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STUDY OF THE FORCE LOAD OF A CAR WHEEL WHEN IT RUNS OVER AN OBSTACLE

The operational properties of the car system determine the car system's performance of its production functions (that is, the properties that determine the average speed of movement, fuel consumption, traffic safety, the ability to drive on and off various roads, and the like).

Qualified manufacturers define the main operational properties of the automotive system as dynamism, fuel economy, controllability, stability, smoothness of movement, passability, capacity, strength, reliability, durability, adaptability of the car to maintenance and repair, adaptability to loading and unloading operations.

The main characteristic of the automobile system from the point of view of accident-free operation is its dynamism, which is characterized by maximum speeds of straight-line movement in various road conditions, as well as the ability to quickly change the speed of movement and encounter an obstacle without an accident. The dynamics of the automobile system includes traction and braking dynamics. Traction dynamics is determined by the maximum speeds and accelerations of movement, and braking dynamics is determined by the ability to quickly reduce the speed of movement.

The article examines the dynamics of the movement of the car wheel of the car system and the interaction of the wheel drive of the truck with the obstacle of the supporting surface, which allows the process of moving the truck to be subordinated to the process of rolling directly through the resistance of the obstacle of the supporting surface. For this purpose, a physico-mathematical model of the movement of a car wheel through an obstacle of the support surface was proposed, which also corresponds to the movement of the wheel drive of a truck.

When developing a mathematical model, a theorem was used that describes the occurrence of a kinetic moment when a car wheel hits an obstacle on a support surface. Calculations and graphical dependencies were performed in the Excel environment. The results of these calculations showed the zone of the most effective operation of the wheel drive rolling with the help of rotary motion.

Key words: *car wheel, barrier, support surface, car, resistance, movement, rolling.*

Formulation of the problem. In world practice, the movement of car wheels through an obstacle of a support surface has not been solved in a justified way, and therefore the substantiation of the physical parameters of overcoming an obstacle with a car wheel is necessary.

Analysis of recent research and publications. New powerful trucks play a major role in increasing efficiency in the transportation of large volumes of cargo. New trucks must have increased energy density and work at higher speeds. For this, it is necessary to work out the constructive development of new technological solutions, as well as to substantiate the main parameters that are related to the rolling of the wheel drive of the car in adverse conditions.

When the undercarriage of a truck interacts with the ground, it deforms. The deformation remains in the form of a rut, as well as in the momentary deformation of the tire under the influence of solid fractions of the supporting surface. The possibility of movement, carrying out transportation and technological operations in conditions of weakly bearing supporting surfaces has a great impact on the development of the economy and infrastructure in these regions where the car is operated. Only a vehicle with a small pressure of the engines on the ground can move on a support base with a low bearing capacity.

The efficiency of truck operation in difficult road conditions is largely determined by their passability. The problem of the passage of trucks on supporting surfaces with low bearing capacity is solved mainly by improving the design of the engines. In general, leading global companies that produce trucks make the following requirements for engines:

– maximum efficiency (increasing traffic flow and safety);

– versatility (possibility of use in a wide range of operating conditions);

– high traction and traction qualities;

– minimal traffic losses;

– rational interaction with the supporting surface from the point of view of preserving its ecology;

– qualitative indicators of manageability and stability;

– good elastic and shock-absorbing properties;

– good self-cleaning;

– high indicators of strength and reliability, sufficient wear resistance and durability;

– ease of use (simplicity and speed of installation, disassembly and repair of engines);

– light weight and low cost.

These requirements are met by pneumatic tires that complement the wheel drive of a truck. Pneumatic tires are one of the simplest and most effective means of increasing the passability of wheeled vehicles. By varying the main tire parameters (size, shape, number of layers, cord, material, internal pressure, pattern and depth of the tread) within wide limits, it is possible to change the coefficients of adhesion and rolling resistance, as well as the contact plane between the wheel drive and the support surface and, accordingly, the pressure on it.

Use of wheel drives allows you to provide trucks with high speeds and economical indicators.

The development of pneumatic wheel drives in the direction of increasing patency was the creation of highly elastic ultra-low pressure tires on the basis of existing wide-profile tires. Such ultra-low-pressure tires have a thin-walled rubber cord shell with a frame that is structurally composed of, as a rule, six of two layers of cord, thanks to which its high elasticity.

When rolling a wheel with a similar tire, the stress in the contact zone of this tire with the supporting surface is distributed very evenly both along the length and across the width of the contact with the supporting surface, reducing the ultimate load on the soil protrusions and preventing its destruction. When interacting with the soil, such a tire does not destroy its surface and acquires the ability (to flow around) unevenness of the road, and the protrusions and depressions of the tread repeat the profile of the road surface, perform the role of soil grips, increasing adhesion to the supporting surface [2, p. 46].

Highlighting previously unresolved parts of the overall problem. An assessment of the dynamics of complex cases of a car wheel encountering a moving obstacle is impossible without taking into account the processes that arise as a result of the load forces of the wheel drive. At the same time, for many automotive systems, the action of such a power load is not something a side phenomenon from which, if possible, they are freed, and a process that can and should be managed. Management is impossible without the development of an adequate mathematical model that reflects the main laws and characteristics of the collision process, which must be used.

Setting objectives. To develop a mathematical model of the rolling of the wheel drive of a truck using the equations of the influence of variable parameters on this process, for which calculations and graphical dependencies should be performed in the “Excel” environment. The results of these calculations should show the zone of the most effective rolling of the wheel drive with the help of the traction force compensator.

Presentation of the main research material. Road conditions are characterized by the parameters of the area in which the car is operated, the parameters of the support surface on which it moves, the stability of the state of the support surface, the intensity and organization of traffic. Some parameters of road conditions (those that determine the quality of the supporting surface) can be used in the design of cars and included in their operational characteristics, as well as in the development of individual units and components of the car.

When developing the structure, it is necessary to take into account the geometric parameters of the profile of the support surface, that is, the angles of ascents or descents and its physical and mechanical characteristics.

Consider the movement of a car wheel when it meets a moving obstacle (Fig. 1).

As a result of the collision of a car wheel with road damage, the rolling energy of the car wheel is transformed into the energy of its rolling over the barrier.

Let’s assume that the impact of a car wheel with an obstacle is inelastic and we neglect the road resistance. Also, let’s take it as a hypothesis that when a car wheel hits when crossing an obstacle, a momentary center of rotation appears, so-called

Calculation method. Angular speed of rotation of a car wheel when it moves over an obstacle.

To find the angular velocity, let’s turn to the theorem that describes the occurrence of a kinetic moment when a car wheel hits an obstacle [1, p. 335–353]:

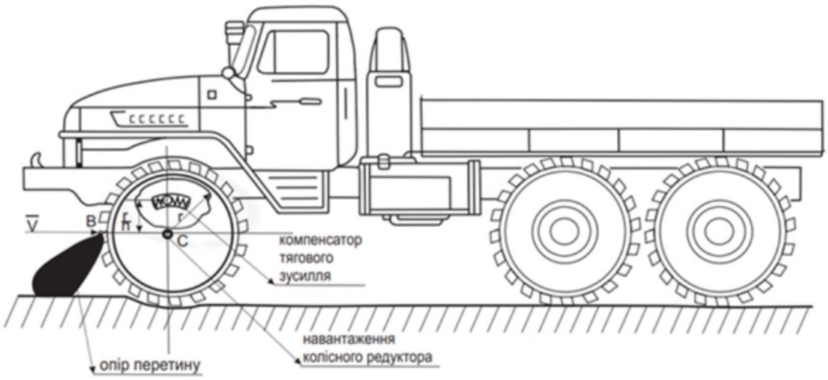

Figure 1. Scheme of the meeting of a car wheel with an obstacle

$$L_a - L_O = \sum M[S] \qquad (1)$$

According to this theorem, during the impact of a car wheel relative to the instantaneous axis of rotation, the kinetic moment of the whole system “car wheel-obstacle” changes. At the suggestion of L. M. Petrov, we are introducing an innovative device “traction force compensator” into the automobile system – the wheel drive at the O point of the wheel drive disk.

The “car wheel-obstacle” system, which is loaded with a shock pulse (Fig. 2).

The equation of moments during the impact of a car wheel with an obstacle takes the form

$$L_a - L_O = \sum M\,[S_O] \qquad (2)$$

Let’s assume that during the impact the obstacle acquired a speed of V, then the kinetic moment relative to the O axis of the considered system takes the form:

$$L_O = \frac{P}{g} \cdot V \cdot \frac{r}{2} \qquad (3)$$

After a car wheel collides with an obstacle, the car wheel will rotate with an angular velocity ω and the obstacle will move together with the car wheel (the impact is not elastic).

So

$$L_\Sigma = L_1 + L_2 \qquad (4)$$

Since the axes of rotation are parallel, we determine the moment of inertia of a car wheel using the formula:

$$I_1 = \frac{Q}{g} \cdot \frac{r^2}{2} + \frac{Q}{g}\left(\frac{r}{2}\right)^2 \qquad (5)$$

and the moment of inertia of the obstacle is determined by the formula:

$$I_2 = \frac{P}{g}(\mathrm{OB})^2 \qquad (6)$$

Let’s assume that point O is at a distance of r/2 from point C, then formula (4) takes the form presented in (7).

Substituting (5) and (6) into formula (4), we obtain the total kinetic moment of inertia of the system:

$$L_\Sigma = \frac{r^2}{4 \cdot g}(5 \cdot P + 3 \cdot Q) \cdot \omega \qquad (7)$$

After substituting formula (3) into formula (7), the mathematical dependence for determining the angle speed of rotation of the “car wheel-obstacle” system takes the form:

$$\omega = \frac{2 \cdot P \cdot V}{(5 \cdot P + 3 \cdot Q)}$$

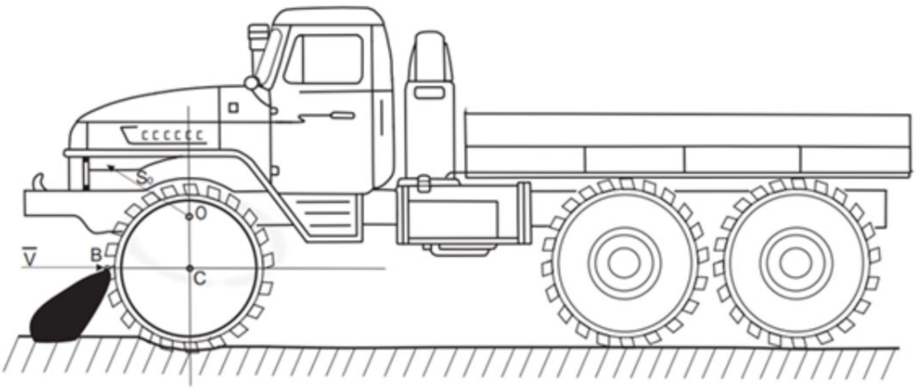

Figure 2. Loading of the “vehicle system-obstacle” with a shock pulse

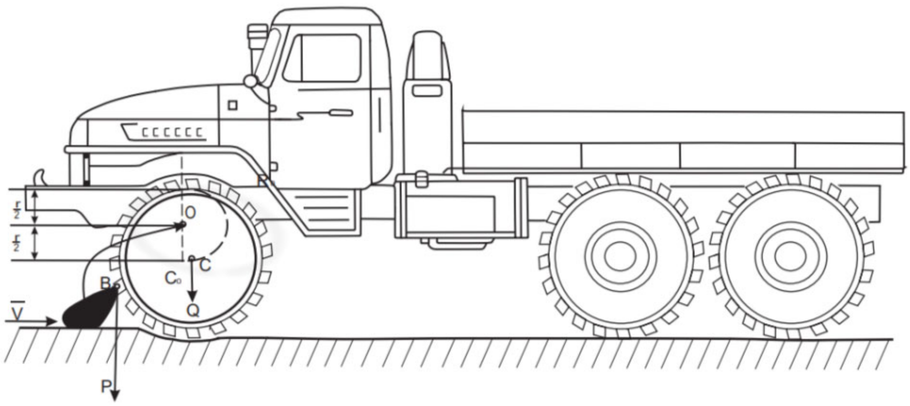

Figure 3. Diagram of the power load of a wheeled motor when rolling it over an obstacle

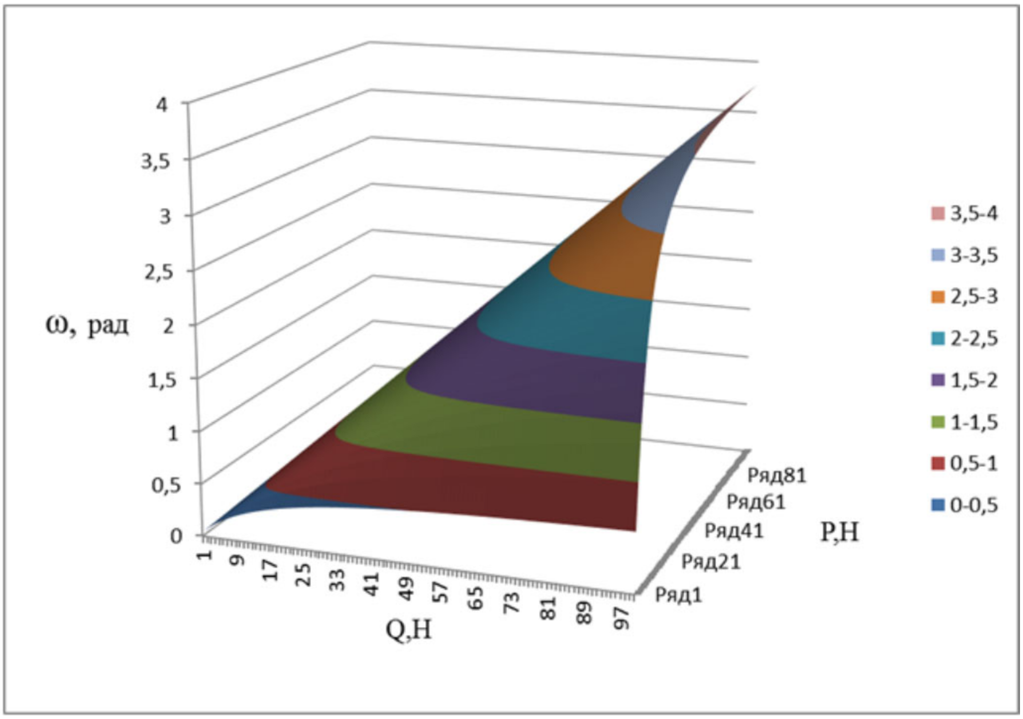

Figure 4. Dependence of the angular speed of rotation of the "Car wheel-obstacle" system on the weight of the car wheel Q and the collision force P of the car wheel with the barrier

The scheme of the power load of the wheeled motor when it rolls over the barrier is presented (Fig. 3).

Dependence of the angular speed of rotation of the "Car wheel-obstacle" system on the weight of the car wheel Q and the collision force P of the car wheel with the barrier (Fig. 4).

Conclusions and prospects for further research. According to the calculations, it can be concluded that the speed of rolling of a car wheel through an obstacle is more affected by the impact force than the weight of the car wheels The use of the innovative device "traction compensator" on the drive wheel effort" can significantly improve the dynamics of its rolling and reduce dynamic loads on automotive system as a whole.

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Петров Л.М., Кішянус І.В., Петрик Ю.М. ДОСЛІДЖЕННЯ СИЛОВОГО НАВАНТАЖЕННЯ АВТОМОБІЛЬНОГО КОЛЕСА ПРИ ПЕРЕКОЧУВАННЯ ЇМ ЧЕРЕЗ ПЕРЕПОНУ

Експлуатаційні властивості автомобільної системи визначають виконання автомобільною системою своїх виробничих функцій (тобто властивості, що визначають середні швидкості руху, витрати палива, безпеку руху, можливість руху по різноманітних дорогах і поза ними та тому подібне). Основними експлуатаційними властивостями автомобільної системи кваліфіковані виробники визначають як то динамічність, паливна економічність, керованість, стійкість, плавність ходу, прохідність, місткість, міцність, надійність, довговічність, пристосованість автомобіля до технічного обслуговування і ремонту, пристосованість до вантажно-розвантажувальних робіт. Основною характеристикою автомобільної системи з точки зору безаварійної експлуатації є її динамічність, яка характеризується максимальними швидкостями прямолінійного руху в різноманітних дорожніх умовах, а також спроможністю швидкої зміни швидкості руху та безаварійну зустріч з перепоною. Динамічність автомобільної системи включає тягову і гальмівну динаміки. Тягова динаміка визначається максимальними швидкостями і прискореннями руху, а гальмівна динаміка – спроможністю швидкого зменшення швидкості руху.

У статті розглянуто динаміка руху автомобільного колеса автомобільної системи та взаємодії колісного рушія вантажного автомобіля з перепоною опорної поверхні, що дозволяє процес переміщення вантажного автомобіля підпорядкувати процесу перекочування безпосередньо через опір перепони опорної поверхні. З цією метою була запропонована фізико-математична модель руху автомобільного колеса через перепону опорної поверхні, що також відповідає руху колісного рушія вантажного автомобіля. При розробці математичної моделі використано теорему, яка описує виникнення кінетичного моменту під час удару автомобільного колеса у перепону опорної поверхні. Розрахунки та графічні залежності виконувались у середовищі «Excel». Результати по цим розрахункам показали зону найбільш ефективної роботи коченню колісного рушія за допомогою обертального руху.

Ключові слова: *автомобільне колесо, перепона, опорна поверхня, автомобіль, опір, рух, перекочування.*