УДК 629.1

ВЛИЯНИЕ ПРОДОЛЬНО-УГЛОВЫХ КОЛЕБАНИЙ КОЛЕСНЫХ ТРАНСПОРТНЫХ СРЕДСТВ НА УСТОЙЧИВОСТЬ ДВИЖЕНИЯ

INFLUENCE OF LONGITUDINAL ANGULAR OSCILLATIONS OF WHEELED VEHICLES ON THE STABILITY OF MOVEMENT

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Аннотация. Исследовано влияние продольно-угловых колебаний подрессоренной массы колесных транспортных средств с нелинейной силовой характеристикой системы подрессоривания и кинематических параметров движения вдоль криволинейных участков пути на устойчивость движения. Установлено, что критическое значение устойчивого занесения движения вдоль криволинейных участков пути: а) без учета продольно - угловых колебаний подрессоренной массы значительно завышенным; б) большим значением амплитуды колебаний подрессоренной массы соответствует меньшее значение критической скорости устойчивого движения; в) для колесных транспортных средств с прогрессивной силовой характеристикой амортизаторов при малых амплитуд колебаний является большим чем за линейной их силовой характеристики, в для регрессивной – наоборот.

Abstract. The influence of longitudinal angular oscillations of the submersible mass of wheeled vehicles with nonlinear force characteristic of the system of sprinkling and the kinematic parameters of motion along the curvilinear sections of the path to the stability of motion is investigated. It is established that the critical value of the motion-bearing stability along the curvilinear sections of the path: a) without regard to the longitudinal *angular oscillations of the submerged mass is considerably overestimated; b) the greater value of the amplitude of the oscillations of the submerged mass corresponds to less than the value of the critical speed of steady motion; c) for wheeled vehicles with a progressive power characteristic of shock absorbers at small amplitudes of oscillations is greater than their linear power characteristics, and for regressive – vice versa.*

Ключевые слова: критическая скорость устойчивого движения, колебания подрессоренной массы, амплитуда, частота.

Key words: critical speed of steady motion, oscillations of submerged mass, amplitude, frequency.

INTRODUCTION

The stability of motion, handling and smoothness of the course are determined not only by external factors (inequalities of the path, its curvature, height differences, coverage), but also internal (distribution of mass along the vehicle, power characteristics of the suspension system and tires, but from the dynamics of the submersible and not submersed parts, etc.). Ensure the smooth running of the wheeled vehicles (KTZ) while driving along the path with irregularities is capable of suspension system with nonlinear power characteristics of an elastic shock absorber. The latter give the submersible mass (PM) a qualitatively new characteristic of its motion. At the same time as changing the dynamics of PM all the performance characteristics of the KTZ are changed. If the question of the influence of the power characteristics of the suspension system on vertical and transverse angular oscillations, and on both the stability of motion was partially considered, then the effect of longitudinal angular oscillations on nonlinear characteristics of the SP was not properly studied. It is the study of the dynamics of the submersible mass of the KTZ, and more precisely its impact on the stability of motion along the curvilinear sections of the path or maneuvers is the subject of consideration of work.

FORMULATION OF THE PROBLEM

In order to investigate the effect of longitudinal angular oscillations on the stability of the KTZ along the curvilinear sections of the path for the calculation model, three mass systems are adopted: the undiluted (front and rear axles) and the subjected mass. They interact with each other using a suspension system - elastic shock absorbers and dampers. It is believed that during the KTZ movement, the inequality of the road under the right and left wheels has the same vertical section, and the power characteristics of the right and left sides of the joint venture are the same. Regarding the values of the SP characteristics, it is assumed that: the elastic forces of the front (F_{1np}) and rear (F_{2np}) suspensions are described by the dependencies $F_{inn} = c_i \cdot \Delta_i^{v+1}$ (c_i, v are the constants, Δ_i is deformation of the i elastic element), and the forces of resistance of the damper devices as a function of the velocity of their deformations $R_{inn} = \alpha_i \cdot \dot{\Delta}_i$ (α_i, are the constants, $\dot{\Delta}_i$ is the deformation velocity of the i damper, the forces of counteraction to the drift of the front Q_1 and rear Q_2 axles are proportional to the normal dynamic forces N_i of pressure on the support surface of the road ($Q_i = k_i \cdot N_i$, k_i are the constants).

The problem is to determine the magnitude of the critical velocity $\bar{V}$ along the curvilinear section of the radius of curvature ρ, provided that the inequalities of the path cause longitudinal angular oscillations of the PM.

DISCUSSION METHOD

The basic ratios of the study of the impact of transverse angular oscillations on the stability of the KTZ motion will be the kinetic statics equation and the differential equation of the longitudinal angular oscillations of the PM

$$I_C \frac{d^2\psi}{dt^2} = -c_1 a(a\psi(t) - \Delta_{cm.})^{\nu+1} - c_2 a(b\psi(t) + \Delta_{cm.})^{\nu+1} - \alpha_1 a\left(a\frac{d\psi}{dt}\right)^s - \alpha_2 b\left(b\frac{d\psi}{dt}\right)^s \quad (1)$$

in which I_C is the moment of inertia of the PM relative to the transverse axis passing through the center of mass; $\psi(t)$ - the angle of rotation of the PM around the axis indicated above, a, b are the parameters that characterize the position of the center of mass of the PM. As for the forces of inertia, these forces are the inertia of the front $\vec{\Phi}_1^e$, rear $\vec{\Phi}_2^e$ axles and submersible mass in the portable $\vec{\Phi}^e$ and relative movements.

Their values are determined according to the dependencies:

$$\Phi_1^e = \frac{P_1}{g}\frac{V^2}{\rho}, \quad \Phi_2^e = \frac{P_2}{g}\frac{V^2}{\rho}, \quad \Phi^e = \frac{P}{g}\frac{V^2}{\rho},$$

(P, P_1, P_2 – weights, respectively, PM and front and rear axles). In relative motion, the forces of inertia of PM are reduced to a moment M_C^{Φ} whose value is equal to $M_C^{\Phi} = -I_C \frac{d^2\psi}{dt^2}$.

Taken together, the above gives a critical value of the velocity of stable motion along the curvilinear section of the path, taking into account longitudinal angular oscillations in the form

$$\overline{V} = \min\begin{cases} \sqrt{\dfrac{k_2\left[(P+P_2)a + P_2 b - \left(c_1 a^{\nu+2} + c_2 b^{\nu+2}\right)a_{\psi}^{\nu+1}\right]}{\left(P_1+P_2\right)ha - \left(P_1 a - P_2 b\right)\left(R+h\right)}\left(R+h\right)\rho g} \\ \sqrt{\dfrac{k_1\left[(P+P_1)b + P_1 a - \left(c_1 a^{\nu+2} + c_2 b^{\nu+2}\right)\overline{a}_{\psi}^{\nu+1}\right]}{\left(P_1+P_2\right)hb + \left(P_1 a - P_2 b\right)\left(R+h\right)}\left(R+h\right)\rho g} \end{cases} \qquad (2)$$

where a_ψ – the amplitudes of longitudinal angular oscillations PM, R, h – the radius of the wheels and the distance of the mass of the PM mass to the horizontal line passing through the centers of the weights of the front and rear axles, k_1, k_2 the coefficients of the resistance of the skidding of the front and rear tires.

CONCLUSIONS

The obtained analytical dependencies show that the critical value of the steady motion on the placement along the curvilinear sections of the path, without taking into account the longitudinal angular vibrations of the PM, is significantly overestimated. In addition, the higher value of the amplitude of the oscillation of the PM corresponds to less than the value of critical velocity; For the progressive characteristics of the system of sprinkling under the higher values of the static deformation of the system of sprinkling, the critical value of the speed of stable motion is greater, and for the regressive, on the contrary, is smaller.

Представлено 17.05.2019