Ways to increase the efficiency of the seed linting process

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Abstract. The current state of local and foreign linters has been studied. It has been determined that local 5LP linters when linting cotton seeds do not meet the increased requirements of ginneries in cotton-textile clusters. The practice of operating serial 5LP linters shows that the actual performance of a 5LP linter is on average 50% of that stated in the passport. It was revealed that one of the main reasons for the decrease in the efficiency of the linter is not the perfection of the working body-turner. Due to the imperfection of the agitator design, the density of the seed roller increases, the quality of the lint and seeds deteriorates, and the productivity of the linter decreases. Studies of the Chinese-made MR-160-11C linter operated at the Djuma cotton plant in the Samarkand region showed an increase in the dust content of the air in the workshop due to the absence of a cleaning section for cleaning seeds in the feed system. At the same time, the increase in mechanical damage to seeds by 1.5-2.5% and clogging of the lint by 2.5-3.5% is higher than recommended by the regulations. Due to increased seed damage, these linters were not used to process plant seeds. An increase in the degree of clogging of the lint and an increase in the amount of lint with a short staple length in its composition sharply reduced the quality of the lint. When linting, the productivity of machines for seeds decreased by an average of 50-60%, for linting by 25-35% compared to passport data. To increase productivity and improve the quality of lint and seeds, a new design agitator for the 5LP linter was proposed.

1. Introduction

In contemporary circumstances, the primary determinant of an enterprise's production activity is the competitiveness of its goods. This competitiveness is ascertained through the achievement of minimal production costs and the attainment of high quality, facilitated by the utilization of state-of-the-art equipment and technology.

The reduction of manufacturing costs can be accomplished through various aspects, including the assurance of feedstock property safety, the efficient utilization of material and labor resources, energy conservation, and other related measures.

In this regard, ginneries in cotton-textile clusters are faced with the task of increasing the level of profitability with a decrease in production costs. The linter farm at the cotton plant is the only technological line equipped with a large number of equipment [1-3].

In a regulated technological process, after ginning, a short fiber is left on the seeds, which is called lint. According to average statistics, lint remains on the seeds, which in the total volume is about 10-15% of the initial fiber content of raw cotton, and therefore, the ginneries provide for a technological operation - linting of cotton seeds in order to obtain this product [4-6]. The removal of linters from cotton seeds is carried out on linter machines installed in batteries. Lint is a valuable product for the textile, chemical and paper industries.

Under the conditions of state financing, the costs of lint production were attributed to the cost of cotton fiber and their impact on the selling price was not so significant. In modern conditions of self-financing, this problem requires a revision of selling prices for products, which should take into account the corresponding production costs and the level of profitability. Therefore, linter farming at cotton plants has become unprofitable in the production of lint due to the low productivity of machines for lint.

Among the factors that most significantly affect the reduction of production costs are throughput and removal of linters, as well as reducing the cost of the main parts, by using them economically in the linting process. However, the throughput of the operating saw linters does not meet the requirements of modern technology for the primary processing

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of cotton, and besides, they are not highly reliable in operation. Therefore, in the technological process of linting, machines must be installed that meet the requirements of conjugation in terms of throughput and lint removal, as well as high reliability with lower production costs in operation [7-9].

2. Methods

Currently, linters of the 5LP brand are used to implement the technological process of seed linting [10-11]. The lintering process on this machine is carried out by the interaction of the saws on the seed roller in the working chamber of the linter. Under the influence of the agitator and saw cylinder rotating in the working chamber, the seeds form a dense rotating seed roller (Fig. 1 and 2). The saw tooth, penetrating into the mass of the seed roller, scrape off the fibrous cover-lint from the surface of the seeds and take it out of the grate [12]. Seeds, as the lint is removed from them and exposed, stand out from the mass of the seed roller and are dropped onto the grate, along which they roll down and are removed from the working chamber [13].

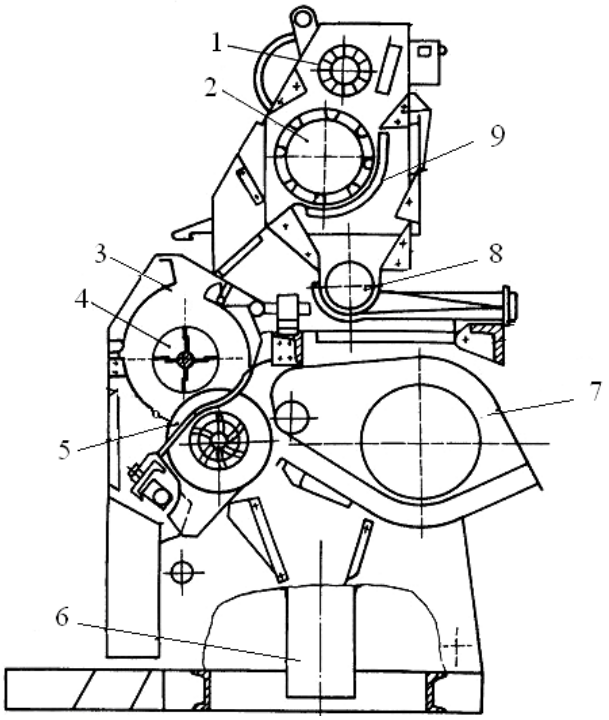

Fig. 1. Scheme of saw linter 5LP: 1 - feed roller, 2 - screeding drum, 3 - working chamber, 4 - agitator, 5 - saw cylinder, 6 - plenum chamber, 7 - air chamber, 8 - waste auger, 9 - perforated mesh

The practice of operating serial 5LP linters shows that the actual performance of a 5LP linter is on average 50% of that stated in the passport. Due to the low seed throughput and lint productivity at ginneries, according to the regulations (PDI 70-2017), two rows of linters are installed in the production line, each of which consists of 6 machines (a total of 12 machines) of the 5LP type, which is unprofitable for its processing.

One of the main working bodies that determine the performance of the linter is the agitator. Due to the imperfect design of the agitator, lintered seeds do not leave the working chamber in a timely manner. At the same time, the density of the roller increases, and the productivity of the linter decreases.

In developed cotton-growing countries such as China, the USA, Turkey and India, linter machines are used for linting cotton seeds [14, 15, 16, 17]. By design, they are similar to local linters. But an increase in the throughput of foreign linters is achieved mainly by increasing the speed of the saw cylinder, and the intensity of scraping of the linter from the surface of the seeds is achieved due to the height of the saw tooth and the angle of inclination.

The Chinese-made linters of the MR-160-11C brand used in the Djuma cotton plant in the Samarkand region showed an increase in the dust content of the air in the workshop due to the absence of a cleaning section for cleaning seeds in the feed system [18]. The increase in mechanical damage to seeds in the machine is 1.5-2.5% and the clogging of the lint is 2.5-3.5% higher than recommended by the regulations. Due to the increase in seed damage, such linters were not used for the processing of sowing seeds (Fig. 3). An increase in the degree of clogging of the lint and an increase in the amount of lint with a short staple length in its composition sharply reduced the quality of the lint. When linting, the

productivity of machines for seeds decreased by an average of 50-60%, for linting by 25-35% compared to passport data. Due to the lack of air consumption for removing the lint from the saw cylinder and for transporting it along the lint outlet to the condenser, air is dusted and the lint is lost [19].

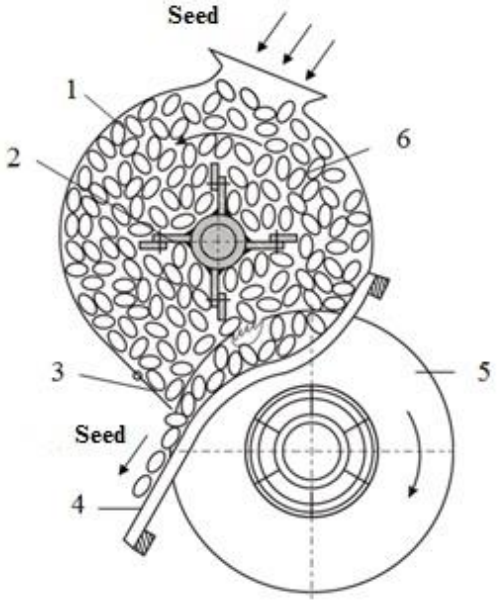

Fig. 2. Linter working chamber 5LP: 1 - working chamber, 2 - agitator, 3 - seed comb, 4 - grate, 5 - saw cylinder, 6 - seed roller

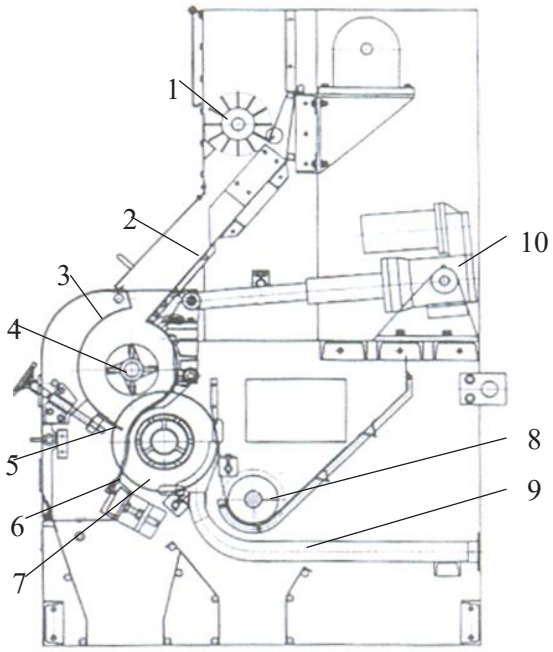

Fig. 3. Scheme of the linter MR160-11C: 1 - feed roller, 2 - patch, 3 - working chamber, 4 - agitator, 5 - seed comb, 6 - grate, 7 - saw cylinder, 8 - weed auger, 9 - linter channel, 10 - mechanism for raising and lowering the chamber

Due to the above shortcomings, local 5LP linters were installed in the place of Chinese linters at local ginneries. Speaking about the seed throughput of the linter, it should be noted that the process is associated with a slight scraping of the linter from the surface of the seeds. One of the reasons for this is the imperfection of the agitator design, in connection with which this is associated with a decrease in seed throughput and lint removal. The solution to the problem of increasing the throughput of the linter and removing the lint can be achieved on the basis of fundamentally

new approaches to the linting process. One of the ways to solve this problem is to modernize the main unit of the linter 5 LP with its length unchanged by simultaneously solving the problem of intensifying the seed throughput and removing the lint due to the effective participation of the working parts of the agitator in the linting process.

3. Results and Discussion

In the process of seed linting, the degree of linter removal depends on many factors, one of them is the pressure of the generated rotating flow of seeds located between the two bars of the agitator and the surface of the saw cylinder. But due to the design flaws of the agitator in the linting zone, the necessary pressure on the surface of the saw cylinder is not sufficiently carried out, due to the departure of part of the seed flow in the area between the slats and the agitator shaft. In addition, due to the absence of deformation on the driving seeds from the side of the agitator, there is an increase in damage to the seeds during the passage of seed molasses between the metal blade of the agitator and the saw tooth of the saw cylinder during linting.

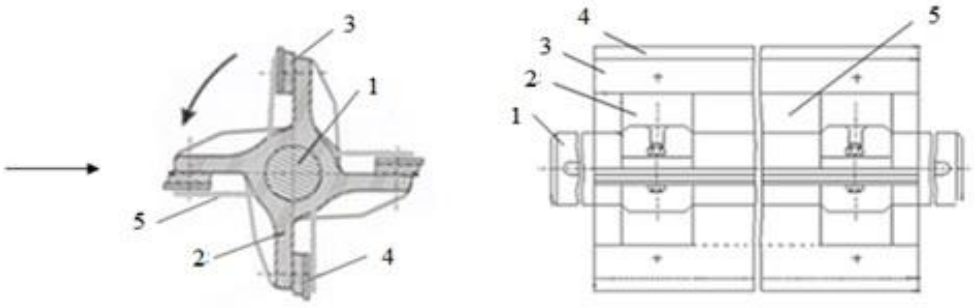

Fig. 4. Scheme of the upgraded 5LP linter agitator: 1- shaft, 2- cross, 3- metal blade, 4- rubber, 5- sheet

Fig. 5. Working chamber 30 saw linter 5LP

The need to increase the productivity of linters, improve the quality of manufactured products, save energy and material costs in the production of linters and seeds, requires further improvement in the technique and technology of lintering [20].

In this regard, research has been carried out to improve the process of linting cotton seeds by modernizing the turner providing the necessary pressure on groups of seeds in the linting zone.

To create the necessary pressure from the side of the moving flow of seeds located between the two bars of the agitator on the surface of the saw cylinder in the process of scraping the lint from the surface of the seeds in the linting zone, the gaps between the bars and the shaft were closed with leaves (Fig. 4). To reduce damage to seeds in the linting zone, rubber nozzles are installed on the agitator bars.

Theoretically, algorithmic solutions were studied and obtained for the influence of the stiffness coefficient over the thickness of the rubber, the height of the rubber protrusion from the metal bar at the intensity of scraping the lint from the driving mass of seeds in the zone between the saw tooth of the saw cylinder and the rubber mounted on the metal bar [21].

According to laboratory studies, the optimal gap between the saw cylinder and the rubber bar is 10 mm, the height of the rubber protrusion from the metal bar is 6 mm, the rubber stiffness coefficient is $-15 \cdot 10^4 N/m^2$.

To determine the performance of the upgraded turner and its effectiveness with a serial turner, the proposed turner is installed on a 30-saw linter 5LP located in the technological laboratory of "Paxtasanoat ilmiy markazi" JSC (Fig. 5). A comparative experimental study was carried out with a 5LP linter with an existing agitator in the production line (Fig. 6 and 7).

The research was carried out by changing the distance between the agitator blades and the saw cylinder by 9-12 mm. Experimental work was carried out on cotton seeds of the 1st grade of selection C-6524 with an initial pubescence of 10.28%, damage of 3.21%.

When seeds were lintered in a 5LP linter with a serial agitator, seed pubescence was 6.81% and 8.53%, seed damage was 6.28% and 4.76% with a gap between the saw cylinder and the agitator bar in the range of 8–12 mm [22, 23]. The mass fraction of weed impurities and whole seeds in the linter produced by the linter averaged 6.48% and 6.16%. At the same time, the lint was obtained with a staple length of 6/7 mm, which corresponded to grade I of the "Iflos" class, type B, according to GOST O'zDst 645:2016.

Fig. 6. Working chamber 30 of the saw linter with a serial turner: 1 - working chamber, 2 - blade, 3 - cross, 4 - shaft, 5 - saw cylinder

When lintering seeds in a 30-saw 5LP linter with a serial feeder, its productivity for seeds averaged 157 kg/h and 128 kg/h, for linter - 5.96 kg/h and 4.93 kg/h.

These figures for the 30 saw 5LP linter with a modernized agitator, seed pubescence after the linter averaged 6.76% and 8.21%, damage averaged 6% and 4.26% with a gap between the saw cylinder and the rubber bar in the range 8-12 mm, that the degree of pubescence and damage is lower than that of seeds from a 5 LP linter with a agitator of the existing design, and the quality of seeds improved by an average of 0.28 (abs)% and 0.5 (abs)% (Fig. 8).

At the same time, in the gap between the saw tooth of the saw cylinder and the rubber blade of the agitator, at a value of 12 mm, the pubescence averaged 8.21%, the damage was 4.26%, which corresponded to the technological requirement of the 5LP linter when linting seed and industrial seeds.

The mass fraction of weed impurities and whole seeds in the lint averaged 5.96% and 5.38%, which is 0.52 (abs)% and 0.78 (abs)% lower than the contamination of the lint obtained from the 5LP linter with serial turner (Fig. 9). At the same time, the quality of the lint improved, and an increase by one class was achieved, which corresponded to grade I, class "Urta" type B according to GOST O'zDst 645:2016 [24].

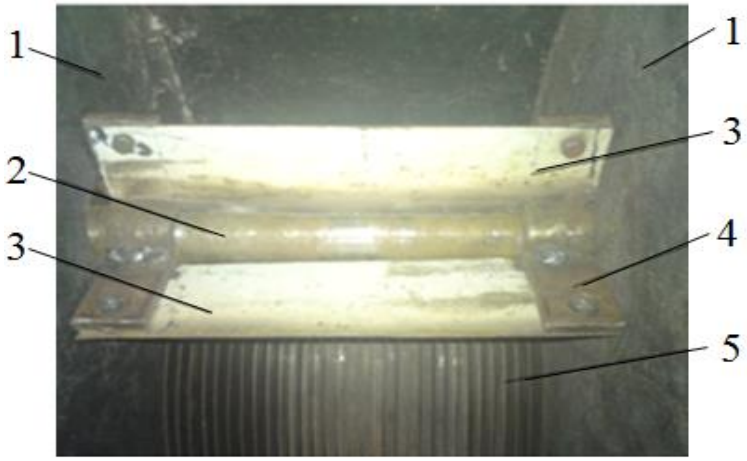

Fig. 7. Working chamber 30 of the saw linter with a modernized agitator: 1 - working chamber, 2 - blade, 3 - cross, 4 - shaft, 5 - sheet

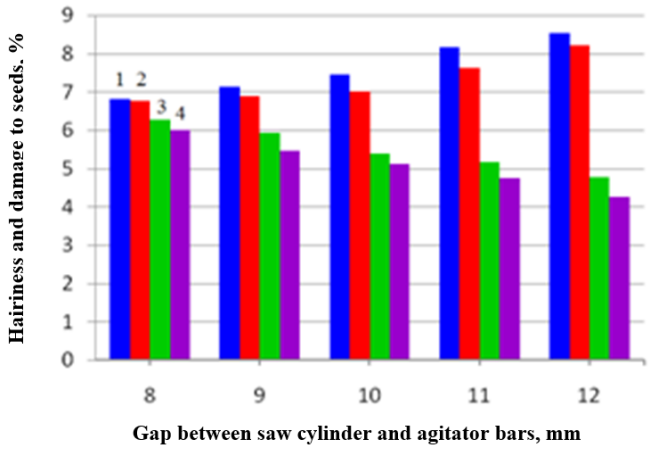

Fig. 8. Histogram of the dependence of the gap between the saw cylinder and the agitator on the degree of pubescence and damage to the seeds after 30 saw linter 5LP: 1, 3 - in the existing agitator
2, 4 - in the modernized agitator

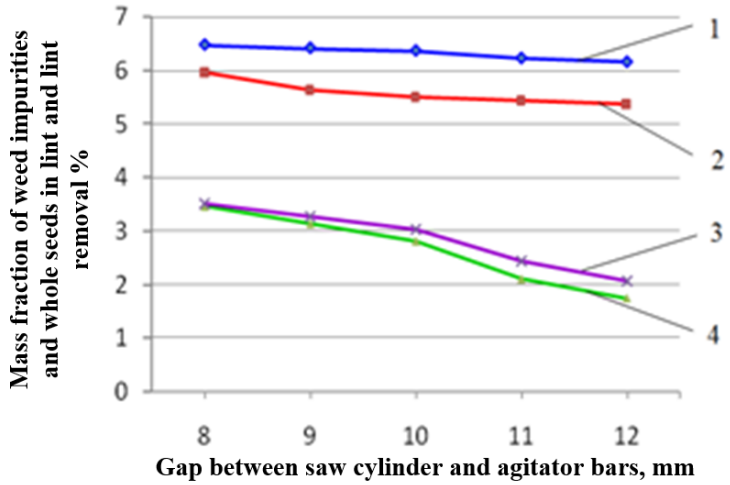

Fig. 9. Dependences of the tooth gap of the saw cylinder with a turner on the removal of the linter and on the mass fraction of weeds and whole seeds in the linter: 1, 4 - in the existing agitator, 2, 3 - in the modernized agitator

In the modernized 5LP linter, when lintering technical seeds of the 1st grade, the productivity of the linter for seeds averaged 185 kg/h and 138 kg/h, for lint 6.35 kg/h and 5.28 kg/h, which is 28 kg/h higher and 10 kg/h for seeds and 0.39 kg/h and 0.35 kg/h for linters compared to a 5LP linter with a conventional agitator design. During the seed lintering process in the 5LP linter equipped with a modernized agitator, there was an enhancement in the speed at which seeds exited the working chamber. Additionally, there was an increase in the supply of new pubescent seeds from the feeder to the working chamber. As a result, a more efficient seed linting process was achieved when compared to the 5LP linter of the previous design [25].

4. Conclusions

Having studied the advantages and disadvantages of linters operated at local and foreign cotton-cleaning and fat-and-oil enterprises, a new design agitator for the 5LP linter was developed that increases the productivity of the linter, improves the quality of the linter and seeds while saving electricity and spare parts. On the basis of theoretical and experimental studies, the optimal gap between the saw cylinder and the rubber bar is 10 mm, the height of the rubber protrusion from the metal bar is 6 mm, and the rubber stiffness coefficient is $15 \cdot 10^4 N/m^2$ of the modernized linter 5LP.

When lintering seeds of the I variety of selection C-6524 under laboratory conditions, the degree of pubescence and damage to seeds obtained from 30 saw linter 5LP with a modernized agitator was lower than that of seeds from 30 saw linter 5LP with an agitator of the existing design, and the quality of seeds improved by 0.28 (abs)% and 0.5 (abs)%. The mass fraction of weed impurities and whole seeds in the linter after the upgraded linter was lower by 0.52 (abs)% and 0.78 (abs)% than the contamination of the linter obtained from the 5LP linter with a serial agitator. At the same time, the quality of the lint improved, and corresponded to the I grade class "Urta" type B according to GOST O'zDst 645:2016. At the same time, the productivity of the linter in the proposed linter was higher for seeds by 28 kg/h and 10 kg/h, for lint by 0.39 kg/h and 0.35 kg/h compared to the 5LP linter with a conventional agitator. In the process of lintering seeds in the 5LP linter with a modernized agitator, the exit of seeds from the working chamber was accelerated, the supply of new pubescent seeds from the feeder to the working chamber was increased, and an effective process of seed linting was carried out compared to the 5LP linter of the existing design.

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