Consideration of the effect of flue gas emissions into the atmosphere when selecting construction sites

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Abstract. The influence of the district gas boilers emissions on the atmospheric air is studied. Prediction of the air pollution by determining concentrations along the length of the dispersion of smoke emissions will determine the degree of pollution in the existing buildings and the suitability of vacant land for construction near thermal enterprises. The proposals for the selection of sites for construction near thermal power plants have been developed.

1. Introduction

In order to provide the residents of the cities with hot water and heat, construction and subsequent operation of gas boiler houses, which are a complex of buildings equipped with equipment for burning natural gas and heating water supplied to the consumer, is carried out. However, the process of gas combustion is accompanied by the release of pollutants that adversely affect the quality of the natural environment, and in particular, atmospheric air.

The process of air pollution from the chimneys of district gas boilers goes through four stages: the formation of harmful substances, their emission, distribution and impact on objects [1-17].

2. Analysis of calculated parameters

One of the main harmful substances emitted into the atmosphere is nitrogen dioxide. To study the effect of smoke emissions on the air, the authors conducted studies on the length of the dispersion of smoke torches within a radius of 300 m from the emission sources. To determine the level of pollution of the surface layer of the atmosphere in the industrial and residential areas, 8 control points were set.

The research was conducted in theoretical and experimental ways [3-17].

3. Methodology

The theoretical method is based on the calculation of the dispersion of pollutants in the surface layer of the atmosphere [1-2] by means of software "Ecologist" (version 4.0) of firm "Integral". There are also the number of programs, including those certified in Russia. For example, in 2018, instead of OND-86 "Method of calculation of concentrations of harmful substances in the air contained in emissions of enterprises" [1], "Methods of calculation of dispersion of emissions of harmful (polluting) substances in the air" are introduced by the order of the Ministry of nature of Russia from 06.06.2017 № 273 [2].
The calculation of pollutants dispersion did not show exceeding the established hygienic standards of the maximum permissible concentrations of pollutants (MPC) in the surface layer of the atmosphere for any of the substances under consideration.

According to [2] in the presence of a large number of the same type point sources (boiler chimneys) at calculations of influence of the emitted substances in the atmosphere the combination of these sources into one is allowed. However, this method of calculation of dispersion does not take into account the imposition of flare emissions from heated sources, respectively, there is a probability of air pollution of residential areas [15-17].

Consider the conditions of dispersion of nitrogen dioxide emitted from 29 boilers with a total capacity of more than 200 Gcal, working on gaseous fuel in two cases: the allocation of harmful substances through 29 of chimneys and the emissions of nitrogen dioxide through one consolidated source. In the first case, the boundary of the sanitary protection zone is established from each source separately and then circled along the most distant points on a tangent; in the second one – from the border of the combined source. At the set parameters of boiler capacities, the size of the sanitary protection zone is 300 m [18]. Also, the South-West wind direction is set as the prevailing one.

**Figure 1.** SPZ boundary, the location of the control points and the calculation result of the dispersion of nitrogen dioxide with the emission of the 29-point sources
Figure 2. SPZ boundary, the location of the control points and the calculation result of the dispersion of nitrogen dioxide with the emission of the combined source of atmospheric pollution

Figure 3. SPZ boundary, the location of control points and the result of calculation of nitrogen dioxide dispersion at emission from two combined sources of atmospheric pollution under real operating conditions of gas boilers

When calculating the dispersion, the following parameters of the combined emission source are taken, according to [2]:

The maximum one-time emission of substance g/sec:

\[ M = M_1 + M_2 + \ldots + M_N, \]  

(1)

Source diameter, m:

\[ D = (D_1 + D_2 + \ldots + D_N)/N, \]  

(2)

where \( N \) – the number of the sources to combine.

The speed of the gas-air mixture, m/sec:
\[ v = (v_1 + v_2 + \ldots + v_N)/N. \] (3)

The temperature of the gas-air mixture, °C:
\[ T = (T_1 + T_2 + \ldots + T_N)/N. \] (4)

As can be seen from figures 1 and 2, the boundary of the sanitary protection zone has the same location under both conditions of construction and, accordingly, the same location of the control points, in each of which the concentration of nitrogen dioxide in fractions of MPC is determined.

It should be noted that the concentrations obtained in the first case are lower than in the second. It follows from this conclusion that the more accurately is taken into account the location of the sources of emission of pollutants, the more reliable are the required data.

The maximum total concentration of \( c_m \) of harmful substances from \( N \) closely located single point emission sources having the same values of height, diameter of the mouth, the rate of release into the air and the temperature of hot water is determined by the formula 5:
\[ c_m = A \cdot F \cdot m \cdot n \cdot \eta \cdot H \cdot \frac{N}{\sqrt{V \cdot \Delta T}}, \] (5)

where \( A \) – the coefficient depending on the temperature stratification of the atmosphere, which determines the conditions of horizontal and vertical dispersion of pollutants in the air (defined in accordance with [2]);

\( F \) - dimensionless coefficient taking into account the rate of sedimentation of pollutants (gases and aerosols, including solid particles) in the atmospheric air;

\( m \) and \( n \) - dimensionless coefficients taking into account the conditions of discharge from the mouth of the emission source;

\( \eta \) - dimensionless coefficient taking into account the influence of terrain (determined in accordance with [2]);

\( H \) - the height of the emission source, m;

\( V \) - hot water consumption, m\(^3\)/sec, determined in accordance with formula 6;
\[ V = \frac{\pi D^2}{4} \cdot v, \] (6)

\( \Delta T \) - the difference between the temperature of the emitted hot water \( T \) and the temperature of the air \( T_a \), °C.

**Table 1.** The results of the comparison of the calculated \( NO_2 \) concentrations in a variety of modes to calculate dispersion

| Point number | Calculated values concentrations | Calculated values concentrations | Calculated values concentrations | \( \Delta \), [%] |
|--------------|----------------------------------|----------------------------------|----------------------------------|-----------------|
|              | \( C \), fraction of MAC, in the | \( C_1 \), fraction of MPC, the   | \( C_2 \), fraction of MPC, the   |                  |
|              | calculation of 29 single emission | calculation of one integral       | calculation of two integral       |                  |
|              | sources                           | source of emission                | sources of emission               |                  |
| 1            | 0.025                            | 0.035                            | 0.035                            | 40.00           |
| 2            | 0.026                            | 0.037                            | 0.037                            | 42.31           |
| 3            | 0.036                            | 0.036                            | 0.036                            | 0.00            |
| 4            | 0.036                            | 0.036                            | 0.036                            | 0.00            |
| 5            | 0.020                            | 0.034                            | 0.034                            | 70.00           |
| 6            | 0.018                            | 0.036                            | 0.036                            | 100.00          |
| 7            | 0.018                            | 0.034                            | 0.034                            | 88.89           |
| 8            | 0.022                            | 0.035                            | 0.035                            | 59.09           |
The comparison showed that there was no difference between the nitrogen dioxide concentrations obtained from the dispersion calculations from the combined emission sources. But at the same time, the concentration values obtained as a result of dispersion of 29 emission sources differ by 2 times.

It can be concluded that the method of calculation of surface concentrations from nearby sources by combining with insufficient accuracy describes these operating conditions and can not be used in the calculation of emissions of boilers.

The current sanitary rules and regulations Sanitary Rules and Regulations 2.2.1/2.1.1.1200-03 [18] for the object in question establish a normative sanitary protection zone equal to 300 m from the sources of emission. However, when applying flare emissions, such situations can be created when it is possible to increase the surface concentrations of pollutants in the atmosphere above the established sanitary and hygienic standards at distances significantly exceeding the established [18] boundaries of the sanitary protection zone. In this case, air pollution by harmful emissions of a significant part of the residential area is not taken into account.

Summary
The sanitary protection zone for thermal enterprises, taking into account the imposition of flare emissions, should have an elongated shape along the line connecting the centers of the pipes (along the vectors of full overlay). The impact of the flare emission overlay is felt at a distance of up to 10 km from the emission sources [15-17].

Analyzing the above, we can offer the following:
- when selecting areas for construction near several nearby boiler houses, it is necessary to take into account the effect of smoke emissions;
- it is recommended to take into account the imposition of flare emissions from nearby sources of thermal enterprises when calculating the dispersion of pollutants in the surface layer of the atmosphere according to [2];
- for the projected groups of boiler houses it is recommended to place either in the industrial zone of the city at a considerable distance from the residential area or outside the city, which will eliminate the influence of the imposition of flare emissions on residential buildings.

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