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AIR POLLUTION BY EMISSIONS OF HEAT SOURCES

Pavel Aleksandrovich Khavanov and Anatoly Sergeevich Chulenyov
National Research University Moscow State University of Civil Engineering, Yaroslavskaya Road, Moscow, Russia
E-Mail: a.p.khavanov@mail.ru

ABSTRACT

In this publication, a comparative assessment of air pollution from sources of heat supply systems for a different type of development was carried out. A qualitative and quantitative assessment of the sanitary and hygienic indices of the air basin state is provided for the location of heat generating plants. Based on a comparison of quantitative characteristics, one can obtain the results of comparative calculations and the main qualitative indices of the technical solutions under consideration. The characteristics of the source of heat in each particular case were determined by the power of the heat source and the technical characteristics of the chimneys. It is revealed that the change in the dispersion zones taking into account the "wind rose" does not have a significant effect. It is received that the overlapping of dispersion zones in the housing and cottage heat supply is due to the density of construction and must be taken into account when developing architectural and planning concepts and technical solutions for heat supply.

Keywords: heat generating plants, air pollution, heat, autonomous heat supply.

1. INTRODUCTION

A significant reduction in the cost of heating is possible while increasing the proportion of decentralized heating [1]. This will help create more comfortable conditions, as well as provide real fuel economy. Decentralized heat supply is efficient and relatively inexpensive. Reasonable application of decentralized systems of heat supply in combination with energy-saving in construction and reconstruction of buildings will give huge energy saving.

For the past twenty years in European countries, almost do not build quarterly and district boiler houses.

Autonomous heat generating plants, such as individual gas boilers [2], roof and modular boiler houses are able to provide the most effective and comfortable solutions for the needs of a separate apartment or cottage, as well as an apartment building or a cottage community. Development of heat generation systems for heat has led to the emergence of new approaches, aimed mainly at decentralized systems. Comparative evaluation of the energy efficiency of heating systems [3] with varying degrees of centralization was carried out in many works, and authors largely determined the field of rational use of such systems.

However, in publications, the issues of comparative assessment of air pollution for the various technical solutions under consideration were practically not reflected.

With the growth of industrial production, exceptional sharpness acquired the problem of the interaction of human society with the environment, in particular the problem of protection of the atmosphere [4], hydrosphere and soil from pollution. The needs of human society are increasing continuously. However, the amount that we take from nature, due to the needs of development, growing exponentially, because the doubling of industrial production in the world occurs every 8-10 years. Every year, billions of tons of mineral resources are extracted from the bowels of the earth, but approximately one percent of all the raw materials produced are converted into useful products for society. All the rest is thrown into the environment in an environmentally dangerous, poisonous form.

All this leads to irreversible shifts in the Earth's biosphere, and consequently, the main problem is the protection of the environment, i.e. its protection from pollution and changes that occur as a result of the operation of enterprises for technological processing of resources and heat and power engineering. The main pollutants are Sulphur and nitrogen oxides, carbon dioxide, smoke and soot particles, as well as many other gases.

2. METHOD

Carrying out this comparison, it is necessary to start from the most common indicators and characteristics of the operation of systems. Do not specify their quantitative side, but highlight, define and evaluate qualitative aspects. For this purpose, three technical solutions for the heat supply of different type of development areas with approximately the same population for the same climatic conditions are compared.

A. Manor buildings with one source of warmth and centralized heat supply (Figure-1).

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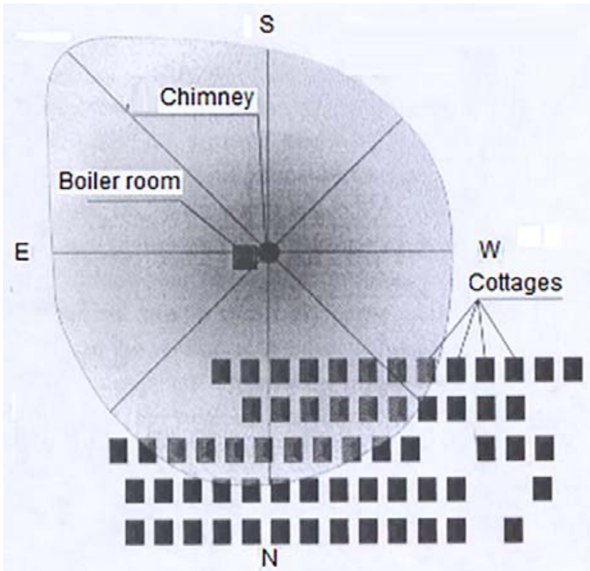

Figure-1. Dispersion of impurities for option 1.

B. Mansion building of the same layout (Figure-2) with the installation of the heat generator in each cottage.

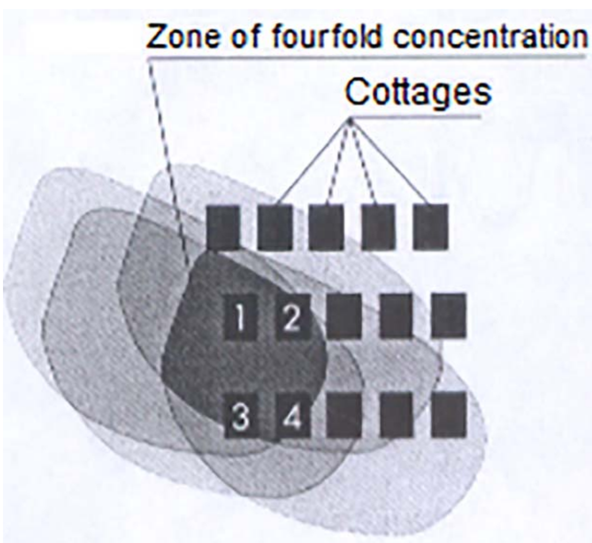

Figure-2. Dispersion of impurities for option 2 (fragment).

C. Multistory building (two five-storey buildings on the same number of mixtures) (Figure-3) with pokvartirnymi heat supply systems of Combi boilers [5].

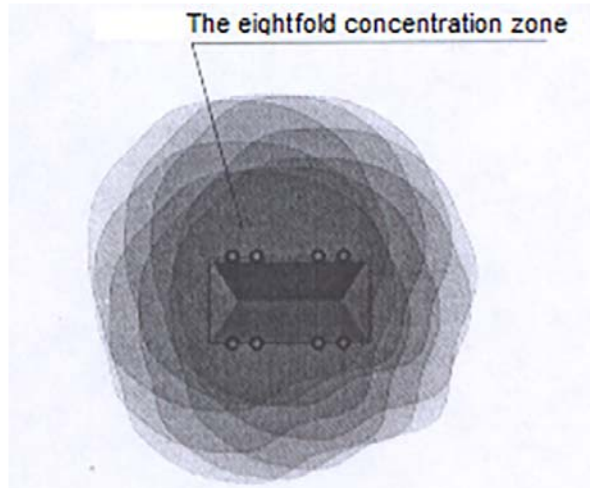

Figure-3. Dispersion of dangerous substances for option 3 (fragment).

For carrying out the general qualitative research of a question, it is possible to allow:

a) the type of fuel is not critical for a qualitative assessment, although according to point 3 it is possible to use only network natural gas;

b) the total capacity of the heat generating plants will be different and determined by the consumption norms in these types of buildings;

c) all emission sources with lumped parameters are considered as point, and the dimensionless total concentration (total toxic multiplicity) is defined as the additive quantity:

$$K_\Sigma = \sum_{i=1}^{n} K_i = \sum_{i=1}^{n} \frac{C_i + C_{bi}}{MAC_i}, \quad (1)$$

K_Σ - total toxic multiplicity; MAC_i - maximum allowable concentration of pollution, mg/m^3; C_i - the concentration of component i, mg/m^3; C_{bi} - background concentration of component i, mg/m^3.

In accordance with [6], that:

a) the total toxic multiplicity when overlapping the zones of dispersion of harmful emissions is determined by summing the calculated values for the most unfavorable conditions according to the maximum values of surface concentrations of harmful substances;

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b) calculation of harmful emissions is carried out at the maximum design capacity of heat generating equipment;

c) specific emission values are calculated for the comparative evaluation: carbon monoxide, nitrogen oxide, benz(a) pyrene, taking into account the background concentration C_{bi} of harmful substances [7];

d) influence of wind load for clarity is taken into account shown in Figure-1 eight-screw "wind rose".

Calculation of surface concentrations C_i of harmful emissions and distance from the chimney $X_м$ at which the surface concentration of harmful substances under unfavorable meteorological conditions reaches a maximum value and other characteristics were made according to the recommendations of OND-86

The characteristics of the heat source and the chimney dispersion conditions in each specific case were determined by the power of the heat source and the technical characteristics of the chimneys.

For centralized source options (item 1): the total TDP 6000 kW boiler with free-standing chimney height of 30 m, a diameter of 0.81 m (per boiler Vitoplex S (Viessman).

For suburban sprawl: auxiliary source ACV Heat Master output 64 kW (80 cottages-total capacity of 5120 kW) with chimney in each cottage complete with a height of 8 m, a diameter of 160 mm. The calculation is performed for a single cottage. For multi-storey cottages: gas boiler SD 235E ISOFAST TDP 32 kW (total power sources 2560 kW), the chimney of the building for each partition, i.e. 5 boilers, with a height of 18 m, a diameter of 220 mm. 8 pipes per building, the total number of pipes (two buildings) -16 pieces.

The calculation is performed for a single building.

3. RESULTS

The main results of the calculation to the data source for the Central European zone of Russia at a temperature of cold five days $t_{x5} = -29^{\circ}C$ and calculated year $t_{x5} = +29^{\circ}C$ are shown in table 1 and their graphic illustration given in Figures 1-3.

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Table-1. Basic results of comparative calculations.

No.	Characteristic	Centralized source	Independent source (cottage)	Apartment source
1	Power, kW: unit/quantity total	 2000/3 6000	 64/80 5120	 32/5 (total 80 boiler) 2560
2	Annual leave heat Mj/g when h_{year} = 4300 h/g (kW·h/g)	$9.29 \cdot 10^7$ ($2.57 \cdot 10^7$)	$7.93 \cdot 10^7$ ($2.2 \cdot 10^7$)	$3.96 \cdot 10^7$ ($1.1 \cdot 10^7$)
3	Chimney: height, m number of tubes mouth diameter, mm	 30 1 800	 8 80 160	 18 16 220
4	Natural gas consumption, m^3/s	0.181	0.00224	On one pipe 0.004263
5	The consumption of products of combustion at the outlet from the chimney, m^3/s	4.25	0.047	0.117
6	Calculated values from one source, the g/s: carbon oxides nitrogen oxides benzo (a) pyrene	 3.4 0.34 $0.8 \cdot 10^{-7}$	 0.0336 0.00376 $0.01 \cdot 10^{-7}$	On one pipe 0.084 0.00716 $0.02 \cdot 10^{-7}$
7	Mass emission, g/kWh: CO NO_x benzo (a) pyrene	 $5.7 \cdot 10^{-4}$ $5.7 \cdot 10^{-5}$ $1.4 \cdot 10^{-11}$	 $5.25 \cdot 10^{-4}$ $5.7 \cdot 10^{-5}$ $1.6 \cdot 10^{-11}$	 $4 \cdot 10^{-4}$ $4.5 \cdot 10^{-5}$ $1.25 \cdot 10^{-11}$
8	The annual mass emissions, thousands of kg/year: CO NO_x benzo (a) pyrene	 14.71 1.47 $5.06 \cdot 10^{-4}$	 11.55 1.3 $3.52 \cdot 10^{-4}$	 4.4 0.495 $1.38 \cdot 10^{-4}$
9	Maximum surface concentrations, mg/m^3: CO NO_x benzo (a) pyrene	 0.046 0.0046 $1.16 \cdot 10^{-9}$	 0.02122 0.00237 $6.3 \cdot 10^{-10}$	 0.009551 0.00107 $6.3 \cdot 10^{-10}$
10	Total toxic emissions per source multiplicity (one tube), taking into account the background concentrations	0.125	0.090	0.071
11	Distance to the zone of maximum concentrations from the emission source, $X_м$, м (without wind load)	414.4	55.8	104
12	The number of overlapping zones of dispersion for the architectural planning solutions, pieces	-	4	8
13	Possible local maximum total toxic multiplicity given overlay zones scattering	0.12	0.376	0.576

The results of comparative calculations based on the comparison of quantitative characteristics allow us to identify the main qualitative indicators of technical solutions [8]. Thus, the considered architectural and planning solutions for the construction of residential areas suggest significant differences in living conditions in a multi-storey building or in a cottage, however, in the issues under consideration, it should be noted that the total installed capacity of all heat generators has decreased significantly (#. 1 Table-1).

Therefore, the total mass of emissions reduced for high-rise buildings more than two times (# 8 Table-1) under identical environmental performance of boilers [9].

Comparing the total multiplicity of toxic emissions from a single source of pollution, it is easy to see that the change of the capacity and height of the chimney leads to minimum contamination from a group of pipe with a height of 18 m (5 boilers, when a five-storey building, # 10 Table-1) [10]. However, the analysis of the imposition of dispersion zones from all sources of pollution (# 12 Table-1) shows that residential heat supply is inferior to other solutions considered by environmental indicators (# 13 Table-1).

4. CONCLUSIONS

It should be noted that changing the dispersion zones when taking into account the "wind rose" does not have a significant effect on quality, and in terms of quantitative characteristics when using natural gas and moderate background concentrations, the sanitary indicators of air pollution are very far from the limit values

Moreover, the lowest air pollution at the maximum total toxic multiplicity, despite the significantly higher values of the installed capacity of the heat source, takes place for the central boiler house (# 13 Table-1).

Certainly, the provided calculations have estimated character and are executed with a number of assumptions. However, it is important to conclude that the eightfold imposition of dispersion zones in the apartment heat supply and the fourfold overlap in the case of cottage heat supply is due to the corresponding density of construction and must be taken into account.

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