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EXPERIMENTAL CONSTRUCTION DEVELOPMENT OF THE DEVICE FOR CLEANING COTTON FROM SMALL IMPURITIES

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Abstract: In the article, the working scheme and experimental design of the device for cleaning cotton from small impurities have been developed. In this study, the improved device was tested for its efficiency and energy efficiency, and corresponding results were obtained. This study focuses on optimizing the cleaning efficiency of cotton ginning by developing a device that reduces mechanical damage and improves fiber quality. The experimental device includes a continuous slotted mesh surface and a pile drum system, which significantly enhances impurity removal. The article further explores the mechanical phenomena occurring during the cleaning process, such as wire deformation and drum rotation speeds, through real-time analysis with electronic devices like tensometers and oscillographs. The results show that the device achieves a cleaning efficiency increase of 12-14%, contributing to higher fiber quality and economic benefits for cotton processing enterprises.

Keywords: cotton, fine impurities, aggregate, cleaning, pile drum, device, seed, improvement, opening drum.

Introduction. Currently, cotton ginning enterprises use the UXK complex unit to remove large and small impurities from raw materials. It is known that impurities are divided into small and large types, and during cleaning, various technological processes are carried out in the devices according to these types. Large impurities are cleaned in the zone of the saw and grid bar, and small impurities are cleaned in the zone of the pile drum and mesh surface. Cleaned raw cotton is sent for ginning.

Cotton raw materials may contain cotton leaves, husk residues, broken and broken seeds, and small mineral impurities. If the impurities in the cotton are not cleaned to the maximum during cleaning (usually the cleaning efficiency is 70-75%), the quality of the fiber produced after further processes may decrease [1]. Taking this into account, in the newly improved device for cleaning small impurities, small impurities from the content of cotton raw materials are prevented from being added to the air and passed to the next technological processes. The advantage of the newly proposed cleaning device is to increase efficiency and reduce mechanical impact on the raw material as a result of cleaning with a continuous mesh surface and belt piles.

The main working organs of the improved small impurity cleaning device are mesh surface with continuous slits [2] (the slits have no obstacles along the total area of the surface, the rings ensuring the strength of the wires are on the lower level of the mesh surface is located and does not interfere with the impurities falling on the ring) and consists of a drum with pegs mounted on a belt element (Fig. 1).

In the improved small impurity cleaning device, as a result of an increase of 12-14%, the improvement of fiber quality brings significant economic efficiency to the enterprise.

The device works as follows: From the supply rollers 1, through the drum 2, the cotton raw material meets the pile drums 3, which are installed on the strap base 5. Drums with piles carry the mass of raw cotton and bring it to the mesh surfaces 6, and the cotton is thoroughly crushed as a result of the influence of the piles and the drag over the mesh surface. As a result of cleaning, small impurities in the cotton raw material pass through the slits of the mesh surface.

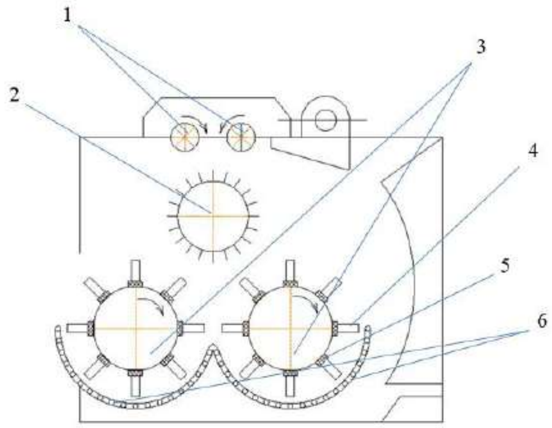

Figure 1. The technological scheme of the improved small impurities cleaning zone: 1-supply rollers, 2-opening drum, 3-pile drums, 4-piles, 5-belt base of piles, 6-continuous slotted mesh surface.

The main technological difference of the device from other cleaners is that the mesh surface is made of smooth steel wires, and because the wires form continuous slits, the useful area of the mesh surface is almost doubled (54.2%), resulting in a significant increase in cleaning efficiency. In addition, due to the increased smoothness of the surface, it is possible to work easily without jams at the given maximum productivity, and since the piles are installed on a strapped base, as the intensity of opening increases, the condition of mechanical damage decreases.

When the amount of defects and impurities in the fiber content of the cotton ginning enterprise is within the set accounting standards, it is carried out based on a certain cleaning plan for the processing of cotton raw materials. The choice of cotton cleaning plan depends on its initial contamination, selection, and industrial type, and cotton cleaning is carried out in the next process.

Currently, the main technological equipment for cotton processing is the 1XK type cotton cleaner, the 1XK pile cleaner, and the UXK cleaning unit. The use of such machines in the cotton ginning industry makes it possible to obtain cotton fibers of the required quality [3].

Therefore, in practice, in some selected types of cotton, machines are used that provide high cleaning efficiency and have good performance, because the separation of different types of cotton from the fiber is different due to the strong attachment of dirt to the fiber.

The speed of rotation of the drums of the equipment for cleaning raw materials from impurities, the mode of operation, and their constructions were used for the processing of industrial varieties of previously grown cotton.

In addition, the recommendations resulting from the research are based on previously grown cotton varieties and differ in some parameters from those of new cotton varieties, such as yield, ripening time, fiber length, and seed size. One of the main decisive factors in the technological process of cotton raw material cleaning is the cotton seed size. The size of the cotton seed is reduced in the newly selected varieties of raw material. For example, in the experiments on determining the size of cotton seeds of the selection variety "Porlok-1, 2", the methodology was carried out as follows: the sizes of 100 seeds were determined for testing. After measuring the test samples, the length and width of each seed were measured using a micrometer, then the width and length of the seed were divided into three groups, and the number of seeds in a certain group was determined [4].

From the information given in Table 1, it can be seen that the amount of seeds 0.0068-0.0072 m long is 14%, the amount of seeds 0.0075-0.0081 m long is 36%, 0, 0083-0.01 m long seeds amount was 50%. It should also be noted that the amount of seeds with a width of 0.0035-0.0040 m is 22%, the amount of seeds of 0.0041-0.0045 m is 55%, and the amount of seeds of 0.0050-0.0055 m is 23%.

The results of the experiment showed that the sizes of Porlok selection variety cotton seeds were 15-18% smaller than the sizes of previously grown cotton seeds [5]. This requires paying attention to the established technological parameters and procedures of cotton cleaning equipment.

First, small seeds are more susceptible to mechanical damage than relatively large seeds, and second, the size of the grooves of the cleaning surfaces (currently around 6 mm) should be reduced. For this, it is necessary to quickly replace the working parts of the cleaning equipment and adapt it to the working mode.

Table 1. The results of measuring the size of the seed.

Seed weight, g	Length, m	Seed amount, pcs	The width of the seeds in the cross section, m	Number of seeds, pcs
	0,0068-0,0072	15	0,0035-0,0040	25
10,12	0,0075-0,0081	37	0,0041-0,0045	49
	0,0083-0,010	48	0,0050-0,0055	26
	0,0068-0,0072	14	0,0035-0,0040	22
10,16	0,0075-0,0081	36	0,0041-0,0045	55
	0,0083-0,010	50	0,0050-0,0055	23
	0,0068-0,0072	37	0,0035-0,0040	36
10,18	0,0075-0,0081	23	0,0041-0,0045	38
	0,0083-0,010	40	0,0050-0,0055	24

It follows from this that during the processing of cotton raw materials with relatively small seeds, there are cases where the seeds are squeezed into the large slits or the raw material passes through the slits. When designing a new device, it is advisable to make the distance between the slots 5 mm or less.

To analyze the reason for the low cleaning efficiency of technological machines, the dependence of the total cleaning efficiency of the cleaner equal to the number of working bodies of the cleaning section was used, which has the character of geometric progression and is expressed by the following equation:

$$K_{\sum m} = K_1 \frac{1-q^m}{1-q}$$

Where, K_1 – cleaning efficiency of the first section, %;

q - the denominator of a geometric progression;

m – number of cleaning sections (working drums), pcs.

In general, the amount of working bodies in the cleaner is not very large. Also, the monotony of the process not only reduces the cleaning efficiency of each subsequent section but also leads to the deterioration of its appearance and the appearance of defects.

Thus, it is not advisable to use one type of working body in the cleaner. This idea is also based on experiences in the textile industry, where different working bodies are used in each pass of fiber processing (opening, beating, and carding), the same machines are never installed in a row [6].

In the cotton cleaning industry, the use of various working bodies for cleaning cotton, including the installation of pile drums on a belt base (rubber, metal, etc.) in the 1XK cleaners used for cleaning cotton from small impurities, has been studied in various researches, and all the proposed the working bodies work under the impact of the cleaning cotton. In addition, to increase the useful area of the cleaning surface, one of the main working bodies in the cleaning zone from small impurities was recommended to be installed with continuous slits, and continuous slits were developed using 4 mm steel wires.

Also, it is desirable to consider the possibility of using an adaptive technological system, which is effectively used in various fields of mechanical engineering, and cleaning it in an adaptive system depending on the selection and industrial grade, class, and initial contamination of cotton [7-8].

STUDY OF MECHANICAL PHENOMENA OCCURRING IN THE DEVICE IN SMALL TIME INTERVALS

The purpose of the research is to determine the change in the state of the slits as a result of the vibration of the wire element forming the mesh surface during the technological process of cotton cleaning in the cotton cleaner.

To achieve the above-mentioned goal, the following tasks were defined:

- study of the state of vibration and bending of the mesh surface under the influence of raw materials;
- determination of loads and technological resistances falling on wires;

- study of changes in the speed of rotations of a drum with a pile.

It is necessary to study the mentioned factors to increase the productivity and cleaning efficiency of the technological process, besides, the main goal is to improve the quality indicators of the cotton coming out of the process.

Practical studies were carried out to optimize the values and limits of geometric and kinematic parameters.

An experimental device was developed to study the dynamic and force-based loading of the improved continuous slotted mesh surface of the cleaner. In this experiment, the effect of different values of the main geometric and kinematic parameters on the changes in the loads on the wires was studied.

By adjusting the rotation frequency of the supply rollers, it is possible to change the amount of cotton transferred to the cleaning zone at one time. These tests were carried out to establish the regularity of loading of wire surfaces and to determine the nature of bending and vibration of wires from the volume of cotton raw material transfer during a unit time.

The experimental parameters mentioned above are usually determined using the tensiometry method [9-10].

Figure 2 shows the surface of wires installed to clean cotton from small impurities, and the position of strain gauges attached to the center and edges of the wire surfaces. As can be seen from this case, this situation of attaching the strain gauges to the wires forming the slits of the mesh surface is sufficient to determine the condition of the entire surface.

Figure 2. A view of the device with strain gauges installed on the wires

Tensobeam calibration was carried out in 5 steps of loading and unloading at intervals of 1, 2, 3, 4, and 5 mm, and each step was recorded using a recording device. The taring coefficient was obtained according to the taring indicators. Then, the values obtained from the experiment are multiplied by the calibration coefficient and thus the actual values of the loading forces appear. The obtained values are processed on a computer using the method of mathematical statistics [11].

Experimental work for raw materials of the first grade from the harvest of 2023 - C-6524 selection grade, moisture 7.8, impurity 12.1%, and Namangan-77 selection grade, moisture 7.5%, impurity 10.9% was conducted. Before testing, the following was done:

- check the reliability of contact with the surface of the active element installed on the cleaning surface of the stand device;
- checking the readiness of tensometric equipment;
- setting the distance between the piles and the grid surface;
- control of the supplier's timely delivery of raw materials.

After each test, all tensor resistors were recalibrated.

To study the mechanical stress caused by the bending of a metal rod with the help of electronic devices. A mathematical analysis of the phenomenon of bending deformation occurring in a metal rod located between two supports was performed (Fig. 3.9). As a basis, a continuous mesh surface is used, which is an improved option for cleaning cotton from small impurities.

Transverse compressive modulus describes the elastic property of the body. When stretching or compressing forces are applied to the ends of the stern, a tension equal to this force occurs in the cross-section corresponding to its arbitrary section. If we say that the mast is homogeneous, then it can be said that the tension is evenly distributed along the cross-section of the mast. If we designate the stress as the quantity that describes the stress acting on the unit surface of the cross-section by σ:

Using the received theoretical data, we perform calibration work for the stern with a tension element attached [12].

Tenso element is a semiconductor electronic element that changes its electrical conductivity under the influence of small deformations and is useful in high-precision measurement of deformation magnitudes.

In addition, in the study, a device designed to determine Young's modulus based on bending deformation, a sample of metal rods used to form a mesh surface for cleaning cotton from small impurities (on the condition that the length and cross-section are the same as the part in the device), the strain gauge. (Half-bridge (1000Ω-50kg), LC1-HX711 (1000Ω-1kg)), AVO meter. (To measure the potential difference in microvolt value) and resistance magazine (10Ω, 100Ω, 1000Ω) were used. Description of the experiment tracking device. Device platform *S* - base, M_1, M_2 - columns, Q_1, Q_2 - supports, *P* - platform for load placement (dynamometer impact point), *S* - tested metal rod.

There are two different methods of bending deformation:

1. By fixing one end of the rod and applying a deforming force *F* to the other end.
2. Rod is placed on supports and a deforming force is applied to its center. We use the second method in our measurement research. The reason is that our metal rods, which make up the mesh surface, are always located between two supports.

The calibration method is as follows: each of the lengths L, width a and thickness b of the tested boom is measured at least 3 times using a caliper and the average value of the measurements is recorded in the table (the distance between the supports is considered as the length of the boom); Rod is installed on supports Q_1, Q_2 and the value of the initial position of its thickness in the middle line is recorded by reading *V* from the vertical scale (graduated in millimeters); An artificial deformation of a known size is created by placing a load *P* on the beam or using a dynamometer and screws, and the value of the next situation of the middle line of the rod thickness is recorded by reading from the scale; The value of the bending beam is found from the difference of the values obtained from the scale describing the situations of the middle line of the stern and is written in the table.

The measurements indicated in points 1-4 were carried out on three different rods under the influence of 1 kg, 2 kg, and 5 kg mass loads or artificial deformation magnitudes created using an electronic dynamometer, and the obtained results were recorded in the table.

Using the obtained results,

$$F = (E4ab^3\lambda)/L^3$$

is calculated by the formula F and it is also written in the table. Here, E is Young's modulus, F is the deformation force, l is the length of the rod, and b is its width and thickness, respectively, and is the bending constant.

STUDY OF THE DEFORMATION OCCURRING ON THE MESH SURFACE OF THE DEVICE

In the working state of the improved device for cleaning cotton from small impurities, the stresses generated in the tensor element were studied based on the magnitudes of the deformations that occurred on the mesh surface for the no-load and loaded states.

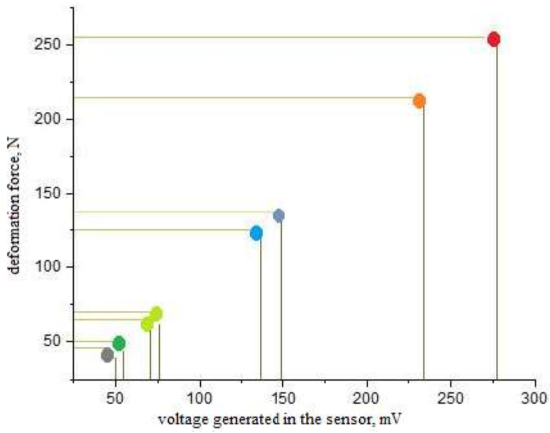

Figure 3. Calibration results (experimental work performed 8 times using reference weights and electronic dynamometer)

Studying the deformation formed in the metal rods of the mesh surface, considering that the sensor is under the device, the deformation is calculated as the bending deformation. The graph in Figure 3 is derived from its Volt-Newton description.

To increase the accuracy of the values obtained in the results of the experiment, a Whitson bridge was prepared using a set of resistances, and the value of the voltage in millivolts from the difference of the resistances was recorded using an oscillograph in real-time. LATR laboratory autotransformer, bridge of rectifier diodes, and filtering LC circuits were used as a current source in the experiment. First, it is necessary to start the oscillograph and make sure that it is well connected to the computer using the software.

Then, based on the number of sensors placed on the mesh surface of the device and the number of channels on the oscillograph, the data is exported to the computer. To increase the accuracy of the observation when obtaining the results, more than 5 times of data are obtained from the same studied point. In this case, the average value of the results is performed in graphics processing programs.

It was determined that the mechanical stress on the mesh surface of the device working in the salt state is 0.00002656485% compared to the strength limit of the metal rod.

A signal output in the range of -±600mV was achieved using a set of resistors and a balanced supply (Figure 4).

When creating an improved scheme of the working bodies of the unit for cleaning cotton from small impurities, information was collected to determine the level of continuous operation and durability of the parts of the device by obtaining the magnitudes of deformation in different parts of the mesh surface. For this, together with the amount of deformation, it is possible to determine the value of the vibrations occurring in the device. Using an induction sensor that induces an electric signal through the projection of the progress of the vibration movement, a set of data was obtained that determined the vibration frequency and amplitude values.

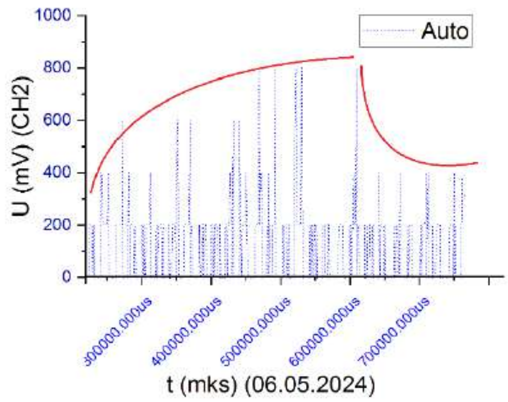

FIGURE 4. Deformation magnitudes in different parts of the mesh surface

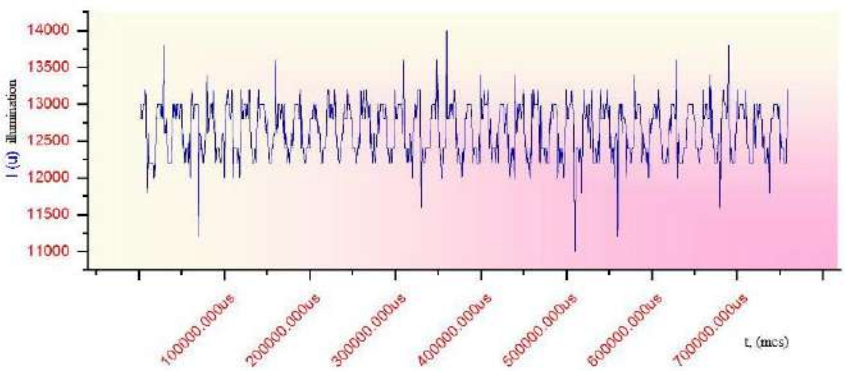

FIGURE 5. Small impurity precipitation analysis

To obtain the graphic analysis presented in Figure 5, a large metal piece was placed under the mesh surface in the form of a groove, and through it, small impurities falling from a surface area of 1 cm^2 were lowered. As a result, it became possible to analyze the efficiency of the device in real-time by analyzing the voltage change depending on whether the object passing through the photoresistor blocks the light or not.

Conclusion. In short, as a result of the use of electronic devices such as photoresistors, tensor resistors, Whitson bridges, amplifiers, and oscillographs, it became possible to analyze the processes occurring in a short time. The accuracy of the obtained results is high, and they depend on the sizes of the used active electronic elements. The strength of the metal rods of the mesh surface, which was used to improve the device for cleaning cotton from small impurities, is durable even when the device is operated at maximum voltage, which does not adversely affect the operation of the device in a stable mode for a long time. The fact that the side wall of the rod is in the form of a cylinder causes it to reduce the resistance forces due to the permeability of the airflow compared to other forms. This leads to an increase in the useful work coefficient.

In the course of research, an experimental design of an improved cleaning device was developed and the principle of operation was established. The physico-mechanical properties of the currently produced cotton were determined depending on the selective varieties, and it was determined through research that the amount of seeds varies from 14% to 55% depending on the length of the seed.

Based on the experiments, the mechanical phenomena occurring in the device at intervals of time were determined. The deformation of the wires that make up the mesh surface of the experimental device when the loads are applied was studied, and a system was developed based on electronic devices to determine it in a short period.

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