dilution $D_i = M/Ci$ (where C_i is the local concentration, M is the source strength) may be used for that aim. Three groups of sources: own building sources, interior sources within a building wake and exterior sources should be taken into account for the choice of the air inlet locations near an isolated building. It is necessary to reveal the minimum contamination zones near the building for all active sources. The zone pollution rate may be described by using an average coefficient of dilution D_m as follows:

$$D_m = \frac{\sum M_i / M}{\sum (M / M_i * Di)} \qquad (1)$$

where M is the strength of all sources; M is the strength of i- source, D_i is the coefficient of dilution of i- source.

Thus the maximum values D will define the most pure zone near a building in each case. It is expedient that the ventilation air inlets must be located in these zones. It is possible to estimate the effectiveness of ventilation systems using a parameter $\beta = L_{min} / D_m$, where L_{min} is minimum outdoor air volume needed to provide the indoor air quality standards, D_m is an average coefficient of dilution of the outdoor contamination near the building. The parameter β must be a minimum value.

REFERENCE

1. Yablonskiy K., Datsuik T. 1994. Dispersion of low emission near building and indoor climate, Proceedings of the International Conference on HVAC in Cold Climate'94, p. 134.
2. T.Dutsuik, K. Jablonskiy, U. Leonteva. Indoor air quality and toxic emissions in building wake. Proceedings of the 7th International Conference on Indoor Air Quality & Climate – Indoor Air '96, Vol.7, pp. 943-947.
3. Szepesi D.J. Compendium of Regulatory Air Quality Simulation Models. Akademiai Kiado, Budapest, 1989.