DEVELOPMENT OF METHODS FOR ASSESSING THE STABILITY OF THE CONTACT OF CAR WHEELS WITH THE ROAD UNDER THE ACTION OF RANDOM DISTURBANCES

Foziljon Abdullaevich Mamadaliev,
Mobile number: +99897 590 98 77
Email: fozil.bek.80@mail.ru

Doctor of Physical and Mathematical Sciences, Associate Professor.
Kokand branch of Tashkent State Technical University named after Islam Karimov,

One of the important factors affecting road safety is the choice of the optimum in terms of stability and handling of the car, speed of movement on rough roads. The loss of controllability of the vehicle can also occur at low speeds, which is much lower in terms of stability due to the insufficient stability of the wheels in contact with the road. With strong vertical vibrations of the car caused by the disturbing effect of the road microprofile, the probability of the wheels coming off the road increases. Let's consider the calculated definition of the average probability of separating the wheels when driving on a road with a known spectral density of the microprofile. Based on the scheme of the two-mass construction, we write the equations of body vibrations: $m_{\Pi i}\ddot{z}_i + k_{\Pi i}(\dot{z}_i - \dot{\xi}_i) + C_{\Pi i}(z_i - \xi_i) = 0$ (1)

$$m_{Hi}\ddot{\xi} - k_{\Pi}(\dot{z}_i - \dot{\xi}_i) - C_{\Pi i}(z_i - \xi_i) + C_{Ш}\xi_i = C_{Ш}q_i$$

where i is equal to 1 for the front axle and equal to 2 for the rear axle.

$m_1 = m_\Pi\, b / L$; $m_2 = m_\Pi\, a / L$;

(a, b, L - distance from the center of mass of the body to the front axle and the vehicle base)
where m N and m P - unsprung and sprung masses;
kp, Sp and Ssh - shock absorber resistance, suspension and tire stiffness;
z1 and z2 are vertical displacements of unsprung and sprung masses.
Let's write the transfer functions from the road to tire deformations (2) and elastic suspension elements (3):

$$W_{\delta\Pi q}(p) = \frac{\Delta\delta_{Шq}(P)}{D(P)}, \qquad (2)$$

Where $\Delta\delta_{Шq} = P^2[m_\Pi m_{H\Pi}P^2 + P\lambda_\Pi(m_\Pi + m_{H\Pi})] + C_\Pi(m_\Pi + m_{H\Pi})$;

$$D(P) = a_0P^4 + a_1P^3 + a_2P + a_3P + a_4,$$

Where $a_0 = m_\Pi + m_{H\Pi}$; $a_1 = m_\Pi(\lambda_\Pi + \lambda_Ш) + m_\Pi\lambda_\Pi$;

$$a_2 = m_{П}(C_{П} + C_{Ш}) + C_{П} m_{НП} + \lambda_{Ш}\lambda_{П};$$

$$a_3 = C_{П}\lambda_{Ш} + C_{Ш}\lambda_{П}; \quad a_4 = C_{П}C_{Ш};$$

$$W_{\delta Пq}(p) = \frac{P^2 m_{П}(P\lambda_{ш} + C_{ш})}{D(P)} \qquad (3)$$

The spectral density of the perturbing action, in the most general case, is usually taken in the following form:

$$S_q(\omega) = D_0 V_a \frac{\omega^2 + \omega_1^2}{\omega^2(\omega^2 + \omega_2^2)} \qquad (4)$$

where $\omega_1 = V_a\,\Omega_1$; $\omega_2 = V_a\Omega_2$; Ω_1 and Ω_2 – road frequencies;

From this spectrum of disturbances, a number of spectra can be obtained that approximate the spectra of disturbances for most types of roads.

The spectral density of the input signal $\mathbf{S_q(\omega)}$ is related to the spectral density of the output signal $\mathbf{S_{вых}(\omega)}$ by the relation:

$$S_{вых}(\omega) = |w(i\omega)|^2 S_q(\omega), \qquad (5)$$

where $w(i\omega)$ - frequency transfer function of the system obtained by replacing the transfer function of the differentiation operator **P** with the complex frequency **iω**.

The dispersion of the output signal is calculated by the formula:

$$D_{вых} = \frac{1}{2\pi}\int_{-\infty}^{\infty} |w(i\omega)|^2 S_q(\omega)d\omega,$$

Since the microprofile of the road is a normal random process, the distribution of the vehicle vibration parameters (according to the linear model) will also be normal. Assuming that the road microprofile is a stationary centered random process and has a normal distribution, using the formulas of statistical dynamics, one can determine the average number of wheel separations from the road.

For a process with a normal distribution, the probability that the random process x(t) will exceed the level x(t) is determined by the formula

$$P[x(t) \ge \lambda] = 0{,}5\left[1 - \Phi\left(\frac{\lambda - m_x}{\sigma_x}\right)\right] \qquad (7)$$

Mathematical expectation of the number of excesses of the level λ by a stationary random process per unit of time

$$n(\lambda)=\int_0^\infty \dot{x} f(\lambda,\dot{x})d\dot{x}, \qquad (8)$$

Where $f(x,\dot{x})$ – joint distribution density of processes x(t) and .

For a normal process $\dot{x}(t)$ is determined by the formula

$$f(x)=\frac{1}{\sigma_x\sqrt{2\pi}}\exp(-\frac{(x-m_x)^2}{2\sigma_x^2}) \qquad (9)$$

a $f(x,\dot{x})$ is determined by the formula

$$f(x,\dot{x})=\frac{1}{2\pi\sigma_x\sigma_{\dot{x}}}\exp\left[-\frac{(x-m_x)^2}{2\sigma_x^2}\right]\exp\left[-\frac{\dot{x}^2}{2\sigma_{\dot{x}}^2}\right] \qquad (10)$$

Hence, the average number of wheel breaks per unit of time is determined by the formula:

$$n(\lambda)=\frac{\sigma_{\dot{x}.}}{2\pi\sigma_x}\exp\left[-\frac{(\lambda-m_x)^2}{2\sigma_x^2}\right], \qquad (11)$$

Where n(λ) – average number of breaks; $\sigma^2{}_x$, $\sigma^2{}_{\dot{x}}$ - dispersions of deformations and speed of tire deformations; λ -zero tire deflection.

On fig. Figure 1 shows the average number of rear wheel separations of the car depending on the effectiveness of the resistance of the shock absorbers, from which it can be seen that both a decrease in the effectiveness of the shock absorbers and their increase, associated, for example, with a low ambient temperature, leads to an increase in the probability of wheel separation from the road. Calculations have shown that the ratio of the sprung mass of the car to the mass of unsprung parts has a great influence on the probability of wheel separation from the road. Changing the payload in the body leads to a change in this ratio. So for the Nexia passenger car, this ratio for the rear axle varies from 5.86 to 9.72. Figure 5 shows the average number of rear wheel separations depending on the ratio of the car mass to the mass of unsprung parts. The probability of rear wheel separation for an empty vehicle is several times higher than for a vehicle with a full load.

The conducted studies show that the microprofile of the road, the value of the payload and the technical condition of the car are important factors that should be taken into account when calculating the driving modes of the car.

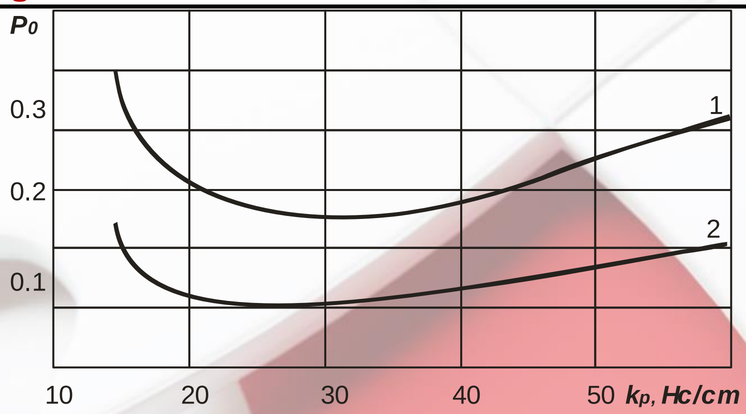

Figure 4. Dependence on the average separation number of the rear wheels from the coefficient of resistance of shock absorbers: 1 with anti-roll bar; 2 without stabilizer.

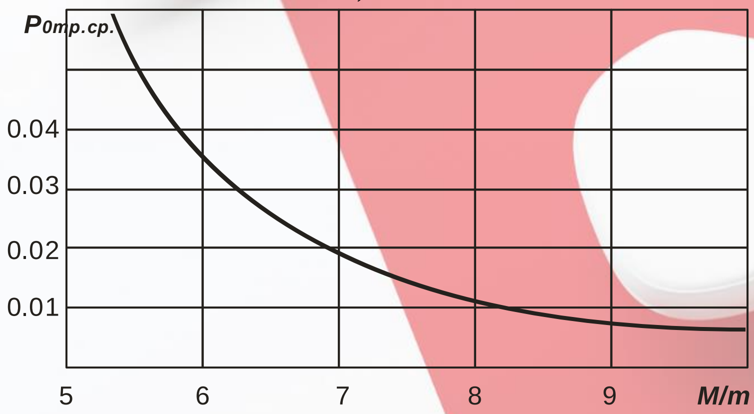

Figure 5. Dependence on the average number of wheel separation from the road, depending on the ratio M / mnp (passenger car with a gross weight of 1420 kg, the range of the load on the rear axle is 260 kg, unladen weight is 63 kg.)

Literatures

1. Литвинов А.С., Фаробин Я.Е. Теория эксплуатационных свойств автомобиля. М.: Машиностроение, 1989.-240 с.: ил.

2. Мамадалиев Ф.А., Хашимов Д.А.. "Прибор для измерения коэффицента сцепления и микропрофиля дорог"

3. Хашимов А.Д., Турсунов И.С., Хашимов Д.И. Математическая модель управляемости автомобиля при маневрах типа «переставка». «Автомобильная промышленность», №8, 2003, Москва, стр.18-20.

4. Динамика системы "Дорога - шина – автомобиль - водитель"/ Под ред. А.А. Хачатурова. М.: Машиностроение, 1976. - 536 с.