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DEVELOPMENT OF DESIGN SOLUTIONS AND STUDY OF THE VIBRODYNAMICS OF A REED BASED ON ELASTIC ELEMENTS OF A LOOM DRUM MECHANISM

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Аннотация. *В статье приводится конструктивная схема и принцип работы рекомендуемого батанного механизма с бердом на упругой опоре. Представлена динамическая и математическая модели колебаний берда с несимметричной упругой опорой. Аналитическим методом решена задача динамики колебательного движения берда. Получена формула для расчета перемещений берда батанного механизма. Обоснованы параметры системы.*

Abstract. *This article presents the design and operating principle of a recommended reel-mounted reed mechanism. Dynamic and mathematical models of reed oscillations with an asymmetric elastic support are presented. The dynamics of the reed's oscillatory motion are solved analytically. A formula for calculating the reed's displacement is derived. The system's parameters are substantiated.*

Introduction. A known loom spool mechanism comprises a light alloy spool bar with a longitudinal groove into which the reed is placed and secured with its lower slit. A comb guide for the thread guide is attached to the spool bar. The rectangular cross-section spool bar is secured to blades, which are attached to a spool shaft. Levers with rollers are rigidly mounted on the spool shaft. The rollers contact paired eccentrics (cams) mounted on the main shaft [1].

A disadvantage of this design is that the reciprocating motion of the spool bar generates unbalanced inertial forces in the mechanism, leading to increased reactions in the kinematic pairs and uneven rotation of the loom's main shaft. As a result, the spool's law of motion differs from the designed law of motion. In addition, under the action of the inertial forces of the spool, during one revolution of the cam (eccentric), the contact of the spool rollers from the cam to the contour cam occurs twice, which causes impacts in the mechanism of the weaving machine and increased vibration, reducing the reliability of the structure.

To ensure a uniform warp and weft thread density, increase structural reliability, and improve loom productivity, the design of the spool mechanism has been improved by ensuring the necessary laws of reed motion during weft beating during loom formation.

The design consists of a spool mechanism comprising a cam and an associated countercam mounted on the main shaft. Two rollers are pivotally mounted on a three-arm lever capable of engaging the cam profiles. The third arm of the lever, mounted on the spool shaft, serves as the spool blade, to which a spool bar is attached. The reed is mounted in the longitudinal groove of the spool bar with its lower spool, using a rubber gasket with an asymmetrical trapezoidal cross-section. The thickness of the rubber lining in the working area is twice that of the idling area.

The reed, installed in the longitudinal groove with the lower slack, is constructed using a rubber lining with an asymmetrical trapezoidal shape in the longitudinal cross-section to ensure the required dwell time in the weft beating zone, resulting in fabric with a uniform density. The proposed design is illustrated by a drawing, where Fig. 1 shows the general diagram of the weaving loom's reed mechanism.

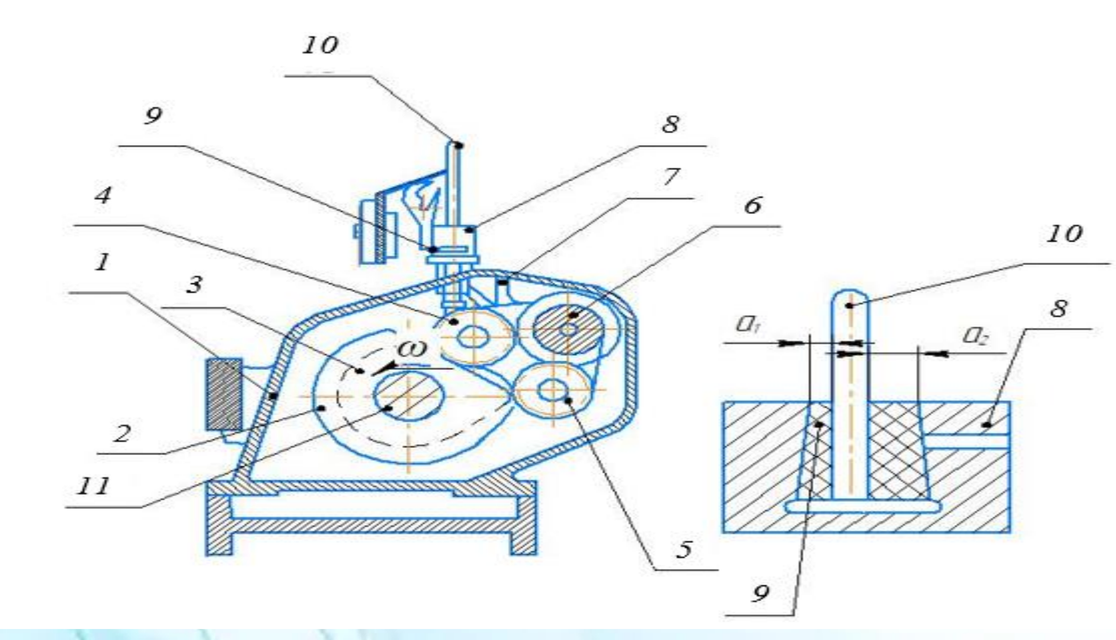

Fig. 1. Batton mechanism of a weaving loom

The loom's batten mechanism comprises a housing 1, a cam 2, and a countercam 3 mounted on a main shaft 11. Rollers 4 and 5 are pivotally mounted in a three-arm lever 7 and engage the profiles (surfaces) of cams 2 and 3. Lever 7 is pivotally mounted on batten shaft 6. The third arm of lever 7 is rigidly connected to a block 8. A reed 10 is installed in a longitudinal groove of block 8 via a rubber gasket 9 with an asymmetrical, prape-shaped cross-section.

The proposed batten mechanism of a loom increases its reliability by reducing reactions in kinematic pairs, ensures smooth operation due to the necessary deformations of the rubber gasket, and allows for the required reed oscillation during weft beating. In this case, the thickness of the rubber gasket 9 in the working zone a2 is made twice as large as the thickness a1 of the rubber gasket 9 in the idle zone:

a_2 - 2 a_1

The batten mechanism operates as follows. Cam 2 and its paired counter-cam 3 receive rotational motion from main shaft 11. The three-arm lever (pusher) receives a rocking motion due to the constant contact of rollers 4 and 5 with the profiles of cams 2 and 3. This motion is transmitted to the beam (lever arm 7) 8 with the reed 10.

In operating mode, reed 10 beats up the weft thread. Due to the large deformation of rubber pad 9 (thickness a2), the reed 10 oscillates for a sufficient time, ensuring the required weft beating up and producing fabric with the required uniform density. Furthermore, in idle mode, due to the lesser deformation of pad 9 (thickness a1), the reed 10 oscillates with asymmetrical harmonic oscillations. This design enables fabric formation with uniform density.

The proposed reed design with an asymmetrical elastic support of the beating mechanism ensures the required dwell time during weft beating up due to the increased thickness of the elastic shock absorber in operating mode. This means that the reed oscillates nonlinearly due to the process load and, in particular, the different stiffnesses of the elastic supports installed on both sides of the reed. Figure 2 shows the calculation scheme of the oscillations of a reed with an asymmetric elastic support.

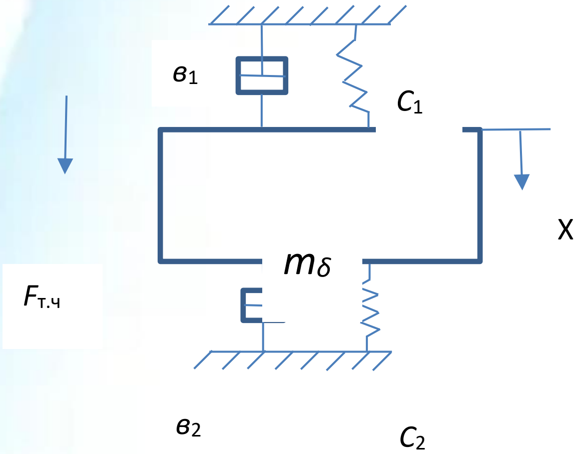

Fig. 2. Calculation diagram of the reed oscillations with an elastic support of the spool mechanism.

To create a mathematical model of the oscillations of the reed of the battan mechanism, we use the Lorentz equation of the second row [7, 8]:

$$\frac{d}{dt}\left(\frac{\partial T}{\partial \dot{q}}\right) - \frac{\partial T}{\partial q} + \frac{\partial \Pi}{\partial q} + \frac{\partial \Phi}{\partial \dot{q}} = Q(q) \qquad (1)$$

where T, P, F are the kinetic and potential energies of the reed of the batten mechanism and the Rals dissipative function [9, 10]; q is the flexible force, t is the time.

To determine the members of the Lagrangian equation (1), we calculate the reduced coefficient of rigidity and dissipation of the components of the elastic support of the reed of the ram mechanism [11, 12]:

$$C_n = \frac{C_1 \cdot C_2}{C_2 - C_1}; \; в_n = в_1 - в_2 \; \ldots \qquad (2)$$

where C1, C2 are the stiffness coefficients of the elastic elements; b1, b2 are the dissipation coefficients of the elastic elements.

In this case, according to [13, 14] we have:

$$\mathrm{T} = \frac{1}{2} m_\delta \left(\frac{dx}{dt}\right)^2; \; \Pi = \frac{1}{2}\frac{C_1 \cdot C_2}{(C_2 - C_1)}; \; \Phi = \frac{1}{2}\,(в_1 - в_2)\left(\frac{dx}{dt}\right)^2 \qquad (3)$$

where m_δ – is the reduced mass of the reed.

Generalized force [15]:

$$Q\,(x) = F_1 + F_0 sinwt \qquad (4)$$

where F1; F0 are the constant and amplitude components of the disturbing force (thread resistance) during fabric formation.

Substituting the obtained expressions (2), (3), and (4) into the graphical equation (1), we obtain a differential equation describing the law of motion of a reed with an elastic support [16]:

$$m_{\delta}\frac{d^2x}{dt^2}+(в_1-в_2)\frac{dx}{dt}+\frac{C_1\cdot C_2}{C_2-C_1}\quad X=\mathrm{F}_1+\mathrm{F}_0 Sin\mathrm{wt} \qquad (5)$$

The obtained differential equation (5) is reduced to a standard form using the known analytical method according to [16, 17] and we obtain its solution in the form:

$$X=\frac{Fsin(\omega t-\alpha)}{\sqrt{\frac{C_1C_2}{(m_{\delta}(C_2-C_1)-\omega^2)+\frac{\omega(в_1-в_2)}{m_{\delta}}}}} \qquad (6)$$

Where, $\mathrm{P}_{б}=\sqrt{\frac{C_1C_2}{m_{\delta}(C_2-C_1)}}$; $\quad F=\frac{F_0}{m_{\delta}}$

Conclusions. An efficient reed design with asymmetric elastic supports has been developed. Based on the solution to the reed oscillation dynamics problem, graphical dependences of changes in the reed oscillation amplitude on changes in system parameters were obtained, and recommended parameter values for high-quality fabric formation were determined.

Using a reed design with an asymmetric elastic support ensures the required dwell time during warp and weft thread penetration, allowing for the required fabric density. This design significantly reduces the load on the spooling mechanism and the noise level during fabric formation.

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