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Methods for Reducing Seed Damage in the Technological Process of Cotton Processing

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Abstract

The article describes the transfer of cotton to the next technological process while preserving its natural properties during the initial processing process. The analysis of methods of reducing impact forces when removing displaced stones with cotton is analyzed. For this, it is based on the primary processing of cotton.

Keywords

Cotton, Pneumatic Transport, Separator, Fan, Pipe, Cyclone, Stone Holder, Auger, Solenoid, Vertical Pipe, Blade, Drum, Cleaner, Mesh Surface, Shaft, Vacuum Valve, Discharge-Separator, Volumetric

1. Introduction

Primary cotton processing consists of a number of technological processes that form a unique technological chain. The performance and quality of each piece of equipment in this chain are closely related to the performance and quality of previous machines. Considering this situation, it can be concluded that the impact of each piece of equipment in the technological chain on the quality of cotton products is significant.

Seed damage is important in the technological process of ginning plants. This is due to the fact that damage to the seeds leads to various defects that affect the quality of the fiber [1] [2] [3].

2. Methodology

In a study conducted by A. Burkhanov, in the technological process of primary processing of cotton on a linter machine, cotton samples were taken at 8 points and the damage to the seeds was checked.

The greatest damage to the seeds occurred by 2.5% - 3% at the fifth and eighth points of the gin linter machine. At the five points before the gin, the seed damage was 1.5%, then from 1.0% to 1.2% at the first and third points, that is, the cotton was in the air supply to the pipes (**Figure 1**).

The occurrence of damage to the seeds in the technological process of processing such cotton affects the quality of the fiber obtained after the gin machine. This prevents high-end fiber from being sold, which in turn lowers the economic performance of the ginneries (**Figure 2**).

On the territory of ginneries and workshops, various types of transport are used to transport raw materials and finished products from place to place during the primary processing of cotton. In this case, the mode of transport used to transport cotton from ginneries and warehouses to workshops and from one workshop to another can be mechanical or air. The pneumatic device has a number of advantages over mechanical transport.

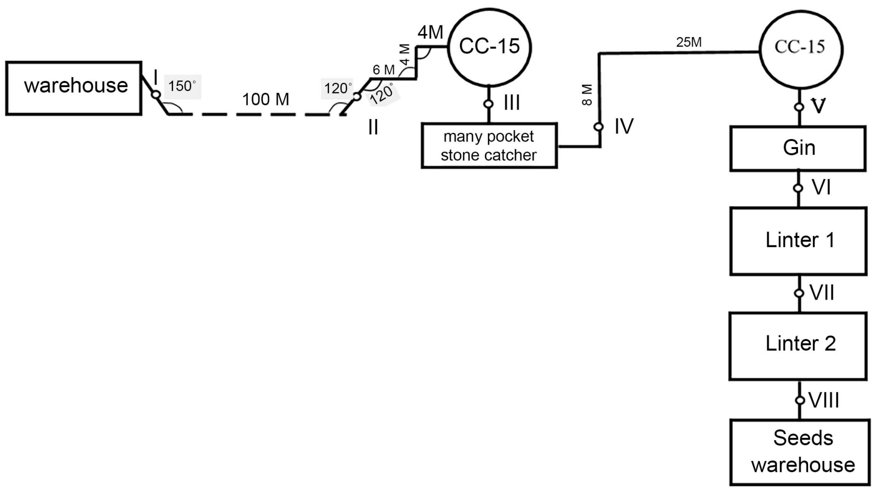

Figure 1. Scheme of raw cotton processing in ginneries. I-VIII sample points.

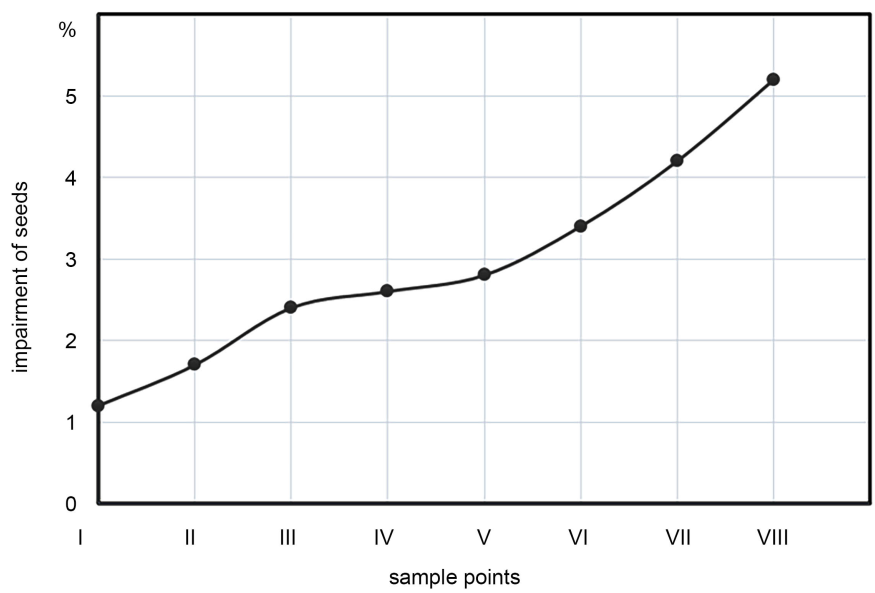

Figure 2. Seed damage graph in the technological process of cotton processing.

With mechanical belts, it is much more difficult to transport cotton from the coil to the workshop. The main reasons for the widespread use of a pneumatic conveying device are its reliable operation, minimal material loss during cotton transportation, compactness of the device, the ability to use in places inconvenient and cramped for mechanical transportation, ease of maintenance and repair. In addition, the air transport of the cotton contributes to the shrinkage of the cotton and the loss of a certain amount of moisture. Also, when separating cotton from air, primary cleaning of cotton from small impurities and dust is provided. It is also widely used in the cotton ginning industry due to the advantages of the air dispensing device [4].

Pneumatic devices also differ from other devices in ease of use, ease of use, and the ability to automate transport processes.

The disadvantages of the device for transporting cotton by air are damage to the seeds in the transported cotton and high energy consumption. Currently, pneumatic conveying devices are also used to mechanize the transport, loading and unloading of seeds and production seeds.

In ginneries, a suction-type air transport device is used primarily to transport cotton (**Figure 3**).

It consists of the following main working elements: cotton is fed into the pipe using a mechanical conveyor (1), which is transported by air through the working pipe (2), cotton is separated from heavy mixtures on a stone trap (3) and fed into the separator (4) through the suction air duct (5) a centrifugal fan (6) which creates pressure in the pipes, in the exhaust duct (7). Contaminated air enters the cyclone (8) and dust chamber (9). They, in turn, provide air purification from dust before it is released into the atmosphere [5] [6] [7] [8].

The principle of operation of the air-carrying device is that under the action of the flow formed by the pressure drop, atmospheric air is sucked into the pipe after the material transported by it. Inside the tube, the cotton moves with the air and reaches the separator. The separator separates the material from the carrier air and transfers it to the processing equipment.

The advantage of the intake air supply device is that the working pipe system can be easily expanded without any difficulty, depending on the location of the nozzles, and its length can be increased by connecting additional pipes to the primary pipes. The performance of the duct depends on the production capacity of the gin (*i.e.* the amount of raw cotton processed per hour). For a ginnery with one battery, this is 10 tons per hour [9]-[16].

The growth in the volume of cotton production poses the task of increasing production capacity, increasing the productivity of equipment, and improving the quality of products for the cotton processing industry. The fulfillment of these tasks largely depends on the operation of the air duct installed on the site. This is due to the fact that it is directly involved in the continuous technological process of the ginnery and is an important part of determining its initial and operating speed.

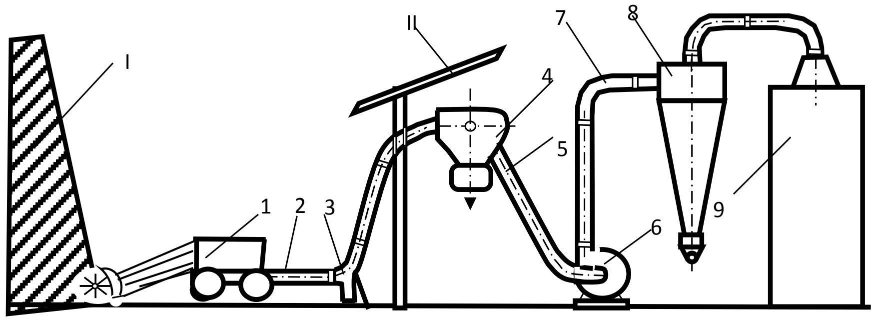

Figure 3. Air transport device in ginneries. 1-mechanical cotton transfer equipment for pipe; 2-working tube; 3-stone catcher; 4-separator; 5-suction air duct; 6-fan; 7-exhaust air duct; 8-cyclone; 9-dust collector; (I-riot, II-production workshop).

The increase in cotton production has led to the expansion of the territory of enterprises and an increase in the length of the network of pneumatic transport equipment on it, in some cases up to 200 m or more. Since the radius of movement of one pneumatic conveying device, serviced by a VTs-12M fan, does not exceed 100 - 110 meters, the transportation of cotton over very long distances is usually carried out by serial connection of transport devices using additional moving air [17] [18] [19].

In the technological process of a cotton ginning factory, a suction-type pneumatic conveyor is more common. When transported at high speeds, the speed of raw cotton inside the pipe reaches 20 - 25 m/s, at which it hits the pipe walls, rubs, hits the pipe bends (shells), the inner walls of the stone catcher and separator (4, 5) negatively affects quality indicators of cotton. However, one of the conditions for maintaining the quality of cotton, that is, preventing damage to cotton seeds and the appearance of technological defects in the fiber, is the choice of the optimal mode of pneumatic transport.

When transporting cotton raw materials at high speeds during pneumatic transport, the shells of the pneumatic transport pipe hit the wall in front of the working chamber of the stone catcher with great force, which leads to damage to the fibers and seeds. The stone catcher is one of the main elements of the pneumatic conveying device.

Currently, an urgent task is to increase the efficiency of the technological process, productivity, maintain the quality of raw cotton by improving the design of the existing stone catcher equipment at ginning factories. A number of theoretical and practical works are being carried out in this direction.

During the process of picking cotton, drying it in the field, loading, transportation, preparation for storage and processing of cotton bales, heavy objects of different sizes fall into the cotton. Such objects fall into the working chamber of the machine, disrupting its operation, damaging the working organs, resulting in reduced productivity of the machine. However, heavy bodies are a major cause of fires in ginneries. Therefore, the issue of separating cotton from heavy bodies is important. Nowadays, the need to create new, sufficiently efficient stone-holding devices in order to ensure the long-term operation of cotton processing machines has increased in recent years.

The stone catcher device is one of the main elements of the pneumatic transport device.

At present, the urgent task is to increase the efficiency of the technological process, productivity, maintaining the quality of raw cotton by improving the design of existing ginning equipment at ginneries. A number of theoretical and practical works are being carried out in this regard. In cotton ginning machines, the cleaning efficiency is reduced, and more cotton particles are added to the waste. Heavy contaminants can also cause fires as a result of hitting recycling machines on metal working bodies. Therefore, the fact that heavy mixtures fall into the working chambers of cotton processing machines has always been in the focus of scientists and experts in the field, and they have been looking for ways to keep heavy mixtures completely in the air-carrying device. Of these, T.D Mahametov, K.M Kabuljanov, M.T Khasanov and others have conducted research on these problems [20].

The above stone (**Figure 4**) mainly consists of the inlet pipe, separation chamber, pocket, outlet pipe.

The method of operation of this stone is as follows: in an air-carrying device, the cotton and its heavy mixtures transported by the suction air enter the separation chamber through the inlet pipe and hit the walls of the separation chamber with a slight decrease in speed. As a result, heavy compounds from the cotton content fall into the bottom pocket.

A vertical screening device has been developed to separate heavy mixtures from cotton. This device consists of an inlet pipe, a working chamber, a pocket, a valve, an outlet pipe (**Figure 5**).

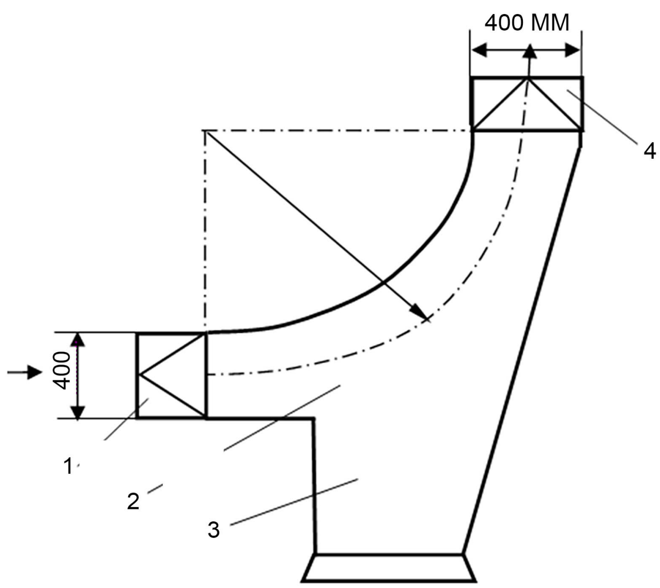

Figure 4. Radial stone catcher. 1-inlet pipe, 2-separation chamber, 3-pocket, 4-outlet pipe.

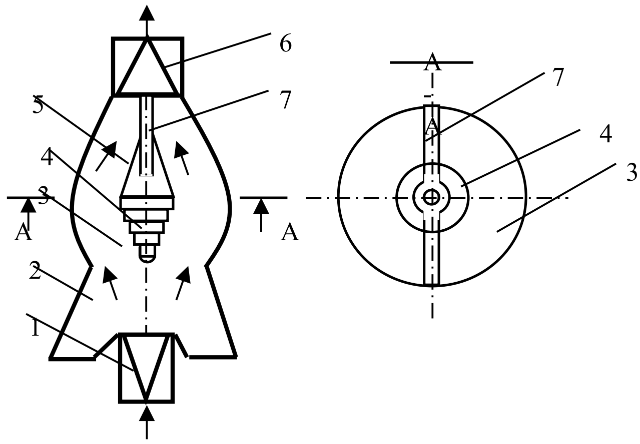

Figure 5. Vertical stone chatcher. 1-inlet pipe; 2-pockets; 3-separation chamber; 4-return step wall; 5-Router; 6-outlet pipe; 7-plate.

The trap works in the following order: When this device is operating, the cotton enters the separation chamber (3) through the inlet pipe (1) along with the air flow and hits the stepped surface of the return wall (4) through its inertia. Here the cotton is crushed and the heavy impurities in it fall into the bottom pocket (2). the cotton separated from the heavy mixtures passes through the return surface by means of a stream of air, moves along the surface of the guide (5), which is fastened with plates (7) from the separation chamber, and exits through the outlet pipe (6).

However, the main disadvantages of the design of the stone are that they do not process the cotton in the working chamber, the efficiency of holding heavy mixtures is low, a certain amount of cotton falls into the pockets during its operation and the seeds are damaged.

To overcome the existing problems in stone trapping devices, a new and improved design of the stone trapping devices was developed (**Figure 6**, **Figure 7**).

Cotton raw material, transported on a conveyor device by pneumatic transport, enters the working chamber (2) through the inlet pipe (1) by air flow. A winged drum (3) with an elastic coating, freely mounted on a stone, rotates due to its own inertia with the help of an air stream, compressing the raw cotton into balls. At the same time, the elastic coating of the drum also helps to reduce damage to the seeds. The crushed cotton raw material is hit by an air flow against the surface of the net (7), installed on an elastic base, small impurities (8) fall into the pocket, and the raw cotton is sent to the outlet pipe (10). The heavy mixtures, separated from the cotton pieces, slide off the segmented plate, which is moved by its own weight by means of a hinge mechanism, into the pocket (9) and outward.

3. Results

In the study, the impact force of the raw material from the central part of the entrance wall surface of the working chamber of the improved stoning device was determined by a sensor type FSR. A change in impact force was observed as a result of time change (**Figure 8**).

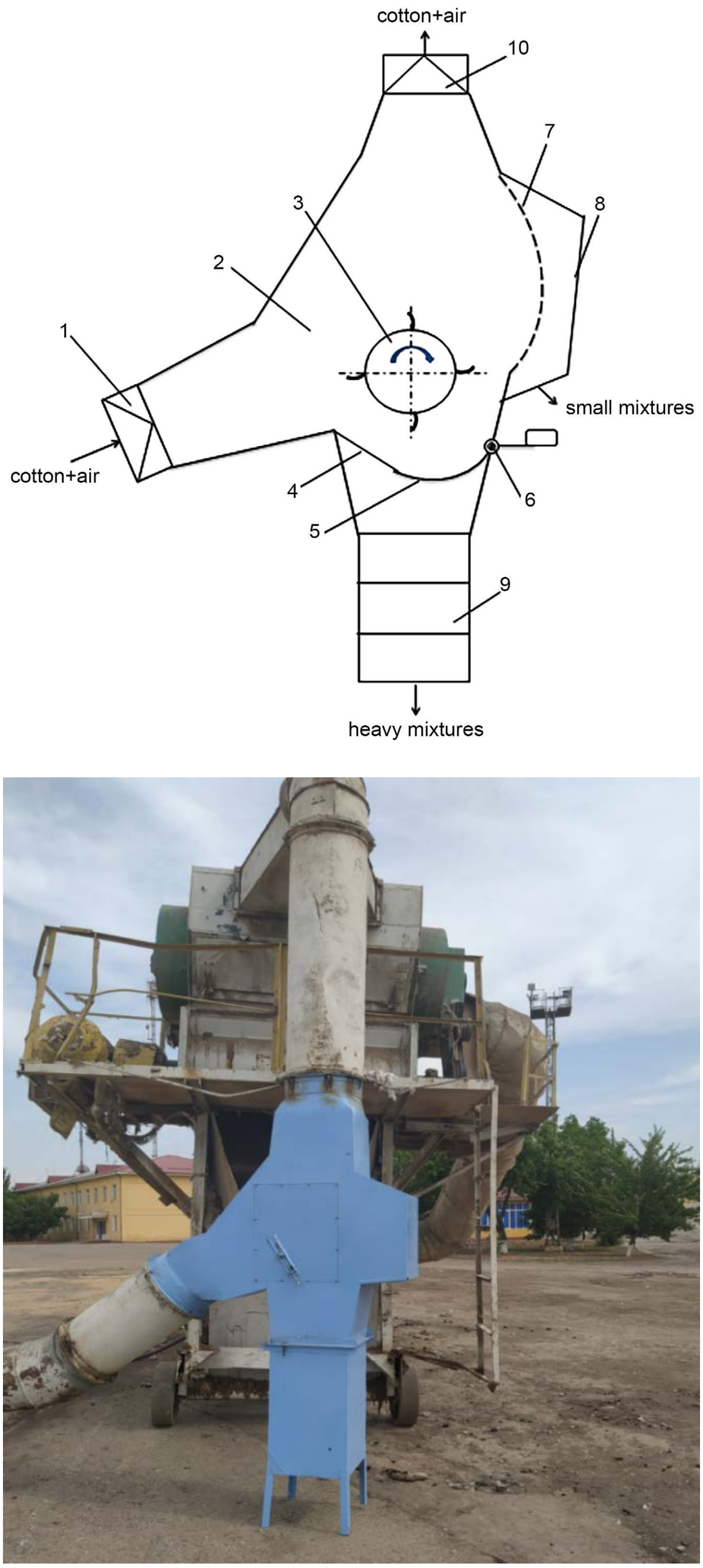

Figure 6. Improved stone trap device.

(a) (b)

Figure 7. Working bodies of the improved stone trap device. (a) Mesh surface; (b) elastic-coated, bladeed drum.

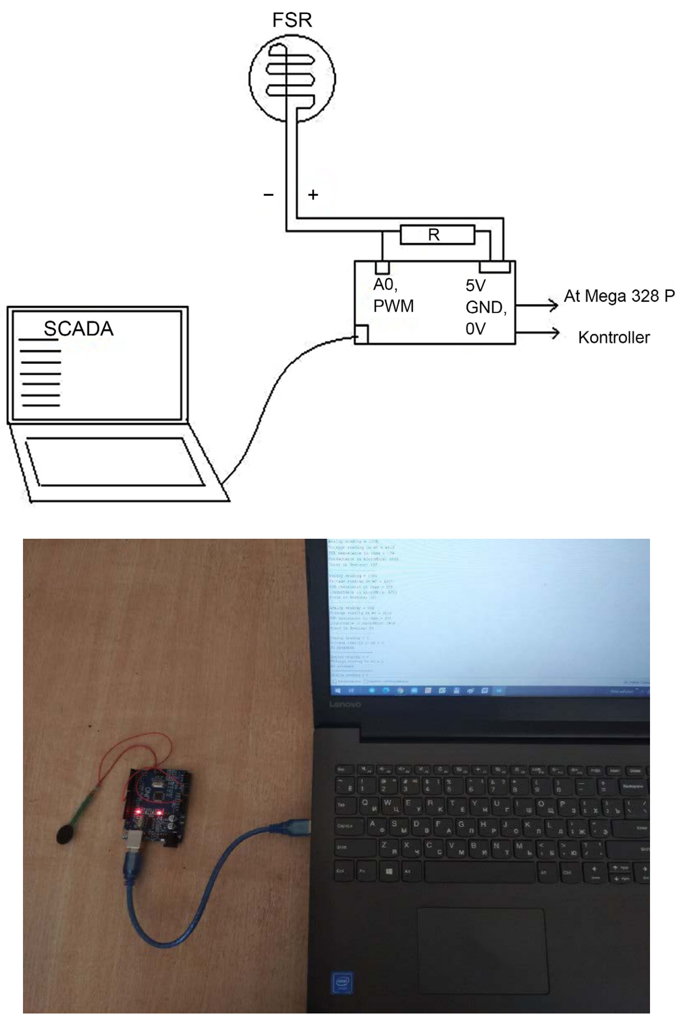

Figure 8. A computer-generated view of the FSR sensor that detects the force of an impact.

Time (second)	Strength (Newton)
0.1	1.09
0.6	1.04
1.1	1.05
1.6	1.06
2.1	1.51
2.6	1.21
3.1	1.19
3.6	1.23

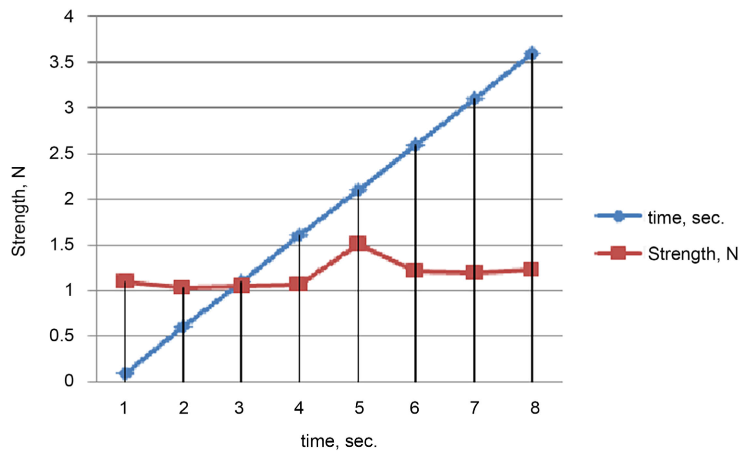

Figure 9. Results of experiments on the determination of the impact force in an improved stone catcher device.

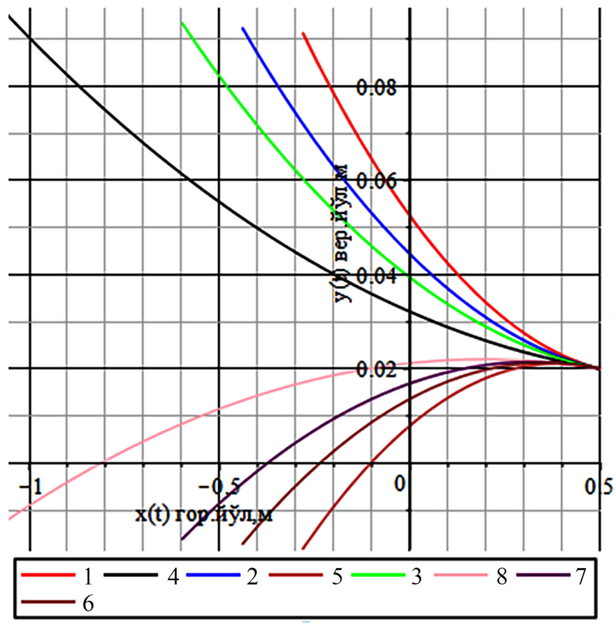

Figure 10. Laws after impact movement of cotton and heavy mixtures entering the improved stone trapping chamber. On the graphs, the coefficient of high-speed return of the receiving and softening mesh of the curvilinear plate of the impact force is equal to n = 0.5; 0.6; 0.7; 1; Graphs 1 - 4 are for the cotton portion and graphs 5 - 8 are for heavy mixes.

When the impact force per unit time unit of the advanced crushing device was tested in the time range of 1 second to 20 seconds, a shock force of 2.775 N to 2.51 N was detected. It was found that the impact force from the central part of the entrance wall of the improved stamping working chamber per unit time was measured from 3908 N to 2775 N when measured in 1 second to 24 seconds. It can be seen that during the transfer of raw cotton to the production process, the impact force of the raw material was found to vary with time. The transfer of raw cotton from the gin to the production process is also a result of its impact on the initial quality indicators.

Cotton ginning plants have a great impact on the production process from the storage process to the production of high quality products. In the work carried out by the researchers, it was studied that the raw material is damaged by the force that occurs as a result of hitting the device that determines the impact force. 1.09 N, 1.04 N, 1.05 N when the impact force is detected in 1, 6, 11, 16, 21, 26, 31, 36 seconds using a FSR sensor to detect the impact of the working chamber on the wall of the working part in the process of determining the impact force in the advanced rocker. 1.06 N, 1.51 N, 1.21 N, 1.19 N, 1.23 N were found to strike with force (**Figure 9**, **Figure 10**). It can be seen that in the process of transporting the raw material, the impact force on the body in front of the inlet pipe changes with the change of time in the improved stone.

The seed damage on the stone trap was reduced from 3.6% to 3.1%, the amount of fine impurities was reduced from 3.6% to 3.3%, and heavy impurities in the cotton were removed. The amount of deposits increased from 60% - 70% to 85% - 90%.

4. Conclusions

In conclusion, in this article, the authors conduct a detailed analysis of the problem of determining the degree of damage to seeds in the technological process of cotton processing, focusing on the operation of a pneumatic transport device, which causes the greatest damage to seeds.

Focusing on the classification of the device for transporting cotton by air, the advantages and disadvantages of the pneumatic transport device and its main elements are shown.

In our next work, research will be carried out to reduce the risk of seed damage in the technological process of cotton processing.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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