Qualitative and Quantitative Composition of Gas Emissions of Energy-Technological Equipments

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Abstract. Power-generating plants are devices for producing heat, electrical and mechanical energy. They are widely used as internal combustion engines for ground and air vehicles. A significant drawback of internal combustion engines is their exhaust gases - the main environmental pollutants. The article identifies benchmarks (CO, NOx, CmHn, SOx) and secondary chemical compounds in the exhausts of internal combustion engines, their percentage and degree of toxicity are given. The influence of the highway on the surrounding territory and processes that reduce the migration of pollutants into the airspace are considered. Recommendations are given on reducing the number of parameters for analyzing the state of the environment and the possible penetration of pollutants into the human body.

1. Introduction

Energy and technological equipment includes power and heating boiler houses, technological furnaces and energy and industrial equipment, motor vehicles, including aircraft, gas-diesel generators or internal combustion engines, mini-CHPP. The main pollutants contained in the gas emissions of the following equipment: nitrogen oxide, sulfur oxide, carbon oxide, compounds of heavy metals, ash, benz (a) pyrene, vanadium five-oxy and other emissions, whose impact to the environment is very small.

Emissions from road transport include waste and crankcase gases, fuel vapor [10]. Clean soot does not apply to harmful pollutants. However, it has strong adsorbing properties and therefore it may contain carcinogens: benz (a) pyrene, vanadium five-oxy and hydrocarbons [6, 7, 11, 12].

The main pollutants in urban and roadside areas are the exhaust gases (EG) of cars, since the impact of emissions of industrial and agricultural objects on pollution is less significant [4, 12, 13, 14]. In the exhaust of automobile gases more than two hundred substances, of which reference are: CO, NOx, CmHn, SOx, compounds of heavy metals, in particular lead. Technological and ventilation emissions of accompanying production (for example, the preparation of dust-resistant solid fuel in boiler rooms) contain a significant amount of dust of various composition [15, 16, 17].

Quantitative analysis shows that the absolute contribution of toxic emissions of cars to environmental pollution is 2.6% sulfur anhydride, 17.5% nitrogen oxides, 63% carbon monoxide and 75% heavy metals (lead compounds) [1, 9].

Pollution by toxic emissions of cars is increasing in large cities and locality [4, 5, 10]. This is due to the restriction of migratory processes of pollutants in the air, which is hampered by the multi-story urban development, irrational planning of streets and highways [18, 19, 20]. The greatest concentrations of...
toxic substances are observed in the zone of influence of highways. Three areas of road impact on the surrounding area can be identified [1, 9]:
- the reserve process zone is located at a distance of up to 30 m. from the edge of the road; within this zone, the concentration of pollutants is higher or equal to the maximum permissible concentration (maximum permissible concentration – MPC);
- the sanitary gap is 150…300 m, on the outer boundary of which the concentrations of pollutants should not exceed the maximum permissible concentration;
- the area of influence of the road is up to 3000 m, in which the concentrations of toxic substances are below the MPC, but the overall effect of pollutants on the environment is quite significant.

The concentration of toxic components in exhaust gases depends mainly on the type of engine of vehicles and its modes of operation (table 1) [2, 3].

Analysis table 1 indicates that the pollution of the environment by toxic exhaust gas components is minimal for diesel engines. However, studies by Swedish scientists [9] show that the exhaust gases in the burning of diesel fuel contain traces of lead compounds in the amount of 0.0205 g / km of the road. In addition, the content of oxides of nitrogen and hydrocarbons has been increased by 1.5 to 2 times in diesel gases.

Table 1. The content of harmful substances in the exhaust gases of motor transport.

| Groups of vehicles (engine type) | Harmful substances, g/km. |
|---------------------------------|---------------------------|
|                                 | CO | C\textsubscript{2}H\textsubscript{8}n | NO\textsubscript{x} | Pb |
| Trucks with a load capacity of up to 6 tons (internal combustion engine) | 98.7 | 4.8 | 26.2 | 0.06 |
| Trucks with a load capacity of more than 6 tons (internal combustion engine) | 101.5 | 4.93 | 26.2 | 0.07 |
| Buses (internal combustion engine) | 128.7 | 6.25 | 34.2 | 0.08-0.09 |
| Cars (internal combustion engine) | 13.2 | 2.4 | 1.6 | 0.049 |
| Trucks (diesel engine) | 24.4 | 3.75 | 47.9 | 0.0205 |

The products of combustion of heat-generating plants contain up to 6 types of nitrogen oxides, the physico-chemical properties of which are very different from each other (table 2). This does not allow us to find the only effective method of capturing them.

Table 2. Physical and chemical properties of nitrogen oxides.

| Properties nitrogen oxides | N\textsubscript{2}O | NO | N\textsubscript{2}O\textsubscript{3} | NO\textsubscript{2} | N\textsubscript{2}O\textsubscript{4} | N\textsubscript{2}O\textsubscript{5} |
|---------------------------|------------------|----|-----------------|-----------------|-----------------|-----------------|
| Molecular weight (atomic mass unit) | 44.01 | 30.01 | 76.01 | 46.0 | 92.02 | 108.01 |
| Density, kg/m\textsuperscript{3} | 1.98 | 1.34 | - | 1.491 | 1.491 | - |
| Critical pressure, MPa | 7.0 | 6.35 | - | 98.0 | - | 0.14 |
| Critical temperature, °C | 36.4 | -93.2 | - | 158.0 | - | 41.0 |
| Boiling point under normal conditions, °C | -89.5 | -151.8 | 3.5 | 21.15 | - | 45.0 |
| Melting temperature, °C | -102.4 | -163.6 | -102.0 | - | -11.2 | 29-30 |

Piston, gas turbine and rocket engines of aircraft emit toxic components dispersed in the atmosphere: carbon and nitrogen oxides, hydrocarbons, soot, aldehydes, etc. [3, 9], and when rocket fuel is burned - water vapor, carbon monoxide, hydrochloric acid vapor, chlorine, carbon dioxide and nitrogen dioxide, aluminum trioxide.

According to GOST 17.2.1.01-76 [8] emissions from internal combustion engines and aircraft are divided into the following groups:
gaseous and ferries - oxides of sulfur, nitrogen, etc.;
liquid emissions – acids, alkalis, organic compounds, solutions of salts and liquid metals;
solid emissions – lead compounds, organic and inorganic dust, soot, resin substances, etc.

The composition and concentration of pollutants contained in the exhaust gases of air transport engines depend on the mode of their operation. Pollution of the environment in the airport area by certain types of pollution is: for carbon oxides 55%; for nitrogen oxides 77%; for hydrocarbons 93%; for aerosols 97%.

Pollution of the surface layer of the atmosphere from rocket engines is local and short-term in nature during the launch and landing of the spacecraft. The visual analysis of diffusion processes shows [3, 20] that a high-temperature aerosol cloud rises above the starting pad to a height of 3 km, which under the influence of the wind moves to a distance of 30 - 60 km and contributes to the formation of acid rain.

In order to reduce the number of parameters under study that affect the process, environmental pollution analysis is promising to conduct in dimensionless parameters, for example, in the dimensionless concentration of the component expressed in the shares of the MPC.

Another dimensionless parameter is the width of the road lane or the width of the flight corridor of aircraft, given to the conditional width. At the boundary of the conditional width, the concentration of the component is close to the background. When determining the toxicity of the internal combustion engine, the maximum concentration of exhaust gases should be determined by a coefficient of reduction using the formula [2, 9, 21]

\[ k_{np,i} = \alpha_i \lambda_i \beta_i \]

where \( \alpha_i \) – the relative risk of contamination in the air \((\alpha_i = 1 \ldots 5)\); \( \alpha_j \) – an amendment that takes into account the probability of accumulation of harmful substances or secondary pollutants in the atmosphere and other environmental components, as well as their entry into the human body \( (a_{jCO} = 1, a_{jNox} = 41,1, a_{j} = 3,16, a_{jPb} = 22400) \); \( \delta_i \) – a factor that takes into account the impact of harmful substances on different recipients, except humans \((\delta_i = 1 \ldots 2)\); \( \lambda_i \) – a factor that takes into account the probability of secondary admixture entering the atmosphere after settling on the surface (turbulence, wind behind the vehicle, tire impact on the road surface, etc.) \((\lambda_i = 1 \ldots 1,2)\); \( \beta_i \) – a coefficient that takes into account the probability of formation with the participation of initial harmful substances emitted into the atmosphere of other (secondary) contaminants, more dangerous than the initial ones \((\beta_i = 1 \ldots 5)\).

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