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IMPROVING SEED AND LINT QUALITY THROUGH INDEPENDENT CONTROL OF SAW CYLINDER AND AGITATOR SPEEDS IN THE LINTER MACHINE

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Annotation

Effective separation of planting cottonseed and industrial cottonseed in linters and prevention of lint damage are urgent issues for the modern cotton industry. This article aims to analyze the problems that arise during the operation of linters and consider advanced technological approaches to eliminate them. In particular, the possibilities of using automation systems, sensor technologies and innovative materials for optimal separation of seed and technical seeds, preservation of lint quality and reduction of damage are discussed.

Keywords

damage, seeds, lint, saw cylinder, saw tooth, comb, roll box.

Introduction. The Cotton Ginning Machinery Market was valued at USD 4.32 billion in 2023, expected to reach USD 4.61 billion in 2024, and is projected to grow at a CAGR of 6.65%, to USD 6.79 billion by 2030. The global cotton ginning machinery market is defined by equipment used to separate cotton fibers from seeds, facilitating the production of clean and high-quality cotton for textile manufacturing. The necessity of cotton ginning machinery is underscored by the global demand for cotton in textiles, as it enhances production efficiency and product quality while reducing manual labor costs. Its primary application is in textile mills and cotton processing units, serving both large-scale industrial operations as well as small and medium enterprises (SMEs) in the textile sector. The end-use scope extends to industries producing apparel, home textiles, and industrial textiles, among others. Key growth factors in this market include the rising demand for cotton textiles, technological advancements in machinery, and strategic government support for modernizing agricultural sectors [1].

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The global delinting machine market size reached USD 1,499.6 million in 2023. Over the forecast period, global delinting machine demand is anticipated to rise at 4.3% CAGR. The market value is predicted to increase from USD 1,562.6 million in 2024 to USD 2,380.6 million in 2034. The global delinting machinery market is predicted to rise over 1.5x through 2034, amid a 0.8% increase in expected CAGR compared to the historical one. This is due to the increasing demand for efficient, reliable, and economical devices in agricultural sector. The market is further projected to grow due to technological innovations, agricultural expansion, resurgence of the textile industry, and focus on sustainable practices. By 2034, the total market revenue is set to reach USD 2,380.6 million [2].

Materials and Methods. The textile industry relies on cotton, the most important raw material, emphasizing the need for improved delinting techniques for the cotton process to increase production. Introduction of genetically modified cotton, advanced agricultural practices, and favorable weather conditions are increasing cotton yield, leading to a surge in demand for delinting machines. As technological innovations continue to rise across the delinting machinery sector, manufacturers are developing more advanced solutions that fulfill the required demand and are following sustainability standards & regulatory requirements.

There is a high need to create simple, low-material and energy-consuming and automated designs of compact technologies and equipment that allow maintaining the initial quality indicators of lint and seed and controlling product quality in the process of separating short fibers from cottonseed for planting and technical seed.

Methodology. Today, in the separating short fibers from the seed technological system of cotton ginning, linter machines of the 5LP type are used (Fig. 1). The linter throughput, lint productivity, and lint removal rate from the surface of the grain are related to the weight, density, and strength of the lint roller, the number of blades in the roller, the parameters of the saw roll box, the diameter of the teeth, and the position of the saw in the roll box. The linter roller parameter is related to the roll box profile, the design of the mixer, its location in the roll box, and its speed [3].

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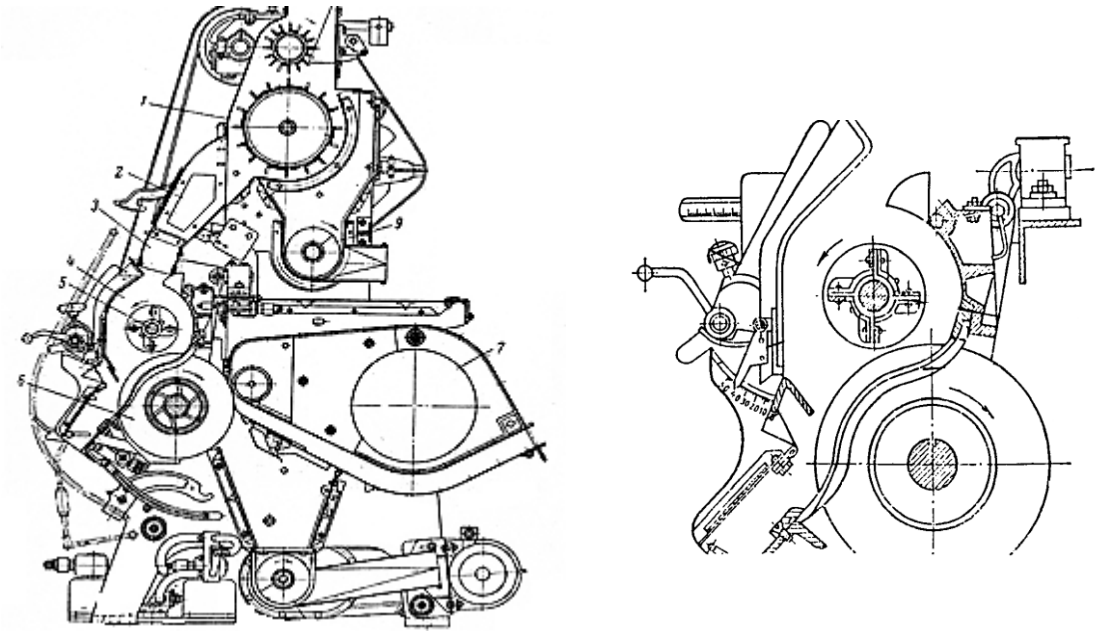

a) b)

Figure 1. 5ЛП-160 type linter machine and roll box

1-KPP type feeder; 2-seed forming chute; 3-rubber barrier preventing the seeds from returning from the roll box; 4-roll box (seed);

5- accelerator; 6-saw cylinder; 7-air box; 8- conveyor; 9-waste conveyor;

The correct selection of the operating speed of the linter machine directly affects production efficiency and product quality. An increase in speed leads to an increase in lint separation efficiency, an increase in fine impurities in the lint composition, and a decrease in the length of the lint staple. It can cause damage to seed and technical seeds and a decrease in germination properties (Fig. 2). To maintain optimal balance, the working parts must operate within the specified RPM range. It is especially important to regularly calibrate the speed of the saw cylinder when processing different cotton varieties or seeds with different moisture levels. Calibration is a necessary technical process to ensure optimal operation of the saw cylinder, improve lint quality and machine efficiency, and prevent seed damage [4].

Results and Discussion. Technical seeds have a shorter shelf life, cracked and damaged seeds deteriorate faster under the influence of microorganisms and moisture. Overheating and mold growth of seeds, as well as improper storage of damaged seeds in improper conditions, can accelerate microbiological processes and mold formation. Oil yield decreases, when the seed shell cracks, losses occur during the oil separation process. Increased solid residues in the oil The oil obtained from damaged seeds may contain small shells and fibers, which

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complicates the filtration process [5]. Oil quality deteriorates, cracked seeds oxidize quickly, and this negatively affects the taste and stability of the oil (Fig. 2).

a) b)

Figure 2. Lint and seeds separated from the linter machine

Deterioration of lint quality, small pieces of seed coat are mixed with the lint composition. Dust and crushed debris contaminate the lint. Traces of seed oil make the lint sticky, making it difficult to process. The quality of the lint decreases, and the cleaning and processing process becomes more complicated (Fig. 3). As a result of the deterioration of the quality of products obtained from low-quality lint, lint is sold at a low price for the paper industry and other products [6].

Figure 3. Damaged seed and lint

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Reduced germination in seeds, cracking or damage to the seed coat leaves the embryo inside the seed vulnerable. As a result, the seed's germination ability decreases during planting. Increased susceptibility to diseases, cracked seeds create conditions for faster penetration of bacteria and fungi, which increases the risk of disease spread (Fig. 3). Reduced shelf life, damaged seeds can rot or deteriorate during long-term storage.

In cotton textile enterprises, it is possible to maintain the natural quality of the product by developing a new automated technological system that prevents damage to white seeds and technical seeds and improves the quality of the lint in linter machines during the cotton production process by automatically adjusting the rotation speeds of the rollers and saw cylinders in accordance with the saw diameters, which provide the density of the raw material in the working chamber through the load current of the accelerator's electric motor.

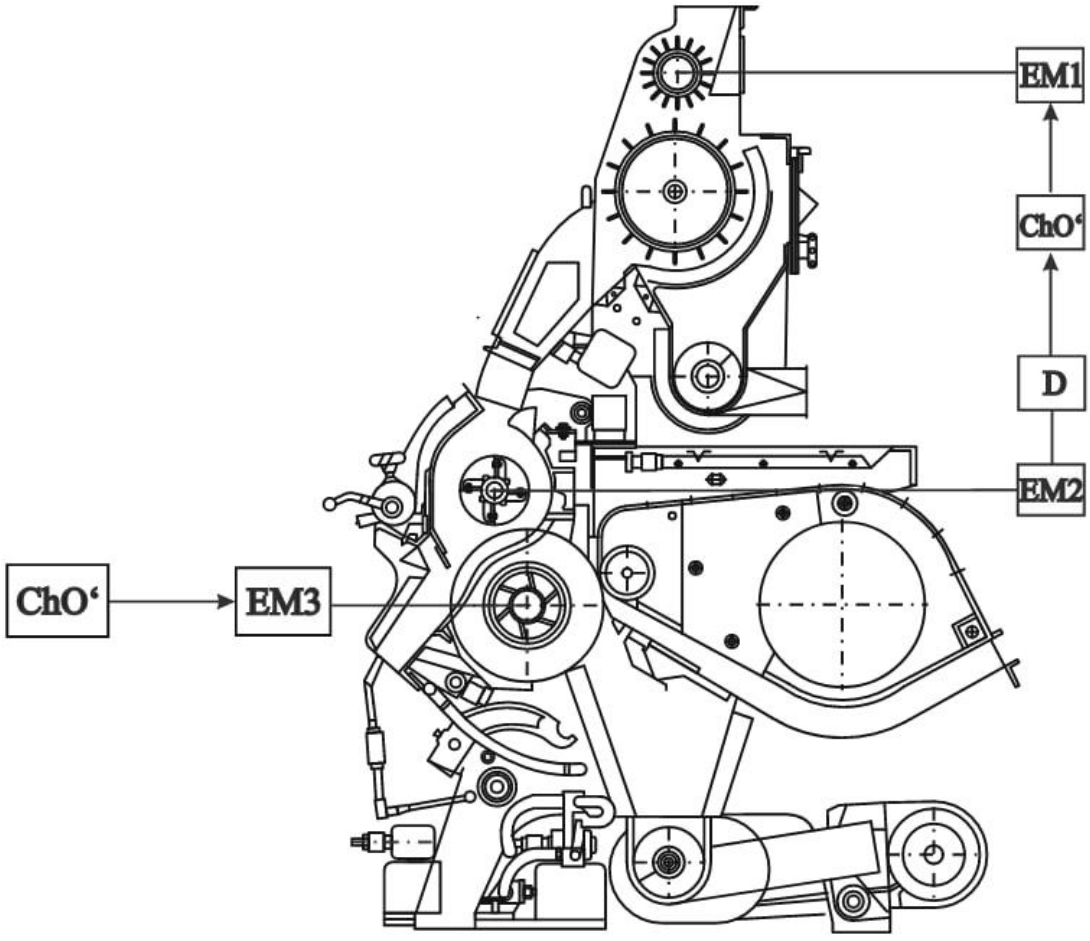

Figure 4. Linter machine control system using Variable Frequency Drives (VFDs)

The experiments showed that the fuzziness level of seed cotton exiting the linter machine significantly decreased due to the proposed technological solution.

Previously, the average fuzziness level on a 5LP-160 type linter machine was about 1.2%. However, with the new technology — involving separate control of the rotational speeds of the saw cylinder and the beater using variable frequency drives — this indicator was reduced to a range of 0.8–1.0% [7].

The experiments revealed that the average mechanical damage rate of cottonseed in the 5LP-160 type linter machine was 3.8%. With the proposed new technological approach — independent control of the saw cylinder and beater rotation speeds using frequency converters — this indicator was reduced to 3.0%. This demonstrates that mechanical damage to cottonseed can be significantly reduced through the improved control method [8].

The automatic control system helps to accurately and efficiently control each process of the machine (Fig. 4). This helps to improve the speed and quality of the process of separating lint from grain, increasing production efficiency. With the help of automatic control, the machine's performance can be maintained in an optimal state, reducing energy consumption. This helps to reduce production costs and increase energy efficiency. Automatic control systems allow you to constantly monitor the condition of the machine. This makes it easier to plan maintenance and repair processes, ensuring uninterrupted operation of the machine.

Conclusion. Effective separation of seed and technical seeds in linters and prevention of lint damage are important tasks for the modern cotton industry. Studies show that the introduction of advanced technologies helps to increase the efficiency of linters and improve product quality. The use of automation systems is an important factor in the quality of lint and the preservation of seed. In addition, processes can be optimized through structural changes in linters and modern control systems. There is also an opportunity to minimize technical failures in production processes, improve maintenance systems, and reduce lint damage by using new materials. These approaches not only increase the efficiency of the cotton processing industry, but also provide high economic profitability. Therefore, the introduction of modern technologies into linters is one of the main directions of industrial development, which will play an important role in obtaining high-quality products and increasing production efficiency in the future.

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