

**STUDY OF THE CONSTRUCTION FOR REMOVING SEEDS SEPARATED FROM
THE FIBER DURING THE GINNING PROCESS**

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Abstract: The article highlights the improvement of a device design that removes seeds separated from the fiber during the ginning process. The processes of seed separation from fiber in roll boxes of different design shapes were analyzed, and factors affecting the efficiency of existing constructions were identified. To ensure rapid and complete removal of seeds, experimental studies were carried out concerning the shape and dimensions of the grate bars on the front frame. The proposed design was tested on an experimental gin with 30 saws, and the results showed that it increases the gin's productivity and has a positive effect on fiber quality.

Keywords: ginning process, cotton, fiber, cottonseed, roll box, seed roller, front frame, grate bar, construction, density, efficiency, experiment.

Introduction. In the process of separating cotton fiber from seeds in a gin machine, the formation of a seed roller depends on several factors. The most important of these include the rotational speed of the seed roller, its fiber content, density, the amount of separated seeds, and other parameters. In saw gins, the main working unit is a cylinder assembled from saw disks. In these gins, the separation of fiber from seeds is carried out through the joint operation of the saw disks and the grate bars (gin ribs). Cotton entering the roll box of the gin is caught by the teeth of the rotating saw disks near the seed comb. Inside the roll box, cotton particles caught by the saw teeth adhere to other cotton particles, pulling them along and forming a seed roller. This roll rotates in the direction opposite to the rotation of the saw cylinder and continuously supplies cotton fiber to the saw teeth.

The authors determined the density of seeds accumulated in the center of the seed roller and the conditions under which this density exceeds that of the roll itself. In this case, at different productivity levels of the gin machine, the proportion of fiber-separated seeds moving toward the center of the seed roller was varied from 4% to 20%. For the initially processed raw cotton, when 5,294 kg/h, 5,882 kg/h, and 6,470 kg/h of cotton were supplied to a single gin machine, the amounts of fiber and seeds obtained, as well as the movement of fiber-separated seeds during the process, are presented in the corresponding tables [1].

According when the fiber productivity of the gin machine is 1.8 t/h and 4% of the seeds move toward the center of the roll box, the mass of these seeds is 116.5 kg, while at 12% it reaches 349 kg. When productivity increases to 2.0 t/h, these values amount to 129.4 kg and 388.2 kg, respectively. The results show that as productivity increases, the accumulation of fiber-separated seeds in the center of the roll box also increases. In addition, a newly invented design intended to remove fiber-separated seeds accumulated in the center of the roll box and the principles of its operation were analyzed.

Some researchers have claimed that seed separation occurs only in the seed comb zone. However, studies by G.I. Boldinsky [2] and D.A. Kotov [3] demonstrated that seeds are separated throughout the entire part of the roll box penetrated by the saw cylinder, with more intensive separation occurring in the seed comb zone. B.A. Levkovich [4] established that as the speed of the seed roller increases, the gin productivity increases, and conversely, productivity decreases with a reduction in speed. D.A. Kotov and G.I. Boldinsky theoretically substantiated that installing a seed roller accelerator in the roll box changes the structure and rotational speed of the

roll, and when the saw cylinder speed is 10–12 m/s, the maximum speed of the seed roller can reach 3–4 m/s.

The residence time of seeds in the roll box is also an important indicator. In existing gin equipment, the residence time of seeds in the roll box is relatively long. As a result, seeds from which fiber has been completely removed cannot leave the roll box in time and continue rotating in the central zone. When fiber-separated seeds account for 60–70% of the seed roller mass, the roll density increases, leading to deterioration of fiber quality [5]. Various researchers have studied ways to optimize the structure, mass, and density of the seed roller. However, the issues of excessive roll density and the inability of seeds to exit the roll box in a timely manner remain pressing scientific problems. Several researchers attempted to address this issue by installing accelerators to increase the rotational speed of the seed roller in the gin roll box. In particular, M. Tillayev proposed a paddle-type accelerator and investigated the influence of its geometric and speed parameters on the fiber content, mass, density of the seed roller, and the residence time of seeds in the roll box.

It was observed that the residence time of seeds in the roll box decreases with increasing accelerator speed and gin productivity. The application of the accelerator reduced the intensive seed discharge time from 60 seconds in a conventional gin to 40 seconds, and seed discharge increased threefold. However, these recommendations did not reach the level of a constructive solution suitable for wide industrial implementation. It is known that during the ginning process, fiber-separated seeds tend to accumulate in the central part of the seed roller. As a result, the density of the roll increases, leading to increased damage to both seeds and fiber. Studies have recommended the use of gin ribs (grate bars) of various shapes as a method for removing fiber-separated seeds from the roll box. The results showed a relationship between the rotational speed of the seed roller formed in the roll box and the gin productivity. In the proposed rib design (Fig. 1a), grooves are provided, allowing fiber-separated seeds to fall downward under the action of gravity through these grooves [6].

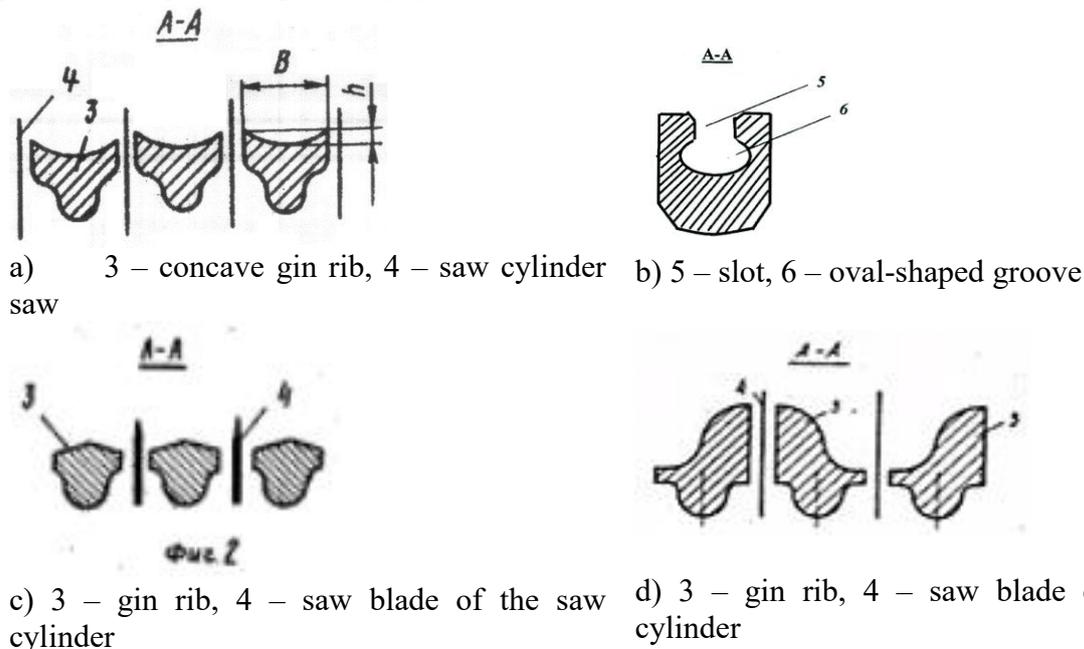


Figure 1. Cross-sectional views of the proposed gin ribs

The newly proposed rib design (Fig. 1b) is intended to ensure timely discharge of seeds, preventing their prolonged retention in the roll box. In this design, fiber-separated seeds pass through slot 5 into oval-shaped groove 6 and fall downward under gravity. This prevents excessive increase in seed roller density, reduces seed damage, and improves fiber quality [7].

The rib proposed by P.N. Tyutin [8] has a convex upper surface, which, in turn, increases productivity but also leads to damage of seeds and fiber (Fig. 1c). The rib proposed by Sh.T. Ergashev [9] aims to increase productivity by improving fiber engagement by the saw disks. The upper working surface of the rib is wedge-shaped, inclined on both sides, which ensures more effective transverse movement of seeds between adjacent saws. However, these ribs were not implemented in industrial production (Fig. 1d).

In the work of R. Sulaymanov [10], a theoretical solution was obtained for determining the optimal parameters of cantilever ribs and the spacing between ribs and spacers based on the dynamics and mathematical modeling of seed motion. Based on these results, the spacing between saws was reduced, and a new method and device for additional seed discharge were proposed (Fig. 2).

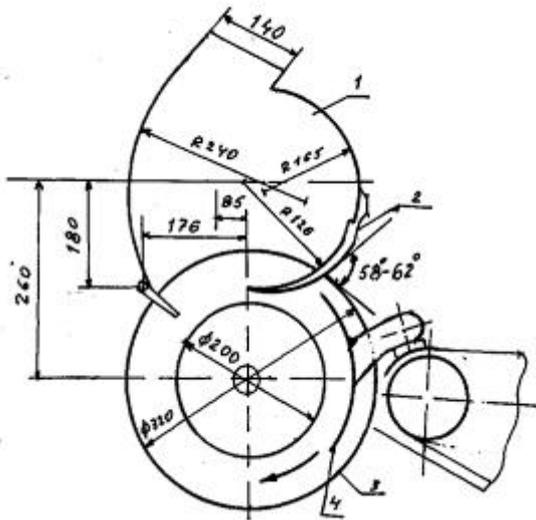


Figure 2. Gin rib proposed by R.Sh. Sulaymanov

1 – roll box, 2 – cantilever rib,
3 – saw cylinder, 4 – guide

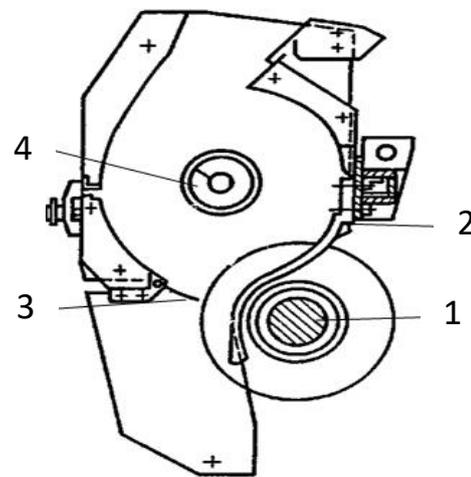


Figure 3. Roll box equipped with a seed discharge mechanism

1 – saw disk, 2 – rib grate,
3 – seed comb, 4 – seed discharge accelerator

In studies by X.K. Davidbayev [11], designs facilitating the discharge of fiber-separated seeds from the central zone of the gin roll box were installed (Fig. 3). Efficient separation of delinted seeds along the rib surfaces is crucial, since a large portion of delinted seeds repeatedly circulate inside the roll box while being caught by the saw teeth, leading to reduced productivity.

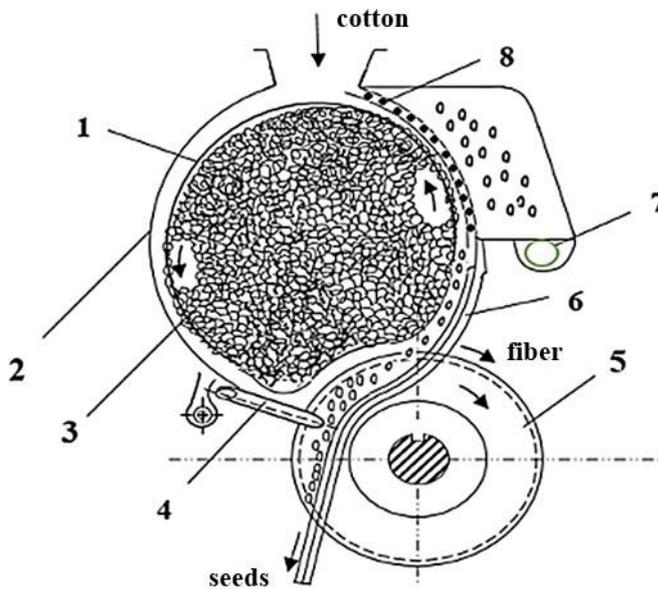
In the dissertation by Q. Sabirov [12] titled “Development of a Highly Efficient, Step-by-Step Ginning and Linting Technological Process”, the quantitative distribution of seeds after ginning based on complete delinting degree was scientifically substantiated, and a second-stage ginning process was recommended. In the first stage, the density of the seed roller in the roll box was reduced by fully opening the seed comb, and a short-staple fiber gin was developed for the second stage. The optimal spacing between saws, distances between the seed comb, accelerator blades, and the saw cylinder, as well as the protrusion of saws from the rib grate, were scientifically justified through experimental studies, and the roll box was selected accordingly. A step-by-step ginning and linting process that increases production efficiency in cotton processing plants was developed.

Based on the above, it can be concluded that in the saw ginning process, the density and speed parameters of the seed roller depend on the balance between fiber separation intensity and the discharge of cleaned seeds. Therefore, scientific studies aimed at stabilizing the ginning process

and ensuring the effective removal of fiber and seeds from the saw gin roll box are of particular importance.

Materials and Methods. Within the scope of theoretical studies, new working elements of the gin roll box were developed and experimental investigations were conducted to ensure the timely discharge of fully delinted seeds from the roll box (Fig. 3).

The main concept of the study is that, to accelerate the discharge of fiber-separated seeds, the lint apron beam surface is equipped with ribs of various shapes, including horizontal, vertical, and roller-type designs. The spacing between ribs was set to $t = 6$ mm. As a result, the discharge of fiber-separated seeds through the openings in the apron beam surface is accelerated, increasing gin productivity. The reason for installing horizontal, vertical, and roller-type ribs in place of the apron beam is that this zone corresponds to the point of minimum seed roller speed in the roll box.



**Figure 3. New gin roll box.
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1 – roll box, 2 – front apron,
3 – seed roller, 4 – seed comb,
5 – saw cylinder, 6 – rib grate,
7 – screw conveyor for fiber-separated seeds, 8 – apron beam made in the form of a grate

The proposed saw gin operates as follows: cotton entering the roll box moves uniformly along the flat surface of the chamber (1). Due to the rotation of the saw cylinder, a seed roller is formed, and the roll (3) and saw cylinder (5) rotate in opposite directions. As the saw cylinder rotates, the saw teeth catch the fibers, separating them from the seeds. Since seeds cannot pass through the spaces between the ribs (6), they fall downward. Some fiber-separated seeds, upon reaching the point of minimum roll speed in the roll box, pass through the apron beam with 6 mm spacing between ribs (8) and are transported by the collecting screw conveyor (7) to the next technological stage.

Experimental comparison of seed roller rotational speeds in 30-saw and 130-saw gins showed that the difference between them is insignificant [12]. Additionally, the fiber productivity per saw is the same for both configurations. Considering these factors, experiments were conducted on a 30-saw gin, which also provides greater convenience for modifying and fabricating working elements.

To experimentally study the discharge of fiber-separated seeds from the saw gin roll box, a 30-saw experimental gin stand was constructed (Fig. 4). Experimental tests were carried out in the scientific laboratory of the university.

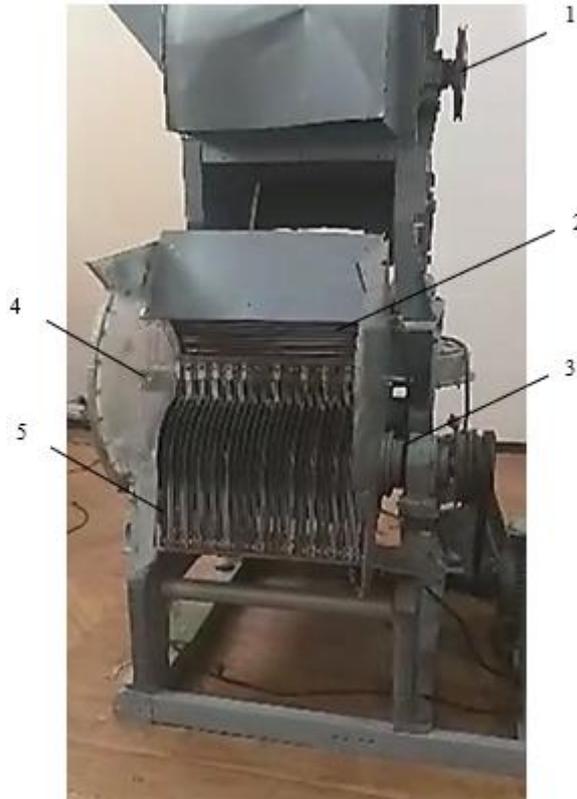


Figure 4. External view of the saw gin test stand equipped with an apron beam of various shapes

1 – feed roller pulley, 2 – apron beam made in the form of a rib grate, 3 – saw cylinder, 4 – roll box, 5 – rib grate

Initially, experiments were conducted by installing ribs with diameters of Ø8 mm, Ø10 mm, and Ø12 mm on the apron beam surface to accelerate seed discharge. Based on seed thickness, the spacing between ribs was set at 6 mm. The effects of rib diameter on seed discharge, seed roller speed, and roll density were studied. Preliminary results showed that ribs with Ø8 mm diameter yielded relatively better performance, and thus were selected for further studies.

The experiments revealed that as the density of the seed roller increased, its rotational speed decreased during operation of the saw gin stand. This indicates that ribs of various diameters installed on the apron beam surface increased resistance to roll rotation, i.e., the friction coefficient in the roll box increased.



Figure 5. Experimental prototypes of the proposed designs manufactured in various shapes

1 – apron beam with ribs of Ø12 mm diameter, 2 – apron beam with ribs of Ø10 mm diameter, 3 – apron beam with ribs of Ø8 mm diameter, 4 – vertically shaped rib

Therefore, it was concluded that the rib grate installed in place of the apron beam should be oriented vertically. A vertical rib grate was designed in SolidWorks, and a prototype was

manufactured and tested. However, this configuration also did not yield satisfactory results, as the alignment of slots with the direction of roll rotation led to the discharge of incompletely delinted seeds and clogging (Fig. 5).

Based on the analysis of the conducted studies, it was concluded that the rib grate profile on the apron beam surface should be designed in a roller shape. In this case, the roller-shaped ribs do not resist roll rotation and do not increase the friction coefficient in the roll box. The roller-shaped rib grate was also designed in SolidWorks, a prototype was manufactured, and experimental tests were conducted (Fig. 6).

Results and Discussion. During the experiments, the rotational speed of the seed roller was measured using a tachometer by creating a slot at the center of the front apron of the roll box. It was observed that changes in the shape of the apron beam surface significantly affect the rotational speed and density of the seed roller, as well as gin productivity, seed discharge, and product quality [13].



Figure 6. Experimental prototype of the proposed roller and roller-type design

The results showed that when horizontal ribs were used, increasing roll density led to a decrease in rotational speed and eventual stoppage due to increased friction. Vertical ribs showed better performance but caused the discharge of incompletely delinted seeds. The best performance was achieved with roller-shaped ribs, which had a positive effect on both roll speed and density (Fig. 7).

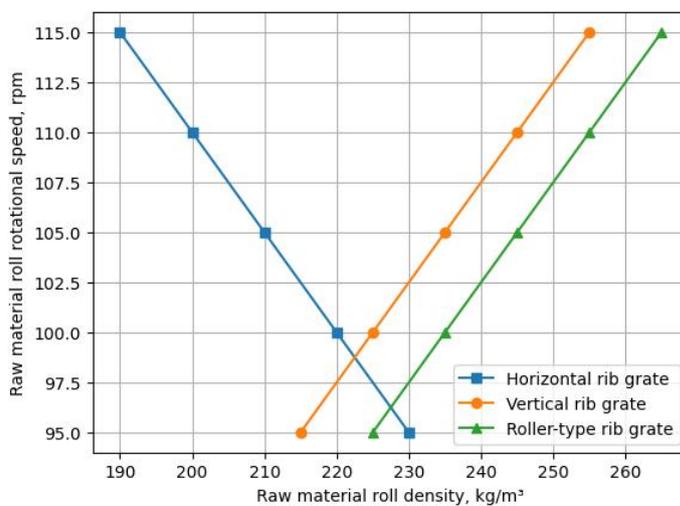


Figure 7. Effect of rib geometries on the rotational speed and density of the seed roller

- 1 – results obtained with a rib grate of horizontal profile on the apron beam surface;
- 2 – results obtained with a rib grate of vertical profile on the apron beam surface;
- 3 – results obtained with a roller-type rib grate on the apron beam surface.

At a roll density of 230 kg/m³, the rotational speed dropped to 95 rpm with horizontal ribs. In contrast, with vertical and roller-shaped ribs, at densities of 260–270 kg/m³, the rotational speed remained at approximately 115 rpm. Experimental tests conducted on a 30-saw gin stand showed that, within one minute, the mass and fuzziness of discharged seeds varied depending on rib

shape. Experiments were performed on hand-picked cotton of the medium-staple Namangan-77 variety, industrial grade II, with moisture content of 8.5% and trash content of 2.8%. The results indicated that within one minute, the mass of discharged seeds was 45 g with horizontal ribs (fuzziness 11%), 71 g with vertical ribs (fuzziness 13%), and 76 g with roller-shaped ribs (fuzziness 11%).

Conclusion. The conducted studies demonstrated that horizontal ribs installed on the apron beam surface create resistance to the rotation of the seed roller, leading to increased density and eventual process stoppage, resulting in the poorest performance. Vertical ribs improved roll rotation but caused the discharge and clogging of incompletely delinted seeds due to the alignment of slots with the direction of roll movement. Analysis of experimental graphs showed that the best performance was achieved with roller-shaped ribs, where gin productivity was the highest..

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