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Determination of Technological Parameters of Fiber Separation Device from Cotton Waste

Sultanov Mirzaolim Mirzaraxmatovich

Department of Technological Machines and Equipment, Namangan Institute of Engineering and Technology, Namangan, Uzbekistan
Email: msultonov@mail.ru

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Abstract

This article examines the technological parameters of the device for the separation of fibers suitable for spinning by processing fibrous waste from the technological processes of ginneries. Technological processes in the cotton ginning industry include a complex of physical and mechanical advantages, the successful study of which is possible only with the use of modern achievements in science and technology. Therefore, it is advisable to conduct scientific research based on mathematical modeling. To justify the effective operation of the selected design of the cotton fiber separation device, it is necessary to select its optimal technological parameters. Improving the efficiency of the process of separation of spinning fibers from the composition of fibrous waste depends directly on technological parameters. The application of mathematical methods in the planning and conduct of research allows for determining the individual effects of the interaction of several factors that characterize the combined parameters of the optimization parameters, in contrast to traditional computational methods of research. As a result, it will be possible to obtain a mathematical model of the object understudy in a relatively small number of tests, which will simultaneously serve to obtain optimal solutions.

Keywords

Device, Cotton Fiber, Fiber Waste, Down, Lint, Short Fiber, Guide, Diameter, Steel Coating, Strength, Strength Reserve, Shaft, Centrifugal Force, Cotton, Technology

1. Introduction

In this study, the cases of loss of cotton fiber, valuable raw material for the textile industry in the technological process of ginneries, were studied, and in theory, the possibility of separation of fiber in the saw drum was considered. The results obtained based on theoretical research are the basis for experimental research, and it is necessary to select the optimal design for use in the production of a new device [1] [2].

To justify the effective operation of the selected design of the new fiber separation device, it is first necessary to select its optimal technological parameters. Improving the efficiency and effectiveness of the process of extracting long fibers from the composition of the fibrous waste (short fibers, down) is directly related to them.

The application of mathematical methods in the planning and conduct of research allows for determining the individual effects of the interaction of several factors that characterize the combined parameters of the optimization parameters, in contrast to traditional computational methods of research. As a result, it will be possible to obtain a mathematical model of the object understudy in a relatively small number of tests, which will simultaneously serve to obtain optimal solutions [3] [4] [5].

2. Determination of Factors Affecting the Operation of the Device

An important issue in optimization is to identify important factors that affect the separation of long fibers from the fiber mass composition. This serves to ensure that the work is efficient by ensuring that the saw drum adheres well to the fibers. As optimization parameters y—the efficiency of the device in the separation of long fibers was selected. That is, the study of the device takes into account what percentages of the long fibers present in the fiber waste are separated by the device.

Taking into account the results of theoretical research and literary reviews of the new device, as well as the following factors were selected as input factors influencing the output parameters in the first one-factor experiment [5]:

X_1—Number of revolutions of the saw drum (n_{ab}) rpm;

X_2—The distance between the saw and the brush drum (a) mm;

X_3—the slope angle of the guide (α) grad.

Based on the analysis, the possibility of creating a device for the separation of long fibers was substantiated. This device is the main working body saw and brush drum zone, and the process is carried out as a result of the rotation of these drums. Also, a switch mounted on the inlet side of the device has a significant effect. It can ensure that the fibrous mass comes directly to the surface of the saw drum. During the operation of the device, the saw drum will be able to hold the long fibers well; it will be possible to effectively remove the fibers from the saws as a result of choosing the optimal distance from the brush drum.

To ensure the efficient operation of the separator, the number of saw drum rotations, the distance between the saw drum and the brush drum and the angle of inclination of the guide, the size of the inlet and outlet pipes, the slope of the saw, the number of brushes must be chosen. Based on practical and theoretical research, we have selected the following factors that have a significant impact on efficiency (**Table 1**).

The number of revolutions of the saw drum X_1. The number of revolutions of the saw drum is one of the main factors which determines the efficiency of separation of long fibers from the fiber waste; the speed of the drum can make it possible to accurately separate long fibers; besides, the drum creates a state of fibrous mass. It is convenient to separate a separate body from a spontaneously crushed mass. In selecting the value of this factor, the values accepted in the fiber cleaning-separation machines were used, the value was selected in the range of 200 - 400 rpm.

The distance between the saw and the brush drum X_2. This distance also ensures that the fiber separation process is efficient. This is because the optimal distance between the two drums ensures maximum separation of the fibers adhering to the drum using brushes and transmission to the pipe. The possibility of free movement of the drums should also be taken into account when selecting this value. With this in mind, this distance was chosen in the range of 1 - 3 mm.

The angle of inclination of the guide X_3. The router of the fiber separation device serves to direct the incoming fiber mass from the inlet pipe from the receiving drum to the saw drum. Given that no previous studies have been conducted on structures close to this device, the slope angle was taken to be 5 to 15 degrees relative to the device inlet pipe wall due to the structure of the structure. Because the analysis of initial experiments showed that if the angle of inclination is taken less than 5 degrees or more than 15 degrees, it becomes impossible to direct the flow along the desired trajectory [6] [7].

Experiments were conducted using modern mathematical planning methods to determine the optimal performance of the fiber separation device [8] [9]. Based on these experiments, it is necessary to select the most optimal sizes that will ensure the efficient operation of the fiber separation device.

The fiber separation process, which depends on many factors, has been studied using modern mathematical planning methods using computer software. This allows you to get the optimal solution with the least cost.

It is necessary to use instruments capable of measuring with the required accuracy to conduct experimental tests. In particular, the Precision PT-2235B digital

Table 1. The factors under study are the choice of levels and intervals of change.

Name and designation of factors		Change levels			Change interval
		−1	0	+1	
The number of revolutions of the saw drum (n_{ab}) rpm	X_1	200	300	400	100
Between the saw and the brush drum distance (a) mm	X_2	1	2	3	1
The angle of inclination of the guide (α) *grad*	X_3	5	10	15	5

tachometer was used to measure the number of revolutions of the Arrali drum. In our experiments, changing the diameter of the pulleys to change the number of revolutions of the shaft was done using an electric motor. The distance and slope angle were determined using known methods [10].

A fiber mixture of 30 kg was passed through the inlet pipe at the specified number of revolutions. Each test was repeated five times. It was found in the tests that the production productivity was properly selected by the number and timing of cycles accordingly. The angle of inclination of the guide was measured using a protractor. The experiments were performed in a randomized order [11].

Before testing, the amount of fiber in the fiber mass longer than 16 mm is determined using an AX analyzer. After the test, the short fiber mass from the device is again checked using an analyzer to determine the number of long fibers. As a result, the percentage of long fibers separated by the device is known, the inspection is carried out under the rules established in the laboratories of ginneries.

3. Theoretical Studies of Determining the Optimal Values of Factors

On a general basis, we move from the natural values of the factors to the coded values.

The results of the Full Factor Experiment (TOT) show that the process under study is represented by a higher-level equation. Therefore, to obtain a mathematical model of secondary regression, a central non-composite experiment (CNC) was selected and implemented, which is much simpler and more convenient than other methods, as well as widely used in the study of technological processes of ginneries. [12].

The CNC working matrix and the results of the experiments are presented in **Table 2** below.

Based on the experimental results, we look for a secondary regression multivariate mathematical model. As a result of this experiment, we can obtain the following general regression model:

$$Y_R = b_0 + \sum_{i=1}^{M} b_i x_i + \sum_{\substack{i=j=1 \\ j\neq 1}}^{n} b_{ij} x_i x_j + \sum_{i=1}^{M} b_{ii} x_i^2$$

or because three factors are involved in our experience, the above expression takes the following form:

$$Y_R = b_0 + b_1 x_1 + b_2 x_2 + b_3 x_3 + b_{12} x_1 x_2 + b_{13} x_1 x_3 + b_{23} x_2 x_3 + b_{11} x_1^2 + b_{22} x_2^2 + b_{33} x_3^2$$

In the equation

$b_0, \cdots, b_{33}$ —regression coefficients,

x_1, x_2, x_3 —the coded value of the factors.

We determine the regression coefficients:

$$b_0 = \frac{1}{N_u} \sum_{u=1}^{N_u} \bar{Y}_{\bar{u}} = \frac{1}{3}(70 + 69 + 69) = 69.33$$

Table 2. Central non-composite experimental matrix.

№	Factors x_1	x_2	x_3	x_1x_2	x_1x_3	x_2x_3	x_1^2	x_2^2	x_3^2	$\bar{Y}_1$	$S_u^2\{Y_1\}$
1	+	+	0	+	0	0	+	+	0	65	7.8
2	+	–	0	–	0	0	+	+	0	67	9.2
3	–	+	0	–	0	0	+	+	0	42	8.2
4	–	–	0	+	0	0	+	+	0	60	6.3
5	+	0	+	0	+	0	+	0	+	75	9.2
6	+	0	–	0	–	0	+	0	+	60	4.1
7	–	0	+	0	–	0	+	0	+	63	6.7
8	–	0	–	0	+	0	+	0	+	52	9.8
9	0	+	+	0	0	+	0	+	+	51	6.7
10	0	+	–	0	0	–	0	+	+	41	9.1
11	0	–	+	0	0	–	0	+	+	60	7.2
12	0	–	–	0	0	+	0	+	+	48	6.4
13	0	0	0	0	0	0	0	0	0	70	8.1
14	0	0	0	0	0	0	0	0	0	69	6.8
15	0	0	0	0	0	0	0	0	0	69	6.4

$$b_i = g_3 \sum_{u=1}^{N} x_{iu} \bar{Y}_u$$

To calculate the regression coefficients, we use the values of Table 3 in Sevastyanov's textbook [13] (Table 2).

$$g_1 = 0.2$$

$$g_2 = 0.166$$

$$g_3 = 0.125$$

$$g_4 = 0.25$$

$$g_5 = 0.125$$

$$g_6 = 0.0625$$

$$g_7 = 0.3125$$

$$b_1 = 0.125(65 + 67 - 42 - 60 + 75 + 60 - 63 - 52) = 6.25$$

$$b_2 = 0.125(65 - 67 + 42 - 60 + 51 + 41 - 60 - 48) = -4.5$$

$$b_3 = 0.125(75 - 60 + 63 - 52 + 51 - 41 + 60 - 48) = 6$$

$$b_{ij} = g_4 \sum_{u=1}^{N} x_{iu} x_{ju} \bar{Y}_u$$

$$b_{12} = 0.25(65 - 67 - 42 + 60) = 4$$

$$b_{13} = 0.25(75 - 60 - 63 + 52) = 1$$

$$b_{23} = 0.25(51 - 41 - 60 + 48) = -0.5$$

$$b_{ii} = g_5 \sum_{u=1}^{N} x_{iu}^2 \overline{Y}_u + g_6 \sum_{i=1}^{M} \sum_{u=1}^{N} x_{iu}^2 \overline{Y}_u - g_2 \sum_{u=1}^{N} \overline{Y}_u$$

$$\sum x_1^2 \overline{Y}_u = 65 + 67 + 42 + 60 + 75 + 60 + 63 + 52 = 484$$

$$\sum x_2^2 \overline{Y}_u = 65 + 67 + 42 + 60 + 51 + 41 + 60 + 48 = 434$$

$$\sum x_3^2 \overline{Y}_u = 75 + 60 + 63 + 52 + 51 + 41 + 60 + 48 = 450$$

$$\sum \overline{Y}_u = 65 + 67 + 42 + 60 + 75 + 60 + 63 + 52 + 51 + 41 + 60 + 48$$

$$= 892 \sum_{i=1}^{M} \sum x_i^2 \overline{Y}_u = 484 + 434 + 450 = 1368$$

$$b_{11} = 0.125 \times 484 + 0.0625 \times 982 - 0.166 \times 1368 = -2.07$$

$$b_{22} = 0.125 \times 434 + 0.0625 \times 982 - 0.166 \times 1368 = -8.32$$

$$b_{33} = 0.125 \times 450 + 0.0625 \times 982 - 0.166 \times 1368 = -6.32$$

We write the equation taking into account the determined regression coefficients:

$$Y_R = 69.33 + 6.25x_1 - 4.5x_2 + 6x_3 + 4x_1x_2 + x_1x_3 - 0.5x_2x_3 - 2.07x_1^2 - 8.32x_2^2 - 6.32x_3^2$$

We determine the significance of the regression coefficients.

To do this, we determine the variance of the outgoing parameter.

$$S^2\{Y\} = S_m^2\{Y\} = \frac{1}{N_ц - 1} \sum_{u=1}^{N_ц} S^2\{\overline{Y}\}$$

$$S^2\{\overline{Y}\} = \frac{1}{3-1} \times 21.3 = 10.65$$

and on this basis we calculate the variance in determining the regression coefficients:

$$S^2\{b_0\} = g_1 S^2\{\overline{Y}\} = 0.2 \times 10.7 = 2.13$$

$$S^2\{b_i\} = g_3 S^2\{\overline{Y}\} = 0.125 \times 10.7 = 1.33$$

$$S^2\{b_{ij}\} = g_4 S^2\{\overline{Y}\} = 0.25 \times 10.7 = 2.66$$

$$S^2\{b_{ii}\} = g_7 S^2\{\overline{Y}\} = 0.3125 \times 10.7 = 3.33$$

We find the standard deviation in determining the regression coefficients:

$$S\{b_0\} = 1.46$$

$$\{b_i\} = 1.15$$

$$S\{b_{ij}\} = 1.63$$

$$S\{b_{ii}\} = 1.82$$

We then determine the calculated value of the Student Criterion using the following equation:

$$t_R\left\{b_i\right\}=\frac{\left|b_i\right|}{S\left\{b_i\right\}}$$

$$t_R\left\{b_0\right\}=\frac{|69.33|}{1.46}=47.5,\quad t_R\left\{b_{12}\right\}=\frac{|4|}{1.63}=2.45$$

$$t_R\left\{b_1\right\}=\frac{|6.25|}{1.15}=5.42,\quad t_R\left\{b_{13}\right\}=\frac{|1|}{1.63}=0.61$$

$$t_R\left\{b_2\right\}=\frac{|-4.5|}{1.15}=3.9,\quad t_R\left\{b_{23}\right\}=\frac{|-0.5|}{1.63}=0.31$$

$$t_R\left\{b_3\right\}=\frac{|6|}{1.15}=5.2,\quad t_R\left\{b_{11}\right\}=\frac{|-2.07|}{1.82}=1.13$$

$$t_R\left\{b_{22}\right\}=\frac{|-8.32|}{1.82}=4.56,\quad t_R\left\{b_{33}\right\}=\frac{|-6.32|}{1.82}=3.46$$

We get the table value of the Student criterion from:

$$t_{ж}\left[P_{Д}=0.95;\ f\left\{S_{ц}^2\right\}=3-1=2\right]=2.77$$

It is known that if the calculated value of the criterion is less than the table value, that coefficient is not significant and we subtract it from the equation. In research $b_{12}, b_{13}, b_{23}, b_{11}$ the coefficients were found to be insignificant for the parameters under study.

We rewrite the equation with significant coefficients:

$$Y_R=69.33+6.25x_1-4.5x_2+6x_3-8.32x_2^2-6.32x_3^2$$

To check whether the above regression mathematical model is adequate or not, we determine if using the calculated value of the Fisher criterion.

$$F_R=\frac{S_{над}^2\left\{Y\right\}}{S^2\left\{\overline{Y}\right\}}$$

here

$$S^2\left\{\overline{Y}\right\}=\frac{\sum_{u=1}^{N}S^2\left\{Y\right\}}{N_{ц}-1}=\frac{21.3}{3-1}=10.65$$

$$S_{над}^2\left\{Y\right\}=\frac{\sum_{u=1}^{N-N_{ц}+1}\left(Y_{Ru}-\overline{Y}_u\right)^2}{N-N_{к.эн}-\left(N_{ц}-1\right)^2};$$

$$N-N_{к.эн}-\left(N_{ц}-1\right)^2=15-7-(3-1)^2=4$$

$$N-N_{ц}+1=15-3+1=13$$

$$Y_R=69.33+6.25x_1-4.5x_2+6x_3-8.32x_2^2-6.32x_3^2$$

$$Y_{R1}=69.33+6.25-4.5-8.32=62.76$$

$$Y_{R2}=69.33+6.25+4.5-8.32=71.76$$

$$Y_{R3}=69.33-6.25-4.5-8.32=50.26$$

$$Y_{R4}=69.33-6.25+4.5-8.32=59.26$$

$$Y_{R5} = 69.33 + 6.25 + 6 - 6.32 = 75.26$$

$$Y_{R6} = 69.33 + 6.25 - 6 - 6.32 = 63.26$$

$$Y_{R7} = 69.33 - 6.25 + 6 - 6.32 = 62.76$$

$$Y_{R8} = 69.33 - 6.25 - 6 - 6.32 = 50.76$$

$$Y_{R9} = 69.33 - 4.5 + 6 - 8.32 - 6.32 = 56.19$$

$$Y_{R10} = 69.33 - 4.5 + 6 - 8.32 - 6.32 = 44.19$$

$$Y_{R11} = 69.33 - 4.5 + 6 - 8.32 - 6.32 = 65.19$$

$$Y_{R12} = 69.33 - 4.5 + 6 - 8.32 - 6.32 = 53.19$$

To simplify the calculations, we create the following **Table 3**:

$$\sum_{u=1}^{N-N_{ц}+1} \left(Y_{Ru} - \bar{Y}_u\right)^2 = 199.7$$

$$S^2_{\text{над}}\{Y\} = \frac{199.7}{4} = 49.93$$

It is known that if the calculated value of the criterion is less than the value of the table, that coefficient is adequate and proves that the calculations were performed correctly

$$F_R = \frac{S^2_{\text{над}}\{Y\}}{S^2\{\bar{Y}\}} = \frac{49.93}{10.65} = 4.68$$

$$F_{ж}\left[P_{Д} = 0.95;\ f\left\{S^2_{\text{над}}\{Y\}\right\} = 15 - 6 - (3-1) = 5;\ f\left\{S^2_u\right\} = 3 - 1 = 2\right] = 4.74$$

$$F_R = 4.68 < 4.74 = F_{ж}$$

Hence, the obtained regression mathematical model represents the studied process with sufficient accuracy.

Table 3. Simplified values for calculations.

№	$\bar{Y}_u$	Y_{Ru}	$\left(Y_{Ru} - \bar{Y}_u\right)$	$\left(Y_{Ru} - \bar{Y}_u\right)^2$
1	65	62.76	−2.24	5.01
2	67	71.76	4.8	22.7
3	42	50.26	8.3	68.25
4	60	59.26	−0.74	0.55
5	75	75.26	0.26	0.07
6	60	63.26	3.26	10.64
7	63	62.76	−0.24	0.06
8	52	50.76	−1.24	1.53
9	51	56.19	5.19	26.93
10	41	44.19	3.19	10.17
11	60	65.19	5.19	26.93
12	48	53.19	5.19	26.93

$$Y_R = 69.33 + 6.25x_1 - 4.5x_2 + 6x_3 - 8.32x_2^2 - 6.32x_3^2$$

Given that the main goal in the optimization of factors is "maximization", namely:

$$y_i \Rightarrow \max$$

in which case the search is somewhat simplified.

It is known that the contribution of factors to the efficiency of the separation device in the transition from the minimum value to the maximum value determines the effect of the factors. It can be seen from the obtained models that the rotation speed of the machine drum is at a medium value, the distance between the drums and the angle of inclination of the guide is at a minimum value, which leads to an increase in productivity. In this case, the effect of the first factor is 98%, the change of the second factor is 92%, and the effect of the angle of inclination can lead to an increase in machine productivity up to 98%. However, it should be borne in mind that the existing limitations, *i.e.*, the increase in productivity, lead to the efficiency of long fiber separation. The results of the numerical search method also showed that the number of drum revolutions was 410 rpm (in the first experiments), and the machine had the maximum productivity when the distance between the drums was 1 mm and the angle of inclination of the guide was around 10 degrees [14].

It is possible to observe the law of variation of the separation efficiency according to the length of the separated fibers. As shown above, in the first experiment, we can see that the slope angle of the guide is not significant for its efficiency, since the separation of the longest fibers from the fine mixtures is constructively assumed. Indeed, experiments have shown that a change in the maximum value of the rotational speed allows the separation of long fibers up to 5.2% and an increase in the angle up to 5.7%. This confirmed the conclusion of the theoretical part of the work that such an effect of factors, that is, the fiber rotates faster around the center of gravity and is oriented relative to the saw teeth.

The decrease in the efficiency of the fiber separation machine causes the geometrical parameters of the main working bodies to change according to a certain pattern. This can also be seen from the analysis of mathematical regression models. This situation can be explained by the fact that the fiber content of the fiber mixture prevents it from gaining orientation relative to the saw teeth.

The fiber separation process in the brush drum section was an important step and was confirmed by increasing the fiber yield during the initial processing of the cotton. As can be seen from the regression model, the distance between the drums serves as an important factor in the separation of the fibers. At the same time, its efficiency can increase up to 6.4% [15] [16] [17].

From the above analysis of the effect of factors on each outgoing parameter, it is clear that in determining the optimal values of the factors, multifaceted mutually exclusive aspects must be taken into account. For this purpose, it is necessary to use the following mathematical apparatus of optimization:

Since the equation constructed to determine the fiber separation efficiency of the device taken as the output parameter for the study is three-dimensional, we construct a two-dimensional graph of the field of variation on two factors of value $X_i = 0$, one of the input factors in the analysis (Figures 1-3).

x_1 \ x_2	-1	-0.8	-0.6	-0.4	-0.2	0	0.2	0.4	0.6	0.8	1
-1	59,26	61,36	62,79	63,55	63,65	63,08	61,85	59,95	57,39	54,16	50,26
-0.8	60,51	62,61	64,04	64,80	64,90	64,33	63,10	61,20	58,64	55,41	51,51
-0.6	61,76	63,86	65,29	66,05	66,15	65,58	64,35	62,45	59,89	56,66	52,76
-0.4	63,01	65,11	66,54	67,30	67,40	66,83	65,60	63,70	61,14	57,91	54,01
-0.2	64,26	66,36	67,79	68,55	68,65	68,08	66,85	64,95	62,39	59,16	55,26
0	65,51	67,61	69,04	69,80	69,90	69,33	68,10	66,20	63,64	60,41	56,51
0.2	66,76	68,86	70,29	71,05	71,15	70,58	69,35	67,45	64,89	61,66	57,76
0.4	68,01	70,11	71,54	72,30	72,40	71,83	70,60	68,70	66,14	62,91	59,01
0.6	69,26	71,36	72,79	73,55	73,65	73,08	71,85	69,95	67,39	64,16	60,26
0.8	70,51	72,61	74,04	74,80	74,90	74,33	73,10	71,20	68,64	65,41	61,51
1	71,76	73,86	75,29	76,05	76,15	75,58	74,35	72,45	69,89	66,66	62,76

Figure 1. Graph of the number of revolutions of the saw drum depending on the distance between the saw and the brush drum.

x_1 \ x_3	-1	-0.8	-0.6	-0.4	-0.2	0	0.2	0.4	0.6	0.8	1
-1	50,76	54,24	57,21	59,67	61,63	63,08	64,03	64,47	64,41	63,84	62,76
-0.8	52,01	55,49	58,46	60,92	62,88	64,33	65,28	65,72	65,66	65,09	64,01
-0.6	53,26	56,74	59,71	62,17	64,13	65,58	66,53	66,97	66,91	66,34	65,26
-0.4	54,51	57,99	60,96	63,42	65,38	66,83	67,78	68,22	68,16	67,59	66,51
-0.2	55,76	59,24	62,21	64,67	66,63	68,08	69,03	69,47	69,41	68,84	67,76
0	57,01	60,49	63,46	65,92	67,88	69,33	70,28	70,72	70,66	70,09	69,01
0.2	58,26	61,74	64,71	67,17	69,13	70,58	71,53	71,97	71,91	71,34	70,26
0.4	59,51	62,99	65,96	68,42	70,38	71,83	72,78	73,22	73,16	72,59	71,51
0.6	60,76	64,24	67,21	69,67	71,63	73,08	74,03	74,47	74,41	73,84	72,76
0.8	62,01	65,49	68,46	70,92	72,88	74,33	75,28	75,72	75,66	75,09	74,01
1	63,26	66,74	69,71	72,17	74,13	75,58	76,53	76,97	76,91	76,34	75,26

Figure 2. Graph of the dependence of the number of rotations of the saw drum on the angle of inclination of the guide.

x_3 \ x_2	-1	-0.8	-0.6	-0.4	-0.2	0	0.2	0.4	0.6	0.8	1
-1	53.19	55.29	56.72	57.48	57.58	57.01	55.78	53.88	51.32	48.09	44.19
-0.8	56.67	58.76	60.19	60.96	61.05	60.49	59.25	57.36	54.79	51.56	47.67
-0.6	59.64	61.73	63.16	63.93	64.02	63.46	62.22	60.33	57.76	54.53	50.64
-0.4	62,10	64,20	65,63	66,39	66,49	65,92	64,69	62,79	60,23	57,00	53,10
-0.2	64.06	66.15	67.58	68.35	68.45	67.88	66.65	64.75	62.18	58.95	55.06
0	65,51	67,61	69,04	69,80	69,90	69,33	68,10	66,20	63,64	60,41	56,51
0.2	66.46	68.55	69.98	70.75	70.85	70.28	69.05	67.15	64.58	61.35	57.46
0.4	66,90	69,00	70,43	71,19	71,29	70,72	69,49	67,59	65,03	61,80	57,90
0.6	66.84	68.93	70.36	71.13	71.22	70.66	69.42	67.53	64.96	61.73	57.84
0.8	66.27	68.36	69.79	70.56	70.65	70.09	68.85	66.96	64.39	61.16	57.27
1	65.19	67.29	68.72	69.48	69.58	69.01	67.78	65.88	63.32	60.09	56.19

Figure 3. Graph of the dependence of the angle of inclination of the guide on the distance between the saw and the brush drum.

Table 4. Influence of values of selected factors based on theoretical research results on fiber separation productivity.

n, rpm	a, mm	α, grad	$v_{\breve{y}p}$, m/sec	Y, %
200	2.0	5	0.16	83
300	1.5	10	0.21	92
400	1.0	10	0.26	96
500	1.5	15	0.31	91
600	3.0	20	0.37	86

4. Conclusions

As a comparative solution comparing, analyzing the extremums of the output parameters, and satisfying all the requirements, the following optimal values of the factors influencing the performance of the fiber separation device were determined:

The number of revolutions of the saw drum—400 rpm;

The distance between the saw and the brush drum—1 mm;

The angle of inclination of the guide is 10 degrees.

Based on the results of the above studies, to compare the theoretical conclusions, the results on fiber separation efficiency were obtained from the regression equations by setting the values of the required factors (Table 4).

Optimal values of the main factors influencing the separation efficiency of the device by mathematical planning methods were determined: the number of revolutions of the saw drum was 400 rpm, the distance between the saw and the brush drum was 1 mm, and the slope angle of the guide was 10 degrees.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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