# IMPACT OF PILE AND PLANK SIZES ON THE CLEANING PROCESS

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https://doi.org/10.5281/zenodo.17274741

**Abstract.** The article analyzes the effect of different sizes of a pile-slat drum on the efficiency of separating small impurities from a cotton stream. A second-order differential model is written for the movement of a cotton piece at the "drum-mesh surface" interface, taking into account the coefficients of viscosity kkk and viscosity η\etaη, as well as aero-inertia factors. The process of impurities exiting the mesh holes is studied parametrically based on the AG Sevostyanov model. Results: initial ~0.5 s decisive phase; ε increases with increasing pile (h) and slat (L) sizes; after 8 drums, the overall cleaning efficiency reached ~48–49%. The device is recommended as a "protective optimum" (zone III), taking into account energy safety and mechanical impact on the fiber ; $L \approx 80$ mm, $h \approx 70$ mmconfigurations are appropriate for lines with short residence times .$L \geq 70$ mm, $h \geq 80$ mm**.**

**Keywords :** kolkovo -planchatyy drum; setchataya poverkhnost; letuchki klopka; melkie prime; cleaning efficiency; differential model; aero -inertsionnoe vozdeystvie; high collar; dlina plank; jyostkost; vyazkost.

**Introduction.** In our republic, large-scale measures are being implemented to develop cotton-textile clusters, technically re-equip and modernize cotton ginning enterprises, increase the profitability of primary processing of raw materials, as well as the competitiveness of manufactured products, and positive results are being achieved. Special attention is paid to the creation of effective technologies for cleaning cotton from fine impurities and resource-saving designs of cleaners, optimization of air flow speed and pressure, and operating modes during the cotton cleaning process.

Many scientists have conducted scientific research on improving local techniques and technologies for cleaning cotton from small impurities. In particular, A. Parpiyev, A. Djurayev, A. Ye. Lugachev, P. N. Borodin, I. D. Madumarov, S. Sh. Sh. Khakimov, X. S. Osmonov, R. I. R. O. Zmetov, O. P. Mavlonov, T. O. Tuychiyev and others conducted research on improving the working parts and technology of equipment for cleaning cotton from small impurities.

In the scientific research work conducted by A.P. Parpiyev et al. [ 1 ], the results of experimental studies aimed at analyzing the composition of waste from a cotton cleaning unit for cleaning large and small impurities, separating cotton into single-seeded pieces, and assessing the amount of free fibers released together with the waste were determined. The effects of the seed variety, cotton quality, contamination and initial moisture content, as well as the number of sawn drums of the cleaning unit and the open or closed position of the protective cover under the pile drums on the amount of pieces in the waste were studied.

In the research work conducted by A.Djuraev et al. [ 2 ], the design features of the proposed cotton raw material cleaner from small impurities are presented. The system, which includes dynamic and mathematical models of the mechanisms of driving the working bodies of the cleaner, takes into account the mechanical and dynamic characteristics of the electric drive, inertial, technological, elastic-dissipative parameters. Based on the numerical solution of the problem, the laws of motion of the working body are obtained, and graphs of the parameters are presented. The values of the system parameters are based on

In the scientific research work conducted by AA Makhmudov [ 3 ], the results of analytical determination of the friction force between the concave part of the mesh surface and the cotton ball in a cotton ball cleaner from small impurities are presented. Graphs of the dependence of the friction force on the mass of the cotton ball, the coefficient of friction and the angle of impact were constructed. Based on the analysis, the optimal parameters of the cleaning zone were determined.

In the scientific research work conducted by RGRakhimov [ 4 ], a cotton gin was developed to separate small impurities from cotton raw materials, consisting of four pile drums mounted on a horizontal plane and mesh surfaces below them. The surfaces of the pile drums were selected to be inclined to their axes at an angle $\alpha=30^{0}$, and the angle of installation of pile rows of adjacent drums was chosen to be opposite, while the mesh surfaces were made in the form of a prism with many faces, the edges of which were made inclined to the axis of the drums at an angle $\beta=30^{0.}$ The edges of the mesh surfaces were located opposite the angles of inclination of the pile rows of the corresponding drums.

In the scientific research work conducted by ODMurodov [ 5 ], a design of a cleaning device with a changed mesh surface was proposed. When using a cylindrical mesh in a drum cleaner with a peg, the movement of cotton balls is monotonous. This is explained by the fact that the driving force acting on the cotton balls from the mesh surface has a stable frequency, which is mainly determined by the frequency of rotation of the peg drum.

In the scientific research work conducted by Ye.V. Tadayeva et al. [ 6 ], a cleaner of an unusual design was proposed. A four-rotating mesh drum is placed at 450 degrees and cotton is supplied to its inner part. Due to the rotation of the mesh drum, passive impurities in the cotton content are separated. It is recommended to use this cleaner before baling without mechanically affecting the passive impurities in the cotton content.

In the scientific research work conducted by DA Usmanov et al. [ 7 ], it was stated that the angle of the mesh surface of the fine dirt cleaning equipment covering the pile drum at 1100 degrees leads to its low cleaning efficiency. For this reason, experiments were conducted with a mesh surface surrounding the pile drum at 2700 degrees. The mesh surface was studied in six sections, and in the first sections, 20, 19 and 18% cleaning efficiency was achieved, and in the subsequent sections, 16, 14 and 11% cleaning efficiency was achieved. It was proposed to use the cleaning module of this design in the OXB-10M equipment.

In a scientific research work conducted by B.CH. Pardayev et al. [ 8 ], by increasing the diameter of the inner lining of the pile drums, the height of the pile was increased, which improved the cotton's movement and movement without clogging, and ultimately increased the cleaning efficiency. The distance between the rows of piles in the pile drum was taken to be the same size. The inner lining of the pile drum was made in an octagonal shape.

In the scientific research work conducted by RKDjamolov et al. [ 9 ], a design was proposed that allows for the separate removal of small impurities separated in the UXK cleaning unit. As a result, it was achieved to facilitate the processing of cotton pieces mixed with impurities in the RX cotton regenerator in the cleaning section from large impurities, increasing the cleaning efficiency and regeneration efficiency.

cotton moves along a drum with a peg and a mesh surface is observed for each size of cotton ball between the drum with a peg and a mesh surface. [10]. When cotton is subjected to impact force through a drum with pegs and dragged across a mesh surface, the force of compression of the cotton causes the movement of small impurities in the cotton, which in turn carries out the process of separating the impurities from the cotton [11].

each drum with different-sized pegs along the mesh surface, a contact force is created between the impurities contained in it and the mesh surface, under the influence of which the impurities move spatially, as a result of which some of them exit through the holes of the mesh surface [12]. A model was proposed by AGSevostyanov to describe this mechanism. According to this model, the decrease in the amount of impurities on the mesh surface is proportional to the amount of cotton and the system of movement along the surface.

, we will theoretically study the process of separating impurities from the composition of a cotton ball by a drum with pegs of different sizes . Before modeling the process of separating impurities , it is necessary to study the speed of movement of a cotton ball on a mesh surface under the influence of pegs of different sizes. The second-order differential equation of the action of a peg drum on the cotton flow is presented. Let us assume that a cotton ball is located between pegs of different lengths moving at a constant rotational speed, connected to each of them by equal elastic forces, the value of which is proportional to the displacement and speed of the balls relative to the pegs and directed along the arc of the circle. (Figure 1) The forces acting on the cotton balls $m_i \cdot g$are the forces of gravity (when passing through the drum with each peg), $F_{\mu k}$ is the centrifugal force, and $\varphi_{\mathbf{i}}$F μ is the angle between the pegs.

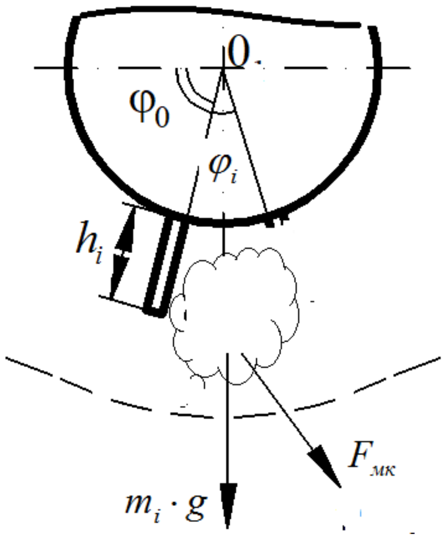



**Figure 1. Diagram of the effect of different sized piles on cotton balls on a mesh surface.**

of cotton balls under the action of a drum with pegs by and , ηrespectively k, and call them the coefficients of viscosity and stiffness.

stakes on cotton balls $t = 0$over time0 relative to the points $= s_0$ Starting from the arc. From the arc motion $S = (R + h_i) \cdot \varphi_i$- the circular motion of the cotton balls along the arc under the action of each peg-shaped drum is expressed by the following equation

$$m_i \cdot h_i \cdot \ddot{\varphi}_i = m_i \cdot g \cdot \sin\varphi_i - f \cdot m_i \cdot g \cdot \cos\varphi_i - 2 \cdot h_i \cdot (k \cdot (\varphi_1 - \omega_0 \cdot t) + \eta \cdot (\dot{\varphi}_i - \omega_0)) - m_i \cdot h_i \cdot \dot{\varphi}_i^2 \quad (1)$$

Here t- time $m_i$- the mass of cotton balls on the mesh surface with each drum with pegs, f- the coefficient between the mesh surface and the cotton balls. Since the cotton balls move along a circular arc, the friction forces arising from the action of centrifugal force in the direction normal to it are taken into account in equation (1). $f \cdot m_i \cdot h_i \cdot \dot{\varphi}_i^2$The initial conditions set in $\varphi = \dot{\varphi}_0 = \frac{s_0}{h_i}$equation (1) in the general case are numerically integrated in $f = 0$. To find an analytical solution to the equation $\dot{\varphi} = \omega_0$, we write equation (1) in terms of the displacement of cotton balls relative to pegs of different sizes. $\varphi_i = \dot{\varphi}_i - \omega_0 \cdot t, i = 1 \ldots .4$

$\ddot{\varphi}_i \cdot \frac{g}{h_i} \cdot \sin(\varphi_{*i} + \omega_0 t) - \frac{g}{h_i} \cdot f \cdot \cos(\varphi_{*i} + \omega_0 \cdot t) - \frac{2 \cdot k}{m_i} \cdot \varphi_{1*} - \frac{2 \cdot \eta}{m_i} \cdot \dot{\varphi}_{*i} - f \cdot (\varphi_{*i} + \omega_0)^2 (2)$

( 2 ).

$$a_i = \frac{g}{h_i}, \omega_i = \sqrt{\frac{2 \cdot k}{m_i}}, n_i = \frac{\eta}{m_i}.$$

then equation (2) is expressed as follows.

$\ddot{\varphi}_{i*} + 2n_i \cdot \dot{\varphi}_{i*} + \omega_i^2 \cdot \varphi_{i*} = a_i \cdot [\sin(\varphi_0 + \omega_0 \cdot t) - f \cdot \cos(\varphi_0 + \omega_0 \cdot t)] (3)$

here, $n_i = n + f \cdot \omega_0 \quad \omega_i = \omega^2 + f \cdot \omega_0^2$

We write the general solution of equation (3).

$$n_i > \omega_i \text{бўлганда } \phi_{i*} = A_i \cdot e^{k_i \cdot t} + B_i \cdot e^{k_{i+1} \cdot t} + F_i(t)$$

$$\frac{dm}{m} = -\lambda \cdot R \cdot \dot{\varphi}_i \cdot dt$$

where, $\lambda$is a coefficient determined experimentally. By deriving this equation, we determine the law of the same amount of fine impurities being removed from the cotton stream passing through each drum with different sizes of piles.

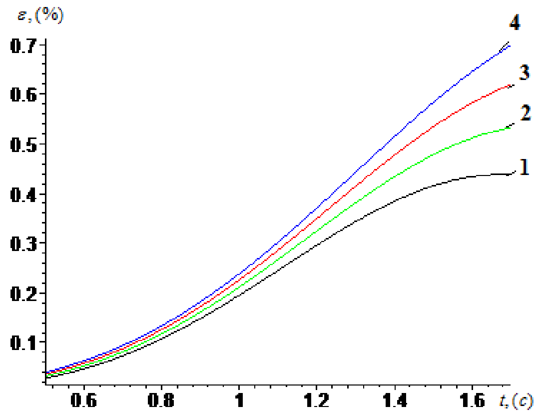
$$m_i = m_{i-1} e^{-\lambda \cdot R \cdot (\omega_0 \cdot t + \varphi_0 + \varphi_i(t))}$$

We define the following expression for the efficiency coefficient

$$\varepsilon_i = \frac{m_{i-1} - m_i}{m_{i-1}} = 1 - e^{-\lambda \cdot R \cdot (\omega_0 \cdot t + \varphi_0 + \varphi_i(t))}$$

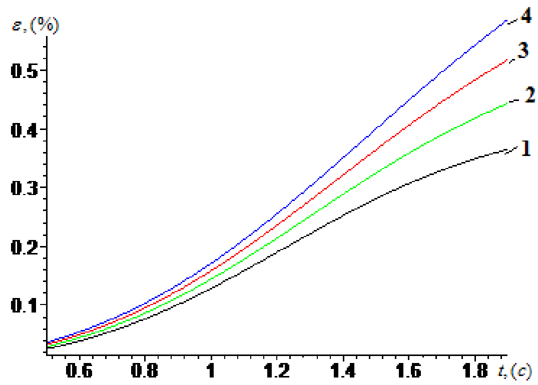
(Figure 1) $\varepsilon_i(t)$shows graphs of the change in the efficiency coefficients over time at the inlet and outlet intervals of each cleaning zone at the moment when $0 < t < t1, \; t1 < t < t2, t2 < t < t3, \; t3 < t < t4$the coefficient (N/m) of each kof the cotton pieces is different $.t = 0$

Here is $S = h_i \varphi_i$the section part where the arc is located, in the calculations$\omega_0 = 52 s^{-1}$; $R = 0{,}16$ m; $f = 0{,}2$; $m = 25 \cdot 10^{-4}$ kg; $n = 10\ H \cdot c/m$The values of are taken, different sizes of piles are accepted to participate in the cleaning process from the pile-plank drum, and the effect of each pile on the cleaning process $0 < \varphi < \pi$is reasonable. The results obtained from the graphs show that with the decrease of the pile length $h_i = 50 \div 95$ mmand the length of the planks $L = 40 \div 85$ mmand the coefficient of the bickering, kthe cleaning efficiency of the cotton flow in each pile-plank drum is the same, and with the increase of the experimental coefficient, the cleaning efficiency in each pile-plank drum can increase proportionally to the coefficient λof the cleaning efficiency in each different value .



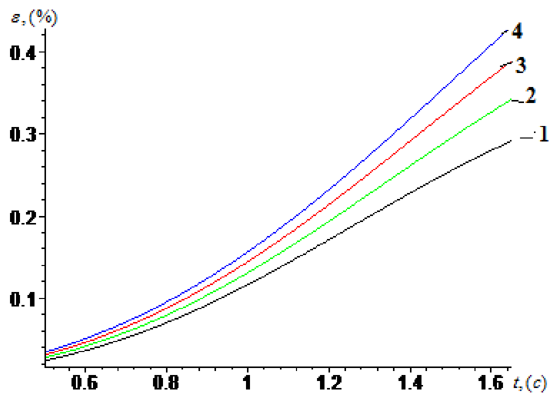

For I-plank drum

Figure 2. Efficiency of separating impurities from cotton stream with different sizes of planks$L_1 = 25$ mm, $L_2 = 30$ mm, $L_3 = 35$ mm, $L_4 = 40$ mmGraph of changes in values over time



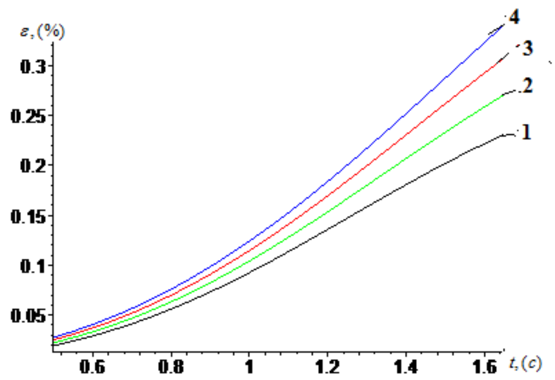

For II-plank drum

Figure 3. Efficiency of separating impurities from cotton stream with different sizes of planks$L_1 = 40$ mm, $L_2 = 45$ mm, $L_3 = 50$ mm, $L_4 = 55$ mm Graph of changes in values over time




For III-plank drum

Figure 4. Efficiency of separating impurities from cotton stream with different sizes of planks$L_1 = 55$ mm, $L_2 = 60$ mm, $L_3 = 65$ mm, $L_4 = 70$ mm Graph of changes in values over time




For IV-plank drum

Figure 5. Efficiency of separating impurities from cotton stream with different types of planks$L_1 = 70$ mm, $L_2 = 75$ mm, $L_3 = 80$ mm, $L_4 = 85$ mm Graph of change in values over time

the change in cleaning efficiency when passing through each of the slatted drums depending on the length of the slats were determined. The graphs show that the cleaning efficiency increased when passing through each of $L_4 = 40$mmthe slatted drums with pegs when the separation efficiency for the I-slatted drum was divided by the length of the slat , when $L_4 = 55$ mmthe separation efficiency for the II-slatted drum was divided by the length of the slat $L_4 = 70$ mm, when the separation efficiency for the III-slatted drum $L_4 = 85$ mmwas divided by the length of the slat, and when the separation efficiency for the IV-slatted drum was divided by the length of the slat.

As a result of changing the lengths of the pile-plank drums, the cleaning efficiency of the improved pile-plank drums technology is increased, which reduces the amount of impurities in the cotton fiber. As a result, the quality indicators of the produced fiber improve, and the fiber is upgraded from one grade to another.

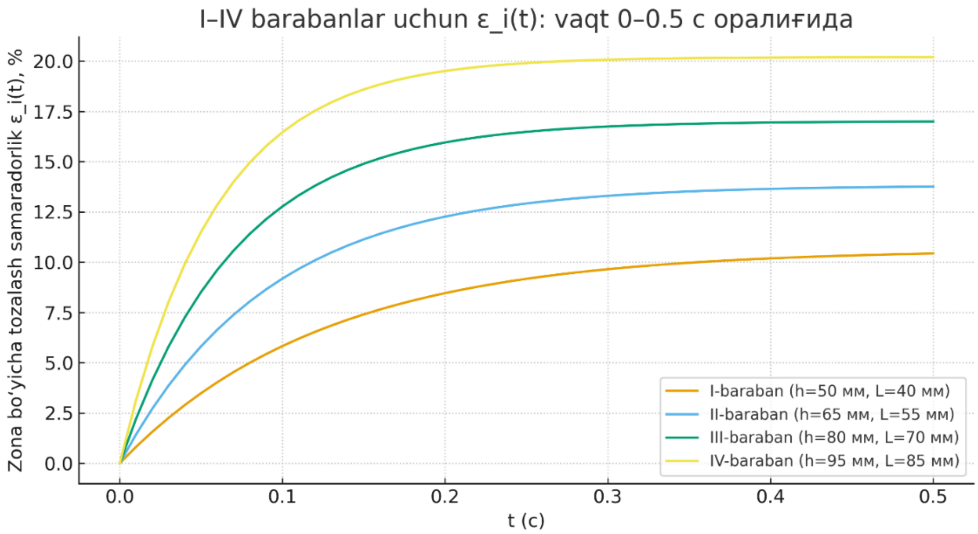



**Figure 6. Graph of the change in cleaning efficiency when installing pegs and planks of different sizes in the drum structure**

Analyzing the graph in Figure 6, **the aero-inertia effect :** As L increases, the air flow and the working area at the drum-mesh interface expand, the impact/sweeping forces acting on the cotton pieces increase → $\lambda_{\text{increases}}$ . As the height of the drum piles with piles increases h , the contact/impact radius increases → $S_i^{max}$increases . The first 0.5 s of cleaning **are the decisive phase** , and the main part of the zone result is formed at this time. For lines with short residence times, configurations L≥70 mm, h≥80 mm are recommended — the graph indicates this (lines III–IV are high and quickly saturated). Although zone IV (95/85 mm) gives the highest cleaning efficiency ε , the potential energy consumption/risk of mechanical impact (injury) may increase — in production, **III (80/70 mm)** is often considered a "protective optimum". To **reduce the time constant** (increase the output at the compressed time), it is advisable to : increase ω , decrease k or η (by design/mode), and optimally direct the air flow with additional channels.

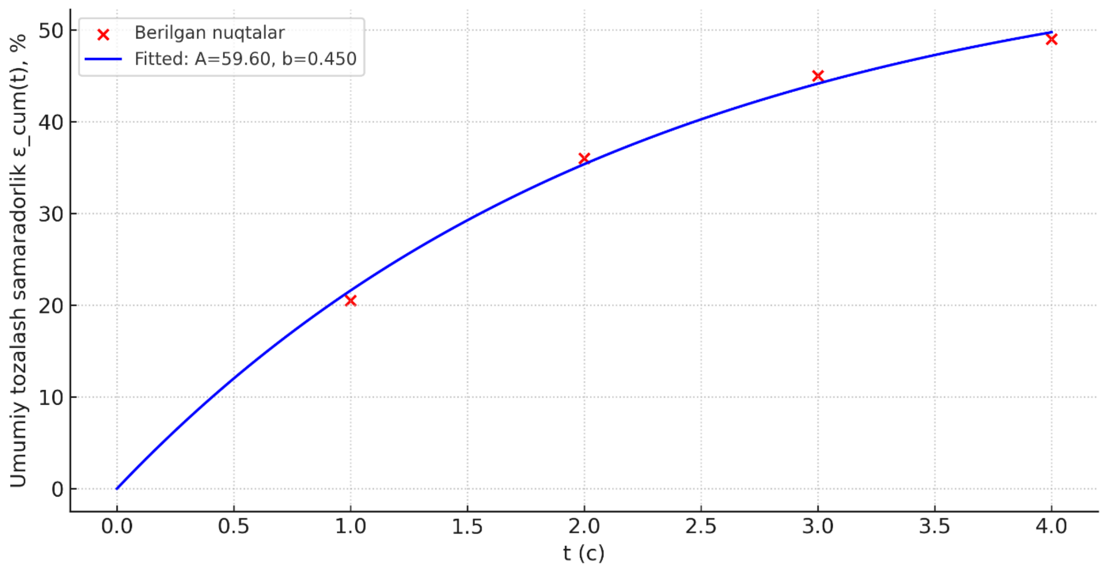



Figure 7. Pile and planks of various sizes are installed in the drum structure Graph of change in cleaning efficiency of the equipment

If we analyze the graph in Figure 7 , we can see that the separation of impurities from the cotton composition is high in the first seconds, and then the cleaning efficiency decreases . This is explained by the fact that the easily separated passive impurities in the cotton composition are separated from the raw material faster, and it is necessary to increase the mechanical effect to separate active impurities from the fibers. By reducing the inner lining of the pile-plank drums, increasing the height of the pile and the plank, increasing the air volume and accelerating the faster exit of the separated impurities from the mesh surface holes, the cleaning efficiency is 48-49% after the eight-pile drum. It is advisable to conduct practical experiments on the equipment for cleaning small impurities with changes in the design of the recommended variant.

**Conclusion.** The movement of cotton particles at the "pile-slat drum - mesh surface" interface k, ηwas modeled using a second-order differential equation and taking into account aero-inertia factors. The initial ~0.5 s is the crucial stage of the cleaning process, during which the cleaning efficiency εincreases sharply; in the subsequent stages, the increase slows down. With an increase in the height of the drum pile hand the length of the slat L, the removal of impurities from the mesh holes accelerates and the overall efficiency increases; the overall cleaning efficiency for 8 pile-slat drums $\varepsilon \approx 48-49\%$was . To minimize energy consumption and mechanical impact on the fiber, $L \approx 80$ mmand $h \approx 70$ mmare recommended as a “protective optimum”. $L \geq 70$ mm, $h \geq 80$ mmConfigurations for short residence time lines are appropriate. By reducing the inner lining, directing the air flow and ωincreasing the optimal ε, it is possible to quickly and safely increase ; it is recommended to conduct practical experiments under production conditions on the proposed design solutions.

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