DEVELOPMENT OF MODEL OF WHEEL SLIPPAGE SELF-PROPELLED VEHICLES ON BENDS

Bekenov T.N., doctor of technical sciences (L.N.Gumilyov Eurasian National University, *Astana*);
Nussupbek Z.T., candidate of technical sciences (*Saken Seifullin Kazakh Agrotechnical University, Astana*);
Tassybekov Z.T., candidate of technical sciences (Nazarbayev University, *Astana*)

Patency and safety of self-propelled wheeled machine are complex indicators of its quality, which will depend on the performance of its properties and performance of road conditions. When assessing the passability and safety of self-propelled machines, the issues of redistribution of tractive forces (or slippage) on their wheels when moving along a curve are practically not considered. The machine is a one-piece structure, considering only the greatest load when assessing the movement of machines on the ground and on a paved road on a turn is not sufficient. Therefore, when assessing the complex indicators of the quality of patency and machine safety, it becomes necessary to take into account also the redistribution of their skidding.

Controllability and rotatability, are characterized by kinematic (trajectory, turning radius, etc.) and power (torque on driving wheels, reactions, etc.) parameters [1].

With the movement of self-propelled wheeled vehicles in general, and at the turn in particular, the question arises of determining the loss of the speed of the machine, that is, the question of determining their skidding. Usually, under the skidding of a wheeled vehicle, we mean the loss of speed of the center of the driving bridge, that is, the skidding of some fictitious wheel having a free radius equal to the radius of the driving wheels and located in the middle of the drivetrain. This definition of skidding is acceptable for cases of rectilinear motion. The movement of the wheeled vehicle in the turning mode is estimated from the movement of its center of mass. Therefore, the skidding of the wheeled vehicle in the turning mode will be defined as the loss of its center of mass velocity.

$$\delta = \frac{v_{TC} - v_C}{v_{TC}}, \quad (1)$$

v_{TC}, v_C – respectively, the theoretical and actual speeds of the center of mass of the machine.

The object of the study is a self-propelled machine with a 4x4 wheel arrangement with two controllable drivetrain and an onboard blocked transmission [2, 3, 4]. In this case, the angular velocities of the driving wheels and the dummy wheel located at the center of the machine's masses are the same $w = w_1 = w_2$.

Let us express the angular velocities in terms of linear velocities and the radii of the rolling of the wheels. Considering, that $r_{ki} = r_{ki}^0 (1 - \delta_i)$, where r_{ki}, r_{ki}^0 – valid and free rolling wheel radius. i; δ_i – Wheel slippage i, we get

$$\frac{v_C}{1-\delta_H} = \frac{v_2''}{1-\delta_2''} = \frac{v_1''}{1-\delta_1''}; \quad \frac{v_C}{1-\delta_H} = \frac{v_2''}{1-\delta_2''} = \frac{v_1''}{1-\delta_1''}, \quad (2)$$

$v_1', (\delta_1'), v_1'', (\delta_1'')$ - speed (skidding) of the lagging and running wheels of the front drivetrain; $v_2', (\delta_2'), v_2'', (\delta_2'')$ - speed (skidding) of the lagging and running wheels of the rear drivetrain;

Taking into account the equality of the projection of the absolute velocities of the points of the machine onto the line passing through them, we obtain

$$\begin{cases} v_C \cos(\varepsilon_2 - \eta_M) = v_2' \cos(\varepsilon_2 - \alpha_2'); \\ v_C \cos(\varepsilon_2 + \eta_M) = v_2'' \cos(\varepsilon_2 + \alpha_2''), \\ v_C \cos(\varepsilon_1 + \eta_M) = v_1' \cos(\varepsilon_1 - \alpha_1'); \end{cases} \quad (3)$$

$$v_C \cos(\varepsilon_1 - \eta_M) = v_1'' \cos(\varepsilon_1 + \alpha_1''), \quad (4)$$

$\alpha_1^э, (\alpha_2')$ and $\alpha_1'', (\alpha_2'')$ - angles of rotation of the lagging and running wheels, respectively, of the front (rear) drivetrain; ε_1 and ε_2 - angles that depend from the design of the machine; η_M - the angle that makes up the velocity vector of the center of mass $\overline{v_C}$ with its longitudinal axis.

These angles are determined by formulas [5]

$$\varepsilon_1 = \arccos \frac{a}{\sqrt{a^2 + (0{,}5B)^2}}, \quad (5)$$

$$\varepsilon_2 = \arccos \frac{b}{\sqrt{b^2 + (0{,}5B)^2}}, \tag{6}$$

$$\eta_M = arctg \frac{btg\alpha_1 - atg\alpha_2}{Ltg^2\alpha_1}, \tag{7}$$

a, b – distance of the center of mass of the machine, respectively, to the front and rear wheels; *B* – track; *L* – longitudinal base; α_1, α_2 - average rotation angles of the front and rear axles.

Knowing the tractive forces on all wheels, you can determine the slip coefficients on each wheel, using formula [2]

$$\delta = \frac{l}{Gr_c}\left(Gf - \sqrt{Gf(Gf - P_T)}\right), \tag{2.21}$$

l - half the contact length of the machine wheel with support; G - the weight falls on the wheel; r_c - static wheel radius; f - coefficient of friction rolling wheels; P_T - tractive power of the wheel.

From equations (3) and (4), we find the velocities of the centers of mass of the front and rear drivetrain, and taking into account (2), (5), (6), and (7) we obtain

$$\delta_B = 1 - \frac{(1-\delta_1^{'})\cos(\varepsilon_1 - \alpha_1^{'}) + (1-\delta_2^{'})\cos(\varepsilon_2 - \alpha_2^{'})}{\cos(\varepsilon_2 - \eta_M) + \cos(\varepsilon_1 + \eta_M)}, \tag{8}$$

$$\delta_H = 1 - \frac{(1-\delta_1^{''})\cos(\varepsilon_1 + \alpha_1^{''}) + (1-\delta_2^{''})\cos(\varepsilon_2 + \alpha_2^{''})}{\cos(\varepsilon_2 + \eta_M) + \cos(\varepsilon_1 - \eta_M)}, \tag{9}$$

δ_B, δ_H - coefficients of slipping by the inside (lagging) and outside (running) sides of the machine with a rigid frame.

As is known, at a given angle of rotation of the bridges, the corresponding angles of rotation of the inner and outer wheels of a self-propelled wheeled vehicle with a rigid frame relative to the center of rotation are different. This difference is calculated by formulas [5]

$$tg\alpha_i' = \frac{Ltg\alpha_i}{L - 0{,}5B(tg\alpha_1 + tg\alpha_2)} \tag{10}$$

$$tg\alpha_i'' = \frac{Ltg\alpha_i}{L - 0{,}5B(tg\alpha_1 + tg\alpha_2)} \tag{11}$$

$a_i^{'}$ and $a_i^{''}$ - angles of rotation of the inner and outer wheels of the *i*-th drivetrain.

Proceeding from this in the article, in the final analysis, expressions are derived for the calculation of the slipping along the inner and outer sides of the self-propelled machine relative to the center of rotation.

Thus, it is possible to make a theoretical estimate of the redistribution of wheel slippage along the sides for various designs of self-propelled machines with a rigid frame, respectively, to make a comprehensive assessment of both the passability and safety of the machine and its efficiency.

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