

# Improving the Efficiency of Seed Cotton Cleaning Technology through Differentiated Technological Clearances in Peg-Spike and Saw Drum Sections

Azimdjan Parpiyev<sup>1</sup>, Farxod Sadikov<sup>1</sup>, Alisher Usmankulov<sup>1</sup>, Abdul-Malik Kayumov<sup>2</sup>

<sup>1</sup>Department of Natural Fiber and Fabric Processing Technology, Jizzakh Polytechnic Institute, Jizzakh, Uzbekistan

<sup>2</sup>Department of Technological Machines and Equipment, Namangan State Technical University, Namangan, Uzbekistan

Email: azimdjanparpiyev@gmail.com, sadikovfarxod88@gmail.com, Usmankulov1968y@mail.ru, abdulmalikhamidovich@gmail.com

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## Abstract

**Purpose:** This study aims to improve the efficiency of seed cotton cleaning technology by establishing rational, differentiated technological clearances between the peg-spike and saw-drum working elements and the underlying grid/mesh surfaces, accounting for the progressive structural transformation of cotton locks during processing. **Methodology:** The structural composition of seed cotton was quantified using a structural indicator  $K$ , defined as the ratio of the total count of individual cotton locks to the total count of seeds in 50 g samples taken before processing and after each cleaning section. The proportion of single-seed locks ( $P_{\text{single}}$ ) was evaluated independently to distinguish structural loosening from lock dispersion. Two cleaning-line configurations were evaluated on a laboratory test bench at the Tashkent Institute of Textile and Light Industry: Variant 1, the standard configuration (32 drums: 4 peg-spike and 4 saw-drum sections) with a constant clearance of  $\Delta = 15$  mm, and Variant 2, a proposed combined redesigned line (24 peg-spike drums in 6 sections and 6 saw drums) with a differentiated clearance sequence of  $\Delta = 18 \rightarrow 15 \rightarrow 12$  mm. Trials were conducted under fixed operating parameters across five independent replications ( $n = 5$ ). **Findings:** The share of single-seed cotton locks reached 70% - 96% after only two peg-spike/saw-drum passes, confirming that cotton-lock geometry diminishes rapidly during cleaning. Implementing the combined line redesign with differentiated clearances in Variant 2 raised the overall cleaning efficiency from 80.70% to 95.06%, with fine- and coarse-trash removal improving by 4.71 and 9.65 percentage points, respectively ( $p < 0.05$ ), without inducing fiber damage or seed chip-

ping. **Originality/Value:** This study provides the first quantitative link between an empirical structural indicator of lock disintegration and a stage-wise, differentiated clearance schedule, providing an industrial engineering basis for upgrading primary cotton-cleaning lines.

## Keywords

Seed Cotton, Cotton Ginning, Cleaning Efficiency, Structural Indicator, Peg-Spike Drum, Saw Drum, Technological Clearance, Trash Removal, Fine Trash, Coarse Trash.

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## 1. Introduction

In the cotton-ginning industry, peg-spike (paddle) cylinders, saw cylinders, grid surfaces, and grid bars are the principal working elements used to remove fine and coarse trash from seed cotton. Over recent decades, cleaning-line configurations have evolved from battery-type arrangements to continuous multi-section lines that combine peg-spike and saw-drum modules, and primary cleaning equipment has undergone continuous modernization as a result.

Today, the UHK cleaning complex is the standard line used in most ginning mills. It typically combines a 1XK-type cleaner, whose peg-spike cylinder sections target fine trash, with a UHK-type cleaner, whose saw-cylinder sections remove both fine and coarse trash. In standard industrial lines, seed cotton passes sequentially through 20 - 32 peg-spike cylinders and 3 - 4 saw-cylinder sections.

### 1.1. Related Work

The theoretical foundations of raw-cotton cleaning technology were laid by Burnashev [1] and further developed by Muhsinov [2], who examined feeding and cleaning processes within continuous-flow ginning technology. Subsequent studies concentrated on individual working elements: Ibrogimov [3] and Dzhuraev [4] investigated the design parameters of feeding devices and feed-grid-bar systems, respectively, while Usmanov *et al.* [5] proposed a combined drying-and-cleaning line for raw cotton.

More recent work has focused on optimizing drum arrangement and working-element geometry. Fayziyev [6] examined stripping peg-spike drums for fine-trash cleaning sections; Khakimov [7] and Bozorov [8] analyzed how the number of installed drums affects both cleaning efficiency and fiber quality; Djurayev *et al.* [9] evaluated the cleaning performance of currently operating cotton cleaners; and Raxmonov [10] proposed upgraded working elements for fine-trash cleaners.

A separate group of studies addressed the structural and deformation behavior of seed cotton as it passes through cleaning equipment [11]-[15], establishing that the geometric dimensions and bulk density of cotton locks change substantially during processing. Most recently, Parpiyev *et al.* [16] reported detailed studies of cotton movement, equipment performance, and grid-bar positioning within indus-

trial cleaning lines operating at Uzbek ginneries.

Despite this substantial body of work, none of the cited studies has quantitatively linked the progressive structural transformation of cotton locks to a correspondingly differentiated, stage-wise technological clearance between the working elements and the grid/mesh surfaces. In current practice, this clearance is kept constant—typically  $\Delta = 15$  mm—throughout the entire cleaning line, regardless of how the physical dimensions of the cotton locks change from one section to the next.

## 1.2. Problem Statement

A structural and technological analysis of the working elements described above highlights two critical issues:

1. In standard peg-spike cleaners, a mesh surface with  $6 \times 50$  mm openings is positioned at a constant 15 mm clearance beneath the cylinder. Trash particles larger than 6 mm therefore cannot pass through the mesh and remain mixed with the cotton mass; moreover, repeated spike impacts compress the cotton, increasing its bulk density and further embedding fine trash particles within the fiber structure.
2. In saw cleaners, trash separation occurs as cotton locks are dragged along grid bars (20 mm in diameter, with a 40 mm inter-bar gap). The working clearance between the saw-tooth tips and the grid bars is likewise kept constant at 15 mm across all processing stages.

Seed cotton undergoes marked structural changes during processing: as large, dense locks disintegrate into smaller units, their geometric volume decreases substantially. A uniform 15 mm clearance creates a mismatch across the line: in the early stages, oversized locks are subjected to excessive mechanical friction and seed damage, whereas in later stages the now-smaller locks fail to make active contact with the grid bars, sharply reducing cleaning efficiency.

Optimizing seed-cotton cleaning technology requires a dynamic approach, in which the working clearances between the cylinders and the grid surfaces are progressively adjusted to match the changing physical dimensions and density of the cotton locks as they move through the cleaning line.

## 1.3. Research Aim, Objectives, and Novelty

**Research aim:** to evaluate the structural transformation of seed cotton during cleaning and to establish rational, differentiated technological clearances across peg-spike and saw-drum sections that maximize cleaning efficiency while preserving fiber and seed quality.

To achieve this aim, the following objectives were addressed:

1. To quantify the structural transformation of seed cotton locks during sequential cleaning using a structural indicator  $K$ , while distinguishing it from the mass fraction of single-seed locks;
2. To evaluate the cleaning performance of a standard line ( $\Delta = 15$  mm) versus a

proposed line redesign incorporating a differentiated clearance schedule ( $\Delta = 18 \rightarrow 15 \rightarrow 12$  mm);

3. To determine the individual and cumulative cleaning efficiency of peg-spike and saw-drum sections for fine and coarse trash under both configurations.

**Novelty:** for the first time, a quantitative structural indicator of cotton-lock composition is linked to a stage-wise, differentiated clearance schedule for a combined peg-spike/saw-drum cleaning line, providing a practical route to increasing cleaning efficiency without additional fiber or seed damage.

## 2. Materials and Methods

### 2.1. Structural Evaluation Method of Seed Cotton

To quantify changes in the structural composition of seed cotton during processing, the structural indicator  $K$  was evaluated using the following relationship:

$$K = \left( \frac{M}{N} \right) \times 100\% \quad (1)$$

where  $M$  is the total number of individual cotton locks in the tested sample, and  $N$  is the total number of seeds in that sample.

To prevent confounding structural loosening with lock dispersion, the structural indicator  $K$  was treated as a metric of lock fragmentation, whereas the proportion of single-seed locks ( $P_{\text{single}}$  %) was recorded as an independent dimensional distribution metric based on physical sorting into seed-count categories (1-seed, 2-seed, up to 10-seed locks). Samples weighing 50 g each were extracted before processing and after passing through each cleaner section.

### 2.2. Experimental Test Bench, Line Configurations, and Clearance Justification

Experimental investigations were conducted on a laboratory test bench at the Tashkent Institute of Textile and Light Industry (**Figure 1**).



**Figure 1.** Experimental test bench (schematic configuration with 4 peg-spike drums and 1 saw drum shown).

Variant 1 (Control/standard configuration): represents the conventional industrial setup, consisting of 32 drums in total: 4 peg-spike drum (PD) sections and 4 saw-drum (SD) sections. A constant technological clearance of  $\Delta = 15$  mm was maintained between the main working elements and the grid/mesh surfaces across all stages.

Variant 2 (Proposed combined line redesign): featured 24 peg-spike drums (6 sections) and 6 saw drums arranged in an alternating sequence. The operational clearance was differentiated stage-wise: In the initial 4 sections (2 PD + 2 SD), clearance was set to  $\Delta = 18$  mm; In the subsequent 2 sections (1 PD + 1 SD), clearance was set to  $\Delta = 15$  mm; In the remaining 6 sections, clearance was set to  $\Delta = 12$  mm.

**Physical Justification of Clearances:** The clearance values (18 mm, 15 mm, and 12 mm) were determined directly from the empirical geometric envelope of the cotton locks measured across the stages. Initially, multi-seed locks exhibit mean diameters of 20 mm to 26 mm; setting  $\Delta = 18$  mm prevents aggressive mechanical pinching, minimizes seed damage, and permits the release of large coarse debris without crushing. As locks disintegrate into intermediate clusters (15 mm - 18 mm), the clearance is narrowed to  $\Delta = 15$  mm. In the final sections, where over 85% of locks disintegrate into single-seed units with diameters of 12 - 14 mm, reducing the gap to  $\Delta = 12$  mm ensures active contact between the cotton tufts and the grid bars, eliminating inactive bypass.

### 2.3. Determination of Cleaning Efficiency

Waste fractions separated from each individual section were collected, weighed, and categorized into fine and coarse trash. Individual section cleaning efficiency ( $\Delta C$ ) and cumulative efficiency ( $K_{cum}$ ) were calculated relative to both the initial trash content ( $C_{total} = 12.53\%$ ,  $C_{fine} = 4.89\%$ ,  $C_{coarse} = 7.64\%$ , moisture content  $W = 8.8\%$ ) and the localized, pre-section trash content ( $C_i$ ):

$$K = \left[ (C_i - C_{i-1}) / C_i \right] \times 100\% \quad (2)$$

where  $C_i$  is the cotton trash content prior to the cleaning section (%),  $C_{i-1}$  is the trash content of the cotton after the section, and  $C_i - C_{i-1} = \Delta C$  is the trash separated in that section.

## 3. Results and Discussion

### 3.1. Structural Dynamics of Seed Cotton Locks

Experimental analysis revealed that as seed cotton moves through sequential cleaning passes, its structural composition changes significantly: the initially large and irregular cotton locks are progressively disintegrated into smaller units under mechanical impact. **Table 1** shows the dynamic variation of the structural indicator  $K$  and lock distribution across three cotton varieties.

As shown in **Table 1**, the proportion of single-seed locks reached 75.48%, 74.65%, and 70.93% after cleaning through one set of peg-drum and saw-drum sections, and

87.32%, 96.00%, and 87.54% after processing through two sets of sections, respectively. That is, the cotton locks predominantly transformed into near-spherical shapes with an effective diameter of 14 mm - 16 mm [13]. In subsequent peg drums of a standard line, this transformation causes spike impacts to strike the upper fiber layer rather than lock edges, weakening trash expulsion. In saw drums with excessive clearance, a compact single-seed lock engaged by a saw tooth may pass through without contacting the grid bar, reducing separation efficiency.

**Table 1.** Variation of seed cotton structural composition during cleaning.

| No. | Number of Seeds per Cotton Lock      | Number of Cotton Locks |                 |                 | Number of Cotton Locks |                 |                 | Number Of Cotton Locks |                 |                 |
|-----|--------------------------------------|------------------------|-----------------|-----------------|------------------------|-----------------|-----------------|------------------------|-----------------|-----------------|
|     |                                      | C65-24 5/3, C = 28.97% |                 |                 | C65-24 1/3, C = 10.62% |                 |                 | Porloq 2/3, C = 16.3%  |                 |                 |
|     |                                      | Initial                | After 1PD - 1SD | After 2PD - 2SD | Initial                | After 1PD - 1SD | After 2PD - 2SD | Initial                | After 1PD - 1SD | After 2PD - 2SD |
| 1   | 1                                    | 29                     | 196             | 278             | 20                     | 182             | 257             | 17                     | 176             | 261             |
| 2   | 2                                    | 9                      | 23              | 15              | 9                      | 20              | 7               | 6                      | 28              | 11              |
| 3   | 3                                    | 6                      | 8               | 5               | 5                      | 4               | 2               | 5                      | 5               | 4               |
| 4   | 4                                    | 5                      | 6               | 3               | 5                      | 2               | 0               | 5                      | 5               | 2               |
| 5   | 5                                    | 5                      | 1               | 1               | 5                      | 2               | 0               | 6                      | 5               | 1               |
| 6   | 6                                    | 5                      | 2               | 0               | 7                      | 2               | 0               | 8                      | 1               | 1               |
| 7   | 7                                    | 8                      | 1               | 1               | 7                      | 1               | 0               | 10                     | 1               | 1               |
| 8   | 8                                    | 5                      | 0               | 0               | 4                      | 1               | 0               | 5                      | 1               | 0               |
| 9   | 9                                    | 1                      | 0               | 0               | 3                      | 1               | 0               | 1                      | 0               | 0               |
| 10  | 10                                   | 0                      | 0               | 0               | 1                      | 0               | 0               | 0                      | 0               | 0               |
| 11  | Number of cotton locks, M            | 73                     | 237             | 303             | 66                     | 215             | 266             | 63                     | 222             | 281             |
| 12  | Number of seeds in sample, N         | 231                    | 314             | 347             | 258                    | 288             | 277             | 262                    | 313             | 321             |
| 13  | Structural indicator of cotton, K, % | 31.60                  | 75.48           | 87.32           | 25.58                  | 74.65           | 96.00           | 24.04                  | 70.93           | 87.54           |

### 3.2. Performance Evaluation of Cleaning Variants

Based on the structural results above, the possibility of enhancing cleaning efficiency was investigated by introducing a variable clearance between the drums (peg and saw) and the grid surfaces, matched to the evolving structural composition of seed cotton, together with a partial replacement of peg-drum sections by saw-drum sections. The experiments were conducted in two variants in the laboratory of the Tashkent Institute of Textile and Light Industry (**Figure 1**).

Variant 1 consisted of 32 drums, with the clearance between the drums and the grid bar or mesh surface set to  $\Delta = 15$  mm across all 4 peg-drum and 4 saw-drum sections. Variant 2 consisted of 24 peg drums (6 sections) and 6 saw drums, with the clearance set to  $\Delta = 18$  mm in the initial 4 sections (2 PD + 2 SD),  $\Delta = 15$  mm in the subsequent two sections (1 PD + 1 SD), and  $\Delta = 12$  mm in the remaining six sections. The waste separated from each cleaning section was weighed individually to calculate the respective cleaning efficiencies; the results are presented in **Table 2** and **Figure 2**.

**Table 2.** Influence of the clearance between drums and mesh/grid surfaces on trash separation from seed cotton ( $C_{\text{total}} = 12.53\%$ ,  $C_{\text{fine}} = 4.89\%$ ,  $C_{\text{coarse}} = 7.64\%$ ,  $W = 8.8\%$ ).

| No.                                                                                                    | Section      | $\Delta$ ,<br>mm | Cotton,<br>kg | Trash,<br>g   | Trash,<br>% | Fine,<br>g    | Fine,<br>%  | Coarse,<br>g | Coarse,<br>% | Fine<br>Eff., % | Coarse<br>Eff., % | Total<br>Eff., % |
|--------------------------------------------------------------------------------------------------------|--------------|------------------|---------------|---------------|-------------|---------------|-------------|--------------|--------------|-----------------|-------------------|------------------|
| <b>Variant 1 (Constant Clearance, <math>\Delta = 15</math> mm)</b>                                     |              |                  |               |               |             |               |             |              |              |                 |                   |                  |
| 1                                                                                                      | 1 PD         | 15               | 10            | 91.04         | 0.91        | 88.0          | 0.88        | 3.45         | 0.03         | 7.02            | 0.24              | 7.26             |
| 2                                                                                                      | 2 PD         | 15               | 8.9           | 63.18         | 0.74        | 59.53         | 0.7         | 3.56         | 0.04         | 5.35            | 0.32              | 5.67             |
| 3                                                                                                      | 3 PD         | 15               | 7.83          | 49.89         | 0.64        | 46.26         | 0.59        | 3.52         | 0.05         | 4.71            | 0.4               | 5.11             |
| 4                                                                                                      | 1 SD         | 15               | 7.761         | 239.68        | 3.08        | 20.18         | 0.26        | 218.86       | 2.82         | 2.07            | 22.51             | 24.58            |
| 5                                                                                                      | 4 PD         | 15               | 6.524         | 28.33         | 0.43        | 25.44         | 0.39        | 2.61         | 0.04         | 3.11            | 0.32              | 3.43             |
| 6                                                                                                      | 2 SD         | 15               | 6.495         | 119.91        | 1.85        | 11.04         | 0.17        | 109.12       | 1.68         | 1.36            | 13.41             | 14.77            |
| 7                                                                                                      | 5 PD         | 15               | 5.356         | 16.8          | 0.31        | 15.2          | 0.28        | 1.61         | 0.03         | 2.23            | 0.24              | 2.47             |
| 8                                                                                                      | 3 SD         | 15               | 5.34          | 59.14         | 1.11        | 5.87          | 0.11        | 53.47        | 1.0          | 0.88            | 7.98              | 8.86             |
| 9                                                                                                      | 6 PD         | 15               | 4.27          | 9.37          | 0.22        | 8.54          | 0.20        | 0.85         | 0.02         | 1.6             | 0.16              | 1.76             |
| 10                                                                                                     | 4 SD         | 15               | 4.227         | 25.69         | 0.61        | 3.28          | 0.08        | 22.47        | 0.53         | 0.64            | 4.23              | 4.87             |
| 11                                                                                                     | 7 PD         | 15               | 3.228         | 4.35          | 0.13        | 3.55          | 0.11        | 0.64         | 0.02         | 0.88            | 0.16              | 1.04             |
| 12                                                                                                     | 8 PD         | 15               | 2.223         | 2.44          | 0.11        | 2.0           | 0.08        | 0.44         | 0.02         | 0.72            | 0.16              | 0.88             |
| 13                                                                                                     | <b>Total</b> |                  |               | <b>709.82</b> | <b>10.1</b> | <b>288.89</b> | <b>3.85</b> | <b>420.6</b> | <b>6.28</b>  | <b>30.57</b>    | <b>50.13</b>      | <b>80.70</b>     |
| <b>Variant 2 (Differentiated Clearance, <math>\Delta = 18 \rightarrow 15 \rightarrow 12</math> mm)</b> |              |                  |               |               |             |               |             |              |              |                 |                   |                  |
| 1                                                                                                      | 1 PD         | 18               | 10            | 138.44        | 1.38        | 132.86        | 1.33        | 5.58         | 0.05         | 10.61           | 0.4               | 11.01            |
| 2                                                                                                      | 1 SD         | 18               | 10            | 444.72        | 4.45        | 69.61         | 0.7         | 375.11       | 3.75         | 5.59            | 29.93             | 35.52            |
| 3                                                                                                      | 2 PD         | 18               | 10            | 52.85         | 0.53        | 50.07         | 0.5         | 2.78         | 0.03         | 3.99            | 0.24              | 4.23             |
| 4                                                                                                      | 2 SD         | 18               | 10            | 170.44        | 1.7         | 26.45         | 0.26        | 143.99       | 1.44         | 2.08            | 11.49             | 13.57            |
| 5                                                                                                      | 3 PD         | 15               | 7.153         | 33.92         | 0.47        | 32.58         | 0.45        | 1.34         | 0.02         | 3.59            | 0.16              | 3.75             |
| 6                                                                                                      | 3 SD         | 15               | 7.153         | 105.66        | 1.47        | 24.0          | 0.33        | 81.66        | 1.14         | 2.63            | 9.1               | 11.73            |
| 7                                                                                                      | 4 PD         | 12               | 7.153         | 17.29         | 0.24        | 16.53         | 0.23        | 0.76         | 0.01         | 1.84            | 0.08              | 1.92             |

## Continued

|    |              |    |       |                |      |               |             |               |             |              |              |              |
|----|--------------|----|-------|----------------|------|---------------|-------------|---------------|-------------|--------------|--------------|--------------|
| 8  | 4 SD         | 12 | 7.153 | 44.43          | 0.62 | 6.57          | 0.09        | 37.86         | 0.53        | 0.72         | 4.23         | 4.95         |
| 9  | 5 PD         | 12 | 4.921 | 10.77          | 0.22 | 10.28         | 0.21        | 0.49          | 0.01        | 1.67         | 0.08         | 1.75         |
| 10 | 5 SD         | 12 | 4.921 | 20.59          | 0.42 | 6.35          | 0.13        | 14.29         | 0.29        | 1.24         | 2.31         | 3.35         |
| 11 | 6 PD         | 12 | 4.921 | 7.68           | 0.15 | 7.04          | 0.14        | 0.64          | 0.01        | 1.12         | 0.08         | 1.2          |
| 12 | 6 SD         | 12 | 4.921 | 12.79          | 0.26 | 2.46          | 0.05        | 10.73         | 0.21        | 0.4          | 1.67         | 2.07         |
| 13 | <b>Total</b> |    |       | <b>1059.58</b> |      | <b>385.82</b> | <b>4.44</b> | <b>674.78</b> | <b>7.49</b> | <b>35.28</b> | <b>59.78</b> | <b>95.06</b> |

As presented in **Table 2**, in Variant 1 the cleaning efficiency for total, fine, and coarse trash was 80.70%, 30.57%, and 50.13%, respectively. In Variant 2, these figures were 95.06%, 35.28%, and 59.78%—higher by 14.36, 4.71, and 9.65 percentage points, respectively.

In the first four cleaning sections (3 PD + 1 SD) of Variant 1, with a constant clearance of  $\Delta = 15$  mm, a total of 5.37% of trash was separated (2.29% in the three PD sections and 3.08% in the SD section), comprising 2.43% fine and 2.94% coarse trash. In contrast, in the first four sections of Variant 2 (2 PD + 2 SD), with  $\Delta = 18$  mm, a total of 8.06% of trash was separated (1.91% in the two PD sections and 6.15% in the two SD sections), comprising 2.73% fine and 5.27% coarse trash. This confirms that widening the clearance to  $\Delta = 18$  mm and replacing a peg drum with a saw drum increases the separation of both fine and coarse trash.

For these initial sections, the cleaning efficiencies for total, fine, and coarse trash were 42.62%, 19.15%, and 23.47% in Variant 1, compared with 64.33%, 22.27%, and 42.06% in Variant 2.

In cleaning sections 5 - 8, the total, fine, and coarse trash separation rates were 3.70%, 0.95%, and 2.75% for Variant 1, and 2.80%, 1.10%, and 1.70% for Variant 2—that is, 0.9 percentage points higher overall in Variant 1. This was primarily attributable to higher trash-separation rates at the 2nd and 3rd saw-drum positions in Variant 1 relative to the corresponding 3rd and 4th saw-drum positions in Variant 2. However, this result alone does not indicate that the saw drums in the 6th and 8th cleaning sections of Variant 1 operate more efficiently than those in Variant 2; this apparent discrepancy is clarified by the individual-section efficiency analysis in **Figure 2**.

The individual cleaning efficiency of the peg drums and saw drums was determined relative to the fine and coarse trash content of the cotton prior to the corresponding cleaning section, using Equation (2). It should be emphasized that the cleaning efficiencies reported in **Table 2** were calculated relative to the initial total trash content of the cotton ( $K = \Delta C/C_{\text{cum}} \times 100\%$ ), not relative to the local fine/coarse trash content entering each section. Because peg drums separate only fine trash, evaluating their efficiency relative to the initial fine-trash content of the cotton gives a more representative picture. Likewise, determining the true individual efficiency of sequential cleaning sections requires accounting for the reduction in trash content already achieved by the preceding sections; **Figure 2** presents

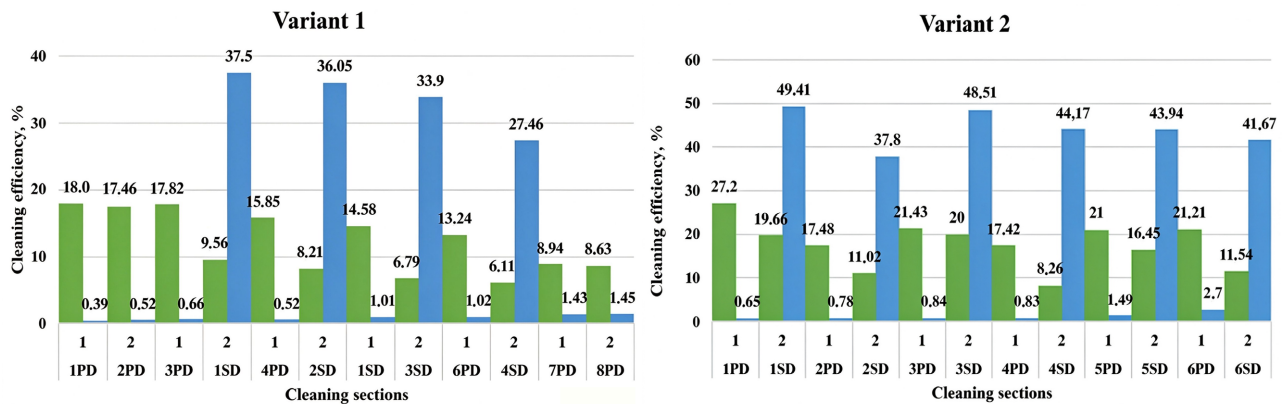


**Figure 2.** Individual cleaning efficiency of the peg-drum and saw-drum sections for fine and coarse trash, Variant 1 (left) and Variant 2 (right).

the individual efficiencies obtained on this basis.

In Variant 1, when calculated relative to the total initial trash content, the cleaning efficiency for fine trash on the 1st, 2nd, and 3rd peg drums was 7.02%, 5.35%, and 4.71%, respectively (Table 2), whereas the individual cleaning efficiency (relative to local fine-trash content) was 18.0%, 17.46%, and 17.82%, respectively. In the four saw-drum sections, the individual cleaning efficiencies for fine and coarse trash were 9.56% and 37.5%, 8.21% and 36.05%, 6.79% and 33.90%, and 6.11% and 27.46%, respectively.

In Variant 2, the cleaning efficiency on the initial three peg drums, relative to total initial trash content, was 10.61%, 3.99%, and 3.59%, respectively, while the individual cleaning efficiency was 27.2%, 17.48%, and 21.43%, respectively. In the six saw-drum sections, the individual cleaning efficiencies for fine and coarse trash were 19.16% and 49.41%, 11.02% and 37.8%, 20.0% and 48.51%, 8.26% and 44.17%, 16.45% and 43.94%, and 11.54% and 41.67%, respectively (Figure 2). As these results show, the individual cleaning efficiency of the sections in Variant 2 is consistently and substantially higher than in Variant 1.

Although the cleaning efficiency calculated relative to total trash content at the 2nd and 3rd saw drums was nominally higher in Variant 1 than in Variant 2, Figure 2 shows that their individual efficiency for fine and coarse trash was only 8.21% and 36.05% (2nd SD) and 6.79% and 33.90% (3rd SD) in Variant 1, compared with 11.02% and 37.8%, and 20.0% and 48.51% at the corresponding positions in Variant 2—confirming the superior performance of Variant 2 once local trash content is accounted for.

Table 3 presents the individual cleaning efficiency for cleaning sections 5 - 8 of the line, calculated both relative to the total trash content of the cotton and relative to the fine and coarse trash content before and after each section.

It is well established that the cleaning efficiency of a given section depends on the trash content of the cotton entering it and on the number of cleaning sections already traversed: a higher initial trash content, and fewer preceding cleaning passes, both result in a larger proportion of weakly bonded trash and, consequently, higher separation efficiency.

**Table 3.** Overall and individual cleaning efficiency of cleaning sections 5 - 8.

| No. | Section V1 | Section V2 | Eff. V1 % | Eff. V2 % | Trash Prior V1 % | Trash Prior V2 % | Repeat V1 | Repeat V2 | Indiv. V1 Fine % | Indiv. V1 Coarse % | Indiv. V2 Fine % | Indiv. V2 Coarse % | $\Delta K$ % |
|-----|------------|------------|-----------|-----------|------------------|------------------|-----------|-----------|------------------|--------------------|------------------|--------------------|--------------|
| 1   | 4 PD       | 3 PD       | 3.43      | 3.75      | 2.46             | 2.1              | 4         | 3         | 15.85            | 0.52               | 21.43            | 0.84               | 5.9          |
| 2   | 2 SD       | 3 SD       | 14.77     | 11.73     | 4.66             | 2.35             | 2         | 3         | 8.21             | 36.05              | 20.0             | 48.51              | 24.25        |
| 3   | 5 PD       | 4 PD       | 1.47      | 1.92      | 1.90             | 1.32             | 5         | 4         | 14.58            | 1.01               | 17.42            | 0.83               | 2.65         |
| 4   | 3 SD       | 4 SD       | 8.86      | 4.95      | 2.95             | 1.2              | 3         | 4         | 6.79             | 33.90              | 8.26             | 44.17              | 11.74        |

In sections 5 - 8, the cotton in Variant 1 had passed through one additional peg drum and one fewer saw drum than in Variant 2. Because one fewer saw-drum pass had been applied, the pre-cleaning trash content entering these four sections was higher in Variant 1, which explains the higher efficiency values calculated relative to total trash content for Variant 1 in this range. However, once individual efficiency is considered (**Table 3**), Variant 2 outperforms Variant 1 at every one of these four sections—by 5.9, 24.25, 2.65, and 11.74 percentage points, respectively.

#### 4. Conclusions

This study demonstrated that, after passing through two peg-drum and two saw-drum sections in the existing cleaning line, seed cotton is disintegrated almost to the level of individual, single-seed locks. This structural transformation must be taken into account when specifying the technological clearances of the cleaner's working elements.

It was substantiated that setting the clearance between the peg/saw drums and the mesh surface or grid bars differentially—from 18 mm down to 12 mm across the successive stages of the cleaning line, in accordance with the changing geometric dimensions of the cotton locks—significantly increases cleaning efficiency. Under laboratory conditions, this approach raised the overall cleaning efficiency from 80.70% (constant  $\Delta = 15$  mm) to 95.06% (differentiated  $\Delta = 18 \rightarrow 15 \rightarrow 12$  mm), with individual-section efficiency higher at every comparable stage and without additional damage to fiber or seed quality.

From a practical standpoint, the proposed differentiated-clearance scheme can be implemented in existing UHK-type cleaning lines with only local adjustment of the working clearances and a partial substitution of peg-drum sections by saw-drum sections, making it a low-cost, readily deployable route to improving ginning-mill performance. Further research should extend the structural-indicator-based approach to a wider range of cotton varieties, moisture and trash-content conditions, and industrial-scale trials, in order to generalize the recommended clearance schedule for broader implementation.

#### Author Contributions

Conceptualization: A.P. and F.S.S.; Methodology: A.P. and A.K.U.; Validation:

A.K.U. and A.Kh.K.; Formal analysis: F.S.S.; Investigation: F.S.S. and A.P.; Data curation: F.S.S.; Writing—original draft preparation: F.S.S.; Writing—review and editing: A.P., A.K.U. and A.Kh.K.; Supervision: A.P. All authors have read and agreed to the published version of the manuscript.

## Conflicts of Interest

The authors declare no conflict of interest.

## References

- [1] Burnashev, V.Z. (1983) Theoretical Bases of Raw Cotton Cleaning Technology. Doctoral Dissertation, Kostroma State Technological University. (In Russian) <https://www.dissercat.com/content/teoreticheskie-osnovy-tehnologii-ochistki-khlopka-syrtsa>
- [2] Muhsinov, I., Isayevshahboz, and Xasanboy, Y. (2021) Theoretical Analysis of the Motion of Raw Cotton with Uniform Feeder in A Cotton Cleaner. *The American Journal of Engineering and Technology*, **3**, 13-20. [https://scholar.google.com/citations?view\\_op=view\\_citation&hl=en&user=iC-NBbgAAAAJ&citation\\_for\\_view=iC-NBbgAAAAJ:2osOgNQ5qMEC](https://scholar.google.com/citations?view_op=view_citation&hl=en&user=iC-NBbgAAAAJ&citation_for_view=iC-NBbgAAAAJ:2osOgNQ5qMEC)
- [3] Ibrogimov, K.I. (2009) Improvement of the Theory and Technology of Raw Cotton Preparation for the Ginning Process to Preserve the Natural Properties of Fiber and Seeds. (In Russian) <https://www.dissercat.com/content/sovershenstvovanie-teorii-i-tehnologii-podgotovki-khlopka-syrtsa-k-protssesu-dzhinirovaniya>
- [4] Dzhuraev, A.D., Tashpulatov, D.S. and Plekhanov, A.F. (2019) Justification for Selection of Parameters of Bars on Elastic Supports of Raw Cotton Pulp Cleaner. (In Russian) [https://tvgpu.com/wp-content/uploads/2019/12/381\\_17.pdf](https://tvgpu.com/wp-content/uploads/2019/12/381_17.pdf)
- [5] Usmanov, D., Umarova, M., Abdullaeva, D. and Rustamova, M. (2021) Study of Cleaning and Storage of Fine-Fiber Cotton from Trash Impurities. *Bulletin of Science and Practice*, **7**, 212-217. <https://doi.org/10.33619/2414-2948/64/22>
- [6] Fayziyev, S.H., Ibodullayev, O.O., Rasulov, E.N. and Muxidinova, Sh.N. (2025) Energy-Efficient Cleaning Technology of Cotton Raw Material Using a Vibrating Mesh Surface. *Development of Science*, **3**, 78-89. <https://devos.uz/files/934.pdf>
- [7] Khakimov, Sh.Sh. (2015) On the Development and Implementation of Skimming Slat-drum Drums in Sections and Cleaners of Raw Cotton. *Universum: Engineering Sciences. Electron*, No. 11. <http://7universum.com/ru/tech/archive/item/2768>
- [8] Bozorov, B.T., Parpiev, A. and Sobirov, I.K. (2021) The Influence of the Number of Installed Drums on Fiber Quality during Cotton Cleaning. *Universum: Technical Sciences*, **7**, 5-9. (In Russian) <https://7universum.com/ru/tech/archive/item/12073>
- [9] Djurayev, M., Hakimov, S., Abbazov, I. and Kaldybaev, R. (2024) Research on an Improved Cotton Cleaner Unit. *Technical Science and Innovation*, **2023**, Article 10. <https://btstu.researchcommons.org/journal/vol2023/iss4/10>
- [10] Parpiyev, A.P., Kuziyev, B.N. and Raxmonov, A.O. (2023) Analysis of Cleaning Efficiency of Available Cotton Cleaners. *International Journal of Advanced Research in Education, Technology and Management*, **2**, 212-217. <https://zenodo.org/records/8040943>
- [11] Fayziev, S.Kh., Ibodullaev, O.O., Rakhimov, Kh.K., Muxiddinova, Sh.N. and Razoqova, O.B. (2025) Improving the Efficiency of Cleaning Raw Cotton Based on Optimizing

- the Design of the Brush Drum. *Development of Science*, **6**, 241-256.  
<https://devos.uz/files/3071.pdf>
- [12] Ashurov, A.K. and Ro`zmetov, M.E. (2020) Theoretical Analysis of Cotton Breaking and Calculation Device for Production. *International Journal of Academic and Applied Research (IJAAAR)*, **4**, 156-157.  
<http://ijeais.org/wp-content/uploads/2020/7/IJAAAR200724.pdf>
- [13] Sharachmedova, M. and Parpiyev, A. (2020) Analysis of Deformation of Cotton in Technological Processes. *International Journal of Emerging Trends in Engineering Research*, **8**, 6618-6622.  
<https://www.warse.org/IJETER/archives/Vol-ume%208%20No.%209%20%282020%29>
- [14] Parpiyev, A., Shorakhmedova, M.D. and Khabibullaeva, D. (2020) Study of the Deformation of the Raw Cotton Structure in Technological Processes. *Universum: Technical Sciences*, **9**, 27-30. [https://7universum.com/pdf/tech/9\(78\)/9\(78\\_2\).pdf](https://7universum.com/pdf/tech/9(78)/9(78_2).pdf)
- [15] Cai, Y., Cui, X., Rodgers, J., Thibodeaux, D., Martin, V., Watson, M. and Pang, S.-S. (2013) A Comparative Study of the Effects of Cotton Fiber Length Parameters on Modeling Yarn Properties. *Textile Research Journal*, **83**, 961-970.  
<https://doi.org/10.1177/0040517512468821>
- [16] Parpiyev, A.P., Navruzov, N.A., Mardonov, I.B., Mardonov, J.Sh. and Sadikov, F.S. (2025) A Comprehensive Study of the Operation of Equipment for Cleaning Raw Cotton at Cotton Mills in Uzbekistan. *American Journal of Research*, No. 7-8, 41-49. (In Russian) <https://journalofresearch.us/wp-content/uploads/2025/09/41-49.pdf>