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IMPROVING THE FIBER SEPARATION DEVICE FROM FIBROUS WASTE

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Annotation: The article conducts research to increase the volume of fiber production at the enterprise by separating the fibers that can be spun from cotton waste.

As a result of theoretical research, a device has been developed to separate spinning fibers from waste and based on production requirements.

In the development of the design of the new device, the properties of the fiber coming out of the gin and remaining in the waste were studied and the results were used in experiments. When testing the device with metal saw working bodies, it was found that the overall efficiency is 71-72% when the rotational speed of the main separating metal saw drum is nab = 400 rpm, the angle of inclination of the guide is 100, the distance between the main saw drum and the brush is 1 mm.

Keywords. Cotton fiber, fibrous waste, lint, short fiber, short fiber, long fibers, solid metal saw tape, cotton seed, gin, fine impurities, quality, drum, rotation speed, angle of inclination.

注释：本文通过从废棉中分离出可纺成的纤维来进行研究，以增加企业的纤维产量。

作为理论研究的结果，已根据生产要求开发了一种将纺丝纤维与废料分离的装置。

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在新装置的设计开发中，研究了从杜松子酒中出来并留在废物中的纤维的特性，并将结果用于实验。 用金属锯工作体对该装置进行测试时发现，当主分离金属锯滚筒的转速为 nab = 400 rpm，导轨倾斜角为 100 度时，整体效率为 71-72%， 主锯鼓和刷子之间的距离为 1 mm。

关键词。 棉纤维、纤维废料、皮棉、短纤维、短纤维、长纤维、实心金属锯带、棉籽、轧花机、细杂质、质量、转鼓、转速、倾角。

ABBREVIATIONS

OVM - fiber waste treatment machine

ROV - fibers regenerator-cleaner

INTRODUCTION

Although research has been conducted to improve the process of fiber separation from waste, some aspects of this process have not been fully disclosed, in particular, the development of fiber separation technology for fibrous waste - lint and lint, the parameters of the working bodies and influencing factors The issues of setting optimal values have not been fully resolved. In addition, the possibility of determining the optimal parameters of metal saw drums and the direction of the fibrous mass to the drums during the separation of long fibers from the lint and groove composition has not been sufficiently studied. Based on the above, a more in-depth study of the possibility of introducing technologies to increase fiber production at the enterprise, the development of the design of fiber separation devices from waste, which does not adversely affect product quality [1-4].

The aim of the research conducted in the article is to increase the volume of fiber production by creating a rational design of a fiber separation device from fibrous waste and its introduction into the enterprise.

Objectives of the research: theoretical study of the strength and reliability of the main working bodies of the fiber separation device and the process of interaction of metal saw teeth with fiber; study of fiber movement in device saw drums and determination of optimal values of factors influencing the separation process by mathematical modeling; creation of an experimental design of a fiber separation device and substantiation of its effective operation; conducting production tests on a fiber separation device and studying the properties of the separated fibers; to determine the effectiveness of the adopted technical solutions and recommend them to production.

MATERIALS AND METHODS

It is known that cotton fiber plays an important role in the economy of Uzbekistan. The issue of non-destructive production of cotton fiber, which is a valuable raw material for the textile industry, has been considered in many scientific studies conducted in the Republic and around the world.

This means that the work to increase fiber output in the enterprise has always been relevant and remains relevant.

After the ginning process at the ginning plant, the cotton fibers are cleaned of various contaminants and sent for pressing. The seeds from the demon are sent to processes such as lintering, delintering, and from them fibrous products such as lint (down) and short fiber are produced. Lintering and delintering of cotton seeds, i.e. the separation of fiber and short fiber remaining after seed germination, is extremely important as the main process. As a result of the initial processing of seed cotton in ginneries, fiber, short fiber, seeds and technical seeds, fur and wool products are obtained [5-7].

The industrial grade of cotton fiber is determined by the indicators of tensile strength, maturity, defects and contamination, moisture content (as a percentage of dry weight). The tensile strength and maturity are the most important criteria in determining the industrial grade of cotton fiber. The indicators characterizing the varieties of cotton fiber according to the state standard are given in Table 1.

Table 1

Indicators characterizing the type of cotton fiber

Indicators	Norms by varieties						
	High	I	II	III	IV	V	VI
Breaking force	4.6 and more	4.8-4.4	4.3-3.4	3.8-3.4	3.3-3.0	3.9-2.5	Less than 2.5
Maturity coefficient	2.1	2	1.8	1.6	1.4	1.2	Not less than 1.2
Defects and pollution total, in%	1.9	2.1	2.6	3.5	5.3	8.6	12.8
Moisture relative to dry fiber weight, in% (for all cotton-growing districts)	8	8	9	10	11	12	12

During the processing of cotton seed, its complete hair coverage and residual fiber (after fiber separation) are analyzed. The less hair the cotton seed is covered with, the more efficient it will be in the production of oil and in its use for planting.

The amount of short fiber that can be separated from the cotton seed in a gin machine varies considerably. It also depends in part on the seed and industrial varieties of cotton as well as the growing conditions. In the research of scientists of JSC "Pakhtasanoat Ilmiy Markazi" for different seed varieties of cotton, after separation from the fiber in the gin machine, the average calculation criteria for full coverage of the seed is set (Table 2).

Residual fiber content of a seed is the weight of individual fibers of more than 6 mm in length that adheres to the seed after manual separation of the fibers from 200 cotton seeds.

This size is compared with the standards that determine the degree of purification (whether it is partially cleaned or over-scraped) and the correctness of the fiber separation process. Incomplete cleaning of the seed, ie an increase in the amount of residual fiber, leads to the retention of pure spun fiber, which reduces the fiber output from seed cotton. Excessive scraping of the seed also reduces its staple length due to an increase in the amount of lint [8-9].

Table 2

After the fiber is separated, the seeds are completely covered with hair

Seed variety of cotton	Complete hair coverage of the seed, in%		The average percentage of full hair coverage.
	Varieties I- II	Varieties III- IV	
Medium fiber varieties			
Namangan -77	12.7	14.0	13.0
S-6524	12.5	14.0	12.8
137-F	12.7	14.0	13.0
138-F	14.0	15.5	14.3
S-1472	11.5	13.0	11.8
Fine-grained varieties			
2I3	2.5	3.5	2.7
5476-I	2.5	3.5	2.7
504-V	4.5	5.0	4.6
5904-I	3.0	4.0	3.2

To date, a lot of research has been done to purify fiber mixtures from enterprises and to separate long fibers from them and increase the amount of fiber that can be spun or used in industry. Such studies have been carried out mainly by purification and separation of fibrous seeds or separation of long fibers from short fiber content.

Residual fiber is the amount of fiber that is not removed from 200 seeds during germination. A well-known scientist in the cotton ginning industry, Professor B.A.Levkovich, noted that the residual fiber in the product after ginning is one of the main factors that ensure the normal course of the ginning process. In order to determine the norm of residual fiber, scientists conducted research in three stages [10-11]:

- Collection of statistical data on ginneries and their processing by mathematical statistics;

- Carrying out inspections in the production conditions for the processing of the main selection varieties of raw cotton;

- Development of new norms of residual fiber content in gin products.

The need to create a device for trapping non-ginned fractions in the technological process of primary processing of cotton requires theoretical research on the products of gin, which are working normally. Studies [12-14] have shown that two types of residual fiber can be found in the seeds that come out of the genus: free fibers that cling to the seed and fibrous seeds that are not torn by saws.

The main reason for the formation of free fibers is the large difference between the rotational speeds of the raw material roller and the saw cylinder.

RESULTS

The reason for the presence of long fibers in the fiber waste is that the ginning process does not proceed normally. In order to fully capture the fibers from the raw material shaft, it is necessary to direct the finely ground fractions to the additional grinding and saw cylinder teeth. The amount of free fiber and well-fermented seeds coming out of the gin depends not only on its normal functioning, but also on several other factors. Examples include high moisture content of raw cotton, untimely replacement of saws with damaged teeth, broken or no seed comb piles [15].

It is necessary to prepare fractions from the composition of fibrous wastes, as well as to select them for further processing technology, to distribute them according to the degree of fiber and to know the amount of long fibers in this composition. For this purpose, special research was conducted in the dissertation. To study the composition of the fractions, fibrous wastes from normally operating gin and linter machines were randomly selected and included in the table (Table 3). This test was repeated several times until a 95% result was obtained. The separated fractions were divided into 7 groups according to the length of the fibers in them.

Table 3

Fiber length indicators in fibrous wastes

№	**Lint and fiber length, mm**						
	0-5	**5-10**	**10-15**	**15-20**	**20-25**	**25-30**	**30-35**
1	30	77	67	17	3	3	2
2	34	55	72	16	3	4	1.5
3	35	67	65	19	6	5	0.8
4	33	74	61	21	4	3	0.5
5	39	65	71	13	5	4	1.5

The following formula was used for further work:

$$P(x_1 \le \xi \le x_2) = -F\left(\frac{x_1-\bar{x}}{\sigma}\right) + F\left(\frac{x_2-\bar{x}}{\sigma}\right) \quad (1.1)$$

$\sum P_i$ - a value that obeys the probability of a normal distribution.

Table 4

P_i	$\sum P_i$
$P_1 = 0.1484$ P_1=0.1484	0.1484
$P_2 = 0.3050$ (P_1=0.3050 формулалар гап ичида ва жадвалда ёзув шаклида бўлсин)	0.4534
$P_3 = 0.2903$	0.8437
$P_4 = 0.1132$	0.9669
$P_5 = 0.0311$	0.9880
$P_6 = 0.0065$	0.9945
$P_7 = 0.0047$	0.9992

When developing values:

$$F(x_i) = \frac{1}{\sqrt{2\pi}} \int^{x_i} l^{\frac{t^2}{2}} dt \qquad (1)$$

Based on this situation (normative function of Laplace), for the values of $F(x_i)$, the table given in the study [16] was used..

Here P_i is the theoretical value of the probability that the fibers will fall into the range of their respective classes.

In order to improve the quality of lint produced and increase the amount of fiber, the task is to study the fractional composition of the waste in terms of fiber content and contamination. It is recommended to divide the fibrous waste into the following fractions according to the degree of fibrousness:

- contaminants;

- Fibers up to 5 mm;

- Fibers of 5-10 mm;

- Fibers of 10-16 mm;

- Fibers 16-22 mm long.

As mentioned above, fibrous wastes (lint, husks and seeds) produced at ginneries contain fibers that are suitable for spinning and can be used in industry [16], the level of fiber production through their separation is significant (1.9-2, 5%) increases. Based on these analyzes, the aim of the dissertation was to create a new device that separates long fibers from lint and alfalfa.

Taking into account the task of separating long fibers from waste in the manufacture of this device, the working principle and design features of the ROV-type fiber waste regeneration machine, previously used in enterprises, were analyzed.

A ROV machine (fiber waste regenerator) is used to separate the spinning fibers from the fiber yarn. This machine is installed in the waste treatment plant together with OVM brand waste treatment machine. They continuously clean and separate the waste generated by gin and fiber cleaning machines in the technological process. The ROV machine consists of the following main parts: cleaning section, mesh drum section, regeneration section, supply adjustment section, frame and control cabinets.

The regenerator carries out the technological process of separation of fibers suitable for spinning from fibrous waste.

The main disadvantages of this device are the complexity, high material consumption, high energy consumption. Therefore, at present it is not used in modern ginneries. The fact that such devices are not used in ginneries, first of all, leads to the loss of valuable fiber, which in turn eliminates the additional economic benefits obtained by separating the fibers from the waste.

In creating the new device, the aim was to prevent the addition of an average of 1.5-2% of valuable cotton fiber to the fiber waste (down and down) in the technological process of primary processing of cotton. With the introduction of a new fiber separation device, the company will be able to separate long fibers from fibrous mixtures from various processes.

To date, no high-efficiency device has been developed, such as a fiber separation device, which is offered at the primary processing plants of cotton. The devices created are mostly low-yielding or capable of separating fiber by sorting and re-ginning fibrous seeds, but there are a few disadvantages to increasing fiber yield by this method. In particular, the separation of fiber from the waste has a low or complex design, the ability to absorb the content of the husk is good, and those that work through seed sorting, such as mechanical damage to the seed, fiber damage, low productivity. Therefore, today it is expedient to create an efficient device using resource-saving methods without changing the structure of the technological process.

The initial work was aimed at creating a device for the separation of long fibers from the fibrous waste from ginning, fiber cleaning and lintering. As a result, the amount of fiber output in the enterprise will increase and the enterprise will have significant economic benefits. In addition, the introduction of the device will prevent the addition of long fibers (longer than 16 mm) that can be used in the textile industry to the waste.

It is known from research [16-20] that the separation of long fibers from the fiber waste has been used in experiments in the following ways:

- saw bodies;

- drums with metal saw heads;

- mesh surfaces of various shapes;

- straight and stepped vibrating surfaces.

The device proposed in the article [2,5,9] consists of the following main elements: 1-receiving drum, 2-separator (metal saw) main drum, 3-brush drum for removing long fibers, 4-drills, 5-lint mine, 6-housing, 7-mine for long fiber, 8-long fiber guide, 9-mesh surface (Fig. 1).

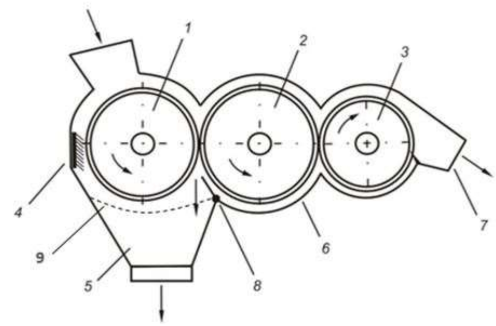

Figure 1. Schematic of a new fiber separation device

This device works as follows: for example, the fibrous waste from the ginning process is fed to the receiving drum 1 through a straight-through inlet pipe, and the mass is pulverized using drum saws, the long fibers are hung and sent to the curved-sawed sawmill 2. A straight saw is mounted on the side of the receiving drum 1 with a crusher 4, which controls the fine grinding of the fiber mass. As a result, the possibility of obtaining long fibers from the crushed mass increases and comes through the mesh surface 9 to the main belt saw drum 2, where the fibers hung on the saws pass to the brush drum 3 and are pulled out of the teeth by the brush drum and out through the outlet pipe 7. . Short fibers and waste not attached to the saw drum 1 are discharged through the outlet shaft 5 for short fibers.

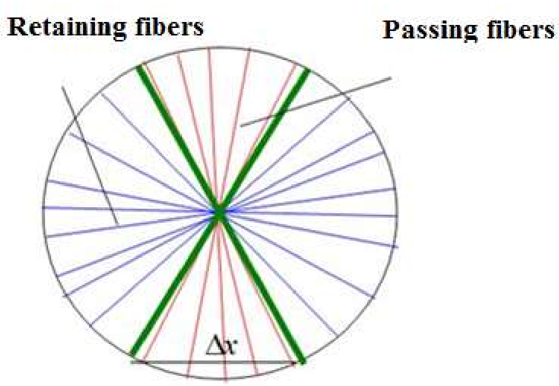

Figure 2. The location of the fibers on the separation surface

The effective operation of this device has been theoretically tested. In addition, the amount of long fibers in the fiber waste from the technological process at the gin was checked using an analyzer.

The fact that the placement of the fibers relative to the teeth of the metal saw tape is different causes some of the fibers to be trapped. If we consider the location of the fibers on the basis of equal distribution (Fig. 2) it is the case the probability of fiber retention is calculated on $P(l) = 1 - \frac{2\arcsin(\Delta x/2l)}{\pi}$. In this case, Δx is the distance between the teeth of the saw, and the length of the fiber fraction.

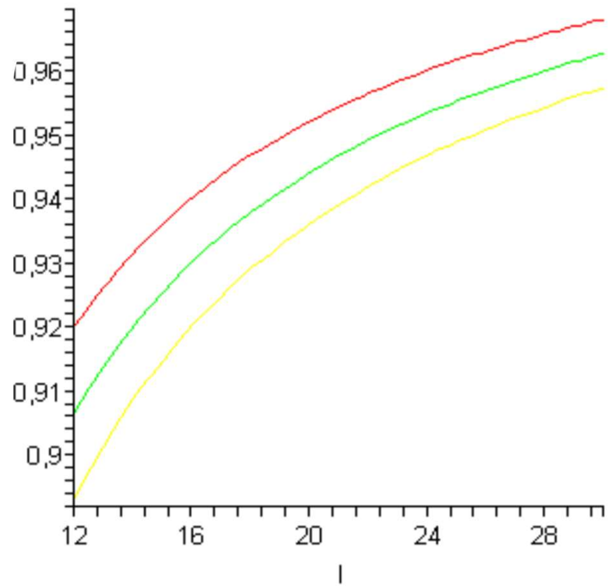

Figure 3. Graph of fiber retention in a metal saw tape

Example: when $\Delta x = 3$ mm, $l = 20$ mm - $P(l) = 0{,}95$; when $\Delta x = 3$ mm, $l = 18$ mm $P(l) = 0{,}94$. In general, the distance between the teeth of the saw tape and the probability that the fibers will be trapped relative to the length of the fiber fractions are as shown in the graphs in Figure 3.

In order to deepen the mathematical-statistical analysis, it is necessary to carry out several experiments on the device being created, taking into account the above. This, in turn, allows you to create a mathematical model for calculating the efficiency of the production of the separation device, taking into account the working process, ie the length of the fiber fractions and the location of the saw teeth in the separation of fibers. The mathematical model determines the factors that make its cost-effectiveness high when creating a device.

In the next study, the effect on the efficiency of the interconnection of the three drums (receiver, separator (main) and brush), which play a key role in the efficient operation of the device, was studied. The results of the experiment are given in Table 5.

Table 5

Effect of rotational speed of working drums on fiber separation efficiency

№	**Receiving drum rotation speed, rpm**	**Main drum rotation speed, rpm**	**Brush drum rotation speed, rpm**	**Device efficiency, %**
1.	300		900	55
2.	310		1000	59
3.	320	300	1100	59
4.	330		1250	65
5.	340		1350	66
1.	300		900	68
2.	310	400	1000	68
3.	320		1100	71
4.	330		1250	73
5.	340		1350	73
1.	300		900	71
2.	310		1000	71
3.	320	500	1100	66
4.	330		1250	66
5.	340		1350	62

This experience shows that the maximum efficiency is achieved when the main drum speed is 400 rpm, the receiving drum speed is 330 rpm and the brush drum speed is 1350 rpm. Graphs of this process were built on the basis of a special program.

Subsequent experiments showed that the distance between the drums (a = 1-2.5 mm) and the directional slope at the optimum rotational speeds of the metal saw tape and brush drums, i.e. $n_{qb} = 330$ rpm, $n_{ab} = 400$ rpm, $n_{shb} = 1350$ rpm The values of the angles (a = 5–200) were changed (Table 6).

Table 6

Influence of working body parameters on device efficiency

Distance between metal saw and brush drum (a), mm	**Reference slope angle (α), grad**	**Main drum rotation speed, rpm**	**Receiving drum rotation speed, rpm**	**Brush drum rotation speed, rpm**	**Device efficiency,%**		**Work productivity, kg/h**	
					According to Lint	**On short fiber**	**According to Lint**	**On short fiber**

1	5				61	56	452	256
1,5	10				68	67	495	295
2	15	400	330	1350	56	58	506	315
2,5	20				53	59	535	360
1	10				72	71	506	301
2	20				68	66	512	325

CONCLUSION

The results of the above experiments show that the values of the parameters determined in the theoretical studies were also confirmed in the experimental studies. In particular, the overall efficiency was 71-72% when the rotational speed of the main separating metal saw blade was nab = 400 rpm, the angle of inclination of the guide was 100, and the distance between the main saw blade and the brush was 1 mm.

In theoretical studies, if the values are set to the production copy, the operating productivity of the device at the rotational speeds of the drums in Table 5 is 300 (lug) - 500 (lint) kg/h, which is sufficient to implement the device in production conditions. That is, when the device operates at this capacity, it will be possible to process any fibrous mass produced at the enterprise.

The data presented in the table showed that as a result of the introduction of a new spinning fiber separation device, the output of spinning fiber was increased, and the quality performance of the lint was significantly improved. Fiber output increased by 0.22% by separating long fibers that could be used in industry from the fiber mass composition. The possibility of splitting the fibrous mass into fractions in the spinning fiber separation device significantly reduced the contamination in the lint as a result of the separation of impurities.

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