Scientific Research Publishing

Engineering, 2026, 18(2), 17-29
https://www.scirp.org/journal/eng
ISSN Online: 1947-394X
ISSN Print: 1947-3931

Research on Factors Affecting the Operation of Cotton Cleaning Machine

Akhmad Alokhodjayev*, Mirzaolim Sultanov

Namangan State Technical University, Namangan, Uzbekistan
Email: *obidovavazbek66@gmail.com

How to cite this paper: Alokhodjayev, A. and Sultanov, M. (2026) Research on Factors Affecting the Operation of Cotton Cleaning Machine. *Engineering*, **18**, 17-29.
https://doi.org/10.4236/eng.2026.182002

Received: December 4, 2025
Accepted: January 26, 2026
Published: January 29, 2026

Abstract

The article studies the main factors affecting the pile drum of a cotton cleaning device for removing small impurities. As a result of the study, graphs were constructed, and the influence of the pile diameter and the rotation speed of the pile drum on the overall cleaning efficiency was analyzed in the graphs. As a result, it was found that at low values of the drum rotation speed, the cleaning process is not active enough and the efficiency is relatively low, and as the rotation frequency increases, the effect on the cotton mass increases and the probability of separation of small impurities increases. As a result of the study, the optimal values of the main factors affecting the operation of the device were determined.

Keywords

Cotton, Fine Impurities, Pile Drum, Piles, Rotation Frequency, Slope Angle, Cleaning Zone, Improvement, Cleaning Device, Regression Equation

1. Introduction

As previously mentioned, the goal of improving the cleaning device is to achieve the maximum level of cleaning by successively increasing the degree of cotton sieving. For this, the design consists of four sieving pile drums with piles arranged in rows with alternating piles along the longitudinal direction of the drum surface at an angle in both directions, and the angle of adjacent piles is selected in the opposite direction. The increasing pile inclination angles in successive drums ensure that the cotton is shaken and dragged as it is sieving in each cleaning zone, resulting in effective removal of impurities [1]-[3].

The device has the lowest level of agitation in the cotton raw material entry zone for cleaning, since the first drum has the smallest pile angle, set at 6 degrees. The pile angle of the next drum is higher than 4 degrees, resulting in a pile angle of 18 degrees in the longitudinal direction of the drum at the outlet and a high level of agitation (Figure 1).

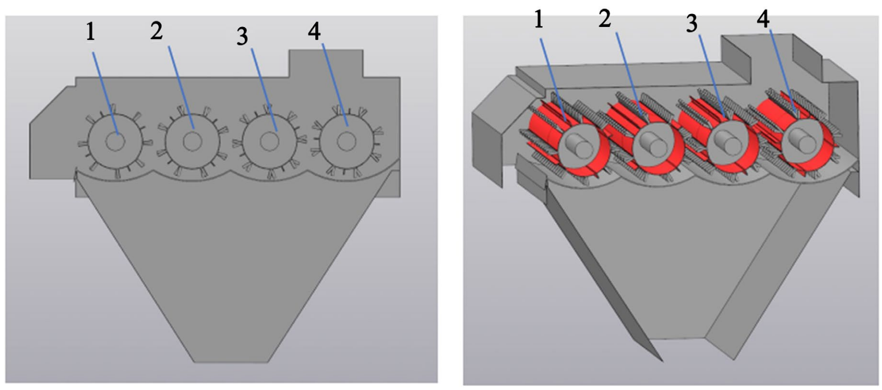

Figure 1. Technological scheme (a) and model (b) of the cleaning device. 1—drum with a pile slope of 60, 2, 3, 4—drums with pile slopes of 10, 14, 180, respectively.

The piles of the drums at the inlet are set at a minimum angle, since the cotton in the entry zone is less agitated, so larger pieces of cotton are easily captured and pulled by the piles at an angle of 6 degrees. The cleaning zone at the outlet remains composed of single cotton slivers. Therefore, to ensure complete capture and drag, the piles are set at an angle of 18 degrees. This allows the piles to capture and drag all cotton pieces over the surface, which significantly increases the efficiency of cleaning cotton raw material from small debris.

The cleaning device, as shown in Figure 1, consists of 4 stacked drums arranged in series:

Table 1. Slope conditions of piles in the dam.

Drum No.	Number of piles on opposite slopes (right + left)	Slope angle (α)
1	150 + 150 (2 ta qatorda 75 dona qoziq)	$\alpha_1 = 6^\circ$
2		$\alpha_2 = 10^\circ$
3		$\alpha_3 = 14^\circ$
4		$\alpha_4 = 18^\circ$

The piles of each subsequent drum are installed at a slope of 4˚ greater than the previous one. The slope angles of adjacent piles are arranged in opposite directions (*i.e.*, in a sinusoidal order). The possible pile slope angles of 4 drums $\alpha_1, \alpha_2, \alpha_3, \alpha_4 = 6^\circ, 10^\circ, 14^\circ, 18^\circ$ were analyzed (Table 1).

$$\alpha_i \in \{6^\circ, 10^\circ, 14^\circ, 18^\circ\} (i = 1, 2, 3, 4)$$

We take the matrix of this set and construct an analysis matrix.

We adopt 2 functional models that are suitable for physical content in Table 2. According to the results, its practical cleaning efficiency and damage results are consistent with the results given in Table 3 as follows:

Table 2. The matrix of individual changes of the piles for improving the cleaning device.

Option	α_1	α_2	α_3	α_4
1	6˚	6˚	6˚	6˚
2	10˚	10˚	10˚	10˚
3	14˚	14˚	14˚	14˚
4	18˚	18˚	18˚	18˚
5	6˚	10˚	14˚	18˚
6	6˚	14˚	10˚	18˚
7	10˚	6˚	14˚	18˚
8	10˚	14˚	6˚	18˚
9	14˚	6˚	10˚	18˚
10	14˚	10˚	6˚	18˚
11	6˚	10˚	18˚	14˚
12	6˚	18˚	10˚	14˚
13	10˚	6˚	18˚	14˚
14	10˚	18˚	6˚	14˚
15	14˚	6˚	18˚	10˚
16	18˚	6˚	14˚	10˚

1 - 4—same angle on drums; 5 - 16—successively increasing or mixed angles on drums.

Table 3. Applied cleaning efficiency and damage results for the study.

No.	$\Sigma\alpha$ (level)	σ (%)	Rct
1	24	37.5	4.2
2	40	44.6	4.4
3	56	48.6	3.8
4	72	45.8	3.4
5	48	61.2	3.1
6	48	53.2	3.2
7	48	49.8	3.4
8	48	51.2	3.4
9	48	49.5	3.3
10	48	50.5	3.1
11	48	52.4	3.1
12	48	51.2	3.4
13	48	52.4	3.2
14	48	51.8	3.4
15	48	50.5	3.3
16	48	52.1	3.4

The efficiency of cleaning cotton raw materials is one of the important technological indicators of the cotton ginning process, which characterizes the degree of separation of foreign impurities, mineral and organic, as well as small particles from the raw materials. High efficiency of the cleaning process allows you to preserve the physical and mechanical properties of cotton fiber and seeds, minimize their damage, and ensure stable product quality indicators.

At the same time, the cleaning efficiency directly depends on the structural design of the cleaning machines, the mode of operation of the working bodies, the optimal selection of technological parameters, and the initial state of the raw materials. At the same time, it is also necessary to study the cases of product damage during the operation of the device (**Figure 2**).

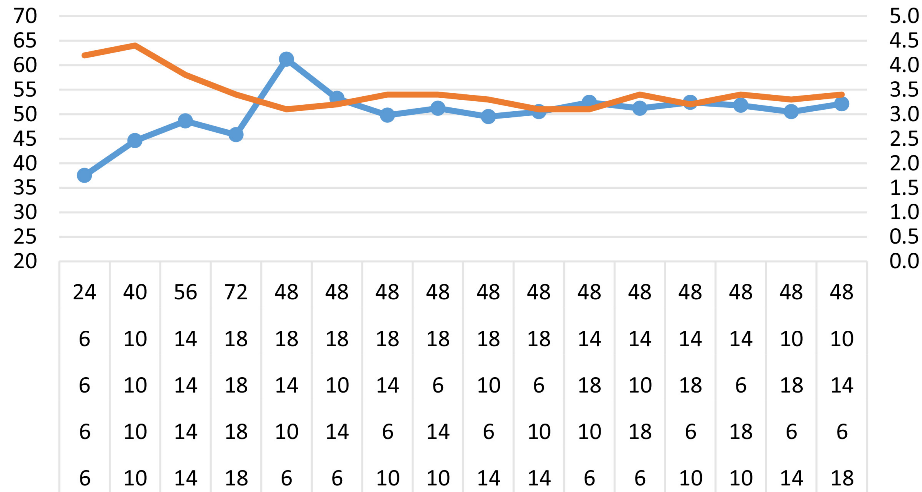

Figure 2. Graphical representation of the effectiveness of manual cleaning and damage results.

From the analysis, it can be seen that the most optimal option is to have 4 consecutive pile drums in the improved cleaning device, and the pile slope angle increases by 4˚ from the inlet to the outlet:

$$\alpha_1 = 6^\circ, \quad \alpha_2 = 10^\circ, \quad \alpha_3 = 14^\circ, \quad \alpha_4 = 18^\circ$$

Also, the direction of the adjacent row of piles was chosen to be opposite.

For the mathematical expression for the sequential change in the angle of the piles, if we take the drum number $i = 1, 2, 3, 4$, the sequence of angles is an arithmetic progression:

$$\alpha_i = \alpha_1 + (i-1)\Delta\alpha$$

Here: $\alpha_1 = 6^\circ$, $\Delta\alpha = 4^\circ$;

So: $\alpha_i = 6 + (i-1)4$

Results: $\alpha_1 = 6^\circ$, $\alpha_2 = 10^\circ$, $\alpha_3 = 14^\circ$, $\alpha_4 = 18^\circ$

For the condition (symbol) of "opposite direction" of adjacent piles, it is convenient to represent the direction by a symbol if the piles are installed in rows on the drum surface in opposite directions. Let us take the index of the row (or "adjacent pile group") as $k = 1, 2, 3, \cdots$:

$$\alpha_{i,k} = s_k \alpha_i,\ s_k = (-1)^{k-1}$$

Here:

- $for\ \ k = 1 \quad s_1 = +1 \gg \alpha_{i,1} = +\alpha_i$
- $for\ \ k = 2 \quad s_1 = -1 \gg \alpha_{i,1} = -\alpha_i$

In the proposed design solution, a gradual increase in the angle of inclination of the piles from the inlet to the outlet $\alpha_i = 6 + (i-1)4$ ensures an increase in the degree of cotton shaking: at the inlet, since the cotton is in a "large piece" state, a small angle facilitates its capture and dragging, while at the outlet, due to the increase in individual pieces (flakes), a large angle enhances complete capture and dragging.

2. Construct a Regression Equation for an Improved Device for Cleaning Cotton from Fine Impurities

Effective separation of fine impurities in the processes of primary and deep cleaning of cotton is one of the most important stages of the technological process. Because it is at this stage that the quality of further processing of cotton raw materials, the degree of mechanical damage to the fibers, and the state of preservation of the seed are directly formed. Practical experience shows that the non-optimal selection of structural and technological parameters in existing cleaning devices leads to a decrease in cleaning efficiency, excessive damage to the seed, and the loss of useful fibers. Therefore, an in-depth analysis of the technological process for an improved device and the determination of optimal operating modes based on mathematical modeling are an urgent scientific and practical task [4]-[6].

The purpose of constructing a regression equation is to determine the quantitative relationship between the main input factors affecting the cleaning process and output indicators, to assess their interaction, and to create a mathematical model that allows optimizing the process. In this study, the most important structural and technological parameters of the device were selected as input factors [7].

Table 4. Selecting levels and ranges of change of the factors under study.

Name and designation of factors	Change levels			Change interval
	−1	0	+1	
X_1—Diameter of piles. mm	10	12	14	0.1
X_2—Distance between posts and mesh. mm	45	50	55	5
X_3—Pile drum(s) rotation frequency. rpm	400	425	450	25

In particular, X_1 is the diameter of the piles (mm), which determines the intensity of the interaction of the working zone with the cotton mass; X_2 is the distance between the piles and the mesh (mm), which determines the conditions for the separation of impurities; X_3 is the rotation frequency of the pile drum (s) (rpm), which directly affects the dynamics of the cleaning process. The selection of the levels and intervals of change of the factors under study is presented in **Table 4**.

These factors were changed in certain ranges, and their levels were measured, coded on the basis of a central non-compositional experiment (**Table 5**).

Table 5. Central non-compositional experience matrix.

No.	**Factors**			x_1x_2	x_1x_3	x_2x_3	x_1^2	x_2^2	x_3^2	Y_1	Y_2	$S_u^2(Y_1)$	$S_u^2(Y_2)$
	x_1	x_2	x_3										
1	+	+	0	+	0	0	+	+	0	37.0	5.20	0.860	0.151
2	+	−	0	−	0	0	+	+	0	40.0	6.20	0.780	0.248
3	−	+	0	−	0	0	+	+	0	41.0	4.10	0.800	0.231
4	−	−	0	+	0	0	+	+	0	46.0	6.70	0.720	0.328
5	+	0	+	0	+	0	+	0	+	42.0	8.20	0.760	0.274
6	+	0	−	0	−	0	+	0	+	50.0	4.80	0.680	0.385
7	−	0	+	0	−	0	+	0	+	48.0	4.50	0.700	0.356
8	−	0	−	0	+	0	+	0	+	56.0	5.10	0.620	0.478
9	0	+	+	0	0	+	0	+	+	35.9	3.69	0.812	0.007
10	0	+	−	0	0	−	0	+	+	52.7	8.90	0.644	0.004
11	0	−	+	0	0	−	0	+	+	40.7	5.53	0.778	0.018
12	0	−	−	0	0	+	0	+	+	50.8	7.90	0.677	0.011
13	0	0	0	0	0	0	0	0	0	42.0	3.80	0.023	0.173
14	0	0	0	0	0	0	0	0	0	43.0	3.40	0.289	0.250
15	0	0	0	0	0	0	0	0	0	41.0	4.10	1.700	0.049

The values (+) (−) and 0 must be used in the matrix.

For accurate and reliable measurement of input factors, measuring instruments suitable for laboratory and production conditions were used, and based on the experimental data obtained, factors characterizing output parameters such as Y_1—cleaning efficiency (%) and Y_2—seed damage level (%).

Based on the experimental results, we search for a second-order regression multifactorial mathematical model [7]-[10]. As a result of this experiment, the following general form of regression model can be obtained:

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

Or, since there are three factors involved in our experiment, the above expression takes the form:

$$Y_R = b_0 + b_1x_1 + b_2x_2 + b_3x_3 + b_{12}x_1x_2 + b_{13}x_1x_3 + b_{23}x_2x_3 + b_{11}x_1^2 + b_{22}x_2^2 + b_{33}x_3^2$$

In the equation:

$b_0, b_1, \cdots$—regression coefficients,

x_1, x_2, x_3—coded value of factors.

$g_1 = 0.2$ $g_2 = 0.17$ $g_5 = 0.13$ $g_3 = 0.13$

$g_6 = 0.06 \qquad g_4 = 0 \qquad g_7 = 0.31$

Y_1—Calculation of models for optimizing cleaning efficiency and determination of regression coefficients:

$$b_0 = \frac{1}{N_s}\sum_{u=1}^{N_s}\overline{Y_{\bar{u}}} = \frac{1}{3}(42+43+41) = 42$$

$$b_i = g_3\sum_{u=1}^{N}x_{iu}\overline{Y_u}$$

$$b_1 = 0.125(37+40+(-41)+(-46)+42+50+(-48)+(-56)) = -2.75$$

$$b_2 = 0.125(37+(-40)+41+(-46)+35.9+52.7+(-40.7)+(-50.8)) = -1.36$$

$$b_3 = 0.125(42+(-50)+48+(-56)+35.9+(-52.7)+40.7+(-50.8)) = -5.36$$

$$b_{ij} = g_4\sum_{u=1}^{N}x_{iu}x_{ju}\overline{Y_u}$$

$$b_{12} = 0.25(37+(-40)+(-41)+46) = 0.50$$

$$b_{13} = 0.25(42+(-50)+(-48)+56) = 0.00$$

$$b_{23} = 0.25(35.9+(-52.7)+(-40.7)+50.8) = -1.68$$

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

$$\sum x_1^2\overline{Y_u} = 37+40+41+46+42+50+48+56 = 360$$

$$\sum x_2^2\overline{Y_u} = 37+40+41+46+35.9+52.7+40.7+50.8 = 344.1$$

$$\sum x_3^2\overline{Y_u} = 42+50+48+56+35.9+52.7+40.7+50.8 = 376.1$$

$$\sum\overline{Y_u} = 37+40+41+46+42+50+48+56+35.9+52.7+40.7+50.8+42+43+41 = 666.1$$

$$\sum_{i=1}^{M}\sum x_i^2\overline{Y_u} = 360+344.1+376.1 = 1080.2$$

$$b_{11} = 0.125\cdot 360 + 0.0625\cdot 1080.2 - 0.166\cdot 666.1 = 1.94$$

$$b_{22} = 0.125\cdot 344.1 + 0.0625\cdot 1080.2 - 0.166\cdot 666.1 = -0.05$$

$$b_{33} = 0.125\cdot 376.1 + 0.0625\cdot 1080.2 - 0.166\cdot 666.1 = 3.95$$

Taking into account the determined regression coefficients, the equation is written:

$$Y_{R1} = 42 - 2.75\cdot X_1 - 1.36\cdot X_2 - 5.36\cdot X_3 + 0.5\cdot X_1\cdot X_2 + 0\cdot X_1\cdot X_3 - 1.68\cdot X_2 * X_3 + 1.94\cdot X_1^2 - 0.05\cdot X_2^2 + 3.95\cdot X_3^2$$

Y_1—Determine the significance of the regression coefficients for optimizing cleaning efficiency, for this, the variance of the output parameter is determined and, on this basis, the variance in determining the regression coefficients is calculated:

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

$$S^2\{\overline{Y}\} = \frac{1}{3-1}\cdot 2.012 = 1.0060$$

$$S^2\{b_0\} = g_1 S^2\{\overline{Y}\} = 0.2\cdot 1.006 = 0.201$$

$$S^2\{b_i\} = g_3 S^2\{\overline{Y}\} = 0.125\cdot 1.006 = 0.1258$$

$$S^2\{b_{ij}\} = g_4 S^2\{\overline{Y}\} = 0.25\cdot 1.006 = 0.2515$$

$$S^2\{b_{ii}\} = g_7 S^2\{\overline{Y}\} = 0.3125\cdot 1.006 = 0.3144$$

The mean square deviation in determining the regression coefficients is found:

$$S\{b_0\} = 0.4486;\quad S\{b_i\} = 0.3546;\quad S\{b_{ij}\} = 0.5015;\quad S\{b_{ii}\} = 0.5607$$

Then, the calculated value of the Student's test is determined using the following equation:

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

$$t_R\{b_0\} = \frac{|42|}{0.4486} = 93.62 \qquad t_R\{b_{12}\} = \frac{|0.5|}{0.5015} = 1$$

$$t_R\{b_1\} = \frac{|2.75|}{0.3546} = 7.76 \qquad t_R\{b_{13}\} = \frac{|0|}{0.5015} = 0$$

$$t_R\{b_2\} = \frac{|1.36|}{0.3546} = 3.84 \qquad t_R\{b_{23}\} = \frac{|1.68|}{0.5015} = 3.35$$

$$t_R\{b_3\} = \frac{|5.36|}{0.3546} = 15.12 \qquad t_R\{b_{11}\} = \frac{|1.94|}{0.5607} = 3.46$$

$$t_R\{b_{22}\} = \frac{|0.05|}{0.5607} = 0.09 \qquad t_R\{b_{33}\} = \frac{|3.95|}{0.5607} = 7.04$$

The table value of the Student's criterion is obtained as follows:

$$t_j\left[P_D = 0.95; f\{S_s^2\} = 3-1 = 2\right] = 2.77$$

It is known that if the calculated value of the criterion is less than the table value, then this coefficient is not significant and is removed from the equation. In the studies, it was found that the coefficient b_{12}, b_{13} b_{22} is insignificant for the parameters under study, and we remove the insignificant coefficients, and rewrite the equation with significant coefficients:

$$Y_{R1} = 42 - 2.75\cdot X_1 - 1.36\cdot X_2 - 5.36\cdot X_3 - 1.68\cdot X_2\cdot X_3 + 1.94\cdot X_1^2 + 3.95\cdot X_3^2$$

Obtained Y_1-Checking the adequacy of the equations for the efficiency of cleaning. The check is carried out using the Fisher criterion. The calculated value of the Fisher criterion is determined. The calculated value of the factor being optimized is calculated by substituting the coded values of all columns of the matrix (−1, 0 and +1) of the **Table 5** Y_1 equation. The values are obtained row by row, not column by column. The calculation for the Y formula is as follows, and the calculation results are given in **Table 6**.

Table 6. Calculation results of the values encoded in the equation for adequate dispersion.

No.	Y_1-Cleaning efficiency			
	Y_{1i}	Y_{1i}	$(Y_{1i} - Y_{R1i})$	$(Y_{1i} - Y_{R1i})^2$
1	37	39.83	2.83	8.01
2	40	42.55	2.55	6.50
3	41	45.33	4.33	18.75
4	46	48.05	2.05	4.20
5	42	39.78	−2.22	4.93
6	50	50.5	0.50	0.25
7	48	45.28	−2.72	7.40
8	56	56	0.00	0.00
9	35.9	37.55	1.65	2.72
10	52.7	51.63	−1.07	1.14
11	40.7	43.63	2.93	8.58
12	50.8	50.99	0.19	0.04

In order to check whether the above-mentioned regression mathematical model is adequate or not, we will use the calculated value of Fisher's criterion to determine.

$$F_R = \frac{S_{nad}^2\{Y\}}{S^2\{\overline{Y}\}}$$

Here:

$$S^2\{\overline{Y_1}\} = \frac{\sum_{u=1}^{N} S^2\{Y\}}{N_s - 1}$$

$$S_{nad}^2\{Y\} = \frac{\sum_{u=1}^{N-N_s+1}\left(Y_{Ru} - \overline{Y}_u\right)^2}{N - N_{k.en} - \left(N_s - 1\right)^2};$$

$$N - N_{k.en} - \left(N_s - 1\right)^2 = 15 - 7 - \left(3 - 1\right)^2 = 4$$

$$N - N_s + 1 = 15 - 3 + 1 = 13$$

Calculate the resulting Y_1-encoded values by substituting them into the equation for the cleaning efficiency:

$$S^2\{\overline{Y_1}\} = \frac{\sum_{u=1}^{N} S^2\{Y\}}{N_s - 1} = \frac{2.012}{3-1} = 1.006$$

$$Y_{R1} = 42 - 2.75 \cdot X_1 - 1.36 \cdot X_2 - 5.36 \cdot X_3 - 1.68 \cdot X_2 \cdot X_3 + 1.94 \cdot X_1^2 + 3.95 \cdot X_3^2$$

$$Y_{R1.1} = 42 - 2.75 - 1.36 + 1.94 = 39.83$$

$$Y_{R1.2} = 42 - 2.75 + 1.36 + 1.94 = 42.55$$

$$Y_{R1.3} = 42 + 2.75 - 1.36 + 1.94 = 45.33$$

$$Y_{R1.4} = 42 - 2.75 - 1.36 + 1.94 = 48.05$$

$$Y_{R1.5} = 42 - 2.75 - 5.36 + 1.94 + 3.95 = 39.78$$

$$Y_{R1.6} = 42 - 2.75 + 5.36 + 1.94 + 3.95 = 50.50$$

$$Y_{R1.7} = 42 + 2.75 - 5.36 + 1.94 + 3.95 = 45.28$$

$$Y_{R1.8} = 42 + 2.75 + 5.36 + 1.94 + 3.95 + 0.8 = 56$$

$$Y_{R1.9} = 42 - 1.36 - 5.36 + 3.95 = 37.55$$

$$Y_{R1.10} = 42 - 1.36 + 5.36 + 3.95 = 51.63$$

$$Y_{R1.11} = 42 + 1.36 - 5.36 + 3.95 = 43.63$$

$$Y_{R1.12} = 42 + 1.36 + 5.36 + 3.95 = 50.99$$

$$\sum_{u=1}^{N-N_s+1} \left(Y_{R1.u} - \bar{Y}_{1u}\right)^2 = 62.53$$

$$S_{nad}^2\left\{Y_1\right\} = \frac{62.53}{4} = 15.63$$

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

$$F_{R1} = \frac{S_{nad}^2\left\{Y\right\}}{S^2\left\{\bar{Y}\right\}} = \frac{15.63}{1.006} = 15.54$$

$$F_j\left[P_D = 0.95; f\left\{S_{nad}^2\left\{Y\right\}\right\} = 15 - 9 - (3-1) = 4; f\left\{S_u^2\right\} = 3 - 1 = 2\right] = 19.25$$

$$F_{R1} = 15.54 < 19.25 = F_j$$

Therefore, the resulting regression mathematical models represent the studied process with sufficient accuracy.

3. Result

Since the equation constructed to determine the characteristics of the output parameter for the study is three-dimensional, one of the input factors in the analysis is assumed to be $X_i = 0$ (central position), and we construct a two-dimensional graph by transforming the models into 3 equations.

$$Y_{R1} = 42 - 2.75 \cdot X_1 - 1.36 \cdot X_2 - 5.36 \cdot X_3 - 1.68 \cdot X_2 \cdot X_3 + 1.94 \cdot X_1^2 + 3.95 \cdot X_3^2$$

The graph in **Figure 3** shows the combined effect of the pile diameter and the distance between the piles and the mesh on the overall cleaning efficiency. Analysis of the graph shows that as the pile diameter increases from small to medium values, the cleaning efficiency steadily increases. This is explained by the more active movement of the cotton mass in the working zone and the improvement of the separation conditions of fine impurities. When the distance parameter is too small, the cotton becomes denser, which negatively affects the free separation of impurities. On the contrary, when the distance is too large, the cleaning intensity decreases. The graph shows that the optimal region is formed in the middle range, and it is in this area that the overall cleaning efficiency reaches maximum values. Thus, this graph confirms that a balanced selection of design parameters is an important factor in increasing the efficiency of the cleaning process.

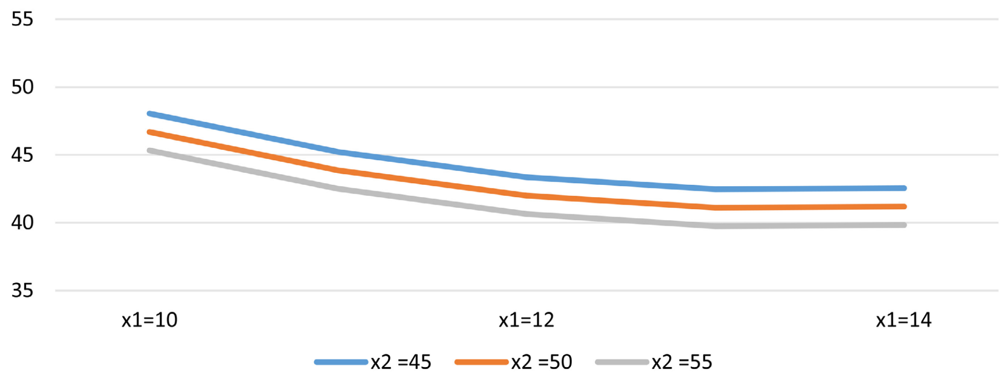

Figure 3. The effect of pile diameter and distance between piles and mesh on cleaning efficiency.

The graph in **Figure 4** shows the interaction between the distance between the pegs and the mesh and the drum rotation speed. According to the graph analysis, when the distance parameter is in the optimal range, increasing the rotation frequency leads to a significant increase in cleaning efficiency. If the distance is too small, the high rotation frequency causes excessive compaction of the cotton, limiting the cleaning efficiency. On the contrary, when the distance is too large, no matter how much the rotation frequency is increased, the cleaning efficiency does not increase as expected. It is observed that a clear optimal zone is formed in the graph, and the technological capabilities of the device are fully manifested in this area. This indicates that the mutual compatibility of the distance and rotation frequency is one of the main factors determining the efficiency of the cleaning process.

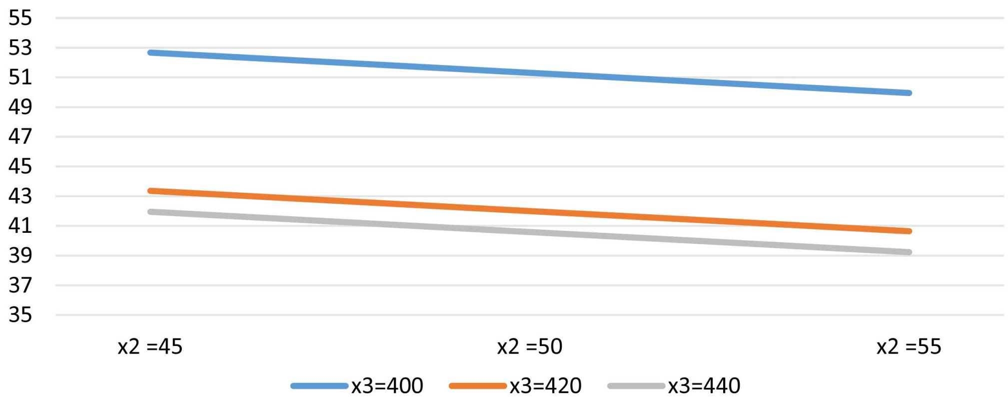

Figure 4. The effect of the distance between the pegs and the mesh screen and the drum rotation speed on the cleaning efficiency.

The graph in **Figure 5** analyzes the effect of the pile diameter and the pile drum rotation speed on the overall cleaning efficiency. The graph shows that at low values of the drum rotation speed, the cleaning process is not active enough and the efficiency is relatively low. As the rotation frequency increases, the impact on the cotton mass increases, and the likelihood of separation of small impurities increases. However, when the rotation frequency is above a certain limit, the growth rate of cleaning efficiency slows down, which indicates that the process is approaching a saturated state. When the pile diameter is at medium values, the positive effect of the rotation frequency is more pronounced. As a result, the graph shows the existence of an optimal operating mode and proves that maximum cleaning efficiency can be achieved by choosing the drum speed and pile diameter together.

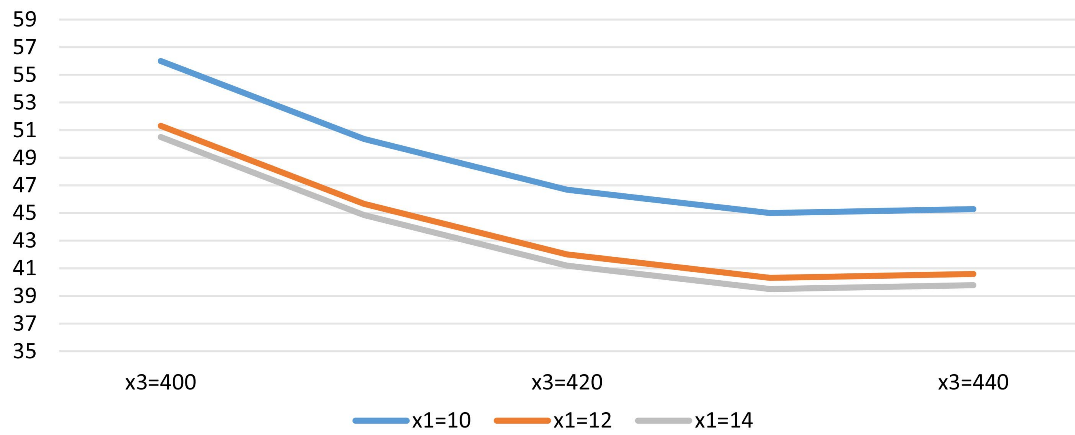

Figure 5. The effect of pile diameter and drum rotation speed on cleaning efficiency.

4. Conclusions

As a result of the regression equation and the graphical analysis based on it, the optimal quantitative ranges of the main factors affecting the process of cleaning cotton from small impurities were determined, and the possibility of predicting the cleaning efficiency was created. According to the results of the study, when the pile diameter is X_1 = 12 mm, the overall cleaning efficiency approaches maximum values, and in this case the efficiency is 52% - 56%. When the distance between the piles and the mesh is selected in the range X_2 = 48 - 52 mm, the conditions for the separation of impurities improve, and the efficiency increases by an average of 4% - 6%.

When the rotation speed of the pile drum is in the range X_3 = 420 - 440 rpm, the intensity of the cleaning process is optimal, and the cleaning efficiency reaches the highest values. A rotation frequency below 400 rpm reduces the efficiency by 6% - 8%, while a rotation frequency above 450 rpm leads to stabilization of the process without a sharp increase in efficiency.

It was found that the overall cleaning efficiency predicted by the regression model in the optimal combination of three factors is formed within 55% - 56%, and the deviation compared to experimental values does not exceed ±2% - 3%.

This indicates that the developed regression model is sufficiently adequate and reliable. As a result, the numerical parameters determined for the improved device allow for a sustainable increase in cleaning efficiency and optimization of the technological process by applying it in production conditions.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Zikriyoev, E.Z. and Mekhnat, T. (1999) Primary Processing of Raw Cotton. 84-86.

[2] Yakubov, B.N. (1995) Improving the Process of Cleaning Raw Cotton from Foreign Impurities in Saw-Tooth Cleaners in Order to Reduce the Loss of Cotton Fiber Mass. TITLP, 156 p.

[3] Rasulov, R.K. (2008) Justification of the Parameters of the Serrated-Grate System of the Cotton Cleaner for Removing Large Debris. 130 p.

[4] Obidov, A., Akhmadalieva, D. and Otaqo'ziyev, D. (2024) Development of an Experimental Construction of a Device for Cleaning from Small Piece of Contaminants. *Scientific and Technical Journal of Namangan Institute of Engineering and Technology*, **9**, 202-207.

[5] Avazbek, O., Dilnoza, K. and Nurillo, K. (2024) Study of Mesh Surface Deformation during Cleaning of Cotton from Fine Impurities. *Republican Scientific and Practical Conference on Innovative Methods of Using Energy and Resource-Saving Modern Technologies to Ensure Product Quality Based on International Standards. NamIET* 2024, 428-432.

[6] Kamalov, N.Z. and Makhmatkulov, C.M. (1991) Methods of Optimization of Separation Processes. *Dep. in UzNIINTI No.* 1442-*Uz*, 28 p.

[7] Buriev, R.A., Jumaniyazov, K.J. and Salimov, A.M. (2016) Determination of Cotton Quality. "Uzpakhtasanoateksport" Holding Company "Cotton Scientific Center" Joint Stock Company, 144 p.

[8] Sevastyanov, A.G. and Sevastyanov, P.A. (1991) Optimization of Mechanical and Technological Processes in the Textile Industry. Legprombytizdat, 255 p.

[9] Norboeva, D.V. and Rosulov, R.K. (2019) Researching the Problems of Cotton Decontamination. *FarPI Scientific and Technical Journal*, **23**, 162-165.

[10] Juraev, A., *et al.* (2012) The Grate of the Fibrous Material Cleaner. Patent of the Republic of Uzbekistan FAP 00769, N10.