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Study of Optimal Parameters of Improved 1RX Regenerator

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Abstract

In this article, researches on improvement of 1RX regenerator used in cleaning processes of cotton ginning enterprises were carried out. The effect of changing the parameters of the new working body—rubber-plate drum and machine inlet on the efficiency of cotton separation was studied in the research, and the maximum level of efficiency of separation was determined. In this paper work, the main factors affecting the efficient operation of the regenerator were identified, their value limits were determined, and research was conducted using the mathematical planning method. As a result, effective operation of the improved 1RX cotton regenerator was observed at the value of the given factors, that is, the separation efficiency was 99.5%, the cleaning efficiency was higher than 88.7%, and the amount of seed cotton in the waste was reduced lower than 2.5%.

Keywords

Regenerator, Cotton, Impurities, Rubber-Plate Drum, Cotton Piece, Brush Drum, Separation Effect, Enterprise, Plate Axis, Parameter, Working Body, Grate-Bar Grid

1. Introduction

The increase in the amount of cotton pieces in the waste separated from the technological equipment for cleaning cotton from large impurities in cotton ginning enterprises causes them to disappear with the waste. That's why 1RX cotton regenerator is installed for each cleaning system in enterprises. One of the main disadvantages of the used regenerators is their efficiency, the low efficiency of cleaning the separated cotton pieces, and it was observed that waste and cotton pieces pass through the colognes due to the impact of the air from the

middle pipe of the waste cotton supplier. Due to the extreme dirtiness of the cotton coming out of the regenerator, if it is re-added to the cotton coming to the cleaning system, the negative effect on the overall quality indicators of the received fiber will increase [1] [2] [3] [4] [5]. It is necessary to strengthen the cleaning of separated cottons in the regenerator, taking into account the need to bring the level of contamination to the same state in order to add the piece of cotton separated from the regenerator to the cotton in the flow. In this regard, a regenerator device with a new working body was proposed and its main parameters were studied in this research [6] [7] [8].

Some changes were made to the construction of the unit to increase the cleaning and separation efficiency of 1RX type cotton regenerators used in cotton ginning enterprises (**Figure 1**).

It was observed that the 1RX regenerator was fed from both ends of the waste cotton sawdust drum, and air was drawn from the middle, resulting in a reduction of cotton pieces in the waste. In this case, when the waste cotton is divided into two parts during its movement in the air duct, it is easier to clean it by dividing it into small pieces towards the saw drum. Our next change is that the slats of the drum with the separator plate are installed at an oblique angle along the axis to the center of the drum, so that the cotton is removed from the saw tooth and directed towards the center. In order to reduce the amount of cotton pieces from the regeneration drum to the waste, the distance between the grate-bar of the lower grate-bars grid is reduced [9] [10].

2. Determination of Technological Parameters through Experiments

Based on the results of the conducted theoretical and practical experiments, the main factors influencing the quality performance of the cotton regenerator were

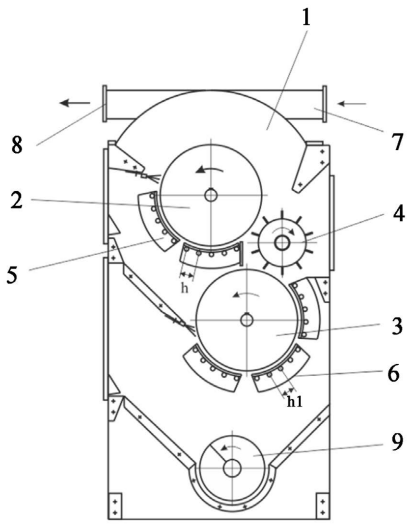

Figure 1. Construction of an improved cotton regenerator. (1—Pneumatic supply, 2—main cleaning saw drum, 3—regeneration saw drum, 4—separator plate drum, 5 - 6—column grid, 7—waste cotton inlet pipe, 8—cleaned cotton outlet pipe, 9—waste auger).

identified and multi-factor experiments were conducted. Experiments were carried out during processing of Namangan-77 selection sort, I-industrial sort, 2nd class initial impurity—8.7%, moisture content—9.3%, raw cotton [11] [12].

As a criterion limit for evaluating the quality of seed cotton separated from the improved regenerator, the separation efficiency of the regenerator Y_1, the cleaning efficiency Y_2, and the amount of cotton pieces in waste Y_3 were taken. The main factors affecting the specified criteria: X_1—angle of deviation of the plates towards the center of the drum, β degrees, X_2—rotation speed of the separating drum, rev/min, X_3—distance between regeneration columns, in mm.

Based on preliminary experiments, the step and range of factors affecting the performance quality of the regenerator are presented in Table 1.

The fully factored PLANEXP-2 [13] [14] second-order V_3 planning method was used for the experimental tests. V_3 planning matrix, experimental results and experimental calculations are presented in Tables 2-4.

Table 2 shows the results of the experiment on the effectiveness of cotton separation Y_1 from saw teeth in a rubber-plate drum.

According to the calculation of the separation efficiency of the equipment, the table index of Student's criterion is T (28) = 2.048, the table index of Cochran's criterion is G (2, 14) = 0.3539, the calculation index of Cochran's criterion is equal to = 0.2557249, and the variance of repeatability is equal to = 6.238141E−02.

The regression equation of the separation efficiency of the regenerator was obtained:

$$Y_1 = 99.48542 + 0.19333X_1 + 0.36333X_2 + 0.16667X_3 - 0.90208X_{12} - 0.19583X_1X_3 - 1.11874X_{22} + 0.19583X_2X_3 - 0.43546X_{32} \quad (1)$$

Checking the adequacy of the mathematical model (1) showed that: the adequacy variance is equal to 4.025069E−02, the calculated index of Fisher's criterion is equal to 1.935706, the tabular index of Fisher's criterion is equal to FT (5, 28) = 2.56, which shows the adequacy of the obtained model.

The results of the experiment on cleaning efficiency Y_2 are presented in Table 3 below.

According to the criterion of purification effect Y_2, the table index of the Student's criterion was equal to T (28) = 2.048, the table index of the Cochrane criterion was equal to G (2, 14) = 0.3539, the arithmetic index of the Cochrane criterion was equal to = 0.2627458, and the variance of reproducibility was equal to

Table 1. Range of factors and their steps.

No	Factors	Unit of measure	Identification of factors		Step	Calculation range of factors		
			Natural	Coded		−1	0	+1
1	The angle of deviation of the planks towards the center of the drum	angle	β	X_1	5	10	15	20
2	Separation drum rotation speed	rpm	V	X_2	200	750	950	1150
3	Spacing of regeneration grate-bar	mm	h	X_3	15	10	25	40

Table 2. Experimental results on separation efficiency Y_1.

№	Input Parameters			Output Parameters			Average Value Y average	Variance
	X_1	X_2	X_3	Y_1-1	Y_1-2	Y_1-3		
1	−1	−1	−1	96.2	96.9	96	96.4	0.22
2	1	−1	−1	97.2	97	97.1	97.1	0.01
3	−1	1	−1	96.6	96.8	96.5	96.6	0.02
4	1	1	−1	97.8	97.2	97	97.3	0.17
5	−1	−1	1	96.2	96.6	96.9	96.6	0.12
6	1	−1	1	96.7	96.8	96.9	96.8	0.01
7	−1	1	1	97.8	98	97.9	97.9	0.01
8	1	1	1	97.2	97.8	97.6	97.5	0.09
9	−1	0	0	98	98.6	98.2	98.3	0.09
10	1	0	0	98.8	99	98.9	98.9	0.01
11	0	−1	0	97.9	97.6	98	97.8	0.04
12	0	1	0	99	98.9	98.8	98.9	0.01
13	0	0	−1	98.9	98.8	99	98.9	0.01
14	0	0	1	99.2	99.4	99	99.2	0.04

Table 3. Results of experiments on cleaning efficiency Y_2.

№	Input Parameters			Output Parameters			Average Value Y average	Variance
	X_1	X_2	X_3	Y_1-1	Y_1-2	Y_1-3		
1	−1	−1	−1	81.9	82	81.8	81.9	0.01
2	1	−1	−1	81.3	81.2	81	81.2	0.02
3	−1	1	−1	83	83.9	83.2	83.4	0.22
4	1	1	−1	84.7	84.8	84.6	84.7	0.01
5	−1	−1	1	85.1	84.9	85	85.0	0.01
6	1	−1	1	84.8	84	84.8	84.5	0.21
7	−1	1	1	85.3	85.5	85	85.3	0.06
8	1	1	1	86.4	86.2	86.6	86.4	0.04
9	−1	0	0	86.9	87.1	87.2	87.1	0.02
10	1	0	0	87.9	88	87.8	87.9	0.01
11	0	−1	0	86	86.6	86.2	86.3	0.09
12	0	1	0	87.8	87.8	87.6	87.7	0.01
13	0	0	−1	85.1	85.5	84.9	85.2	0.09
14	0	0	1	87.6	87.8	87.5	87.6	0.023

0.0607145.

In this case, we get the following regression equation:

$$Y_2 = 88.42084 + 0.21X_1 + 0.86X_2 + 1.25334X_3 - 0.93749X_{12} + 0.45833X_1X_2 - 1.42082X_{22} - 0.35833X_2X_3 - 2.02084X_{32} \quad (2)$$

Checking the adequacy of the mathematical model (2) showed that: the adequacy variance is equal to 3.513349E−02, the calculated index of Fisher's criterion is equal to 1.736002, the table index of Fisher's criterion is equal to FT (5, 8) = 2.56, which shows the adequacy of the obtained model.

The results of the experiment on the amount of seeded cotton pieces in the waste Y_3 are presented in Table 4 below.

According to the criteria of Y_3, the amount of seeded cotton pieces in the waste is equal to the table index of the Student's criterion T (28) = 2.048, the table index of the Cochrane criterion G (2, 14) = 0.3539, the arithmetic index of the Cochrane criterion = 0.1166667, and the repeatability dispersion was equal to = 1.428571E−02.

In this case, we get the following regression equation:

$$Y_3 = 2.38125 - 0.05X_1 + 0.33X_3 + 0.48542X_{12} + 0.10417X_1X_3 + 0.36875\,X_{22} + 0.07917X_2X_3 + 0.25208X_{32} \quad (3)$$

Checking the adequacy of the mathematical model (3) showed that: the adequacy variance is equal to 9.726857E−03, the calculated index of Fisher's criterion is equal to 2.04264, the tabular index of Fisher's criterion is equal to FT (6, 28)

Table 4. The results of experiments on the amount of seeded cotton pieces in waste Y_3.

No	Input Parameters			Output Parameters			Average Value Y average	Variance
	X_1	X_2	X_3	Y_1-1	Y_1-2	Y_1-3		
1	−1	−1	−1	3.2	3.3	3.4	3.3	0.010
2	1	−1	−1	3.1	3	3.2	3.1	0.010
3	−1	1	−1	3.3	3.2	3.3	3.3	0.003
4	1	1	−1	2.9	2.8	3	2.9	0.010
5	−1	−1	1	3.5	3.6	3.8	3.6	0.023
6	1	−1	1	3.8	4	3.7	3.8	0.023
7	−1	1	1	3.9	4	3.8	3.9	0.010
8	1	1	1	4	3.9	4	4.0	0.003
9	−1	0	0	3	2.8	3.1	3.0	0.023
10	1	0	0	2.8	2.7	2.8	2.8	0.003
11	0	−1	0	3	2.7	2.9	2.9	0.023
12	0	1	0	2.5	2.6	2.8	2.6	0.023
13	0	0	−1	2.2	2.5	2.4	2.4	0.023
14	0	0	1	2.9	3	2.8	2.9	0.010

= 2.44, which shows the adequacy of the obtained model.

3. Results

Graphs were constructed showing the effect of each input factor on the process in the regression equation that adequately describes the effectiveness of cotton separation from saw teeth Y_1 in a rubber-plate drum (Figure 2).

As can be seen from the graphs in Figure 2 below, X_1—increasing the angle of deviation of the planks towards the center of the drum to the baseline had a positive effect on the efficiency of the planks in separating the seed cotton from the saw teeth. We can see a decrease in the separation cam from the saw teeth as it passes from the baseline (a), and we also see an increase in the separation efficiency up to the baseline values in the graphs (c) in the change of X_2—Separation drum rotation speed (b) and X_3—regeneration column spacing, and decrease with the passage of the baseline. In this case, it means that the speed of the drum increases, it cannot be removed from the saw, the increase in the distance between the colosniks leads to a decrease in the number of cotton pieces

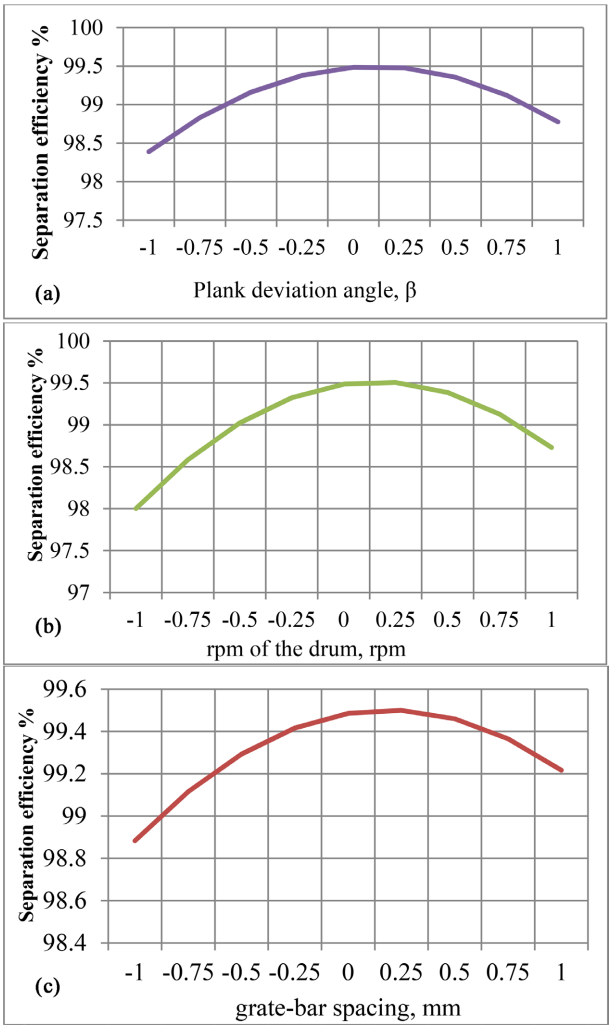

Figure 2. Influence of incoming factors on separation efficiency.

in the teeth of the saw, and the reduction of the separation efficiency due to the negative effect on the amount of separated cotton.

Graphs were constructed showing the effect of each input factor on the process in the regression equation that adequately describes the cleaning effect Y_2 (Figure 3).

In the graph (a) of Figure 3, we explain the effect of the deviation angle β of the plate on the cleaning efficiency as follows. Due to this, the angle of deviation of the plank is excessively increased, as it resists the cotton to be re-punched and cleaned. In the graphs of plate drum rotation speed (b) and grate-bar spacing

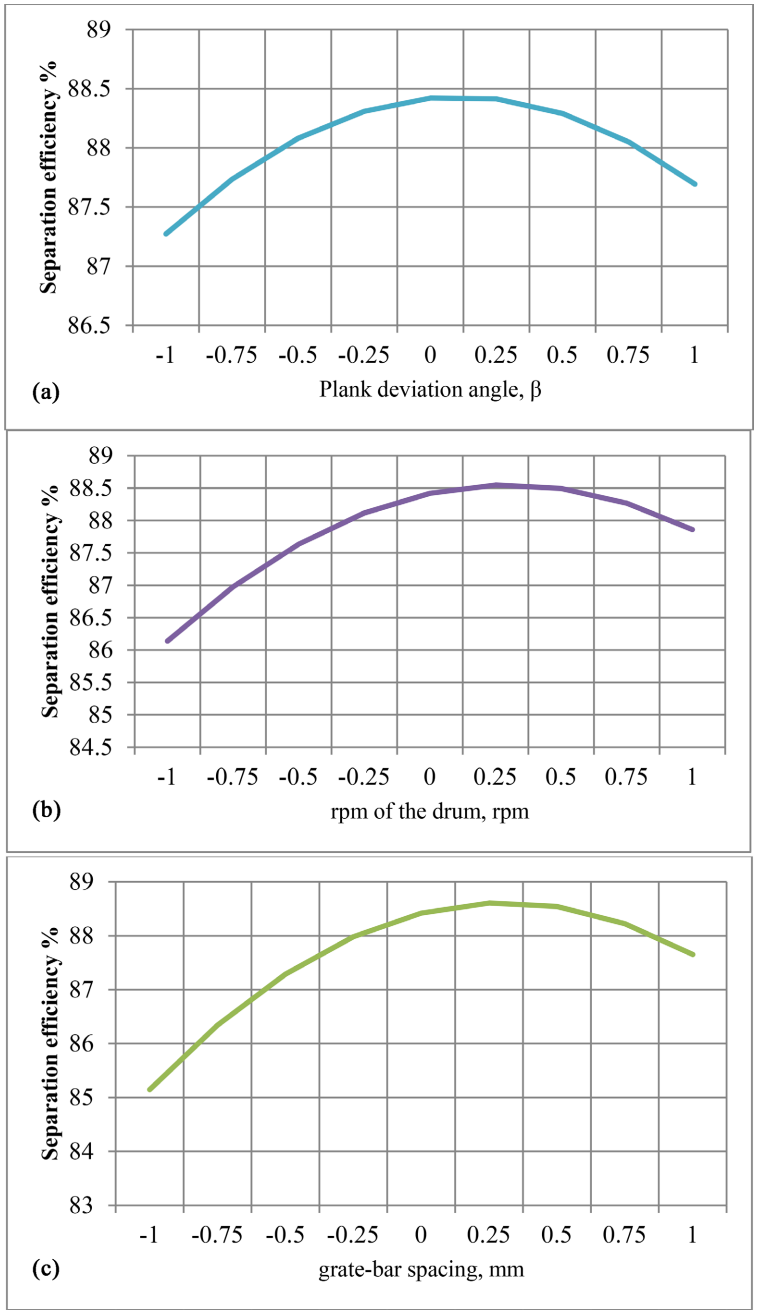

Figure 3. Influence of unwanted factors on cleaning efficiency.

(c), we can see that the cleaning efficiency gradually decreases as the basic parameters are passed. Therefore, the speed of rotation of the drum and the excessive increase of the distance between the grate-bars also affect the cleaning effect.

Graphs were constructed showing the effect of each input factor on the process in the regression equation that adequately describes the amount of seed cotton in waste Y_3 (Figure 4).

From the graph (a) in Figure 4, we can see that the decrease of the amount of cotton in the waste to the base amount and the increase from the base amount of the angle of installation of the plank on the separation drum causes the amount of cotton in the waste to increase slowly. Also, in graph (b), increasing the rotation speed of the drum from the basic one has a negative effect on the amount of

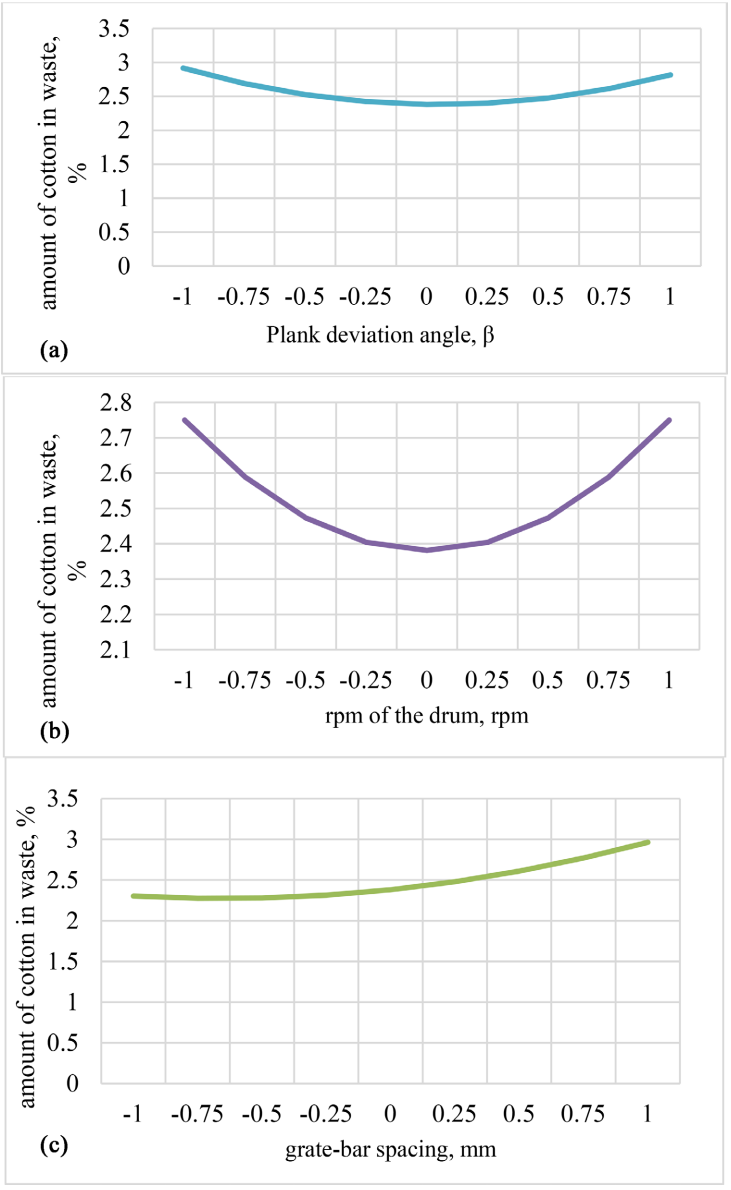

Figure 4. Effect of unwanted factors on the amount of seed cotton in waste.

seeded cotton in the waste, which causes it to spill into the waste without having time to separate the cotton from the surface of the saw due to the increase in the rotation speed. It can be seen from the graph that the amount of seeded cotton in the waste increases with the increase of the distance between the grate-bars (c), where we see the increase of the seeded cotton in the waste as the distance of the grate-bars exceeds the basic amount.

In order to confirm the results of the multi-factor experiment, we consider the optimization problem of determining the optimal values of the cotton regenerator.

Boundary conditions:

$Y_2 \rightarrow$	max
$Y_1 \geq$	99%
$Y_3 \leq$	3%

4. Conclusions

The resulting optimization problem was solved using the random search method and modern computer application programs, and the following optimal solutions were obtained (Table 5).

Table 5. Results of mathematical model optimization.

Factors	X_1	X_2	X_3
Coded	0.184507	0.296613	0.283806
Natural	15.923	1009.323	29.257
Rounded up	15	1000	30

So, according to the results of the experiments, X_1—the angle of deviation of the plates towards the center of the drum, β—15 degrees, X_2—the rotation speed of the separating drum, 1000 rev/min, X_3—the distance between regeneration columns, was 30 mm.

Effective operation of the improved 1RX cotton regenerator was observed at the value of the given factors, that is, the separation efficiency was 99.5%, the cleaning efficiency was higher than 88.7%, and the amount of seed cotton in the waste was reduced to 2.5%.

Conflicts of Interest

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

References

[1] Djamolov, R.K. and Ismailov, U.M. (2021) Improving the Efficiency of Cotton Regeneration Technological Equipment. *Proceedings of the International Scientific-Practical Conference "Modern Innovative Technologies in Light Industry: Problems*

and Solutions", Bukhara Institute of Engineering and Technology, Bukhara, 19-20 November 2021, 391-396.

[2] Obidov A.A. and Sultanov, M.M. (2020) To Research the Method of Separating Fibers Suitable for Spinning on a Needle Drum. *International Scientific and Practical Conference CUTTING EDGE-SCIENCE*, Shawnee, 29-30 June 2020, 128-131.

[3] Djamalov, R., *et al.* (2020) Drum for Removing Raw Cotton from Saw Cylinders and Transporting It in Cleaners. Patent FAP 00335 RUz.

[4] Obidov, A.A. and Sultanov, M.M. (2020) Study of Technological Parameters of Fiber Separation Device. *International Journal of Psychosocial Rehabilitation*, **24**, 6400-6407. https://doi.org/10.37200/IJPR/V24I5/PR2020624

[5] Borodin, P.N. (1999) Report on Topic 9807, JSC SPC "Paxtasanoatilm", Tashkent.

[6] Obidov, A., Mamatqulov, O. and Sultanov, M. (2018) Theoretical Analysis of the Movement of Cotton Piece on the Slope Surface. *International Conference* "*Science and Practice*: *A New Level of Integration in the Modern World*", Berlin-Warsawa, May 2018, 151-156.

[7] Vzenkonsky, A.B., Boldinsky, G.I., *et al.* (1966) Method of Calculating the Number of Slats on the Removable Drums of Raw Cotton Cleaners. *Cotton Industry*, No. 1, 128-132.

[8] Obidov, A.A. (2007) Improvement of the Technology of Cleaning and Sorting of Ginned Seeds. Dissertation of Candidate of Technical Sciences, TITLI, Tashkent, 200 p.

[9] Loginov, B.V. (1961) Investigation of the Process of Removing Raw Cotton from Saw Drums in Heap Cleaners and Raw Cleaners. Ph.D. Thesis, TITLI, Tashkent.

[10] Avazbek, O., Mirzaolim, S., Ibrohim, M. and Shokir, A. (2018) The Theoretical Studies of the Cultivation of Three Cotton Seeds along the Plain. *Engineering*, **10**, 514-520. https://doi.org/10.4236/eng.2018.108037

[11] Kuliev, T.M., Dzhamolov, R.K., Nazirov, R.R. and Kurbanbaev, E.B. (2018) Development of a Raw Cotton Regenerator from Raw Cotton Waste. NTO, Topic No. 12, Tashkent.

[12] "Uzpakhtasanoat" OAJ (1994) Handbook of Primary Processing of Cotton. Book 1. Fan, Tashkent, p. 445.

[13] Khakimov, Sh.Sh. (2015) On the Development and Implementation of Skimming Slatted Drums in Sections and Cleaners of Raw Cotton. Universum: Engineering Sciences: Electron, No. 11. http://7universum.com/ru/tech/archive/item/2768.

[14] Kulmatov, I.T. (2021) Upgraded Regenerator for Efficient Extraction and Purification of Raw Cotton from Waste. Ph.D. Thesis, "Uzpakhtasanoat" OAJ, Tashkent, p. 120.