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Cleaning of Atmospheric Air in a City Street and Road Network as an Environmental Safety Technology for Road Transport

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Abstract:

The article provides scientific basis for a new innovative concept of cleaning the polluted ambient air in a city road network during road transportation and a calculative model for changes in concentrations of polluting agents for mobile cleaning units used as part of road traffic flow.

The article describes the design of equipment (reactor) used to decontaminate the toxic components of exhaust gas and disperse particles and explains its difference from the existing facilities by its function to clean the air within a city highway with a wide speed range of dust and exhaust gas flows (proved by two patents of the RF: No.2237816, No.3231858).

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Key words: Road transport, environmental safety, city street and road network, UV-reactor and electric filter package

1. Introduction

When we consider city ground transport systems, road transport in particular, as a means of transportation for city dwellers we can distinguish several components of this special process of road transportation:

– main process: transportation – moving of material objects (passengers and cargoes);

– auxiliary processes: maintenance of functional status of rolling stock, city road network, infrastructure, traffic safety, decrease in the level of polluting agents as a result of transportation services (exhaust gases, solid particles, noise, electromagnetic radiation, service and repair waste materials)

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Objective necessity for using of engineering methods to decrease the concentration of polluting agents in ambient air of city street and road network. There are commonly known traditional ways of decreasing the mass of polluting agents in the traffic flows. These include improving environmental safety of vehicles (packaging with electric motors, electronically control engines and three stage exhaust gas reactors, emission monitoring during operation, usage of advanced and alternative fuels); improvement of the transportation process (usage of buses with large passenger capacity, distribution of traffic flows according to their carrying capacity); mitigation of unsteady operation modes of engines (construction of continuous traffic highways, road junctions in different levels, underground crossings, etc.).

As we have stated in [Fedotov (2011)], technical solutions implemented to decrease the emission level of the combustion engines should significantly limit the impact of polluting agents on the quality of the city ambient air in the immediate future. At the same time, the emissions caused by the wear of brake parts, tyre protectors and wear of road surface (fractions $PM_{10} - PM_{2,5}$) by road transport still remain the major sources of pollution which require effective strategies for their removal.

2. Main part

The calculations made according to the western procedures for environmentally friendly external conditions which are close to the European ones (good quality of roads, contamination of the road surface with suspended particles of 0.4 g/mg^3) yielded the following emission values of *PM*-particles: 0.04–0.12 g/km and 0.20–0.80 g/km for each passenger and commercial car (with carrying capacity of more than 9 t), respectively, for a speed range of 20–50 km/h, typical for a road network in Saint Petersburg and other large cities [Denisov (2013)].

Table 1 gives concentration values for polluting agents for a length of 2000 m of the road network of a large city with traffic density of 50–60 cars/km (1000–1200 cars/h) with adjacent buildings (average number of floors of 7–12; building density of 70–80%) and wind speed of 2–5 m/s. Emission of *PM*-particles in traffic flow amounted for passenger cars to 63–72 g/km, for buses and commercial cars to 120–150 g/km [Fedotov (2011)].

Table 1. Concentration of polluting agents within a length of the road network of a large city (for Volgograd as an example).

Assessment points for concentration of polluting agents	Concentration values of polluting agents according to the measurements [Fedotov (2011)]	Concentration values of polluting agents according to calculations
At the edge of a highway at an elevation of 0.4–2.0 m	3.7–5.6 mg/m^3, including total concentration of solid particles 0.28 – 0.41 mg /m^3, concentration of PM-10 particles and lower 0.14–0.24 mg/m^3	2.1–3.5 mg/m^3
In the center of traffic flow	12.2–18.1 mg/m^3	31.6–40.7 mg/m^3

Near the ground concentrations of polluting agents can be increased by 2-3 times due to unfavourable weather conditions which include still air, fog, dangerous wind direction and speed, trapping layers, high air temperature.

Estimate calculations for unfavorable weather conditions with equations proposed by the author in [Fedotov (2012)] are in line with the figures and conclusions given in [Fedotov (2011)]. With the traffic intensity of 1000–1500 cars/h (more than 90 % of road transport with category M1, M2, M3) the volumes of air polluted with exhaust gases and solid particles with a three lane traffic in concentrations which make harmful effect on human body can amount to: 60–72 th. m^3/h with an average height of air passage of 2.8-3.2 m, (99% of the mass of impurities dissipate in the volume) per 1 km of a highway in the city center and other districts with a dense residential development.

Such volumes of polluted air in a city street and road network are comparable with emission levels of polluting agents during production of metal, cement, gas and coal combustion where special air cleaning methods are used [Fedotov (2012)]. These figures prove the urgency for developing the air cleaning system within city highways to clean the air from polluting agents of traffic flows.

Road transport dust and gas emission cleaning system. We designed a reactor for cleaning the air from solid and gaseous particles to be moved in traffic which is covered by the patent of the RF [Komarov et al. (2008)]. The reactor has a dust and gas flow speed damper and a conical gas duct which ensure a narrow speed range and an onward movement of dust and gas flow in the reactor, Fig. 1.