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KINEMATIC ANALYSIS OF A CAM MECHANISM WITH ELASTIC ELEMENTS

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Abstract.
The article provides a diagram and principles of operation of the crank mechanism with composite cams. The results of the kinematic analysis of the mechanism with compound cams are presented, taking into account the maximum deformations of the elastic elements of the composite cams of the cam mechanism of the weaving loom. Analytical expressions describing the laws of motion of the connecting rod and rocker arm of a replacement linkage-joint mechanism with their four-link length changing are given. The kinematic characteristics of the crank mechanism with composite cams have been analyzed, and the main parameters of the system have been substantiated.

Key words: Cam mechanisms, fastened elastic element, pusher, connecting rod, rocker arm, angular movements, speed, screws, maximum deformation, elongation, rigidity, loom, transformation.

Kinematics of a cam mechanism with composite cams and elastic elements. During the process of fabric formation in a weaving loom, some dwell time is required with a slight oscillation of the end of the beam (reed). To obtain such a pattern of movement of the pusher, a cam with elastic elements is used in the drum mechanism [1]. In this case, due to the deformation of the elastic element of the composite cam, the position of the cam profile changes. This causes some vibration at the end of the pusher. Berda will carry out the required laws of motion. In this case, it is important to determine the kinematics of the characteristics of the movement of the rocker arm, taking into account the maximum deformations of the elastic rings of the paired cams of the baton mechanism. To do this, the cam mechanism is replaced by a four-link lever mechanism. In the kinematic pore of the fourth class, two kinematic pairs of the fifth class are introduced, the cam is replaced by a crank and connecting rod [2].

Deformations of elastic rings are taken into account only by maximum values [3]. The design diagram of the replacement mechanism, taking into account the maximum deformations of the elastic rings of the rear cams, is presented in Fig. 2.

Using the well-known closed vector method [4], we obtained equations to determine the angular displacements φ_2 and φ_3.

In the mechanism under consideration, we will compose vector equations for the contours ABD and BCD:

for ABD circuit:

$$\bar{l}_4 + \bar{q} - \bar{e}_1 = 0 \qquad (1)$$

for circuit BC ABD:

$$\bar{q} + \bar{l}_2 + \Delta\bar{l}_2 - \bar{l}_3 - \Delta\bar{l}_3 = 0; \quad \bar{q} + \bar{l}_2 - \bar{l}_3 = 0;$$

$$\bar{q} + \bar{l}_2 - \Delta\bar{l}_2 - \bar{l}_3 - \Delta\bar{l}_3 = 0 \qquad (2)$$

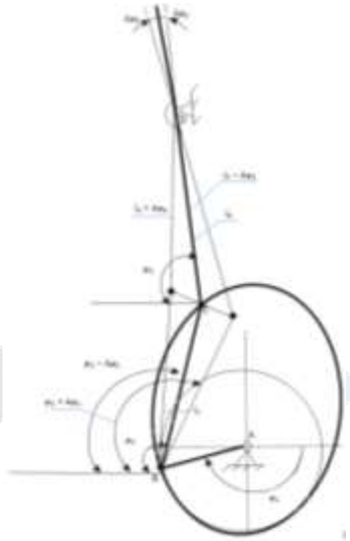

Fig. 2. Diagram of the replaceable cam mechanism of the loom batan.

At the same time, projecting the vectors of equation (2) on the coordinate axes x and y we have: [5].

$$l_4 + q\cos\varphi_q - l_1\cos\varphi_1 = 0$$

$$q\sin\varphi_q + l_1\sin\varphi_1 = 0 \qquad (3)$$

According to the methodology given in [13,14], from (3) we have:

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

Taking into account the values of $\Delta l2$ and $\Delta l3$ for the corresponding angles *BCD* using the cosine theorems we have [6]:

$$l_2^2 = q^2 + l_3^2 - 2ql_3\cos\varphi_{3q};$$

$$l_3^2 = q^2 + l_3^2 - 2ql_2\cos\varphi_{2q};$$

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

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

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

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

In this case we have:

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

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

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

$$\varphi_{3q} - \Delta\varphi_3 = \arccos\frac{q^2 + (l_3 - \Delta l_3)^2 - (l_2 - \Delta l_2)^2}{2q(l_3 - \Delta l_3)}; \tag{6}$$

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

We obtain the patterns of angular displacements in the form:

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

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

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

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

$$\Delta\varphi_2 = \frac{1}{2}\left[\arccos\frac{l_1^2 + l_4^2 - 2l_1l_4\cos\varphi_1 + (l_2 + \Delta l_2)^2 - (l_3 + \Delta l_3)^2}{2(l_3 + \Delta l_3)\sqrt{l_1^2 + l_4^2 - 2l_1l_4\cos\varphi_1}} - \\ - \arccos\frac{l_1^2 + l_4^2 - 2l_1l_4\cos\varphi_1 + (l_2 - \Delta l_2)^2 - (l_3 - \Delta l_3)}{2(l_2 - \Delta l_3)\sqrt{l_1^2 + l_4^2 - 2l_1l_4\cos\varphi_1}}\right] \tag{8}$$

According to the design diagram in Fig. 2... we can write:

$$\varphi_{3\max} = \varphi_3 + \Delta\varphi_3; \qquad \varphi_{3\min} = \varphi_3 - \Delta\varphi_3;$$

$$\varphi_{2\max} = \varphi_2 + \Delta\varphi_2; \qquad \varphi_{2\min} = \varphi_2 - \Delta\varphi_2 \qquad (9)$$

Numerical solution of the problem posed in the form of the law of conditional movement of the rocker arm (reed) of the cam batan of the loom mechanism. In Fig. Figure 3 shows the patterns of movement of the rocker arm in the absence of an elastic element, that is, for the existing version of the baton mechanism [11].

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