YAKOVENKO-PETROV METHOD FOR AN ESTIMATION OF THE QUALITY OF INDICATORS OF WHEEL PROPULSION UNITS IN TRACTIVE TRANSPORTATION FACILITIES

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A THEORY OF THE STABILIZATION OF A GIVEN CURRENT OF A TRACTIVE ENERGY RESORT TRAFIC

During the tractive energy resort operation it can be seen that at its unprogrammed diversions from a givent current of traffic every cross section of its construction is returned considering a given current of trafic (axis Z) as a strong beam.

Thus the trajectory of a motion is transmuted into devices of a circular helix BS (Fig. 1) [1, 2].



Fig. 1. A diversion from a given current of traffic of a transport resort

It is also apparent, that at refracted TTF from a given current of traffic in a contact plane of a wheel propulsion unit with an area of bearing there are detrusions and tangential transformations of a drag force, the quantity of which is proportionally brought to a wheel propulsion unit from an engine installation of a torsional moment. The predetermined value of tangential transformations of a tractive power enables to prevent an unprogrammed diversion of TTF transport from a given current of traffic, to create instruction cards of a secure motion in the defined operation conditions TTF, to estimate a state of an area of bearing and quality of the busbar of a wheel propulsion unit and phylum of a protector.

For a definition of tangential transformations of a tractive power in an area of bearing I select its devices under the dextral and left-hand wheel propulsion units, we shall treat each one as a spot of contact with the radius r, and the length of the distance between the dextral and left-hand wheel propulsions units is dx.



Fig. 2. An advance of the treatment velocity of one of the wheel propulsion units in a plane of resistance



Fig. 3. A definition of tangential transformations of a tractive power for an area of bearing

It is also apparent, that at an advance of the rotation rate of one of the wheel propulsion units in a plane of resistance there are detrusions of a spot of contact, the bent and most approximate one will be similar to an oval. Let's consider a case if under an activity of the moment M_x brought from an engine installation up to one of the sprockets, the one that has a small hitch with a plane of support is returned to the corner, and the point K_1 transfers for a standing K_{11} . Simultaneously this point will be moved with a sprocket in currents of traffic of a transport resort. As the travel of a point K_1 descends on an arc of slide of a wheel propulsion unit, it is always perpendicular to the radius of a sprocket. Therefore the intensity of tangential thrust force P_{τ} on an area of bearing of a spot of contact arising at the detrusion of a point K_1 will be also perpendicular to the radius.

Ft transition of a point K_1 for a standing K_{11} , generator K_1 , which corresponds to the basis of a transport resort, will occupy a standing K_1 . We shall determine the corner $K_1 K_2$ as an angle of displacement of a trajectory, as it displays the quantity of an angular variation K_1 DN, between the basis of a transport resort and direction of a trajectory of its motion during a diversion from a given rectilinear motion.

Allowing a low value of a quantity of breadth between wheel propulsion units dx, it is possible to record, that the advance of a wheel propulsion unit which turns round for more speed will be

$$K_1 K_{11} = \gamma \cdot dx, \tag{1}$$

where:

 γ – corner of relative detrusion,

 $K_1 K_{11}$ – quantity of an arc slide off diversion from a planned trajectory of a motion.

On the other hand this distance will be

$$K_1 K_{11} = r \cdot d\varphi \,. \tag{2}$$

Therefore

$$\gamma \cdot dx = r \cdot d\varphi \tag{3}$$

Or

$$\gamma = \left(d\varphi \,/\, dx \right) \cdot r \tag{4}$$

Considering that at removal TTF the degree of embodying of tangential thrust force on a wheel propulsion unit will be characterized by the intensity of its appendix in a spot of contact with an area of bearing, it is possible to state a principle of a removal of a transport resort, expressed mathematically as

$$P_{\tau} = I \cdot \gamma \tag{5}$$

where:

I-a constant of proportionality which displays the physical-mechanical performances of an area of bearing and wheel propulsion unit within the boundaries of the time of elastic deformation.

We shall determine the coefficient I at the loading of a wheel propulsion unit on manifold area of bearings in the boundaries of elastic deformations of a wheel propulsion unit.

As the quantity of relative detrusion γ is quantity dimensionless, coefficient *I* is measured in those units as the intensity of allocation of tangential thrust force P_{τ} (Pa or MPa).

From expression 5 it follows that

$$\gamma = P_{\tau} / I \tag{6}$$

The greater the coefficient I for a given wheel propulsion unit and an area of bearing, the smaller γ at the same intensity of tangential thrust force and the rigider operation of a wheel propulsion unit is observed. From the equations 4 and 6 we have

$$P_{\tau} / I = \left(d\varphi / dx \right) \cdot r \tag{7}$$

Or

$$P_{\tau} = I \cdot \left(d\varphi / dx \right) \cdot r \tag{8}$$

The formula 8 determines the intensity of tangential thrust force, which arises in a band of contact of a wheel propulsion unit with an area of bearing at the rotational displacement first on the corner $d\phi$ or the formation of the corner γ . Let's designate

$$L = I \cdot \left(d\varphi \,/\, dx \right) \tag{9}$$

where:

L – quantity of a stationary value for the given area of bearing, construction of a undercarriage of a transmission of a designed transport resort.

Then

$$P_{\tau} = L \cdot r \tag{10}$$

From the formula 10 it follows, that P_{τ} in the boundaries of elasticity of a wheel propulsion unit is proportioned under the linear law (formula 1, 2).



Fig. 4. Reproduction of the requirement of the build-up of tangential thrust force

With the purpose of the reproduction of a requirement of the build-up of tangential thrust force (Fig. 4a) I select under a wheel propulsion unit a separate circular device (Fig. 4a), which under the activity of a torsional movement and the kinematics of a wheel propulsion unit is driven near the point 0, thus the generator K_2K_{21} will equal the generator KK_1 . Then:

$$K_2 K_{21} = R \cdot d\varphi_1 = r \cdot d\varphi = K_1 K_{11}$$
(11)

where:

R – a standard radius of an area of bearing turning around,

 γ – a radius of a wheel propulsion unit.

In the equation 3 the right member is replacable:

$$\gamma \cdot dx = R \cdot d\varphi_1 \tag{12}$$

Whence

$$\gamma = R \cdot d\varphi_1 \,/\, dx \tag{13}$$

From the equation 6 we have:

$$P_{\tau} / I = R \cdot d\varphi_1 / dx \tag{14}$$

$$P_{\tau} = I \cdot R \cdot d\varphi_1 / dx \tag{15}$$

So, the tangential thrust force on an area of bearing (generator K_2K_{21}), and on a wheel propulsion unit (generator K_1K_{11}) can be spotted as

$$P_{\tau} = I \cdot R \cdot d\varphi / dx = I \cdot d\varphi_1 / dx \tag{16}$$

Conclusions:

1. The intensity of tangential thrust force will vary under the rectilinear law;

2. The tangential thrust force can be implemented also outside a wheel propulsion unit;

3. The equation 16 resolves to create new approaches to a structural arrangement of a wheel propulsion unit. So, at making actual requirements of a removal of a tractive transport resort, that is if an area of bearing (Fig. 3) cannot turn around a point, the intensity of allocation of tangential thrust force on a wheel propulsion unit will look like this (Fig. 5):



Fig. 5. Actual requirements of a removal of tractive transportation facilities

Loadings of a wheel propulsion unit by a reaction torque M_p take place at an intensive loading of wheel propulsion units of tangential power traction (Fig. 6).



Fig. 6. Allocation of a reaction torque in a horizontal plane



Fig. 7. The optimum embodying of a tractive power by a wheel propulsion unit

For embodying the best value of tangential thrust force (Fig. 5), the plan of hooking up of a wheel propulsion unit to an engine installation is offered (Fig. 7).

DIFFERENTIAL DEPENDENCIES BETWEEN TRAFFIC INTENSITY ON A WHEEL PROPULSION UNIT, TANGENTIAL THRUST FORCE AND CROSS REACTION TORQUE

Tractive transport relies on the basic force which renders assistance to the motion TTF, that is a drag force affixed on driving wheels. The drag force or tangential force results from an operation of an engine installation TTF, which transmutes chemical energy of fuel into mechanical operation, and created by an interaction of driving wheels with an area of bearing. Two resistance forces fall into a frictional force in a transmission: the resistance force of a road and resistance force of the air.

Let's complete a procedure, if the external forces are the couple of resistance forces, which one is formed at a moment. Then for the execution of a working process TTF we shall affix on a wheel propulsion unit a tangential thrust force and reaction torque in a horizontal plane.

Let's consider an area of bearing between a wheel propulsion unit and select from an indefinitely small length a device dx. On this length TTF should be in equilibrium under an activity of a part of a seating load with the intensity of a Po, one lengthwise dx of which we shall consider as a constant value (Fig. 8), as well as the tangential thrust forces on the left-hand and right-hand wheel propulsion units P_k , P_{k1} and the reaction torques of M, M_1 in a horizontal plane, which render assistance stabilization of a given current of traffic.



Fig. 8. A seating load on a wheel propulsion unit of tractive transportation facilities

Let's mark, that

$$P_{k_1} = P_k + dP_k \tag{17}$$

$$M_1 = M + dM \tag{18}$$

where:

 dP_k and dM – indefinitely small quantities of tangential thrust force and reaction torque.

The requirement without a refracted motion TTF on a site (segment) dx will be recorded

$$\sum Z = 0; \quad P_k + P_o \cdot dx - (P_k + d \cdot P_k) = 0;$$
(19)

$$\sum M_{z} = 0; \quad M + P_{k} \cdot dx + P_{o} \cdot dx \cdot dx/2 - (M + dM) = 0$$
(20)

From the equation 19 we shall receive

$$P_o \cdot dx - dP_k = 0 \tag{21}$$

Whence

$$dP_k / dx = P_o \tag{22}$$

That is the derivative from tangential thrust force on an axis of wheel propulsions unit equals intensities of a seating load on TTF in a spot of contact with an area of bearing.

From the equation 20, neglecting an indefinitely small second order, we shall receive

$$P_k \cdot dx - dM = 0 \tag{23}$$

From here

$$dM / dx = P_k \tag{24}$$

Thus the derivative from a reaction torque on an axis of a wheel propulsion unit TTF equals to tangential thrust force. The velocity of change of a torsional moment between wheelbases creates conditions for the prediction of the embodying of a tangential thrust force of major value [3] Let's take a derivative from both parts of the equation 24:

$$d^2M / dx^2 = dP_k / dx \tag{25}$$

Otherwise:

$$d^2M / dx^2 = P_o \tag{26}$$

That is the second differential coefficient from a reaction torque on an axis of a wheel propulsion unit equals intensities of a seating load.

Besides the rate of change of a function geometrically figures by itself a tangent of a slope angle, which is gained with an axis of a wheel propulsion unit, tangential in the given point of a curve (Fig. 6) reaction torque, that is the tangential thrust force can be considered as a tangent of a slope angle by a tangential to a curve of a reaction torque in a horizontal plane end-on.

From the equation 23 it is visible if the intensity of a seating load $P_o = 0$. The tangential thrust force will be:

$$P_k = P_{k \max} \tag{27}$$

or

$$P_k = P_{k\min} \tag{28}$$

From the equation 24 it follows, that the reaction torque reaches a maximum in that section, where

$$P_k = dM / dx = 0$$

That is where the tangential thrust force transits through (Fig. 4a)

CONCLUSION

The obtained dependencies can be utilized at the construction of tractive transportation facilities.

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SUMMARY

The paper aims at an estimation of quality indicators of wheel propulsion units of tractive transportation facilities. The tests and calculations show that the tangential thrust force varies under the rectilinear law and may be implemented also outside a propulsion unit.

A new approach is proposed to the construction of tractive transportation facilities.