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THE POSSIBILITTES OF CATERPILLAR TRACTOR TOWARDS ENERGY-SOWING

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Summary The mathematical dependence is received which gives evidence of energy accumulation at the torsion-caterpillar mover of tractor at the period of acceleration, which allows to minimize energy expenditures.

Key words: mathematical dependence, energy tractor expenditures

INTRODUCTION

The earlier determined value of tangent conventions of the wheel movers [Wielikanow 1962, Voenoe izdanie 1968, 1969, Voenizdat 1975, 1978, Yakovenko *et al.* 2002] makes it possible to create the technological charts of perfected movement of the tractor-transport facility (TTF) in accordance with the value of the torque, transmitted to the movers from the power unit [Tabore 1960, Ziemielew 1969, Ivanov *et al.*1970, Zabrodskii *et al.* 1986]. An increase of the torque is expected for the torsion – caterpillar movers.

We suggest considering the force (tangent tractor force), which is applied to a tractor-transport facility (TTF) at the period of its acceleration, as that, which is depending on its position at the beginning of acceleration:

$$F = F(x) \tag{1}$$

It is possible, in that case, that there exists a determined energy U(x) for the period of TTF system acceleration, that is correlated with the force on movers as:

$$F(x) = -\frac{dU(x)}{dx} \tag{2}$$

where:

U(x) – the energy, that determines the position of the TTF at the period of its acceleration.

As it is known in the theoretical mechanics [Voronkov 1965], the general movement equation looks as:

$$m \cdot \frac{dV}{dt} = F(x) \tag{3}$$

The time derivative is present in equation (3). And the force at movers is presented as *x* coordinate`s function. Therefore this equation cannot be solved immediately. It is necessary to find the values, that have an influence on the tractor-transport facility acceleration dynamics, as coordinate *x* function.

Investigations will be undertaken for the dependence of the velocity on the coordinate x. The time derivative *dv/dt* will be presented, in this case, as the derivative of the compound function, since the coordinate *x* depends on the time itself:

$$\frac{dV[x(t)]}{dt} = \frac{dV[x(t)]}{dx} \cdot \frac{dx}{dt} \tag{4}$$

In this way:

$$\frac{dV}{dt} = V \cdot \frac{dV}{dx} \tag{5}$$

From which:

$$m \cdot \frac{dV}{dt} = m \cdot V \cdot \frac{dV}{dx} = \frac{d}{dx} \cdot (\frac{mV^2}{2}) \tag{6}$$

The formula (6) will be put to the TTF movement equation (3) and next there will be obtained:

$$\frac{d}{dx} \cdot (\frac{mV^2}{2}) = F(x) \tag{7}$$

The formula (7) will be integrated and next there will be obtained:

$$\int_{V_0}^{V_1} \frac{d}{dx} \cdot (\frac{mV^2}{2}) \cdot dx = \int_{V_0}^{V_1} F(x) \cdot dx \tag{8}$$

But dx/dt is nothing else, as velocity *V(x)*. Or

$$\frac{m \cdot V_1^2}{2} - \frac{m \cdot V_0^2}{2} = \int_{x_0}^{x_1} F(x) \cdot dx \tag{9}$$

The physical sense of the dependence (9) is, that the changed kinetic energy is equal to the tangent force work at the wheel movers at the period of TTF acceleration.

Using the formula (2) and equation (7), the following equation will be obtained:

$$\frac{d}{dx}\left(\frac{mv^2}{2}\right) = -\frac{dU}{dx} \tag{10}$$

The equation will be changed as:

$$\frac{d}{dx}\left(\frac{mV^2}{2} + U(x)\right) = 0 \tag{11}$$

As it is known, the expression will not be changed, if its derivative is equal to zero:

$$\frac{mV^2}{2} + U(x) = const \tag{12}$$

That is, the law of the tractor–transport facility movement at its acceleration period is received. The energy sum at the expression (12) is the total energy, which the TTF engine is expending at its acceleration period.

$$E = \frac{mV_0^2}{2} + U(x_0) \tag{13}$$

The velocity of the tractor-transport facility will be determined as a dependence on the acceleration distance value x using the formula (13) and knowing the engine expending energy E:

$$V(x) = \sqrt{\frac{2}{m}\left[E - U(x)\right]} \tag{14}$$

The dependence between x and t will be determined using the formula (14):

$$dx = \sqrt{\frac{2}{m}\left[E - U(x)\right]} \cdot dt \tag{15}$$

Some values, which are taking part in the expression (15) cannot be presented in analytical form. Therefore the acceleration distance will be applied for the caterpillar mover immediately.

Both the points, the contact point of caterpillar track and driving wheel teeth profile and the point of friction force application by caterpillar tracks sliding on the driving wheel are turning around the axis Z by the caterpillar track movement. (Fig. 1)

By this, the distance AB which will be covered by tractor facility, the proposed torsion caterpillar track along, will be converted into a spiral AB_1 (Fig1).

The torsion-caterpillar mover is for relaying of the tractor movement relative to caterpillar track.

The caterpillar track envelopes the driving and driven wheels, and the power unit leans on caterpillar track by means of rollers. When the torque is applied to the driving wheel, the caterpillar track will be wound at the driving wheel and driven wheels relatively, and transfer and relative movements of the power unit will be realized.

The displacement area presence is the indispensable condition for torsion-caterpillar mover functioning. The certain quantity of displacement areas and their certain pitch of the tangent at the displacement area and driving wheel attaching point are limited to the functioning of the torsion-caterpillar mover.

The relative to caterpillar track displacements take place in the driving wheel plane by its turning and the torsional force N appears. The displacement`s value and the torsional force N are proportional to the driving wheel torque M.

The movement way AB will be unwound conditionally for the torsional force N determination and the elementary way dx (Fig.1) will be marked out on the unwound way. The point of displacement and torsional force N application turns for the angle dφ under the action of torque M, therefore the point C transfers to the point B_1. As the transference of the point C realizes along the driving wheel, it is always perpendicular to the driving wheel radius r, therefore the torsional force N, that arises by displacement of the point C, is also perpendicular to the radius r.

The generatrix CD will occupy the position C_1D_1 by the point C transference to B_1. The angle CDB_1 will be named as the tractor facility displacement angle relatively to the caterpillar track as it shows the right angle CDK change value during the transference process of the torsion-caterpillar track facility in relation to the ordinary caterpillar track facility.

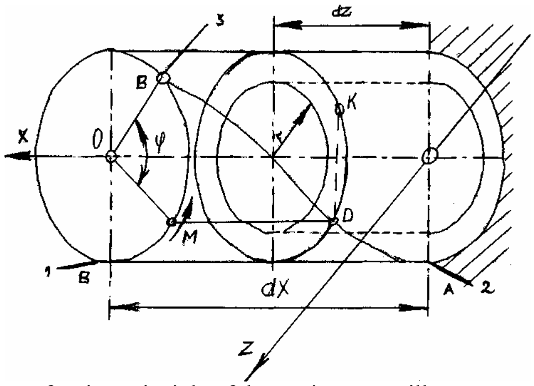

Fig.1. The formalization of action principle of the torsion-caterpillar mover and the driving wheel elementary movement

1, 2 – the transference of the points B and A on the driving wheel according to the analogous method;
3 – the transference of the point B accordingly to the proposed method;
1- CD – the elementary transference accordingly to the usual method;
2 – CD – the elementary transference accordingly to the proposed method

Taking into account the small value of the $d\varphi$ and dx, we can write:

$$CB_1 = \gamma \cdot dx \tag{16}$$

where:

γ – the tractor facility displacement angle relatively to the caterpillar track

On the other hand: $$CB_1 = r \cdot d\varphi \tag{17}$$

Therefore: $$\gamma \cdot dx = \gamma d\varphi, \qquad \gamma = \frac{d\varphi}{dx} \cdot r \tag{18}$$

It is established from the L. M. Petrov investigations [2003], that

$$\gamma = \frac{N}{P} \tag{19}$$

where:

P – the tractor force by using the ordinary caterpillar track, taking into account the theory of movement resistance forces [Agg 1928, Kent's 1953].

The right parts of the formulae (18) and (19) will be equated:

$$\frac{d\varphi}{dx} \cdot r = \frac{N}{P} \tag{20}$$

From the equation (20) the torsion force is determined as:

$$N = P\frac{d\varphi}{dx} \cdot r \tag{21}$$

From the equation (21) the torsion force will be determined. This force is arising on the driving wheel by its turning for the angle dl and by arising of the displacement angle y.

It will be marked $$K = P \cdot \frac{d\varphi}{dx} \tag{22}$$

and the value K will be named as constant for the driving wheel of the tractor torsion caterpillar mover.

It will be obtained, taking into account (22):

$$N = K \cdot r \tag{23}$$

It results from (23) that the torsion force is distributed according to the linear law. The value *N* will be determined as follows.

Since *N* is perpendicular to the driving wheel radius, the elementary torque *dM*, that is transmitted by torsion-caterpillar mover, will be determined as:

$$dM = N \cdot dr \tag{24}$$

Therefore, the full torque, that is transmitted by torsion-caterpillar mover, will be determined as:

$$M = \int_r dM = \int_r N \cdot dr = \int_r K \cdot r \cdot dr = K \int_r r \cdot dr \tag{25}$$

It follows from the equation (13):

$$M = K \cdot \frac{r^2}{2} \Rightarrow K = \frac{2M}{r^2} \tag{26}$$

And from the equation (14) the force *N* will be determined as:

$$N = \frac{2M}{r^2} \cdot r = \frac{2M}{r} \tag{27}$$

The expression (27) will be named as formula for determination of the torsion force of the caterpillar mover.

The driving wheel torque serves as a criterion for evaluation of the main parameters for evaluation of the main parameters of the torsion-caterpillar mover.

It appears, the tangent tractor force by tractor movement may be redoubled by criterion application.

The displacement areas quantity limits the application of the criterion.

In Fig. 2 you can see the diagram of the suggested torsion-caterpillar mover.

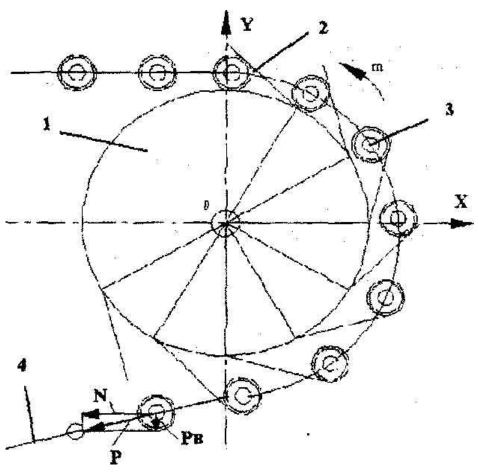

Fig. 2. The diagram of the tension of the torsion-caterpillar mover: 1 – driving wheel; 2 – displacement area; 3 – pin; 4 – caterpillar track

The considered possibilities of the energy accumulation by the tractor-transport facility can be suggested for the caterpillar tractor whose torsion-caterpillar mover is shown in Fig, 3.

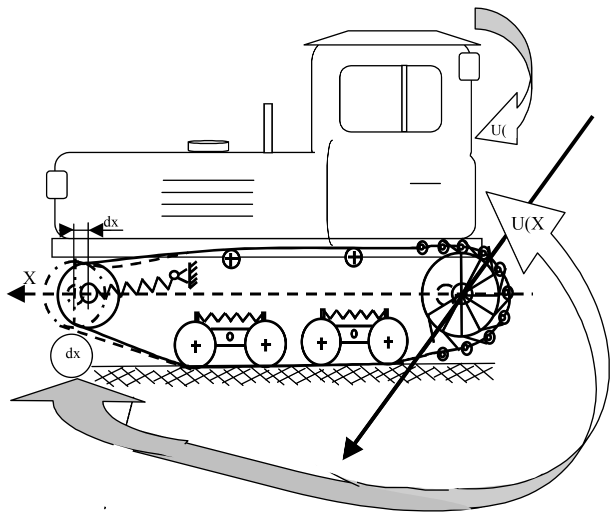

Fig. 3. The diagram of the caterpillar mover, which reduces total energy expenditures.

CONCLUSIONS

1. The received mathematical dependence is evidence of the energy accumulation by the caterpillar tractor-transport facility during the period of accelerations.
2. The accumulated energy application on the displacement areas permits to raise the efficiency of the caterpillar track.
3. The torsion force *N* received value is distributed according to the linear law and increases following an increase of the angles γ and driving wheel radius *r*.

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