17-osios jaunųjų mokslininkų konferencijos „Mokslas – Lietuvos ateitis“ teminės konferencijos
TRANSPORTO INŽINERIJA IR VADYBA,
vykusios 2014 m. gegužės 8 d. Vilniuje, straipsnių rinkinys

Proceedings of the 17th Conference for Junior Researchers ‘Science – Future of Lithuania’
TRANSPORT ENGINEERING AND MANAGEMENT, 8 May 2014, Vilnius, Lithuania

Сборник статей 17-й конференции молодых ученых «Наука – будущее Литвы»
ИНЖЕНЕРИЯ ТРАНСПОРТА И ОРГАНИЗАЦИЯ ПЕРЕВОЗОК, 8 мая 2014 г., Вильнюс, Литва

FEATURES OF MEASUREMENT OF HARMFUL VEHICLE EMISSIONS CONCENTRATIONS IN THE ATMOSPHERE OF THE URBAN AREA

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Abstract. The design procedure that allows to determine with sufficient reliability the proportion of pollutants in emissions produced by road transport vehicles in different modes of their operation is offered.

Keywords: road transport, ecology, pollution, emissions, concentrations.

Introduction

Measurement and comprehensive quantitative assessment of pollutants emissions discharged into the atmosphere by vehicles refers to the extremely urgent problem, as it depends on numerous factors: the technical state of the rolling stock and the mode of vehicles movement in the traffic flow, the structure of the road network (RN), the quality of both the motor fuel and pavement, the intensity and density of motor vehicles traffic (MVT), climatic conditions, the terrain and the driver’s skills.

Main part

Using the proposed method one can estimate the amount of pollutants emissions into the atmosphere produced by vehicular traffic on urban highways. For this purpose, they use the results of field studies of the structure and intensity of road traffic flows with the division on the basic types of vehicles. Research is carried out according to the scheme (Fig. 1).

To determine the emissions of vehicles on urban highways of Kharkiv and their subsequent use as input data for measurements of air pollution there was carried out a study of features of motor vehicles flows distribution (their composition and intensity) within the city limits and their variation in time (during the day, a week and year). Previously, we obtained data on the number, composition of vehicles in Ukrainian cities, including Kharkiv (Луканин, Буслаев, Яшина 2001; Луканин, Трофименко 2001).

Spatial differences in the composition and intensity of traffic flows depends on the area and transverse dimensions of the city, the amount of the population, the scheme of the road network planning (RN), the features of industrial enterprises arrangement, automobile fleets, and service stations.

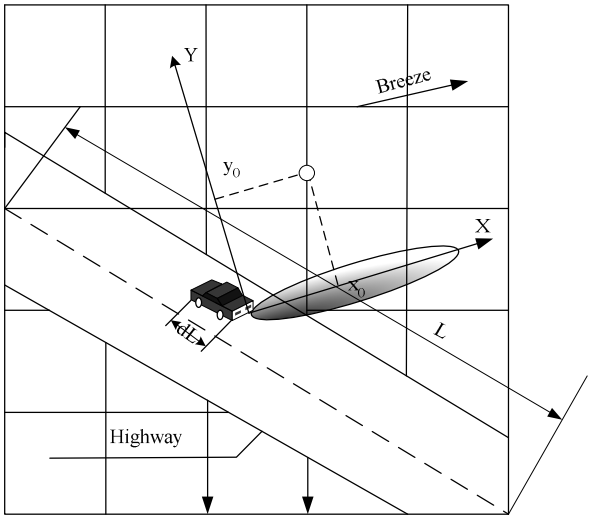

Fig. 1. On the measurement of concentration distribution (concentration field) of vehicle exhaust gases on the territory adjacent to the highway

Temporary differences are largely associated with the method of working of industrial enterprises and institutions of the city and the climatic characteristics of the region in which the town is situated.

Based on the study of the scheme of the road network of the city, as well as the data concerning the traffic load obtained in architectural offices they compile a list

ISSN 2029-7157 / eISSN 2029-7149
http://jmk.transportas.vgtu.lt
ISBN 978-609-457-714-7 / eISBN 978-609-457-713-0

of major highways (and their sections) with increased traffic density and intersections with high traffic load. As these roads (sections) they consider:

– for cities with a population of 500 thousand people – highways (or sections thereof) with traffic density on the average more than 200–300 vehicles per hour;

– for cities with a population of over 500 thousand people – highways (or sections thereof) with traffic density on the average more than 400–500 cars per hour.

The selected highways (or sections thereof) and intersections are mapped on the town layout (taking into account the scale of the map), where they record the intersections, where additional research is supposed to be conducted.

To determine the characteristics of road traffic flows on selected sections of the road network they record the vehicles passing in both directions. To identify the maximum traffic load the observations are made during the summer season (at peak hours in the morning and evening (from 7–8 o'clock, respectively, to 10–11 o'clock and from 16–17 to 19–20 o'clock)). Sequentially on each direction of movement during the period of red light they calculate the number of vehicles generating queues, besides they record the queue length in meters. Determination of the average rate of motion of the main groups of vehicular traffic is performed along the entire length of the highway under study, including the areas of regulated and unregulated intersections.

Numerous studies allowed determining that the most toxic exhaust gas components are carbon monoxide, CO, CH hydrocarbons, nitrogen oxides NO_x, sulfur oxides SO_2, formaldehyde, lead compound (composed of leaded gasoline) and benzaperen.

Mileage emissions are determined according to the known procedures and regulations (Охрана природы. Атмосфера. 2004, Склад і зміст матеріалів. 2003) on the basis of the following standards.

Measurements of emissions of *i*-pollutant produced by the motor vehicle flow is determined for a particular highway, along the entire length of which the structure and the traffic density varies no more than by 20–25 %. At bigger differences of motor vehicles characteristics the highway is divided into sections, which are then treated as separate sources of pollutants.

In the area of intersection there is discharged the biggest amount of harmful substances due to the deceleration and stopping of motor vehicles at red traffic light and its subsequent movement at green traffic light.

Thus, for a highway with a controlled intersection the total amount of emissions can be expressed by the formula:

$$M = \sum_{1}^{n} M_{n_i} + \sum_{1}^{m} M_{L_i}, \quad (1)$$

where: M_{n_i} – the emission of pollutants into the atmosphere produced by motor vehicles at the junction banning traffic light, t/year; M_{L_i} – emission of pollutants into the atmosphere produced by motor vehicles moving along this highway within a given time period, t/year.

Specific emissions of pollutants according to the listed modes are given in Tables 1 and 2.

Using specific indicators of pollutants emissions (pollutants) allows measuring the emissions for both vehicles moving on the RN, and at parking areas, at enterprises and parking lots (Экологические требования. 1998 Методика определения выбросов. 1999, Муравьева С. И. 1991.].

Table 1. Mileage and specific pollutants emissions produced be motor vehicles

V_{en} (l)	Engine type	Milleage pollutants emissions, g/km				Specific emissions of pollutants, g/min			
		CO	CH	NO_x	SO_2	CO	CH	NO_x	SO_2
Up to 1.2	P	13.8	1.3	0.23	0.040	2.5	0.20	0.02	0.008
More than 1.2 до 1.8	P	15.8	1.6	0.28	0.060	3.5	0.30	0.03	0.010
More than 1.8 до 3.5	P	17.0	1.7	0.40	0.070	4.5	0.40	0.05	0.012
More than 3.5	P	24.0	2.4	0.56	0.105	7.0	0.80	0.08	0.016

Table 2. Mileage and specific emissions produced by trucks

V_{en} (l)	Engine type	Milleage pollutants emissions, g/km				Specific emissions of pollutants, g/min			
		CO	CH	NO_x	SO_2	CO	CH	NO_x	$S0_2$
Up to 2.0	P	22.7	2.8	0.6	0.09	4.5	0.40	0.05	0.012
	D	2.3	0.6	2.2	0.33	0.8	0.20	0.16	0.054
More than 2.0 до 5.0	P	29.7	5.5	0.8	0.15	10.2	1.70	0.20	0.020
	G	15.2	3.3	0.8	0.14	5.2	1.00	0.20	0.018
	D	3.5	0.7	2.6	0.39	1.5	0.25	0.50	0.072
More than 5.0 до 8.0	P	47.4	8.7	1.0	0.18	13.5	2.20	0.20	0.029
	G	24.2	5.1	1.0	0.16	6.9	1.30	0.20	0.026
	D	5.1	0.9	3.5	0.45	2.8	0.35	0.60	0.090
More than 8.0 до 16.0	P	79.0	10.2	1.8	0.24	13.5	2.90	0.20	0.029
	D	6.1	1.0	4.0	0.54	2.9	0.45	1.00	0.100
More than 16.0	D	7.5	1.1	4.5	0.78	2.9	0.45	1.00	0.100

The motor transport located at parking areas, parking lots and the idle one is regarded as a stationary source of emissions (Методика определения выбросов. 1999) Emissions of major pollutants are measured by the formula, where the summation of the main pollutants is measured by the formula, where the summation is performed according to vehicles of *k* group:

$$M_{n_i} = \sum N_k \left(m_{1kj} T_1 + m_{2kj} T_2 \right) D \cdot 10^{-6}, \quad (2)$$

where: M_{n_i} – the total emission of i component, t/year; N_k – the number of motor vehicles of *k* – group with operating engines; m_{1kj} – specific emission of *j* substance during warming up of vehicles engines of *k* group, g/min; T_1 – time of engine warming up, min; m_{2kj} – specific emission of *j* substance of idling vehicles of *k* group, g/min; T_2 – time of idle engine operation, min; *D* – number of days of operation per year.

The motor transport moving on the RN and located at crossings of nodal intersections vehicles is considered as a mobile source of pollutants emissions into the atmosphere. The total mass of pollutants emissions produced by motor vehicles of specific payload and engine capacity when in motion is calculated by the formula:

$$M_{L_i} = \sum N_k \left(m_{1ij} L_1 + m_{2ij} L_2 \right) \cdot 10^{-6}, \quad (3)$$

where: M_{L_i} – the total emission of i component, t/year; m_{1ij} – mileage emission of *j* substance produced by motor vehicles of *i* group, g/min; L_1 – total mileage of motor vehicles, km; m_{2ij} – mileage emission of *j* substance produced by trucks of *i* group, g/min; L_2 – the total mileage of trucks, km.

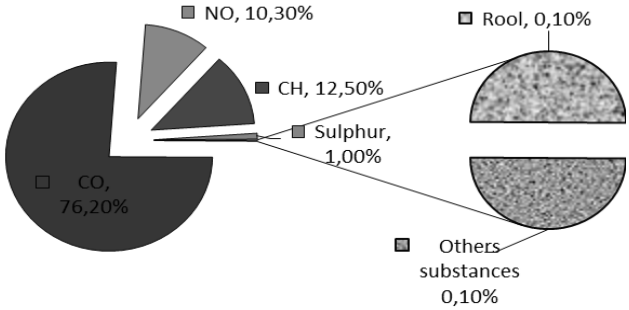

Fig. 2. According to the type of toxic substances

Fig. 2 shows the distribution of emissions produced by motor vehicles according to the type of toxic substances.

Conclusions

Thus, the proposed ratio and the results obtained allow measuring and adjusting emissions produced by different types of vehicles in any mode of operation with a sufficient degree of certainty.

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Склад і зміст матеріалів оцінки впливів на навколишнє середовище (ОВНС) при проектуванні і будівництві підприємств, будинків і споруд. – ДБНА.2.2-2003; 2004. [Чинний від 2004-04-01] К.: Держбуд України, 25 с. (Нормативний документ Держбуду України. Проектування).

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