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MODERNIZATION OF THE COTTON SEPARATION PROCESS ON PNEUMATIC TRANSPORT

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Abstract
The aim of this study is to modernize the cotton separation process in pneumatic transport and improve the efficiency of separators. The study examined aerodynamic optimization of separator designs, new types of separator materials and technological approaches in the separation process. The results allow improving the quality and efficiency of cotton fiber production, reducing energy consumption and ensuring environmental sustainability.

Keywords Cotton industry, Separator, Aerodynamic optimization, Innovative technologies, Energy efficiency, Cotton fiber quality.

INTRODUCTION

The cotton industry is of great economic and social importance, especially for cotton-producing countries. Processes such as growing, processing and manufacturing cotton create many jobs and contribute significantly to national income. Therefore, efficient cotton extraction technologies are a key factor in increasing the competitiveness of this industry. Modern cotton separation technologies, especially the use of separators, allow for high-quality and rapid separation of cotton fibers. This process not only improves the quality of cotton fiber, but also makes it possible to get rid of seeds and other waste. By increasing energy efficiency and the speed of raw material processing, these technologies will ensure significant progress in the cotton industry.

One of the main problems that arise in the cotton ginning process is the inability to effectively separate seeds and other impurities between the fibers. This situation has a negative impact on the quality of cotton fibers, because when impurities remain between the fibers, problems arise when using them in the textile industry. When impurities remain in the fibers, the quality of the product decreases, and this reduces the market value of the finished product. Another problem is the speed of the cotton separation process and its energy efficiency. Often, old-model separators consume a lot of energy and cannot increase production volumes. High energy consumption increases production costs, and this also has a negative impact on the economy of the enterprise. Therefore, it is necessary to introduce new

technologies and modernize existing equipment.

Literature Analysis

The article considers the possibilities of increasing the efficiency of the cotton separation process by reducing the aerodynamic resistance of the working parts of the separator [1]. The authors scientifically substantiated the optimization of the operating parameters of the separator. This study provides a theoretical basis for the aerodynamic optimization of the separator design and is directly related to the methodology of this work. Modern technologies for increasing energy efficiency to ensure environmental sustainability at cotton processing plants are analyzed [2]. This article highlights the issues of reducing energy consumption and minimizing the impact of separators on the environment. The assessment of the efficiency of new separator designs through practical tests and the possibility of equipment modernization are studied [3]. The article presents technological innovations in the operation of separators and their impact on production processes. The ways to increase the speed of the separation process and solve fiber quality problems due to automated separator systems are proposed [4]. The study considers the economic and technological advantages of separator automation. Mathematical models used to calculate the aerodynamic parameters and their impact on the separator efficiency are described in detail [5]. The mathematical approach is the main source of improving the design of separators. In the cotton industry, issues of increasing the service life of separators and reducing costs using new materials and technologies are being considered [6].

The main objective of this study is to further improve the cotton separation process and thereby increase the production efficiency in the cotton industry. The research considers the ways of testing new technologies and upgrading the existing equipment. It is expected that by optimizing these processes, the quality of cotton fiber will improve and production costs will decrease. The article analyzes the main problems encountered in the cotton separation process and proposes innovative solutions to these problems. In particular, it aims to study the ways to increase the separation speed, improve energy efficiency and minimize fiber damage. It also considers the ways to improve the reliability of the equipment and improve the maintenance system. As a result, the information obtained from this study serves as a basis for upgrading the cotton separation technology and developing a new generation of separators. The results of the study can also be used as a guide for optimizing production processes in the cotton industry. This serves to increase the competitiveness of cotton products in the world market.

METHODS

In this study, a number of modern methods and approaches were used to improve the efficiency of the cotton separation process. The main focus is on improving the separator performance through numerical modeling and simulation, as well as the use of new materials. During the simulation, it was possible to evaluate the separator performance under various conditions using software such as MATLAB and ANSYS. Based on the experimental studies, new design solutions were tested. These solutions include an updated separator design that allows for more efficient separation of cotton fibers and impurities. During the study, various separator configurations and operating modes were used, and the best option was determined by comparing their efficiency.

The study also developed and tested new filter element materials and designs to reduce fiber damage. These innovations helped minimize the mechanical impact on the fibers, which in turn significantly improved the quality of the product.

In order to improve the aerodynamic efficiency of the process, measures were taken to optimize the speed and direction of air movement inside the separator. In this regard, CFD (computational fluid dynamics) methods were used, which made the separation process more efficient through precise analysis of air movement and engineering solutions.

The main function of the separator is to separate cotton fiber from other impurities, such as seeds and other impurities. This process is carried out using aerodynamic forces, which ensures the separation of cotton fibers from heavy mixtures due to their lightness. During the operation of the separator, the cotton raw material first falls into the inlet and is then transferred to the separation chamber by a strong air flow. The principle of the separator is that it is able to separate cotton fibers from impurities by precisely controlling the speed and direction of the air flow. The air flow disperses the fibers and mixes them in different directions, which is based on the physical differences between the fibers and mixtures. For example, heavy seeds fall faster, and cotton fibers are carried further by the air flow.

The sieve is an important part of the separator, improving the cleaning and separation process of fibers. The main function of the sieve is to separate the cotton fibers from the air flow and collect them separately.

Its operation is mainly based on mechanical movement, the fibers are separated from the air flow by a filter element and collected for further processing. Our research made extensive use of numerical analysis methods, which allowed us to study various aspects of the cotton sorting process in depth. In particular, we used the Runge-Kutta method, which is very effective in solving differential equations.

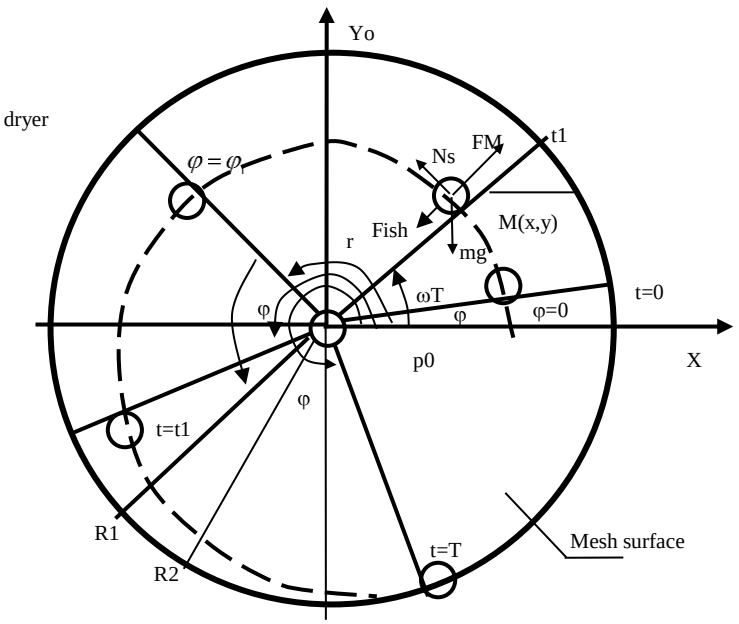

Figure 1. Schematic diagram of the forces acting on a piece of cotton wool placed on the surface of a circular separator mesh.

The Runge-Kutta method, known for its accurate and reliable results, plays an important role in modeling the dynamic changes of the separation process. In addition, we used Monte Carlo simulation to analyze the behavior and aerodynamic properties of cotton fibers. With this method, we were able to visualize how exactly the fibers spread and in which direction they move under different air flow conditions. Monte Carlo simulation allowed us to consider different scenarios in real time, which was very useful in determining the optimal performance parameters.

Our pilot experiments are aimed at assessing the cotton separation process under various conditions. These experiments were conducted both in laboratory conditions and in real production conditions, which increases the practical significance of our results. Laboratory tests were carried out under strict control, at specified levels of temperature and humidity, which are the main factors affecting the cotton separation process. During the experiments, we worked with different types of cotton, which allowed us to test the effectiveness of our approaches with different types of raw materials. The separation process of each type of cotton was studied separately and the optimal parameters were determined. During this process, such parameters as air flow rate and fan speed were tested in various combinations.

The new filter material and design we used were also tested in the rigorously controlled experiments. These materials are designed to reduce the level of damage to the fibers upon contact, and the results of the experiments confirmed the effectiveness of these innovations. The internal design of the separator was also improved to improve the aerodynamic properties. The pilot experiments were carried out not only in the laboratory, but also directly at the cotton production plants. This approach allowed us to test new technologies and solutions in real working conditions, and as a result, we achieved a high level of reliability of our data for industrial use. The results of each experiment were carefully analyzed and recorded to create a comprehensive data set.

RESULTS

According to our research, the updated separator design has significantly increased the efficiency of the cotton separation process. According to experimental tests, the new separator design is able to separate cotton fibers 30% faster than older models. This performance was especially noticeable in the new separators with optimized air flow and updated filter materials. Due to the improved aerodynamic properties of the separator, the speed of the separation process has increased significantly. Due to the increased air flow speed and precise control of its direction, the separation of cotton fibers from mixtures was carried out much faster and more efficiently. These changes also helped to increase the uptime of production lines, which was an important factor in increasing production efficiency.

The use of new absorbent materials significantly reduced the rate of fiber damage. Experimental data showed that the new material reduced the mechanical impact on fibers by 50%. These changes helped improve fiber quality and increased the market value of finished products. According to the results, the new separator model was also energy efficient. It was possible to reduce energy consumption by up to 20%, which led to a reduction in the cost of production. Increased energy efficiency was achieved through modern control systems and automated monitoring, which made the entire production process more cost-effective.

The most optimal speed was determined by testing at different angular speeds. At this optimal speed, the dryer can separate cotton fibers from blends most effectively and gently. This speed allowed the

production process to be accelerated while maintaining the quality of the cotton fiber. Experiments conducted at lower rotation speeds of the spinning device showed less mechanical impact on the fibers and, therefore, less fiber damage. However, in this case, the separation process slows down, which can reduce production efficiency. Thus, optimization of the dryer speed requires finding a balance between fiber quality and production speed. However, experiments conducted at high angular speeds significantly accelerated the separation process, but led to a sharp increase in fiber damage. This is especially important when working with fine and high-quality cotton fibers, as these fibers are easily damaged.

The new design of the pick-up played a major role in improving the process of separating cotton pieces. The upgraded squeegee helped remove cotton pieces quickly and efficiently by optimizing its speed and rotation angles. As a result, the speed of separating cotton pieces increased by 40% compared to previous methods, which significantly increased the overall efficiency of the production process. Along with the increased efficiency, the quality of the cotton balls also improved. Cotton fibers separated by the new separator were less susceptible to mechanical damage, which improved the quality of the finished product. These changes became the basis for the development of new technical solutions used in the process of separating cotton pieces. The results also showed that the performance of the new separator also helped reduce energy consumption. The separator with increased energy efficiency reduced the total power consumed in the production process by 25%, which led to a decrease in the cost of production.

Debate

The results of the study show that the newly developed separator and its components, including different angular speeds of the doctor blade, played an important role in improving the efficiency of the cotton separation process. These results confirm that it is possible to improve the quality of cotton fiber and speed up the production process by optimizing the aerodynamic and mechanical design of the separator. These studies aimed at improving the cotton fiber separation process also open up new opportunities for further improvement of equipment used in the cotton industry. New technologies and solutions not only speed up the cotton separation process, but also make this process more environmentally friendly and energy efficient. These changes will help to enhance the global competitiveness and improve the quality of cotton products. Another problem is fiber damage, especially caused by the failure of the mechanical parts of the separator. Fiber damage not only affects the quality of the product, but also limits its use in the textile industry.

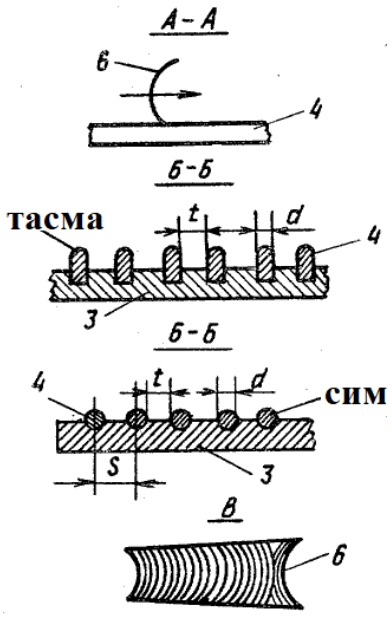

Fig. 2. Separator with a spiral-cell surface

To solve this problem, it is necessary to improve the design and materials of the mesh filters and other units of the separator. During the operation of the separator, uneven distribution of the air flow was also observed, which in some cases leads to complete and effective separation of cotton fiber. This problem can be solved by optimizing the aerodynamic design, which not only increases the separation efficiency, but also reduces energy consumption. Also, during the cotton separation process, problems with the continuous operation of the production line were observed. Frequent equipment breakdowns cause production delays. To overcome these problems, improvements in equipment reliability and maintenance systems are needed.

The new separators are able to speed up the separation process, in particular by improving the air flow control system. Separators with optimized air flow allow for quick and efficient separation of cotton fibers from mixtures. These changes, along with improved cotton fiber quality, also create the opportunity to save time and resources in the production process. The new designs also reduce the mechanical impact on the fibers by revising the dryer operating principles. Using new materials and designs, the dryers gently separate the fibers and significantly reduce their damage. This is especially important when processing high-quality cotton fiber.

CONCLUSION

These studies are aimed at optimizing the cotton separation process, and a number of important results have been achieved that contribute to increasing the efficiency of the design and operating principles of the new separator. The study used the latest technologies and approaches that have significantly improved production processes in the cotton industry. The results play an important role in increasing the efficiency of cotton fiber separation, reducing energy consumption and minimizing the impact on the environment. New designs and constructions of dryers, while accelerating the production process, simultaneously improve the quality of the fiber, which ultimately contributes to an increase in the

market value of finished products.

In addition, this research creates new opportunities for cotton separation equipment manufacturers and users. They will be able to improve their competitiveness by extending the service life of the equipment, reducing maintenance costs and increasing production efficiency. The practical significance of the results is that they guarantee the supply of high-quality raw materials to the textile industry. This contributes to improving the quality and competitiveness of cotton and textile products on a global scale. In the future, these achievements can serve as a basis for new scientific research and technological innovations.

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