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MODELLING OF THE WORK OF THE PROPULSION WHEEL OF A TRACTION VEHICLE UNDER THE DYNAMIC LOAD

Summary: The article presents an analysis of the accumulation of elastic energy with a dynamic weight with the subsequent transfer of this energy into the process of moving the wheelbase of the vehicle, which provides a reduction of the total energy consumption and a high level of efficiency of running systems energy resources.

Keywords: wheel propulsion, car, bearing surface, dynamic masa, wheel disk

MODELOWANIE PRACY KOŁA NAPĘDOWEGO CIĄGNIKA W WARUNKACH OBCIĄŻENIA DYNAMICZNEGO

Streszczenie: W artykule przedstawiono analizę akumulacji elastycznej energii z uwzględnieniem masy dynamicznej, a następnie transferu tejże energii w obrocie koła napędowego pojazdu (ciągnika). W procesie następuje redukcja zużycia energii całkowitej oraz proces ten cechuje się wysokim poziomem efektywności energetycznej.

Słowa kluczowe: koło napędowe, pojazd, masa dynamiczna, tarcza koła

Introduction

The development of vehicles expands the range of designs of wheeled motors on pneumatic tires and stimulates the intensification of research and development work that is aimed at more fully satisfying operational requirements, reducing weight and improving the technology of real-time torque on the wheel.

The peculiarity of the working process of a wheel motor of a vehicle is the inconsistency of its dimensions, which is conditioned by the elastic deformation of the pneumatic tire when it interacts with the support surface. In this case, the degree of size change depends on the elastic properties of the tire. Such a characteristic has

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an important theoretical and practical significance, since it directly enters the equation of variations of the dynamic system of road-wheel-machine and is used in solving the problem of improving the quality of rolling stock rolling stock.

Analysis of existing designs of wheeled motors

In work [8], the method of transmission was first developed through the elastic wheel of the torque in the direction of rolling of the driving wheel. When creating a model of rolling of a driving wheel the author is suggested to take into account that the rim of the wheel has a particularly high tangential elasticity. Thanks to such a theory, it was found that the tire of the car tires has a high elasticity not only in the radial, but also in the tangential directions, and therefore the transmission of traction forces noticeably changes the radius of rolling of the driving wheel.

In [3], it was proposed to use the gravitational moment by introducing into the transmissions of a tractor of gravitational throw an equation for the force of support of the tractor movement was obtained.

In the works [1, 2, 4] the questions of the theory of a wheel propulsion with oscillator device, a flexible bandage and its pulse-power support are considered.

The purpose of research

The purpose of the research is to increase the qualitative indexes of wheel propulsion vehicles due to the accumulation of elastic energy of a flexible element with its realization in the contact spot of the reference surface.

Research results

A vehicle was proposed, the wheeled motor of which was loaded with dynamic weight [7], Fig. 1.

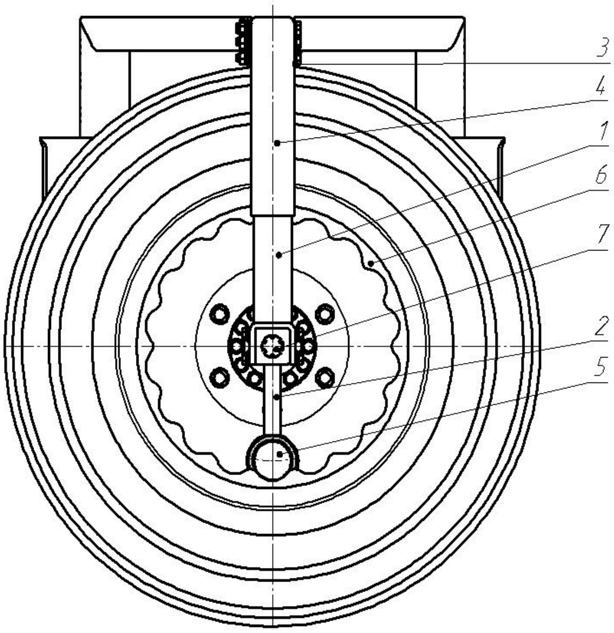

Figure 1. Vehicle with a wheel drive loaded with dynamic weight:
1 - telescopic stand; 2 - dynamic lever (flexible element); 3 - an edge of rigidity;
4 - guide; 5 - dynamic weights; 6 - comb; 7 - the axis

Consider the solution of the problem of energy accumulation with a dynamic weight with an elastic element, which subsequently turns into a vehicle's motion. First, let's consider the case when the dynamic lever (the flexible element) is not held in the contact area of the tire with the support surface, Figure 2.

In this case, the flexible element is not loaded with the moment M_0. Dynamic forces caused by the coupling of the tire of a wheel motor with a dynamic lever can be decomposed into two perpendicular components R_x and R_y .

That is selected so that it passes through the center of the wheel mover and dynamic lever.

The torque that acts on a flexible element counterclockwise is:

$$T = R_x \cdot r . \quad (1)$$

Where r - kinematic radius of the wheel;

R_x is the horizontal component of the tangential force of traction.

For a moment that acts at the contact point of the dynamic weight with the comb profile, determined by the coordinates x and y we will have:

$$M_0 = R_x (r + y) - R_y \cdot x = T\left(1 + \frac{y}{d}\right) - R_y \cdot x \ , \quad (2)$$

where d - wheel diameter;

R_y - Vertical component of the tangential force of traction;

M_0 - an additional moment of rolling resistance of the wheel propulsion.

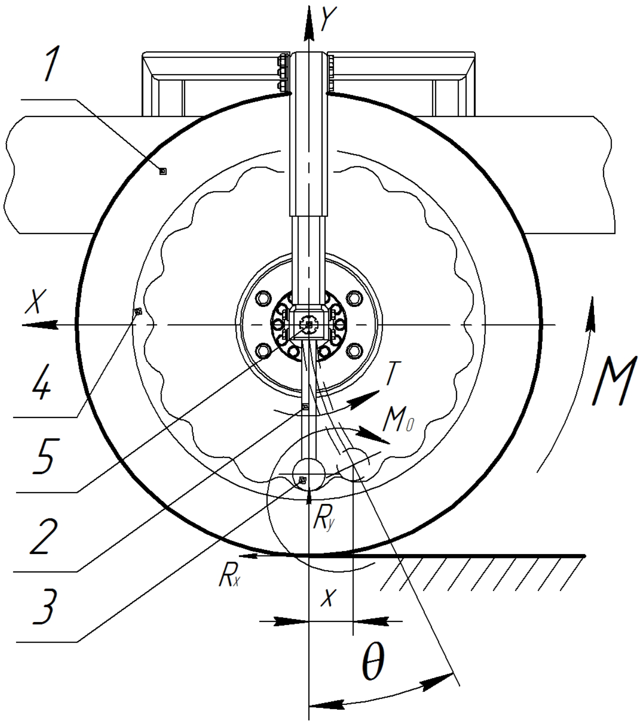

Figure 2. Scheme of a wheel propulsion with a dynamic load:
1 - driving wheel; 2 - dynamic lever (flexible element); 3 - dynamic weights;
4 - comb; 5 - fixed axle

The complete elastic energy of the flexion lever of a dynamic-flexible element will be determined from the formula [6]:

$$U = \frac{1}{2}\int_0^l \frac{M_0^2}{B} ds \tag{3}$$

where *B* - constant stiffness at bending;
l - the total length of the flexible element;
ds is the elementary distance.

Assuming that the point of application of the vertical component of the tangential thrust force R_y is immobile, then by the Castigliano theorem we obtain the equation of the angle of deflection:

$$\Theta = \frac{\partial U}{\partial R_y} = \frac{1}{B}\int_0^l M_0 \frac{\partial M_0}{\partial R_y} ds = -\frac{1}{B}\int_0^l \left(T\left(1+\frac{y}{d}\right) - R_y \cdot x \right) x\, ds \tag{4}$$

With the deviation of the dynamic weight with the simultaneous bending of the flexible element, by acting on the profile of the comb combustion wheel and moment of twisting T, we obtain the equation of the angle of loading of the wheel propeller:

$$\Theta = \frac{\partial U}{\partial R_y} = \frac{1}{B}\int_0^l M_0 \frac{\partial M_0}{\partial T} ds = \frac{1}{B}\int_0^l \left(T\left(1+\frac{y}{d}\right) - R_y \cdot x \right)\left(1+\frac{y}{d}\right) ds \tag{5}$$

From equation (4) we obtain:

$$R_y \int_0^l x^2 ds = T\int_0^l \left(x + \frac{xy}{d} \right) ds \tag{6}$$

From equation (5) we obtain:

$$B\Theta = T\int_0^l \left(1 + 2\frac{y}{d} + \frac{y^2}{d^2} \right) ds - R_y \int_0^l \left(x + \frac{xy}{d} \right) ds \tag{7}$$

Applying the concept of "approximate symmetry" the deviation and return of a flexible element with a dynamic weight to the initial state can be taken:

$$\int_0^l x\, ds = \int_0^l y\, ds = \int_0^l xy\, ds = 0 \tag{8}$$

Then from (6) and (7) we have:

$$R_y = 0 \ ; \qquad B\Theta = T\int_0^l \left(1 + \frac{y^2}{r^2} \right) ds \tag{9}$$

From (9) we have the expression for the moment of twisting:

$$T = \frac{B\Theta}{\int_0^l \left(1 + \frac{(l\cdot\Theta)^2 - (l\cdot\sin\Theta)^2}{r^2} \right) ds} \tag{10}$$

In the Matlab software environment, studies have been conducted on the twisting moment of the variables and B.

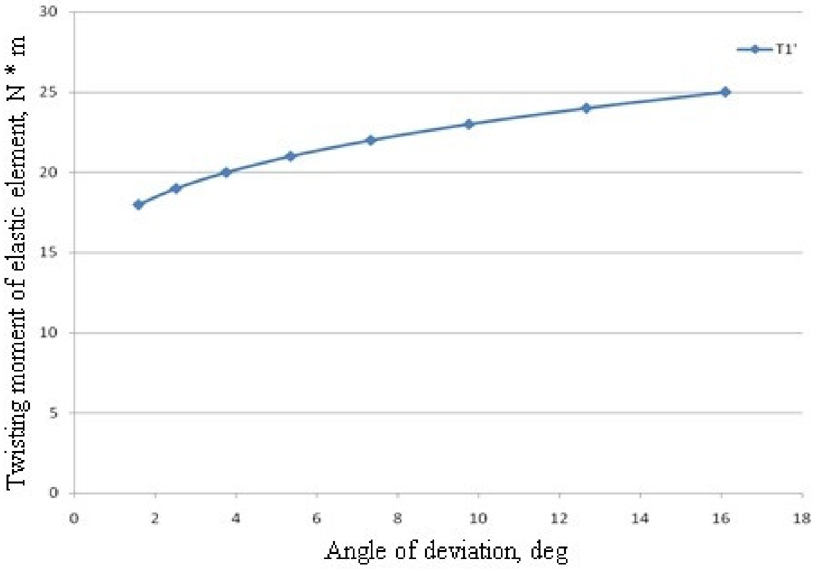

Figure 3. Dependence of the moment of twisting of the elastic element from the angle of deviation of the dynamic weight

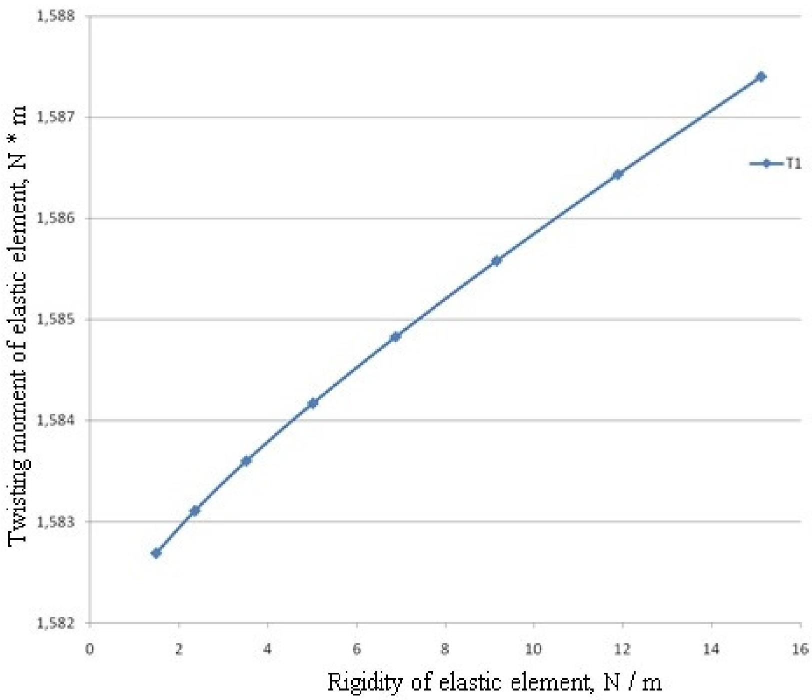

Figure 4. Dependence of the twisting moment on the stiffness of the elastic element

Conclusions

By means of theoretical calculations, the dependence of the moment of twisting of the elastic element on variable factors is established.

The parameters of the influence of angle loading on the elastic element on the wheeled motor, and also the influence of the stiffness of the elastic element at the moment of its twisting are revealed.

Figure 5. General view of the tractor with dynamic loading wheel propellers

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УКРАЇНА

ПАТЕНТ

НА КОРИСНУ МОДЕЛЬ

№ 85848

СПОСІБ ПЕРЕМІЩЕННЯ ТЯГОВО-ТРАНСПОРТНОЇ СИСТЕМИ ЗА ДОПОМОГОЮ ПОШТОВХУ КОЛІСНОГО РУШІЯ В ЗОНІ ЙОГО СТИСНЕННЯ ТА ОСЕРЕДКУ ОБЕРТАННЯ

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