

ANALYSIS OF SCIENTIFIC RESEARCH ON DELINTING TECHNOLOGIES AND TECHNIQUES FOR SEED COTTON

<https://doi.org/10.5281/zenodo.20591519>

Djamolov R.K.¹, Aloydinov M.G.², Gayratov J.G.²

¹*Research Institute of Cotton Crops*

²*Fergana State Technical University*

Abstract

Cotton production is a key driver of Uzbekistan's agricultural economy, making seed quality a critical factor in achieving high yields. This paper reviews scientific research on mechanical delinting technologies for seed cotton preparation, focusing on the working principles, chamber design, and operational parameters of delinting machines. The study analyzes the physico-mechanical properties of seed cotton and their influence on delinting efficiency, including the effects of seed layer density, working gap dimensions, and rotational speed on linter separation quality and seed integrity. It is established that seed layer density in the working chamber—ranging from 175 to 550 kg/m³ depending on machine type—directly affects delinting performance and seed damage. The paper discusses the limitations of open-chamber designs with uncontrolled feeding, and identifies the development of a precise feeder-dosing mechanism as a priority for stabilizing seed flow, maintaining optimal layer density, reducing seed damage, improving short linter quality, and lowering energy consumption. The findings contribute to the theoretical and practical basis for improving mechanical delinting machine design.

Keywords

seed cotton; delinting; mechanical delinting machine; seed layer density; working chamber; linter separation; feeder-dosing mechanism.

Cotton growing plays an important role in the sustainable development of the economy of the Republic of Uzbekistan and in increasing the potential of its agricultural sector. Therefore, the quantity and quality of cotton products must be high, and efficiency must be ensured in cotton production processes. In this regard, cotton seed farming and the quality of the seed cotton fund being prepared are of special importance, as low seed quality directly affects future crop yields.

At present, both fuzzy and delinted seed cotton is mainly used for planting in Uzbekistan. The quality indicators of these seeds must comply with the requirements of the O'zDst 663:2017 standard "Seed Cotton. Technical Conditions".

This standard includes requirements for seed cotton purity, moisture content, fuzziness level, and other key indicators [1].

Work on improving seed cotton preparation technology should primarily focus on improving seed quality and the productivity of technological lines. This is because the working process in existing equipment is not fully stable, and problems are observed in seed damage and in bringing the fuzziness level to the norm.

It is known that the physico-mechanical properties of seed cotton—including its shape, dimensions, hardness, fuzziness, friction coefficient, and other indicators—have a significant effect on the operating mode and adjustable parameters of delinting machines. Therefore, proper selection of working elements and technological modes for each variety and condition of seed is considered important [2].

D.E. Kharmats, based on his theoretical and experimental research, determined the magnitude of the force generated by a saw-tooth-shaped working body without causing damage to the seed kernel. According to him, the permissible impact force is in the range of 0.256–1.28 N.

As fibers are separated from the seed surface during ginning and linting processes, the length of remaining fibers also decreases. According to research results, the average remaining fiber length on ginned seeds is 5.3 mm, and on linted seeds it is 4.5 mm. Therefore, as the fiber length decreases, removing it mechanically becomes increasingly difficult.

As residual fuzziness decreases, the fibers on the seed surface become shorter. In this case, the process of mechanically scraping short fibers becomes considerably more complex. As a result, mechanical damage to the seed increases, contamination of short linters rises, and energy consumption grows.

As V.N. Gerasimchuk noted, directly extracting the separated linters from the working zone through the working element preserves their quality. If the linters are separated through a mass of seeds, their level of contamination increases and fiber length decreases.

To further improve the mechanical method of preparing delinted seed, it is necessary to deeply analyze the shape of the working chamber, study the possibilities of replacing open-chamber designs with closed-chamber systems, and evaluate the effectiveness of organizing various mixing zones in the working zone. In addition, research is needed on the proper selection of machine operating modes, taking into account seed fuzziness, size, shape, fiber attachment strength to the seed coat, and the characteristics of fiber arrangement around the kernel.

The idea of using convex working surfaces to separate linters from the seed surface has attracted the attention of many researchers. Such working surfaces

allow seeds to be processed simultaneously over a wide area, increase the contact surface between the working element and the seed, and expand the possibilities of filling the chamber with seeds [3].

As seen from production practice, the efficiency of the delinting process mainly depends on the condition of the working surfaces and the density of the seed layer in the working chamber. If the working chamber is well filled with seeds, the mutual interaction between the convex working elements and the seed layer is enhanced.

The method of pressing fuzzy seeds against the working surface through the mass of other seeds has a number of advantages. First, the seed layer is elastic, which helps preserve the integrity of the seeds. Second, when a seed moves among other seeds while surrounded by the working surface, the resistance forces increase rapidly. As a result, a tangential force F_{τ} is generated and braking of the seed occurs.

However, compaction alone is not sufficient. The relative movement of the seed along the working surface must also be ensured for the delinting process. If the seed does not move, the linter separation process proceeds slowly or produces no result at all.

It is known that seeds can stick to the surfaces of the drum and outer casing. For this reason, the entry of seeds into a stationary drum chamber is difficult. When the drum rotates, seeds that have entered from the feeder are captured by the working elements and thrown, and as a result, seeds move randomly under the influence of the upper layer pressure and fill the working chamber. In many designs, solutions have been proposed to ensure forced movement of seeds along the drum length.

Almost all currently used mechanical delinting machines have an internally horizontally placed cylindrical drum with active working elements. The drum is enclosed by an outer casing and in some designs the casing may also have active elements. Seeds are usually introduced into the chamber from the top and removed from the bottom.

The density of the seed layer in the working chamber is controlled through the placement, shape, and special adjustment devices of the feeder. In general, two limiting conditions can be observed in the working chamber.

In the first condition, there are few seeds in the chamber and they are not densely connected to each other. When the drum rotates, seeds are attracted to the working surface within a short time, then thrown at the screen and may fall back down. In this case, despite the presence of interaction with the working elements,

delinting efficiency is low. The likelihood of seed damage increases and fiber separation is not adequately ensured.

In the second condition, the maximum amount of seeds is forcibly introduced into the working chamber. As a result, the seed layer becomes extremely dense, the seed coat and kernel are deformed, and the seeds stick tightly to each other and to the working surfaces. Drum rotation becomes difficult, blockages occur in the chamber, and the machine may stop.

Normally, seeds begin to actively interact with the working elements after approximately one-third of the chamber is filled, and linter separation begins from that moment. During the working process, the seed layer is formed.

When the distance between the working surfaces is much larger than the seed size and the relative speed is low, the seeds mainly move in laminar flow. In this case, seeds rub against the drum surface and form a stationary layer on the screen. Although there is movement of seeds within the layer, heating intensifies due to friction and the delinting effect decreases.

Above a certain speed, disordered movement of seeds begins and turbulent flows appear. Seeds actively move relative to each other and to the working surfaces. In this case, the process of scraping the fiber and processing the seed coat intensifies and delinting accelerates.

If the distance between the working surfaces is less than twice the seed diameter, seeds alternately touch one working surface or the other. In this case, linter separation speeds up, but due to the hardness of the working elements, seed damage increases sharply.

Therefore, by increasing the working gap 2–3 times, it is possible to form an elastic seed layer at a certain density. This serves to preserve the integrity of the seeds during processing.

In laboratory experiments, the density of the seed layer was observed to vary from 0.3 to 3.0 times the natural bulk density of the seed. At the same time, due to the influence of the feeding system and the fact that seeds are passing through the chamber and linters are being extracted, the seed mass decreases, the elasticity of the layer is lost, and density begins to decrease. This disrupts stable operating conditions of the machine.

The filling of the working chamber with seeds depends on its shape, feeder design, and installation position relative to the drum. For example, in the LB machine, the feeder shaft outlet is located above the downward-facing part of the drum. Seeds falling from the shaft are caught by the drum surface and drawn into the working gap. However, as the working gap narrows sharply from top to

bottom, the seed layer is compressed downward and there is a risk of blockage in the continuous fall of seeds [4].

For this reason, in machines with an open working chamber, the operator must constantly monitor the feeding. In practice, this is done by measuring the current strength (ammeter reading) based on drum loading. In single-drum benches with a closed working chamber and in two-drum machines, it is possible to form a layer of the required density due to the movement of seeds captured by the working elements. However, this requires the feeding shaft to be continuously filled with seeds.

Abdurashidov G.A. and Zokirov T., based on research conducted on a laboratory bench, determined that the average density of the seed layer is 175–200 kg/m³. It was noted that this indicator is considerably lower compared to the bulk density of scattered seeds (320–400 kg/m³).

In a single-chamber laboratory device, the average density of the seed layer was brought up to 500–550 kg/m³. It was determined that to ensure such high density, seeds with 10% fuzziness require more than 40 kPa/m² of specific pressure. In practice, such high density can mainly be achieved by fully delinted seeds.

The optimal density of the seed layer depends on the delinter design, the initial and final fuzziness of the seeds, the breeding or industrial variety of the seed, and the product quality requirements. At the same time, the machine's productivity and energy consumption are directly related to layer density, and in some conditions the machine may be adapted to operate with a dense layer.

Visual, stroboscopic, and photographic observations of seed movement in the working gap between the saw cylinder and the screen showed that in the lower and lateral areas, some seeds form a layer adhering to the cylinder surface. In the upper area, seeds fall onto the cylinder surface under the effect of gravity, move at high speed, separate from it, and strike the screen at a certain angle. In this process, the seed flow reflects off the screen and falls back onto the cylinder or into the space between the cylinder and the screen.

The radial movement of seeds in the layer mainly occurs under the influence of gravity and centrifugal and friction forces generated by drum rotation. Axial movement in some machines (for example, the 4SOM and OS types) may be ensured by the difference in seed layer density at entry and exit of the working site, or with the help of special guide elements.

Calculations and experimental results showed that when the density of the seed layer changes from 200 kg/m³ to 500 kg/m³ under otherwise identical conditions, the efficiency of linter separation does not change significantly. This can

be explained by the fact that in this range, seeds interact sufficiently with the working elements and the fiber scraping process continues stably. For this reason, in delinters of the 4SOM and OS types, the density of the seed layer is not separately adjusted.

The process of filling the working chamber with seeds mainly depends on the method of seed delivery by the feeder. Feeding can be carried out along the entire length of the chamber or organized frontally through a certain section of the machine. Entry of seeds into the working chamber in some cases is carried out by gravity, while in other designs it is regulated with special mechanisms.

The transfer of seeds through the working chamber and the formation of a certain dense layer there is considered the main condition of the delinting process. At the same time, in some cases, seeds can arrange themselves in two rows in the working zone, which accelerates the linter separation process to some extent. However, during the working process in metal brush drums, wear of the brushes causes the working surface to expand, as a result of which processing time increases, seed heating rises, and product quality may decrease.

When the seed layer density is low, the interaction between the working elements and the seed is insufficient, resulting in a decrease in linter separation intensity and the delinting effect not being ensured at the required level. Conversely, when layer density increases excessively, seeds are pressed tightly against each other and the working surfaces, drum rotation becomes difficult, and blockage situations can arise. Under such conditions, mechanical damage to the seed coat and kernel increases, seed quality decreases, and energy consumption rises sharply.

In most mechanical delinting machines currently in use, the process of feeding seeds to the working chamber is mainly based on the free fall method through a shaft. Due to the design and placement of the feeder, seeds do not enter the chamber uniformly, and the narrowing of the working gap from top to bottom leads to uneven compaction of the seed layer. For this reason, disordered movement, partial blockage, and recirculation of seeds are observed in the chamber.

Especially in machines with an open working chamber, the feeding process is in many cases controlled by the operator based on drum loading. The seed flow is manually adjusted based on whether the current increases or decreases on the ammeter reading. This shows that the process is not automated, depends on the human factor, and as a result the delinting process is not stable.

For this reason, developing a feeder-dosing device that ensures stable delivery of seeds to the working chamber in delinting machines and allows precise dosing of

the seed flow at a specified rate is a pressing task. Such a device serves to continuously maintain the optimal density of the seed layer in the working chamber, stabilizing the interaction between the working elements and the seeds. As a result, delinting efficiency increases, seed damage decreases, short linter quality improves, and energy consumption is reduced.

REFERENCES:

1. Handbook of Primary Cotton Processing. Book 1, Tashkent, 1994, pp. 373-379.
2. Rakipov V.G. et al. Technological Regulation for Seed Cotton Preparation. PDQI 82-2007. "Cotton Cleaning Industrial Association" JSC, Tashkent, 2007.
3. Rubidinov, Sh.G.U., & Gayratov, J.G.U. (2021). Use of modern chrome plating technology in die repair. *Scientific progress*, 2(5), 469-473.
4. Rubidinov, Sh.G.U., & Gayratov, J.G.U. (2021). Analysis of productivity in processing body parts of multi-operation milling machining centers. *Oriental renaissance: Innovative, educational, natural and social sciences*, 1(9), 759-765.