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EXPERIMENTAL RESEARCH OF THE ANGULAR VELOCITY OF MAIN SHAFT OF LOOM STB

ЭКСПЕРИМЕНТАЛЬНЫЕ ИССЛЕДОВАНИЯ УГЛОВОЙ СКОРОСТИ ГЛАВНОГО ВАЛА ТКАЦКОГО СТАНКА СТБ

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The paper presents the experimental research of the angular velocity of main shaft of loom STB. Measuring the angular speed of the main shaft of the loom STB conducted using an accurate measurement of time for which the shaft is rotated by one and the standard angle. For the experimental research were applied the photosensors with integrated amplifiers current, and as a recording device cymometer. To improve the analysis of the experimental results, we proposed to build a combined graph of the angular velocity of main shaft with timing diagram of mechanisms loom STB.

В статье приводятся экспериментальные исследования угловой скорости главного вала ткацкого станка СТБ. Измерения угловой скорости главного вала ткацкого станка СТБ проводятся с помощью точного замера времени, за которое вал поворачивается на один и тот же эталонный угол. Для экспериментального исследования применялись фотодатчики с встроенными усилителями тока, а в качестве регистрирующего прибора – частотомер. Для улучшения анализа экспериментальных результатов предлагается строить совмещенный график угловой скорости главного вала с циклограммой механизмов ткацкого станка СТБ.

Keywords: loom STB, main shaft, timing diagram, photosensor, cymometer.

Ключевые слова: ткацкий станок СТБ, главный вал, циклограмма, фотодатчик, частотомер.

In the research of the dynamics of the loom STB is necessary to have information about the variation of the angular velocity of the main shaft and the influence of different factors.

These factors primarily include changes in the laws reduced moments of inertia of the moving parts of the loom [1], change of resistance forces, the mechanical characteristics of the engine, and others [2].

With the known the variation of the angular velocity $\omega = \omega(\alpha)$ or $\omega = \omega(t)$ of the main shaft of the loom can be estimated or uneven rotation, angular accelerations found necessary to analyze the dynamics of separate mechanisms.

For a more detailed analysis of the impact separate loom mechanisms on the character of the law of change of the angular velocity of the main shaft of the loom, the loom is necessary build a combined graphics cyclogram of the most loaded mechanisms [3].

Combined graphics with timing diagram mechanisms of loom allow: to determine variation of the angular velocity on the transient regimes motion of the loom together with the operation of the loom cyclogram mechanisms; to determine the influence of individual mechanisms, through their disconnection, on fluctuation in the angular velocity of the main shaft of the loom.

There are many different methods and devices for measuring the angular velocity of the rotating links for which different types of sensors [4...6] are used. The sensors can be in contact and non-contact, continuous and impulsive actions. According to the principle of work are divided into slide-wire gage, induction, photo sensors, vibration sensors, etc. Each of these types of sensors possesses certain advantages, depending on the sensor device is necessary to apply an appropriate range of measuring and recording equipment and mathematical apparatus for data processing. When choosing the type of sensor is necessary in each case assume from experimental conditions produced and accuracy obtained as a result of the experiment data.

Let us consider the method of measuring the average angular velocity of the main shaft of the loom STB with pulse encoder.

Regardless of the type of average speed pulse encoder is defined by the formula:

$$\omega_j = \frac{\Delta\alpha}{\Delta t_j}, \qquad (1)$$

where $\Delta\alpha$ – given angle; Δt_j – measured period of time.

Equation (1) can be used to measure the velocity in a selected area if the angular displacement change linearly. Otherwise, there are difficulties associated with the calculation of truncation error as to decrease the angle of the rounding error increases. If on the main shaft is set slide-wire gage angular displacement sensor and ignore the effect of the use of the galvanometer, the angular displacement:

$$K_y y(t) = \alpha(t), \qquad (2)$$

where y(t) – oscillogram records of angular movement of the shaft; $\alpha(t)$ – measured displacement; K_y – scale records.

Let the expression (2) is considered as the first member of the differentiated polynomial interpolation Newton at equidistant points:

$$\omega_0 = K_y y_0^{(1)} = \frac{K_y}{h}(y_1 - y_0), \qquad (3)$$

where h – step differentiation.

The error $y_0^{(1)}$ is represented as the sum of the rounding and truncation errors. It can be shown that the total error is minimal, and when the condition $h = h_{cp}$ is met:

$$\frac{h}{2} f^{(2)}(\eta) \approx \frac{1}{2h}\Delta^2 y_0 \approx \frac{\varepsilon_y}{h}, \qquad (4)$$

where $\frac{h}{2} f^{(2)}(\eta)$ – truncation error; $\Delta^2 y_0$ – the absolute value of the second-order difference; ε_y – the absolute error, waveform rounding ordinates.

If the expression (3) is written in a different form which is convenient for the determination of the derivative at the midpoint, then the sequence of computations is raised by one:

$$\omega_1 = K_y y^{(1)} = K_y \frac{y_2 - y_1}{2h} + 0\left(h^{p+1}\right). \quad (5)$$

This increase results from the accuracy of the numerical differentiation formulas for Newton unequal intervals:

$$L_n^{(1)}(x) = f(x_0, x_1) + \left[(x - x_0) + (x - x_1)\right] f(x_0, x_1, x_2),$$

when the second term on the right is treated as the remainder. If x is considered symmetrically with respect to x_0, x_1 it is the root of the equation $(x - x_0) + (x - x_1) = 0$, and the remainder term (5) vanishes.

In calculating the same derivative with a large number o f expression produce a greate order of accuracy. However, they are bulky, require high-order and often can not be used because the waveform records are not very accurate. Therefore, you can use the low accuracy of the formula to further improve order accuracy, and then simplify the result Runge [7] according to the formula:

$$\alpha_2^{(1)} = K_y y_2^{(1)} = \frac{K_y}{h}\left[\left(1 + \frac{1}{r^p + 1}\right)(y_3 - y_1) - \frac{0,5}{r^p - 1}(y_4 - y_2)\right],$$

where r – the amount of increase in step; p – order accuracy of the calculation of derivatives.

The interval $[t_0, t_4]$ is divided into four equal parts t_0, t_1, t_2, t_3 and are calculated at p=2, r = 2:

$$\alpha_2^{(1)} = H_y y_2^{(1)} = \frac{K_y}{2h}\left[1,33(y_3 - y_1) - 0,166(y_4 - y_0)\right].$$

Here are the results of measurement of the angular velocity of the main shaft of the loom STB performed using precise measurement of time over which the shaft is rotated by one and the reference angle. The average angular velocity of shaft rotation in this angle is defined as the angle at the time of this rotation. Due to the smallness of the reference angle (less than 5°), consider the angular velocity constant within said portion.

In the research of the main shaft rotation non-uniformity of this method applied to the integrated photo sensors current amplifiers, and as the cymometer CH3-33. On the main shaft of the loom was fixed disc with radial slits, which was formed with the help of the signal applied to the photo-sensor angular velocity Fig. 1. The angular velocity sensor 2 is a photoelectron pulse converter with integrated signal amplifier.

By rotating the main shaft uniformly arranged radial slits disc 1 turn open the way for a ray of light bulbs 4 and the photodiode 3 which converts the pulsed light signal into an electric, amplified current integrated cathode follower.

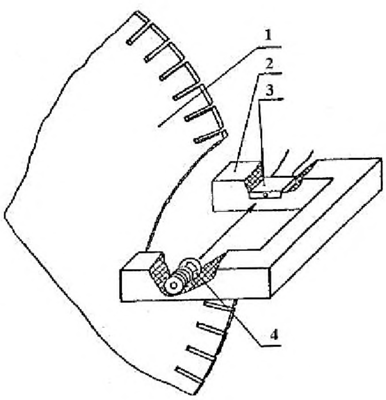

Fig. 1

The amplified signal is transmitted to the recording apparatus. When measuring the angular speed of the main shaft are two rigidly connected to each other by means of the screw of sensor. In this case, strictly fix the angular distance between the sensors photodiodes relative to the rotational center of the main shaft. The slits except for one disc 1 are sealed. Since the disk is rigidly connected with the main shaft of the machine, each slit that corresponds to a well-defined position of the main shaft.

Opening the slit and in order to change the time interval between the pulses of the two sensors, it is possible to find the average values of the main shaft rotational speed close to instantaneous, according to the formula:

$$\omega = \frac{1}{\Delta t} \operatorname{arctg} \frac{\ell}{r_1}, \qquad (6)$$

here ℓ – the distance between the photo sensors; r_1 – distance from center of rotation to the photodiode; Δt – time frame.

It is known that the accuracy of the system forming the signal, the higher the ratio the greater the distance between the sensors to drive slit width. The slit width is limited to the size of a light layer of the photodiode, the more accurately match these sizes, the smaller pulse time, which in this case is an absolute error.

On the other side, the average values of the angular velocity will be closer to the instantaneous ratio of less ℓ than r_1, as follows from the formula (6).

The amount is limited only by the design features of the test mechanism and should be chosen as large as possible. The distance between the sensors on the one hand it is desirable to increase and the other decrease. It is known that the formation of the signal minimum allowable ratio of the distance between the sensors to the width of the slot is ten. From timing diagram work it can be concluded that the average speed within 5° of rotation of the main shaft will not affect the qualitative picture. Quantifying the evaluation showed that the error does not exceed 10% of the value of the instantaneous speed.

To measure the time interval between the pulses of the angular velocity sensor used electronic frequency CH3-33 who worked pulses from one of the sensors and stops the pulse coming from the second sensor. For each of the positions of the main shaft was made 25 equally accurate independent measurements.

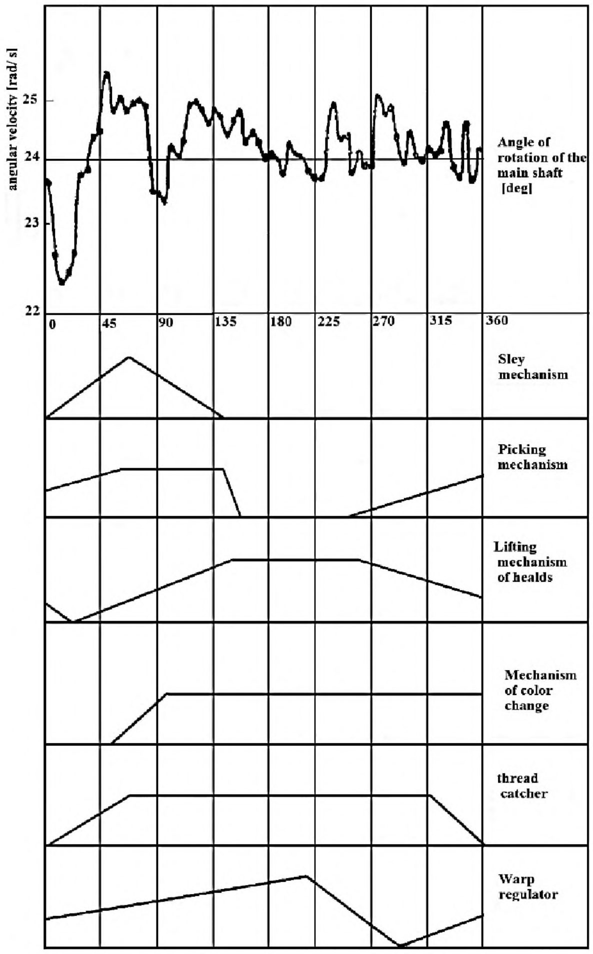

Fig. 2

An experimental determination of the angular velocity of the main shaft of the loom STB4-175KN with filling: warp №20 cotton, weft №8.

Fig. 2 shows combined with timing diagram separate mechanisms loom STB graph of the angular velocity of the main shaft $\omega = \omega(\alpha_{m.sh})$.

As seen from the combined graph $\omega = \omega(\alpha_{m.sh})$ (Fig. 2), the greatest fluctuations of the angular velocity of the main shaft occurs in the range 0...140° of the timing diagram loom. On this site there is intensive work of sley mechanism, picking mechanism, lifting mechanism of healds, mechanism of color change, thread catcher mechanism, warp regulator.

CONCLUSIONS

1. Combined graph of the angular velocity of the main shaft with timing diagram mechanisms loom STB, is allowed identify the most loaded mechanisms and correct the course of experimental research according to timing diagram of loom STB.

2. To reduce the coefficient of rotation unevenness of the main loom STB, is proposed to: reduce clearances between the rollers and cams in sley mechanism; not to twist the torsion shaft of picking mechanism by an angle more than 30 degrees; not exceed the shed opening angle of lifting mechanism of healds at an angle greater than 22 degrees; reduce backlash in the gears of warp regulator.

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