SPECIAL FEATURES OF DYNAMIC DESIGN OF A TRACTOR TRACK

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Abstract

In the paper chosen problems of dynamics of caterpillar finger in an open metal seven eyelet hinge is described. A low reliability of the caterpillar chains seems to be a consequence of design process of agricultural tractors. For this reason, dynamic calculation of the caterpillar finger of tractor is presented. Probe is spent on tractor VT – 150 manufactures TK "VgTz" having caterpillars with seven eyelets cast track in a mode of correction of the set direction of working-class movement on plough. In the paper example results of theoretical and experimental researches is presented. Results of the study experimental of the dynamics loads in caterpillar finger of the tractor with plow have shown that it is possible his consideration as springy symmetric steel peg on two steel full tilts. Analysis of usage of the agricultural caterpillar tractors and results of calculations confirm that the dynamics calculations are more exact then previous assumptions. New recommendations to caterpillars' constructors are put in order to increase tractors' reliability. The frequency of caterpillar finger should be enlarged by increasing of his acerbity. In the paper, a new set of main parameters of VT – 150 caterpillar fingers is presented in comparison with nominal one.

Keywords: tractor caterpillar, track (a caterpillar link), eyelets of track, caterpillar hinge, caterpillar finger, dynamic calculation

1. Introduction

Background of experience in Russia and overseas usages of agricultural caterpillar tractors has shown low reliability of the caterpillar chains in consequence of quick wear-out of caterpillar fingers [1]. We think that one of the reasons of this it is hidden in method of their calculations, conducted by constructor. When designing caterpillar finger, his sizes and form are not calculated, but are assigned. Hereon checking is conducted for cut on formula [6]:

$$\tau_{cp} = 0.85 \left(P_i / d^2 \right) \leq \left[\tau \right]_{cp},\qquad(1)$$

where:

P_i – 65 % from weight of the tractor, attached to middle of finger,

d – diameter of caterpillar finger,

$\left[\tau \right]_{cp}$ – allowed voltage of the cut.

Defect of such calculation in that is not taken into account important features - an amplitude and frequency of the compelled fluctuations of the caterpillar finger, appearing when moving the tractor with plow and changing in process of the operation (of work) of the tractor. The experiment installs that that amplitude and frequency of the fluctuations of caterpillar finger are changed in process of his wear-out [4].

Authors in this article consider dynamic calculation of the caterpillar finger of tractor, checked theoretically and experimentally when working the tractor with plow.

2. Theoretical part

We shall consider the accounting scheme of the caterpillar finger of the serial agricultural tractor (Fig. 1). Here [5] are shown seven internal surfaces track of the caterpillar and one external surface of the caterpillar finger.

The Internal surfaces of the track are got in foundry production and do not be subjected to no mechanical processing. For ensuring the unconditional assembly of the details the clearance between their surfaces, according to design documentation, varies within: 1.3 mm…2.3 mm. Presence of such clearance creates the apparent uncertainty of the mutual position of the caterpillar finger and track in process of work of the caterpillar chain.

Results of the study experimental of the dynamic loads in caterpillar finger of the tractor with plow has shown that his of possible consider as springy symmetric steel peg residing on two steel full tilts.
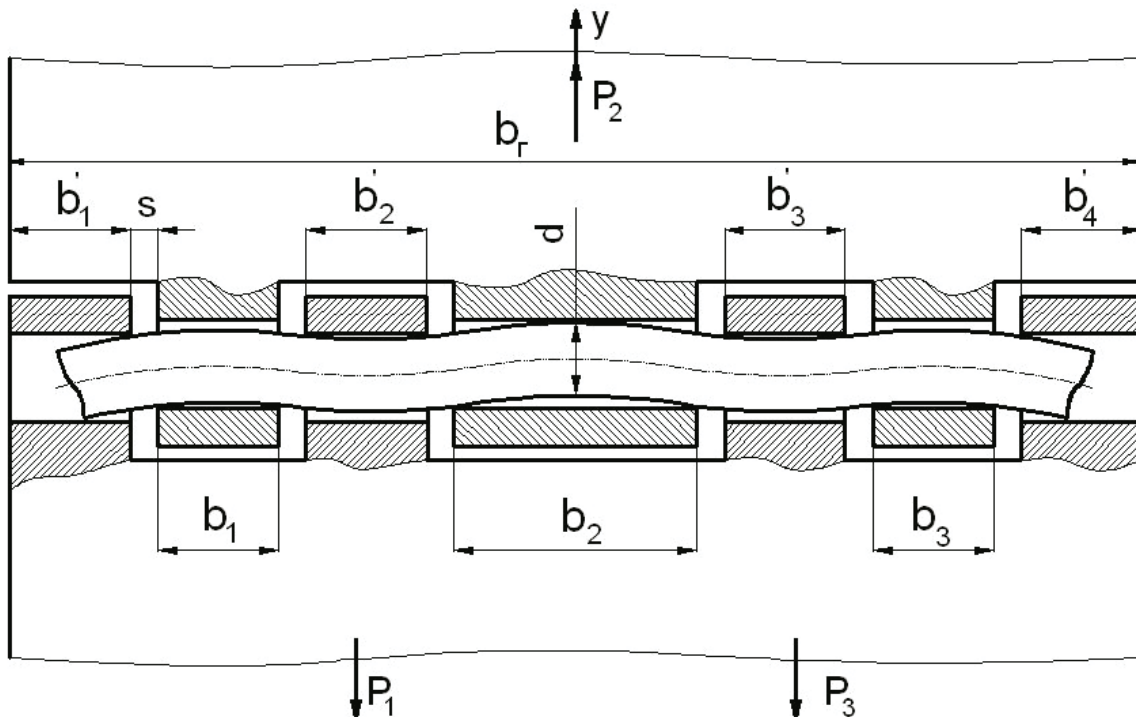

Fig. 1. Scheme of the calculation caterpillar finger

The Accepted admissions: 1– sections of the caterpillar chain have absolute acerbity; 2 – the small size on absolute values and velocities of the mutual moving the surface of the caterpillar finger and of seven internal surfaces of the caterpillar track do possible is to do not accounted loss on friction.

Conditional indications on Fig.1: b_1, b_2, b_3 - lengths of leading section of the caterpillar; b_1', b_2', b_3', b_4' – lengths not leading of the section of the caterpillar; d – diameter of the caterpillar finger; s – the clearance between ends of the sections; P_1, P_3 – reactive powers; P_2 – active power; y – the coordinate of the dynamic deformation of the caterpillar finger -general coordinate.

The Caterpillar finger on Fig. 1 is considered as one mass dynamic system.

In this case his springy deformation with provision for taken admissions can be described by equation [7].

$$(d/dt)(\partial T/\partial \dot{y}) - (\partial T/\partial y) + (\partial \Pi/\partial y) = P_2, \qquad (2)$$

where:

$T = 0.5 \, m \dot{y}^2$ – a kinetic energy of the considered dynamic system (here m – a mass of the caterpillar finger),

$\Pi = 0.5 \, c \, y^2$ – potential energy of the caterpillar finger (here c – a factor of acerbity of the caterpillar finger).

For tractor caterpillar finger [2]

$$c = (6EJ)/s^2 \left(1{,}5b_2 + s\right), \qquad (3)$$

where:

E and J – a module to bounce of the caterpillar finger and moment of the inertias his of the cross-section.

For expression of the outraging power will use the results of the experimental studies

$$P_2 = H \sin pt, \qquad (4)$$

where:

H and p – a maximum amplitude, and frequency outraging power P_2 on leading caterpillar at period of the correcting the course of the tractor with plow.

Having substituted (3) and (4) in equation (2) and entering indication $h = H/m$ we shall get [3]:

$$\ddot{y} + k^2 y = h \sin pt, \qquad (5)$$

where:

$k = \sqrt{c/m}$ – a frequency of the own fluctuations of the caterpillar finger.

This equation possible to consider as collection of two forming of describing of free fluctuations (vibrations) of the caterpillar finger with frequency appearing in consequence of its bounce and fluctuations outraging power with frequency, of appearing in consequence of "twitches" and of "jerks" of the caterpillar on moment of governing of tractor. For caterpillar finger $k \gg p$, consequently, the general decision of the equation (5) can be presented in the manner of:

$$y = [h/(k^2 - p^2)] \sin pt. \qquad (6)$$

3. Results of calculations

Importance's of main constructive parameters of the caterpillar (Fig.1) of the agricultural caterpillar tractor VT - 150 companies "VGTZ", are provided in tab. 1, results of steady-state and dynamic calculation of the caterpillar finger - in tab. 2. Graphics of fluctuations of the new and of the most worn-out caterpillar finger, calculated on formula (6) under initial condition:

$t = 0$; H = 34.5 кН; $p = 10 \, c^{-1}$; $y(0) = 0$ – are brought on the Fig. 2.

From Tab. 2 and Fig. 2 follows: amplitude of the compelled fluctuations increases in 2.4 times, acerbity and frequencies of the own fluctuations in falling accordingly in 2.5 times and on 25 %.
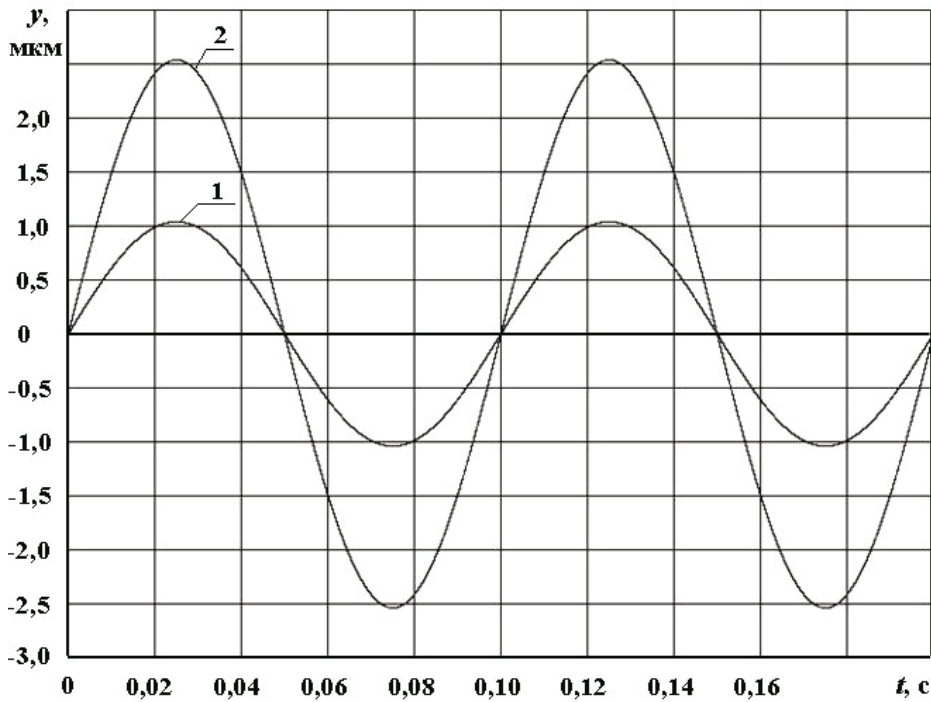
Fig. 2. Graphs of the compelled fluctuations of the new (1) and at most of the worn-out (2) of the caterpillar finger

4. Conclusions

Analysis of usage of the agricultural caterpillar tractors and results of the calculations confirm that the dynamics calculations of possible consider that the most exacts, the theoretically the motivated and demonstrative. Then problem of the constructor on increasing of reliability of caterpillar finger possible formulate in the manner of the recommendations:

1- The strive greatly possible enlarge frequency k of caterpillar finger by increase of his acerbity c ;

2 - For each of variants of the caterpillar finger, considered within the framework of technical offer install his most possible importance's of the lower threshold of the frequency of the own fluctuations and upper threshold of the amplitude of the compelled fluctuations.

Tab. 1. Main parameters of the caterpillar finger of tractor VT – 150

Parameters	At nominal	At most from possible
Theoretical diameter of the caterpillar finger, d , m	0.025	0.024
working diameter of the caterpillar finger, d , m	Too	0.020
Mass of caterpillar finger, kgs	1.73	1.11
J , m^4	$1.9175 * 10^{-7}$	$0.7854 * 10^{-8}$
E , n/m^2	$2.1 * 10^{11}$	–
$[\tau]_{cp}$, n/m^2	$80 * 10^6$	–

Tab. 2. Results of the calculations caterpillar finger of the tractor VT – 150

Parameters of the caterpillar finger	At nominal	At most from possible
Importances τ_{cp}, n/m^2	$10.8 * 10^6$	$16.9 * 10^6$
The Factors of importance's of toughness: $[\tau]_{cp} / \tau_{cp}$	7.4	4.7
Acerbity of the caterpillar finger, C, n/m	$3.4 * 10^{10}$	$1.4 * 10^{10}$
Amplitude of the compelled fluctuations, m	$0.99 * 10^{-6}$	$0.24 * 10^{-5}$
Frequency of the own fluctuations, k, s^{-1}	$14.2 * 10^4$	$11.3 * 10^4$

References

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