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IMPROVEMENT OF THE LINTER MACHINE AND DEVELOPMENT OF ITS WORKING SCHEME

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Abstract: This research is dedicated to improving the linters process in the cotton industry and increasing energy efficiency. The study explores opportunities to enhance the effective cleaning of lint products, introduce resource-efficient technologies, and automate production in the linters process. A new cleaning device has been installed in the technological processes of the new linters machine to improve cleaning efficiency, which has led to improvements in product quality and process effectiveness. Additionally, the design of the cleaning device and the main working parts has been analyzed, enabling increased productivity and resource efficiency.

Keywords: Linting, lint cleaning, cotton industry, energy efficiency, resource efficiency, cleaning device, automated technology, cotton cleaning, technological process, linters machine.

Introduction. In global practice, cotton fiber is considered the main raw material for the textile industry. Along with improving the techniques and technologies for processing cotton raw materials, significant attention is being paid to increasing productivity, enhancing the cleaning efficiency of machines, and improving the quality of the produced fiber, lint, and cottonseed. In developed countries such as the USA, China, Turkey, and India, there is a strong focus on modernizing methods of managing technological processes, developing automated methods for designing equipment and technologies, and creating automated control systems for cotton processing. In this regard, priority is given to creating resource-saving equipment that increases production efficiency, improving cottonseed linting and lint quality, and developing energy-saving technical tools.

Many scientific research projects are being conducted globally to establish scientific foundations for processing cotton raw materials and developing new techniques and technologies. In this regard, automating the linting and lint cleaning processes, which are key operations in cotton processing plants, increasing process productivity, and equipping machinery with resource-saving units are of critical importance. The development of mathematical models that optimize tasks such as improving the quality of lint and seeds through resource-efficient technologies is essential. Additionally, there is a need to design new lint cleaners and determine the key parameters that improve product quality during the linting and cleaning of cottonseeds.

Methods. After the ginning process, a short fiber layer known as lint (fluff) and delint (fuzz) remains on the seeds. Depending on the variety and industrial grade of the cotton, different amounts of lint and delint remain after ginning. For medium-staple cotton seeds, 11-17% of lint and delint remains relative to the initial weight of the seeds, while for fine-staple cotton seeds, the amount is between 2.4-5%. The percentage of lint and delint remaining on the seeds after ginning, relative to the seeds' initial weight, is referred to as the seed's overall fuzziness [1].

The linters machine is equipped with an electric motor with a power of 18.5 kW, a worm gear reducer, and a mechanism for raising the working chamber that consists of levers. This mechanism is controlled via a button on the control panel. When the button is pressed, the working chamber is lifted, and with a short second press, the chamber lowers back to its initial position. The technological processes of the 5LP and PMP-160M linters are similar.

In fiber separation machines, the fiber-separated seeds are transported through the RNS regenerator, the USM-A pneumatic seed cleaner, and, if necessary, the SM mechanical seed cleaner. They are then dropped into the linters machine’s feeding shaft using transportation devices. The saw teeth separate the lint from the seeds, passing it through the slots between the gratings. The lint is then removed from the saw teeth by an air stream from the air chamber nozzle, carried through the lint removal pipe, and finally transported to the condenser. Waste and impurities are separated by centrifugal force and dropped into the collection conveyor through the ducts and shafts. They are then sucked into cyclones using pneumatic transport. The lintered seeds, cleaned to the required level of fuzziness, slide along the grating surface and fall into the screw collection conveyor through a chute. Maintenance of the machines involves closely monitoring the technological gaps specified in the technical descriptions and ensuring the proper functioning of the linters during seed cleaning.

In the working chamber of the linter (Figure 1.2), the consistent fall of seeds and their thorough opening is due to the chessboard-like arrangement of the pegs and planks, which rotate at a uniform speed. This ensures consistent density of the seed roll in the working chamber, leading to uniform delinting (separation of lint from the seeds), thereby reducing seed damage.

Currently, scientists are exploring opportunities to improve the cleaning of lint products during the linting process. Some modern studies have developed separate lint cleaning devices, while others have conducted comprehensive research on improving product cleaning during the linting process.

One of the main drawbacks of lint cleaners is that if they are not forcibly shaken, the impurities are not broken down into smaller pieces, and the cost of space required for installation is high. Mechanical cleaning devices that have an active impact on the product stand out, such as pegs, beaters, blades, teeth, and others found in rotating working parts. Based on the movement of lint, mechanical cleaners are divided into machines with longitudinal and transverse movements. Cleaners with longitudinal movement mainly include peg-screw and beater-screw types, while those with transverse movement include saw, peg, and blade drums.

One of the key objectives of this research is to analyze the performance of linter devices developed from previous studies and identify the scientific and technical challenges. The analysis reveals that the linters machines used in the cotton cleaning industry until now have not adequately met the requirements for energy efficiency and resource conservation.

In this dissertation, an energy-saving linter machine has been developed, where the issue of lint cleaning without affecting the technological process has been thoroughly examined [43].

During the operation of existing linter machines, various defects and impurities tend to appear in the fiber, and these machines are unable to remove such foreign contaminants in a timely manner. Therefore, additional research was conducted on linter machines in this dissertation to address these issues.

It is well-known that many studies aimed at improving the linting process have made significant contributions to the development of the cotton industry. However, as highlighted in the previous chapter, several problems still remain unresolved, according to the analysis. Several studies in the field have been reviewed: various sizes of mesh surfaces were used in linter machines equipped with cleaning devices, which increased the efficiency of impurity removal from lint. Furthermore, these devices allowed for the enhancement of cleaning efficiency without altering the technological process.

Additionally, when using linter machines, attention should be paid to the simplicity of construction, cleaning reliability, high productivity, and low labor and material costs. The design of the cleaning device must also meet requirements such as simplicity, the ability to quickly replace or adjust working parts, and overall ease of maintenance.

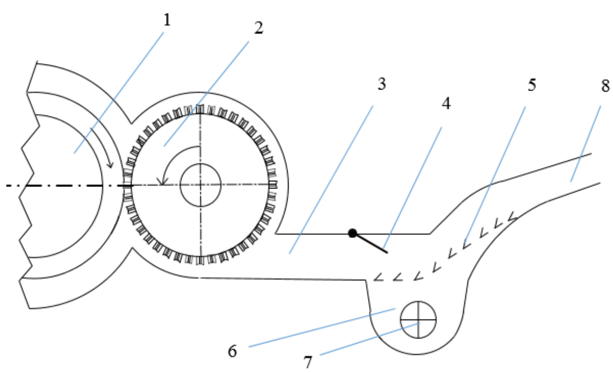

Figure 3.1. Diagram of the Cleaning Device Installed on the Linter Machine:

1. Saw drum 2. Brush drum 3. Pipe-conduit 4. Guide 5. Mesh surface with a plate barrier 6. Impurity chamber 7. Impurity removal screw 8. Outlet pipe

The prototype of the linter machine proposed in the dissertation is based on the 5LP type machine, and the cleaning device has been installed at the lint discharge section, equipped with a brush drum. Overall, the energy-efficient linter machine developed in this dissertation has been modernized from the cleaning-device-equipped linter machine created by scientists from the Namangan Engineering and Technology Institute (Figure 3.1). The cleaning device installed in the linter machine removes various impurities from the lint without affecting the technological process. Currently, one of the main priorities in the cotton industry is the delivery of high-quality fibers, a key strategic product for the industry.

Before building a new design, it is necessary to consider the production possibilities from the mechanical side, such as the functioning of the working parts, their processing, and so on. However, the primary methodology is based on parameters identified through previous research and should ensure productivity according to the machine type used in the enterprise. Afterward, it will be possible to study efficiency and other parameters.

The process of preparing an improved version of the linter for practical research was carried out in strict compliance with the requirements set for these machines. The schematic diagram of the improved linter machine's design is presented in Figure 3.1. The device consists of the following main working parts: 1—saw drum, 2—brush drum, 3—conduit, 4—guide, 5—obstructed mesh surface with plate barriers, 6—contaminant chamber, 7—contaminant discharge screw, 8—discharge pipe.

Results. As mentioned in previous work, the main working part is the mesh surface, and many inspections have been carried out on this surface. The diameter of the brush drum 2 is 250 mm, and the size of the obstructed mesh surface 5 with plate barriers is 3x6 mm. The length of the mesh surface 5 is kept at 400 mm, and the width at 1600 mm. Contaminants separated from the cleaning device are collected in the contaminant chamber 6. The plate barriers forming the mesh surface slots are placed at an initial slope of 30° relative to the plane.

To increase the productivity of the improved linter machine, a brush drum was installed to transfer the lint after the separation process from the saw. It operates at 1000-1200 rpm. In addition, an energy-saving device is installed in the linter.

The working principle of the improved linter machine operates as follows. The lint fibers separated from the seed cotton in the saw drum 1 are transferred to the brush drum 2. The brush drum 2 catches the lint and delivers it to the air conduit. The lint product passes through the conduit 3 and reaches the obstructed mesh surface 5 with plate barriers, while the upper layer is redirected by the guide 4 onto the surface. At this time, as the lint mass starts sliding across the mesh surface's barriers, it is shaken, and the contaminants fall into the contaminant chamber 6 through the mesh surface slots. The cleaned lint is discharged through the outlet pipe 8, and the contaminants in the chamber are removed by the contaminant discharge screw 7.

The mesh surface's slots, being the main working part, are designed with plate barriers to ensure thorough shaking of the product and to prevent the lint from entering the contaminant chamber along with the air flow. The special plates not only shake the product but also direct the air toward the discharge pipe. Each barrier height is 2 mm, and they can be positioned at an angle of 30° to 45° relative to the plane.

During research and in developing the improved design, it was determined that its simplicity and ease of use, as well as the ability to handle various sizes and fractional compositions of the material being processed without changing the technological process, are beneficial. The use of a meshed surface with plate barriers is particularly effective for thicker layers of material. From a theoretical perspective, airspeed, the trajectory of the lint's movement, and the geometric dimensions of the cleaning device are all significantly important during the lintering process. Especially, the length and size of the mesh surface slots used for cleaning must be selected to maximize cleaning efficiency. It is advisable to determine the optimal dimensions of the mesh surface using a special methodology.

By implementing and testing the improved energy-efficient linter machine in production, the optimal technological parameters for its use in real conditions will be determined, and its operational reliability will be tested. The new design should stand out for its simplicity and provide the ability to conduct experiments. The machine must allow for adjustments to productivity, the geometric dimensions of the cleaning mesh surface, the angle of the surface's plate barriers, their height, and other parameters of the working parts that affect the cleaning process.

It is considered effective to have uniform slopes for the barriers forming the mesh surface. However, as mentioned above, starting from the last right side of the guide barriers, the slope rises by 250 mm, so attention should be given to this when setting the slope angle of the plate barriers.

Therefore, during the installation and testing of the cleaning surface, various slope angles were experimented with. Additionally, the current method for lint removal by the linter machine does not meet current technological requirements. Although the fibers are scraped off in time by the saws, the inaccuracies present in the air transfer process need to be eliminated.

Conclusion. In the lintering process, the goal is to first remove small impurities and broken fragments from the lint. To ensure effective cleaning, the lint mass must be well-shaken on the mesh surface. Therefore, during the movement of the lint over the mesh surface, it is directed onto the mesh through a special guide and thoroughly shaken by the barriers. Initial results indicate that the mesh surface can remove about 58-60% of the impurities from the lint.

Another innovation introduced in the energy-efficient linter machine is the brush drum, which was developed to extend the service life of the saw drums. It is known that when the saw drums are cleaned using air, they are sometimes not fully cleaned, which leads to clogging over time. As a result, the efficiency of the saws decreases, and they wear out faster. Research has shown that by fully cleaning the saws with the brush drum, their working life can be extended to up to 60 hours.

In order to test the new working parts of the machine, experimental work needs to be carried out. The experiments conducted for the dissertation were performed in laboratory conditions on S-6524 selective cotton seeds of both the first and second industrial grades. The lint mass was consistently measured at 50 kg to ensure accuracy, with indicators recorded both before and after sorting.

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C O N T E N T S

PRIMARY PROCESSING OF COTTON, TEXTILE AND LIGHT INDUSTRY