

# Studying the Efficiency of the New Cotton Regenerator

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**Abstract:** The article reflects the results of studies to determine the effectiveness of the created technological process from the waste of purifiers. The purpose of this work is to substantiate the improvement quality and output of fiber due to the modernization of the process regeneration of cotton slices from the waste products of cotton purifier machine. Improvement of the process of regeneration of the cotton slices from the waste of cotton purifiers by supplying the cotton slices to the regenerator, previously separated from the passive litter, with the development of a special device. In order to obtain the most complete characterization of such processes with a minimum number of experiments, experiments were carried out with extreme variants - with the supply of regenerated cotton slices to raw cotton before cleaning and ginning processes. Calculation based on weighted average clogging shows that if the number of regenerated cotton slices after the regenerator did not exceed 4% of the mass of raw cotton being cleaned, then their debris after triple cleaning by 1XK did not exceed 7.75%, which is almost 5 times higher than the debris of the cotton being cleaned raw. The most promising way of implementing the developed recommendation on the supply of sufficiently purified regenerated cotton slices into raw cotton before ginning is the development of a regenerator-purifier based on the 1PX regenerator with built-in purifying sections from small litter.

**Keywords:** Cotton Purifier, Cotton Slices, Regenerator, Waste, Litter, Seeds, Free Fiber, Drum with Steel Rods

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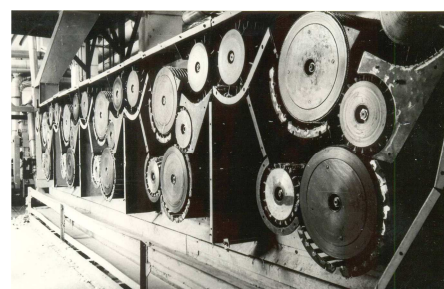
## 1. Introduction

Studies were conducted on a model of a cotton-purifying unit simulating the conditions for purifying raw cotton in sections of a YXK type unit and on a model of a regenerator simulating the regeneration and purification of regenerated volatiles in the 1PX regenerator.

The model of the unit (figure 1) was made in full size with the exception of the working bodies, whose length is 300 mm.

The model of the unit consists of docked and alternating different types of purifying sections - six sections of purifying from small litter and five sections of purifying from large litter. The first and last sections of purifying from small litter contain one drum with steel rods, and the other four, installed between sections of purifying from large litter on two drums with steel rods and modeling the rod block - EH.177. Perforated meshes are enveloped under the drum with steel rods. The total number of spinning reels in the layout is ten.

The coarse decontamination section models the EH.177 section and contains two serrated drums with lapping brushes and grate one above the other, and a stripping drum, and the lower serrate drum regenerates the sheaves falling through the grate of the upper serrate drum, and the upper grab the drum can operate in the reverse mode, which allows either to direct the flow of raw cotton to the section for purifying large litter, or to lead around it.



**Figure 1.** General view of the layout of the raw cotton purifier.

A cumulative shaft is installed above the caulk drum of the

first section for purifying debris, and above it is a KB-0.3 condenser with a suction line for feeding raw cotton for purifying into the model of the unit.

The required performance of the layout of the unit was achieved by regulation using the variable speed drive ИВА of the peripheral speed of the feed rollers, which was previously determined by the formula:

$$P = a \cdot \omega \quad (1)$$

where:  $P$  - productivity, t/h

$\omega$  - feed roller speed, rpm

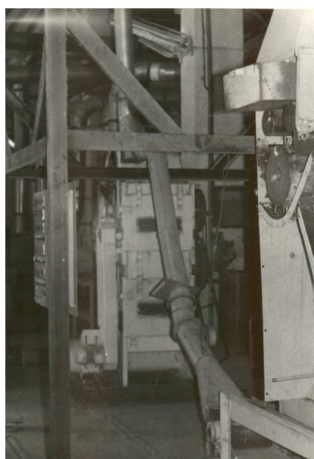
$a$  - certain empirically constant coefficient ( $a=0.76$  when used in industrial purifiers of the design and the gap between the feed rollers, for raw cotton medium-fiber breeding varieties of machine collection with a humidity of 8-9% and contamination 7-10%).

The range of regulation of the rotational speeds of the feed rollers of the layout of the unit is from 0 to 26 rpm, which ensures the achievement of its performance, in terms of the length of the working bodies on medium-sized raw cotton accepted in industry, from 0 to 20 tons/hour.

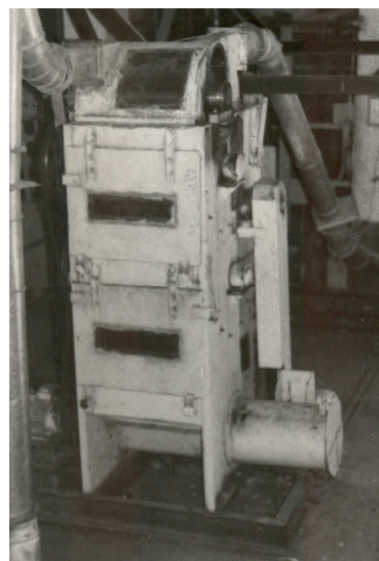
The performance of the layout of the unit in each experiment was controlled by weighing the portion of the experienced raw cotton and the chronometer of the time it was purified.

In the model of the unit, the weed impurities isolated during the purifying of raw cotton and the volatiles that fell together with them get on a horizontal conveyor belt, on which they can be accumulated, then collected, weighed and sampled for laboratory analysis, and if necessary, include movement of the tape to the suction pipeline of the layout regenerator PX.

The layout of the regenerator PX (figure 2 and 3) is also made in full size with the exception of the working bodies, whose length is 600 mm. At the same time, unlike the PX regenerator, in the pneumo-feeder of which there is one inlet 140×280 mm in size located in the middle of its length and two outlet openings of 140×140 mm in size located at the sides, there is one inlet in the pneumo-feeder of the model single outlet, each 140×140 mm in size, located at the sides.



**Figure 2.** General view of the layout of the regenerator PX from the inlet side.



**Figure 3.** General view of the layout of the regenerator PX from the branch pipe.

Thus, the length of the working bodies of the layout is 70.6% of half the length of the serial working bodies, which makes it possible to simulate the process of regeneration of the volts from the waste almost completely, and the purifying ratio, taking into account the axial movement of the voltages in the pneumo-feeder is 70-80%. In order to compensate, a paddle drum was installed in the pneumo-feeder, which increases the cleaning effect of the regenerator layout to the rating values of the PX regenerator [1].

The inlet of the pneumo-feeder is supplied to the waste conveyor, and the outlet is connected to the suction pipe of the KB-0.3 condenser.

If, according to the conditions of the experiment, it is necessary to supply regenerated flyers to raw cotton before purifying, then the waste tape and the regenerator model were included in simultaneous work with the model of the unit and the KB-0.3 condenser.

At the same time, the regenerated volatile materials are mixed with the raw cotton supplied for purifying in the suction pipe and then the condenser are jointly unloaded into the accumulating shaft of the model of the unit.

If according to the conditions of the experiment it is necessary to collect the regenerated flyers, then during the purifying of a portion of raw cotton, the waste accumulated on the tape, and after the purifying of the raw cotton was completed, the layout of the unit was turned off, then a special box was installed on the feed rollers (figure 3) and included a regenerator layout, condenser, and tape movement. As a result, the regenerated bolls fell and accumulated in a special box. The required load on the layout of the regenerator was provided by shifting and leveling the waste on the tape, as well as its discrete inclusion.

If, according to the conditions of the experiment, it is necessary to purify the regenerated flyers on the assembly model, then also during the purifying of the raw cotton portion the waste accumulated on the tape, and after the raw cotton purifying was completed, the required rotation speed

of the feed rollers was set, the regenerator layout and the tape movement were included.

If necessary, the regenerated bats were also cleared on the layout of the 1XK purifier.

The raw cotton to be purified was ginned on a 20 gin saw model, and the fiber was purified on a 3OBIM fiber purifier model with a saw cylinder length between the sidewalls of 440 mm.

The mode of operation and adjustment of the mockup for the purifier, gin and fiberglass, as well as aerodynamic parameters corresponded to those recommended for industry [2, 3].

## 2. Materials and Methodology

The methodology for conducting experiments and processing the results obtained was adopted as follows [4-6].

Designed for a series of comparative experiments, raw cotton with a certain debris and moisture for the first varieties of raw cotton in the range of 8–9% and for low 9–10% was hanged up to portions of the required mass. The minimum weight of a portion of 30 kg is selected on the basis of previously conducted poster studies [7, 8].

Samples of the initial and purified raw cotton, waste of the aggregate and regenerated volatiles, as well as fibers after fiber purifying and waste of gin and fiber purifiers, were selected in accordance with accepted sampling methods for laboratory analysis [9].

The number of analyzes was assigned depending on the purpose and responsibility of the experience, as well as the scatter of the values of the data obtained.

The weediness of the original raw cotton and regenerated volatiles was determined, as a rule, in at least three replicates for a series of compared experiments, and the remaining indicators - in one three replications. The grade and length of the fiber was determined in one repetition, the content of defects and trash in the fiber was determined in five replicates for each experiment. In addition, the quality of the fiber was determined on the device Spinlab.

If necessary, increase the reliability, the number of analyzes increased.

The obtained data were statistically processed in accordance with ГОСТ 8207-76 and the ПДМУ-109-77 guidelines.

The confidence limits of the values of debris in cotton and defects in the fiber were determined with a confidence level of 0.95.

The total cleaning effect, as well as large and small litter was calculated by the following formula [10]:

$$K = \frac{(C_1 - C_2) \cdot 100}{C_1} \quad (2)$$

where:  $K$  - cleaning effect, %

$C_1, C_2$  - debris of raw cotton before and after purifying, %

The cleaning effect of gin and fiber purifiers, as well as the entire process, was calculated by formula (2), for which the final contamination value was determined by the following

formula:

$$C = \frac{B \cdot C_f}{100} \quad (3)$$

where:  $B$  - fiber output, %

$C_f$  - the content of litter in the fiber, %

In the calculations, the fiber yield was taken equal to the planned.

The content of raw cotton flakes (or other fractions) in the waste of the purifiers as a percentage of the mass of the raw cotton was calculated by the formula:

$$S = \frac{L \cdot M_w}{M_{r/c}} \quad (4)$$

where:  $S$  - the content of raw cotton flakes (or other fractions) as a percentage of the mass of the initial cotton raw;

$L$  - content of raw cotton in the waste of purifiers, %;

$M_{r/c}$  - initial mass of raw cotton, kg;

$M_w$  - mass of waste purifiers, kg.

The technique of some series of experiments, depending on the tasks of experimental studies, had its specific features, which are described in the respective chapters.

For the development of a general methodology for conducting research, we have drawn up well-known and promising schemes for technological processes for the processing of regenerated volatiles, the studies of which should allow us to choose from them the optimal process or promising for improvement.

The first option is a regulated process of processing regenerated cotton slices, which include their supply after the regenerator to raw cotton before purifying and further joint processing.

The second variant differs from the first one by additional purification of the regenerated bats before they are fed into raw cotton.

The third option includes the additional purification of regenerated volatiles and their supply to the purified raw cotton before ginning.

The fourth option includes the accumulation and storage of regenerated volatiles, and then their separate processing from raw cotton on the same equipment.

The fifth option includes the purifying and ginning of regenerated bats on special equipment.

In the first place, the regulated process of processing regenerated bales will be investigated, and then the most promising processes, including additional purifying of regenerated cotton slices and their supply to raw cotton, either before purifying or before ginning (2nd and 3rd variants). It will also determine the efficiency of the processes with the separation of raw cotton from the processing of regenerated bales (4th and 5th variants).

Such a sequence of studies will allow choosing the optimal technological process for processing regenerated volatiles with a minimum amount of experiments.

When enterprises of the cotton-ginning industry operate in a market economy, the most important task of the industry is

to increase the competitiveness of products, both domestically and internationally. But, along with this, it is important to reduce the cost and increase the yield of products.

Solving these problems requires a significant increase in production efficiency, i.e. radical improvement in the quality of cotton fiber, maximum reduction of its losses, unproductive energy costs and equipment downtime.

Under these conditions, one of the main ways to improve production efficiency is the modernization and technical re-equipment of enterprises in the industry, with the introduction of the latest achievements of science and technology into production [11].

At the enterprises of the cotton-purifying industry for the effective purifying of raw cotton, which has increased contamination with small weed impurities, as well as clogged with large weed impurities-casement boxes, bracts, branch particles, etc., use of purifiers equipped with serrated drums working in combination with grates. Moreover, the clearance between the grate bars should exceed the size of large weed impurities, which are commensurate with the size of the raw cotton. As a result, raw cotton bolls, uluk, seeds and free fiber, the amount of which depends on the design of the purifying sections, their mode of operation and the place of incorporation into the process, fall into the waste of the saw blades through the grates, and also on the variety, debris and moisture of the raw cotton being purified.

In accordance with the current technological regulations for the processing of raw cotton, regenerated from the waste of serrate purifiers in the 1PX (PX) regenerators, the sheaves are mixed with the raw cotton supplied to the purifying equipment.

There are numerous reports that when applying regenerated by the existing technology of volatiles, the quality of the fiber deteriorates due to the content of defects and trash in the fiber.

The reason for this is the lack of technological process, which is expressed in the supply of the whole mass of "passive", i.e. isolated from cotton purifying sections from small weed impurities and not mixed with cotton, into the regenerator.

The studies conducted earlier at Bektemir Cotton Plant showed that due to the return of regenerated volatiles to the beginning of the purifying process, the content of defects and trash in the 2nd grade fiber increases after fiber purifiers 1BII by 0.9%, after BIIK - by 0.6%, after ББ-0.3%. Laboratory experiments also found that the regenerated volatiles have a fiber content of 30% (rel.) And a grade one point below the volatiles of the main stream. Based on this, it can be assumed that a part of the regenerated volatiles is re-released into the waste of the purifiers, and this happens before their almost full ginning and losses with the waste.

Thus, the existing technology for processing raw cotton vapors recovered from waste purifiers does not meet modern industry requirements.

The chosen topic today is very relevant, as it is aimed at improving the quality of products and, thus, increasing its

competitiveness in the world market, reducing losses of volatile materials together with irretrievable waste, which naturally has a positive effect on the yield of the final product.

The solution of the tasks is not possible without a thorough study of individual aspects of the process of regenerating raw cotton bolls from the waste of purifiers, ways to improve both the technological process and the design of individual parts and assemblies, process mechanics.

The purpose of this work is to justify improving the quality and yield of fiber by upgrading the process of regeneration of the volatiles from the waste products of raw cotton purifiers. Improvement of the process of regeneration of the volatile material from waste cotton purifiers by feeding the regenerator the volatile material previously separated from the passive litter with the development of a special device.

To achieve the above goal, the following research objectives:

- a. to analyze the previous studies on the process of purifying and regeneration of wastes from the waste, to choose and justify the direction of research;
- b. to develop a dynamic and mathematical model of the shock interaction between the shells and the grate in order to establish the reasons for the re-deposition of shells into waste;
- c. to justify the chosen direction of the solution of the problem arising from the compiled dynamic and mathematical models;
- d. to derive equations for calculating the force and time of impact of the cotton bolls on the grid-iron by using the theory of impact taking into account local deformations.
- e. determine the influence of mass and cross-sectional area of the regenerated fly on its absolute speed at the moment of impact on the grate;
- f. calculate the forces and time of impact of the bat on the grate, taking into account local deformations at its different masses.
- g. to determine the average values of the masses of volatiles, seeds, and fiber by the transitions of purifying raw cotton and regenerating volatiles;
- h. investigate the effect of supplying regenerated volatiles to the purifying process on the efficiency of the purifying process itself and the quality of the fiber;
- i. to investigate the effect of the supply of regenerated volatiles to the purifying process on the quantity and fractional composition of the waste;
- j. to carry out studies to determine the number and physical parameters of raw cotton flakes, re-dropping out of the sawed sections of the purifier;
- k. to investigate the effectiveness of a separate process for the purification of raw cotton and regenerated bales;
- l. to study the effect of various purifying plans of regenerated cotton slices and the places of their supply in raw cotton on the efficiency of the purifying process and the quality of the fiber;
- m. conduct pilot testing of the results of the thesis.

Previous studies have shown that the process is not

promising with separate processing of regenerated volatiles.

Technological processes with additional purification of the regenerated volatiles remained unexplored, at which the optimal place for their supply to the raw cotton purification process should be determined.

In order to obtain the most complete characterization of such processes with a minimum number of experiments, experiments were carried out with extreme variants - with the supply of regenerated bales to raw cotton before purifying and before ginning.

### 3. Experimental Results and Discussion

Studies conducted by the following method. Twelve servings of raw cotton of breeding S-6524 of machine collection of the II grade with humidity of 9.0 and contamination within 12.54-13 were prepared, 87% with mass of 50 kg each. Then nine batches were separately purified on the model of the unit according to plan 3 ( $10K + 2P$ ) =  $30K + 6P$  with a capacity of 7000 kg/h (in terms of). The waste selected during the purifying of each portion was separately collected and passed through the regenerator, and the regenerated vouchers were also collected separately. Then two portions of the regenerated volatiles were separately purified on the 1XK purifier mock-up once, two more portions were likewise purified twice, one portion was purified three times, another one four times.

After that, three portions of regenerated volatiles, one after the regenerator without additional purification, the second with single purification at 1XK, the third with double purification at 1XK, were added separately to three raw portions of raw cotton and mixed thoroughly, and then the mixed portions were purified on the model of the unit in the same mode with the previous portions. Thus, we simulated the supply of reclaimed regenerated bales to raw cotton, which had been purified according to different plans, before purifying.

Five servings of regenerated volatiles, one after the regenerator without additional purification, the second with a single purifying at 1XK, the third with double purifying at 1XK, the fourth with three times purifying at 1XK, the fifth with four times purifying at 1XK, separately added into five portions purified raw cotton and mixed thoroughly. Thus, we simulated the supply of regenerated bales purified according to different plans to raw cotton before ginning.

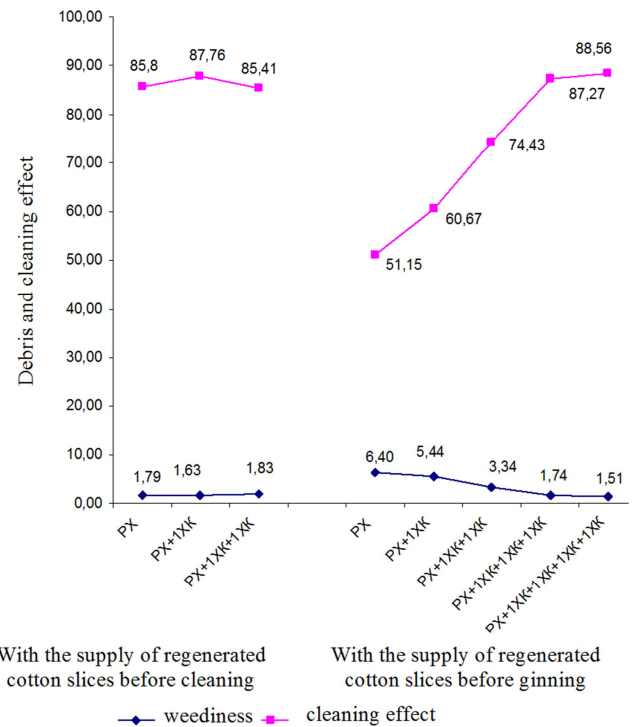
Regenerated flyers were not added at all to one portion of the purified raw cotton.

After that, all nine servings were upgraded to a 20-saw gin mock-up with a productivity of 10 kg per saw per hour, and the fiber was purified on a 1BII fiber purifier mock-up.

Plots of dependencies of raw cotton debris were plotted before ginning and the values of 1.49% calculated from them, and with three-fold purification of the regenerated volatiles on the 1XK purifier, almost the same contamination is achieved as in supplying the regenerated volatiles to the raw cotton before purification.

Also shown in the graph (figure 4), the dependences of the

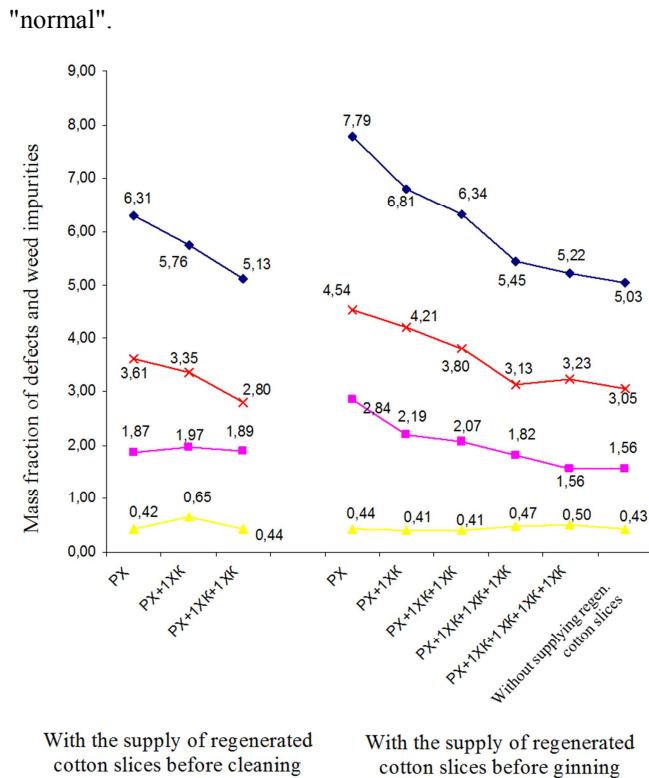
purifying effects almost completely correspond to the values of the residual purifying effects on the purifying plans of the regenerated volatile particles and the place of their supply to raw cotton (figure 5).



**Figure 4.** Weediness of raw cotton before ginning and cleaning effect, depending on the plans for purifying regenerated cotton slices and the place of their supply to raw cotton.

As can be seen from the graph (figure 5), when feeding regenerated bolls into raw cotton before purifying, their purifying plan has almost no effect on the weediness of purified raw cotton, which is obtained within 1.63-1.83%, and when fed regenerated bolls in purified raw cotton, their purifying plan significantly affects the clogging of mixed raw cotton, which decreases with an increase in the multiplicity of additional purifying from zero to four 1XK purifier and decreases from 6.4 to 1.51%. It should be noted that the latter values are almost the same with the clogging of raw cotton, to which no regenerated batters were applied at all - raw cotton with an increase in the frequency of their purification cleaning effects increase from 51.15 to 88.56%. The dependences of the content of defects and weed impurities in the fiber on the purifying plan and the place where the regenerated bales are fed into cotton are constructed. With an increase in the multiplicity of purification of the regenerated volatiles from zero to two times on the 1XK purifier and their supply to raw cotton before purifying, the content of defects and trash impurities decreases from 6.13 to 5.13%, respectively, the fiber grade increases from II to I when the fiber class is "normal", and when feeding regenerated batters into raw cotton, before ginning, as their purifying ratio increases from zero to four times, the content of defects and trash is reduced from 7.79 to 5.22%, respectively, the fiber grade increases from III- go to i-th when class All fibers are





**Figure 5.** The content of defects and weed impurities in the fiber, depending on the purifying plan and the place where the regenerated cotton slices are fed into raw cotton.

As can be seen, in experiments with double purification of regenerated volatiles and their supply to the original cotton, with four purifiers and feeding into purified cotton, as well as without feeding regenerated volatiles into raw cotton, the values of the content of defects and weed impurities in fiber, respectively 5.13%, 5.22% and 5.03%.

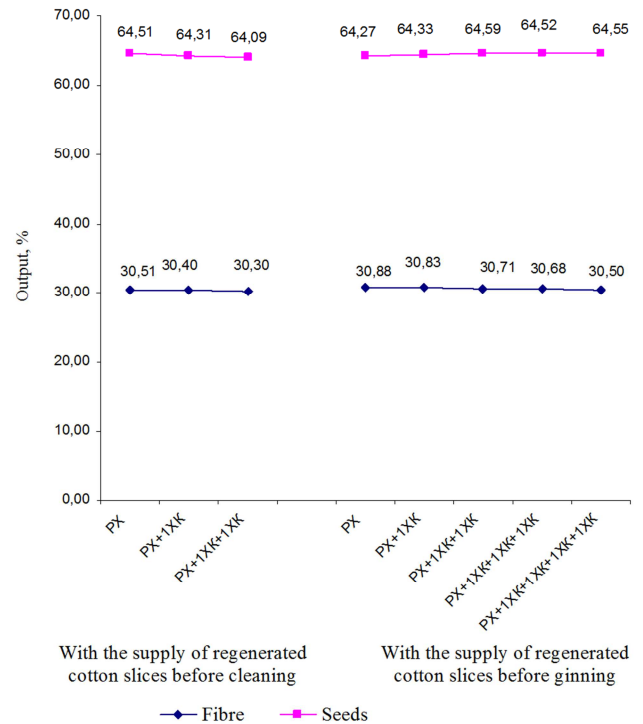
According to these results, it can be concluded that additional purifying with the optimum regime for regenerated bats can practically eliminate the negative effect of supplying regenerated bats to raw cotton both before purifying and before ginning [12-15].

Graphs were also plotted of the yields of fiber and seeds on the purifying plan for the regenerated volatile material and the place of their supply to raw cotton (figure 6).

Thus, when feeding raw cotton before ginning untreated regenerated bales, i.e. practically without waste during their purifying, the fiber yield increases by 0.78%, and seeds - by 1.48%.

According to the obtained results, we can conclude that the best option for processing the regenerated bats is their three-fold purifying with a 1XK type purifier and feeding into raw cotton before ginning.

In this variant, in comparison with the regulated process of processing regenerated volatiles, an increase in the yield of fiber by 0.17%, and of seeds by 1.8% is achieved while retaining the 1st grade of fiber.



**Figure 6.** The output of fiber and seeds, depending on the purifying plan and places for feeding raw regenerated bales.

The calculation based on the weighted average clogging shows that if the number of regenerated volatiles after the regenerator did not exceed 4% of the weight of the raw cotton being purified, then their contamination after triple purifying by 1XK did not exceed 7.75%, which is 5.17 times higher than the debris of the cotton being purified raw. This condition may be a criterion for choosing the minimum purifying plan for regenerated volatiles.

The most promising way of implementing the developed recommendation on the supply of sufficiently purified regenerated bats into raw cotton before ginning is the development of a regenerator-purifier based on the 1PX regenerator with built-in purifying sections for small litter, for example, of the EH.178 type, and with adjustable purifying ratio on the drum with saws and drum with rods.

## 4. Conclusions

1. It has been established that during the purification of difficult-to-clean raw cotton of the C-6524 selection of machine collection of Class II with an initial contamination of 12-14%, due to the supply of regenerated vials to it, the process efficiency and fiber quality are significantly deteriorated. With a maximum purifying plan that includes 40 spiky and 8 serrated drums, the purifying effect is reduced by 4.35% (abs.) And by a hive by 17.62% (abs.), which is equivalent to excluding from the purifying process, respectively, 33.62% and 18.6%, and the increase in seed damage increases by 1.47% (abs.). The content of defects and weed impurities in the fiber increases by 1.29-1.4% (abs.), with the result that the fiber grade decreases from the 1st to the 2nd.

2. It was determined that the supply of regenerated volatiles to raw cotton before purifying significantly affects the quantity and fractional composition of the waste of the purifying sections by the transitions of the purifying process: including the number of volatiles increases from 1.0 to 1.69%, fiber increases from 0.355 to 0.652%, seeds decrease from 0.342 to 0.328%, uluk increases from 0.18 to 0.492%, weed impurities increase from 11.99 to 15.53%. An increase in the amount of waste, fiber and uluk, as well as trash impurities, indicates that they will fall out repeatedly. This process will eventually lead to a deterioration in quality and lower yields of cotton products.

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