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THE INTERACTION OF POTENTIAL AND KINETIC ENERGY ON THE WHEEL WITH THE POTENTIAL AND KINETIC LOAD OF THE TRUCK

In the article "Interaction of potential and kinetic energy on a wheel with the potential and kinetic load of a truck" by the authors L.M. Petrova, I.V. Kishianusa, Yu.M. Petryka, V.A. Nikishina, A.V. Rudenka, materials are given that highlight the interaction of potential energy pressing on a wheel with a potential and kinetic load and its transformation into kinetic energy of a wheel with a potential and kinetic load by dividing the potential and kinetic energy into primary and secondary motion.

The movement of the car is carried out with the help of wheeled motors, which partially satisfy the performance of technological tasks in the zone close to combat. The main drawback is the fulfillment of the requirements for moving a military vehicle in difficult conditions, especially when performing combat missions, and in some cases, the impossibility of moving it, which will affect its survivability. To increase the reliability of the technology of moving a car in difficult conditions, the development of world-class specialists is aimed at improving the design of its suspension, as well as the technology of moving vehicles in difficult operating conditions.

The purpose of the study is to improve the design of the load scheme of the wheel drive when it moves over an obstacle, and as a result, the transformation of the energy supplied to the wheel drive and movements according to a certain number of kinematically-distributed in the wheel drive into the controlled movement of the vehicle relative to the wheel with the addition of the traction force of the vehicle with the transfer forces movement, which is an auxiliary factor to the innovative technology of its movement.

The conducted research showed the results of the work carried out, which will make it possible to make a contribution to the field of domestic mechanical engineering.

The proposed model of the vehicle is suitable for use in order to increase the driving capabilities when they perform combat tasks.

Key words: *wheel with potential and kinetic load, potential energy, kinetic energy, primary motion, secondary motion, difficult conditions.*

Formulation of the problem. Military vehicles that perform tasks in difficult operating conditions receive the action of external forces, as well as shocks from the side of the road, while various movements and oscillations of vehicles appear along the longitudinal, transverse and vertical axes.

In order to pose and solve the problem of the occurrence of negative forces and shocks during the movement of the car on its comfort, safety and high-quality performance of combat tasks, it is necessary to qualitatively select and perform kinematic connection to achieve better characteristics of elastic suspension elements and shock absorbers, and also contribute to increasing the traction capabilities of the car.

Highlighting previously unresolved parts of the overall problem

The evolution of the creation and development of mechanical vehicles began several thousand years

ago with the creation of the first type of motor – the wheeled one on the (fig. 1).

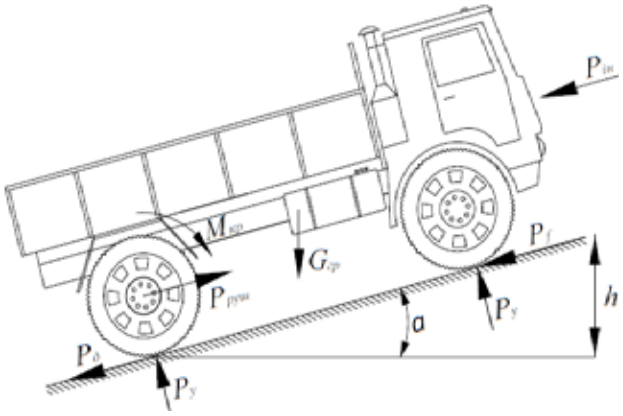
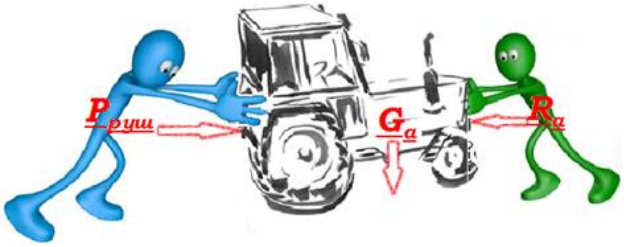


Fig. 1. Power load of a military vehicle
$P_{гак}$ – traction force of the car; $P_д$ – tangential traction force of the car; P_f – the force of rolling resistance of the wheel drive of the car; P_i – the car's lifting resistance; $P_{ін}$ – inertia force; $P_{руш}$ – driving force of the car; $G_{тр}$ – operating weight of the car; P_y – the force of the road's reaction to the car's transmission

The movement of the vehicle is carried out with the help of wheel drives, which partially satisfy the performance of technological tasks in the zone close to combat. The main disadvantage is the fulfillment of the requirements for moving the vehicle in difficult operating conditions, and in some cases the impossibility of moving it at all.

In order to increase the reliability of the technology of moving vehicles in difficult conditions, the development of specialists of the world is aimed at improving the design of the suspension, as well as the technology of moving in difficult operating conditions.

Setting objectives. In order to increase the reliability of the movement of a vehicle performing a combat mission, the authors proposed a technology for this vehicle with modernized wheeled motors, the movement of which, when overcoming difficult road conditions, is supported by inertial components that are formed during the movement of the vehicle.



Presentation of the main research material

Scientists of many countries, who are leaders in the field of creating cars with modern technologies, did not pay attention to the interaction of energies (potential and kinetic).

The scheme regarding the load of the truck is shown in (fig. 2).

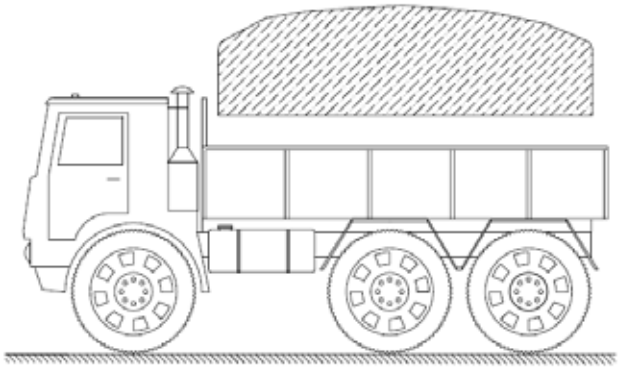


Fig. 2. A diagram showing a truck before it is loaded

In (fig. 3) shows the loading of the truck with the operating weight, which creates the primary movement of the wheel with potential and kinetic load.

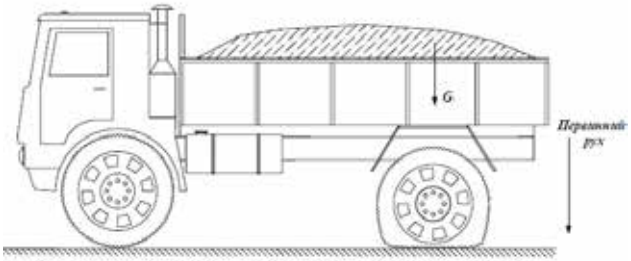


Fig. 3. Scheme of a truck with the primary movement of a wheel drive

In (fig. 4) shows a truck with a wheel force load with potential and kinetic load under the action of secondary motion.

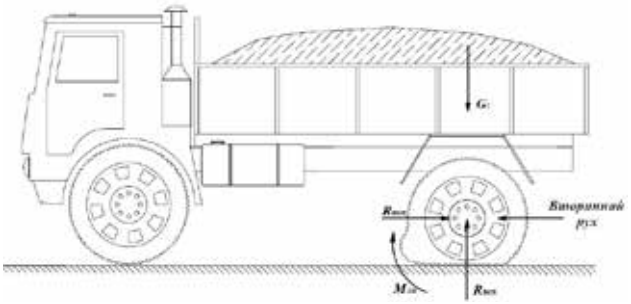


Fig. 4. Scheme of a truck with a power load of a wheel with potential and kinetic load under the action of secondary motion

The physical model of primary and secondary movements of a car wheel with potential and kinetic load is shown in (fig. 5, 6).

As can be seen from (fig. 3, 4), the following forces are applied to ensure the movement of the car:

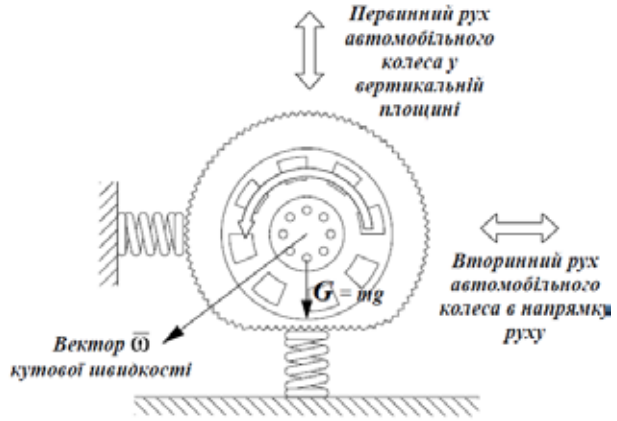


Fig. 5. Physical model of a car wheel with potential and kinetic load under the action of primary and secondary motions

– load of the wheel with potential and kinetic load from the operating weight (primary movement of the wheel with potential and kinetic load from the vertical component of the operating weight G, which deforms the flexible part of the wheel with potential and kinetic load and which contributes to the emergence of a vertical reaction from the support surface);

– the load of the wheel with potential and kinetic load from the torque applied to the wheel with potential and kinetic load from the car transmission (secondary movement of the wheel with potential and kinetic load, which contributes to the appearance of the horizontal reaction of the support surface and the moment of rolling resistance of the wheel with potential and kinetic load) .

This distribution of many forces on the wheel with potential and kinetic load contributes to the appearance of both useful and negative moments that can improve or worsen the movement of the car [2, 3 p. 1–3].

For the proposed mechanical system "wheel with bi-dynamic load", the Lagrange equation was drawn up, in which the perspective of the competition of the kinetic and potential energy of the wheel with the potential and kinetic load is embedded. In the general case, for the degree of freedom, the Lagrange equation, taking into account the kinetic and potential energy, is reduced by the author to the formula (1):

$$\frac{d}{dt}\left(\frac{\partial L}{\partial q_i}\right) - \frac{\partial L}{\partial q_i} = Q_i, \qquad (1)$$

where,

$L=T-П$ – the Lagrange function; T, П – total stock, respectively, kinetic and potential energy of the system; Q_i – generalized non-conservative forces.

Also to the authors [1, p. 123–133,145–147] as generalized coordinates, the following variables are adopted: horizontal movement of the wheel with potential and kinetic load – x and angular movement of the wheel driver – φ.

At the same time, the kinetic and potential energy of interaction on the wheel with the potential and kinetic load of the truck will be determined by the formulas:

$$T = m_1 + m_2\frac{x^2}{2} + m_2 lx\varphi cos\varphi + J\frac{\varphi^2}{2};$$

$$П = -m_2 glcos\,\varphi,$$

where, $J = l^2 \cdot m_2$ – moment of inertia of operating weight;

m_1 – car weight;

m_2 – operational weight

Thus, the Lagrange function for a truck can be written as:

$$L = T - П = m_1 + m_2\frac{x^2}{2} + m_2 lx\varphi cos\varphi + J_{zp}\frac{\varphi^2}{2} + m_2 glcos\varphi \qquad (2)$$

The generalized forces corresponding to the accepted generalized coordinates will have the form:

$$Q_x = F \qquad (3)$$

$$Q_\varphi = 0 \qquad (4)$$

F – is the force responsible for the secondary movement of the wheel loaded with the primary movement with potential and kinetic load.

The potential energy of a flexible tire is similar to the case of translational movements, except for the angular stiffness of the elastic metal cord:

$$E_p = \frac{k_1}{2}\alpha_1^2 + \frac{k_2}{2}\alpha_2^2. \qquad (5)$$

Here k_i are the constants of the angular stiffness of the metal cord. Substitution of the obtained expressions of kinetic and potential energies into the Lagrange equation leads to rather large equations that are difficult to analyze. At the same time, these equations are nonlinear due to the presence of sinusoidal and cosine functions from the generalized variables α_1 і α_2.

However, taking into account that elastic suspensions usually do not allow.

large angular deviations, it is reasonable to assume that angles α_1 і α_2 are small [4, p. 331–335].

Calculations of kinetic and potential energy were carried out in the environment Excel.

Table 1 shows the calculations of potential energy carried out depending on K_2 and α^2.

Table 1

Calculation of potential energy

E_n	K_2	α_2
0,2	10	0,2
28,8	40	1,2
169,4	70	2,2
512	100	3,2
1146,6	130	4,2
2163,2	160	5,2
3651,8	190	6,2

Table 2 shows the calculations of kinetic energy carried out depending on R, m, ω.

Table 2

Calculation of kinetic energy

E_k	R	m	ω
0,004	0,2	5	0,2
4,608	0,4	40	1,2
65,34	0,6	75	2,2
360,45	0,8	110	3,2
1278,9	1	145	4,2
3504,4	1,2	180	5,2
8099,3	1,4	215	6,2

The results of the calculations are shown in (fig. 5).

According to the results of the conducted scientific work, for the first time, an unaccounted part of the energy of the interaction of kinetic and potential energy was discovered, which manifests itself on the graph in the form of an area that is sandwiched between the lines that create: 1 line – potential energy; the second line is kinetic energy. Kinetic and potential energy on the graph are functions depending on the change in angle α by time and angular velocity ω by time. The smaller this area on the graph, the faster potential energy is transformed into kinetic energy and the more dynamic the "wheel with bi – dynamic load" becomes

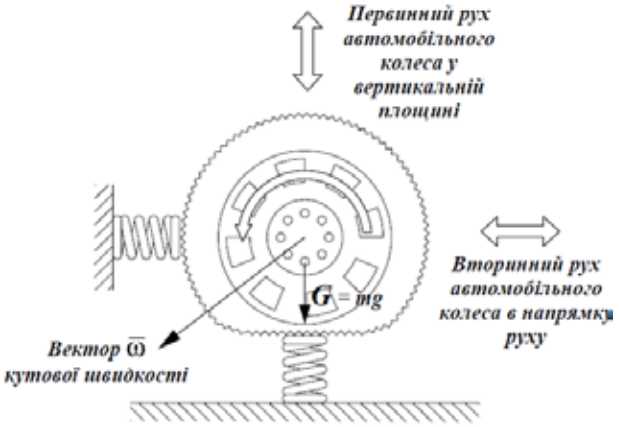


Fig. 5. Dependence of kinetic and potential energy on variables α і ω

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ВЗАЄМОДІЯ ПОТЕНЦІЙНОЇ І КІНЕТИЧНОЇ ЕНЕРГІЇ НА КОЛЕСІ З ПОТЕНЦІЙНИМ ТА КІНЕТИЧНИМ НАВАНТАЖЕННЯМ

Приведені матеріали, які висвітлюють взаємодію потенційної енергії, яка тисне на колесі з потенційним та кінетичним навантаженням і її перетворення на кінетичну енергію колеса з потенційним та кінетичним навантаженням шляхом розділення потенційної і кінетичної енергії на первинний і вторинний рух.

Рух машини здійснюється за допомогою колісних двигунів, які частково задовольняють виконання технологічних завдань у зоні, наближеній до бойової. Основним недоліком є виконання вимог щодо пересування військової машини в складних умовах, особливо при виконанні бойових завдань, а в окремих випадках і неможливість її пересування, що вплине на її живучість. Для підвищення надійності технології руху автомобіля в складних умовах розробки фахівців світового рівня спрямовані на вдосконалення конструкції його підвіски, а також технології руху транспортних засобів в складних умовах експлуатації.

Метою дослідження є удосконалення конструкції схеми навантаження колісного приводу при його переміщенні через перешкоду і, як наслідок, перетворення підведеної до колісного приводу енергії та переміщень за певною кількістю кінематично-розподілених в колісному приводі в керований рух транспортного засобу відносно колеса з додаванням тягового зусилля транспортного засобу з передавальним зусиллям руху, що є допоміжним чинником інноваційної технології його руху.

Проведене дослідження показало результати проведеної роботи, що дозволить зробити внесок у галузь вітчизняного машинобудування.

Пропонована модель автомобіля придатна для використання з метою підвищення ходових можливостей при виконанні ними бойових завдань.

Ключові слова: *колесо з потенційним і кінетичним навантаженням, потенційна енергія, кінетична енергія, первинний рух, вторинний рух, складні умови.*