Analytical studies of the cotton seed linting process

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Abstract. Thearticle presents the history of development of cotton seeds linting technological process, brief analysis of research works carried out to improve linter productivity, theoretical analysis of seeds interaction with sawing cylinder, as well as the results of previously conducted experimental studies. On the basis of the analysis it was concluded that it is necessary to continue research work on increasing productivity of 5LP linter for seeds and getting lint. The direction of the forthcoming work was chosen, which provides for the development of the linter design using the working chamber of the gin, manufacturing of the developed linter and research of the linting process, providing rational conditions of its operation in the effective process of cotton seed linting.

1 Introduction

Dependingon the breeding and industrial variety of processed raw cotton, the amount of lint remaining on seeds after ginning of medium-fiber cotton varieties ranges from 11 to 17% (to the initial mass of seeds) and from 2.4 to 5% - for fine-fiber varieties [1].

The process of removing the cotton lint from the seeds is called linting, and the machines by which this process is carried out are called linters. Currently, the 5LP linter is used in cotton processing plants. The linting process in 5LP linter machines is carried out as a result of interaction between the saw cylinder and the seed roller rotating in the linter working chamber [1,2]. However, there are significant shortcomings in the technological process and in the design of the 5LP linter that need to be solved.

The main first disadvantage of the 5LP linter is the use of a seed comb, which makes it impossible to bring the profile of the working chamber to a circle. In the working chamber, when the tedder rotates, the seeds by centrifugal force are thrown to its walls, forming circular layers. The outer layer, denser, forms an arch of the seed roller, and the inner, sparse layer is in the rotation zone of the tedder. The height of the layers varies across the chamber and depends on its profile. The highest height of the outer compacted layer reaches in the upper open part of the chamber, forming a vaulted surface. For normal operation of the working chamber, it is necessary that the outer layer of the seed roll had a dense connected structure and was stable in motion, and its vault, when passing the upper part of the chamber, did not

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collapse, for which the density valve is used.At uniform loading of the vault, for its stability the chamber profile should be close to the circle [3].

The second disadvantage of the 5LP linter is that it is impossible to reduce the distance between the saws, because with its reduction, the seeds from the working chamber can not go through the gaps between the saw blades, but will go only through the gap between the seed comb and saws, which reduces the performance of the linter.

The third disadvantage of the 5LP linter is the complicated profile of the grates that make up the grate [3, 4]. On the 160-saw linter set 161 grates. Grate width, especially in the working place, should be observed very strictly, since the gap between the adjacent grates in this area is only 2,5-3,1 mm. Inaccurate manufacturing of the grate legs leads to their friction against the saws, wear of the grate edges and the saws themselves.

It has been noted in theoretical sources that when changing industrial varieties to 1500-2000 kg/hour, the productivity of lint work is 35-50 kg/hour, but in practice the actual productivity of seed work is 433.4 kg/hour, the productivity of lint work is on average 18.1 kg/hour [5].

One of the main reasons for the drastic difference in productivity is that in the 1980s and 1990s the lint separation process was carried out in three stages. The technological processes are adjusted step by step depending on the seed pubescence. Indicators in this three-stage process of lint separation can correspond to the indicators in the scientific literature [5,6]. At present, the technology of one-stage lint separation from cotton seeds is used at cotton ginning plants. Therefore, for this situation, it is necessary to conduct scientific research work to increase the actual lint withdrawal capacity and seed throughput capacity of linter equipment.

Analysis of studies of the litho process has revealed a number of factors that significantly affect the main indicators of the litho process - productivity, lint removal and its quality [7-11]:

-Breeding, industrial variety of cotton seeds and their pubescence;
-linting modes;
-the state of the saws and their diameter;
-parameters of the linter working chamber and its working elements;
-speed modes of the tedder and saw cylinder.

2 Methods

To find new design solutions and choose the direction of research to determine the rational parameters and modes of operation of the linter, we used theoretical analysis of the interaction of seeds with the sawing cylinder, as well as the results of previously conducted experimental studies.

Theoretical research on increasing the intensity of linterization

To separate the lint from the seeds it is necessary to use such a force impact of the saws in which qualitative and quantitative indicators of the lint and processed seeds are not reduced. It is reasonable to increase the efficiency of the linting process by increasing the intensity of the impact of the saws on the seed roll.Consider the interaction of seeds with the saw cylinder (Fig. 1).

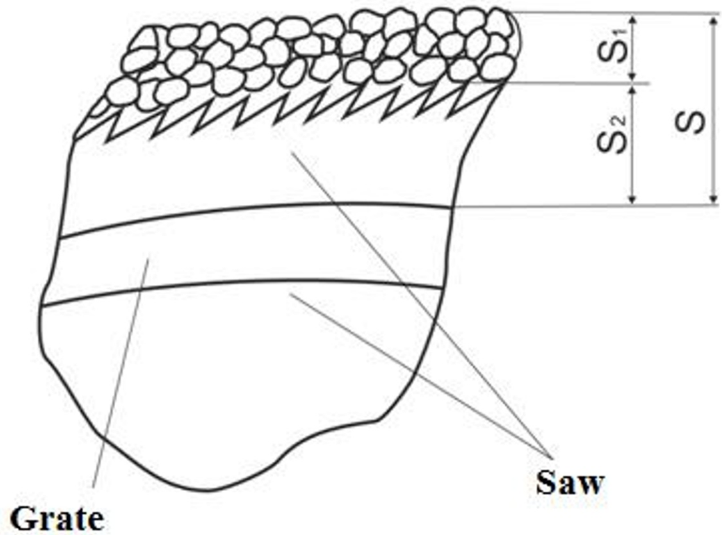


Fig. 1. Schematic of the interaction zone of the seed with the saw cylinder

The total height of the seed layer S (generally assumed to be equal to the thickness of the seed roller layer) consists of the seed layer directly in contact with the saw teeth S_1, and the inter-saw layer S_2, the height of which is determined by the size of the protrusion of the saws behind the grates. Assuming that all seeds in the seed roll are in equal conditions, we obtain [12]:

$\frac{S_1}{S}$ -probability of finding the seeds above the saws;
$\frac{S_c}{S_1}$ -probability of contact of the seeds in the layer S_1 with the saws;
S_c-parameters of the seed.

Based on the probability pattern and kinematic features of the considered zone, the equation that determines the intensity of the impact of saws on the seed is derived

$$Z = \frac{\omega_{св}}{2\pi} . \frac{S_c}{S} . \frac{l}{\upsilon_c} . \upsilon_n . P, \quad (1)$$

where: Z- the intensity of the impact of the saws on the seed, s^{-1};
$\omega_{св} -$ rotational speed of the seed roll, s^{-1};
l - arc length of the saws in the working chamber, m;
υ_c -is the average speed of the seed layer above the saws, m/s;
P - probability of the seed meeting the saw, depending on the pitch of the saw cylinder;
υ_n -frequency of impact of the saws on the seeds, s^{-1}.

As the seed layer S_1 above the saws moves with some slippage relative to the saw teeth, the value υ_n is calculated by the following expression:

$$\upsilon_n = \frac{\Delta \upsilon_n}{m} = + \frac{\upsilon_n - \upsilon_{n.c}}{m}, \quad (2)$$

where: $\upsilon_{n.c}$ -speed of the seeds in contact with the saws, m/s;
υ_n - circular velocity of the saws, m/s;
m - saw tooth pitch, m.

By formulas (1, 2) it is possible to determine the intensity of impact of saws on seeds taking into account geometrical and kinematic parameters of the seed roller, working chamber, saws and sawing cylinder and conduct theoretical and experimental research on improving the linting process. From the results of theoretical analysis it follows that by changing the volume of the working chamber, i.e. geometrical and kinematic parameters of the seed roller, we can expect an increase in the intensity of the impact of saws on seeds and improvement of the linting process.

3 Discussion

Choosing the direction of research. In JSC "Paxtasanoatilmiymarkazi" K. Sabirov conducted research work, the results of which developed and implemented in production gin regenerator DR-119 for the removal of short-staple fiber from ginned cotton seeds [12].

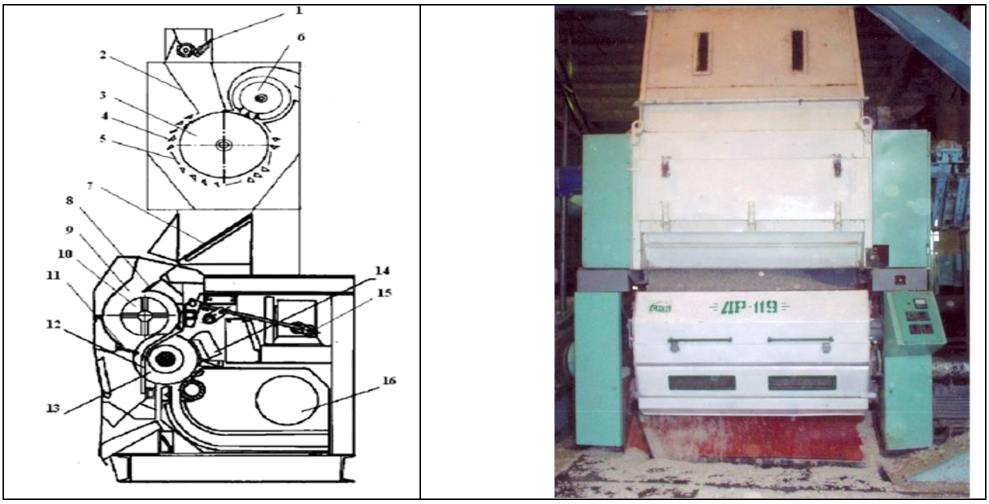
This unit provides for the use of a working chamber for gin 4DP-130 with reduced size, which accommodates a tedder, structurally similar to those used on the 5LP linter, but of increased diameter, and the sawing cylinder consists of 119 linter saws with a spacing of 13 mm. The function of the feeder-divider is performed by the RNS regenerator installed on the gin body. Design capacity of the complex unit is 7 tons of seeds per hour.

The DR-119 gin regenerator works as follows (Fig. 2).

In the technological chain of raw cotton processing after jinning the seeds are cleaned from impurities in the USMA installation, from where they are fed to the sawing drum 3 through the feeder pipe 1 and guide 2. The serrated drum interacting with seeds drags them through the grate 4 and guides 5, extracting from the overall mass of the seeds un-fertilized volatiles and seeds with strands of fiber which are removed from the drum 3 by removable brush drum 6 and sent for re-fining.

The rest mass of seeds, which still contains seeds with strands of fiber length 21 mm or more, falling out through the feed tray 7 enter the working chamber 8 gin, where they get under the influence of the teeth of a rotating saw cylinder 12 and with the help of a tedder 9 form a seed roll. The teeth of the saw cylinder capture the strands of fiber, tearing it away from the seed, and the fiber is removed from the saw teeth by the air jet coming from the nozzle of the air chamber. The guide 13 also contributes to fiber removal by directing it to the removal zone.

According to the results of production tests at the Hairabad cotton processing plant, after processing the seeds coming into the working chamber DR-119 with 12.5 % pubescence, the fiber removal was 0.5 %, with values of 11.5 % pubescence, mass fraction of defects and trash impurities 17.0 % (abs) and staple length 28.6 mm.



1-feeder, 2-runner, 3-thrower, 4-spike grate, 5, 7, 14-runner, 6-peel drum, 8-density valve, 9-work chamber, 10-agitator, 11-seed comb, 12-speakers, 13-sawing cylinder, 15-chamber lift lever, 16-air chamber

Fig. 2. Schematic diagram and general view of the developed gin regenerator DR-119 for removing short-staple fiber from ginned cotton seeds

In the course of research work the researcher recommended the basic parameters of gin regenerator DR-119 for removal of short-staple fiber from ginned cotton seeds 1 [4, 5].

Based on the analysis of the work carried out, and a thorough analysis of the work carried out by K. Sabirov, we can conclude that the use of the working chamber of increased volume can lead to a significant increase in productivity linter for seeds and lint removal.

Conducted by K. Sabirov research work is valuable material for the justification of the direction of further research, which is outlined in this paper.

It should be noted that the process of seed linting on the developed gin regenerator DR-119 was practically not considered. The main parameters of DR-119 gin regenerator were justified based on the condition of removing short-staple fiber from ginned cotton seeds in small quantity.

4 Conclusion

In view of the above, the task of the present work is to develop the design of the linter using the working chamber of the gin, to manufacture the developed linter and to study the process of lintering, providing rational conditions of its operation in an effective process of cotton seed lintering.

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