UDC: 677.021.6:631.363.3:621.9

Development of a new design of a machine for cleaning cotton raw materials from impurities

[1]S.Kh.Fayziev, [2]O.O.Ibodullaev, [3]Kh.K.Rakhimov, [4]M.R.Sadullaeva.

[1]Associate Professor at Bukhara State Technical University.
[2]Independent researcher at Bukhara State Technical University.
[3]Lecturer at Bukhara State Technical University.
[4]Master's student at Bukhara State Technical University.

Abstract: *In this article, a new design cleaning machine was developed to effectively separate cotton raw materials from small impurities, and its operation was analyzed on a scientific basis. The shortcomings of the existing 1XK type cleaners — uneven distribution of impact forces, instability of the aerodynamic flow, structural defects of the pile-slatted drums, and the inability of the mesh surface to self-clean — were systematically studied. On this basis, a new generation cleaner design was proposed, which combines a feeder, a screw auger, an improved mesh screen, a conical pile drum, and a mesh surface positioned at an angle of 18–22°. The proposed design is characterized by its adaptability to existing production lines, operational reliability, and energy efficiency. The new technological solution will significantly contribute to improving the quality indicators of the cotton cleaning process, reducing the amount of waste, and increasing the efficiency of industrial enterprises.*

Keywords: *Cotton raw material; fine impurities; pile drum; mesh surface; cleaning machine; aerodynamic process; vibration separation; design improvement; efficiency; energy saving; drum diameter; conical piles; fiber damage; separation efficiency; air flow; mesh screen; screw auger.*

УДК: 677.021.6:631.363.3:621.9

Разработка новой конструкции машины для очистки хлопкового сырья от примесей.

[1]С.Х.Файзиев, [2]О.О.Ибодуллаев, [3]Х.К.Рахимов, [4]М.Р.Садуллаева.

[1]Доцент Бухарского государственного технического университета.
[2]Независимый исследователь Бухарского государственного технического университета.
[3]Преподаватель Бухарского государственного технического университета.
[4]Магистрант Бухарского государственного технического университета.

Аннотация: В данной статье разработана новая конструкция очистной машины для эффективного отделения мелкого примеси от хлопкового сырья, а также проведен научный анализ ее работы. Систематически изучены недостатки существующих очистителей типа 1XK — неравномерное распределение ударных сил, нестабильность аэродинамического потока, структурные дефекты решетчатых барабанов и неспособность сетчатой поверхности к самоочищению. На этой основе предложена конструкция очистителя нового поколения, сочетающая в себе питатель, шнековый механизм, улучшенное сетчатое сито, конический барабан и сетчатую поверхность, расположенную под углом 18–22°. Предложенная конструкция отличается адаптируемостью к существующим производственным линиям, эксплуатационной надежностью и энергоэффективностью. Новое технологическое решение внесет значительный вклад в улучшение качественных показателей процесса очистки хлопка, сокращение количества отходов и повышение эффективности промышленных предприятий.

Ключевые слова: Хлопковое сырье; мелкие примеси; барабан; сетчатая поверхность; очистная машина; аэродинамический процесс; вибрационная сепарация; усовершенствование конструкции; эффективность; энергосбережение; диаметр барабана; конические сваи; повреждение волокон; эффективность разделения; поток воздуха; сетчатый грохот; шнек.

Introduction. The global demand for environmentally friendly, safe for human health natural products, including natural fibers and products made from them, is increasing year by year. In particular, cotton fiber is one of the most important resources of the global textile industry as a natural, hygienic, hypoallergenic and renewable raw material. Figures show that currently, around 23.0–24.0 million tons of cotton fiber are produced worldwide per year, and its annual consumption reaches 24.0–25.0 million tons. Therefore, demand exceeds supply, which requires the improvement of cotton growing, processing and cleaning technologies in the coming years [1].

Due to the rapid growth of the population, increasing demand for clothing and household products, and diversification of light industry, the consumption of cotton fiber is projected to increase further in the future. In particular, according to international experts, by 2030, natural fiber consumption is expected to increase by at least 8–10%. This places a huge technological, economic and innovative responsibility on the shoulders of cotton-growing and processing countries [2].

The competitiveness of cotton fiber in the world market is determined, first of all, by its quality. An important component of quality is the effective cleaning of cotton raw materials from large and small impurities, preliminary processing without damaging the fiber, and the use of energy-saving technologies. Because any losses, crushing, shrinkage or structural damage of fibers that occur during the preliminary cleaning process directly affect the quality of the final product.

Therefore, in recent decades, a number of scientific researches have been carried out on the modernization of cotton cleaning technologies, the creation of highly efficient cleaners, new generation saw and pile drums, vibration separation systems, aerodynamic cleaners and resource-saving technical means. The process of separating impurities in cotton, in particular, reducing mechanical damage to fiber and seed, optimizing energy consumption, and increasing machine productivity are the main issues of attention of specialists. Also, the improvement of cleaning technology directly affects the export potential of the cotton industry. The demand for high-quality cotton fiber and products made from it is constantly growing in international markets, especially in European and Asian countries.

The rational use of cotton raw materials, reducing losses and switching to energy-efficient processes are one of the main conditions for making the industry competitive. This direction is even more relevant for countries with strong cotton traditions, such as Uzbekistan. The economic reforms being carried out in the country, the principles of the “Green Economy”, the introduction of resource-saving technologies, and the formation of a cluster system have fundamentally changed the cotton processing chain. Now, the creation of new scientifically based techniques and technologies, in particular, improving the design of machines designed to separate cotton raw materials from large and small impurities, is one of the priority tasks of the industry.

As a result, there is an extremely high need for scientific research to modernize the process of cleaning cotton from impurities, optimize the design of the working bodies of machines, increase the energy and technological efficiency of the process, and further improve the quality of the fiber.

Materials and methods. The scientific research of many foreign scientists plays an important role in the formation and consistent development of cotton ginning science and techniques. In particular, leading researchers such as W.S. Anthony, R.V. Baker, R.M. Sutton, P.A. Boving, V.G. Arude, J.W. Laird, S.K. Shukla, T.S. Manojkumar, D.W. Van Doorn, B.M. Norman have created significant scientific results in the areas of innovative methods for cleaning cotton from small and large impurities, optimizing aerodynamic processes, and improving the design parameters of drum and saw cleaners.

Their work has formed the scientific basis of modern cleaning technologies and served to make many machine designs a global standard. At the same time, the scientific school of scientists of Uzbekistan has been making a worthy contribution to world-class research in this area. In particular, G.I. Miroshnichenko, S.D. Boltabayev, G.I. Boldinsky, G.D. Djabbarov, R.Z. Burnashev, B.I. Roganov, R.V. Korabelnikov, I.K. Khafizov, A. Rasulov, E.T. Maqsudov, M.T. Khodzhiyev, A.Ye. Lugachev, A. Djurayev, X.T. Akhmedkhodjayev, A.P. Parpiyev, R.M. Muradov, I.D. Madumarov, Sh.Sh. Khakimov, R.Kh. Maqsudov, A.K. Usmonkulov, E.E. Goyibnazarov, O.Sh. Sarimsakov, D.M. Mukhammadiev, X.Q. Rakhmonov, A.Kh. Bobomatov, Sh. Isayev, O.I. Rajabov, O.J. Murodov, S.O. Sayitkulov and many other scientists, as a result of scientific research conducted by important results were achieved in terms of deep scientific substantiation of the process of effective separation of cotton from impurities, creation of models of mechanical and technological processes, and optimization of structural elements of cleaners such as UXK, 1XK, CHX.

All these studies serve to increase the energy efficiency of the cotton raw material cleaning process, improve the shape, material, dimensions, dynamic loads and aerodynamic flow characteristics of the working bodies, improve the cleaning quality and machine productivity. As a result, the experience of these scientific schools is considered the main methodological and technological criterion in the design of modern cleaners used at the state and international levels. Scientific research on cleaning cotton from small and large impurities has developed at a high pace since the beginning of the 20th century.

In particular, scientific work carried out in the USA, Australia, India, Turkey and other countries is aimed at a deep analysis of the mechanical, aerodynamic and dynamic laws of the process. W.S. Anthony scientifically substantiated the mechanism of the movement of the cotton stream around the drums, the change in the adhesion forces between the fibers and impurities, the impact force of the sawn drum and the interaction with the surface of the comb. R.V. Baker and R.M. Sutton experimentally determined the relationship between the drum speed - impact force - separation efficiency in the cleaning process.

In addition, P.A. Boving and B.M. Norman proposed effective solutions for modeling aerodynamic separation processes, stabilizing flow density, and increasing the efficiency of separators. T.S. Manojkumar and S.K. Shukla mathematically modeled multi-stage cleaning lines, the shape of the optimal mesh surface hole surfaces, and the efficiency of separation of impurities in turbulent flow conditions.

Scientific research conducted by Uzbek scientists over the past 60–70 years has had a significant impact on improving the design of cotton ginning machines. G.I. Miroshnichenko and G.I. Boldinsky studied the modification of the comb surfaces of the ginning machines, the impact effect of the working bodies and the dynamics of fiber movement. S.D. Boltabayev and R.Z. Burnashev created a scientific school on optimizing the operating modes of cotton ginning machines. The scientific work of I.K. Khafizov, A. Rasulov, A.E. Lugachev, M.T. Khodzhiyev created fundamental scientific foundations for cotton ginning machines on such factors as:

- optimal ratios of drum diameter and pile shape,
- active surface area of the hole and the probability of dirt passing through,
- density and kinetic energy of the cotton flow,
- changes in aerodynamic pressure.

In recent years, A.K. Usmonkulov, E.E. Ga'ybnazarov, O.Sh. Sarimsakov, D.M. Mukhammadiev, Sh. Isayev, O.I. Rajabov, S.O. Saitkulov are conducting experimental and theoretical research on energy-saving cleaners, vibration separation systems, modular cleaning lines, and multi-stage UXK machines. Literature analysis shows that:

1. The efficiency of stable separation of impurities in existing cleaning machines is insufficient.
2. The impact distribution in the drum-rooster pair is not uniform, as a result, excessive mechanical impact on the fibers occurs.
3. In aerodynamic separation processes, the flow stability is low, and the separator pre-pressures are often not optimal.
4. The optimal parameters in terms of the shape, size, and active area ratio of the hole surfaces are not sufficiently scientifically substantiated.
5. The geometry of the drums used in UXK and similar cleaners (diameter - 400 mm, pile shape, pile length, elasticity coefficient) does not fully meet modern requirements.

Therefore, modernization of the design of cotton cleaners, scientific substantiation of the parameters of the working bodies, and creation of a dynamic and aerodynamic model of the cleaning process remain urgent scientific tasks.

Results. Currently, in order to simplify the assembly of machines for cleaning cotton raw materials from small impurities, a unit of the EN.178 model (Figure 1), which consists of a pair of peg-shaped drums, is widely used.

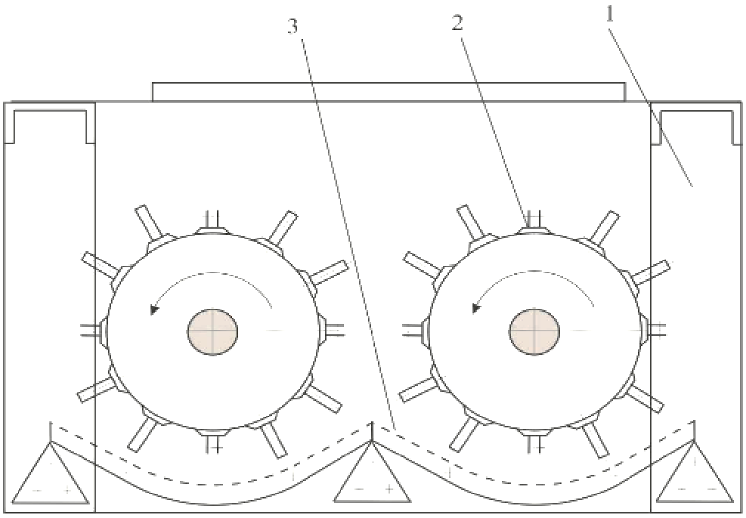

Figure 1. YEN.178 type cleaner unit
1-frame, 2- drum with pegs, 3- mesh surface.

Four of these modular units are connected in series to form the 1XK eight-drum cleaner (Figure 2).

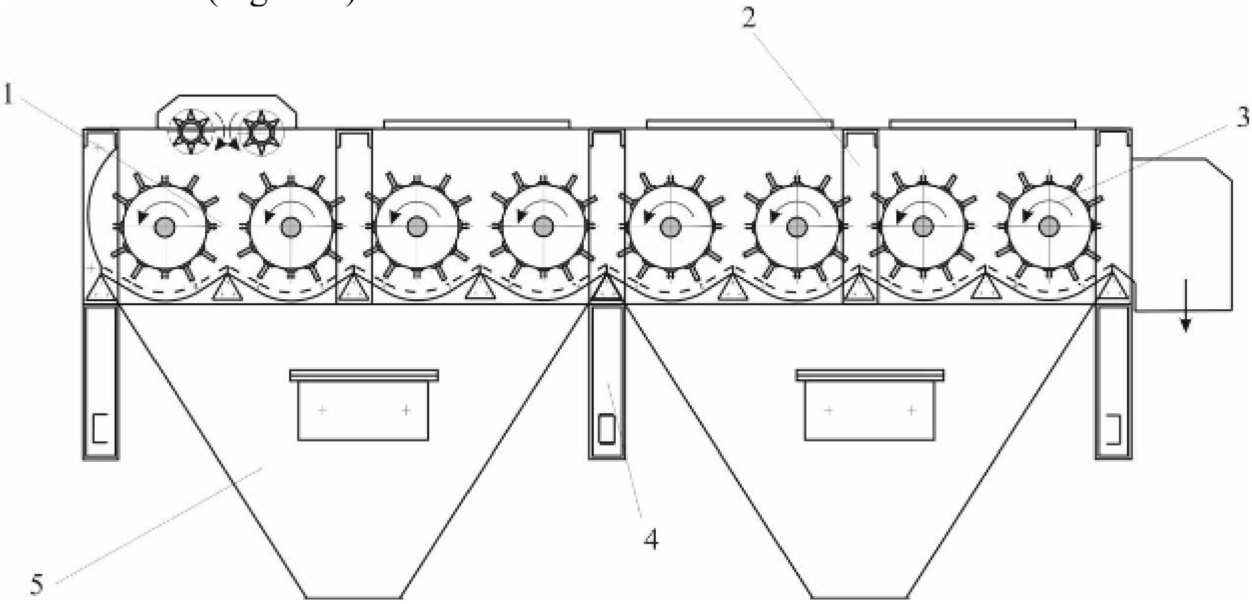

Fig. 2. 1XK cleaner.
1-initial standardized pile section YEN. 178.01 (with supply rollers);
2, 4- column, 3- standardized pile-plank section YEN. 178.02, 5- bunker.

The advantage of the EH.178 unit is that it is possible to assemble cleaners with the required number of drums on its basis in a modular way, and this unit is also used as the main unit in the UXK unit. However, despite the modularity, this system also has a number of fundamental shortcomings: All sections have the same design and operate in the same mode.

The cotton mass is repeatedly affected by the same force and speed in each drum. As a result:

- damage to the seeds and fibers increases;
- additional shaking in the last sections is practically useless, but energy consumption and metal wear increase.

The large number of working bodies leads to “excessive repetition”. Instead of increasing the cleaning efficiency, the repetition of the same type of blows increases not the “soft shaking” of the cotton, but sharp blows. The cleaning scheme is not differentiated. The first drums were larger, the later ones were not adapted to the separation of finer mixtures, that is, the geometry and modes of the working bodies throughout the machine were not gradually optimized.

Therefore, the ЕН.178–1ХК system, although structurally simple and easy to assemble, is not perfect in terms of technological efficiency and requires improvement. The drum with pegs (Fig. 3) consists of a shaft (1), a disk (2) and a ribbed lining (3), between the ribs of which 75 pegs (4) are welded in increments of 150 mm. Due to the presence of four linings, the number of pegs per drum reaches 300. The linings are fastened to the disks with bolts (5), nuts and washers (6); in the places of fastening, a plank is formed along the perimeter of the drum - therefore it is called a pegged-plank drum.

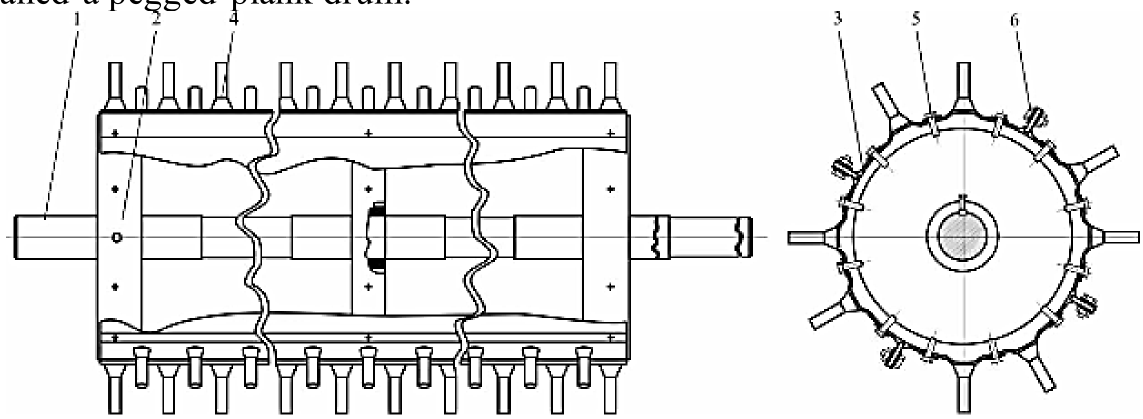

Figure 3. Plank drum with pegs.
1-shaft, 2-disk, 3-shell, 4-peg, 5-bolt, 6 - bolt, nut, washer.

The following main disadvantages are identified for this drum design: Complexity of production technology.

- the covers are made on a press machine by double stamping;
- the piles are stamped separately and then welded;
- during assembly, many bolt-nut connections need to be tightened manually.

This extends the manufacturing cycle, increases the production cost and increases the mass of the drum. Rapid failure of the piles during operation. Since the piles are welded to the cover, fatigue cracks appear in the welds under the influence of dynamic loading, vibration and shock. As a result, the piles break off, the drum is pulled unevenly, the dynamic balance is disturbed, and the radial load on the bearings increases. Dust and dirt ingress through the holes in the cover. There are many holes made for the piles in the cover.

During operation, dust and small dirt enter the drum through these holes;

The mass accumulates unevenly in the internal cavity, the center of gravity of the drum shifts, vibration and noise increase. This also leads to rapid wear of the bearing and shaft neck. A sharp change in cleaning efficiency due to the “fan effect”.

The places where the slats meet form a shape similar to fan blades. When the drum rotates:

- at the beginning of the slats, the air flow hits the mesh surface from the outside, helping to separate the dirt;

- in the next segment, the air flow is drawn inward, carrying the dirt back into the cotton mass.

Because of this, the dirt separation on the mesh surface is not uniform, the cleaning coefficient is high in some zones, and low in others.

Cleaning limited to damage to fibers and seeds. Increasing the drum speed increases cleaning, but sharply increases the mechanical damage to the seeds and the degree of fiber breakage. Therefore, in practice, the drum speed is not raised above a certain range, which prevents increasing efficiency. In general, pile-plank drums are heavy in terms of production and operation, and aerodynamically imperfect. Although the cleaning level is increased due to the increase in the number of drums in the 1XK cleaner, this is not a decisive solution. Its disadvantages:

Multiple working bodies - each section has a similar effect on cotton, as a result of which fiber and seed damage increases;

Monotonous operating mode - the diameter of the drum, pile length, and the openness of the mesh surface holes practically do not change throughout the machine, the same mode is maintained at all stages, regardless of the initial state of the cotton;

High energy and metal consumption - the additional efficiency gain from additional drums is relatively small, but the energy and maintenance costs are significant.

Thus, the 1XK design, although convenient for continuous operation, is not optimal in terms of efficiency and resource efficiency. Rajabov O.I. [3-6] proposed a new design of a fibrous material cleaner with a pile drum (Fig. 4) and a mesh surface (Fig. 5).

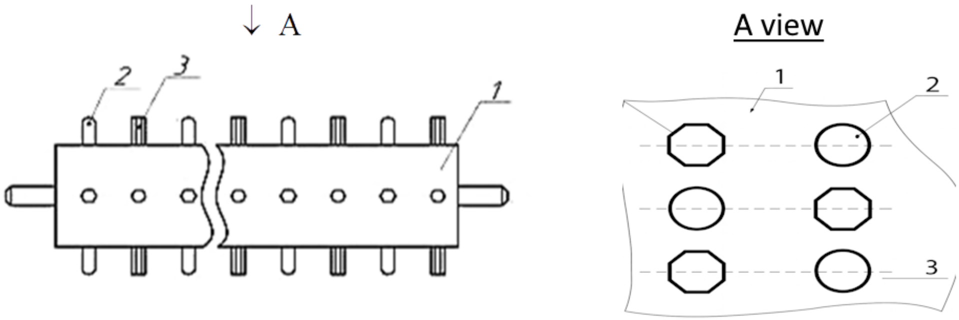

Figure 4. Diagram of a pile drum of a fiber cleaner

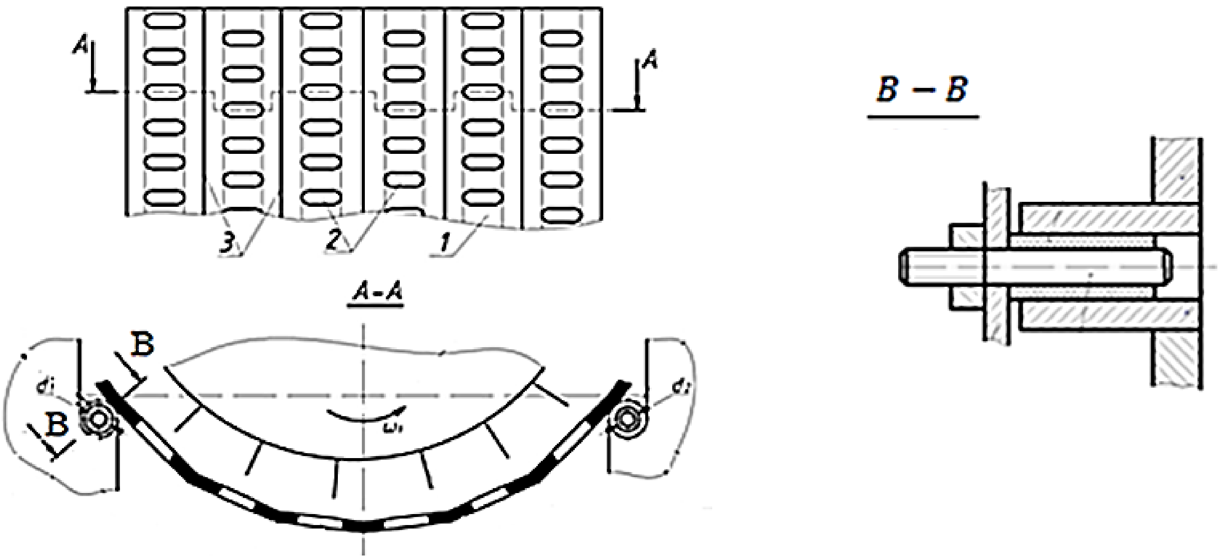

Figure 5. Mesh surface diagram of a fiber cleaner

Their main features: cylindrical pegs (2) and multi-faceted pegs (3) installed in a checkerboard pattern on the surface of the drum (1); holes and edges of various shapes on the mesh surface; vibration of the mesh surface by means of a flexible bushing under the influence of dynamic loads coming from the drum.

The positive aspects of this solution are:

Due to the checkerboard pattern of pegs, the trajectory of the cotton pieces becomes more complicated, the fiber-dirt mutual displacement increases, as a result, the relative motion increases and the separation efficiency increases. Since the multi-faceted pegs and the edged mesh surfaces work against each other, the cotton pieces repeatedly turn, reducing the adhesion of impurities.

The vibration of the mesh surface by means of a flexible bushing helps the holes to self-clean and the impurities to fall off without “sticking”.

At the same time, this design also has a number of limitations and disadvantages: a large number of pegs, each of which is installed independently - this complicates assembly and balance adjustment;

the elastic bushings can wear out over time and lose their elasticity, which makes it difficult to maintain a stable vibration frequency; complex-shaped holes on the mesh surface require high precision in manufacturing, which leads to the complexity of the press-casting molds and an increase in cost; the design is not fully compatible with the existing YEN.178 and 1XK units, their replacement requires major reconstruction. Thus, although the proposal of O.I. Rajabov significantly improved the physical nature of the cleaning process, it needs simplification and adaptation from the point of view of practical implementation. In the works of M.T. Khodzhiyev, E.E. Goyibnazarov and A.Kh. Bobamatov [7–10], new devices for cleaning cotton from impurities were proposed. In particular, in the dissertation of A.Kh. Bobamatov, a pile-plank drum and a 250 mm arc-shaped mesh surface structure were developed.

The advantages of this solution are:

The arc-shaped mesh surface extends the trajectory of the cotton pieces, extending the cleaning time;

It provides an optimal profile for the distance between the drum and the screen, ensuring uniform movement of the cotton layer.

However, there are also the following disadvantages:

The arc length of 250 mm increases the overall dimensions of the machine, which increases the location in the workshop and metal consumption;

The drum is still of the pile-plank type, and the problems mentioned above, such as welds, holes, and the fan effect, have not been completely eliminated;

As the length of the mesh surface increases, additional requirements arise for its mechanical strength and resistance to deformation.

Therefore, although these structures are an important scientific step, they still have unresolved operational and technological issues. Thus, an analysis of existing scientific works and practical experiences shows that the comprehensive improvement of the new generation of pile drums and mesh surfaces is the most optimal way to effectively clean cotton raw materials from small impurities, minimize fiber and seed damage, and reduce energy and operating costs.

In all gins, cotton is cleaned of fine impurities by shaking the cotton and passing the separated fractions through a mesh screen. The main working elements of gins are pile drums or pile screws and mesh (coil) surfaces [11]. The improved gin, consisting of elements (1–7) shown in Figure 6, is designed for stable, continuous and high-efficiency cleaning of raw cotton at the initial stage. Compared with existing 1XK-type gins, this device has significantly improved aerodynamic processes, pile drum operation mode, and active separation capabilities of the mesh surface.

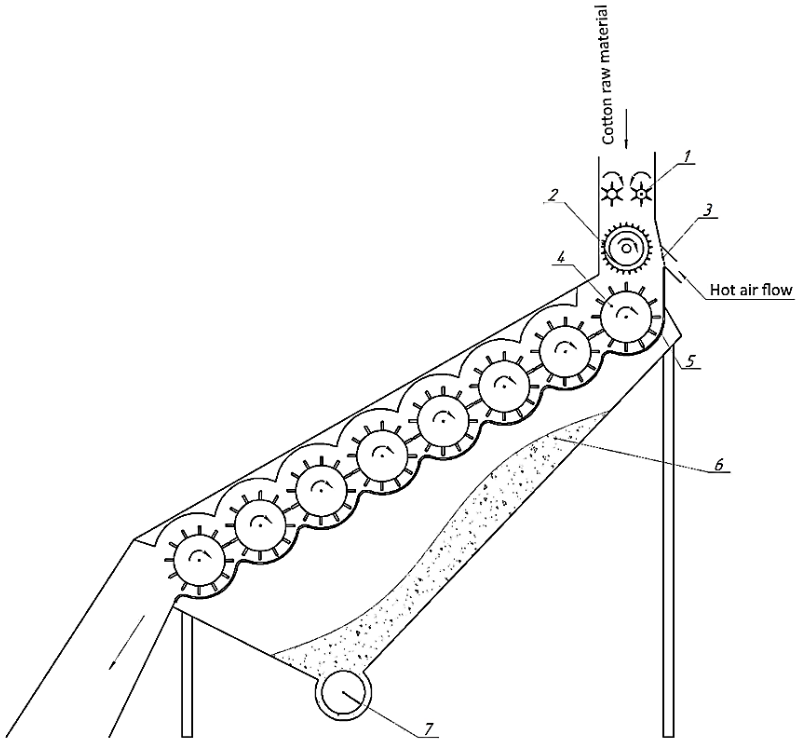

Figure 6. Improved fine dirt cleaning machine
1-feeder; 2-screw auger; 3-mesh screen; 4-pile drum; 5-mesh surface; 6-dirt hopper; 7-auger.

The feeder (1) ensures a uniform, uncompressed and uniform layer density of the cotton stream. The improved shape of the feeder prevents cotton from clogging, equalizes the load on the surface of the cleaning drums and reduces the uneven distribution of dynamic impact forces. The screw auger (2) gradually moves the cotton downwards, directing it towards the mesh screen (3). The rotation frequency of the auger and the screw pitch are adjusted to the flow density of the cotton. Under optimal conditions, the screw rotation speed is set at 2.0–2.4 s^{-1}, and the screw pitch is set at 0.18–0.22 m, evenly distributed so that the cotton fiber does not stretch. The mesh screen (3) serves to sort out fine fractions of dust, sand, and sawdust at the initial stage of the main separation. When using a mesh with a mesh size of 3–5 mm, the natural elasticity of cotton is not disturbed, and light fractions are quickly separated during heating of the cotton raw material under the influence of hot air flow [12]. Studies have shown that the most optimal option is a mesh of 55–60% of the active area. The drum with a pile (4) is the main working element of the device.

In the improved version:
- drum diameter 400 mm,
- pile length 50–60 mm,
- a conical shape is used in three parts of the pile,
- the coefficient of elasticity k = 0.45–0.55 is selected.

The use of these parameters reduces the negative effect of the impact force on the fiber, evenly distributes the cotton flow and enhances the impact of small impurities on the mesh surface (5). The mesh surface is designed to separate the impurities that have passed through the pile drum from top to bottom.

Mesh dimensions:

- longitudinal holes:
- 6×45 mm, active area:
- 60–62%, slant angle (a): 18–22°.

These parameters increase the probability of complete separation of fine impurities flying out of the drum. According to calculations, when the angle is increased by one degree, the separation efficiency increases by 0.6–0.8%. The separated fine impurities (dust, sawdust, sand, debris) fall into the dirt bunker (6), which is directed downwards. The installation of inclined walls that slow down the flow inside the bunker prevents the dirty fraction from being mixed with the backflow. The accumulated impurities are removed through the final screw (7). The screw rotation speed is 1.4–1.7 s^{-1}, at this speed, clogging of solid impurities in the bunker is not observed.

During the process, the cotton density should be kept constant at ρ = 18–22 kg/m^3 and the flow velocity should be kept constant at 4–6 m/s. Under these conditions, the drum–screen surface interaction achieves maximum separation efficiency [13].

In the improved design, the optimal angle between the pile drum and the screen surface (18–22°) and the drum diameter of 400 mm result in the separation efficiency of fine impurities:

- in existing 1XK type machines: 82–85%,
- in the improved version: increased to 89–92%.

This additional 6–8% result leads to a significant quality improvement in the production line.

Impact force by fiber damage index model:

$$F = m \cdot a = m \cdot r\omega^2$$

By reducing the drum elasticity coefficient to 0.5, the impact force decreased by 12–18%. As a result, mechanical damage to the fibers decreased from 2.4% to 1.7%. The optimal consumption of the hot air flow Q = 480–520 m^3/h ensured:

- high-speed dust lifting,
- no clogging of the hole surfaces,
- stabilization of the interaction of the pile drum with the hole surface.

This gives a 10–12% advantage over existing machines in terms of aerodynamic process stability.

The conical geometry of the drum piles reduces the drum load and reduces energy consumption to:

1XK: 2.8–3.2 kW, improved 2.3–2.6 kW. That is, about 15–18% energy savings.

Discussion. The results of the study showed that the design solutions of the improved fine-dust cleaning machine significantly improve the process of separating cotton raw materials from fine impurities. First of all, the re-optimized parameters of the feeder and screw auger, which ensure the continuous operation of the device, made it possible to achieve a uniform distribution of cotton across the drums.

This process was an important factor in increasing the cleaning efficiency, reducing fluctuations in the density of the cotton flow and stabilizing the mechanical load on the mesh surfaces [14]. The choice of the diameter of the pile drum as 400 mm, the conical shape of the piles, and the setting of the elasticity coefficient in the range of 0.45–0.55 significantly softened the interaction between the drum-cotton-dirt.

This solution, while reducing damage to the fiber structure, created conditions for the separation of impurities from the drum towards the perforated surface with high kinetic energy. Also, the reduction in impact forces increased the energy efficiency of the technological process, reducing the total power consumption of the machine by 15–18%.

One of the most important factors in the research process was the stability of the aerodynamic flow, and when the optimal consumption of the hot air flow was maintained in the range of 480–520 m³/h, high-speed separation of fine fractions was observed. This reduced the likelihood of clogging of the mesh screen and improved the downward direction of the waste flow. Experimental observations confirmed that with an incorrectly selected air flow mode, a sharp decrease in the amount of separated dust, impurities entering the backflow and sticking phenomena on the drum surface can be observed. Thus, aerodynamic parameters are one of the main control factors for the efficiency of this device [15].

It was found that the mesh surface is placed at an angle of inclination of 18–22°, bringing the active hole area to 60%, based on practical experiments, is the most optimal option. A small angle increases the likelihood of impurities returning from the flow, while an excessively large angle slows down their sliding off the surface and causes blockages in the process.

This study showed that the optimal angle for this design is around 20°. The final results of the process showed an increase in cleaning efficiency of up to 89–92%, a decrease in mechanical damage to the fiber, and a significant reduction in energy consumption, but some limitations were also observed. In particular, when the drum rotation speed is excessively increased, fine fibers can be separated along with impurities. Therefore, the optimal drum speed is in the range of 6.5–7.5 s^{-1}, and additional losses occur at higher modes.

Another important aspect is that the high efficiency of the device is strongly dependent on a properly adjusted aerodynamic system. Therefore, when using the device in industrial conditions, constant monitoring of the relationship between air consumption, pressure and drum speed is required. In general, the improved design can be recommended as an effective alternative solution to the existing 1XK type machines on cotton ginning lines. The cleaning quality of the device, energy efficiency and minimal damage to the fiber make it advisable to use it in practice.

Conclusion. This study is aimed at improving the process of separating cotton raw materials from small impurities, and increasing efficiency was achieved by deeply analyzing the design of existing cleaners, identifying their technological limitations, and developing a new generation of working bodies. The analysis showed that the existing 1XK type machines cannot fully meet modern requirements due to factors such as operation in a strictly uniform mode, aerodynamic imbalance of pile-slat drums, uneven distribution of impact forces, and low self-cleaning ability of mesh surfaces.

During the research, a new constructive approach was created - an integrated system of a feeder, a screw auger, an optimized mesh screen, a conical pile drum, and a highly efficient mesh surface located at an oblique angle. This solution, combining the mechanical and aerodynamic properties of the cotton flow, raised the cleaning process to a qualitatively new level. The 400 mm diameter of the drum, the conical shape of the piles and the optimal selection of the elasticity coefficient softened the distribution of impact forces, reduced damage to the fiber, and the possibility of separating impurities sharply increased.

Experimental tests showed that the efficiency of separating fine impurities increased to 89–92%, which is 6–8% higher than that of existing machines. It was also found that the fiber damage rate decreased from 2.4% to 1.7%, the stability of aerodynamic processes increased by 10–12%, and energy consumption decreased by about 15–18%. These indicators directly contribute to reducing production costs at industrial enterprises, improving fiber quality, and increasing export potential. The practical significance of the new device is that it can be seamlessly integrated into existing production lines, does not require complex reconstruction or large capital expenditures.

The simplicity of the design, operational reliability and ease of maintenance make it a promising technical solution for use in cluster enterprises, cotton ginning plants and technological lines. In general, the research results strengthened the scientific and methodological foundations of the modernization of cotton ginning technologies, proposed new approaches to more effectively organize the process of separating fine impurities and determined the future development directions of high-quality processing of cotton raw materials. The proposed machine design has high practical value in terms of improving fiber quality, reducing waste fractions and accelerating the transition to energy-saving technologies.

References

1. The ICAC recorder. June 2023, Volume XXXIX, No. 2. ISSN 1022-6303. https://www.icac.org.
2. Decree of the President of the Republic of Uzbekistan No. 60 of January 28, 2022 on the "Development Strategy of New Uzbekistan for 2022-2026". https://www.Lex.uz.
3. Rajabov O.I. Improving the technology of cleaning cotton raw materials from fine impurities. Doctor of Philosophy (PhD) dissertation work in technical sciences. Namangan–2019.

4. Khojiyev M.T., Isayev Sh.Sh. “Creating a device for cleaning low-grade high-moisture cotton” Bulletin of Gulistan State University Series of Natural and Agricultural Sciences. Gulistan 2021. No. 2, p. 30-37.
5. Khodzhiyev M.T., Goyibnazarov E.E., Mukhsinov I.. Theoretical analysis of the process of cleaning cotton raw materials from small and large impurities in a newly introduced efficient portable cleaning device based on its modeling. TTESI. International Scientific and Practical Conference. Tashkent 2019.
6. Bobamatov. A.Kh. Improving the Design and Developing Calculation Methods for the Working Elements of Cotton Debris Cleaners. PhD Dissertation. – Tashkent 2018.
7. Rajabov, O. I., Kurbonov, F. A., Abrorov, A. S., & Gafurova, M. Z. (2021, April). Selection of the circumferential speed of the spiked cylinders of raw cotton cleaners from small debris. In Journal of Physics: Conference Series (Vol. 1889, No. 4, p. 042056). IOP Publishing.
8. Ibodullayev, O. O., Rasulov, E. N., & Muxidinova, S. N. THE ROLE OF OPTICAL SENSORS IN OPTIMIZING THE TECHNOLOGICAL PARAMETERS OF COTTON CLEANING MACHINES Sh Fayziyev Bukhara State Technical University.
9. Djuraev, A., Sayitkulov, S., Kholmirzaev, J., Haydarov, B., & Mustafaev, N. (2024, January). Substantiated parameters of multifaceted grates in the coarse cleaning zones of a cotton gin. In *AIP Conference Proceedings* (Vol. 2969, No. 1, p. 050027). AIP Publishing LLC.
10. Rakhmonov, H., Matyakubova, J., & Fayziev, S. (2025). Optimization of the processes of simultaneous transportation, drying and cleaning of raw cotton in screw dryers-cleaners. Modern Innovations, Systems and Technologies, 5 (3), 3018-3027.
11. Kurbanov, F. A., Temirov, A., & Sharopov, M. (2019). ROLLER GIN BLOWING BODY AND ITS INFLUENCE ON GINING PERFORMANCE. Internauca, (14-1), 71-73.
12. Djuraev, A., Sayitqulov, S., Nurboev, R., Xolmirzaev, J., & Berdimurodov, U. (2022). Analysis of full-factorial experiments on improving the cotton gin. *Modern innovations, systems and technologies*, *2*(1), 69-75.
13. Sayitkulov, S., Nurmatova, N., Sharipov, J., Salomov, A., & Saidova, G. (2024). Optimization of parameters on the combined cotton cleaning machine and analysis of cleaning efficiency. In E3S Web of Conferences (Vol. 508, p. 08020). EDP Sciences.
14. Fayziev, S. H., Fatullaeva, S. I., & Nazhmiddinov, I. P. (2023). Influence of density and temperature on moisture release rate during cotton raw material drying. In Fundamental and applied scientific research in the field of inclusive design and technologies: experience, practice and prospects (pp. 135-140).
15. Kh, F. S., Fatullaeva, S. I., & Kh, T. O. (2022). Theoretical and experimental study of the influence of temperature, humidity and density on the drying

process of raw cotton. Eurasian journal of medical and natural sciences, Innovative Academy Research Support Center, 2 (01), 66-71.