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Development of the design and justification of the parameters of the guide rapier of the weaving machine

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Abstract. The article describes the design feature and the principle of operation of the recommended pattern of the weaving rapier guide. On the basis of theoretical studies, graphical dependencies of the parameters of the guide roller were adjusted, the system parameters were recommended by analyzes.

1. Introduction

The efficiency of the weaving machine mainly depends on the working bodies of the non-forming. In this case, the mode of movement of the rapier plays an important role [1]. Known rapier mechanism of a weaving machine containing rapiers, each of which, by means of a lever system, is connected to groove cams mounted on the swing axis of the batan blade [2].

In addition, in the process of work, when the rapier moves, it passes between the guides in the form of pins, and there may be some contacts with us, leading to their wear, as well as the blade of the pins.

In another design, the rapier guide of a weaving machine, comprising a metal body having an inclined lateral loom in contact with the foil pad, and an antifriction liner attached to the vertical wall of the body, in contact with the cylindrical surface of the rapier, while in order to increase reliability in operation by preventing breakdowns during breakdowns and reduce wear, the body is made in the form of a curved plate of an elastic material to ensure elastic deformation of the inclined side and vertical walls [3]. This design can also have wear and tear on the guide pins when in contact with the rapier.

In the design, the rapier weaving machine has increased efficiency in operation and contains at least one rapier mounted on the cushioning tape, making a translational movement in the throat of the rapier, and the cushioning tape is guided in the throat by both sides on the guide pins in the guide grooves at a distance from the warp threads, and the guides the grooves of the guide pins facing the reed in each case have a lower guide surface that runs at least parallel to the plane of the cushion tape, as well as an upper guiding surface opening at an angle relative to the plane of the cushion tape towards the cushion tape, and the edge of the cushion tape entering the guiding recesses has corresponding cross section. The angle a of the upper guide surface of the guide pins facing the reed is chosen such that this upper guide surface, when leaving the lower throat and crossing the warp threads, forms an angle $\beta \geq 5^0$ with them and the cushion tape on the lower side between the edges has a superstructure. The main disadvantage of this design is the guide pins, which can also be made by the manufacturer and even can occur when they come into contact with the rapier [4].

To increase the reliability of the guide pins on weaving machines, the designs of the guide pins have been improved, ensuring that the friction between the guide pins and the rapier is accommodated when they come into contact.

2. Materials and methods

2.1. Scheme and principle of operation of the recommended rapier guide design
The design essence of the weaving machine rapier guide consists in the fact that the guide pins are made of composite, including rods rigidly fixed in the body on which a roller with a figured head is installed with a small gap. In the process of work, when the rapier contacts the rollers with a figured head, the latter rotates by a certain angle, reduces the friction force between them. In this case, sliding friction is replaced by rolling friction.

The proposed design of the guide rapier of the weaving machine consists of composite roller joints 1 installed in the body 2 with a certain pitch along the edges of the guide body 2. Between these rows of composite roller pins in the middle of the rapier (only the directions of movement of the rapier are conventionally shown) moves back and forth 6. Composite Roller pin 1 consists of a rod (pin) 3 rigidly installed in the body 2. A roller 4 with a figured head is put on the rod 3 with the possibility of free rotation around it 5. The lower part of the roller 4 is rounded, which allows reducing the friction of the base of the roller 4 from the surface of the body 2.

The design works as follows. In the process of shaping, the rapier carries out a reciprocating movement along the guide of the body 2 (in the middle). In this case, the contact of the side surfaces of the rapier with the surfaces of the rollers 4 of the composite roller pins occurs. In this case, the rollers 4 rotate around the guard 3 (pin). This causes the braking to be accommodated by the movement of the rapier, allowing the reliability of the operation of the weaving loom's rapier to be increased.

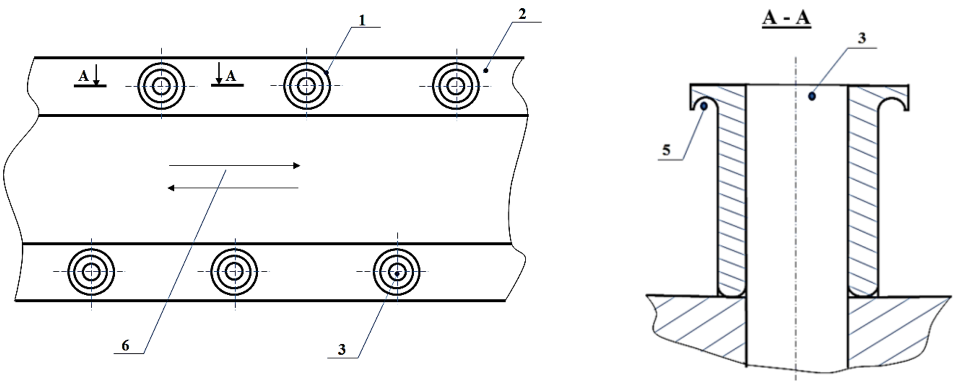

Figure 1. Weaving machine rapier guide.

2.2. Design scheme and mathematical model of the interaction of the rapier with the guide rollers
Figure 2 shows a design diagram of the impact of a rapier on a composite guide roller.

According to the design diagram in figure 2, the force from the rapier $\vec{F}_r$ acts on the sleeve 2 of the guide rapier.

In this case, the horizontal component of this force is the driving force of the sleeve 2, and the component along the vertical axis $\vec{F}_v$ leads to friction between the rapier and the sleeve $\vec{F}_{rs}$.

In addition, the friction force between the sleeve 2 and the rod $\vec{F}_{rs}$ is also a braking force for the sleeve 2. In this case, according to, we compose an equation describing the rotational motion of the sleeve 2 of the weaving machine rapier guide:

$$J_s\ddot{\varphi}_s = M_d - M_{rs} - M_{rs}^{`} \quad (1)$$

Where, J_s is the moment of inertia of the sleeve 2, φ_a is the angular displacement of the sleeve; M_d is the driving moment of the sleeve 2, M_{rs} is the moment of resistance from the friction force between the rapier and the sleeve 2, $M_{rs}^{`}$ is the moment of resistance from the friction force between the sleeve 2 and the rod 1.

In this case, they have the following relationships:

$$M_d = F_{rs}R_s = F_sR_scos\alpha;\ M_{rs} = fF_rR_ssin\alpha;\ rs = F_rR_csin\alpha \tag{2}$$

Substituting (2) into (1) we get:

$$J_s\ddot{\varphi}_s = F_rR_scos\alpha - fF_rR_ssin\alpha(R_c + R_s) \tag{3}$$

Where, R_c, R_s are the radii of the sleeve 2 and the rod 1, α is the angle of action of the rapier on the sleeve 2.

According to the well-known technique for solving differential equations [5, 6, 7, 8], integrating (3) over time, we have:

$$\dot{\varphi}_s = [F_rR_scos\alpha - fF_csin\alpha(R_c + R_s)]\frac{t}{J_s} + c_1$$

$$\varphi_s = [F_rR_scos\alpha - fF_csin\alpha(R_c + R_s)]\frac{t^2}{2J_{bs}} + c_1t + c_2 \tag{4}$$

Given the initial conditional at $t = 0;\ c_1 = 0;\ c_2 = 0$

The numerical solution of problem (4) was carried out for the following values of the parameters: $R_c = (1.5 \div 2.0)\cdot 10^{-3}$m; $R_s = (1.5 \div 2.5)\cdot 10^{-3}$m; $\alpha = (5^0 \div 15^0)$; $f = (0.1 \div 0.2)$; $F_r = (1.0 \div 2.5)\cdot 10^2$ N; $J_s = (5.0 \div 8.0)\cdot 10^{-4}$ kgm^2;

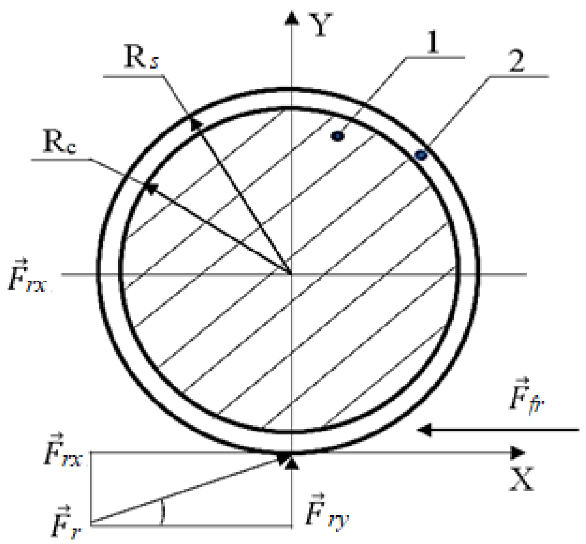

Figure 2. Calculation scheme. 1 – rod, 2 - sleeves.

3. Results and discussion

3.1. Solving the problem and analyzing the results

When solving the problem, it is important to determine the main parameters of the guide rapier of the weaving machine.

Figure 3 shows the graphical dependences of the change in the angular displacement of the guide rapier sleeve on the change in the angle of the disturbing force of the rapier [9, 10]. The analysis of the constructed dependences according to figure 3 shows that an increase in the external load on the sleeve is directed from the side of the rapier leads to an increase in the angular displacement of the sleeve according to a nonlinear pattern.

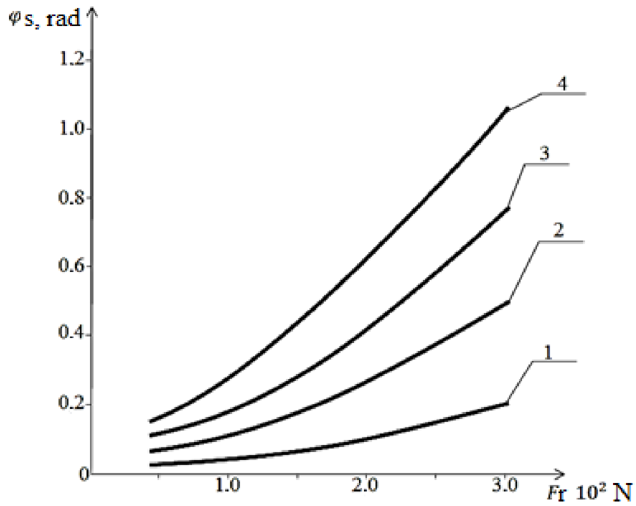

Figure 3. Graphical dependences of the change in the angular displacement of the guide rapier sleeve on the change in the angle of the disturbing force of the rapier: 1 - $\alpha = 3^0$; 2 - $\alpha = 6^0$; 3 - $\alpha = 9^0$; 4 - $\alpha = 12^0$.

So, with an increase, it is loaded from $0.5 \cdot 10^2$ N to $3.0 \cdot 10^2$ N at $a = 3^0$ leads to an increase in φ from 0.05 rad to 0.23 rad according to a nonlinear pattern ... With an increase in the rapier angle of the weaving machine to 12^0 leads to an increase in the angular displacement of the sleeve from 0.13 rad to 1.06 rad according to a nonlinear pattern. From a practical point of view, the banner is considered expedient to reduce the angle α, thereby reducing the disturbing force F_r, which allows a significant decrease in the values and angle φ. Recommended values are α≤ (50 ÷ 70); $F_r \leq (2.0 \div 2.5) \cdot 10^2$ N, at which $\varphi_s \leq (0.5 \div 0.6)$ rad is provided.

Figure 4 shows the graphical dependences of the change in the speed of the guide rapier sleeve on the change in the moment of inertia of the sleeve. An analysis of the plotted graphical dependencies shows that with an increase in mass, that is, the moment of inertia of the guide rapier sleeve leads to a decrease in the angular velocity of rotation of the sleeve according to a nonlinear pattern. So, with $F_r = 2.5 \cdot 10^2$ N to an increase in the moment of inertia from $2.5 \cdot 10^{-4}$ kgm^2 to $5.25 \cdot 10^{-4}$ kgm^2 values of the angular velocity of the sleeve decreases from $1.28 \cdot 10\ \ s^{-1}$ to $0.34 \cdot 10\ \ s^{-1}$ according to a nonlinear pattern. It is smelled by the fact that the calculated J_s, more difficult to establish the action of an external force on the rotation of the guide sleeve. A decrease in F_r, to $1.0 \cdot 10^2$N leads to an even greater decrease in φ_s, from $0.64 \cdot 10\ \ s^{-1}$ to $0.21 \cdot 10\ \ s^{-1}$. Therefore, the recommended values are $J_s = (2.0 \div 2.5) \cdot 10^4$ kgm^2 and $F_r = (2.0 \div 2.5) \cdot 10^2$ N at which $\varphi_s \geq (1.0 \div 1.2) \cdot 10\ s^{-1}$.

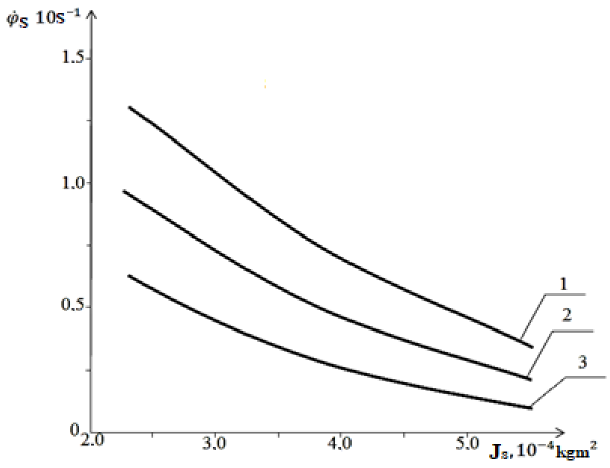

Figure 4. Graphical dependences of the change in the speed of the guide rapier sleeve on the change in the moment of inertia of the sleeve: 1- $F_r = 2.5 \cdot 10^2$N; 2- $F_r = 2.0 \cdot 10^2$N; 3- $F_r = 1.0 \cdot 10^2$N.

Figure 5 shows the graphical dependences of the change in the angular velocity of the guide rapier sleeve on the change in the radius of the sleeve. An increase in the coefficient of friction between the sleeve and the rapier, and between the sleeve and the shank, causes the sleeve to slow down. This, in turn, leads to inhibition of the movement of the rapier [11,12]. That is, an increase in the angular velocity of the sleeve reduces the resistance to the movement of the rapier, thereby effectively shaping the fabric in the loom.

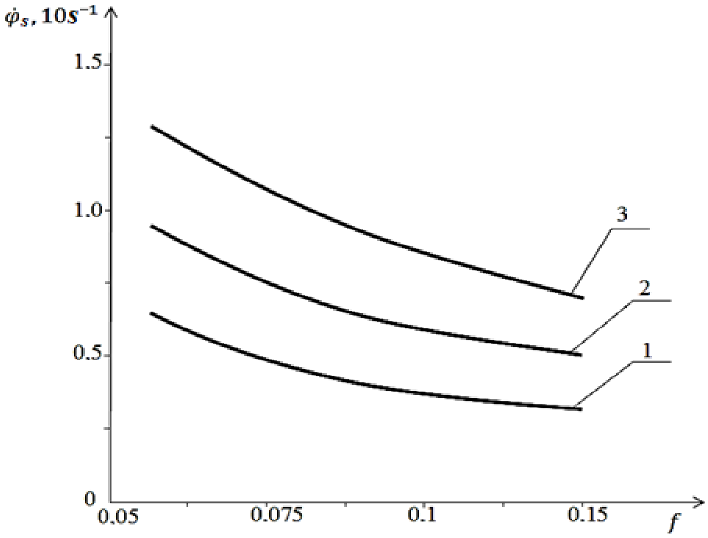

Figure 5. Graphical dependences of the change in the angular velocity of the sleeve of the guide rapier of the weaving machine on the change in the radius of the sleeve: 1- $R_s = 1.5 \cdot 10^{-3} m$; 2- $R_s = 2.0 \cdot 10^{-3} m$; 3- $R_s = 2.5 \cdot 10^{-3} m$.

It can be seen from the graphs that an increase in f from 0.013 to 0.15 leads to a decrease in the angular velocity of the sleeve from $1.25 \cdot 10\ \text{s}^{-1}$ to $0.74 \cdot 10\ \text{s}^{-1}$ at $\text{R}_\text{s} = 2.5 \cdot 10^{-3}$ m according to nonlinear laws. With $\text{R}_\text{s} = 1.5 \cdot 10^{-3}$ m, the values of φ ̇_b for the recipient are less high and reaches only up to $(0.4 \div 0.5) \cdot 10\,\text{s}^{-1}$. Therefore, the recommended values of the parameters are: $\text{f} \leq (0.09 \div 0.1)$ and $\text{R}_\text{s} \leq (2.0 \div 2.5) \cdot 10^{-1}$m.

4. Conclusions

Developed an efficient design of the weaving machine's rapier guide. On the basis of theoretical studies, the parameters of the guide are substantiated.

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