International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-9 Issue-3, January 2020

Development and Substantiation of the Parameters of the Battery Mechanism with Elastic Elements of the Weaving Machines

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Abstract: ***The article provides the scheme and principle of operation of the batan mechanism with elastic elements of looms. Based on theoretical studies, an expression is determined to determine the maximum compression moment of a torsion spring. From the equilibrium condition of the three-arm lever of the batan, the laws of movement of the reed are determined. The results of numerical solution of problems are presented. Studies substantiated the parameters of the mechanism. Based on the tests, the ways of increasing the productivity of the machine are substantiated..***

Keywords: Loom, batan mechanism, elastic element, law of motion, degree of mobility, oscillations, mat, performance.

I. INTRODUCTION

Cam gears with cam drive are widespread on shuttle less looms. All batan mechanisms must meet the following technological and technical requirements: the swing of the reed should be the smallest in order to avoid strong grinding of the warp threads by the teeth of the reed: the weft thread to the edge of the fabric should be beaten by smooth pressure, and not by impact; the mass of the batan should be small and sufficient to perform all the technological and mechanical operations of the mechanism; limitation of speed modes of motion due to large inertial forces and reaction forces in kinematic pairs due to excessive bonds in the mechanism. It should be noted that in the process of work there is a quick failure of the bearing bearings and a low resource of the batan mechanism [1]. Therefore, the development of new resource-saving designs of batan mechanisms that allow obtaining high quality fabrics is an urgent problem in the textile industry [2]. Development of an effective design of the batan mechanism.

Revised Manuscript Received on January 30, 2020.
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To increase the reliability and increase the productivity of fabric formation on shuttle less looms, a new scheme of the cam batan mechanism with elastic elements was developed [3].

In fig. 1 shows the batan mechanism, which comprises a housing 1, cam 2, cam contour 3 mounted on the main shaft 4. The composite rollers 5 and 6 are pivotally mounted in the three-arm lever 7 and are in contact with the profiles (surfaces) of the cams 2 and 3. The composite rollers 5 and 6 include hinges 9 and 12, elastic rubber bushings 13 and 14 mounted on them. The thickness of the rubber bush 13 is two times greater than the thickness of the elastic rubber bush 14. The lever 7 is pivotally mounted on the batan shaft 8. The third shoulder of the lever 7 is connected rigidly to the beam 10 and the reed 11. The shoulders 7 of the three-arm lever are additionally connected to the tuck shaft 8 by a torsion spring 15. The elastic rubber bushings 13 and 14 are made of an oil-resistant rubber grade.

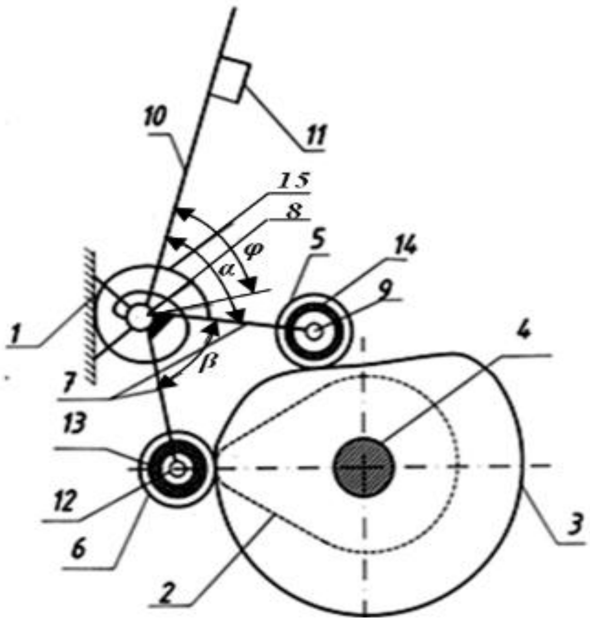

Fig.1. Loom mechanism of the loom with integral cam rollers

II. THEORETICAL RESEARCH

Calculation of the parameters of the batan mechanism with elastic elements. In the batan mechanism, in the process of tissue formation, some retention is required with small fluctuations in the end of the rocker arm.

To ensure this pattern of movement of the rocker arm of the cam mechanism of the roll of the roller is made integral with an elastic sleeve.

At the same time, due to the deformation of the rubber sleeve of the composite roller of the first mechanism, the end of the rocker arm (bird) will be made with the necessary law of motion.

In this case, it is important to determine the characteristics of the movement of the rocker, taking into account the maximum deformations (compression and tension) of the rubber sleeve of the roller, we consider the kinematics of this cam mechanism. To do this, we use the method of higher kinematic pair laws in the cam mechanism by fifth-class rotational kinematic pairs. The deformation of the rubber sleeve of the roller was taken into account in one of the two kinematic pairs of the fifth class of the replacement mechanism (see Fig. 2)

Figure 2 shows the recommended cam mechanism, respectively replacing the mechanism. Using the well-known method of closed vectors, we obtained expressions for determining angular mixed φ_2 and φ_3. In the considered mechanism for the circuits ABD and BCD, we compose vector equations:

for circuit ABD:

$$\bar{l}_4 + \bar{q} - \bar{e}_1 = 0 \tag{1}$$

for circuit BC ABD:

$$\bar{q} + \bar{l}_2 + \Delta\bar{l}_2 - \bar{l}_3 - \Delta\bar{l}_3 = 0$$
$$\bar{q} + \bar{l}_2 - \bar{l}_3 = 0 \tag{2}$$
$$\bar{q} + \bar{l}_2 - \Delta\bar{l}_2 - \bar{l}_3 - \Delta\bar{l}_3 = 0$$

Moreover, projecting the vectors of equation (2) on the x and y coordinate axes, we have:

$$l_4 + q\cos\varphi_q - l_1\cos\varphi_1 = 0$$
$$q\sin\varphi_q + l_1\sin\varphi_1 = 0 \tag{3}$$

According to the methods given in (3), we have:

$$tg\varphi_q = \frac{l_1\sin\varphi_1}{l_4 - l_1\cos\varphi_1}; \qquad q = -l_1\frac{\sin\varphi_1}{\sin\varphi_q} \tag{4}$$

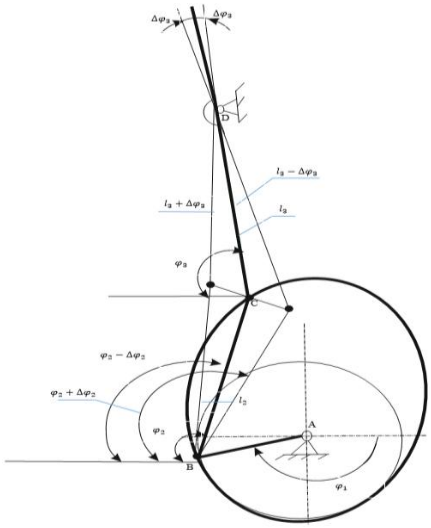

Fig. 2. Scheme of the interchangeable cam mechanism of the loom of the loom.

Given the values of Δl_2 and Δl_3 for the corresponding coal BCD using cosine theorems, we have:

$$l_2^2 = q^2 + l_3^2 - 2ql_3\cos\varphi_{3q}; \quad l_3^2 = q^2 + l_3^2 - 2ql_2\cos\varphi_{2q};$$
$$(l_2 + \Delta l_2)^2 = q^2 + (l_3 + \Delta l_3)^2 - 2q(l_3 + \Delta l_3)\cos(\varphi_{3q} + \Delta\varphi_3);$$

$$(l_3 + \Delta l_3)^2 = q^2 + (l_2 + \Delta l_2)^2 - 2q(l_2 + \Delta l_2)\cos(\varphi_{2q} + \Delta\varphi_2) \tag{5}$$
$$(l_2 - \Delta l_2)^2 = q^2 + (l_3 - \Delta l_3)^2 - 2q(l_3 - \Delta l_3)\cos(\varphi_{3q} - \Delta\varphi_3);$$
$$(l_3 - \Delta l_3)^2 = q^2 + (l_2 - \Delta l_2)^2 - 2q(l_2 - \Delta l_2)\cos(\varphi_{2q} - \Delta\varphi_2);$$

Moreover, we have:

$$\varphi_{3q} = \arccos\frac{q^2 + l_3^2 - l_2^2}{2ql_3} \qquad \varphi_{2q} = \arccos\frac{q^2 + l_2^2 - l_3^2}{2ql_2}$$

$$\varphi_{3q} + \Delta\varphi_3 = \arccos\frac{q^2 + (l_3 + \Delta l_3)^2 - (l_2 + \Delta l_2)^2}{2q(l_3 + \Delta l_3)}$$

$$\varphi_{2q} + \Delta\varphi_2 = \arccos\frac{q^2 + (l_2 + \Delta l_2)^2 - (l_3 + \Delta l_3)^2}{2q(l_2 + \Delta l_2)}$$

$$\varphi_{3q} - \Delta\varphi_3 = \arccos\frac{q^2 + (l_3 - \Delta l_3)^2 - (l_2 - \Delta l_2)^2}{2q(l_3 - \Delta l_3)}$$

$$\varphi_{2q} - \Delta\varphi_2 = \arccos\frac{q^2 + (l_2 - \Delta l_2)^2 - (l_3 - \Delta l_3)^2}{2q(l_2 - \Delta l_2)}$$

The patterns of angular displacements will be in the form:

$$\varphi_3 = \arccos\frac{l_1^2 - l_2^2 + l_3^2 + l_4^2 - 2l_1l_4\cos\varphi_1}{2l_3\sqrt{l_1^2 + l_4^2 - 2l_1l_4\cos\varphi_1}} + arctg\frac{l_1\sin\varphi_1}{l_4 - l_1\cos\varphi_1}$$
$$\varphi_2 = \arccos\frac{l_1^2 + l_2^2 - l_3^2 + l_4^2 - 2l_1l_4\cos\varphi_1}{2l_2\sqrt{l_1^2 + l_4^2 - 2l_1l_4\cos\varphi_1}} + arctg\frac{l_1\sin\varphi_1}{l_4 - l_1\cos\varphi_1} \tag{7}$$

Taking into account the deformation of the elastic element, the determination of values is considered to be cixiform, $\Delta\varphi_2$ and $\Delta\varphi_3$ taking into account the length of the leash (connecting rod) and the blade (rocker arm) of the loom mechanism of the loom. In this case, subtracting the third equation from the first equation (7) and dividing by two, and also subtracting from the second equation and dividing by two, we obtain the following expressions:

$$\Delta\varphi_3 = \frac{1}{2}\left[\begin{array}{l}\arccos\dfrac{l_1^2 + l_4^2 - 2l_1l_4\cos\varphi_1 + (l_3 + \Delta l_3)^2 - (l_2 + \Delta l_2)^2}{2(l_3 + \Delta l_3)\sqrt{l_1^2 + l_4^2 - 2l_1l_4\cos\varphi_1}} - \\ - \arccos\dfrac{l_1^2 + l_4^2 - 2l_1l_4\cos\varphi_1 + (l_3 - \Delta l_3)^2 - (l_2 - \Delta l_2)}{2(l_3 + \Delta l_3)\sqrt{l_1^2 + l_4^2 - 2l_1l_4\cos\varphi_1}}\end{array}\right]$$

(8)

$$\Delta\varphi_2 = \frac{1}{2}\left[\begin{array}{l}\arccos\dfrac{l_1^2 + l_4^2 - 2l_1l_4\cos\varphi_1 + (l_2 + \Delta l_2)^2 - (l_3 + \Delta l_3)^2}{2(l_3 + \Delta l_3)\sqrt{l_1^2 + l_4^2 - 2l_1l_4\cos\varphi_1}} - \\ - \arccos\dfrac{l_1^2 + l_4^2 - 2l_1l_4\cos\varphi_1 + (l_2 - \Delta l_2)^2 - (l_3 - \Delta l_3)}{2(l_2 - \Delta l_3)\sqrt{l_1^2 + l_4^2 - 2l_1l_4\cos\varphi_1}}\end{array}\right]$$

According to the design scheme in Fig.2 you can write:

$$\varphi_{3\max} = \varphi_3 + \Delta\varphi_3; \quad \varphi_{3\min} = \varphi_3 - \Delta\varphi_3; \quad \varphi_{2\max} = \varphi_2 + \Delta\varphi_2;$$
$$\varphi_{2\min} = \varphi_2 - \Delta\varphi_2$$

The numerical solution of the problem posed in the form of the law of conditional movement of the rocker arm (reed) of the cam batan mechanism of the loom.

In fig. Figure 3 shows the patterns of movement of the rocker arm in the absence of an elastic element, that is, for a substantial version of the driving mechanism.

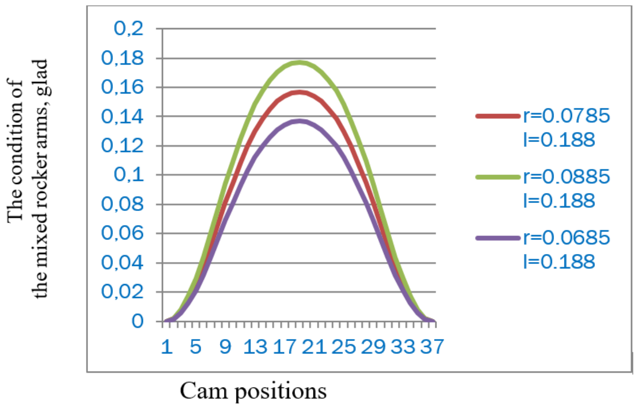

Fig.3. The angular movement of the rocker arm (reed) of the mechanism of the batan from the position of rotation of the cam

III. RESULTS AND DISCUSSION

An analysis of the graphs in Fig. 4 shows that the lengths r and l significantly affect the amplitude and shape of the rocker arm oscillations. The amplitude of the rocker arm oscillations is affected by the values of r. So with a crank radius (minimum radius of the cam profile) of 0.0685 m, the angular displacement of the rocker arm can reach 0.34 rad, and with r = 0.0885 m the angular displacement of the rocker arm will increase to 0.44 rad.

When taking into account the maximum values of the deformation, the elastic element in the kinematic pair (a composite roller) between the connecting rod and the beam (in the replacement mechanism) is the nature of the angular movement of the beam (the reed rubber changes (see Fig. 3).

Based on the processing of the obtained patterns of angular displacements of the reed from changes in the maximum deformations of the rubber sleeve of the roll of the loom mechanism of the loom.

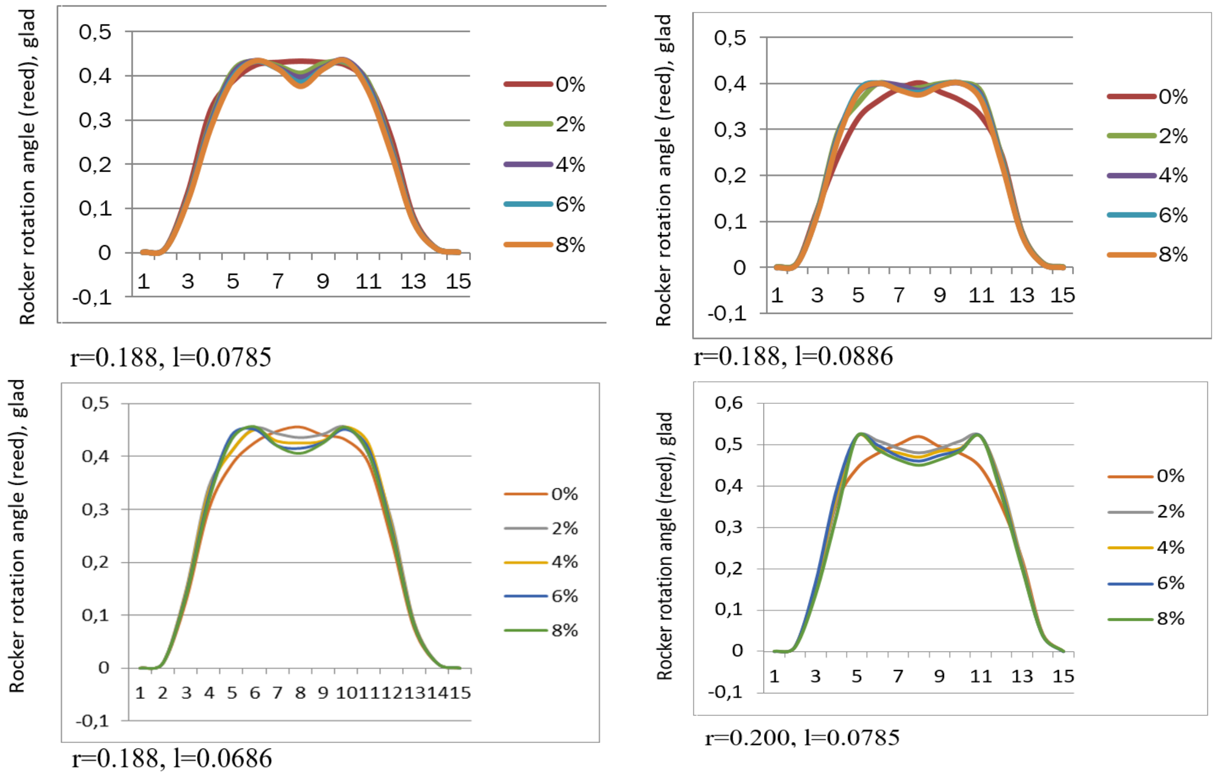

Fig. 4. The patterns of angular movement of the rocker arm (reed), taking into account the deformation of the elastic element

In fig. Figure 5 shows the graphical dependence of the change in the magnitude of the angular displacement of the rocker arm in the surf zone on the change in the strain values of the rubber sleeve of the cam roller.

Analysis of the graphs shows that with an increase in the values of the deformation of the rubber sleeve, it increases the range of movement in the short position of the rocker arm (in the surf zone) according to a nonlinear regularity. Moreover, the value of $\Delta\varphi_3'$ reaches 31^0 with $\Delta_3 = 90\%$.

To ensure the necessary standoff and rocker arm oscillations in this zone $\Delta\varphi_3' \le (1{,}0^0 \div 1{,}5^0)$, the recommended values are $\Delta_3 = (5{,}5 \div 6{,}5)\%$. This ensures the necessary quality of the fabric formation process in the loom.

To justify the parameters of the elastic energy storage, we use the well-known method [4,5]. To determine torsional stiffness obtained:

$$C_s = \frac{I_{gm}\omega_l^2}{\varphi_{\max}^2} \quad (9)$$

where, I_{gm} is the reduced moment of inertia of the lever, ω_l is the angular velocity of the lever of the butt, C_s is the circular stiffness of the spring, is the angle of rotation of the spring.

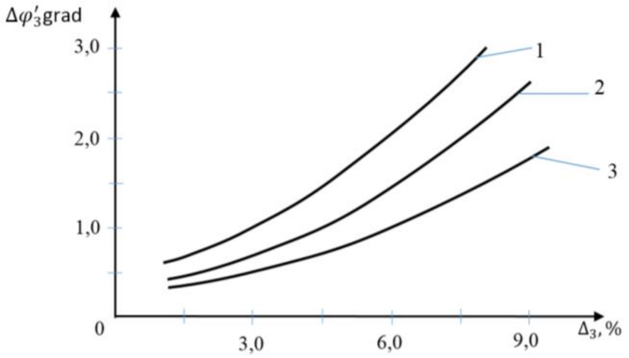

Fig.5. Graphic dependences of the change in the magnitude of the magnitude of the angular displacement of the rocker arm in the surf zone on the change in the strain values of the rubber sleeve of the cam roller

In this case, the maximum twist angle of the spring:

$$\varphi_{в\max} = \frac{\omega_l}{\sqrt{C_s / I_s}} \quad (10)$$

Based on the calculations according to (1), graphical dependences of the change in the torsional stiffness of the spring in the hinge of the batan lever on the variation of its angular velocity are constructed. Dependencies are nonlinear in nature, which are presented in Fig. 6.

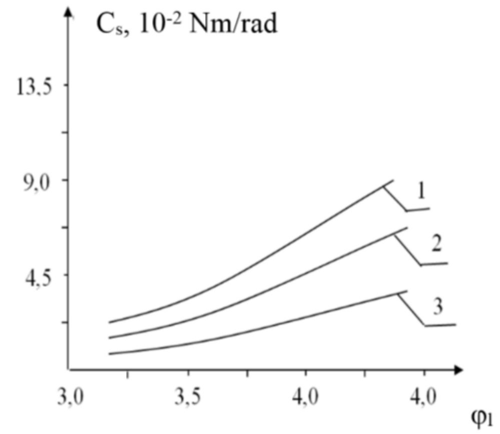

Fig.6. Graphic dependences of the change in torsional stiffness of an elastic energy storage device on the circular frequency of the batan lever

Where, $1 - I_s = 0.009\ kgm^2$; $2 - I_s = 0.011\ kgm^2$; $3 - I_s = 0.013\ kgm^2$;

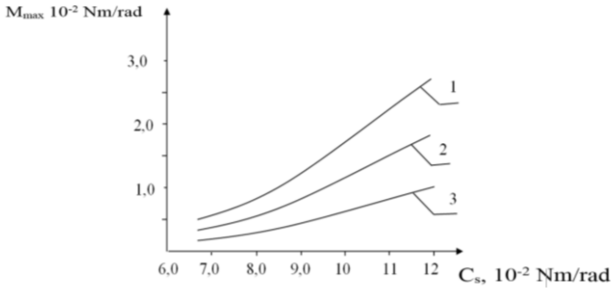

Fig.7. Graphic dependences of the change in the maximum compression moment of a circular spring in the support of the batan lever on the choice of the circular spring stiffness

Where, $1 - I_s = 0.015\ kgm^2$; $2 - I_s = 0.013\ kgm^2$; $3 - I_s = 0.0105\ kgm^2$;

To ensure the accumulation of sufficient energy of the reed of the batan mechanism at $3 - I_s = 0.0105\ kgm^2$; (see Fig. 6), it is considered reasonable to choose C_s in the range $(0.9 \div 1.05)\cdot 10^{-1}\ Nm/rad$.

In this case, the maximum moment of compression of the torsion spring during the accumulation of energy in the idle movement of the lever will be:

$$M_{\max} = \omega_l \sqrt{I_s C_s} \quad (11)$$

With each rotation of the double-disc cams, the batan lever makes a corresponding rocking movement with an angular frequency of $\omega_l = 32\ s^{-1}$. For calculations we accept, $C_s = (950 \div 1150) Nm/rad$ $I_s = (0.0105 \div 0.0140) kgm^2$.

In fig. Figure 7 shows the graphical dependence of the change in the maximum compression moment of a circular spring in the support of the batan lever on the choice of the circular spring stiffness [6,7].

From the obtained results it is seen that an increase in the circular stiffness of the spring leads to an increase in the maximum compression moment. Recommended parameter values are: $C_s = (1000 \div 1050) Nm/rad$, $\omega_l = (35 \div 40) s^{-1}$, $I_s = (0.001 \div 0.013) kgm^2$.

The following moments of forces act on the three-arm lever with a circular spring of the loom mechanism of the loom: from the force of inertia; moments from the elastic and dissipative forces of a circular spring; moment of resistance from the surf; moment of friction in the lever joint; moment from the disturbing force from the side of the paired cams; moments from the gravity of the shoulders of the lever.

Using the D'Alembert principle [5,8], the equilibrium condition of the three-armed lever of the loom mechanism of the loom of the loom has the form:

$$I_l \frac{d^2\varphi_p}{dt^2} = P_b(\varphi_k)\cdot l_1 k - m_2 g l_2^1 \cos(\alpha - \varphi_l) - \quad (12)$$

$$- m_3 g l_3^1 \cdot \cos(\alpha - \varphi_l + \beta) - m_1 g l_1^1 \cdot \cos\varphi_l - M_{fl} - b_k \frac{d\varphi_p}{dt} - C_k \varphi_l$$

where, φ_p - angular movement of the three-armed lever; $P_b(\varphi_k)$ - disturbing force on the cam side; l_2 - the length of the second and third shoulder of the lever;

Retrieval Number: C8902019320/2020©BEIESP
DOI: 10.35940/ijitee.C8902.019320
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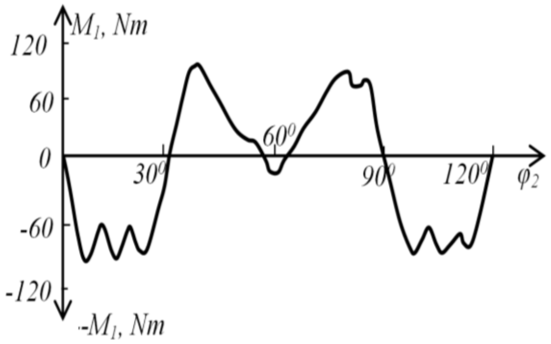
k - coefficient taking into account the stiffness and dissipation of the elastic elements of the rolls of the batan; m_1, m_2, m_3 - the mass of the shoulders of the lever; I_l - reduced moment of inertia of the lever of the batan; $l_1^1; l_2^1; l_3^1$ - the distance from the axis of rotation to the points of the center of gravity of the shoulders of the lever; α, β - constant angles between the shoulders of the lever; M_{fl} - moment from friction in the lever joint; C_k, b_k - coefficients of circular stiffness and spring dissipation in the lever support.

An analysis of the obtained mathematical model of the movement of the three-arm lever of the loom mechanism of the loom (12) shows that the law of movement of the lever is not only influenced by the effects of twin cams, but also the parameters of the circular spring in the support of the lever. According to [9, 10], the laws of change in moment on a tampered shaft are shown in Fig. 8.

Based on the numerical solution of the problem, the laws of motion of the three-armed lever are obtained taking into account the moment values in Fig. 8. The obtained curves show that with the use of a torsion spring, the law of angular movement of the lever will change into the working zone of the surf (see. Fig.9). Moreover, in the surf zone, the bird performs some oscillations with insignificant amplitude. There is some duck stop in this area. This results in high quality fabric.



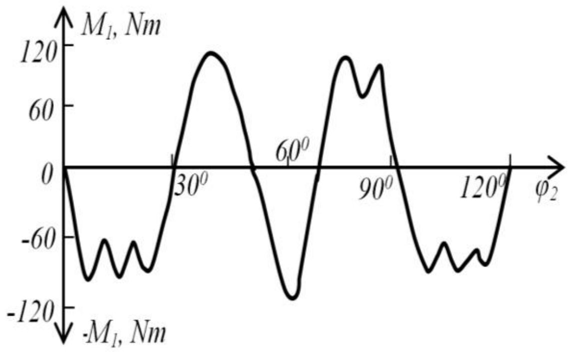


Fig.8. Schedule of change in torsional moment in section I of the set shaft: Under loads:

a) $P_{c\max} = 800\ N$;, b) $P_{c\max} = 800\ N$; .

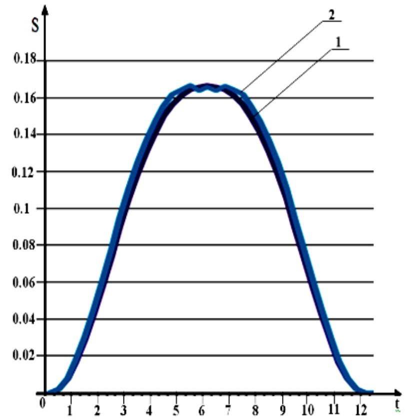


Fig.9. The law of motion of the reed lever of the batan mechanism

1-excluding a circular spring; 2-tailored circular spring

This displacement not only allows a cherished resource, but also an effective duck surf, as well as obtaining high-quality fabric.

IV. EXPERIMENTAL RESEARCH

Test results of the mechanism. A prototype of the batan mechanism with the elastic elements of a shuttle less loom was made. In fig. 10 a shows photographic shots of a composite roller with a rubber sleeve of a cam fist mechanism. In fig. 10 b shows a part of the batan shaft with the installation of an energy storage device in it in the form of a torsion spring.

Preliminary comparative tests were carried out with different grades of rubber for composite rollers, as well as springs with different stiffness.

The test results showed that the recommended version of the batan mechanism can significantly reduce noise during operation, the breakage of threads is practically eliminated. This increases the uniformity of tissue formation, and also increases productivity up to 20% by increasing the speed of tissue formation.

a) where is the weaving rubber sleeve 3 mm

b) where is the weaving rubber sleeve 5 mm

Fig.10. Photographic images of the composite rollers (a) and the energy storage device in the form of a torsion spring (b) of the recommended batan mechanism of the shuttle less loom

V. CONCLUSION

A new effective design of the batan mechanism with elastic elements has been developed. Based on theoretical studies, the parameters of the batan mechanism are substantiated. A prototype of the batan mechanism was made and tested.

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