IMPROVEMENT OF PRIMARY COTTON CLEANING TECHNOLOGIES: ANALYSIS OF SCIENTIFIC RESEARCH

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Annotation. This study analyzes recent scientific developments aimed at improving the effectiveness of cotton cleaning technologies. Emphasis is placed on the structure and shape of the core working components of cleaning machines, particularly spiked drums and mesh surfaces. The research proposes technical modifications that significantly enhance cleaning performance and reduce fiber and seed damage during the process. The findings support further design optimization and testing to ensure high-quality cotton processing.

Keywords: cotton, small impurities, spiked drum, mesh surface, fiber quality.

Annotatsiya. Ushbu tadqiqot paxtani tozalash texnologiyalarining samaradorligini oshirishga qaratilgan so‘nggi ilmiy ishlanmalarni tahlil qiladi. Asosan tozalovchi mashinalarning asosiy ishchi qismlarining tuzilishi va shakliga — xususan, qoziqchali barabanlar, ta’minlovchi valik va panjara yuzalariga — e’tibor qaratilgan. Tadqiqot davomida tozalash samaradorligini sezilarli darajada oshiruvchi va tolalar hamda urug‘larning shikastlanishini kamaytiruvchi texnik modifikatsiyalar taklif etilgan. Olingan natijalar yuqori sifatli paxta xomashyosi olish uchun qurilmalar konstruksiyasini yanada takomillashtirish va sinovdan o‘tkazish zarurligini tasdiqlaydi.

Kalit so‘zlar: paxta, mayda iflosliklar, mixli baraban, panjara yuzasi, tola sifati.

Аннотация. В данном исследовании проводится анализ новейших научных разработок, направленных на повышение эффективности технологий очистки хлопка. Основное внимание уделено конструкции и форме основных рабочих элементов очистительных машин, в частности, игольчатым барабанам и сетчатым поверхностям. В работе предлагаются технические усовершенствования, которые значительно повышают эффективность очистки и уменьшают повреждения волокон и семян в процессе обработки. Полученные результаты подтверждают необходимость дальнейшей оптимизации конструкции и проведения испытаний для обеспечения высококачественной переработки хлопка.

Ключевые слова: хлопок, мелкие примеси, игольчатый барабан, сетчатая поверхность, качество волокна.

Introduction

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Cotton remains a cornerstone of Uzbekistan's agricultural and industrial sectors. According to Presidential Decree No. PF-60 (January 28, 2022), strategic initiatives are being implemented to increase the production and export of textile goods from 2022 to 2026. A critical factor in achieving these goals is the improvement of cotton cleaning technologies, especially due to the growing use of mechanical harvesting, which results in higher levels of impurities compared to manual harvesting. The presence of small and large impurities negatively affects fiber quality, processing efficiency, and the mechanical integrity of cottonseed. Previous studies have examined the design parameters of supply mechanisms used in primary cotton processing equipment. G.A. Kurbonova [11] conducted research on the constructive geometric indicators of shafts and feeder mechanisms, proposing a rectangular shaft-accumulator and an inclined-blade feeder roller.Improving the technological processes and equipment used for cleaning raw cotton has thus become a key area of focus in current research and industrial modernization efforts.

The efficiency of raw cotton processing equipment is largely influenced by the mechanical interaction between raw cotton tufts and the components of cleaning mechanisms. In particular, the impact dynamics between cotton tufts and beater elements such as spikes play a critical role in fiber separation and damage reduction. Prior studies have addressed this aspect only to a limited extent, focusing primarily on global parameters such as impact force and rotational speed.

METHODS

This study examined the performance and design parameters of widely used cotton cleaning machines, such as 1XK, SCH-2, and UXK models. Modifications to the structural elements of cleaning mechanisms, including spiked drums, mesh surfaces, and feed rollers, were tested theoretically and experimentally. The number of optimal blades on the feeder rollers was determined theoretically by assuming a constant rotational speed. Experimental analysis was carried out to compare the fiber supply efficiency in the proposed rectangular shaft-accumulator design. During these experiments, the fiber feed rate was evaluated based on different structural configurations of the feeder mechanisms.

Specifically, the following components were analyzed:

- **Spiked Drums**: Existing flat-tip spikes were redesigned into curved forms with rubber-inserted planks to reduce cottonseed damage.
- **Mesh Surfaces**: Meshes with different shapes and active surface areas (e.g., 4.5×20 mm, 6×50 mm, 8×45 mm) were tested for cleaning efficiency.
- **Feeding Rollers**: The spacing and interaction between feed rollers and spiked drums were evaluated based on prior studies by Sosnovskiy [1] and Burnashev [2].

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Performance criteria included:

- Degree of impurity removal
- Mechanical damage to seeds and fibers
- Energy efficiency
- Ratio of active surface area

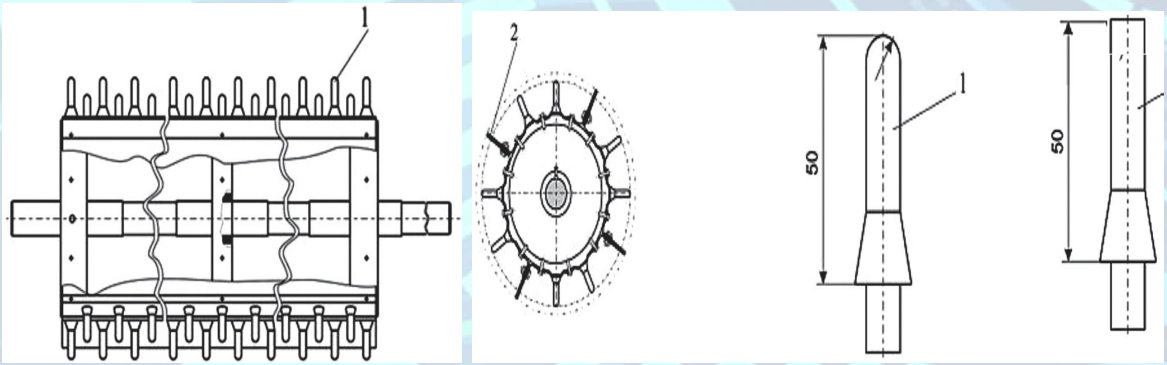
A.A. Safayev [12] carried out a detailed investigation into the interaction between single- and double-seed cotton tufts and the spike elements used in cotton cleaning machines. The study involved both theoretical modeling and experimental analysis of the mechanical collisions between the spikes and cotton tufts, focusing on various impact scenarios: central and eccentric (off-center) impacts. Parameters such as the impact velocity, tuft elasticity, and volume were included in the analysis. The research also modeled the force transmission and deformation behavior of the cotton tufts upon impact.

RESULTS

The modified **curved-spike drum** demonstrated a clear advantage over traditional designs. Both the original and improved models used spikes with dimensions of 50 mm (length) and 12 mm (diameter), maintaining a 14 mm clearance from the mesh. However, the arched spike tips in the new design allowed better penetration and withdrawal from the cotton mass, improving cleaning effectiveness and reducing fiber damage.

In mesh surface testing, the **8×45 mm mesh** with 60% active surface area outperformed the **6×50 mm mesh**, even though the latter had a slightly higher surface ratio (62.5%). This suggests that **hole shape and width along the cotton movement path** are more influential than active surface percentage alone.

Studies on feed roller interaction revealed that reducing the gap between rollers and the spiked drum to less than 10 mm increases damage to cottonseed. A **25 mm spacing** was recommended for optimal performance.



a) **b)**

Figure 1. Schematic diagram of the proposed curved-spike drum with rubber-inserted plank-type spikes.

1)Spikes; 2) Rubber insert

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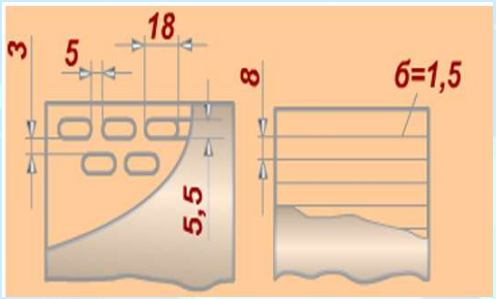


Figure 2. Schematic diagram of the mesh surface

Researcher **Yu.S. Sosnovskiy** [1] studied the gap between the spiked drum and the feed rollers. In his study, he found that reducing the gap to less than 10 mm leads to an **increase in impurities and defects** in the material and causes **damage to the cottonseed**. He proposed adjusting the distance between the spiked paddle drum and the feed rollers to **25 mm**, and suggested a soft operating mode by **reducing the dynamic characteristics** of the mechanism.

Experimental results showed that the cotton feeding efficiency along the length of the rectangular shaft-accumulator increased by a factor of 1.6 to 2 times compared to previous designs. A mathematical model was proposed to describe the relationship between the geometric characteristics of the feeder rollers, the volumetric density of the raw cotton between the blades, and the overall performance of the feeding unit.

The findings revealed that when a spike impacts a single-seed cotton tuft directly through its center of mass, the impact force depends significantly on the tuft's volume, impact velocity, and its elastic properties. However, in most practical situations, spikes tend to hit the tufts off-center. The study emphasized that eccentric impacts are a contributing factor to the tearing and premature disintegration of raw cotton fibers. In such cases, the force is not evenly distributed, leading to localized fiber strain and structural failure.

DISCUSSION

The findings confirm that design optimization of cleaning equipment significantly influences the efficiency of impurity removal and overall cotton quality. The transition from flat to curved spikes not only enhances cleaning force but also minimizes damage, contributing to better preservation of fiber properties.

Mesh surface geometry must be selected not solely based on percentage of open area but also in terms of directional width, which plays a critical role in facilitating the passage of impurities. This insight has practical implications for upgrading mesh design standards in industrial cotton cleaners. Although the optimal number of blades was identified, the study did not consider the effect of varying the rotational speed of the feeder rollers, thereby limiting the ability to control the productivity of the feeding system. Furthermore, the feeder roller and shaft-accumulator were not treated as a single integrated system, neglecting the

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impact of one component's parameters on the overall technological performance of the unit. It was also confirmed that raw cotton tends to separate into distinct portions between the blades during the feeding process.

Previous researchers such as Sosnovskiy and Burnashev have laid foundational theories on feed mechanisms, but further studies are needed to model the behavior of layered fibrous material during dynamic interactions with machine components.

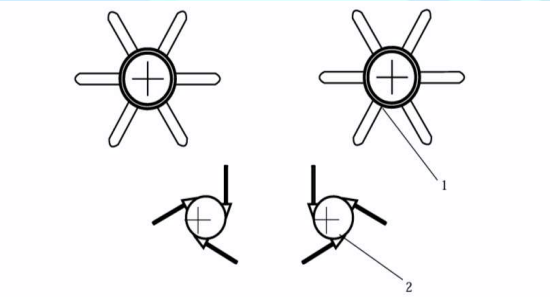


Figure 2. Diagram of the supplying rollers that loosen the structure of raw cotton into smaller particles. 1 – Paddle-type supplying roller; 2 – Spiked loosening roller.

Based on these insights, Safayev proposed a design improvement for the spike face — specifically, making the front surface of the spike flat rather than pointed. This adjustment helps distribute the impact force more uniformly across the cotton tuft, reducing localized pressure and minimizing fiber damage. The study highlighted the necessity of reconsidering spike geometry as a key factor in optimizing the performance and technological quality of cotton cleaning equipment. However, while the proposed shape may reduce fiber damage, further research is needed to evaluate its influence on throughput capacity and long-term wear resistance of the spike elements.

CONCLUSION

The modernization of spiked drums and optimization of mesh surface dimensions significantly increase the efficiency of raw cotton cleaning. The reduction of mechanical damage to seeds and fibers directly supports better downstream processing and higher textile product quality. While this research advances understanding of mechanical and design parameters, future studies should focus on dynamic modeling of cotton mass behavior and adaptive designs for variable cotton conditions.

The conducted analysis of previous studies highlights the importance of optimizing the geometric and kinematic parameters of feeding and loosening mechanisms in raw cotton processing. G.A. Kurbonova’s research provided valuable insights into improving the performance of shaft-feeder systems by introducing a rectangular shaft-accumulator and determining the optimal number of blades for feeder rollers. These modifications significantly enhanced fiber feeding uniformity and productivity, although they did not fully explore the dynamic control possibilities of the feeder system as a whole.

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Similarly, A.A. Safayev's investigation into the interaction between cotton tufts and spike elements revealed the critical influence of impact position and spike geometry on fiber integrity. His findings emphasized that eccentric impacts lead to fiber tearing, suggesting that a flat-faced spike design could reduce damage by distributing force more evenly.

Overall, the integration of geometric optimization with an understanding of fiber behavior under mechanical stress provides a solid foundation for the development of more efficient and less fiber-damaging cotton cleaning systems. Future research should aim to develop adaptive systems capable of dynamically adjusting to different cotton varieties and processing conditions in real time.

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