Improved cotton fences for a sustainable approach to cotton cleaning

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Abstract: The article presents the results of research on the improvement of the grate to improve the efficiency of cleaning cotton gins from major contaminants. To achieve the goals of increasing efficiency, the existing technologies for cleaning raw cotton and the equipment used were analyzed. In the studies, industrial varieties of raw cotton, the most common in the region, were chosen as raw materials. Cotton I - technical grade was used with a soiling level of 6.6% and a moisture content of 8.2%. By attaching the cotton wool to the saw drum, one can increase the distance between the posts by increasing the distance between the strings by moving the first post down a distance L to make sure it also goes to the lower drum of the saw in the access path. In the experiments, the distance between the first column and the second column was set equal to 40 mm, 50 mm, 60 mm and 70 mm, and the distribution of sawdust in the drums was studied taking into account the amount of cotton transported. The main attention during the experimental studies was directed to the location of the grates relative to the saw cylinder and the distance between the grates. For experimental studies, laboratory equipment was manufactured and carried out in the conditions of the Joint Stock Company "Scientific Center of the Cotton Industry". As a result, with the improvement of the location of the grate on the grate, the cleaning efficiency was 42.6%, and the number of pieces of cotton in the waste was 5.2%, as indicated in the technological description of the unit, the number of grates increased by one unit.

1 Introduction

The main problems in the cleaning and regeneration of cotton raw materials and the operation of fiber cleaners are the low efficiency of cleaning from large and small impurities, high damage to fibers and seeds, insufficient efficiency of regeneration of cotton from waste, many repetitions of fiber cleaning, high required power, etc. The research is mainly focused on improving the technology of cleaning raw cotton and fiber from dirty impurities, and the research on the changes in the distance between piled drums and the mesh surface depending

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on the level of cotton contamination, the distribution of the amount of cotton in the cleaning drums by changing the construction of the colosniks, and the additional connection with aerodynamic methods in fiber cleaning have not been sufficiently studied.

ChP-3M (Cotton purifier 3 modernized) and UCC (Universal Cotton cleaning Combined) cleaners are used in ginneries to clean medium-fiber cotton varieties from large contaminants. In order to achieve high cleaning efficiency, a number of scientists have proposed various constructive and technological changes based on theoretical and experimental research on the cotton cleaning process, rational technological performance of cleaning working bodies, optimal operating modes of working bodies.

In the researches [4; 5; 6; 7; 9; 10; 16-19] the effect of the number of chimneys of different diameters of the saw drums on the cleaners on the cleaning efficiency was studied, with the recommended sawmill drum diameter 200-250 mm, rotation speed 7 m/sec. As a result of the research, it was recommended to install 9 chisels with a spacing of 30 mm in the CC-3 (Cotton Cleaner 3 Series) cleaner with a saw drum diameter of 250 mm.

The following [8; 12; 13; 20; 23; 24] scientific studies show that the theoretical and practical studies of the technological process of cleaning raw cotton from impurities increase cleaning efficiency with increasing angle of inclination of the working edge of the chisel, but the increase in cotton particles the distance between the grate is recommended to be 16–18 mm.

The following [1; 2; 3; 11; 21; 22] have recommended a new saw-column system installed in a cleaner designed to clean cotton from major contaminants. It is recommended to install the columns with a group of three columns, with the distance between the saw drum and the first column being 16 mm, the distance between the second column being 14 mm, and the distance between the third column being 12 mm. However, this proposal was not implemented in practice [14; 15].

Although the results have been achieved on the basis of all research, to date, scientific research is underway to increase the efficiency of cleaning cotton by reducing the selection of varieties, reducing electricity consumption of cleaners. Research has shown that in order to increase the efficiency of the UHC cleaner, it is necessary to properly distribute the cotton between the saw drums and perform the spinning process, which can be done by sinusoidal placement of the columns on the grid.

2 Materials and Methods

The purpose of the research is to improve the technology of cleaning cotton from small and large impurities and to create a new efficient construction of fiber cleaning. Research tasks:

- development of resource-saving and high-efficiency constructions of cotton raw material cleaners from small and large impurities and fiber cleaners;
- improvement of the process of sifting and distribution of cotton through colosniks to clean it from large impurities;
- improving the technology of cleaning cotton from large impurities with the use of versatile polymer material colosniks;
- to study the influence of the change of the spacing of the colosniks on the movement of the sawing cylinder on the cleaning efficiency and the change of the amount of cotton in the waste;
- study of modes of technological equipment for aerodynamic cleaning of cotton fiber;
- determining the optimal parameters of cotton raw material cleaners from small and large impurities and fiber cleaners through the results of full-factor experiments.
Theoretical mechanics, theory of vibrations, mathematical statistics, theory of probability, higher mathematics, technology of initial processing of cotton and methods of planning experiments were used in the research process.

In the experimental work, the following parameters of a grating grate with a sinusoidal position mounted under a high-saw drum were studied:
- distance between the first column and the second column, \( L \);
- slip between columns, \( \Delta \);
- rotational speed of the saw drum, \( V \).

In this case, there are 10 cranes in the grate under the upper saw drum, 5 of which are in place, and the remaining 5 are moved along the arc connecting them in the last column axis in the direction of rotation of the saw drum. In this case, the distance \( L \) between the first column and the second column is greater, and the displacement \( \Delta \) of the rest is \( \Delta_1, \Delta_2, \Delta_3, \ldots \) decreases. Separating the columns from the arrowhead by moving one arc along the last axis of the column is sinusoidal, and the impact of the sawdust on the column causes the discharge of contaminants, in which case the distance between the first column and the second column is the largest. It also helps to pass it to the drum, the equalization of the amount of cotton in the saw drums increases its cleaning efficiency. In experiments, it is sufficient to move only the first column along the arc and calculate the distance, because the displacement of the remaining columns occurs in series, depending on the first column.

Fig. 1. Improved grate scheme:
- 1 – saw cylinder, 2 – grate,
where: \( R_1 \) is the distance from the center of the saw cylinder to the center of the first grate in the direction of movement of the fibrous material;
\( R_{ct} \) – saw cylinder radius; \( \delta_1 \) is the gap between the saw cylinder and the second grate; \( r_k \) is the radius of the grate, and each subsequent displacement after the first grate \( \Delta_n = R_n - R_{ct} - \delta_1 - r_k \);
\( t_n - 1 \) – circular step between adjacent grates; \( n \) is the serial number of the grate in the direction of movement of the fibrous material; \( t \) is a constant step between adjacent grates; \( \Delta_n - 1 \) is the displacement between the grates.

The technical result of the invention is to increase the efficiency of cleaning fibrous material.

The first section of the UСC ginning system was prepared in the laboratory building of JSC "Scientific Center of Cotton Industry" (Tashkent, Uzbekistan) for conducting experiments (Figure 2).
Fig. 2. UСС is a laboratory equipment for cleaning cotton from large contaminants. The cotton is also distributed to the lower saw drum by increasing the spacing based on the sinusoidal location of the columns, adjusting the spacing of the three columns at the entrance to the cotton of the column grate. In addition to the distribution of cotton during the movement of the upper column of the sinusoidal position of the upper column with the saw drum teeth, the grinding process is also carried out.

3 Results and Discussion

In order to separate the cotton from the saw drums on the laboratory stand during the experiments, a strip of cotton was cut from the bottom of the upper drum. In the experiments, the amount of cotton transported was cleaned on a high-saw drum and the amount of splitting was determined. It used I-industrial grade cotton with a pollution level of 6.6% and a humidity of 8.2%. By attaching the cotton to the saw drum, it is possible to increase the distance between the struts by increasing the distance between the strings by sliding the first strut down to a distance L to ensure that it also passes to the lower saw drum in the access path. In the experiments, the distance between the first column and the second column was set to 40 mm, 50 mm, 60 mm and 70 mm, and the distribution of sawdust drums was studied taking into account the amount of cotton transported. shown in the Table 1.

<table>
<thead>
<tr>
<th>№</th>
<th>Column spacing, mm.</th>
<th>Distribution of cotton on drums, kg /%</th>
<th>Contamination level of refined cotton, %</th>
<th>High drum cleaning efficiency, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>40</td>
<td>75/75</td>
<td>25/25</td>
<td>5.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>15.1</td>
</tr>
<tr>
<td>2</td>
<td>72</td>
<td>72/72</td>
<td>28/28</td>
<td>5.5</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>16.7</td>
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<tr>
<td>3</td>
<td>74</td>
<td>74/74</td>
<td>26/26</td>
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<td></td>
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<td></td>
<td></td>
<td>16.0</td>
</tr>
<tr>
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<td></td>
<td>73.7 / 73.7</td>
<td>26.4 / 26.4</td>
<td>5.5</td>
</tr>
<tr>
<td>1</td>
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<td>65/65</td>
<td>35/35</td>
<td>5.3</td>
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<td>36/36</td>
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<td>36.4 / 36.4</td>
<td>5.3</td>
</tr>
<tr>
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</tr>
<tr>
<td>mean</td>
<td></td>
<td>60/60</td>
<td>40/40</td>
<td>5.24</td>
</tr>
</tbody>
</table>

Table 1. Influence of column spacing on cotton distribution and cleaning efficiency.
The distance between the first column and the second column at the entrance to the cotton grate is 40 mm. The increase in the amount of cotton passing through the UСС cleaner to the lower saw drum and the decrease in the amount of cotton in the upper saw drum increase the efficiency of the UСС cleaner. Experiments were carried out using two saw drums at these distances, keeping the distance between the columns under the lower saw drum at 40 mm. The results of the experiment are shown in Figure 3 below.

<table>
<thead>
<tr>
<th>Distance (mm)</th>
<th>Overall Cleaning Efficiency (%)</th>
<th>Amount of Cotton in Waste (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>35</td>
<td>5.5</td>
</tr>
<tr>
<td>50</td>
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<td>70</td>
<td>32</td>
<td>8</td>
</tr>
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</table>

Fig. 3. Influence of the distance between the first column and the second column on the total cleaning efficiency of the aggregate and the amount of cotton particles in the waste when sinusoidally placing the columns in the grid.

As can be seen from Figure 3, the total cleaning effect of a UHC unit changed as the amount of cotton in the upper saw drum was reduced and distributed to the lower saw drum by increasing the spacing by lowering the first column of the cotton inlet direction in the sinusoidal position of the upper saw. At the same time, the total cleaning efficiency at 40 mm between the columns is 35%, the amount of waste cotton remains at 5.5%, but further enlargement between the columns is 60 mm, the total cleaning efficiency at 70 mm is 40%, 32%, and the amount of cotton in the waste is 6%, 8%. It was found that the cleaning efficiency at a distance of 60 mm between the columns is 40% higher. Setting the distance to 70 mm resulted in a 32% reduction in the cleaning efficiency from the increase in cotton in the lower saw drum, and a large passage of cotton pieces into the waste. In order to eliminate such cases, the grate installed under the lower saw drum was improved, and the issue of reducing the waste cotton pieces and increasing the cleaning efficiency was considered by reducing the distance between the grate saws along the hexagonal and cotton movement direction.

At the bottom of the lower saw drum there are 15 chisels, which are placed on the side ribs of the chisel grille to reduce the distance between them in the direction of the cotton and drilled a hole by sliding them along the arrow line.
Improved bottom grate grille: 1 - saw cylinder, 2 - grate, $h_1$ - distance between 1th and 2th grate, $h_2$ - distance between the 2th and 3th grate, ..., $h_{14}$ - distance between 14th and 15th grate, $h_{15}$ - distance between 15th and 16th grate.

Observations of the operation of the cleaner showed that mainly large contaminants were more separated in the first five of the grate grate, and in the remaining 10 pieces more cotton particles fell into the waste chamber. Therefore, experiments were carried out by reducing the spacing of the first five columns in the direction of cotton, leaving the first five columns without changing the spacing of 40 columns. 2 mm and 3 mm, in which case the distance between the columns was reduced to 1 mm, 39; 38; 37; 36 mm, 38 when reduced to 2 mm per hectare; 36; 34; 32; 30; 28 mm, 37 when reduced to 3 mm; 34; 31; 28; 25; 32 mm, and 37.

The effect of the decrease in 22 mm on the cleaning efficiency and the amount of cotton pieces in the waste was determined Figure 5.

Fig. 5. The effect of the reduction of the distance between the columns on the cleaning efficiency and the amount of cotton in the waste.

Above show that the reduction in the distance between the columns by 1 mm in the direction of cotton movement is 40.5%, and the amount of cotton pieces in the waste is 8.5%, when the distance between the columns is reduced by 2 mm. The efficiency of cleaning increased by 42.6%, the amount of cotton fiber in the waste was 5.2%, when the distance between the
when the spacing of the columns was reduced to 4 mm, the cleaning efficiency was reduced to 32.6%, and the amount of cotton waste was reduced to 4.2%, while the spacing of the last three columns was adjusted to the same size by 8 mm. This approach also reduces cleaning from contaminants. Reducing the spacing of the columns one after the other increased the number of columns by 1 and 2.

Thus, the conducted experimental studies have shown that their results in terms of the efficiency of cleaning raw cotton are on average 5.6–7.2% higher than those proposed in the work [1–3; 7; 8; 10–12] UCC installations.

4 Conclusion

The scientific and practical significance of the research results is as follows. The scientific significance of the research results is that a resource-efficient, new construction of aggregates for cleaning cotton and fiber from impurities has been developed, rational parameters have been determined and connections have been obtained, and parameters have been based on complex research.

The practical significance of the research results is to improve the constructions of cotton cleaners and fiber cleaners, which ensure obtaining high-quality cotton fiber with high productivity due to the intensification of cleaning processes and the increase of work resources. A cotton processing system was recommended based on the effective composition of the developed constructions.

The Federal Service for Intellectual Property of the Russian Federation has received patents for three inventions for devices in the technological process of cleaning cotton raw materials and fiber from impurities: ("Ochistitel hlopka-syrtsa", RF No. 2784500-2022 g.; "Kolosnikovaya reshetka ochistitelya voloknistogo materiala", RF No. 2710829-2019 g.; "Ochistitel volokna", RF No. 2783448-2022 g.). Scientific results made it possible to develop equipment for effective cleaning of raw cotton and fiber from impurities; the developed new cotton ginning equipment and technologies were introduced to the cotton ginning workshop in the enterprise of the "Cotton-textile clusters" association system, including the cotton ginning enterprise belonging to LLC "APK BUKA" of the Tashkent region. As a result, compared to the existing technological process, the efficiency of the proposed technological process was 3.4% higher in type I and 5.4% in type IV, and the quality indicators of processed cotton fiber were improved.

The developed aeromechanical fiber cleaning equipment was introduced to the ginning workshop at the enterprise of the "Cotton-textile clusters" association system, including the cotton cleaning enterprise belonging to LLC "APK BUKA" of the Tashkent region. As a result, the cleaning efficiency of the improved fiber cleaner is 5.4÷6.5% higher than the current 2VPM fiber cleaner according to industrial grades, the amount of coarse and dirty impurities in the cleaned fiber is reduced by 0.3%, and the fiber content of the waste is reduced by 2.9÷1.7% has been achieved.

From the above results, it can be seen that the cleaning efficiency is higher than the reduction of the distance between the columns by 2 mm along the cotton path, and the amount of waste cotton pieces was 5.2%, as indicated in the technological description of the unit, the number of grates increased by one unit.
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