**Industrial Testings and Economic Efficiency of the Improved Cotton Separation Machine with Rational Indicators**

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**Abstract.** This article examines the production tests and economic efficiency of an improved working chamber lint separation machine with enlarged rational indicators. The relevance of the work lies in improving the quality of equipment by improving the main working parts of the lint separation machine, increasing the productivity of the lint separation machine for separating seeds, reducing mechanical damage to seeds, reducing seed contamination. Based on theoretical, scientific and practical research, technological parameters, operating modes of the new working chamber with an increased volume, which is its main working part, were selected, the exit of saws into the working chamber was 35 mm, as well as the rational distance from the ends of the seed comb to the grate was 35 mm, the diameter of the sprayer was 180 mm, based on the results of scientific research, an improved linting machine was created, and the main technological parameters of the experimental lint separation machine in production were determined. To study the operability and quality of the proposed experimental lint separation machine, comparative tests were carried out using the existing 5LP lint separation machine with seeds of the selection variety C-6524 of industrial grades I and III. Production tests showed that the quality indicators of seeds obtained from grades I and III on the experimental lint separation machine improved by 3.58% and 2.86% by grades, respectively, compared to the quality of seeds obtained on the 5LP lint separation machine, compared to the existing lint separation machine by grades, seed productivity for grades I and III was higher by 7.0% and 7.84%, lint productivity by 50.3% and 35.3%, respectively. The results showed that, based on these parameters, a comparative study of the lint separation machine with an improved working chamber with existing lint separation machines at the cotton ginning enterprise was conducted. Economic efficiency from the implementation: the expected annual economic efficiency based on the implementation of the research results in production by reducing electricity, improving seed quality, and increasing the productivity of the improved linter for lint and seeds amounted to 457.7 million soums.

**Key words:** cotton, seeds, lint, efficiency, trash mixture, seed comb, selection, working chamber, lintering machine

**INTRODUCTION**

In the world, cotton fiber is an important raw material for the production of various types of products in the textile, chemical, and pulp and paper industries. Therefore, due to the current high demand for lint products in world production, one of the main tasks is the creation, improvement, implementation, and creation of a scientific base for new equipment and technologies for primary cotton processing [1].

Increasing the productivity of lint separation machines, which is one of the main equipment of cotton ginning enterprises belonging to cotton-textile clusters in the Republic of Uzbekistan, equipping the working chamber with resource-saving parts, preserving the naturalness of manufactured products: fiber, seeds and lint products, including seed cotton, reducing the cost of lint and improving its quality by saving energy costs for lint production [2].

To fulfill these tasks at cotton ginning enterprises, the development of resource-saving lint separation machines based on the analysis of technological processes is of great importance [3].

Currently, PMP-160M and 5LP lint separation machines are installed in the technological process of all cotton ginning enterprises belonging to the "Cotton-Textile" clusters and are used to separate lint from cotton seeds [4].

Scientific staff of JSC "Paxtasanoat ilmiy markazi" on the scientific problems of separating lint from cotton seeds, new equipment and technologies created [5] based on the results of scientific research conducted by many scientists and research scientists of Tashkent Institute of Textile and Light Industry are recommended for production [6].

Also, new equipment and technologies created [7] based on the results of scientific research conducted by a number of foreign scientists [8] have been recommended for production [9].

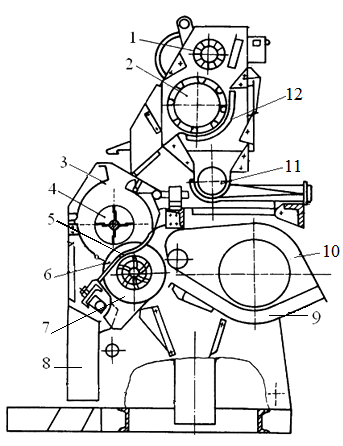
Analysis of cotton seed lint separation equipment used in cotton ginning plants of foreign countries showed that their productivity is insufficient. The design of the lint separation machine is intended only for technical seeds; in such lint separation machines, due to the high mechanical damage to the seeds, it is not possible to separate lint from the seeds. Therefore, research on improving the working chamber of lint separation equipment, which allows saving energy and reducing the consumption of spare parts by reducing the number of lint separation machines in the technology with an increase in the productivity of the lint separation machine, has not been sufficiently studied [10].

5LP machines were installed in the technological process of the Dalvarzin cotton ginning plant, which belongs to the "Cotton-Textile" clusters, for separating lint from the seeds from which the fibers were separated from the cotton composition [2]. One of the main tasks is to increase the productivity of lint separation machines, which are one of these equipment, to equip the working chamber with resource-saving parts, and to preserve the naturalness of the products being manufactured: fiber, seeds, and lint products, including seed cotton [11]. To fulfill these tasks in the cotton ginning industry, the development of resource-saving lint separation machines based on the analysis of technological processes is of great importance. Therefore, in order to ensure high quality of work and save energy and resources in the process of lintering seeds, the main indicators of the experimental lint separation machine, developed on the basis of theoretical and practical research, were determined based on the development of energy-resource-saving machines and its technological process, parameters and operating modes [12]. Also, the productivity of lint separation machines, the separation of short lint that has not separated from the seeds during the ginning process, depends mainly on the probability of hitting the saw teeth and the sprayer that forms the seed roller installed in the working chamber.

The main disadvantage of lint separation machines is that, due to the small size of the working chamber, due to the low probability of seeds with incomplete fiber separation hitting the saw teeth, an enlarged working chamber is proposed, based on scientific research experiments, an enlarged lintering chamber was selected, a saw cylinder of the lint separation machine with a saw diameter of 320 mm was used, the distance between the saws was the same as in the 5LP lint separation machine, but the gin grate bars were polished to the required thickness, the saws' exit into the working chamber was chosen equal to 35 mm, and the rational distance from the ends of the seed comb to the grate bars was also set at 35 mm, the sprayer diameter was set at 180 mm.

**MATERIALS AND METHODS**

The working chamber uniformly feeds the seeds from the distribution auger into the shaft to the leveling spiked-shovel drum 2 with the help of the feed roller 1. There, the chite is cleaned of small impurities, which pass through the mesh surface 12 and enter the filler auger 11. The cleaned seeds flow into the working chamber of the linter uniformly along the length of the equipment from the feed chute. The working chamber of the improved linter 3 is 1.46 times larger than the useful working chamber of currently used 5LP linters (Fig. 1), and its position relative to the saw has also changed.



**FIGURE 1.** Diagram of an improved lint separation machine implemented in the linting department of the cotton ginning plant  
1 - feed roller; 2-leveling spiked-shovel drum; 3-enlarged seed chamber; 4 - sprayer; 5 - grate; 6 - seed comb; 7 - saw cylinder;   
8-seed groove; 9 - lint drain pipe; 10-air chamber; 11 - trash auger; 12-grid surface

The wide volume of the chamber allows more seeds to fit in it and more part of the saw, that is, the saw cylinder arc, enters the chamber, and the saw cylinder 7 works efficiently. The diameter of the sprayer 4, installed in the working chamber, is increased to 180 mm, the gap between the sprayer plank and the saw teeth is taken as 20 mm (Fig. 2), in this gap, the saw teeth, due to the fact that the seeds slow down their movement, tear the longer fibers from the seeds, scrape the short fibers, i.e., lint, and carry them out between the grate bars. The sprayer rotates the seed roller while simultaneously spraying it, improving the delivery of more fuzzy seeds to the saw teeth. The lint on the saw teeth encounters the airflow coming out of the air chamber 10, is separated from it, and is sent to the next process through the common lint removal pipe 9. The short fiber unsuitable for spinning in the lint separates under the action of centrifugal force and is controlled by the ulyuk caserog.

Dead and small debris separated during lint separation from saw teeth are removed from the equipment through the conveyor. The fluffiness of the seeds in the chamber, i.e., the amount of lint separation, is adjusted by seed comb 6. Also, the saw spacers with a thickness of 8.75 mm were brought to the required thickness by machining (Fig. 3). According to the results of the conducted research, it is known that the main part of the seeds exits the working chamber of the lint separation machine through the holes between the seed comb and the saw cylinder. Only a small portion falls into the gap between the seed comb. From this it follows that the productivity of the lint separation machine for seeds largely depends on the size of the hole between the ends of the seed comb and the saw cylinder; the larger the holes, the higher the productivity of the lint separation machine for seeds, and vice versa. The feed of seeds to the working chamber of the lint separation machine is regulated by the seed feeder. Before starting the experiments, as planned in the experimental variants, the necessary adjustments were made to the lint separation machine. The working chamber of the compared gin is 1.46 times larger than the working chamber of the 5LP lint separation machine.

|  |  |
| --- | --- |
| 1 - enlarged working chamber; 2 - sprayer; 3 - saw cylinder **FIGURE 2.** Experiment General view of the seed sprayer installed in the lint separation machine | 1-enlarged working chamber; 2 - saw cylinder; 3 - grate bars **FIGURE 3.** General view of the ribbed grates, installed in the working chamber of the improved lint separation machine, smoothed to the required thickness |

**RESULTS AND DISCUSSION**

The supply of seeds to the working chamber of the lint separation machine is regulated by the seed feeder. The main selected technological parameters of the proposed experimental lint separation machine were established according to the results obtained by comparing the useful volumes of the working chambers of the enlarged working chamber lint separation machine and existing lint separation machines. To study the operability and quality of the proposed experimental lint separation machine, comparative tests were carried out using the existing 5LP lint separation machine at the Dalvarzin cotton ginning enterprise in the Tashkent region with seeds of the selection variety C-6524 of industrial grades I and III. Before conducting tests, the technological parameters were adjusted in accordance with the technical characteristics of the machines. During the work, the influence of the lint separation machine on the quality indicators of the manufactured products and the productivity of the machine was studied. When conducting production tests of the lint separation machine, the following improved experimental equipment was used (Fig. 1). Using the data of the actual geometric parameters of the working chambers of the 5LP lint separation machine and the linter machine with an enlarged working chamber, it is possible to calculate the difference in the useful volume of the compared working chambers. The calculation results are presented in Table 1. As can be seen from the data in Table 1, the magnified working chamber is 1.46 times larger than the working chamber of the 5LP lint separation machine.

**TABLE 1.** Comparison of the usefully used volumes of the working chambers of a linter with an enlarged working chamber and existing linter machines

|  |  |  |  |
| --- | --- | --- | --- |
| № | Parameters | Available camera of the 5LP lint separation machine | Lint separator with an enlarged working chamber |
| 1 | 2 | 3 | 4 |
| 1 | Number of saws, units | 160 | 160 |
| 2 | Number of grate bars, units | 161 | 161 |
| 3 | Saw spacing, mm | 9.7 | 9.7 |
| 4 | Working chamber length, mm | 1560 | 1560 |
| 5 | Working chamber perimeter, mm | 1120 | 1340 |
| 6 | Average radius, m () | 0.18 | 0.21 |
| 7 | Cross-sectional area, m2  () | 0.102 | 0.14 |
| 8 | Total volume of the working chamber, m3 (V=S·) | 0.16 | 0.22 |
| 9 | Sprayer volume, m3 | 0.03 | 0.03 |
| 10 | Usable volume of the working chamber, m3 | 0.13 | 0.19 |

The density of the seed roller in the working chamber of the experimental lint separation machine was determined by weighing the amount of seeds in the working chamber in its steady operating mode.

In the processing process, in order to determine the quality indicators of seeds according to the existing methodology, samples of initial seeds, separated seeds, and lint were selected [13].

During the testing period, the productivity of the lint separation machines was determined by the mass of lint and seeds produced during the continuous operation period. In this case, the initial seeds, separated seeds, and lint masses were recorded. The results of laboratory analyses of the initial seeds are presented in Table 2.

**TABLE 2.** Results of laboratory analyses of the quality indicators of raw cotton seeds

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Cotton seeds | | Seed quality indicators, % | | | |
| Grade | | hairiness | damagedness | contamination | moisture |
| Selection | Industrial |
| С-6524 | I | 10.8 | 3.8 | 3.2 | 8.6 |
| С-6524 | III | 11.5 | 4.6 | 3.2 | 9.4 |

**TABLE 3.** Results of comparative studies of the improved experimental lint separation machine in production conditions of the cotton ginning enterprise with the existing 5LP lint separation machine

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Parameters | Unit of measurement | Comparable machines | | | |
| Available 5LP lint separator | | Improved lint separation machine | |
| Cotton seed variety | | | |
| I | III | I | III |
| 1 | 2 | 3 | 4 | 5 | 6 |
| Seeds after ginning:  - hairiness  - damage | %  % | 10.8  3.8 | 11.5  4.6 | 10.8  3.8 | 11.5  4.6 |
| After lint separation, the seeds:  - hairiness  - damage | %  % | 7.81  4.46 | 8.63  4.88 | 6.9  4.3 | 7.9  4.74 |
| Fluff:  - mass fraction of trash impurities and whole seeds in lint  - staple length  - grade  - type  - class | %  mm | 6.44  6/7  I  B  “Dirty” | 8.78  6/7  I  B  “Dirty” | 5.94  6/7  I  B  “Medium” | 8.31  6/7  I  B  “Dirty” |
| Productivity of the lint separation machine: - for seeds - by lint | kg/hour | 628  18.77 | 612  17.56 | 672  28.22 | 660  23.76 |

As can be seen from Table 3, the fuzziness of seeds of grade I obtained from the existing 5LP lint separation machine is lower than that of the experimental lint separation machine and averages 7.81%, which is higher than the standard for grade I class I according to the current standard. Mechanical damage to seeds was 4.46%. The mass fraction of trash impurities and whole seeds in the lint obtained from the 5LP lint separation machine averaged 6.44%, the staple length was 6-7 mm [14], according to the quality index according to the state standard “O'zDst 645:2016”, it corresponds to class I grade B type "Dirty" [15]. The productivity of the lint separation machine for seeds and lint averaged 628 kg/hour and 18.77 kg/hour, respectively.

On the existing 5LP lint separation machine, the average fuzziness of seeds separated from ginned seeds of grade III was 8.63%, and the average mechanical damage was 4.88%. The mass fraction of trash impurities and whole seeds in the lint averaged 8.78%, which corresponds to grade I grade B type "Trash" class according to the state standard “O'zDst 645:2016”.

In the experimental lint separation machine developed using a lintering machine with an enlarged working chamber, the average lint content of the linted seeds obtained from ginned seeds of grade I was 6.9%, which corresponds to the requirements of the state standard O'zDst 596:2016 "Technical Seeds." Experiments showed that the mechanical damage to the separated lint seeds was 4.3%, which is 3.58% lower than the data obtained on the existing 5LP lint separation machine. The mass fraction of trash impurities and whole seeds in the lint averaged 5.94%, which was less than 7.76% (abs.) of the mass fraction of trash impurities and whole seeds obtained from the 5LP lint separation machine with a smaller volume of the working chamber.

The productivity of the experimental lint separation machine averaged 672 kg/hour for seeds and 28.22 kg/hour for lint, which is 44 kg/hour higher for seeds and 9.45 kg/hour for lint compared to the existing 5LP lint separation machine. Also, the data obtained on the experimental lint separation machine for grade III showed that the seed fuzziness averaged 8.42%, mechanical damage averaged 4.74%, while the degree of mechanical damage for grade III was 2.86% less compared to the 5LP lint separation machine. The mass fraction of trash impurities and whole seeds in the obtained lint averaged 8.31%, which is 5.35% less than the mass fraction of trash impurities and whole seeds in the lint obtained from the existing 5LP lint separation machine due to an increase to the "Middle" class of grade I according to the state standard “O'zDst 645:2016”. Production tests showed that the quality indicators of seeds obtained from grades I and III on the experimental lint separation machine improved by 3.58% and 2.86% by grades, respectively, compared to the quality of seeds obtained on the 5LP lint separation machine, compared to the existing lint separation machine by grades, seed productivity for grades I and III was higher by 7.0% and 7.84%, lint productivity by 50.3% and 35.3%, respectively.

Thus, the results of production research with an experimental lint separation machine with an enlarged volume of the working chamber showed the reliability of the substantiated parameters obtained on the basis of theoretical and experimental studies of this scientific work.

Based on the results of production tests of the experimental lint separation machine, an act of production tests of the experimental lint separation machine with an increased volume of the working chamber compared to the existing 5LP lint separation machine and an act on its implementation were drawn up. When calculating the economic efficiency obtained from the introduction of the improved experimental lint separation machine into production, the economic efficiency of the introduction of the recommended lint separation machine was calculated using the data obtained from the tests of the experimental lint separation machine, conducted under production conditions at the Dalvarzin Cotton Ginning Plant in the Tashkent region. In the calculations, the increase in the quality of lint obtained on the experimental lint separation machine from the "Dirty" class to the "Middle" class was taken into account, the value of which was taken as 50%. In addition, due to the increased productivity of the lint separation machine for seeds, the number of compared lint separation machines was 8 and 7, i.e., the number of experimental lint separation machines was reduced by one. The calculation of economic efficiency was carried out using methodological guidelines for determining the economic efficiency of new technologies, inventory, and rationalization proposals [16, 17, 18]. According to the methodological guidelines, the annual economic effect of the project is determined by the formula 1:

where: C1, С2 – operating costs for the changed items of expenses, thousand soums; P – price difference from the increase in product quality, thousand soums; К1, К2– capital investments in the base and implemented options, thousand soums; En– the standard efficiency coefficient of capital investments (0.15).

Note: in the base variant, the seed fuzziness is 7.21% and belongs to grade I of class 2. The fuzziness of the seeds obtained in the proposed variant was 7.0%, which corresponds to grade I of class 1. Grade III remains within its own grade, with seed fuzziness ranging from 8.63% to 8.42%.

Also, according to the quantity of seeds produced by variants and the effect achieved as a result of improving the quality of seeds, the general indicators of calculating economic efficiency are presented in Table 4.

**TABLE 4.** Total indicators by options

|  |  |  |  |
| --- | --- | --- | --- |
| Parameters | Unit of measurement | Variants | |
| Basic | Project |
| Capital expenditures (К1, К2) | million soums | 1000 | 875 |
| Operating expenses, total (С1,С2) | -"- | 603.5 | 477.6 |
| Electricity | -"- | 403.5 | 302.6 |
| Depreciation | -"- | 150 | 131.25 |
| Repair | -"- | 50 | 43.75 |
| The price of lint depending on the change in its quantity and quality | -"- | 670.5 | 1029.6 |
| Price of seeds depending on the change in quantity and quality | -"- | 18841 | 18795 |
| Differences from product price changes | -"- |  | 313 |

Substituting the values of the data obtained for the calculation from Table 4 into formula (1), we determine the expected annual economic efficiency from the introduction into production of an improved lint separation machine with an increased volume.

million soums.

Thus, as a result of increasing lint yield from seeds, increasing the productivity of lint separation machines, improving the quality of seeds, and transitioning the obtained lint to one upper class, the expected annual economic efficiency for one cotton ginning enterprise amounted to 457.7 million soums.

**CONCLUSIONS**

As a result of the conducted scientific research and experiments, it was recommended to replace the existing lint separation machine with a larger working chamber and an improved lint separation machine;

In the improved lint separation machine, developed using a lintering machine with an enlarged working chamber, the pubescence of the linted seeds obtained from ginned seeds of grade I averaged 6.9%, which corresponds to the requirements of the state standard “O'z Dst 596:2016” "Technical Seeds. Experiments showed that the mechanical damage to the separated lint seeds was 4.3%, which is 3.58% lower than the data obtained on the existing lint separation machine. The mass fraction of trash impurities and whole seeds in the obtained lint averaged 5.94%, which is less than 7.76% (abs.) of the mass fraction of trash impurities and whole seeds obtained from the 5LP lint separation machine with a smaller volume of the working chamber.

The productivity of the experimental lint separation machine averaged 672 kg/hour for seeds and 28.22 kg/hour for lint, which is 44 kg/hour higher for seeds and 9.45 kg/hour for lint compared to the existing 5LP lint separation machine. Also, the data obtained on the experimental lint separation machine for grade III showed that the average fuzziness of seeds was 8.42%, the average mechanical damage was 4.74%, while the degree of mechanical damage for grade III was 2.86% less compared to the 5LP lint separation machine. The mass fraction of trash impurities and whole seeds in the obtained lint averaged 8.31%, which is 5.35% less than the mass fraction of trash impurities and whole seeds in the lint obtained from the existing 5LP lint separation machine due to an increase in quality to the "Middle" class of grade I according to the “O'z Dst 645:2016” standard.

The expected annual economic efficiency based on the implementation of the research results in production by reducing electricity, improving seed quality, and increasing the productivity of the improved linter for lint and seeds amounted to 457.7 million soums.

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