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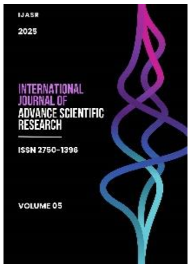

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Research Article

The Effect of The Improved Grate on The Cleaning Process

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Abstract

The article presents the results of a study conducted to determine the effect of the clearance between the cutting edges of the saw teeth of a rasp drum and the working edge of a grate with a diameter of 15 mm on the cleaning process. According to the research findings, the highest cleaning efficiency was observed when the slats had a diameter of 15 mm, the spacing between them was 30 mm, and the distance from the tips of the saw drum teeth to the edge of the slatted grid was 18 mm. As the distance between the saw drum tooth tips and the edge of the slatted grid increased from 15 mm to 18 mm, the cleaning efficiency for first-grade industrial cotton increased from 86. 4% to 90. 5%. However, when the gap increased to 19 mm and 20 mm, the cleaning efficiency decreased to 88. 3%. For third-grade industrial cotton, cleaning efficiency rose from 87. 6% to 92. 9% as the distance increased up to 18 mm, then dropped to 90. 6% at 19 mm and 20 mm. Additionally, it was determined that as the distance increased, the amount of free fibres and the contamination of cotton by impurities decreased.

Keywords

Cotton particle, fibre, impurity, cleaner, saw drum, the working edge of a grate, cleaning efficiency.

INTRODUCTION

The cotton cleaning process is a crucial technological stage that directly affects the quality indicators of the fibre being produced [1]. If the impurities contained in raw cotton are not removed prior to the ginning process, they may become firmly bound to the fibre, leading to additional defects [2] and ultimately reducing the grade of the cotton fibre. Therefore, at cotton cleaning plants, the cleaning process is performed immediately after drying [3].

Numerous theoretical and practical studies have been conducted by researchers to improve cotton cleaning equipment [4–5]. These studies have examined the effects of various factors on the cleaning process and the quality of the product, including the diameter and rotational speed of the saw drum, the shape of the saw teeth, the design and dimensions of the slatted grids, the gap between the saw drum and the slatted grid, the coverage angle of the slatted grid along the arc of the saw drum, the types and inclination angles of the doffing brushes, and the diameter and speed of the separating brush drum [6].

In both domestic and foreign cotton cleaning plants, the main working components of equipment for removing large impurities are generally designed in a similar configuration. These include a saw drum, a slatted grid system, a doffing brush, and a separating-transferring brush, with minor differences in their dimensions [7].

It has been observed that the use of slatted grids with varying diameters and spacing on the slatted grids of foreign cleaning machines enhances the removal of impurities from raw cotton. This improvement is primarily due to variations in the impact and friction forces applied to the cotton, as well as differences in the movement patterns of the cotton particles, depending on the design of the cleaning surfaces [8].

However, while slatted grids of different shapes can increase cleaning efficiency, they may also have a negative impact on the natural properties of cotton. Relying solely on slatted grids of uniform shape has proven to be less effective. This indicates that there is still untapped potential to improve the equipment currently used in cotton cleaning plants for removing large impurities [9].

In the cleaning process, the slatted grids—being one of the main working components—are typically uniform in shape. As a result, the impact forces applied by the saw drum as it strikes cotton particles against the slatted grids remain consistent, which leads to a decrease in impurity separation efficiency after a certain stage of cleaning. This is considered a drawback of the current equipment [10].

The primary goal of the proposed equipment is to increase the efficiency of the cleaning process by using slatted grids with different diameters and varying gap distances from the saw drum on the slatted grid. This variation creates a range of impact forces acting on the cotton, thereby improving cleaning performance. The task is

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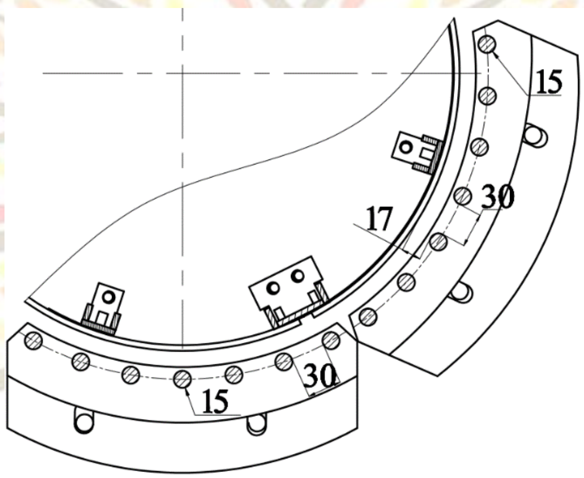
implemented as follows: in the section of the cotton cleaner responsible for removing large impurities, slatted grids with a greater number of round-shaped slatted grids of reduced diameter are installed. These grates are positioned at varying distances from the saw drums to optimize the cleaning process.

Research Methodology Based on the findings of our previous studies, it was determined that using a slatted grid (slatted grid system) with grates of 15 mm in diameter, spaced 30 mm apart, and a gap of 18 mm between the tips of the saw drum teeth and the edge of the slatted grate resulted in high cleaning efficiency (see Figure 1).

METHODOLOGY



1 – saw drum; 2 – slatted grid (kolosnik); 3 – reinforcing base

Figure 1. Diagram of the improved slatted grid with slatted grids.

The improved slatted grate was installed into the UXK cleaning unit flow, and its effect on the efficiency of the cleaning technology was examined. At the beginning of the cleaning line, four peg-and-lattice drums designed to remove fine impurities are installed, followed by four UXK cleaning units in sequence for removing large impurities, and finally, another four peg-and-lattice drums are installed at the end of the process. In this configuration, the improved slatted grids were installed beneath the main saw drums of all UXK machines used for large impurity removal. During the cleaning process, several performance indicators were analysed, including the loss of cotton particles along with the impurities, the content of free fibres in the separated waste, and overall cleaning efficiency. These indicators were determined using methods specified in the national standards (O‘zDSt). The study used raw cotton of the Khor-150 selection variety, grade II, of industrial types I and III, with initial moisture

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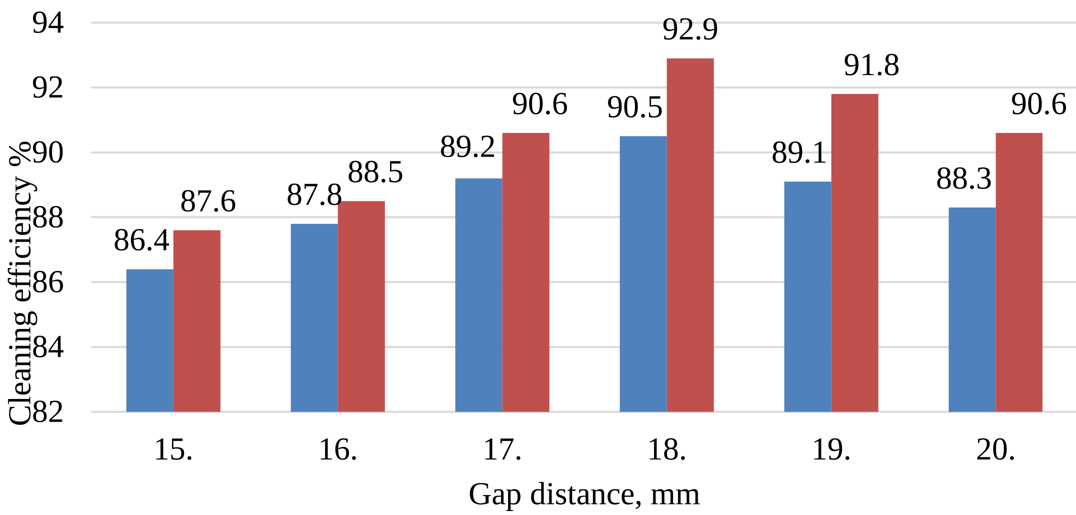
contents of 9. 5% and 13. 2%, and initial impurity contents of 8. 7% and 11. 4%, respectively.

RESULTS

The results of the conducted experiments are presented in the histograms shown in Figures 2 and 3.



– I industrial-grade raw cotton; – III within industrial-grade raw cotton.

Figure 2. Histogram showing the variation in cleaning efficiency at different gap distances between the tips of the saw drum teeth and the edge of the slatted grid.

The cleaning efficiency of the improved slatted grid technology for removing fine and large impurities reached 90. 50% for industrial grade I and 92. 90% for industrial grade III cotton. Thus, by reducing the diameter of the slatted grids and setting the gap between the tips of the saw drum teeth and the slatted grid surface to 18 mm, the impact point where the cotton particles hit the slatted grid surface is optimally selected, resulting in improved cleaning efficiency of the technology.

The research results indicate that when the diameter of the slatted grid changes, it is also necessary to adjust the distance between the tips of the saw drum teeth and the slatted grid. It is important to prevent the cotton particles from striking the lower part of the slatted grid's horizontal axis; otherwise, the cotton particles tend to become mixed with impurities, which increases contamination. This, in turn, leads to a higher amount of material reprocessed in the cotton regenerator and the production of fibres with lower quality indicators. Therefore, further studies were conducted to investigate the effect of the improved slatted grid on the contamination of cotton with impurities. The results of these studies are presented as a histogram in Figure 3. 4. 3.

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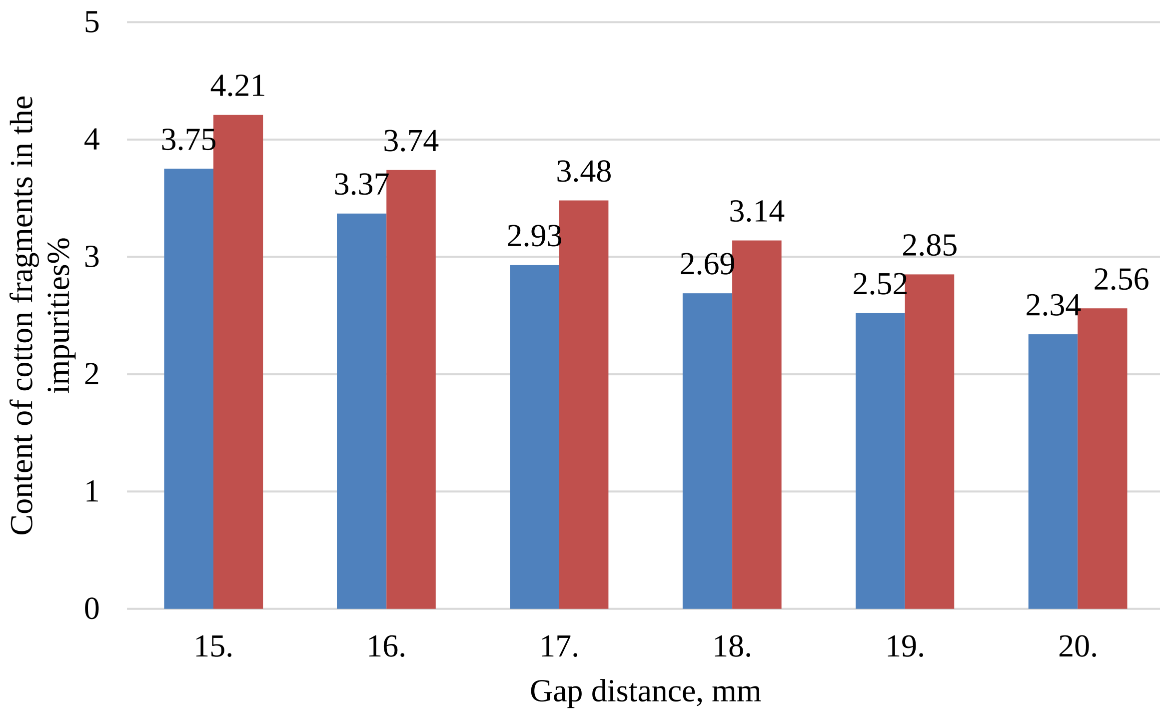

– I industrial-grade raw cotton; – III within industrial-grade raw cotton.

Figure 3. Histogram showing the dependence of cotton particles mixing with impurities on the gap distance between the saw drum and the slatted grate in the cleaning technology.

The histogram clearly shows that as the gap between the slatted grate and the saw drum increases, the amount of cotton particles mixing with impurities decreases. The primary reason for this is that cotton particles tend to strike the horizontal axis or upper part of the grate, reducing their tendency to mix with impurities upon impact. At a gap distance of 15 mm between the saw drum tooth tips and the edge of the grate, 3. 75% of cotton particles mixed with impurities was observed for industrial grade I, while this figure was 4. 21% for industrial grade III.

The histogram also shows that increasing the gap from 15 mm to 18 mm results in a decrease in cotton particle contamination by 1. 06% for grade I and 1. 07% for grade III. When the throughput of reprocessed cotton reaches 7 tons/hour for grade I, the reduction in cotton particles mixing with impurities amounts to 74. 2 kg/hour. For grade III with a throughput of 5 tons/hour, this reduction is 53. 5 kg/hour. This reduction leads to a decrease in the amount of cotton reprocessed by the 1RX regenerator, thereby increasing the production of high-quality fibres.

Analyzing the content of free fibres in the separated impurities during the cleaning process, it was found that as the gap between the saw drum and the slatted grid increased from 15 mm to 20 mm, the amount of free fibres decreased, with the minimum free fibre content observed at a gap of 20 mm.

As the distance between the grate and the saw drum tooth tips decreases, the forces acting on the cotton fibres increase, causing fibre breakage. When cotton particles strike the lower part of the slatted grid's horizontal axis, the elongation of the fibre increases and the friction surface between the cotton particles and the slatted grid grows, which leads to some fibre breakage and an increase in the amount of free fibres.

Therefore, using a slatted grid with slatted grids of 15 mm diameter spaced 30 mm apart and maintaining a gap of 18 mm between the saw drum tooth tips and the edge of the slatted grate improves cleaning efficiency, reduces the amount of free fibres in impurities, and lowers the quantity of cotton particles mixed with impurities.

Conclusion

The highest cleaning efficiency was recorded when the grate diameter was 15 mm, the spacing between them was 30 mm, and the gap between the tips of the saw drum teeth and the edge of the slatted grid was 18 mm. As the distance between the tips of the saw drum teeth and the grate edge increased from 15 mm to 18 mm, cleaning efficiency for industrial grade I cotton increased from 86. 4% to 90. 5%, but decreased to 88. 3% when the gap reached 19 and 20 mm. For industrial grade III cotton, efficiency rose from 87. 6% to 92. 9% as the gap increased to 18 mm, then declined to 90. 6% at gaps of 19 and 20 mm. Additionally, it was observed that both the amount of free fibres and the mixing of cotton particles with impurities decreased as the gap distance increased.

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