Improving the quality of lint by strengthening the cleaning of cotton seeds from waste

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Abstract. The article indicates that in order to obtain a lint in accordance with quality requirements, an amplifier is required for the process of cleaning cotton seeds from weed impurities and the article presents the results of experimental studies of a screw conveyor for transporting cotton seeds from gin to linter machines, which has a unit for cleaning seeds from weed impurities. It is shown that the rotational speed and pitch of the screw have a significant effect on the cleaning effect of the installation. An analysis of the results of experimental studies indicates that with an increase in the speed of rotation of the screw and a decrease in its pitch, the cleaning effect increases.

1. Introduction

In the technological process of processing raw cotton, an important place is occupied by questions of increasing the efficiency of its cleaning. In this regard, a large amount of work has been carried out to study the cleaning process of raw cotton and fiber, technological equipment has been improved, the operation of which, in principle, satisfies the requirements of the textile industry for the quality of products [1].

At the same time, in our opinion, lately, researchers have not paid enough attention to the issues of cleaning cotton seeds before lintering. Increasing the efficiency of the cleaning process of cotton seeds before lintering improves the quality of the resulting lint and reduces the content of weed impurities, which has been confirmed by numerous studies [2].

It is known that in order to improve the quality of lint and reduce the content of weed impurities, the seeds before lintering, according to the recommendations, undergo sequential cleaning with pneumatic and mechanical cleaners.

The principle of operation of a pneumatic seed cleaning plant is based on the separation of weed impurities and seeds according to their speed while transporting them by the suction air flow created by a centrifugal fan, and the mechanical seed of the cleaner is based on the separation of weed impurities from seeds due to their interaction with a rotating ring-and-slat drum and a mesh surface, with the location of the cells "herringbone", with the axial movement of seeds [3].
However, in ginneries such seed cleaners are used very inefficiently, and often almost never, which, of course, negatively affects the quality of the resulting lint and the content of weed impurities of seeds. According to the State Standard of Uzbekistan O’z DSt 645: 2010 “Cotton lint. Technical conditions”, for example for type A and B lint of the 1st grade, the mass fraction of weed impurities and whole seeds, by classes, for “Higher” it should be no more than 4.5%, for “Middle” - 6.0% and for “Weed” - 8.5% [4], and according to the standard O’z DSt 599: 2008 “Technical seeds. A method for determining the mass fraction of mineral and organic impurities” the mass fraction of mineral and organic impurities should not exceed 0.5% [5].

Based on the foregoing, we set a goal to find ways to improve the efficiency of cleaning cotton seeds before lintering and as the object of research we chose a screw conveyor, which is widely used in ginneries for transporting cotton seeds from saw gin to linter machines. Screw conveyors are simple in design, compact and reliable in operation [6,7].

2. Experimental research

To conduct experimental studies, we developed a pilot installation of a screw conveyor, where the lower half-cylindrical part of its trough was made in the form of a screening surface (mesh) for removing weed impurities emitted during transportation of cotton seeds (figure 1).

Figure. 1. Upgraded screw conveyor: A) a longitudinal section of the proposed screw conveyor; B) a section along A - A in figure 1 A.

The screw conveyor contains a groove 1, the lower part of which is in the form of a semi-cylinder, closed on top by a cover 2. The lower cylindrical part of the groove has openings 3, to remove debris emitted during transportation. The cover has an inlet 4 in the left part, and the groove 1 has an outlet 5 in the right part, a screw shaft 6 is installed inside the chute 1. To remove the removed weed impurities, an inclined tray 7 is installed at the bottom of the gutter.

2.1. Screw conveyor operates as follows

Bulk cargo-cotton seeds are fed into the groove 1 through the inlet 4 in the lid 2 and, when the screw 6 is rotated, is advanced by sliding along the groove 1, pushed by the working surface of the rotary screw 6 to the outlet 5. The emitted weed impurities are removed using a specially installed inclined tray 7.

With this movement of cotton seeds, with their continuous turning and dragging, weedy impurities are constantly released, which are removed from the trough 1 due to the presence of holes 3. A patent of the Republic of Uzbekistan was obtained for this design of a screw conveyor [8,9]. The dimensions of the screw and the gutter were identical to the dimensions of the production screw conveyors.
The shape and size of the cells (3x20) of the screening surface (mesh) were selected from the seed pre-treatment section of the linter machine.

In the experiments used sieving surfaces with a length of 1 m. Of three types (figure2):
A) With holes, the major axis of which is parallel to the axis of rotation of the screw;
B) With holes made obliquely, at an angle of 200 relative to the axis of rotation of the screw;
C) With holes made obliquely at an angle of 300 relative to the axis of rotation of the screw.

Figure 2. The layout of the holes of the screening surface.

2.2. Experimental studies were carried out according to the following method
From the ginnery, immediately after the gin, seed samples were taken; in laboratory conditions, prototypes weighing 5 kg were prepared from them. using electronic scales. The conveyor screw rotated with a frequency of \( n = 60 \text{ rpm} \).

The test samples were passed through the experimental setup, then the transported cotton seeds and weed impurities separated through the screening surface were separately weighed.

Table 1. Research results of the modernized screw conveyor.

| Hole arrangement | The mass of weed impurities in the sample, gr. | The mass of selected waste, gr. with the number of passes | In the numerator, the total weight of the selected waste, gr. In the denominator, the cleaning effect of the installation,%.
|------------------|-----------------------------------------------|--------------------------------------------------------|--------------------------------------------------|
| Parallel         | 1.143                                        | 202 102 82                                            | \( \frac{386}{66.4} \)                           |
| Inclined, \( \alpha = 20^\circ \) | 1.143                                        | 183 68 42                                            | \( \frac{293}{50.7} \)                           |
| Inclined, \( \alpha = 20^\circ \) | 1.143                                        | 160 65 43                                            | \( \frac{268}{46.4} \)                           |

It is seen from the table, the best results, from the point of view of the selection of weed impurities, give the use of a screening surface with holes, the major axis of which is parallel to the axis of rotation of the conveyor screw, the total weight of the emitted waste in this case is 384 g with a triple pass. The cleaning effect of the installation is 66.4%.

In the experiments, there was no loss of seeds in the waste, so the accepted hole sizes (3x20) of the screening surface did not allow this [10].

The holes of the screening surfaces inclined relative to the axis of rotation of the conveyor screw did not give positive results, in this case there is a decrease in the mass of emitted waste, which is reflected in the cleaning effect of the installation. So, when applying a screening surface with holes made
obliquely, at an angle of 20° relative to the axis of rotation of the screw, the cleaning effect is only 50.7%, and with an inclination of 30° only 46.4%.

The implementation of a screw conveyor with a node for cleaning seeds from impurities during their transportation requires additional study of the screw speed parameters on the cleaning effect, and therefore, experiments were carried out at the first stage of research to study the effect of the screw rotation speed on the cleaning effect [11,12].

In existing designs of the seed screw conveyor, the screw speed is \( n = 60 \) rpm, and this speed value is set solely because of the need to ensure that seeds are removed from the gin constantly and on time [13,14].

Each series of experiments consisted of a series of experiments performed under exactly the same conditions. To determine the number of experiments in each series, necessary to obtain the measured parameters with a given accuracy and confidence interval, a preliminary series of ten experiments was carried out, the results of which were processed according to the generally accepted method with determination of the arithmetic mean and standard deviation. It was found that the necessary number of experiments to obtain a confidence probability \( \alpha = 0.95 \) and an accuracy of 5% is equal to three.

3. Research methodology
The research methodology for determining the effect of the conveyor screw rotational speed during transportation of cotton seed on the cleaning effect was as follows: cotton seed samples were weighed in a mass of 10 kg, the percentage of weed impurities was determined in them and then passed through an experimental screw conveyor installation with a certain screw rotation speed. After that, the percentage of weed impurities was again determined in the cotton seed sample and the cleaning effect was determined by a known method [15,16].

Obtaining different values of the rotational speed of the screw was carried out through the use of interchangeable pulleys of appropriate diameters.

4. Results and discussion
The results of studies on the influence of the speed parameters of the screw conveyor on the cleaning effect are shown, in the form of a graph, in figure 3.

![Figure 3](image)

**Figure 3.** The dependence of the cleaning effect on the speed of the screw: 1-theoretical line; 2-practical line.

[![Figure 4](image)](image)

**Figure 4.** Dependence of the change in the cleaning effect on the pitch of the screw.
The graph shows that with an increase in the number of revolutions of the screw, the cleaning effect of the screw conveyor with the cleaning unit also increases proportionally, so with the number of revolutions at \( n = 60 \) rpm the cleaning effect is 52\%, and with the number of revolutions of the screw at \( n = 80 \) rpm and \( n = 100 \) rpm, the cleaning effect is already 59 and 73\%, respectively. Also, the increase in the cleaning effect can be explained by a more intensive turning, dragging and dragging of cotton seeds along the screening surface of the gutter.

After processing the experimental data, in a way to minimize the function \([17,18]\), a relationship was obtained between the cleaning effect and the rotation of the screw, which looks like this:

\[
K\% (n) = 73 - 0.875n + 0.0087n^2
\]  
(1)

We checked this dependence according to the Fisher criterion, which confirmed the validity of the formula, the average approximation error in this case was 2\%. To verify the obtained dependence, we conducted additional experiments, which showed that the deviation of the practical values of this formula from the calculated ones is not 5\%, which is quite acceptable.

In the second stage of the research, experiments were carried out to study the effect of the screw pitch on the cleaning effect, for which three screws were manufactured in steps of \( S = 300, 400, \) and \( 500 \) mm, respectively.

The research methodology was similar to that of the above experiment \([19]\).

The results of studies on the influence of the pitch of the screw on the cleaning effect of the screw conveyor are shown, in the form of a graph, in figure 4.

The graph shows that the cleaning effect increases with decreasing screw pitch. So, with a screw pitch \( S = 300 \) mm, the cleaning effect is 67\%, and with a screw pitch \( S = 400 \) mm and \( S = 500 \) mm, the cleaning effect is already 60\% and 55\%, respectively. This can be explained by the fact that with a small pitch of the screw, the time spent by the cotton seeds in the screw conveyor increases, as a result of which they are more intensively trapped and the weed out of impurities.

Having processed the experimental data, a relationship was obtained between the cleaning effect and the rotation of the screw, which looks like this:

\[
K\% = 84.667 - 0.06S
\]  
(2)

We checked this dependence by the Fisher criterion, which confirmed the validity of formula (2). To verify the obtained dependence, we conducted additional experiments, which showed that the deviation of the practical values of this formula from the calculated ones is not an error of 3\%, which is quite acceptable.

The results of the studies indicate the possibility of cleaning cotton seeds during their transportation, it should be especially noted that the use of such screw conveyors practically does not require any large financial costs.

5. Conclusions

To improve the quality of the resulting lint during the lintering of cotton seeds by reducing the content of weed impurities in them, a screw conveyor is proposed, equipped with a screening surface in the semi-cylindrical part of its gutter.

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