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The Shortfalls of the Vacuum Valve Cotton Separator

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Abstract: Working principles of the separators used in cotton processing enterprises have been studied in the article. The parameters of the separator which negatively impact on the quality indicators of cotton have been analyzed. On the basis of studied parameters, a new construction of the separator was suggested which has inclined mesh surface and separates the air from cotton. The movements of raw cotton in an inclined surface are considered. The differential equation of motion is compiled and the necessary results obtained.

Keywords: Cotton Separator, Pneumatic Transport, Vacuum Valve, Mesh Surface, Scrubber, Working Camera, Cotton

1. Introduction

In present cotton cleaning plants pneumatic transport is widely being used for delivering the cotton to the manufacturing process and for carrying the separated cotton fiber, lint and fibrous waste materials. The reasons of the widespread usage of pneumatic transport in cotton-cleaning plants are the simplified constructions of details of pneumatic transport, easiness in separating out and installing, occupation of little place, preserving of particular natural qualities and preventing from destruction while carrying the good to places located in any difficult directions, cleaning of raw cotton, being carried, from different contaminants and not interfering with the movement of transport inside the enterprise. [1-2, 4-8].

The main element of the pneumatic transport is the separator. A separator is required to separate air from the raw cotton.

While using of pneumatic method of transporting the raw cotton moving at the high speed winds up around the propeller of ventilator, consequently it may be the cause for the damage to fibers and seeds. For this reason separator is installed before ventilator in pneumatic transports in order to separate the air from the raw cotton.

Therefore, there is the impact of cotton movement on force of gravity, mass inertia and ax fugal power of operating stream.

It's known that the separators have been installed either in movable or stationary way in cotton cleaning plants and they include two main parts: separation and release. In turn, these parts also divide into structural elements. For instance, separating part consist of mesh surface and scrubber but releasing part (vacuum valve) consists of cylindrical surface and blades of drum.

The vacuum valve, which is the main part of the separator, has a big importance in a proper functional operation.

The main function of the vacuum valve in the operation camera of separator is to bring out separated from air raw cotton on time.

2. Method

2.1. The Shortcomings of Vacuum Valve of Cotton Separator

As in many other spheres, the separator has also its own shortfalls.

Firstly, the sections of vacuum valve become filled with the cotton separated from air, while working. Due to the rotation of the vacuum valve the raw cotton situated in its sections falls down because of its weight and will be passed to the next machine situated in a technological process. However the cotton, that falls to the sections of vacuum valve, due to its weight, stays inside them for a long period of time, as a result of lower or higher rote of compression or rotation because of weight.

Secondly, particular amount of air mass in the vacuum valve comes in the working chamber in the working process of the separator.

The structure of vacuum valve is the cause of passing of amount of air mass to the working chamber. Because of the separator, as cotton becomes separated from air, it gets into the sections of the vacuum valve under influence of its own weight and fills it.

As a result of the rotating of propellers of the vacuum valve the raw cotton falls down, under influence of its own weight.

The section of the vacuum valve which is empty from raw cotton, becomes filled with air and as a result of its rotating particular amount of air is being absorbed into the working chamber. This absorbed amount of air brings to removal of excess air in the separator.

Besides, while passing from entrance to working chamber raw cotton's, (which is falling under influence of its weigh into vacuum valve) upsurge to the mesh and after collision with this surface it becomes the reason for cotton's impairment. Apart from that the absorption of air into working chamber depends on the speed to frequency rotation and impermeability of the vacuum valve.

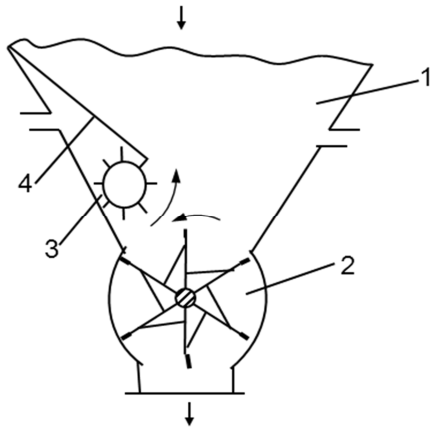
Thirdly, during also process of falling of raw cotton into vacuum valve its propellers' endings and the entrance edge of the cylinder's wall (surface) meet with each other, the cotton flinders situated among them become compressed and the seeds and fiber of the raw cotton turn damaged.

As a result, the next treating procedure leads to decrease in efficiency and to appearance of defects in seeds and fiber.

2.2. In Cotton Processing Enterprises Affecting Parameters to the Quality of Cotton Were Analyzed

In order to get rid of the above mentioned imperfections some variants of separators are suggested [3]. The separator with the roller vacuum valve suggested by R. Muradov consists of separating chamber 1 and vacuum valve 2. In order to separate cotton which is entrapped to the propellers of the vacuum valve there is also propeller roller 3 which is mounted to the upper part of the vacuum valve closer to the side walls of separating and parallel chambers. In order to prevent the collision of cotton, falling from above, with the propeller roller the barrier 4 is set.

As a result of rotation of rubber tips which are attached to vacuum valve and propeller roller into different directions they brush each other.



1-distributing chamber; 2-vacuum valve; 3-propeller roller; 4-barrier.

Figure 1. *Roller vacuum valve.*

Additionally, propellers of rotating rollers are located in an inclined position in relation to its axis. Vacuum valve operates in the fallowing way the raw cotton is separated from air after transporting it from storage locations with the help of pneumatic transport. By absorbing the air through the mesh of separator, cotton passes from separating chamber to vacuum valve. The cotton, which is hooked with the help of rotating roller, is separated from vacuum valve propellers' endings. The main part of cotton is situated between propellers of vacuum valve drum. But the other part stays in the propellers. As a result, in the process of handling the clogging in the separator between the vacuum valve and the walls of the drum is prevented. And this leads to the fact that the quality of cotton is not changing. The proposed roller vacuum valve completely prevents cotton clogging.

R. Muradov and O. Sarimsakov suggested vacuum valve separator with roller in its propeller. It consists of the following main elements: the separating chamber of the separator 1, propellers of vacuum valve 2, a rotating roller 3, the walls of the vacuum valve 4, exit tube 5 and plate installed in an inclined way 6.

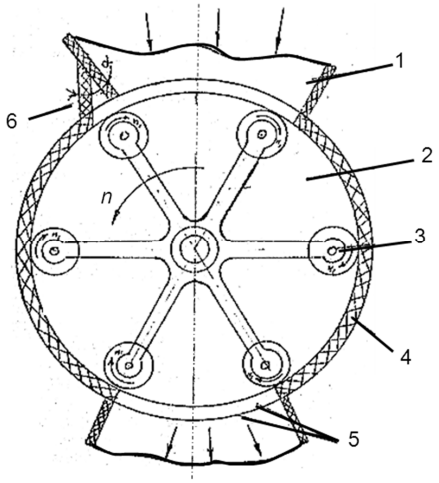


Figure 2. *Vacuum valve with roller installed to its propeller.*

1-separating chamber; 2-propellers of vacuum valve; 3-rotating roller; 4-wall of the vacuum valve; 5-exit tube; 6-plate installed in an inclined way.

The vacuum valve to which rotating roller propellers installed works in the following way: Cotton, separated from the air, falls with its weight to the areas between propellers of vacuum valve. One part of cotton may also get hooked to the rotating roller. The hooked cotton in the roller's surface is separated by the plate. When cotton passes from propellers of vacuum valve to exit tube, it can be released because of its own weight. The priority of the vacuum valve is in its best performance for a long time and absorption of less outside air and maintaining good quality of cotton.

Suggested by R. Muradov and O. Sarimsakov eccentric vacuum valve consists of (Figure 3) inlet pipe 1; shaft 2 which is set to cylindrical drum 3, propellers which are set to it in order to perform radial movement 4 and the outlet pipe 6. Propellers' elastic endings brush the wall of vacuum valve 5. In addition, carved flange 7 is located at the two sides (or edges) of longitudinal vacuum valve in the way that it is eccentric towards cylindrical drum and pushers of propellers come into its carvings. Propellers are installed directly to these pushers. And this maintains the propellers' progressive subsequent feedback movement in relation to the surface of the drum, when drum rotates.

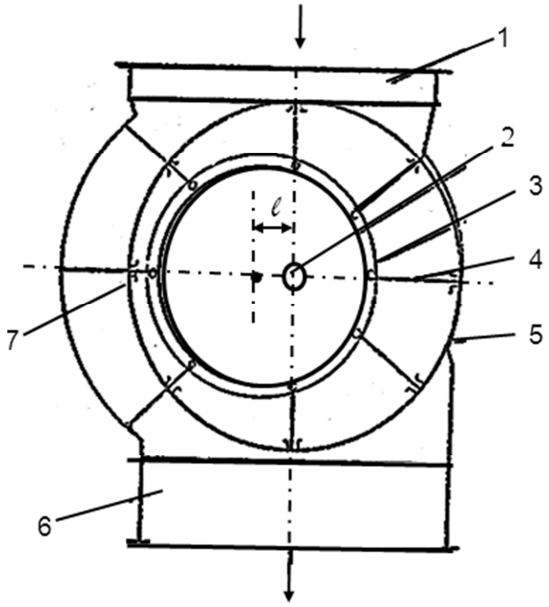


Figure 3. *Eccentric vacuum valve.*

1-inlet pipe; 2-shaft; 3-cylindrical drum; 4-propellers; 5-wall of vacuum valve; 6-outlet pipe; 7-carved flange.

The vacuum valve works in the following way:

The transported cotton falls into entrance pipe from separator chamber and takes up the empty space between the propellers of the drum. Due to drum rotation elastic ending of the propeller collides with the side wall of body and creates a closed section. During the rotation, cotton located in this section is transferred to the outlet pipe and by falling down under the influence of its own weight, it becomes released. Propellers gradually come into the drum when it rotates and by reaching the end of outlet pipe of cylindrical surface it influences inner surface of body's side-wall's right-half part. In this case the eccentric location of cylinder in relation to centers of the vacuum valve and carved flange helps.

This structure of vacuum valve completely excludes the absorption of air from outside because the propellers create a vacuum only in the separating chamber but in release area the propellers totally come into the flange. This provides the release of all the cotton from the vacuum valve. Moreover together with cotton, some amount of air is also discharged from separating chamber. As a result, the aerodynamic resistance of separator considerably reduces and the efficacy of the work increases.

R. Muradov, O. Sarimsaqov, H. Mamarasulov, S. Sultanov suggested vacuum valve with mesh drum (Figure 4). It consists of entrance pipe 1, separating chamber 2, mesh drum 7, blowing 8 and sucking parts 9.

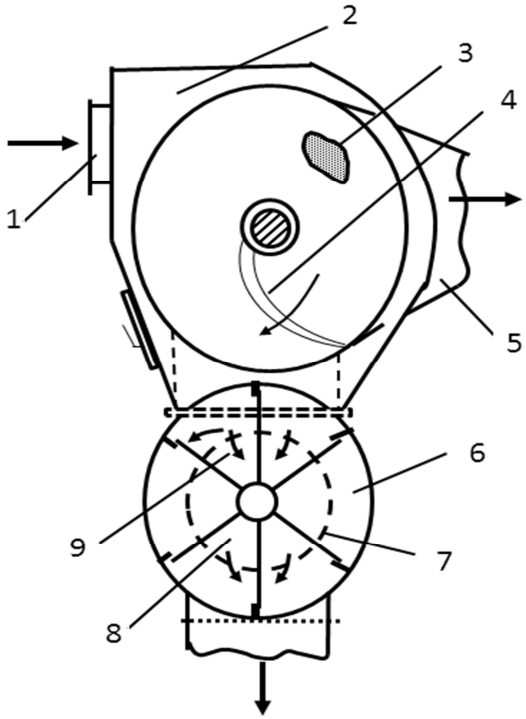


Figure 4. *Mesh drum vacuum valve.*

1-inlet pipe; 2- separate chamber; 3-mesh surface; 4- scraper; 5-air sucking pipe; 6- vacuum-valve; 7-mesh drum; 8- air blowing off part; 9- air sucking part.

When this cotton separator works, cotton falls to separating chamber from entrance pipe. In this chamber its speed slightly decreases and the cotton sticks to the mesh drum. Then, cotton is separated with the help of scrubber. The air with fine dust particles is sucked through mesh surface with the help of tube. Particular amount of air is sucked, through mesh drum, by situated in vacuum valve, mesh drum's sucking part. This separation helps to the falling down of cotton, which has been separated from the mainstream of air in the chamber. When vacuum valve rotates, air stream, coming out of blowing part of mesh drum provides the complete extraction of cotton out of spaces among propellers of vacuum valve. Moreover it helps to purification of cotton from fine contaminants. As a

result, the air transported by vacuum valve that prevents the cotton from falling down in separating chamber vanishes and the process of separating of cotton from air improves.

O. Ishmuratov suggested a separator with a rotary provider (Figure 5). It consists of entrance pipe 1, the suction device 2, frame 3, bladed rotor 4, cell 5, in tern, consists of the inlet pipe 6 [9-10].

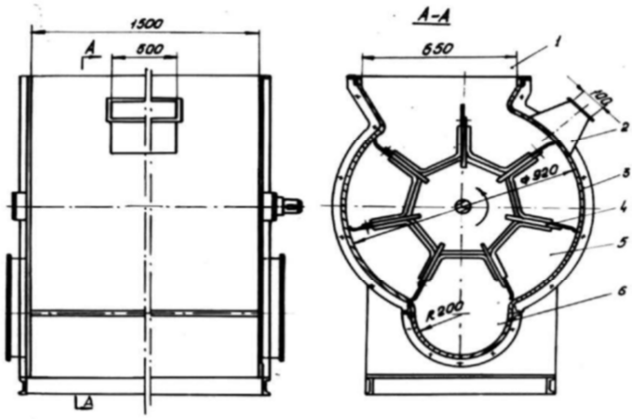


Figure 5. *Rotary provider separator.*

1-inlet pipe; 2-suction device; 3-block; 4-bladed rotor; 5-cell; 6-pipe.

2.3. New Suggested Improved Cotton Separator

Preventively the damage of seeding the vacuum valve the authors suggested a new version of separator (Figure 6).

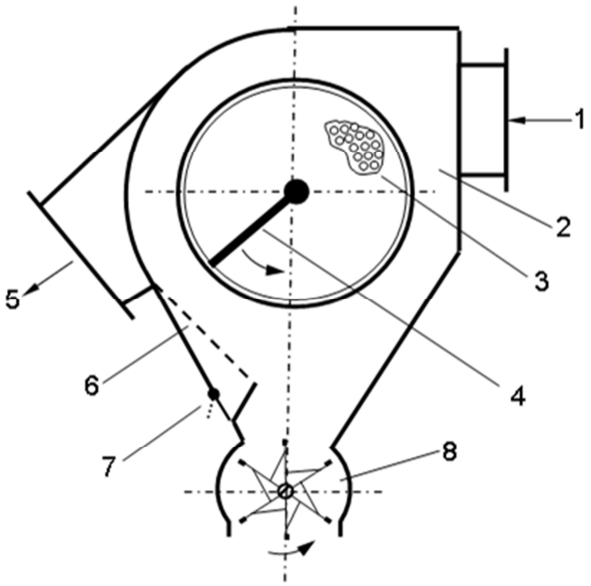


Figure 6. *Suggested new separator.*

1-inlet pipe; 2-working camera; 3-netting surface; 4-scraper; 5-air sucking pipe; 6-slope mesh surface; 7-cover; 8- vacuum valve.

A new separator (Figure 6) that is being suggested by us works in the following way.

When ventilator starts working, as a result of suction of air in air pipe, by moving with airstream the raw cotton enters the working chamber 2 through inlet pipe 1, than it sticks to the mesh surface 3, out of which the cotton is scrubbed by scrubber 4 and after that it is dropped to the working chamber.

The air, that has passed through mesh surface, is sucked from outlet system 5 to ventilator via the pipe. Raw cotton, that is dropped to the bottom of working chamber, collides with mesh surface of small chamber 6 and fine contaminants of it, by passing through mesh surface under influence of inertia, accumulate inside the small chamber. Fine contaminants accumulated in small chamber are removed with the help of opener 7, after being collected at particular period of time.

In order to prevent the damaging of free-of-fine contaminants raw cotton, it slides a long the mesh surface of small chamber 6 directly down the center of vacuum valve 8. Raw cotton that is taken out of working chamber is delivered to the next technological process in no time by keeping the quality indicators along the new separator's mesh surface.

2.4. The Theoretical Research of Movement of Raw Cotton Through the Mesh Surface of the New Separator

We will theoretically look through movement trajectory:

We will determine the forces that influence the piece of cotton, moving along the inclined plane.

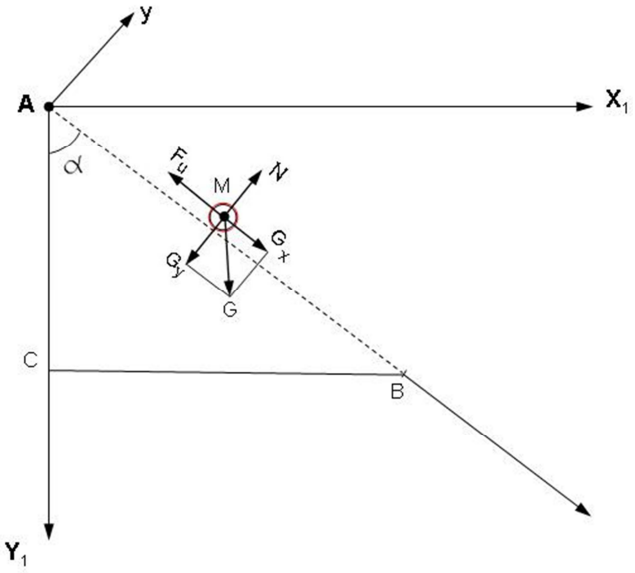


Figure 7. *The movement of cotton per inclined plane.*

$G = mg$ -gravity force

$$G_x = G\cos\alpha$$

$$G_y = G\sin\alpha$$

$$N = G_y = G\sin\alpha$$

N– pressure force of a slice of cotton and mesh;

$$F_{fr} = f * N = f * G\sin\alpha$$

F_{fr}– friction load of a slice of cotton between net and cotton;

Constructing of the mathematical model:

The differential equation of movement of cotton piece along the axes *OX* and *OY* is constructed according to D'Alembert principle.

$$m\ddot{x} = \sum F_x = G_x - F_{fr} \quad (1)$$

$$m\ddot{y} = \sum F_y = N - G_y = 0$$

$$N = G_y \quad (2)$$

$$y = 0$$

$$(1) \rightarrow m\ddot{x} = G\cos\alpha - fG\sin\alpha = mg(\cos\alpha - f\sin\alpha)$$

$$\ddot{x} = g(\cos\alpha - f\sin\alpha) \quad (3)$$

initial phases

$$t = 0;\ x(t) = 0;\ \dot{x}(0) = v_0; \quad (4)$$

Integrating the equations of differential movement and which are based on mathematical model. Finding out $x = x(t)$ by integrating (3) twice. Their initial (phases) are determined.

$$g(\cos\alpha - f\sin\alpha) = a = const \quad (5)$$

$$\ddot{x} = a\ \dot{x} = a * t + C_1 \quad (6)$$

$$x = a\frac{t^2}{2} + C_1 t + C_2 \quad (7)$$

$$C_1, C_2 = const;$$

They determine from initial phases.

$$t = 0;\ x(0) = a * 0 + C_1 * 0 + C_2 = 0$$

$$C_2 = 0$$

$$\dot{x}\ (0) = a * 0 + C_1 = v_0$$

$$C_1 = v_0 \quad (8)$$

$$(8) \rightarrow (7)$$

$$x(t) = a\frac{t^2}{2} + v_0 t$$

$$a = \cos\alpha - f\sin\alpha \quad (9)$$

Theoretical research of the movement of pieces of cotton between *B* and *C*:

Differential movement equation of piece of cotton along the axes *OX* and *OY* arrows is constructed according to the D'Alembert principle (Figure 8).

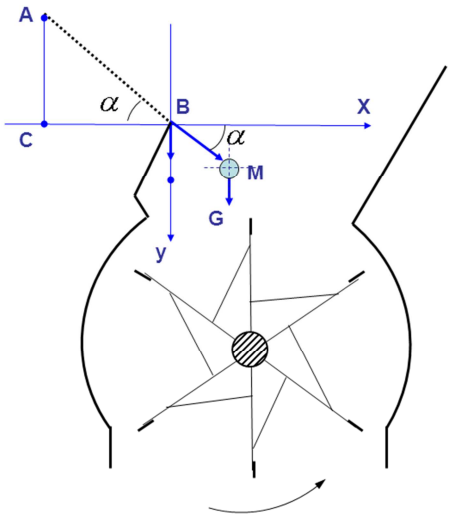


Figure 8. *Piece of cotton moves by influence of gravity force to the middle of the vacuum valve's propellers.*

$$m\ddot{x} = G_x - F_{fr}$$

$$m\ddot{y} = N - G_y - P = 0$$

$$N = G_y + P = G\sin\alpha + P$$

$$F_{fr} = f * N = f * (G\sin\alpha + P)$$

An optional position of piece of cotton between BC is M.

The forces influencing the piece of cotton *M:* force of gravity $G = mg$.

Under influence of this force piece of cotton moves on the plane *XBY*.

The differential movement equation of the piece of cotton *M* as the following:

Directions of the coordinate axes:

$$m\ddot{x} = 0$$

$$m\ddot{y} = mg \quad (10)$$

Initial operations (actions)

$$t = 0;\ x_B = 0;$$

$$\dot{x_B} = v_{B_x} = v_B * \cos\alpha$$

$$y_B = 0$$

$$\dot{y}_B = v_{B_y} = v_B * \sin\alpha \quad (11)$$

Finding out of law of motion by integrating (10) twice.

$$\ddot{x} = 0$$

$$\dot{x} = C_1$$

$$x = C_1 t + C_2 \quad (12)$$

$$\ddot{y} = g$$

$$\dot{y} = gt + C_3$$

$$y = g\frac{t^2}{2} + C_3 t + C_4 \quad (13)$$

$$t = 0;\ \dot{x}(0) = C_1 = v_B * \cos\alpha$$

$$x(0) = C_2 = 0$$

$$\dot{y}(0) = C_3 = v_B * \sin\alpha$$

$$y(0) = C_4 = 0$$

therefore,

$$x(t) = v_B * cos\alpha * t$$

$$\boldsymbol{v}_x(t) = v_B * \cos\alpha \quad (14)$$

$$y(t) = g\frac{t^2}{2} + v_B * \sin\alpha * t$$

$$v_y(t) = gt + v_B * \sin\alpha \quad (15)$$

The theoretical study of movement of piece of cotton under the influence of airstream along the inclined mesh surface and of separation of cotton's contaminant particles.

Determining the law of movement of piece of cotton along the inclined mesh surface.

3. Results and Discussion

The pieces of cotton, moving along the inclined mesh surface of the working chamber, in separator and the mathematical solutions for method and movement of them.

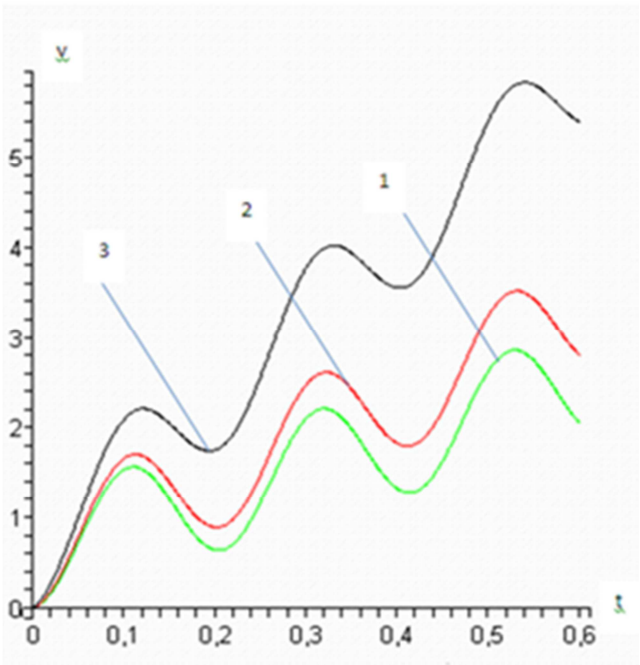


Figure 9. *The diagram of the principle of cotton piece movement per time. 1st, 2nd, 3rd graphics according to the π/10, π/7, π/3 diagrams of relevant parts of trajectory deviation represents the time for change.*

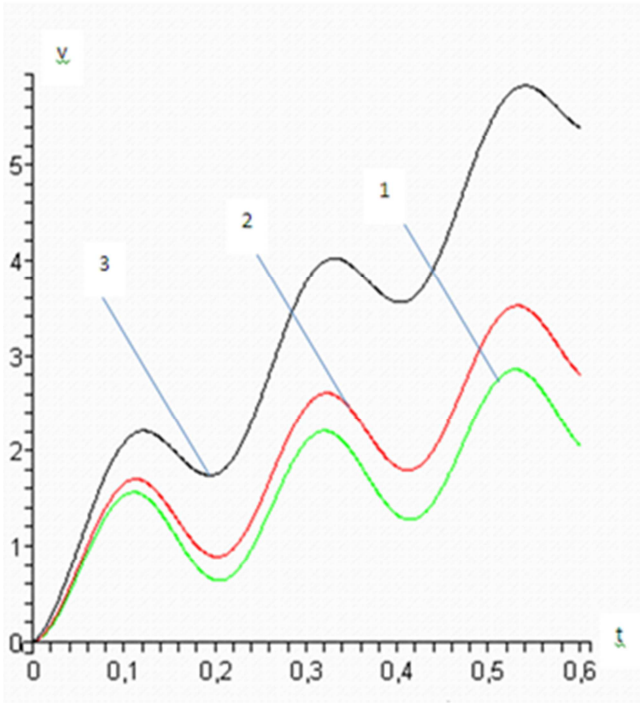


Figure 10. *The diagram of the speed of cotton piece movement per time. 1st, 2nd, 3rd graphics represent from the speed of change of the pieces of cotton to inclined mesh surface deviation angle according to π/10, π/7, π/3 diagrams.*

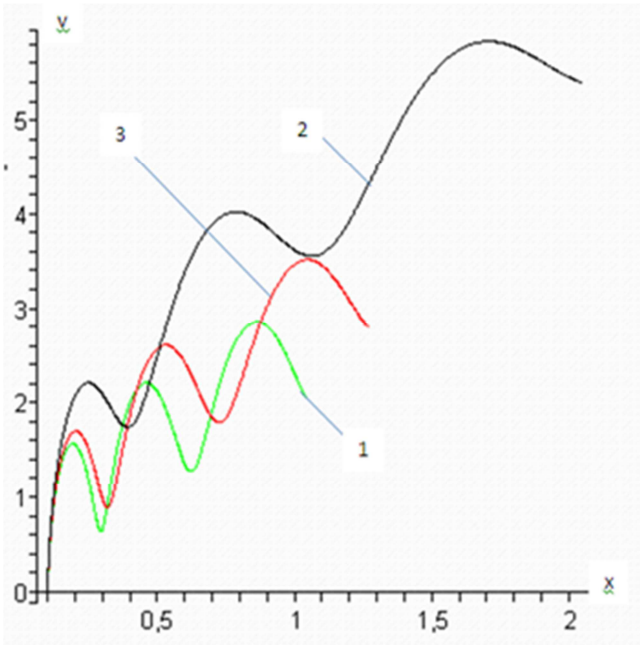


Figure 11. *The changing principle diagram of the speed of cotton piece with trajectory movement. 1st, 2nd, 3rd graphics represents the speed of the pieces of cotton and the alteration per inclined mesh surface.*

4. Conclusion

Parameters affecting to the quality of cotton were analyzed in cotton processing enterprises. The new improved construction of separator was suggested which saves the quality of cotton. The motion laws of the pieces of cotton located in the processing chamber per inclined mesh surface

were theoretically studied. Cotton separator of the working chamber AB mesh surface, studied the movement of the center of the valve, vacuum-valve theoretically defined. Pieces of cotton workers separator chamber located along the inclined surface mesh trajectories, related to the change in the slope of the speed charts. The angle of inclination to reduce the vibrations of the pieces of cotton, but with the increase in the value of the angles of inclination 18˚-27˚, fluctuations been significantly, due to separation small contamination from the cotton have a high.

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