METHOD FOR CALCULATION OF VEHICLE TRAFFIC ON THE ROADS

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ANNOTATION

This article presents the methods of calculating the amount of negative impact forces in dangerous and sharp turns during the movement of vehicles. Analyzes with mathematical laws have been developed taking into account the geometrical characteristics of movement conditions and movement changes.

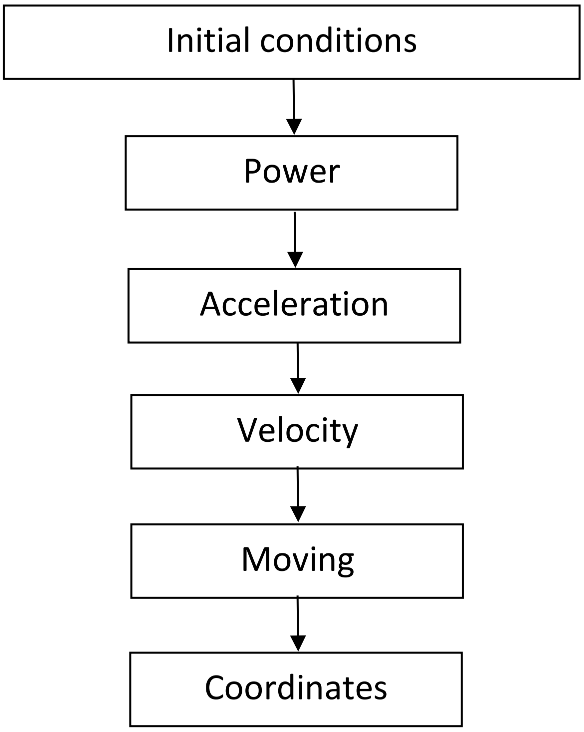

Fig 1

One of the main tasks in mechanics is to determine the coordinates of a body and its velocity at any given time according to known initial conditions. This problem is called a direct mechanics problem. To solve it, it is necessary to know the coordinates and velocity of the body at some initial time and the force acting on the body at any subsequent time.

The sequence of the stage of solving a direct problem can be conditionally written in the following form (Fig. 1):

The solution of the direct problem of mechanics is easy to obtain for calculating the motion of bodies under the action of a constant force. In the case of the action of forces depending on coordinates, the exact calculation of the motion of bodies by elementary methods is impossible. It was the impossibility of solving the problem of the motion of bodies under the action of forces depending on the coordinates of the body by methods of elementary mathematics that led Newton to the discovery of a new mathematical method called the method of mathematical analysis.

However, many problems about the movement of themes under the action of variable forces can be solved approximately with sufficiently high accuracy by numerical method, without the involvement of special mathematical methods. Moreover, the numerical method can solve many problems with a high degree of accuracy and in cases where the application of rigorous methods of mathematical analysis is impossible.

The sequence of steps of the numerical method of solving the problem can be schematically depicted in the form (Fig. 2):

It follows from the scheme (Fig. 2) that according to the known values of the body coordinates (x0, y0, z0) at the initial moments of time, it is possible to determine the projections of the power

F_{ox}, F_{oy} F_{oz}, and hence the acceleration projections $a_{ox}=\frac{Fox}{m}$, $a_{oy}=\frac{Foy}{m}$, $a_{oz}=\frac{Foz}{m}$. Knowing the projections of acceleration and initial velocity, one can find the projections of velocity at the next time $t = t_o + \Delta t$. The velocity projection allows you to determine new coordinates of the body, which in turn make it possible to find projections of power and acceleration at subsequent points in time.

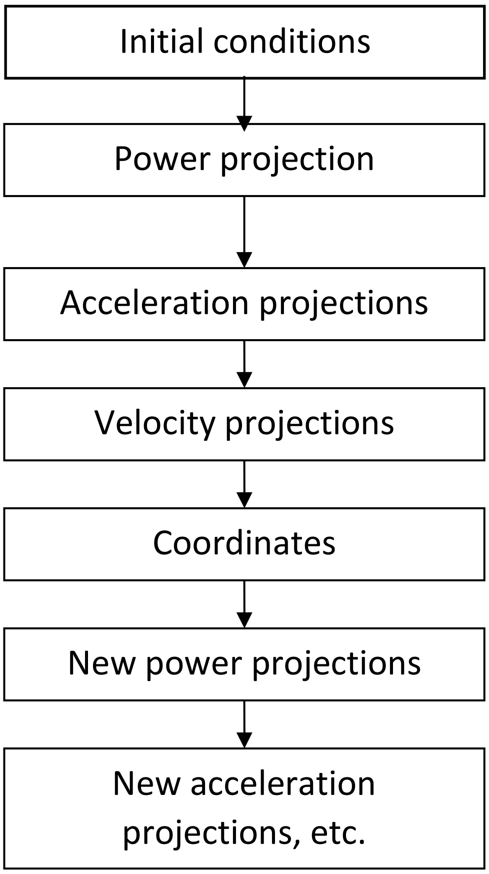

Fig 2

Numerical methods for solving the direct problem of mechanics are widely used in the practice of calculation by engineers, having set the initial conditions from Newton's equations. At the same time, it is possible to calculate all the values of accelerations and new coordinates after a small period of time t and so find the entire trajectory step by step.

Let us consider as an example a numerical method for solving the problem of the movement of motor transport on an inclined plane held by the friction force of rest (Fig.3).

If the car is informed of the speed directed parallel to the base of the inclined plane, then the movement of vehicles would seem to be rectilinear to the base of the plane, since the friction force of movement is greater than or equal to the friction force of rest. However, experience refutes this assumption: the car, when braking sharply, moves along a curved trajectory and slides off the plane towards the side of the road at its slightest incline.

The gravity of the vehicle $\vec{F_T}$ and resultant reaction forces $\vec{N}$ ($N=N_1+N_2$) attached at point A.

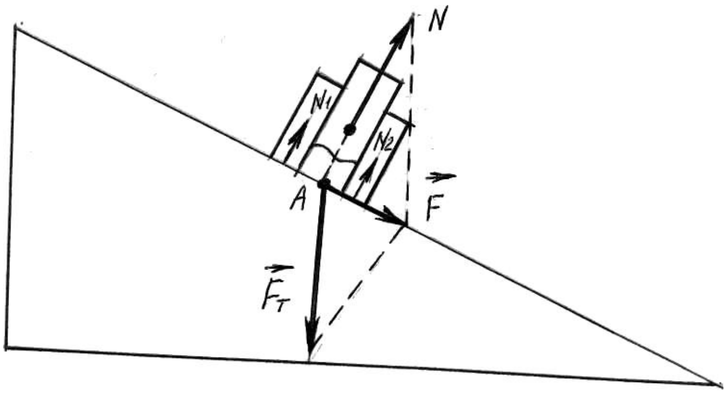

Fig 3.

The resultant of these forces $\vec{F}$ directed to the base of the inclined plane. Under the influence of force $\vec{F}$ the car moves with acceleration $\vec{a}$ and acquires a velocity $\vec{v}_1$, perpendicular to the velocity $\vec{V}_o$ (Рис.4).

The friction force $\mu\vec{N}$, is directed in the direction opposite to velocity $\vec{v}_2$, equal to the geometric sum of velocities $\vec{v}_1$ и $\vec{v}_o$. The projection of the friction force on the direction perpendicular to the base of the inclined plane is equal to $F_1 = \mu N \sin\alpha$, where α–angle between vectors $\vec{v}_2$ и $\vec{v}_o$. At the beginning of the movement $\vec{V}_1 < \vec{V}_o$, so the angle α and the sine of the angle α can be replaced by its tangent $\sin\alpha = tg\,\alpha\,\frac{v1}{vo}$.

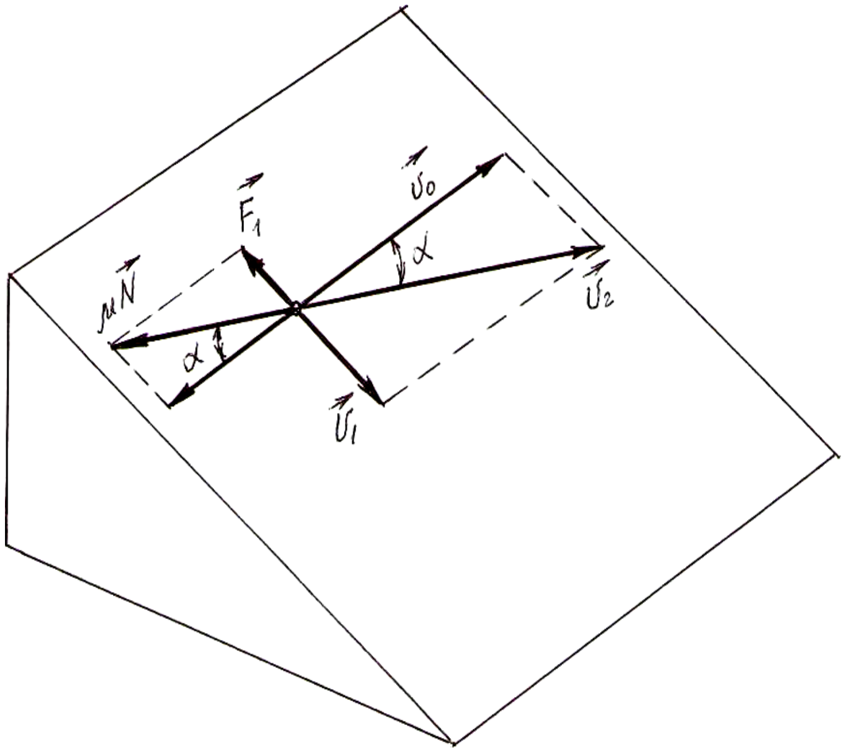

Fig 4

Thus, we have obtained that the friction force in the direction perpendicular to the base of the inclined plane, at the beginning of the movement of the car, when *v>o*, can be any number of times less than the friction force at rest. Therefore, any small component of gravity can cause the car to move in this direction.

The methodology for assessing the fitness of the rolling stock structure in mountain operating conditions is carried out in the following sequence:

- a list of operational properties of rolling stock is established;

- the weight of operational properties factors is determined by the results of a survey of highly qualified specialists using the a priori ranking method.

- theoretical and experimental studies determine the values of operational properties;

- the values of operational properties are analyzed, compared for each brand of rolling stock and the rolling stock with the best indicators is determined as adapted for mountain operating conditions.

Assessment of the adaptability of the design of the rolling stock in terms of operational properties is carried out by theoretical and experimental studies.

The adaptability of the design of the rolling stock in terms of operational properties for mountainous operating conditions is carried out by research and analysis of each factor in the following sequence (Fig. 5).

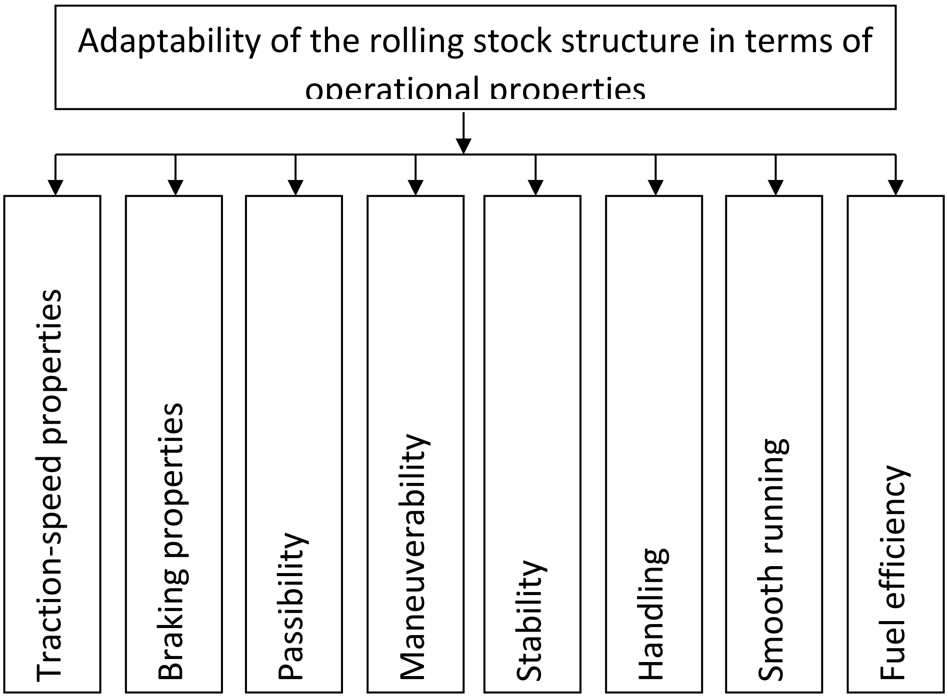

Fig – 5 Adaptability of the rolling stock structure in terms of operational properties

Traction-speed properties are called a set of properties that determine the possible ranges of speed changes and the maximum acceleration rates of the car when it is operating in traction mode in various road conditions, according to the characteristics of the engine or the adhesion of the driving wheels to the road.

Traction qualities of road trains are determined by a dynamic factor, it can be determined by the well-known formula:

$$D = \frac{P_T}{G} = \frac{M_e u_{mp}}{r} \cdot \eta_{mp} \cdot \frac{1}{G}; \qquad (1.)$$

where, P_T – traction force on driving wheels, H;

G – vehicle weight, Н;

M_e – maximum torque developed by the engine, Н·м;

$u_{тр}$ – transmission ratio of the vehicle;

r – the rolling radius of the driving wheels of the vehicle, м;

$\eta_{тр}$ – Transmission efficiency.

Braking properties – a set of properties that determine the maximum deceleration of the car when it is moving on various roads in braking mode, the limit values of external forces, under the action of which the braked car is securely held in place or has the necessary minimum steady speeds when driving downhill. The braking properties of rolling stock in mountainous conditions are characterized by the presence of a mountain brake.

Maneuverability is a group of properties that characterize the ability of a car to change its position in a given way on a limited area in conditions requiring movement along paths of great curvature with a sharp change in direction, including reversing.

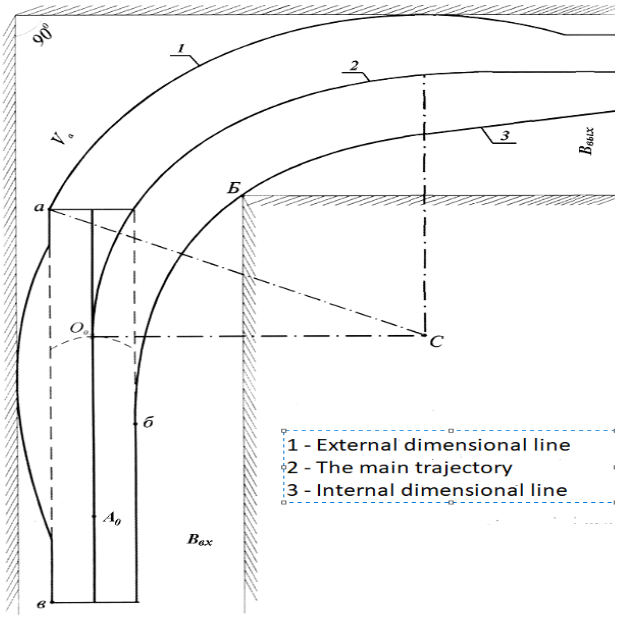

Fig 6. Overall lane of the road train

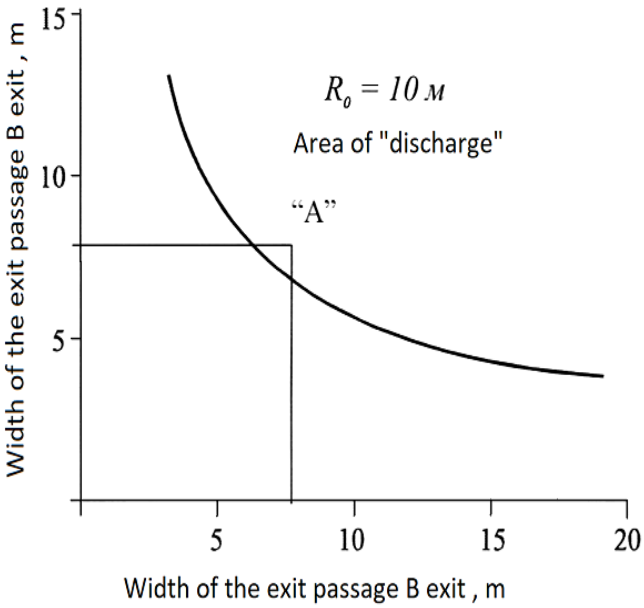

Fig. 7 Maneuverability characteristic

When assessing the maneuverability of a road train, an important characteristic is the overall lane.

Maneuverability or fit-in of a road train on turns can be determined by the computational and graphical method. Having drawn a scheme for determining the overall lane of the car (Fig.6.), you can get a curve (Fig.7), which divides the graph field into two areas: above the curve is the area of "fit-in" of the road train in a rectangular passage (for example, for the narrowest sections of the road, point "A"), under the curve – the area of "non-fit".

It is also possible to determine the maneuverability factor for mountain roads with a turning radius of R = 10 m.

Maneuverability factor for the car:

$$M = \frac{B_0}{B_\Gamma} \qquad (2.)$$

where A_0 – overall width of vehicles on the widest link;

A_Γ- the width is equal to a wide rectangular passage, in which the overall lane of the rolling stock completely "fits".

Passability is an operational property that determines the possibility of driving a car in degraded road conditions, off-road and when overcoming various obstacles. Passability, which determines the possibility of driving a car in degraded road conditions, off-road and when overcoming various obstacle.

The passability is divided into profile and reference. Profile passability characterizes the ability to overcome the irregularities of the path, obstacles and fit into the required lane. The basic passability determines the possibility of movement in degraded road conditions and on deformable soils.

Most of the single indicators of profile passibility are the geometric parameters of cars and trailers. Profile passability of vehicles in accordance with GOST 22653-77 is evaluated according to the following single indicators:

1) the ground clearance; 2) the front (rear) overhang; 3) the angle of the front (rear) overhang; 4) the longitudinal radius of patency; 5) the greatest angle of the ascent to be overcome; 6) the greatest angle of the slope to be overcome; 7) the vertical and horizontal angle of flexibility, determined according to GOST 2349-75 and GOST 12105-74.

The greatest angle of ascent overcome by a road train i_{max}, which is regulated by GOST R 52280-2004, must be at least 18%. Since the speed of movement is small when overcoming the maximum angle of ascent, then we can take $P_в$=0 и f=0,02. In this case, to overcome the angle of ascent i_{max} the engine must develop M_{kmax}. Using the power balance equation , you can write:

$$\frac{M_{k\max} u_T}{r_Д} \cdot \eta_{тр} = G_a f_o \cos\alpha_{\max} + G_a \sin\alpha_{\max} = G_a (f_o \cos\alpha_{\max} + \sin\alpha_{\max}) =$$
$$= \sqrt{f^2 + 1^2} G_a \cdot \sin(\alpha_{\max} + \gamma) \approx G_a \cdot \sin(\alpha_{\max} + \gamma) \quad (3.)$$

where, $tg\gamma = f = 0.02$, $\gamma = 2°$

From the obtained results of the calculated characteristics of the maneuverability of vehicles in the composition of the considered it follows that vehicles can move along sections with sharp turns of the road.

Handling – driving a car is the main production function of the driver. The main purpose of motor vehicles is the movement of goods or passengers, therefore, management should be understood as the purposeful organization of the movement process.

Smooth running – smooth running is understood as a set of properties that provide a limitation within the established norms of vibration load of the driver, passengers, cargo, chassis and body elements. Vibration load standards are set so that on the roads for which the car is intended, in the range of operating speeds, the vibrations of the driver and passengers do not cause them unpleasant sensations and rapid fatigue, and the vibrations of cargo, chassis elements and bodywork – their damage.

Fuel efficiency is a set of properties that determine fuel consumption when a vehicle performs transport work in various operating conditions.

The fuel efficiency of a car is largely determined by such engine indicators as hourly fuel consumption Gt, kg / h – the mass of fuel consumed in one hour, and specific fuel consumption ge, g / (kWh) - the mass of fuel consumed in one hour per unit of engine power.

The main measure of the fuel efficiency of a car in Uzbekistan is the fuel consumption in liters per 100 km of distance traveled (travel consumption) l.

To assess the efficiency of fuel use when performing transport work, fuel consumption per unit of transport work (100 t. km)l is used - the ratio of actual fuel consumption to the transport work performed.

According to GOST 20306-85 , the estimated fuel efficiency indicators are:

1) control fuel consumption (CFC);

2) fuel consumption in the main driving cycle on the road (FCMDCR);

3) fuel consumption in the urban driving cycle on the road (FCUDCR);

4) fuel consumption in the urban cycle at the stand (FCUCS);

5) fuel characteristics of steady motion (FCH);

6) fuel - speed characteristics on the main –hilly road (FSCH).

Stability is a set of properties that determine the critical parameters for the stability of movement and the position of a vehicle or its links, multi-link road trains consider the conditions for the stability of movement of each of the links. Stability is assessed by the parameters of an unstable link.

The parameters of undisturbed motion that define the boundaries between stability are called critical.

Sometimes the boundary conditions of stability and instability are determined not by the parameters of movement, but by the position of the car or its links in the stability space of the position. The critical conditions are determined by the transverse and longitudinal slopes of the road relative to the horizontal plane.

The value of the critical parameters of movement or position significantly depends on some properties of the car, determined by its design parameters.

The critical parameters of movement and position are estimated indicators of stability. There is no generally accepted system for assessing sustainability. In the future, when considering the physical processes that form these properties, we will use the following main evaluation indicators:

Critical speeds $V_{кр.\varphi}$ by side slip и $V_{кроп}$ by side rollover;

Critical speeds $V_{кр.\varphi}$ by course stability и $V_{кроп}$ road train by the wagging of the trailer.

Often violations of stability are manifested in the lateral slip of the wheels or rollovers of the car in a plane perpendicular to the longitudinal axis. Disturbing forces can be: the component of the inertia force, the transverse component of the gravity force $G_a \sin\beta$, resulting from the transverse slope of the road at an angle B, the aerodynamic force P_w.

Loss of stability in a rollover is more dangerous than in a side slip. Therefore, the car tends to be designed in such a way that

$V_{кр.\varphi} \geq V_{кр\ оп}$

The methodology for choosing rolling stock for mountainous operating conditions is carried out in the following sequence:

- the values of operational properties determined by theoretical and experimental studies are analyzed;

- for each factor of the operational properties of rolling stock, the rolling stock with the best indicators is determined;

- the rolling stock with the best indicators for all factors is analyzed, the rolling stock is selected for operation in mountainous conditions.

The final choice of rolling stock for mountain operating conditions is carried out taking into account the adaptability of the rolling stock design and analysis.

Analyzing the results of this explanation of the phenomena given in the formulas, we can come to the following conclusions: the sliding of the car towards the side of the road at its slightest slope occurs at the moment of sudden braking; this methodological explanation is of great practical importance when comparing the results of the calculations performed with the data obtained experimentally; also, the correspondence of the results of approximate calculations performed by numerical methods with the results of accurate calculations performed using methods of higher mathematics: To increase the speed of calculations, electronic computers are currently used, performing tens of millions of arithmetic operations in 1 second.

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