International Journal of Future Generation Communication and Networking
Vol. 13, No. 4, (2020), pp. 964 – 975

Investigation of Optimization of The Speed of The Working Parts of a Rotor Spinning Machine

Korabayev Sherzod Ahmadjonovich
PhD, *Department of Technology of products of the textile industry,*
Namangan Institute of Engineering and Technology,
Namangan, Uzbekistan, 160115
E-mail: sherzod.korabayev@gmail.com
Phone: +998943020207

Meliboyev Umarjon Xaydarovich
Docent, *Department of Metrology Standardization and quality management,*
Namangan Institute of Engineering and Technology,
Namangan, Uzbekistan
E-mail: sherzod.korabayev@gmail.com
Phone: +998972135777

Boboyev Utkirbek Abdullajonovich
Researcher, *Department of Technological Machines and Equipment*
Namangan Institute of Engineering and Technology,
Namangan, Uzbekistan
E-mail: boboyev.utkir@gmail.com
Phone: +998941577711

Rakhimberdiyev Dilmurod Obidkhon ugli
Researcher, *Department of Technological Machines and Equipment*
Namangan Institute of Engineering and Technology,
Namangan, Uzbekistan
E-mail: rakhimberdiyev.d@gmail.com
Phone: +998941543053

Abstract

The article examines the devices that affect the process of yarn production on an OE spinning machine. It has also been studied that densifiers and twist distributors depend on the properties of the yarns being formed, the diameter of the spinning rotor, and the linear density of the yarn. It was analyzed that different funnels and torque stops have a different effect on the stability of spinning and yarn quality in the process of yarn formation. To introduce a new intensifier into the spinning process, full-factor experiments were conducted to modify the machine parameters, and regression equations were constructed. The adequacy of the obtained equations was checked using the Fisher criterion. Through the interrelationships of the regression equations of the mathematical model seen, the velocity of the camera and the discrete drum, the significance of the number of twists and the effect of the value of each factor on the torsional inequality were determined.

Keywords*: yarns, OE spinning, camera, intensiier, twist, Sampling drum, regression equation, full factor experiment, inequality.*

1. Introduction

Many scientists and various firms have conducted effective scientific research on the factors influencing the quality of yarn, production techniques and technology, the requirements for the yarn according to the purpose of use. While acknowledging that in recent years the techniques and technology of open-end yarn (OE) production in leading textile machinery enterprises have been mainly automation and improvement of basic working parts, very little theoretical research has been conducted on the range of yarns, their physic-mechanical and quality characteristics. It was noted that the textile industry is developed in the country, the production and export of not only yarn but also finished textile products is growing from year to year [1].

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As we know, the main function of a spinning machine is to form a roving or sliver from a yarn. Spinning methods differ from each other by the simultaneous or separate nature of the doubling and twisting processes, as well as the method of twist or one (TFO), the diversity of the doubling [2].

Although rotor spinning machines differ in their structural structure, their differences in technological structure are insignificant [3].

The basic technological processes performed on machines of all models and type are almost the same: supply, sampling, transfer of fibres to the spinning chamber, adding fibres to form a fibrous layer, twisting it into yarn and winding the yarn [4]. High efficiency is achieved in OE spinning machines due to the high-speed movement of the working parts. OE spun yarn is widely used in the manufacture of various textile products due to its fact that it is smoother, evenness, poorer, cleaner and has a higher elongation than ring-spun yarn. Open-End spinning machines are divided into chamber, rotor and condenser types. Rotor spinning machines are used to make a wide range of yarns from natural and chemical fibres, while rotor spinning machines are used to spin thick yarns from low-grade cotton fibre and waste fibres. The neuromechanical type of open-ended spinning is used with high efficiency in the world's textile enterprises [5]. OE spinning machines vary in speed, several chambers, quality control devices, and winding mechanisms. At the same time, a smooth, evenness, highly elastic yarn is produced. However, the disadvantage of the OE yarn is that the twist is uneven and the yarn strength is less than that of the ring-spun yarn in a loop. For this reason, the analytical part examines scientific research and practical work done to solve the problem [6].

When analyzing the formation of the yarn in the rod of the spinning rotor by OE method, it was found that it is important to achieve a certain level of twisting, which ensures a stable twisting of the fibres. On the one hand, the technology of pneumo-mechanical forming of yarn requires a lot of twisting of the yarn, on the other hand, the increase in the number of twists of the yarn has a negative impact on the consumer properties of the fabric [6]. To overcome this contradiction, various twist intensifiers, ie devices designed to increase the twisting of the yarn at the point of separation of the yarn from the spinning rotor, have been proposed [7]. In several devices, a false twist is given to increase the stiffness of the yarn taken from the spinning rotor rod. The peculiarity of forging devices is that they do not have a free end of the yarn. These types of devices include a rotating or stationary screw. It is usually mounted in front of the cylinders, which produce a rotating twist [7], and the false twist spreads to the zone where the yarn is formed. False twisting rotary pulleys have not been widely popular due to their high cost, complex construction, and high energy consumption in moving them. Stationary loops can be installed in different places in the direction of yarn movement. Creating a fake twist depends on several factors. For example, the geometric rotation of the yarn axis when rotating a cavity element results in a torsional moment. These types of devices are capable of generating a twisting moment in a doubling yarn and a non-twisted product [8]. Other types of devices use a twist accelerator on the yarn. It is known that there is a difference in the layers of the twist as the twisted thread passes through and out of the barrier. Thus, such barriers serve as a vortex. This working principle is based on the operation of multiple devices. The device [9] has spiral grooves in the output funnel for twisting it on the surface where the yarn is formed.

To improve the physical and mechanical properties of OE yarn, modernization of the yarn production part was proposed by Pigalyov [10]. To improve the quality of the yarn, the inner part of the improved device tube surface is made in the form of a cone and expands in the direction of yarn release. The rod is mounted stationary inside the tube and its hollow end is located at the narrowest part of the tube, creating a circular hollow space with its conical surface to allow the yarn to squeeze on the inner surface of the rod and tube. It has a device for moving the rod and adjusting the ring distance. There is another feature not described by the authors in the description of the invention [11], namely, the presence of a rod in the funnel cavity reduces the friction surface of the funnel by changing the trajectory of the yarn. The effect of frictional forces on the torsion is reduced as a result of the reduction of the angle of winding of the friction surface of the funnel with a yarn. Thus, modification of structures, which requires relatively small costs, allows influencing the process of disappearance of torsions on the friction surface of the funnel.

In several devices, it is recommended to change the friction properties of the working surface of the funnel when twisting the yarn. For example, in the study [12], a grooved channel ring is installed at the entrance to the exhaust funnel channel and the yarn passes through this ring. The surface of the ring is treated in such a way that it has a high unevenness. Similar ideas are proposed to

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make the emitting element from rubber or plastic based on patents. In the patent, the working surface of the extracting funnel has smooth and uneven sections that vary along the circumference. In studies [12], it has been suggested that the coefficient of friction in the longitudinal direction of the working surface of the extracting funnel is less than in the transverse direction. This study argues that such treatment of the surface reduces the tension of the yarn. On the other hand, the patent [13] recommends polishing, chroming and sanding the inner surface of the funnel.

The literature also describes a wide range of vibration-type intensifiers. However, it has been observed that the number of yarn breaks increases when they are used. The operation of several twist intensifiers is based on the combination of devices described above. The device [14] aims to improve the twist in the yarn formation zone. In this device, the axis of the channel for the yarn output is at an angle to the axis symmetry of the spinning chamber. During the operation of the spinning device, there was a periodic spread of the screw to the camera groove.

As a result of the installation of a twist intensifier in the thread separation zone, a new-type twist amplifier with a stem mounted in the funnel cavity was obtained. The advantage of this type of amplifier is the simplicity of construction, the ability to change the trajectory of the thread in the zone of the friction surface of the funnel without the use of mechanical devices. However, the stem in the funnel cavity [15] makes it difficult to machine the machine because it prevents the airflow from spreading, which requires the thread to be pulled into the camera with a certain motion. Placing the rod in the cavity of the funnel narrows the cross-sectional area and increases the resistance to airflow. As a result, the velocity of the airflow holding the thread decreases. Reducing a certain air velocity in the funnel cavity does not ensure the stability of the machine shaft. Therefore, the production of a torsion booster rod located in the cavity of the funnel, which ensures the normalization of machine tuning, is an important task.

The condenser has a great effect on the yarn as a passive element. Therefore, the shape, outer radius, and surface area of the condenser are of great importance, as is the coefficient of friction of the yarn and the angle at which the yarn surrounds the condenser surface. Modernization of condensers allows improving the process of yarn formation.

Figure 1 shows an overview of a funnel with different types of fasteners (magnetic and threaded) and a flat or spiral surface.

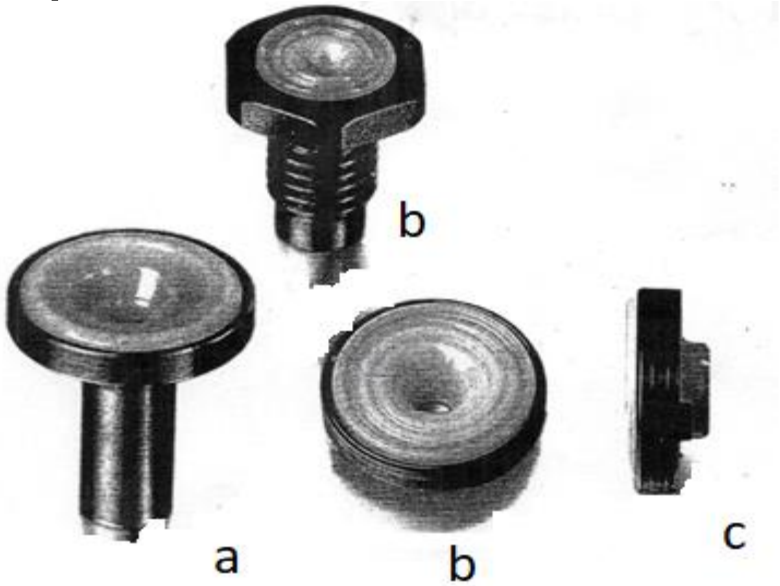

Figure 1. General view of condensers
(a-is a flat-surface magnetically hardened funnel, b- is a spiral-shaped funnel, carved with a thread, c. is a lateral view of the funnel).

Types of sealants (KN, KN3, KN4, KN8, KN8R4, KS, CG, SK4, SK8, ...) are selected according to the material coating, the shape of the sealant surface and its appearance and the purpose for which the yarn is produced. To reduce the coefficient of friction, different types of coatings are used for the sealing surface: ceramic, steel, various profiles with chrome.

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Flat surface funnels produce less yarn and are used in high twists. In grooved funnels, more yarn comes out (due to the twisting that occurs in the funnel groove), but increases the stability of spinning. A modern OE spinning machine consists of a set of complex complexes. Its parts and mechanisms are difficult to express in a single image. In the machines created in recent years, the number of such mechanisms and devices has increased, as well as has a unique design.

At present, the screw fasteners used in the OE spinning machine AUTOCORO of the company SAURER SHLAFHORST are produced in various forms. To increase the stability of the spinning by reducing its twist when pulling the yarn from the rotor, it is recommended to install a Torque stop device (Fig. 2)

Figure 2. The appearance of Torque Stop

The installation of the Torque Stop ensures an equal-sided conical rotation, the thread tension is normal, and the spinning process is normal without hitting the channel wall hard. The TS has a flat surface and a surface that holds 3 types of screws. The Torque Stop characteristic is given in Table 1.

Table 1. Torque Stop characteristic

Torque Stop маркалари	Colour	Characteristics
TS 30-0G	Green	The TS is designed for smooth, high-twist or coarse yarns with a flat surface, no twisting effect, and a linear density of more than 29 texes.
TS 30-3R	Red	The triple twisting elements normalize the spinning process at a high level with a high twisting effect.
TS 30-3W	White	The high degree of twisting effect using twisting elements prevents the formation of false twists, is used in rotors with a diameter of 30 mm and less, can increase yarn fineness, is recommended for the production of woven yarn and knitted yarn less than 29 texts.
TS 30-3S	Black	It has a very high torsional holding effect due to a special element in its construction. Very high spinning stability. It is recommended to use with 33 mm diameter rotors and without top screws. Yarn hairiness may increase.

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TS 37	-	It has a holding effect. There is a tendency for pollution. Can be used for yarns smaller than 29 texes, for rotors less than 33 mm in diameter, or low-level twisting.

The spinning chamber, which is the main working part of the OE spinning machine, has a spinning tube, which has a fixed ceramic twist holder located at a certain angle. The disadvantage of this design is that the resistance at the outlet of the emerging yarn, the unevenness of the twist of the yarn, and the variability in tension are the reasons for the rigidity of the device [16].

A device for removing the thread from the spinning chamber for neuromechanical spinning includes a funnel mounted on one axis of the spinning chamber. The axis of the guide bushing on the sidewall of the funnel is perpendicular to the axis of the funnel and moves along the axis of the funnel in such a way that the thread is perpendicular to the axis of the funnel in the section of the funnel touching the inner surface of the funnel. However, this design does not provide high twisting efficiency and therefore does not reduce yarn breakage [17].

2. The task

Research is planned to apply the results of the initial research in the production environment. At the same time, it was considered that changes in the speed of the chamber and discrete drum and the number of twists on the AUTOCORO 9 machine in the production conditions of FT TEXTILE GROUP LLC (Uzbekistan) affect the quality of yarn.

We know that a large number of machines and equipment are used to produce yarn of a certain thickness. This mechanism, which is part of the technological process, has different quality indicators of machines and semi-finished products, as well as yarn. When determining the quality of the semi-finished product and yarn, alternative solutions are found using certain laws and rules of mathematical and statistical methods, taking into account the specifics of the technological process.

Mathematical planning methods of the experiment are used to alternate these parameters, i.e. factors and optimization parameters, which are included in the spinning technology. These include full factor experiment (FFE), fractional factor experiment, randomized equilibrium experiment, simplex cell experiment, and so on. We use full factor experience in our research.

From this point of view, regression equations are formed by taking into account the changes in the speed of the camera, the speed of the discrete drum and the number of twists as a factor influencing the quality of yarn in the enterprise. It is known that when the analytical expression of the response function is unknown, it can usually be expressed in the form of the regression equation (0.1) with the polynomial of the response function

$$y = b_0 + \sum_{i=1}^{k} b_i x_i + \sum_{i=1}^{k} b_{ii} x_i^2 + \sum_{i<1}^{k} b_{ij} x_i x_j + \sum_{i<j<l}^{k} b_{ijl} x_i x_j x_l \tag{1}$$

Here: y - is the calculated value of the optimization parameter, xi - is the independent input parameter, which changes during the experiment, b_0, bi, bij, bijkb are the regression coefficients determined from the experimental results. To build a mathematical model in the form of equation (0.1), the optimization criterion "u" is selected; an independent variable xi-factor is selected; b0, bi, bij, bijkb are the regression coefficients, the response and the appearance of the plan function are determined.

The coded values of the factors denoted by the letters X_1, X_2 are used to write the experimental plan and process the experimental results. . . x_i coded (dimensionless size) and X_i physical (natural) variable are interrelated in the following ratio.

$$x_i = \frac{X_i - X_{i0}}{\Delta i} \tag{2}$$

Where X_i is the interval of variation of the natural value; X_{i0} is the natural value of the zero levels,

$$X_{i0} = \frac{x_н - x_в}{2}$$ X_n, X_b is the natural value of the lower and upper tier of the factor.

Factor coding is equivalent to moving the coordinate head to the point of the main factor level (the central O point of the experiment) and changing the scale.

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All coded factors are dimensionless and normalized quantities. During the experiment, they take the values of -1, 0, +1.

These values are called the level of factors. (0.1) The coefficients in the independent variables of the approximate polynomial indicate the degree of influence of the factors. If the coefficient is positive, the output factor increases with the increase of the factor, and as the negative coefficient increases with the factor, its size decreases.

A full factor is an experiment in which the levels of possible combination (cumulative) factors take place. If the "k" factors vary in two levels, then all possible sets are $N_2 = 2^k$. If the factors "k" vary by three levels, then $N_3 = 3^k$.

We construct the regression equation for the fractions. First, we create a two-tier (k = 2), three-factor experimental plan, where the first factor is the speed coded head of the X_1 camera, the second is the discrete drum speed with the X_2 code, and the third is the number of twists of the X_3 coded string in two parallel experiments.

Table 2. experience (p=1)

Factors	x_{max}	x_{min}	Δ	x_0
Speed of camera, мин$^{-1}$	165000	139000	13000	152000
Discrete drum speed, min^{-1}	10400	9200	600	9800
Number of twists, Twist per meter	950	750	100	850

Table 3. Experience (p=2)

Factors	x_{max}	x_{min}	Δ	x_0
Speed of camera, min^{-1}	165000	139000	13000	152000
Discrete drum speed, min^{-1}	10400	9200	600	9800
Number of twist speed, min^{-1}	1000	800	100	900

To determine the regression equation, a matrix of two-level (k = 2) three-factor experiment was constructed for each function on the answers. , and the corresponding response values for the coefficient of variation in the relative stiffness of the yarn and the number of twists of the yarn, each obtained in parallel experiments, were determined.

Thus, $\bar{y}_{ui} = \frac{1}{n}\sum_{l=1}^{n} y_{ul}$, $\bar{z}_{ui} = \frac{1}{n}\sum_{l=1}^{n} z_{ul}$, (l = 1.2… m) was considered in two experiments. We provide the number of sets in each variant as m = 2 at $N_2 = N = 8$ and their values are given in Table 3.10.

Table 4. the number of sets in each variant as m = 2 at N2 = N = 8 and their values

Experiences	Factors			A) Y_1 – relative tensile strength, сН/текс		B) Y_2 – unevenness by a twist	
	x_1	x_2	x_3	$\bar{y}_{1u}$	S^2_{1u}	$\bar{y}_{2u}$	S^2_{2u}
1	-	-	-	11,7	0,32	3,24	0,0648

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2	+	-	-	11,2	0,72	3,285	0,02645
3	-	+	-	12,35	0,845	3,015	0,00245
4	+	+	-	12,2	0,72	3,005	0,04205
5	-	-	+	10,75	0,045	3,26	0,1152
6	+	-	+	11,15	0,125	3,29	0,0128
7	-	+	+	12,35	0,245	3,13	0,0072
8	+	+	+	12,75	0,245	2,855	0,00605
					3,265		0,277

Statistical processing of the experimental results for each response was performed in the following order:

Parallel experiments S_u^2 characterizing the distribution of their results in the same number of m, were reproducible in the same category of variance.

$$S_u^2 = \frac{\sum_{p=1}^{2} (\bar{y}_{up} - \bar{y}_u)^2}{m-1} \tag{3}$$

In this case - the sequence number of the option (u = 1.2… N), p = 1.2.3… m - the sequence number of parallel experiments, - the number of each parallel experiment, $\bar{y}_u = \frac{1}{m}\sum_{p=1}^{m} \bar{y}_{up}$ - the average of parallel experiments. We enter S_u^2 the values of the results in the table, and for both cases, this statistic was calculated.

$$G = \frac{S_{u(\max)}^2}{\sum_{u=1}^{N} S_u^2} \tag{4}$$

Here is $S_{u(\max)}^2$ the maximum value of the variance in parallel experiments A) The value was calculated according to formula (0.3)

$S_u^2 = (\bar{y}_{u1} - \bar{y}_u)^2 + (\bar{y}_{u2} - \bar{y}_u)^2$, *(u=1,2,3,4,5,6,7,8)*,

$S_1^2 = 0.32$, $S_2^2 = 0.72$, $S_3^2 = 0.845$, $S_4^2 = 0.72$, $S_5^2 = 0.045$, $S_6^2 = 0.125$, $S_7^2 = 0.245$, $S_8^2 = 0.245$

We accept $S_{u(\max)}^2 = S_3^2 = 0.845$ if we calculate the statistics $\sum_{u=1}^{8} S_u^2 = 3.265$

G=0.2588

B) $S_1^2 = 0.648, S_2^2 = 0.02645$, $S_3^2 = 0.00245$, $S_4^2 = 0.04205$, $S_5^2 = 0.1152$, $S_6^2 = 0.0128$, $S_7^2 = 0.0072$, $S_8^2 = 0.00605$, $S_{u(\max)}^2 = S_8^2 = 0.1152$, $\sum_{u=1}^{8} S_u^2 = 0.277$,

$$G = \frac{S_{u(\max)}^2}{\sum_{u=1}^{N} S_u^2} = 0.4158$$

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Checked for the Cochrane criterion, G_{α,k_1,k_2} - the values were taken from the table data, a-significant level (0<a<1), k1 = N, k2 = m-1 - number of degrees of freedom, we consider a = 0.05, m = 2 , N = 8,, $G_{\alpha,k_1,k_2} = G_{0.05,8,2} = 0.52$ G = 0.506

If the following inequality is observed

$$G < G_{\alpha,k_1,k_2} \tag{5}$$

The Cochrane criterion would be appropriate. In both cases, this condition is met. These equations can be used because the homogeneity of the variance is performed in all variants of all m parallel experiments.

A) $$S_y^2 = \frac{1}{N}\sum_{u=1}^{N} S_u^2 = 0.4081 \tag{6}$$

B) $$S_y^2 = \frac{1}{N}\sum_{u=1}^{N} S_u^2 = 0.0346 \tag{7}$$

That is, this variance is used to assess the adequacy of the model.

If inequality (0.5) is not complied with, the variance by variants is of the same category and is not averaged, and the following measures should be taken: a) to determine the maximum variance of the measurement data in the variance; b) increase the number of m experiments in each variant; c) perform more accurate measurements of output parameters.

The regression coefficients were calculated by the following formula.

$$b_0 = \frac{1}{N}\sum_{u=1}^{N} \bar{y}_u, \quad b_i = \frac{1}{N}\sum_{u=1}^{N} X_{iu}\bar{y}_u, \quad b_{ij} = \frac{1}{N}\sum_{u=1}^{N} X_{iu}X_{ju}\bar{y}_u, \quad b_{ijk} = \frac{1}{N}\sum_{u=1}^{N} X_{iu}X_{ju}X_{ku}\bar{y}_u, \tag{8}$$

Once the coefficients were determined, a coded variable regression equation was written.

$$\hat{y} = b_0 + \sum_{i=1}^{k} b_i x_i + \sum_{i<1}^{k} b_{ij} X_i X_j + \sum_{i<j<l}^{k} b_{ijl} X_i X_j X_l \tag{9}$$

A) For the relative strength of the yarn

$$y = 11{,}81 + 0{,}0187x_1 + 0{,}61x_2 - 0{,}056x_3 + 0{,}0437x_1x_2 +$$
$$+ 0{,}18x_1x_3 + 0{,}19x_2x_3 - 0{,}044x_1x_2x_3$$

B) for the coefficient of variation on the twist

$$y = 3{,}135 - 0{,}26x_1 - 0{,}134x_2 - 0{,}0012x_3 - 0{,}045x_1x_2 -$$
$$- 0{,}35x_1x_3 - 0{,}0075x_2x_3 - 0{,}031x_1x_2x_3$$

Check the significance of the regression coefficients from the student's criterion. First, we use the following formula for all regression coefficients *Δb* in the same confidence range:

$$\Delta b = t_{\alpha,k}\frac{S_y}{\sqrt{N}} \tag{10}$$

T_{ak}- Student's criterion, a- significance level, k = N (m-1) - number of degrees of freedom. If the regression coefficient is higher than the confidence range, then the coefficients are significant.

$$|b_0| \geq \Delta b, |b_i| \geq \Delta b, |b_{ij}| \geq \Delta b, |b_{ijk}| \geq \Delta b \tag{11}$$

In the following case, we consider t0.0516 = 2.16, Δb=$t_{\alpha,k}$, $\frac{S_y}{\sqrt{N}} = 0.136$

We write the regression coefficients with the inequality and the significant level of the coefficients in the regression equation b_o, b_1, b_2 and b_3 (0.11).

For the relative strength of the yarn.

$$y = 11{,}81 + 0{,}0187x_1 + 0{,}61x_2 - 0{,}056x_3 \tag{12}$$

For the coefficient of variation on the twist

$$y = 3{,}135 - 0{,}26x_1 - 0{,}134x_2 - 0{,}0012x_3 \tag{13}$$

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We estimate the adequacy of the model when no significant coefficients are involved in the regression equation.

If the regression equation is taken as (0.10), then the variance of the experiments is zero. In this case, all $N = 2^k$ regression coefficients will be calculated with y values on N, in which case there is no degree of freedom to check the adequacy of the model. In this case, the adequacy condition is fully managed and the experimental plan is called complete. If some non-significant coefficients are not taken into account in the regression equation (0.10), a degree of freedom is formed, and it is necessary to check the adequacy of the model. The adequacy test consists of comparing the experimental values of the output parameter y with the calculated values of the different levels of the input parameters and determining their difference as a percentage according to the formula.

$$R_0 = 100\left|\frac{\hat{y}-y}{y}\right| \quad (14)$$

The residual variance was found according to the formula to verify the adequacy of the linear density model according to the Fisher criterion.

$$S_{oc}^2 = \frac{\sum_{u=1}^{8}(\hat{y}_u - \bar{y}_u)^2}{N-k-1} \quad (15)$$

A) For the relative strength of the yarn.

$$S_{oc}^2 = \frac{\sum_{u=1}^{8}(\hat{y}_u - \bar{y}_u)^2}{N-k-1} = \frac{0{,}5921}{8-3-1} = 0{,}148$$

B) For the coefficient of variation on the twist

$$S_{oc}^2 = \frac{\sum_{u=1}^{8}(\hat{y}_u - \bar{y}_u)^2}{N-k-1} = \frac{0{,}034388}{4} = 0{,}008597$$

where: ŷu is the calculated value of the indicator in the variant, ŷu -is the current value of the indicator, N - is the number of options, k - is the number of factors.

The adequacy of the obtained equations was checked using the Fisher criterion.

$$F = \frac{S_{oc}^2}{S_y^2} \quad (16)$$

A) For the relative strength of the yarn. : $F = \frac{S_{oc}^2}{S_y^2} = \frac{0{,}148}{0{,}4081} = 0{,}363$

B) For the coefficient of variation on the twist $F = \frac{S_{oc}^2}{S_y^2} = 0{,}247$

If we check on the Fisher criterion F_{α,k_1,k_2} by table value, here a is a significant level, depending on (k_1 = N-k-1 = 4, k_2 = N (m-1) = 16,) we find from the table, the hypothesis of adequacy is satisfied if this inequality ($F < F_{\alpha,k_1,k_2}$) is satisfied. The Fisher criterion is appropriate for both cases because $F_{\alpha,k_1,k_2} = 3.84$

The values of the factors on the coordinate axes can be set to X_1, X_2 and X_3. In turn, the input values are given by ŷ = const. In each case, the surface is defined in three-dimensional space X_1 X_2 X_3, without changing the values of the output parameters ŷ = const, several values are obtained for the end surface ŷ, taking into account the values of any factor, for example, X_3 = const.

3. Analysis of results

Determining the value of the so-called factors of regression equation presented below, x_i (i = 1.2.3.k), the formula is expressed by the coded values (0.2).

$$X_i = \frac{x_i - x_0}{\Delta x_i} \quad (17)$$

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In the indicated sequence, we perform statistical processing of the experimental results for the coefficient of variation in terms of the relative strengths of the yarn and the number of twists in the yarn. The number of twists encoded in the regression equation (0.14) obtained for the relative strength of the yarn, the fixation parameter X_3, we graphically represent the relationship between the variables X_2 and X_1 at different values of relative strength.

In Figure 3, when X_3 = -1 (average of the minimum number of twists of two parallel experimental turns (800 + 750) / 2 = 775, the input parameter Y_1 (relative breaking force, sN / tex) at different values of the input factors X_2 (discrete drum speed min$^{-1)}$, The connection graphs between and X_1 (camera speed, min^{-1}) are given. If the camera speed is given using these graphs, the braking force of the yarn is 11.25, 11.5, 12.0, 12.2, 12.4 and 12.46 sN/tex when the number of twists in the graph is 775. If the camera speed is given, the discrete drum speed corresponding to it is determined. For example, suppose that the braking force of the yarn is 11.5 sN/tex when the number of turns is 775. If the camera speed is x_1 = 152000 min^{-1}, the discrete drum speed is plotted from the graph x_2. = 9620 min^{-1}.

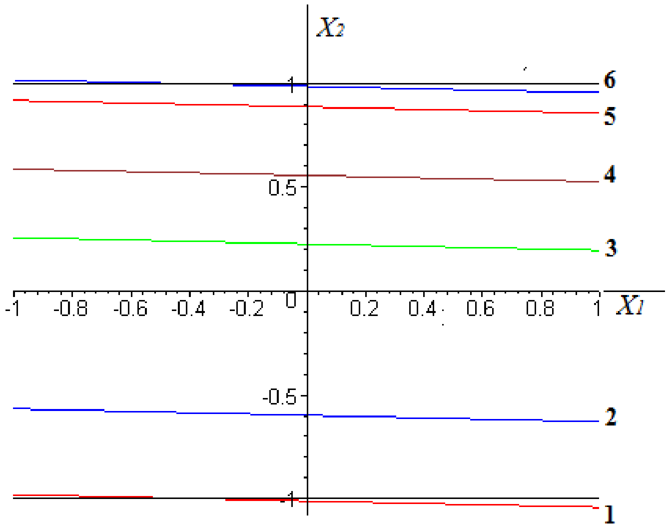

Figure 3. Graph of connection between camera speed X_2 and discrete drum speed X_2 at different breaking forces of the yarn when the number of turns is 775

$1 \rightarrow Y_1 = 11.25$, $2 \rightarrow Y_1 = 11.5$, $3 \rightarrow Y_1 = 12$, $4 \rightarrow Y_1 = 12.2$, $5 \rightarrow Y_1 = 12.4$, $6 \rightarrow Y_1 = 12.46$

These graphs also determine the limits at which the braking force of the yarn occurs at both values of the two factors (camera and discrete drum speeds) when the number of twists is given. For example, if the given twists are 775, the breaking strength of the yarn in the received variation ranges of the chamber and discrete drums cannot be less than 11.25 sN/tex (line 1) and higher than 12.46 sN/tex (line 6).

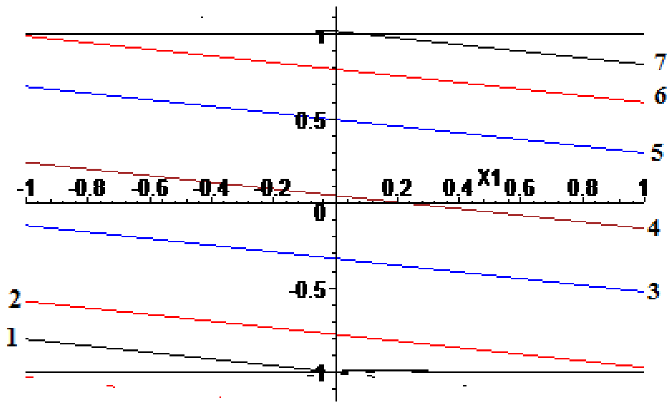

Figure 4. Graph of change of torque inequality on the relationship between camera speed X_1 and discrete drum speed X_2 when the number of twists is 775

$1 \rightarrow Y_2 = 3.27$, $2 \rightarrow Y_2 = 3.24$, $3 \rightarrow Y_2 = 3.18$, $4 \rightarrow Y_2 = 3.13$, $5 \rightarrow Y_2 = 3.07$, $6 \rightarrow Y_2 = 3.03$, $7 \rightarrow Y_2 = 3$

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Figure 4 shows the graphs of the relationship between the incoming factors X_2 (discrete drum speed min^{-1}) and X_2 (camera speed min^{-1}) when the inequality Y_2 (second output parameter) on the twists is different. the unevenness of the twists in the obtained change diapasons of the drums cannot be higher than 3.3 and less than 2.28.

The mathematical model corresponds to the task of optimizing the effect of the value of each factor on the torsional inequality through the connections of regression equations, the camera speed (152000 min^{-1}), discrete drum speed (9260 min^{-1}), the number of turns 775 twists per meter. We can further clarify the results of theoretical research by conducting experiments in production conditions.

4. Conclusion

In short, the types of compactors and TS should be selected depending on the raw material to be processed, the diameter of the rotor of the spinning machine, the linear density of the yarn and its supply. It was found that the use of different funnels and twisting torque stop has a different effect on the stability of spinning, yarn quality in the process of yarn formation.

To introduce a new intensifier into the technological process, full-factor experiments were conducted and regression equations were constructed to alternate the machine parameters. The adequacy of the obtained equations was checked using the Fisher criterion. Through the relationships of the regression equations of the considered mathematical model, the effect of the camera speed, the speed of the discrete drum, the importance of the number of twists on the value of each factor on the inequality of the twists were determined.

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