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Research of the Process of Cleaning of Small Litter and Dust During Transportation of Raw Cotton

Salimov Otabek Alisherovich, Mardonov Botir Mardonovich, Madumarov Ilxom Dedaxanovich, Salimov Alisher Mashrabovich
Tashkent Institute of Textile and Light Industry, UZBEKISTAN

Abstract - The article studies the process of cleaning small litter and dust during the transportation of raw cotton. A system of installations for the experimental study of the process of cleaning raw cotton from dust and small particles of litter has been developed.
A regression relationship between the cleaning efficiency of raw cotton and the initial moisture content and clogging was obtained for various conveyor lengths. For the maximum and minimum lengths of the conveyor, the ranges of change in the cleaning efficiency of the installation system are determined. Based on the results of experiments and analysis of the results of their static processing, it was established that it is possible to reduce the amount of defects and contamination of hoppy fiber through the practical application of the recommended system of cleaning plants in the process of transporting raw cotton.

Keywords: Raw cotton, cotton transportation, fine litter, peg auger, mesh surface, dust, static studies, cotton fiber

I. Introduction

At all stages of primary processing of cotton, a large amount of small impurities in the form of dust is released, which pollutes production facilities and atmospheric air., worsens the working conditions of workers and employees, can cause their diseases [1].

The issue of dedusting cotton ginning enterprises is of paramount importance in connection with the increase in the harvesting of machine-picked cotton [2].

With the introduction of machine cotton picking, it is necessary to improve the technological process of receiving, storing and processing cotton at cotton ginning enterprises, as well as to improve dust removal and air purification systems[3,4].

One of the main disadvantages of modern dust collection systems is the loss of fibrous material and the release of dust into the atmosphere. Atmospheric pollution with dust SanPiN 0246-08 in the settlements of the Republic of Uzbekistan, the concentration of dust emitted by each enterprise is checked on the basis of sanitary standards and rules for the protection of atmospheric air [5].

There are several (calorimetric, indicating, optical, electrostatic or gravimetric, etc.) methods for determining the concentration of dust emitted by cotton gins, and the most common of these is the standard method used in the cotton gin industry.

In the technological process, the used air is divided into two types: technological and aspiration. The first comes from technological machines and equipment, and the second comes from the dedusting system.

The amount of air used in the cotton dryer is 6-8 m^3/s, and the amount of dust in the air used is 1700-2000 mg/m^3 [6].

Together with the dryer-dried cotton and the used drying agent, small impurities and dust particles are emitted into the air. In drying plants, the amount of dust emitted together with the air-treated drying agent exceeds the norm [7].

Therefore, experiments were carried out to study the issues of cleaning fine litter and dust released during the transportation of dried cotton in dryers.

II. Materials and methods. It has been established that the equipment for transporting cotton used at ginneries shows that, due to the low efficiency of cleaning cotton from fine litter and dust, it leads to a decrease in the quality of the product produced and an increase in the amount of dust in the air.

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The reason for this is the high humidity and weediness during the collection and storage of raw cotton. During the storage of cotton, it was studied that various fungi in its composition cause self-heating and rotting of cotton due to the decomposition of cotton fiber and seed components [8,9].

When drying cotton with a high moisture content in dryers, the moisture prevents the fine dust from separating from the raw cotton. Coarse dust is separated even at high humidity and settles without having time to dissipate in the building.

It has been established that when drying self-heating raw cotton in dryers, due to the drying of small impurities and fungi, it passes from the airgel state to the aerosol state and causes an increase in the amount of dust in the air [10].

To reduce dust emissions from cotton dryers, a part of the rotating drum of the dryer and the shaft is sealed with heat-resistant rubber, and the place where cotton is transferred from the dryer to the transport device is covered with material.

Along with the convenience of using the pneumatic transport system for transporting raw cotton in dryers, the cleaning efficiency of the separator contained in it is low, and the dust content of the air is more than normal, despite the use of a two-stage dedusting system.

When using a conveyor belt to transport cotton after the dryer, it releases fine dust particles and various substances into the air along with the cotton, and causes environmental degradation.

Therefore, it was noted that it is necessary to study the issue of transporting dried cotton after the dryer, the use of screw conveyors for transportation and cleaning from small litter and dust [11]. At present, the processes of cleaning raw cotton from small litter and dust, which adversely affect the quality of the fiber during the transportation of cotton on screw conveyors, have not been sufficiently studied.

A system of installations has been developed to study the process of cleaning dust and small particles of litter that are emitted together with dried raw cotton in dryers at cotton ginning plants (Fig. 1).

Figure 1. A system of devices for removing particles of fine litter and dust from raw cotton at ginneries. 1-Device for drying cotton (2SB-10); 2-device for cleaning fine dirt and dust from cotton; 3 and 5 pipes; 4-fan (VTs-10M); 6-device for collecting dust (TsS-6).

The installation system consists of a drying drum 2SB-10 (1), a device for transporting and cleaning cotton from fine litter and dust ShKh (2), air ducts (3.5), a VTs-10M fan (4) and a dust collector TsS-6 (6).

For the purpose of transportation and cleaning of raw cotton after the dryer, the ShKh cotton auger was modernized. The device for transporting and cleaning raw cotton was equipped with an auger with pegs and a mesh surface.

In experimental tests, the quality indicators of cotton and fiber were determined according to standards (O'zDSt 592: 2008, O'zDSt 644: 2008, O'zDSt 632: 2010, O'zDSt 634: 2010).

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Experiments were carried out on cotton breeding Andijan 35, I grade 2 class and IV grade 1 class industrial grades. In accordance with the established procedure, the moisture content of raw cotton was determined on the VHS-M1 device and the contamination in the LKM laboratory device [12].

A rheometer device was used to determine the amount of small particles of litter and dust emitted into the atmosphere from cotton ginning equipment at ginneries. The scheme for determining the dust concentration is shown in Figure 2.

The experiments were carried out as follows: a rheometer was prepared and an AFA filter was selected. This filter retains very fine dust particles well, has low aerodynamic resistance, which makes it possible to pass air in large volumes (up to 100 l / min). In addition, the AFA filter has the ability to repel moisture.

The amount of air that has passed through the filter is measured with a rotameter or rheometer and a Migunov aspirator [13].

The rotameter is a glass tube divided into cone-shaped tables with a hollow ring inside. The amount of air passing through the rotameter is determined by the passport of this device, depending on the height of the hollow ring.

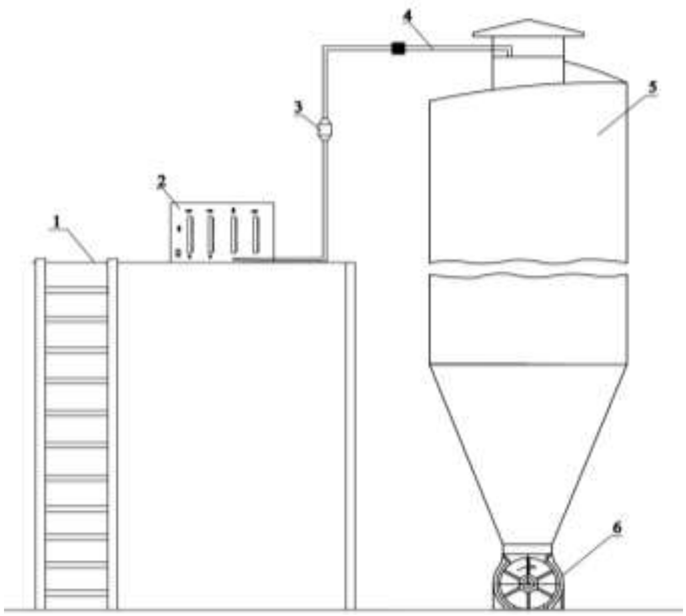

Figure 2. Scheme for determining the concentration of dust.
1-area; 2-rheometer; 3-pipe; 4-air intake tube; 5-device for catching dust TsS-6.

The Migunov aspirator is a compact device consisting of four small rotameters and a pump, which makes it very convenient for measuring dust concentrations in departmental environments. The rheometer device is equipped with four diaphragms that allow you to change the amount of intake air. The scheme of the rheometer is shown in Figure-3.

The principle of its operation is as follows: a certain amount of dusty air is passed through a pre-weighed filter. After the passage of air, the weight of the filter is reweighed. The concentration of dust emitted into the atmosphere is determined by the ratio of the difference in the weight of the filters (mg) to the volume of air sucked through this filter. This value is measured in mg/m^3.

The pre-weighted AFA filter is placed in the nozzle (3) and then one end of the hose is connected to the air sampling tube (4) and the other end to the rheometer (2) Fig. 2.

The prepared experimental equipment is used for 5 minutes by placing the tube vertically in the air channel from the dust collector to the atmosphere, turning on the stopwatch and rheometer at the same time. Then, having stopped both, the AFA filter is selected and put in a paper bag so that the dust in it does not spill out.

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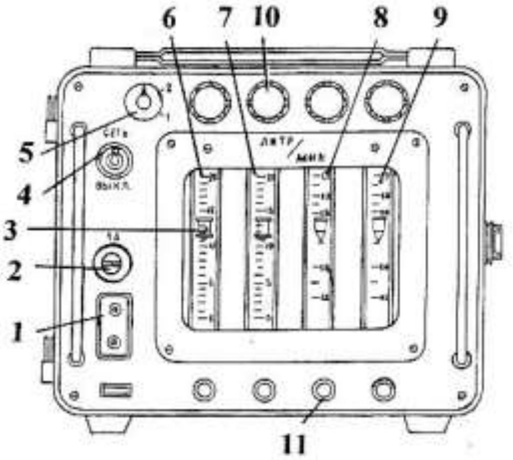

Figure 3. Rheometer scheme.

1 - input block; 2 - drive; 3 - rotameter float; 4 - button to turn on and off the aspirator; 5 - exhaust valve; 6, 7 - rotameters for determining the amount of dust; 8, 9 - rotameters for determining air pollution; 10 - rotameter screw handle; 11 - input device.

The filter is weighed on an analytical balance and its weight is recorded. If the weight of the filter before the experiment is equal to g_1, and the weight after the experiment is determined as g_2, then the concentration of dust in the air is as follows.

$$C = \frac{(g_1 - g_2) \cdot 1000}{Q \cdot T \cdot k}, \quad mg/m^3 \qquad (1)$$

Where: Q – air volume (l/min), T – time (minutes), k – air volume coefficient (k=0.91)

On the basis of experimental tests, statistical data processing was carried out in order to assess the dependence of the efficiency of cleaning the system of devices from small particles of litter and dust in the transportation device, cleaning raw cotton, depending on the degree of contamination and moisture content of raw cotton and the length of the device. Tables 1 and 2 present the plans of two parallel experiments, the values of the input factors and the intervals for their change.

Table 3 shows the complete matrix of results of 2^3 full factor trials for cleaning raw cotton (in percent) obtained in the experiment [14].

Experiment-1 Table-1

№	Naming	The code	Level of change			Change interval
			- 1	0	+ 1	
1.	Device length, m	X_1	2	5	8	3
2.	Infestation of raw cotton, %	X_2	2	12	22	10
3.	Moisture content of raw cotton, %	X_3	7	8.5	10	1.5

Experiment-2 Table-2

№	Naming	The code	Level of change			Change interval
			- 1	0	+ 1	
1.	Device length, m	X_1	2	3	4	1
2.	Infestation of raw cotton, %	X_2	2	12	22	10
3.	Moisture content of raw cotton, %	X_3	7	8.5	10	1.5

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Standard matrix of full factor experiments 2^3

Table-3

№	Range of input factors			y_{1i} - device system cleaning efficiency in 1st parallel experiment, (%) y_{2i} - output factors 2nd parallel experiment						
				$y_i = (y_{1i} + y_{2i})/2$, $S_i = [(y_{1i} - y_i)^2 + (y_{2i} - y_i)^2]$						
	X1	X2	X3	y_{1i}	y_{2i}	y_i	S_i	y_i	$\hat{y}_i$	R_i
1	-	-	-	76.4	74.1	75.25	2.64	75.25	72.75	3.32
2	+	-	-	84.4	81.6	83.00	3.92.	83.00	82.08	1.10
3	-	+	-	78.5	72.2	75.35	19.84	75.35	78.44	4.11
4	+	+	-	89.6	85.3	87.45	9.24	87.45	87.77	0.37
5	-	-	+	69.5	66.7	68.10	3.92	68.10	69.46	2.00
6	+	-	+	79.3	74.2	76.75	13.05	76.75	78.82	2.67
7	-	+	+	77.8	76.4	77.10	0.49	77.10	75.15	2.53
8	+	+	+	86.4	85.5	85.95	0.40	85.95	84.48	1.70

Statistical processing of the experimental results for each answer was carried out in the following order:

1) In one category, they check the reproducibility of the variance characterizing the S_u^2 distribution of their results in the same number m of parallel experiments.

$$S_u^2 = \frac{\sum_{p=1}^{m}(y_{up} - y_u)^2}{m-1} \qquad (4)$$

In this case, u - is the serial number of option ($u = 1.2..N$), $p = 1.2.3..m$ - is the serial number of parallel experiments, is the number of parallel experiments, m - number of parallel experiments, $y_u = \frac{1}{m}\sum_{p=1}^{m} y_{up}$ - average value of parallel experiments. The results S_u^2 are entered in the table wa and these statistics are calculated for both cases.

$$G = \frac{S_{u(\max)}^2}{\sum_{u=1}^{N} S_u^2} \qquad (5)$$

Here $S_{u(\max)}^2$ - is the maximum value of the variance in parallel experiments.

A) (4) the value was calculated by the formula.

$$S_u^2 = [(y_{u1} - y_u)^2 + (y_{2u} - y_u)^2] \ ,$$

Accept $S_{u(\max)}^2 = S_6^2 = 19.845$, $\sum_{u=1}^{8} S_u^2 = 53.4755$

calculate this statistic by calculating.

$$G = \frac{S_{u(\max)}^2}{\sum_{u=1}^{N} S_u^2} = 0.371$$

2) Checking the variance in two parallel experiments based on the Cochran test, G_{α,k_1,k_2} - values are taken from tabular data, α - significant level ($0 < \alpha < 1$), $k_1 = N$, $k_2 = m - 1$ - number of degrees of freedom. How we look $\alpha = 0.05$, $m = 3$, $N = 8$, $G_{\alpha,k_1,k_2} = G_{0.05,8,2} = 0.52$,

If the following inequality holds

$$G < G_{\alpha,k_1,k_2} \qquad (6)$$

Cochran's criterion would be appropriate. In this case $G = 0.38$ the inequality (3) is satisfied, therefore, the Cochran criterion is satisfied, and the variance is small, which ensures that parallel experiments are in the same category. These equations can be used because uniformity of dispersion is achieved in all variants m of the parallel experiment.

$$S_y^2 = \frac{1}{N}\sum_{u=1}^{N} S_u^2 = 6.68$$

3) Let's make a regression equation.

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

Regression coefficients are calculated using the following formulas.

$$b_0 = \frac{1}{N}\sum_{u=1}^{N} y_u\,,\; b_i = \frac{1}{N}\sum_{u=1}^{N} X_{iu} y_u\,,\; b_{ij} = \frac{1}{N}\sum_{u=1}^{N} X_{iu} X_{ju} y_u\,,\; b_{ijk} = \frac{1}{N}\sum_{u=1}^{N} X_{iu} X_{ju} X_{ku} y_u$$

b_0=78.619 b_1=4.669 b_2=2.844 b_3= 1.644 b_{12}= 0.569
b_{13}= 0.293 b_{23}=1.706 b_{123}= 0.519

So the regression equation looks like this.

$$y = 78.618+4.669X_1+2.844X_2 - 1.644X_3+0.569X_1 X_2- 0.294X_1X_3 +1.706X_2X_3-0.519X_1X_2X_3 \qquad (7)$$

4) Checking the significance of the regression coefficients based on Student's t-test. For all regression coefficients with the same confidence interval Δb they are calculated using the following formula.

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

$t_{\alpha,k}$ - Student's criteria, α - level, $k = N(m-1)$ - number of degrees of freedom.

If the regression coefficient is above the confidence interval, then the coefficients are significant.

$$|b_0| \ge \Delta b\,,\; |b_i| \ge \Delta b\,,\; |b_{ij}| \ge \Delta b\,,\; |b_{ijk}| \ge \Delta b$$

Assuming $t_{0.05,16} = 2.16$, we calculate the confidence interval $\Delta b = t_{\alpha,k}\frac{S_y}{\sqrt{N}} = 2.111$,

In the regression equation, according to the inequality b_0, b_1 above, the coefficients are considered significant, we write the regression equation with these coefficients.

$$\bar{y} = 78.62+4.67X_1+2.84X_2 \qquad (8)$$

5. We evaluate the adequacy of the model, (5) the omission of some insignificant coefficients in the regression equation creates a certain degree of freedom, and it is necessary to check the adequacy of the model. The adequacy check consists in comparing the experimental values of the output parameter y with the calculated values of the input factors at different levels and determining their difference in percent using the formula.

$$R_u = 100\left|\frac{\hat{y}_u - y_u}{y_u}\right|$$

At the same time, we have

R_1 = 5.507 R_2 = 3.079 R_3 = 1.916 R_4 =1.508
R_5 = 4.414 R_6= 4.813 R_7= 0.397 R_8 = 0.211

Since the error is higher than 5%, we take into account the coefficient b_3. Then the regression equation will look like this.

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$$\bar{y} = 78.619+4.668X_1+2.84X_2 - 1.644X_3$$

The calculation results presented in the table show that the maximum error does not exceed 4.1%. Thus, the adequacy of the equation is ensured by 95.9%.

6. Fisher Linear Regression

$$\bar{y} = 78.619+4.668X_1+2.84X_2 - 1.644X_3 \qquad (9)$$

to check if the model fits, we determine the residual variance with this formula

$$S_{oc}^2 = \frac{\sum_{u=1}^{8}(y_u - \hat{y}_u)^2}{N-k-1} = 7.18$$

where: $\bar{y}_u$ - the value of the linear regression indicator calculated by the formula (9), y_u-actual (table 2) value of the indicator, N - number of options, k- number of factors.

Let's see the statistics

$$F = \frac{S_{oc}^2}{S_y^2} = 1.054$$

If this inequality $F < F_{\alpha,k_1,k_2}$ is satisfied by the Fisher criterion, then the adequacy hypothesis is satisfied. Here α - is the significance level, $k_1 = N-k-1 = 4$, $k_2 = N(m-1) = 16$, from the table we find $F_{\alpha,k_1,k_2} = 3.01$, since the inequality $F < F_{\alpha,k_1,k_2}$ is satisfied, then the Fisher criterion takes place.

Thus, it is recommended to use linear regression.

7. To use the regression equation in practice, with different values of the input parameters, it will be possible to build a surface $\bar{y} = F(X_1, X_2, X_3) = const$ and determine the maximum and minimum points of the function $\bar{y}$. Solving such a problem usually leads to an optimization problem. The optimization problem is complex and several methods can be used to solve it. In technology, such questions are of particular importance, but it is very difficult to obtain direct solutions to them. For fixed values of the first factor X_1 (device length, m) from the regression equation (10) obtained in the linear form above

$$\bar{y} = 78.619+4.668X_1+2.84X_2 - 1.644X_3 \qquad (11)$$

Based on the analysis of straight lines formed by the intersection of the plane $X_1 = const = X_{10}$ with the plane (11), it is possible to determine the maximum and minimum values of the output factor $\bar{y}$.

In this case, fixing the value of the first factor X_1 (device length, m) in formula (11), we can express the second factor X_2 (contamination of raw cotton,%) through the third factor X_3 (moisture content of raw cotton) and get at $\bar{y} = y_0$ families of straight lines in the plane (X_3, X_2) $(-1 < X_3 < 1, -1 < X_2 < 1)$

For example, a family of such lines at $X_1 = 1$ (device length maximum $l = 8м$) is shown in Fig.4. where the cleansing effect is realized within $78.8 < y_0 < 87.8$ and with a known value of one factor, for example X_3, the value of the other is determined from the corresponding straight line. Thus, the value of small impurities (in percent) is not less than 78.8% and not more than 87.8%. Figure 5 shows the graphs of the relationship between the second factor (contamination) and the third factor (humidity) for the value of the first factor $X_1 = -1$ (at the minimum length of the device $L = 2м$). In this case, the cleaning of the raw material from small litter is realized within $69.5 < y_0 < 78.5$.

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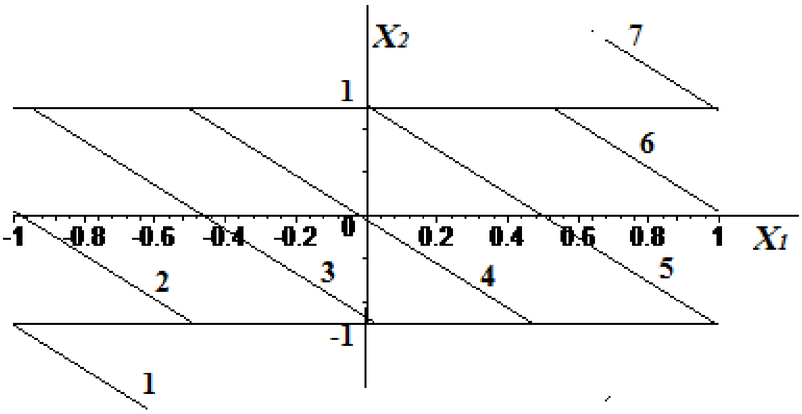

Fig.4. Graphs of the relationship between the second (contamination of raw cotton) and third (moisture content of raw cotton,%) factors for $X_1 = 1$ (maximum length of the device $L = 8м$) and fixed values of cleaning from small litter 3 , at which the cleaning of raw cotton is carried out within $78.8 < y_0 < 87.8$: $1 - y_0 = 78.8$, $2 - y_0 = 80$, $3 - y_0 = 81.5$, $4 - y_0 = 83$, $5 - y_0 = 84.5$, $6 - y_0 = 86$, $7 - y_0 = 87.8$

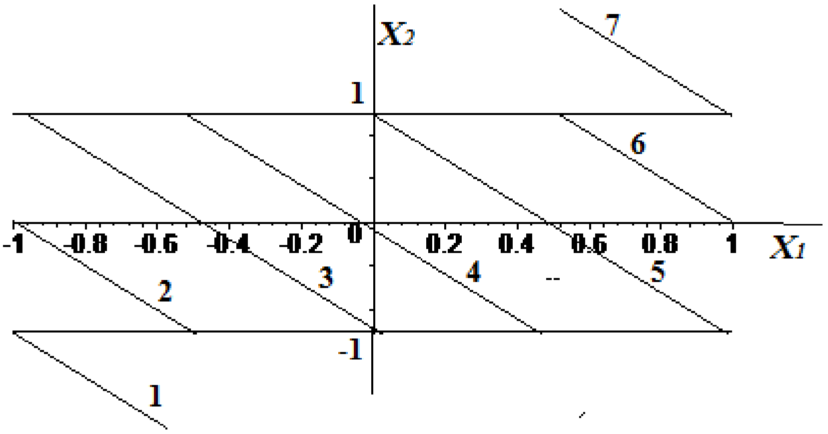

Fig. 5. Graphs of the relationship between the second (contamination of raw cotton) and third (moisture content of raw cotton,%) factors for $X_1 = -1$ (minimum length of the device $L = 2м$) and fixed values of cleaning from small litter y_0 , at which the cleaning of raw cotton is carried out within $69.58 < y_0 < 78.5$: $1 - y_0 = 69.5$, $2 - y_0 = 71$, $3 - y_0 = 72.5$, $4 - y_0 = 74$, $5 - y_0 = 75.5$, $6 - y_0 = 77$, $7 - y_0 = 78.5$

Conclusions. Based on the results of experiments carried out at a cotton gin plant on a system of devices for transporting and cleaning raw cotton and dedusting, the following conclusions are drawn.

1) The results of experiments carried out at a cotton gin plant in the system of used air purification devices showed that it is possible to reduce the proportion of fine particles of litter and dust during the transportation and cleaning of raw cotton.

2) The cleaning effect of the system of devices for transporting and cleaning cotton from particles of small litter and dust is determined, depending on the contamination and moisture content of raw cotton.

3) Statistical processing of experimental data was carried out, a regression relationship was obtained between the efficiency of cleaning raw materials and the initial moisture content, contamination of raw cotton at various values of the length of the device. An analysis of the regression dependence at the maximum and minimum values of the device is presented, with a known initial weediness, rational values of humidity are established at which the maximum selection of small litter from raw cotton is realized

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Referrences

1. R.Usmonov “Paxta tozalash sanoatiida mehnat muhofazasi”. T.: “Mehnat” -2000.
2. A.M.Salimov, F.N.Sirojiddinov "Technology and equipment for primary cotton processing" T.: 2018.
3. Paxtani qabul qilish va saqlash bo‘yicha yo‘riqnoma T.: 2017.
4. Sabirov I., Parpiyev A., Salimov A., Kasimov O., Salimov O. Patent№ FAP 02074 Paxta terish mashinasi. 30.09.2022
5. R.Bo‘riyev, Q.Jumaniyazov, A.Salimov “Mexnatni muhofaza qilish va texnika xavsizligi”. T.:, «Paxtasanoat ilmiy markazi» AJ - 2015.
6. Zikriyoyev E. Pervichnaya pererabotka xlopka-sirsa. Tashkent, 1999. -255 s.
7. Paxtani dastlabki ishlashning muvofiqlashtirilgan texnologiyasi (PDI 70 -2017), Toshkent “Paxtasanoat ilmiy markazi” AJ - Toshkent, 2019 y. 45 b.
8. Salimov A.M. “Modelling of technological conditions of storage of cotton-raw”. International Scientific Journal Theoretical & Applied Science p-ISSN: 2308-4944 (print) e-ISSN: 2409-0085 (online), Published: Philadelphia, USA 30.10.2019 http://T-Science.org.
9. Salimov A., Khusanova Sh., Salimov O., Toshtemirov Q., Yakubov N., Rakhimjanov A. Research of The Process of Preparation and Storage of Raw Cotton Journal of optoelectronics laser ISSN: 1005-0086 Volume 41 Issue 7, 2022.
10. Salimov O. A., Sabirov I. Q., Salimov A. M., Xamidov O. “Paxta tozalash korxonalarida changsizlantirish masalalari”. FarPI ilmiy-texnika jurnali 2022.№ 5.-239 b. ISSN 2181-7200
11. Abdugaffarov X.J., Safoyev A.A. “Paxta chigitini tashishda vintli konveyerning texnologik imkoniyatlarini oshirish”. Monografiya, TTECI Tashkent, 2020, 136 b.
12. Salimov A. M.. “Tovarshunoslik”. Toshkent, 2018, 191 b
13. Mamayeva N. Y. “Otsenka zapilennosti vozduxa” M. 2012
14. Mardonov B., Salimov A., Salimov O. “Statisticheskiy metod otsenki protsessa ochistki melkogo sora i pili pri transportirovke xlopka-sirsa” Problema mexaniki №4 T. 2022