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The impact of the dynamics of take-up mechanism on the distance between the weft threads in the development of fabric with the variable density of weft

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Abstract:
In the commodity is determined by the influence of the dynamics of the regulator to the variable structure of tissues. It is shown that taking into account the compliance of the elements of commodity regulator design results in uneven distances between adjacent weft and smoothing the boundaries between the seal and sparse tissue sections.
Keywords: **weft, warp, vaillant, trademark mechanism, the main regulator, cloth.**

Introduction. A device fitting to the STB type of weaving machine allowing to produce wide range of fabric with variable density in weft has been developed [1]. The principal difference of the device is an additional programme controlled loom motor , abruptly changing the speed of the cross- shaft weaving machine and providing of manufacturing the tighten and loose parts of weft fabric.

Taking into consideration the flexibility of the elements of the construction of take-up mechanism (gears, shafts, etc.), we consider that, fluctuations in the mechanism due to the abrupt change in the angular speed of the cross-shaft leads to irregularity of distances between adjacent weft threads and smoothing of the boundaries between the tightened and loose parts of weft fabric.

Theoretical justification:

Let us estimate the impact of the dynamics of the device on the location of weft threads in the fabric. Imagine a dynamic model of the device in the form of a dual-mass (Fig. 1-a), where the cross section *a* corresponds to a position on the cross- shaft sprocket chain drive connecting the cross shaft with an additional electric loom motor. The driven mass (J_1 and J_2) and stiffness (c_1 and c_2) corresponds to *1* - worm gear of take-up mechanism and 2- take-up roller.

The latter is connected with beam by means of an elastic filling with driven stiffness c_3. The pinning point for the elastic filling systems on the beam is considered fixed/immovable, since it is assumed that the number of pay off the wrap in one turn of the weaving machine corresponds to the amount allocated in the same time for the fabric. In this case, the length of elastic filling system does not change.

Abrupt change of angular speed of the cross-shaft in section *a* allows to consider the system of take-up mechanism in development of fabric with variable density as a kinematically induced system and it considers its movement as a movement of a massless system in adding the forced oscillations/vibrations of the system with the additional fixing at the kinematic excitation point caused by the forces of inertia of the first movement [2]. The dynamic model of the system for determining the forced oscillations (with additionally fixed section *a*) is shown in Fig. 1-*a*.

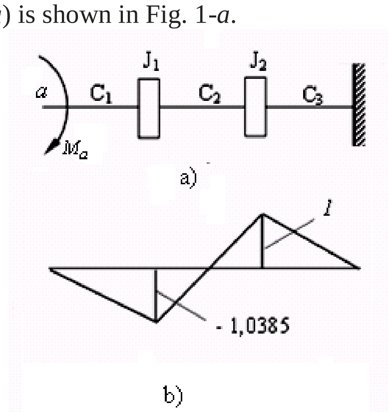

Fig. 1

In determining the forced oscillations of the system with additional fixing in generalized coordinates, the complete displacement of the points of the system can be written as (1):

$$\bar{x}_1 = x_1 + q_1 u_{11} + q_2 u_{12},\qquad (1)$$
$$\bar{x}_2 = x_2 + q_1 u_{21} + q_2 u_{22},$$

Where q_i – is the generalized coordinates; u_{ij} – is the corresponding amplitude; x_i – is the point of massless displacement system.

To determine the correlation between the displacement of the motion of a massless system we will use M_a moment in cross-sectional *a* with the displacement of x_a section. Then

$$x_a = M_a/c_1 + M_a/c_2 + M_a/c_3 = M_a(c_2c_2 + c_1c_3 + c_1c_2)/(c_1c_2c_3)$$
$$x_1 = M_a/c_2 + M_a/c_3,\quad x_2 = M_a/c_3$$

After transformations

$$x_1=x_a(c_1c_2+c_1c_3)/(c_1c_2+c_1c_3+c_2c_3),$$
$$x_2=x_ac_1c_2/(c_1c_2+c_1c_3+c_2c_3)$$

In motion of the system with a fixed section *A* the moments of forces of inertia P are influenced to its mass

$$P_1=-J_1\ddot{x}_a(c_1c_2+c_1c_3)/(c_1c_2+c_1c_3+c_2c_3),$$
$$P_2=-J_2\ddot{x}_ac_1c_2/(c_1c_2+c_1c_3+c_2c_3).$$

The experiments made on the weaving machine and their processing by the method of mathematical statistics indicate that, the angular speed of cross-shaft in the transition from the tightening parts to loose is approximated well by the expression [3]:

$$x_a=\omega(t)=\omega_0+A\,[1-\exp(\alpha t)] \qquad (2)$$

where in ω_0 – is the angular speed of the cross-shaft; A – is the volume of the abrupt action of the angular speed of the cross-shaft , determining the difference between the densities of tightened and loose fabric sections ; α - is an empirical factor depending on the characteristics of the additional engine and design features of the device; t- time.

In our case, α= -0.9. Acceleration of x_a we will find from (2). After substituting in the expression for P_1 and P_2 we will obtain the moments of inertia forces

$$P_1=J_1A\alpha(\exp\alpha t)(c_1c_2+c_1c_3)/c_1c_2+c_1c_3+c_2c_3), \qquad (3)$$
$$P_2=J_2A\,\alpha(\exp\alpha t)c_1c_2/(c_1c_2+c_1c_3+c_2c_3)$$

For the system (3) with a fixed section *a* (Fig. 1-b), mass equations of motion are of

$$J_1\ddot{x}_1+c_1x_1+c_2(x_1-x_2)=0 \qquad (4)$$
$$J_2\ddot{x}_2-c_2(x_1-x_2)-c_3x_2=0$$

The equations of motion in generalized coordinates have the form

$$\ddot{q}_1+p_1^2q_1=Q_1/M_1,\ \ddot{q}_2+p_2^2q_2=Q_2/M_2$$

and after substituting in them the generalized forces $\sum_{i=1}^{n} P_iu_{ik}$
and the generalized mass and $M_k=\sum_{i=1}^{n} m_iu^2_{ik}$ taking into account the permanent and found natural frequencies values

$$\ddot{q}_1+0{,}755\cdot10^6q_1=0{,}507A\exp(-0{,}9\,t) \qquad (5)$$
$$\ddot{q}_2+0{,}274\cdot10^6q_2=-1{,}389A\exp(-0{,}9\,t).$$

The initial conditions, appropriate to the time of transition from the development of tightened to the loose parts:

$$x_{10}=M_T/c_1,\quad \dot{x}_{10}=\omega_0: \qquad (6)$$
$$x_{20}=M_T/c_1+m_t/c_2,\quad \dot{x}_{20}=\omega_0:$$

For density of the loose and tightened fabric parts respectively 20 and 30 threads/cm and the speed of the weaving machine of 240 turns in one minute we have $\omega_0=24\ c^{-1}$,$A=12\ c^{-1}$. The experimental moment of M_t of a tension of fabric on the take-up roller equals to 100 N m.

Since we are interested in movements on the take-up roller, we will use the second equation from (1). Substituting in it the expression for the generalized coordinates found from (5) taking into account (6) - and neglecting insignificant terms, we obtain

$$\bar{x}_2=8{,}85\cdot10^{-3}\,n-4{,}5\,[\,1-\exp(-0{,}9\,n)\,] \qquad (7)$$

where replacement of $t=n\cdot T$ has been made (n-is a number of a turn after transition to development of the loose parts, T – is time of one cycle.

Distances between the adjacent weft thread are characterized by angles of rotation of a take-up roller in the next cycles. The formula (7) gives a total angle of rotation of a take-up roller for *n* turns and allows to determine easily the required sizes as a difference of value x_2 for *n* and *(n-l*) of turns.

Example:

The experimentally determined stiffness and inertial characteristics are having the values: $J_1=2\cdot10^{-2}$ and $J_2=5{,}4\cdot10^{-3}$ kq·м; $C_1=1.12\cdot10^4$ and $C_2=0{,}2\cdot10^4$ and $C_3=40$ Nм. Taking into consideration these values on the equation (4) the natural frequencies are calculated; $P_1=0{,}869\cdot10^3$ and $P_2=0{,}523\cdot10^3$, c^{-1}. The correlation between the amplitudes: $u_{11}=-1{,}0385\ u_{21}$, $u_{12}=0{,}26\ u_{22}$. The forms of vibrations are shown in Fig. 1-*b*.

CONCLUSIONS

1. Has been developed the analytical method of an assessment of impact of dynamics of the take-up mechanism on change of distance between weft threads at production of fabrics of variable density on a weft.

2. Taking into account the forces of inertia and elasticity of links of the take-up mechanism has been obtained the analytical expression (7), for definition of an angle of rotation of a take-up roller depending on consecutive number of a turn of the main shaft after changing the density of the developed part.

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