The American Journal of Engineering and Technology
ISSN 2689-0984 Volume 08 - 2026

Analysis of Equipment for Separating Cotton Pieces from Cotton Cleaning Equipment Waste

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Received: 31 Dec 2025 | Received Revised Version: 20 Jan 2026 | Accepted: 10 Feb 2026 | Published: 28 Feb 2026
Volume 08 Issue 02 2026 | Crossref DOI: 10.37547/tajet/Volume08Issue02-19

Abstract

This article proposes an improved regenerator design for cleaning fibrous material. A drawback of existing analogues is that when the material is conveyed by an air stream, a portion of it passes in transit to the outlet pipe, which leads to a decrease in cleaning efficiency and a large amount of cotton pieces entering the waste. In the proposed device, an auger installed in the upper part of the main saw drum forcibly moves the material along the drum's axis, directing it to the re-cleaning zone and ensuring the regeneration process.

Keywords: Regenerator, RX, pneumatic feeder, saw drum, grate bar, cotton piece, waste, large trash, small trash, cleaning efficiency.

Cite This Article: TeachingDjamolov R.K., & Karimov T.K. (2026). Analysis of Equipment for Separating Cotton Pieces from Cotton Cleaning Equipment Waste. The American Journal of Engineering and Technology, 8(2), 200–202. https://doi.org/10.37547/tajet/Volume08Issue02-19

1. Introduction

Globally, great attention is being paid to the implementation of resource-saving technologies in the primary processing of cotton, maintaining stable fiber quality, and preventing the loss of valuable cotton mass in waste. In particular, the presence of cotton pieces in the waste generated by cotton cleaning machines causes significant production losses. Therefore, improving the technologies for the effective separation of cotton pieces from waste and their return to processing is one of the urgent tasks.

Identifying the factors that affect product quality and yield during the initial cotton cleaning stage, and developing technical solutions to eliminate them, not only reduces energy consumption but also allows for the preservation of the natural properties of the cotton mass. Furthermore, the correct selection of operating modes and the optimization of structural components during the regeneration process are important directions for increasing cotton yield.

2. Method

Cotton Cleaning Equipment and the Waste Problem

At the republic's cotton ginning enterprises, CHX-3M, CHX-5, 1XK, and UXK model cleaning machines are widely used to separate cotton from large and small trash impurities [1]. Although the technological processes in this equipment have been improved, practical experience

shows that a certain amount of cotton pieces is also mixed in with the waste during cleaning. This negatively affects production efficiency.

A number of scientists have conducted research on substantiating the parameters of the working parts of cleaning equipment, selecting operating modes, and improving the design. However, practice confirms that the problem of drastically reducing the loss of cotton pieces in the waste has not been fully resolved.

Analysis of Scientific Developments

In the research of A.B. Pavlyak and N.M. Gulidov [2], a BCH-01 model drum cleaner was proposed for cleaning cotton from large trash impurities. It utilized a saw drum, a doffing brush, and separating brush drums, which served to increase the capability of separating large trash.

An axial-action regenerator-cleaner was developed by P.N. Borodin and E.F. Budin [3]. It used a cylindrical casing, inlet and outlet pipes, a guide auger, two-stage saw drums, grate bars, and separating brush drums. Although the design of this equipment was theoretically effective, the use of a perforated screen under the regeneration drum limited the ability to separate large trash and reduced its operational productivity.

Regenerators in Practical Use

In cotton ginneries, axial-flow cleaners are primarily used for reclamation and are known in practice as "regenerators." For separating cotton tufts from waste, equipment models such as 1RX, RX, RX-1, and 2RX-M are widely used [4].

The RX-1 regenerator is typically installed in the pneumatic conveying system and operates on a vacuum principle. The waste it processes consists mainly of cotton tufts and large trash, with a relatively small share of fine impurities. Under these conditions, the regenerator provides a throughput of around 1 ton per hour, and the reclamation efficiency reaches up to 95%. Cleaning efficiency can be as high as 80%, depending on the trash content of the waste.

Operating Process and Drawbacks of the RX Regenerator

An analysis of the RX regenerator's design highlights the pneumatic feeder and the cleaning section as its main working units. The pneumatic feeder is semi-cylindrical, with its inlet and outlet pipes located tangentially on the upper part.

The regenerator operates on the principle of vacuum creation: a fan draws air through the outlet pipe, creating a vacuum (rarefaction) within the chamber. Consequently, the waste mass is drawn in with air from the external environment through the inlet pipe and into the equipment. According to its specifications, an air intake of 1.1 m3/s through the inlet pipe is required. An additional 0.4 m3/s of air is drawn in from non-hermetic points, bringing the total airflow rate to 1.5 m3/s.

The incoming airflow splits into two directions inside the chamber and moves toward the outlet pipe. The rotation of the saw and brush drums imparts a partially rotational-axial character to the airflow. During this process, cotton tufts are caught on the surface of the saw drum, large impurities are separated through the grate bars, and the cleaned cotton tufts are doffed by the brush drum and thrown back into the airflow.

Observations show that cotton tufts may undergo repeated cleaning 3-4 times within the equipment. This process serves to increase the separation efficiency of large impurities.

However, when the proportion of fine impurities in the waste exceeds 30%, the cleaning efficiency decreases sharply. In such conditions, the trash content of the reclaimed cotton tufts can reach 20% or more, and reintroducing them into the main cotton stream can negatively affect fiber quality [5].

This situation is mainly explained by the following reasons:

- Some cotton tufts are carried by the airflow into the outlet pipe without reaching the working zone of the saw drum;

- Due to their small mass, fine impurities and free fibers have low inertia and do not manage to strike the drum;

- Increased airflow turbulence in the pneumatic feeder hinders the complete separation of fine impurities.

Studies have attempted to reduce the discharge of fine impurities by installing guides of various shapes inside the pneumatic feeder. However, practical application has shown that these baffling mechanisms increase aerodynamic resistance, create additional turbulence in the airflow, and consequently, do not significantly improve cleaning efficiency.

Furthermore, increasing the throughput of the RX regenerator did not have a significant impact on

reclamation efficiency; on the contrary, a decrease in the cleaning performance for fine impurities was observed [6].

3. Discussion and Results

Based on the analysis conducted, it was determined that the main drawback of the RX-type regenerator is its inability to evenly distribute the waste mass to the working components within the pneumatic supply unit. Specifically, a certain portion of freely moving cotton tufts and small impurities bypasses the operational zone of the saw-toothed drums and passes directly into the outlet pipe, which renders the regeneration process inefficient.

In the research, an improved cotton regenerator for cleaning fibrous material was proposed. This device, unlike the prototype, is equipped with a screw conveyor installed in the upper part of the main saw-toothed drum. It forcibly moves the material separated by the brush drum along the drum's axis, redirecting it back to the cleaning zone. This reduces the transit exit of the material under the influence of the air current and ensures regeneration during the cleaning process.

4. Conclusion

The analysis shows that in existing regenerators, cleaning efficiency is reduced because a portion of the material exits in transit due to the air current, and a large quantity of cotton tufts ends up in the waste. Therefore, the use of an improved cotton regenerator equipped with a mechanical feeder featuring a screw conveyor is proposed. The proposed design ensures regeneration by forcibly returning the material to the cleaning zone and increases cleaning efficiency.

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