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THEORETICAL STUDY OF FIBER BEHAVIOR IN A NEW STRUCTURED ELONGATION PAIR

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Abstract: This paper is a theoretical study on the state of movement of a fiber bundle in a stretching pair in a new design of stretching tool for thread formation in a spinning machine depending on the twist of the thread. The problem of increasing the tensile strength of the thread due to the correct choice of linear speed and the amount of twist of the yarn was considered.

Keywords: fiber, thread, number of twists, ribbed tension, elongation, theoretical, linear speed.

Introduction. The creation of new techniques and technologies for the development of normative technological parameters that positively affect spinning in the textile industry is gaining special importance. In this regard, it is one of the important tasks to carry out targeted scientific research in areas such as radically changing the quality indicators of spun yarns, production of yarns with competitive indicators.

The main function of a spinning machine is to form a thread from a pile or a pile. The spinning machine performs the tasks of thinning the pilaf, cooking it, and forming a roll-poch with a convenient shape for use at the next stage.

In textile enterprises of Uzbekistan, foreign companies Zinser-350, 351, 360 (Zinser), G 33, G 35 (Rieter), RST-1, MP1N (Marzoli), RX 220, 230 (Tayota), JWF 1510, 1516 (Jingwei) such as high productivity and computerized spinning machines are being effectively used.

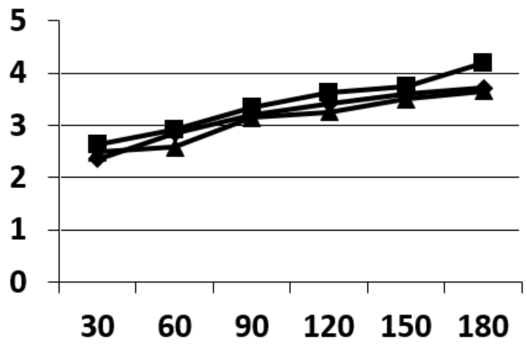
Spinning machines are almost identical in structure and operation, and are usually made double-sided. They differ from each other in the number of rings, the distance between the rings, the stretching device and the structure of the cooking-wrapping mechanism [1].

Stretching devices are one of the main working organs of spinning machines, they straighten and parallelize single fibers by thinning the product to a specified linear density.

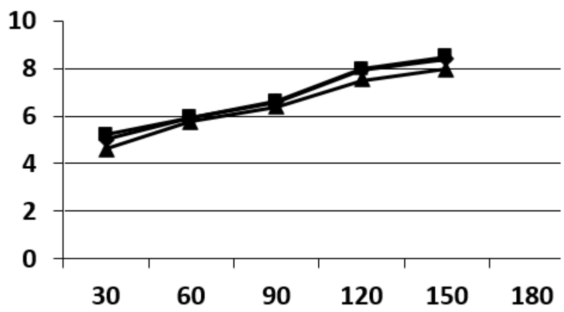
Experimental and theoretical researches. The scientists of the Tashkent Institute of Textile Light Industry have created an improved stretching tool, and its structure is presented in detail.

In order to improve the yarn quality when the upper rollers are subjected to a large load, it was proposed to replace the corrugated part of the cylinder with elastic coatings with a thickness of 4.5 mm [2, 3, 4, 5].

It is known that when using corrugated cylinders, the damage to fibers and elastic coatings increases as the amount of load increases. Applying a soft clamp to the extension pair solves this problem. In the work, the change of the width of the contact line in the output pair in the equilibrium position is shown depending on the load applied to the rollers (Fig. 1). As can be seen from the figure, the width of the contact line increases as the load increases, but when elastic bushings are used instead of rifles in the output cylinder, the width of the contact line increases by almost 2 times, and fiber control is increased. The stability of the yarn forming process increases, the linear unevenness of the yarn cross-section decreases, and its strength increases.



a) corrugated cylinder



b) cylinder with elastic coating

Figure 1. The width of the contact line in the front zone depends on the amount of load and the design of the output cylinder.

First, theoretical studies were conducted on the vibrations of the load roller axis of the stretching tool, and the differential equation and analytical solution representing the vibration of the load roller axis of the ring spinning machine were obtained.

The researchers constructed a graph of the dependence of the vertical vibration range of the shafts of the shafts of the stretching tool on the change in the amplitude of the resistance to the stretching of the shaft. Taking into account the results of the experiment and the unevenness of the stretching pile and the impact force is in the range of (2.3÷3.0) N, the vibration range of the first loading roller axis is (1.7÷2.4)•10-3 m, the second roller axis is (1 ,3÷1,65)•10-3 m and the third roller axis vibration coverage is recommended to be in the range of (0,7÷1,1)•10-3 m.

Further theoretical studies investigated the tension of fibers passing through the fluted cylinder of the stretching device. In the proposed improved stretching technology, the equipment consists of three pairs of lower cylinders 1, 2, 3 with grooves and three pairs of load rollers 4, 5, 6 with elastic coating, and a spring-loaded loading lever 7. The axis of the rollers 4,5,6 with an elastic coating is connected to the conical springs 8,9,10 (Fig. 2) [6, 7].

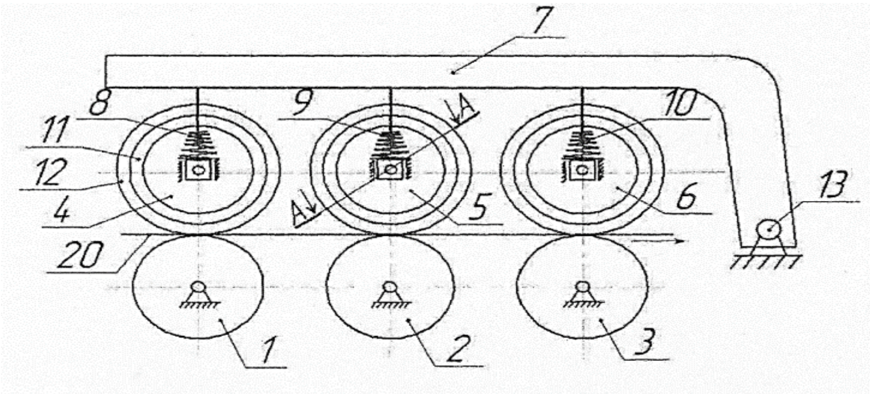


Figure 2. Scheme of thread movement in jeans.

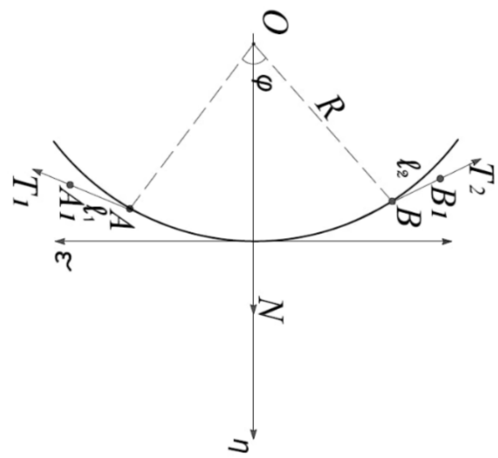


Figure 3. Scheme of the initial movement of the thread along the arc in the first rifle.

The length S of the thread along the arc AB, the radius R passes through the constant φ- coverage angle of the thread. The coefficient of friction between the fibers and the rifle is based on Amonton's rule:

$$T_{\max} = k \cdot N$$

k - coefficient of friction, N- normal compressive force acting on the fibrous layer at the surface.

If the input and output tension forces of the fibers change as T_1 (t) and T_2 (t), the thread is in motion if $T_2 > T_1 \cdot S$. We determine the law of motion of the thread and the tensions at its output. In view of the problem, the tension in the coverage arc is a minimum $\vartheta < \sqrt{\frac{T}{\mu}}$ and is bounded by the time interval equal to T and the condition is satisfied. Here: μ- is the linear density of the fibrous layer:

$$\mu = \frac{\partial m(S,t)}{\partial S}$$

We derive the following differential equation from the motion of the fibers as they pass through the rifle.

$$\frac{1}{\mu}\frac{\partial T}{\partial S}=\frac{d\vartheta}{dt} \qquad (1)$$

(1) from the equation, we determine the tensile strength of the fibrous layer from the movement along the surface of the rifle.

$$T=\mu\cdot\frac{d\vartheta}{dt}\cdot S+c_1(t) \quad (2)$$

originates. (from Fig. 3) At point A, $S=0$ and $T=T_1(t)$ therefore, $C_1(t)=T_1(t)$ we set equation (2) with constant value.

$$T=\mu\cdot\frac{d\vartheta}{dt}\cdot S+T_1(t)$$

At point B, the tension force generated on the surface of the first cylinder depends on the tension force at the entrance $S=S_1$ at $T=T_2(t)$ that's why $0<S<S_1$ we determine the tension strength of the intermediate fibers

$$S_1(t)=T_2(t)-\mu\cdot\frac{d\vartheta}{dt}\cdot S_1 \quad \text{and} \quad T=\mu\cdot\frac{d\vartheta}{dt}\cdot S+T_2(t)-\mu\cdot\frac{d\vartheta}{dt}\cdot S_1$$

$$T=T_2(t)-\mu\cdot\frac{d\vartheta}{dt}\cdot(S-S_1) \qquad (3)$$

rom the initial condition. Let $t=0$ be the length l_1 of the movement of the string in AA_1 the first cylinder, then $AA_1=\Delta S_1$ and $BB_1=\Delta S_2$ from this $l_1=S-l_1$.

$$S_1=l_1-\int_0^t\vartheta\cdot dt \quad \text{ва} \quad S_2=l_2-\int_0^t\vartheta\cdot dt$$

These expressions represent the tension of the thread in the distance between two rifles in the cylinder, so the tension from points A and B

$$T=T_1(t)+\mu\frac{d\vartheta}{dt}\cdot(l_1-\int_0^t\vartheta\cdot dt) \qquad (4)$$

$$T=T_2(t)+\mu\cdot\frac{d\vartheta}{dt}\cdot(S-l_1+\int_0^t\vartheta\cdot dt)=T_2(t)+\mu\cdot\frac{d\vartheta}{dt}\cdot(l_2+\int_0^t\vartheta\cdot dt) \qquad (5)$$

From equations (4) and (5), we express the equation of the dependence of voltages at the input and output. From these expressions, the equation of interrelationship of the fibers passing through different fibers was determined.

$$T_2(t)=T_1(t)+\mu\cdot\frac{d\vartheta}{dt}\cdot(l_1-l_2-2\int_0^t\vartheta\cdot dt) \qquad (6)$$

If the fibrous layer moves in the same plane, it is expressed in the following differential equations.

$$\frac{1}{\mu}\cdot T - N = \omega\cdot\vartheta$$
$$\frac{1}{\mu}\cdot\frac{\partial T}{\partial S} - k\cdot N = \frac{d\vartheta}{dt} \qquad (7)$$
$$\vartheta = \omega\cdot r$$

From the equation (7), we determine the expression of the movement of fibers on the surface of the rifle and the tension force along the surface.

$$\frac{\partial T}{\partial S} - \frac{k}{r}\cdot T = \mu\cdot(\frac{d\vartheta}{dt} - \frac{k}{r}\cdot\vartheta^2) \quad (8)$$

Integrating the equation (8) along the surface of the rifle, we determine the tension force:

$$T = C_2(t)\cdot e^{\frac{k}{r}\cdot S} - \frac{\mu\cdot r}{k}\cdot(\frac{d\vartheta}{dt} - \frac{k\cdot\vartheta^2}{r}) \qquad (9)$$

(9) we form the law of change of fiber layer tension in the coverage arc. Here we use the condition of C2 (t) at point A, that is, the tension force in equation (4) is the movement of the fibrous layer along the arc in the rib.

$$T = T_1(t) + \mu\frac{d\vartheta}{dt}\cdot(l_1 - \int_0^t \vartheta\cdot dt)$$

We put this expression into equation (9) and determine C_2 (t).

$$C_2(t) = \left[T_1 - \mu\cdot\vartheta^2 + \mu\cdot\frac{d\vartheta}{dt}\cdot(l_1 + \frac{r}{k} - \int_0^{l_1}\vartheta\cdot dt)\right]\cdot e^{\frac{k}{r}\cdot(l_1 - \int_0^{l_1}\vartheta\cdot dt)}$$

Putting the determined value of C_2 (t) into equation (9), we determine the tension force of the thread at the exit.

$$T_2(t) = \left[T_1 - \mu\cdot\vartheta^2 + \mu\cdot\frac{d\vartheta}{dt}\cdot(l_1 + \frac{r}{k} - \int_0^{l_1}\vartheta\cdot dt)\right]\cdot e^{\frac{k}{r}\cdot(l_1 - \int_0^{l_1}\vartheta\cdot dt)} - \frac{\mu\cdot r}{k}\cdot(\frac{d\vartheta}{dt} - \frac{k\cdot\vartheta^2}{r})$$

(10)

Equation (10) represents the input and output voltages. Using this equation, we will analyze the graphs from the Marle program.

The following $\vartheta = \frac{n}{k}$ by inserting equation (10) into equation (10) from equation (10) the tension force of the thread at the output is analyzed in graphs from the expression of dependence on the number of twists in the thread. Here n - the number of revolutions of the flywheel, ϑ – thread speed, K – the number of turns in the thread

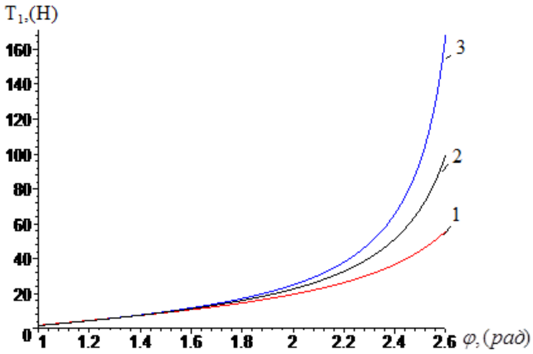


Figure 4. A graph of the thickness of the fiber layer at the entrance as a function of the coverage angle at different speeds.

The tension of the output thread in different twists $K_1 = 400$ twist/meter, $K_2 = 500$ twist/meter, $K_3 = 600$ twist/meter coverage angle graph.

In the above graphs, the question of increasing the thread quality by rationally selecting the speed of fiber flow and the number of revolutions of the spindle, while increasing the tension of the thread by reducing the number of twists of threads passing through each riffle, was seen. Here are $\varphi_1, \varphi_2, \varphi_3$ the camber angles of the thread passing through each span.

$$A_1B_1 = S_1 - T_1^*;$$
$$A_2B_2 = S_2 - T_2^*;$$
$$A_3B_3 = S_3 - T_3^*$$

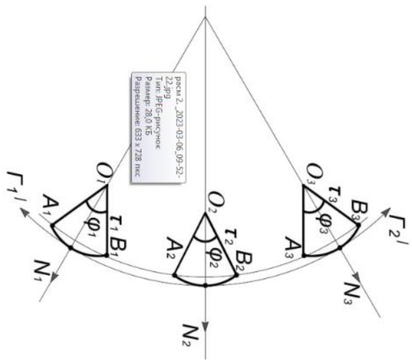


Figure 5. Schematic diagram of the movement of the fibrous layer along the arc during the passage through three successive riffles.

In order to increase the density of the thread passing through each riffle and thereby analyze the tension of the thread, we consider the A_1B_1 of the thread, A_2B_2 and A_3B_3 the increase of the density passing through the arcs based on Amonton's rule. The thread tension in each reflex is determined as follows. $T_1^* = \mu \cdot N_1$, $T_2^* = \mu \cdot N_2$, $T_3^* = \mu \cdot N_3$ here μ- coefficient of friction, N_1 N_2 N_3- normal reaction forces acting on the surface of the thread. Tension forces of threads at the entrance and exit $T_1^*(t)$ and $T_2^*(t)$ if it changes

$T_2^*(t) > T_1^*(t)$ if there is, the thread is in motion. We determine the law of motion of the string and its output tension. When determining the tensile tension of the thread, we form the differential equation of motion depending on its speed originates.

$$\frac{1}{\mu} \cdot \frac{\partial T}{\partial S} = \frac{d\vartheta}{dt} \qquad (11)$$

from this

$$T = \mu \cdot \frac{d\vartheta}{dt} \cdot S + C_3(t) \qquad (12)$$

From Fig. 6, we put $S_1 = 0$ the value of the constant for $C_3(t) = T_1^{/}(t)$ and $T_1 = T_1^{/}(t)$ in the equation (11) at the point A_1

$$T = \mu \cdot \frac{d\vartheta}{dt} \cdot S + T_1^{/}(t)$$

B_1 while at the point $S = S_1$ at $T_1 = T_1^*(t)$ therefore $0 < S < S_1$ $C_3(t) = T_1^{/}(t) - \mu \cdot \frac{d\vartheta}{dt} \cdot S_1$ by putting the constant value in equation (12), we determine the tension force at the exit of the first rifle.

$$T = \mu \cdot \frac{d\vartheta}{dt} \cdot (S - S_1) + T_1^{/}(t) \qquad (13)$$

At the point A_1 in the same sequence $S_2 = 0$ да $T_1 = T_{11}^*(t)$ for $C_4(t) = T_{11}^*(t)$ and put the value of the constant in equation (12).

$$T = \mu \cdot \frac{d\vartheta}{dt} \cdot S + T_{11}^*(t)$$

B_2 point $S = S_2$ да $T_1 = T_{11}^*(t)$ for $0 < S < S_2$

$$T = \mu \cdot \frac{d\vartheta}{dt} \cdot (S - S_2) + T_{11}^*(t) \qquad (4)$$

At the point A_3, $S_3 = 0$ at $T_1 = T_{111}^*(t)$ for $C_5(t) = T_{111}^*(t)$ and put the value of the constant in equation (12).

$$T = \mu \cdot \frac{d\vartheta}{dt} \cdot S + T_{111}^*(t)$$

At the point B_3 $S = S_3$ at $T = T_{111}^*(t)$ therefore $0 < S < S_3$

$$T = \mu \cdot \frac{d\vartheta}{dt} \cdot (S - S_3) + T_{111}^*(t) \qquad (15)$$

Equations expressing the tension of the thread passing through each fiber layer along the arc length are given in (13), (14) and (15) above. We determine the expression of the dependence of the speed of the fibers in these intervals. First of all A_1B_1 by arc $S_1 = \int_0^{t_1} \vartheta \cdot dt$ is determined. A_2B_2 and by arc, $S_2 = S_1 - \int_{t_1}^{t_2} \vartheta \cdot dt$ is expressed, A_3B_3 and in arc $S_3 = S_2 - S_1 - \int_{t_2}^{t_3} \vartheta \cdot dt$ is determined.

Putting these expressions into equations (13), (14) and (15), we determine the output tension of the thread.

$$T_2^{/} = T_1^{/} + \mu \cdot \frac{d\vartheta}{dt} \cdot (S - \int_0^{t_1} \vartheta \cdot dt - \int_{t_1}^{t_2} \vartheta \cdot dt - \int_{t_2}^{t_3} \vartheta \cdot dt) \qquad (16)$$

Here $T_1^{/} = T_1^{*}(t) + T_{11}^{*}(t) + T_{111}^{*}(t)$ is equal.

This equation (16) represents the dependence of the output tension of the fiber layer passing through three riffles on the input tension and velocities.

We express the expression of the dependence on the angles of coverage passing through each rifle in the following differential equations.

$$\begin{aligned} &\frac{1}{\mu} \cdot \frac{\partial T_1^{*}}{\partial S_1} - k \cdot N_1 = \frac{d\vartheta}{dt} \quad \Rightarrow \quad \frac{1}{\mu} \cdot T_1^{*} - k \cdot N_1 = \omega \cdot r \\ &\frac{1}{\mu} \cdot \frac{\partial T_2^{*}}{\partial S_2} - k \cdot N_2 = \frac{d\vartheta}{dt} \quad \Rightarrow \quad \frac{1}{\mu} \cdot T_2^{*} - k \cdot N_2 = \omega \cdot r \qquad (17) \\ &\frac{1}{\mu} \cdot \frac{\partial T_3^{*}}{\partial S_3} - k \cdot N_3 = \frac{d\vartheta}{dt} \quad \Rightarrow \quad \frac{1}{\mu} \cdot T_3^{*} - k \cdot N_3 = \omega \cdot r \end{aligned}$$

From these expressions (17).

$$\begin{aligned} &\frac{\partial T_1^{*}}{\partial S_1} - \frac{k}{r} \cdot T_1^{*} = \mu \cdot (\frac{d\vartheta}{dt} - \frac{k}{r} \cdot \vartheta^2) \\ &\frac{\partial T_2^{*}}{\partial S_2} - \frac{k}{r} \cdot T_2^{*} = \mu \cdot (\frac{d\vartheta}{dt} - \frac{k}{r} \cdot \vartheta^2) \qquad (18) \\ &\frac{\partial T_3^{*}}{\partial S_3} - \frac{k}{r} \cdot T_3^{*} = \mu \cdot (\frac{d\vartheta}{dt} - \frac{k}{r} \cdot \vartheta^2) \end{aligned}$$

By integrating equations (18), we determine the tension forces of the thread passing through each reflex

$$\begin{aligned} &T_1^{*} = C_6(t) \cdot e^{\frac{k}{r} \cdot S_1} - \frac{\mu \cdot r}{k} \cdot (\frac{d\vartheta}{dt} - \frac{k}{r} \cdot \vartheta^2) \\ &T_2^{*} = C_7(t) \cdot e^{\frac{k}{r} \cdot S_2} - \frac{\mu \cdot r}{k} \cdot (\frac{d\vartheta}{dt} - \frac{k}{r} \cdot \vartheta^2) \qquad (19) \\ &T_3^{*} = C_8(t) \cdot e^{\frac{k}{r} \cdot S_3} - \frac{\mu \cdot r}{k} \cdot (\frac{d\vartheta}{dt} - \frac{k}{r} \cdot \vartheta^2) \end{aligned}$$

From equations (19), we determine the pattern of changes in the tension of the fibrous layer passing through each riffle. Here and are constant values.

$$\begin{aligned} &T_1^{/} = T_1^{*}(t) = \mu \cdot \frac{d\vartheta}{dt} \cdot (S_1 - \int_0^{t_1} \vartheta \cdot dt) \\ &T_2^{/} = T_2^{*}(t) = \mu \cdot \frac{d\vartheta}{dt} \cdot (S_2 - \int_{t_1}^{t_2} \vartheta \cdot dt) \qquad (20) \end{aligned}$$

$$T_3^{/}=T_3^{*}(t)=\mu\cdot\frac{d\vartheta}{dt}\cdot(S_3-\int_{t_2}^{t_3}\vartheta\cdot dt)$$

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$$C_6(t)=T_1^{/}-\mu\cdot\vartheta^2+\mu\cdot\frac{d\vartheta}{dt}\cdot(S_1+\frac{r}{k}-\int_0^{t_1}\vartheta\cdot dt)\cdot e^{-\frac{k}{r}}\cdot(S_1-\int_0^{t_1}\vartheta\cdot dt)$$

$$C_7(t)=T_2^{/}-\mu\cdot\vartheta^2+\mu\cdot\frac{d\vartheta}{dt}\cdot(S_2+\frac{r}{k}-\int_{t_1}^{t_2}\vartheta\cdot dt)\cdot e^{-\frac{k}{r}}\cdot(S_2-\int_{t_1}^{t_2}\vartheta\cdot dt) \quad (21)$$

$$C_8(t)=T_3^{/}-\mu\cdot\vartheta^2+\mu\cdot\frac{d\vartheta}{dt}\cdot(S_3+\frac{r}{k}-\int_{t_1}^{t_2}\vartheta\cdot dt)\cdot e^{-\frac{k}{r}}\cdot(S_2-\int_{t_2}^{t_3}\vartheta\cdot dt)$$

determined $C_6(t), C_7(t)$ and $C_8(t)$ we put the values of (19) into equations.

$$T=T_1^{*}+T_2^{*}+T_3^{*}-\mu\cdot\vartheta^2+\mu\cdot\frac{d\vartheta}{dt}\cdot(S_1+S_2+S_3-\int_0^{t_1}\vartheta\cdot dt-\int_{t_1}^{t_2}\vartheta\cdot dt-\int_{t_2}^{t_3}\vartheta\cdot dt)\cdot e^{-\frac{k}{r}}\cdot(S_1+S_2+S_3-$$
$$-\int_0^{t_1}\vartheta\cdot dt-\int_{t_1}^{t_2}\vartheta\cdot dt-\int_{t_2}^{t_3}\vartheta\cdot dt)-\frac{\mu\cdot r}{k}\cdot(\frac{d\vartheta}{dt}-\frac{k\cdot\vartheta^2}{r})$$

(22)

Here $T_1^I=T_1^*+T_2^*+T_3^*$, $S_1=r\cdot\varphi_1$, $S_2=r\cdot\varphi_2$, $S_3=r\cdot\varphi_3$, is equal to where equation (22) represents the tension forces of the thread passing through three riffles at the entrance and exit, the distance between the riffles, the angle of coverage, the number of twists in the thread and the speed at the exit. This was analyzed in graphs by Marle software using this equation.

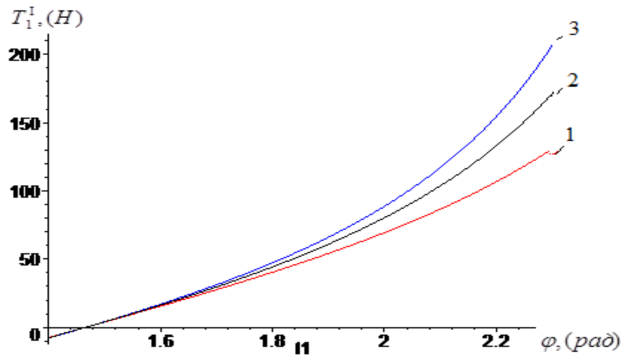

Fig. 6. The graph of the tension of the fiber layer at the input as a function of the coverage angle at different speeds.

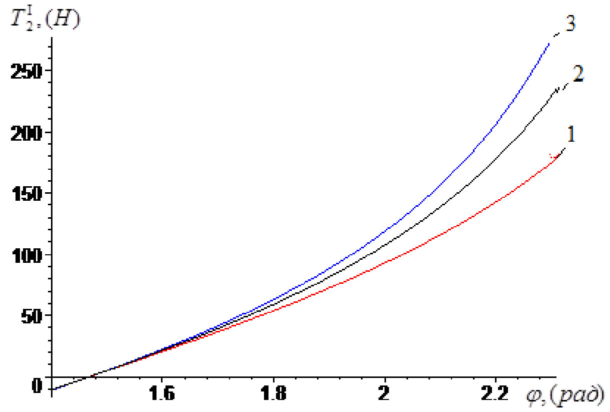

Figure 7. The tension of the output thread in different twists $K_1 = 400$ twist/meter, $K_2 = 500$ twist/meter, $K_3 = 600$ twist/meter coverage angle graph.

Conclusion. From the analysis of the above graphs (Fig. 4-5), the rational of the speed of the tension force of the thread passing through each rifle $\vartheta_3 =$ the number of turns by correctly choosing the value $K_1 = 400$ we can see that the tensile strength of the thread has increased due to the reduction.

From the analysis of graphs (Fig. 7-8), it was seen the problem of increasing the tensile strength of the yarn by choosing the linear speed of the number of twists of the yarn in order to increase the tensile strength of the yarn. In this case, we can see from the graphs that it is possible to increase the tension strength of the thread by determining the rational value of the linear speed and the correct selection of the distance between the riffles in order to reduce the number of twists.

References

1. Jumaniyozov Q.J., Gafurov Q.G., Matismailov S.L. and others. « Technology and equipment of textile products ». Textbook. - T.: G.Gulom, 2012., 160-161 pp.

2. Makarov A.I., and others. “Calculation and design of spinning machines” M; Publishing house "Machine Building", 1981. 235 pp.

3. Borzunov I.T., Badalov K.I., Goncharov V.G.. Spinning cotton and chemical fibers. – M: Legprombytizdat, 1986

4. Horrecks A.R., Anand S.C., «Handbook of technical Textiles», The Textile Institute., Cambridje 2000 y.

5. http://reutovtextil.narod.ru/about/htm. - Modernization of the exhaust device.

6. Djumabaev G'.Kh. Effect of the improved stretching tool of the ring spinning machine on the geometrical properties of yarn// Textile problems. Tashkent, 2018 #3. p. 104-108.

7. G.Djumabaev, G.Mukhamedov, D.Makhmudov J.Usarov, D.Khimmataliev. Basis of the parameters of the spin extractor tool on the interned spinning machine// E3S Web of Conferences, 14033 (2023) https://doi.org/10.1051/e3sconf/202340214033, TransSiberia 2023

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