SLOW MOVEMENT OF THE WAGON AT THE PLACE OF BRAKING BECAUSE OF WIND RESISTANCE

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Annotation. *The article presents the results of a mathematical model of the deceleration of the car in the case of the first throat braking on the section under the influence of wind resistance. For the first time, analytical formulas were obtained to determine the braking distance and distance of the car in the first braking position. A timeline of the braking distance and distance of the car is plotted. According to the graphical analysis, the deceleration of the car in the case of the first brake depends mainly on the resistance of the car to the deceleration of the car on the section.*

Keywords*: hill, wind resistance; Coulomb's law;; wagon speed; first brake position.*

The purpose of this article
It consists of constructing a mathematical model of the movement of the wagon at the first stop of the sorting hill at a speed determined at the site.

Problem statement
At the first stop of the sorting hill, it is necessary to determine the analytical braking path $x(t)$ and velocity $v(t)$ of the wagon movement.

Conditions of the problem and accepted assumptions
v_0 (typically 6 or 8.5 m / s, depending on the structure of the brake devices) as the wagon passes from the sorting peak slope to the first stop position (1TJ) of the sorting peak . When a single wagon (or wagon break) enters a hill 1TJ, it is subjected to gravitational forces *G*, aerodynamic gravitational forces F_{rvx} and F_{rvy} *[15, 16], as well* as forces such as braking force (friction) F_{torm}. 'reveals the mystery [17]. In this case, the pair of wheels slides along the rails.
It should be taken into account that the length of 1TJ is located on the coordinates l_{ab}, *a* and *b* in sections 1 - 2 of the peak profile, in section 1 - a *the* angle of inclination ps $_{02}$, in section *b - 2 in the angle of inclination* ps $_{03}$ (Fig. 1).

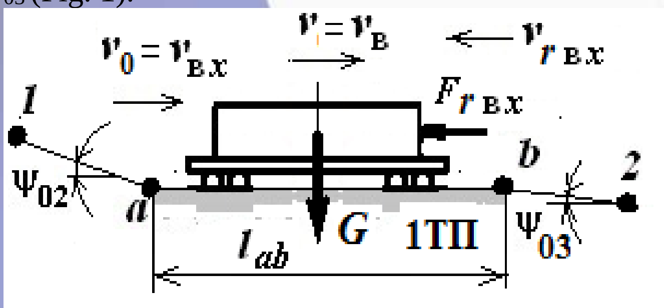

Figure 1 . 1TJ plot profile in wind resistance

Figure 1 shows: l_{ab} is the length of 1TJ; $\overline{V}_0 = \overline{V}_{B.x}$ - speed of access of the car to the section 1TJ; $\overline{V}_{rB.x}$ - relative wind speed; $\overline{V} = \overline{V}_B$ - speed (wagon speed); *G* is the traction of the loaded wagon ; F_{rvx} is the aerodynamic drag force that “holds” the wind resistance.

Forming a model for calculating the movement of the car

Let the calculation model of wagon movement when applying brakes on section 1TJ have the form shown in Figure 2 in accordance with the principle of exemption from the limitations of theoretical mechanics :

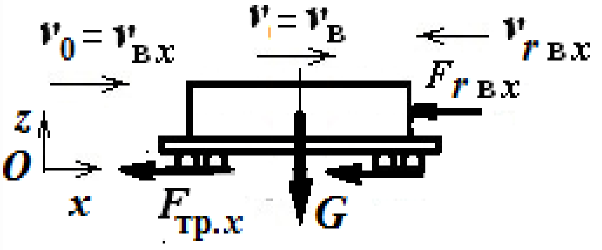

Figure 2 . Calculation scheme of wagon movement on the section 1TJ in wind resistance

Figure 2 also shows the indicators in Figure 1.

Here $F_{tr.x}$, in contrast to , the compression of the compressed brake tires F_{tp} , taking into account the friction F_t *on the sliding of the wheel head on the rail surface . = F is the effect of the wheel head on the lateral surface of the rail under the action of* torm and reciprocal wind $F_{tr.y}$ (taking into account the effect), $F_{tr.x} = F_t + F_{torm.} + F_{tr.}$ is equal to $_y$.

The force at the first braking point on the wagon movement

As shown in , it is necessary to brake the wagon (or wagon wagon) to control the speed of the wagons detached from the structure. This slows down the rotation of the wheel pair, which forces them to partially slide along the rail surface due to the frictional force that occurs on the brake tires. However, due to the maximum pressure of compressed air (0.75 MPa) in the pneumatic system, the significant braking force is F_{torm} , and as a result, the resistance force to the movement of the wagon is $F_{tr.x}$ appears.

In general, the resistance force of the wagon motion to traverse the length of 1TJ is $F_{tr.x}$ is equal to:

$$F_{\text{тр}.x} = F_{\tau} + F_{\text{тп}} + F_{\text{тр}.y} \text{ , (1)}$$

F_t is the reaction on the rails, according to Coulomb's law, $F_t = f_{sk} N$, where f_{sk} is the coefficient of friction of the wheel pair on the surface of the rail ("metal to metal" - f_{sk} = 0.15 ÷ 0.25, where the coefficient depends on the weather conditions), *N - the reaction component* F_z , which is equal in modulus to the sum of the projections of all active forces corresponding to each box :

braking distance of a wagon is *x* (*t*), according to the quadratic law of wind in the time interval *t* : the braking distance of a wagon does not increase linearly, it has a constant magnitude at *v (t) = 0.*

From expression we get *x* = 0 at *t = 0* , i.e. the initial condition of the equation holds.

It should be noted that expressions (11) and (12) are formulas for path and velocity in slow motion known from the physics course.

Thus, using D'Alamber's mechanical principle, a method for separating tables of variables and simple integrals, the final analytical formulas were developed to determine the carriage speed and braking path *x* (*t) over time in the 1TJ section* v_e *(t).*

Calculation method . Let the initial data be: v_0 = 6.0 - initial speed of the wagon, m / s; *G* = 908 - traction of the car, taking into account the inertia of rotating masses, kN; f_{tp} = 0.18; F_{tk} = 90 kN; $F_{torm} = f_{tp} F_{tk}$ = 16.2 kN; $f_{sk\,0}$ = 0.2; n_{ky} = 4; $f_{sk\,0}$ = 0.25; F_{rvy} = 10.4 kN; $F_{tr.x}$ = 208.2 - slip friction force of the wheel pair on compressed brake tires, kN; F_{rvx} = 3.0 kN ; F_0 = -205,1 - "insufficient" forces in the section 1TJ, kN; *M* = $9{,}256 \cdot 10^4$ - mass of the wagon taking into account the inertia of the wheel pair, kg, *a* = 2,2 - acceleration of the wagon in slow motion, m / s^2 .

$$x2(t) := v0 \cdot t - \frac{1}{2} \cdot a \cdot t^2$$

Braking distance *x* (*t*), m in any period of time *t* in 1TJ .

Thus , for the first time, a mathematical model was developed for a sudden decrease in the braking distance $x(t)$ and a wagon speed $v_e(t)$ in the event of a sudden braking on the 1TJ section under the influence of wind resistance .

Conclusion

$v_e(t)$ and braking distance $x(t)$ *were* first determined on the basis of mathematical models of wagon motion, taking into account the force of gravity and the effect of counter wind on the 1TJ section when braking .

2. Based on the time dependence graph of $v_e(t)$ and $x(t)$, the braking time of the wagon on section 1TJ is mainly the resistance force F_{tr}. depends on x : the value of the resistance force F_{tr}. The larger *x , the smaller the acceleration in a decelerating motion and the* smaller the braking time *t of the car. The reduction in* braking time *t* , in turn, makes it possible to control the interval between wagons.

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