INFLUENCE OF FLOW REGIMES OF MOVEMENT AND ACCUMULATION OF TRANSPORTATION TO INCREASE TOXICITY OF EXHAUST GAS EMISSIONS BY CITIES LINES

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In terms of transport flows dense engine operating conditions lead to extensive exhaust emissions into the atmosphere. We think the amount of emissions $\sum N_i$ is proportional with amount time of engines operating under non-standard transmission schemes, therefore:

$$\sum N_i = F(t) \tag{1}$$

where: $\sum N_i$ – total emissions of toxic substances.

$$\sum N_i = n_1 t_1 A_1 + n_2 t_2 A_2 + \ldots + n_n t_n A_n \tag{2}$$

where: $n_1, n_2, \ldots n_n$ – quantity of toxic substances emitted $n_1, n_2, \ldots n_n$ by a car, m^3/s;

$t_1, t_2, \ldots t_n$ – emission of these substances during the performance of distance measurement S_i;

$A_1, A_2, \ldots A_n$ – groups of cars with characteristic toxic emission $n_1, n_2, \ldots n_n$.

Sectors characteristic of the measurements may be areas of acceleration, braking and uniform movement.

Let's examine the three regimes of movement of cars in the areas of acceleration S_1 speed v_1, movement in the regime S_2 speed v_2 and brake S_3 speed v_3 on all the intersections between city bus $S = S_1 + S_2 + S_3$.

The distance travelled by the automobile sector to accelerate S_1, relationship can be determined:

$$S_1 = \frac{1}{2a}\left\{\frac{G_a}{g}\delta \ln\left|av_i^2 + bv_1 + c\right|\Big|_{v_1}^{v_2} - bt_1\right\} \tag{3}$$

where: $a = a_M \frac{u_T^3 \eta_T^3}{r_m^3} - kF$; $b = b_M \frac{u_T \eta_T}{r_m}$;

$c = c_M \frac{u_T}{r_m} - G_a \psi$ – coefficients equal balance of power;

$a_M = -\frac{M_p c'}{100 n_p}$; $b_M = \frac{b'}{10 n_p}$;

$c_M = M_p a'$ – coefficients equal torque;

G_a – vehicle weight, *kg;*

u_T – automobile transmission gear ratio;

η_T – transmission efficiency car;

r_m – car wheel rolling radius, *m;*

M_p – engine torque at maximum power, *Nm*;

n_p – speeds of the crankshaft of the engine at maximum power, *rot/min*;

ψ – road drag coefficient;

a', b', c' – coefficients, which depend on engine type and number of times;

t_1 – time of the acceleration of the vehicle on S_1.

On the S_1 during vehicle movement, t_1 relationship can be determined from power balance:

$$dt = \delta \frac{G_a}{g}\left(\frac{dv_i}{av_i^2 + bv_i + c}\right) \tag{4}$$

Solving differential equality *(4)* has the form:

$$t_1 = \frac{\delta \frac{G_a}{g}}{\sqrt{b^2 - 4ac}} \ln\left|\frac{2av_i + b - \sqrt{b^2 - 4ac}}{2av_i + b + \sqrt{b^2 - 4ac}}\right|_{v_1}^{v_2}$$

$$\text{if } \left(b^2 - 4ac\right) > 0 \tag{5}$$

$$t_1 = \frac{2\delta \frac{G_a}{g}}{\sqrt{4ac - b^2}} arctg \frac{2av_i + b}{\sqrt{4ac - b^2}}$$

$$\text{if } \left(b^2 - 4ac\right) < 0 \tag{6}$$

$$t_1 = \frac{2\delta \frac{G_a}{g}}{2av_i + b} \quad \text{if } \left(b^2 - 4ac\right) = 0 \tag{7}$$

Time t_1 is active toxic emissions during acceleration. In this case it is necessary to focus on dynamics of acceleration of a the less dynamic group of cars. After this group of cars, the attention can be driven at medium speeds of the transport flow:

$$v_{med1} = \frac{S_1}{t_1} \tag{8}$$

On the S_2 – when reaching by the car speed v_2 it can move within the following traffic arrangements:

1. constant speed v_2 as a single car or a reduced intensity of traffic flow;
2. in a dense flow with variable intensity of transport movements;
3. in the transport stream after leader.

Consider the distribution of intervals in the transport stream is subject to the distribution of *Poisson* [1].

$$P_i(\Delta t) = e^{-\Delta t \frac{M}{T}} \frac{\left(\Delta t \frac{M}{T}\right)^i}{i!} \tag{9}$$

where: $P_i(\Delta t)$ – transition probability i vehicles tracking the benchmark in period Δt;
M – number of cars that pass by this benchmark for the entire period of follow-up;
T – follow-up period. If T = 1 *hour* (3600 *s*), then the relationship $m = \frac{M}{T}$ expresses the mathematical expectation of the number of cars at the benchmark in a second. Taking this into account, equation *(9)* takes the following form:

$$P_i(\Delta t) = e^{-\Delta tm} = e^{-\lambda} \tag{10}$$

where: $\lambda = \Delta tm = A_i$ – number of cars passing through this part (sector) during Δt.

Taking into account the distribution of properties *Poisson* can be written that:

$$\Delta t = \frac{A_i}{m} = \frac{A_i T}{M} \tag{11}$$

The average number of cars A_i, on the lane will be:

$$A_i = A_i \pm \sqrt{A_i} = \Delta tm + 1 \tag{12}$$

From equation *(12)* is found time Δt:

$$\Delta t = \frac{(A_i \pm 1)}{m} = \frac{(A_i \pm 1)T}{M} \tag{13}$$

According to his Lithil and Witham [1]:

$$M = cq \ln\left(\frac{q_i}{q}\right) \tag{14}$$

where: q – transport traffic flow density, *auto/km*;
q_i – maximum density of traffic (in case of congestion v = 0 *km/h*; q_i = 228 *auto/mile*);
c – movement speed, set at maximum capacity crossing (c = 17,2 *mile/h*).

Since $q = \frac{M}{v}$, then:

$$\Delta t = \frac{(A_i \pm 1)T}{qv} \tag{15}$$

From equation *(15)* shows that at one and the same density q, time Δt is greater, when v transport stream speed v is less.

If $\Delta t > t_2$, then the movement of vehicle in traffic flow is being performed uniformly with speed v_2. However, if $\Delta t < t_2$, then the movement of vehicle in traffic flow is being performed after the leader and flow velocity can be determined by relations:

$$\begin{aligned} v_a &= 78{,}0 - 0{,}0385\, M - \textit{for}\ \text{cars} \\ v_c &= 54{,}2 - 0{,}0122\, M - \textit{for}\ \text{trucks} \end{aligned} \tag{16}$$

Sector length $S_2 = v_2 t_2$. Speed v_2 may be restricted by appropriate signs prohibiting or limiting the speed or limit speed driving in the city $v_2 \leq 60$ *km/h.*

On the S_3 car slows down approaching the intersection traffic when light signals change. The balance of movement of the car when braking (the motor is disconnected from the transmission) has the form:

$$F_j = F_t + G_a\psi + kFv_a^2 \tag{17}$$

where: $F_t = G_a\varphi\cos\alpha$ – *car* wheels brake force;
F_j – car inertial force for critical brake.

Solving the equality *(17)* we determine the braking time on sector S_3:

$$t_3 = \frac{\left(v_i - \frac{kFgv_i^3}{3\delta G_a}\right)}{\left[\frac{g}{\delta}(\varphi + \psi)\right]} \tag{18}$$

where: v_i – initial braking speed depending on the density flow transport.

Considering the final speed braking zero distance S_3 of braking sector can be determined:

$$S_3 = \frac{t_3 v_i}{2} \qquad (19)$$

The total number of cars that are on the lane in the direction of movement is determined from the relationship *(12)*. Considering the relation *(2)* groups of the same type car, it can be written:

$$\sum N_i = n_1 t_1 A_1 + n_2 t_2 A_2 + n_3 t_3 A_3 \qquad (20)$$

where: n_1, n_2, n_3 – quantity of toxic substances emitted by a car during the regimes of acceleration, braking and uniform movement given m^3/s;

A_1, A_2, A_3 – number of cars that move on acceleration, braking and uniform movement schemes given.

$\sum N_i$ – total emissions of toxic substances on the sector *S*.

CONCLUSIONS

1. The total amount of emissions of toxic substances on the movement of the automobile on sector *S* depends on the number of cars moving, vehicle movement regime and intensity of toxic emissions at those regimes.
2. Time and distance of travel of the vehicle at different regimes of movement depends on its operating characteristics.
3. Regime of movement of cars under intense traffic depends on the intensity of the flow movement and flow distribution ranges density in the automotive transport stream, which can be considered subordinated to Poisson distribution. The greater the period of developing of the car in the range of time given, the less is the dependence of solitary car speed with other road users speed. Otherwise, solitary car speed depends on leader's speed and it diminishes with growing of traffic intensity

Bibliography

1. **Babkov V. F. i. d.** *Dorozhny'e uslovia i rezhimy' dvizhenia avtomobilei// M.: Transport, 1967.-224 s.*

2. **Nefiodov A. F.** *Raschiot rezhimov dvizhenia avtomobilya na vy'chislitel`ny'x mashinax. Kiev. Texnica, 1970.-172 s.*

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