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STUDYING OF PARAMETERS OF THE DIRECTING MECHANISM OF A MESH PLANE BY IS DIFFICULT-HARMONIOUS VIBRATING MOVEMENT

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Abstract

This article is intended to present a solution of raw cotton cleaning process using inertial method of waste separation. Cleaning method is based on use of dynamic methods for waste separation. There is made analysis of such method using theoretical and experimental research. Practical implementation of such method is described. Theoretical researches define conditions of cotton piece fly and meet from cleaning grill. Parameters of the directing mechanism of a mesh plane which is generating difficult harmonious movement of cleaning grill also have been calculated. Efficiency of clearing it is checked up practical on laboratory installation with designed by authors. Finally, conclusions on research results are made.

Keywords: Planar Motion, Cotton Cleaning, Inertial Method, Vibration, Teoretikal Vibration.

I. INTRODUCTION

Cotton is one of most used natural fibers used for clothes, bed linen, industry and quality of fiber is crucial for its implementation. Raw cotton from harvester contains a lot of waste (fig.1), which is cleaned using various methods. There are known that loses of raw cotton reaches about 15% of a fiber [1], [2] in contemporary textile enterprises. Thus because of reduction of dynamism of fibers, the fiber at spinning reduces quality of a yarn. These effects significantly decrease quality of manufactured cotton fibers and textile. During preparation process fibers should be separated from seeds and blossom debris. The crude cotton needs complex cleaning process, because just harvested crude cotton contain high percentage of organic and non-organic waste as it is shown in fig.1. Processes of cotton gathering, drying, sorting and transportation are performed at cotton cleaning factories.

Fig 1: Example of crude cotton

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Process of cotton cleaning is performed using several units of equipment. Cotton cleaning process is based on mechanical treatment of cotton and aerodynamic cleaning using air blow. Recently, for equipment improvement to reduce mechanical damage on cotton fiber and increase efficiency of cleaning process, there are performed a lot of research for cotton treatment improvement. Direction of technology improvement is pointed to decrease of steps of mechanical treatment and increase of one machine efficiency, thus reduces mechanical damage of cotton fibers and seeds, such treatment makes process more efficient. It gives chance to think that, variable influences of forces on cotton reduces occurrence of mechanical defects. Following this paradigm, technology modification is made by replacing two machines of mechanical cleaning by one vibrating crate, which perform planar movement, ensuring jump of cotton wisp from crate surface and bump from gravity and inertia forces beck to crate surface. Crate moves in horizontal and vertical planes thus ensuring proper movement of cotton wisp and ensuring efficient cotton cleaning process without mechanical smashing through metal grill.

Research [3] and [4] shows dependency of cotton cleaning efficiency and productivity to path of vibrating crate.

II. THE PROBLEM-FORMULATION OF A PROBLEM, A PERFORMANCE CONDITION

The essence of work consists in the offer of the vibrating equipment with lifting efficiency which clears the cotton holding its initial properties. With that end in sight it is necessary to design the mechanism of the equipment which gives difficult harmonious vibrating movement of a cotton. Research of problems considers to increase efficiency of storage in the greatest properties of initial degree of seeds of a cotton and a fiber. The mechanism of the equipment of clearing will give cotton vibration, difficult harmonious vibrating.

As stated in [4] for performance of a problem we should choose the form of the mechanism of the equipment, speed and other parameters of movement of a cotton.

III. THE TECHNIQUE OF THE DECISION OF A PROBLEM

For the problem decision we were using to use a theoretical method-analytical calculation of the feeder of vibrating movement.

IV. THE THEORETICAL DECISION

The action studying difficult harmonious vibrating fluctuations in movements of cotton on the equipment.

As stated in [3], [4], [10] analysis of action of difficult harmonious fluctuation on a cotton. Shown in Fig.2.

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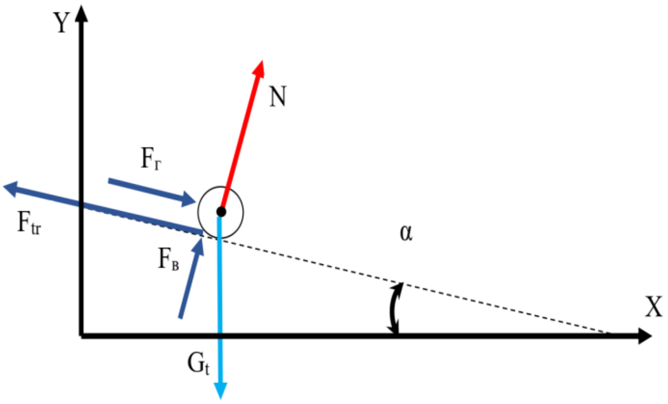

Fig 2: Dynamics of movement of a cotton in inclined oscillating grids. N –force of normal reaction; Fг – horizontal exciting force; Fв - vertical exciting force; α – a grid angle of slope; Fтр –force of a friction; Gт-gravity.

For the analysis difficult harmonious vibrating the equipment it is necessary to design parameters of mechanism, allowing a vibrating grid at once on two parties–vertically and horizontally. With that end in view we project a parameters of the mechanism which will spend a vibrating grid in two directions. For the analysis it is necessary to choose the optimum form and lengths of the form of the mechanism of parameters.

For this purpose we will investigate optimum parameters of the directing mechanism, shown in **Fig.3**.

The first variant if, $L_1 = L_2 = L_3$in this case the difference of phases has 90^0.

Horizontal vibrations will look like. As stated in [4]:

$$x = a\,cos(\,\omega t + 120^0); \qquad (1)$$

Vertical vibrations. As stated in [4]:

$$y = b\,sin(\,\omega t - 30^0); \qquad (2)$$

Where: *x*-the law of horizontal force,

y-the law of vertical force

The second variant if, $L_1 = \frac{L_2}{2} = L_3$in this case the difference of phases is 45^0.

$$x = a\,cos(\,\omega t + 90^0); \qquad (3)$$

$$y = b\,sin\,\omega\,t; \qquad (4)$$

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The third variant if, $L_1 = \frac{L_2}{4} = L_3$ in this case the difference of phases has 30^0. As stated in [4].

$$\left.\begin{array}{l} x = a\,cos(\,\omega t + 60^0) \\ y = b\,sin(\,\omega t + 30^0) \end{array}\right\} \qquad (5)$$

The fourth variant if, $L_1 = \frac{L_2}{6} = L_3$, in this case the difference of phases has 22^0. As stated in [4].

$$\left.\begin{array}{l} x = a\,cos(\,\omega t + 135^0) \\ y = b\,sin(\,\omega t - 45^0) \end{array}\right\} \qquad (6)$$

With reduction of distinction of phases the length of a vertical part of the mechanism of a direction decreases also. Means, parameters of length of the mechanism of a direction are connected with distinctions of phases between two perpendicular oscillatory forces.

Force of action of fascinating force is connected with speed of movement of a cotton and propensity of a corner of a vertical inclined plane of the mechanism of a direction.

At narrowing of distinction of phases the initial phase raises, occurs from it that horizontally flat party of the mechanism of a direction becomes longer than vertically inclined party of the mechanism of a direction.

These four versions on a case which are established each other two parties of the mechanism at an acute angle, communicate. The second a case, it when fastening of two parties of the mechanism doesn't have acute angle and oval for smooth movement of wheels of the mechanism on a mechanism management. In that case a wheel of the mechanism of a management at movements and at transition from one horizontal the parties of the mechanism of a management to another aren't present any interaction of mechanical blow.

By means of corners of optimum propensity it is considered by optimum length of the inclined vertical and horizontal plane of the mechanism of a management. Shown in fig. 4.

$$\alpha = 22^0 = \frac{1}{8};$$

One part from eighth of total length of the directing mechanism, $\beta = 68^0 = \frac{1}{4}$; one part from four total lengths of the directing mechanism.

Then, will be $L_1 = L_3 = \frac{L_2}{2}$;

If to consider identical frequencies of movement of two perpendicular exciting forces then it is possible to calculate following. As stated in [4], [10]:

Vertical exciting force:

$$y = A\,sin\,\omega\,t; \qquad (7)$$

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If to consider from standing of phases of horizontal force from vertical on 450 then the equation of horizontal force will look as follows:

$$x = B\cos(\omega t + \alpha); \qquad (8)$$

The difference of amplitudes will look as follows $A = \frac{1}{2}B$; Then the inclination of an inclined plane of the directing mechanism will be equal on half 45^0 , $\alpha = 22^0$

If the cotton is vibrated coming off a grid then its movement will look. As stated in [2]:

As sphere movement to a motionless kernel:

It, as though as our case, various amplitudes and identical frequencies.

In our case the equation will look as follows. As stated in [4],[10]:

$$\left.\begin{aligned} x &= a\cos\omega t \\ y &= b\sin(\omega t + \alpha) \end{aligned}\right\} \qquad (9)$$

From this equation from analytical geometry, it is possible to calculate the ellipse equations.

In is a case at movement of a wheel of the mechanism on a direction of circular motions of the mechanism, at movement back and in before will look not as an ellipse, as a parabola or a hyperbole.

It depends on force blow. In force increase short movement of a meeting will print a hyperbole kind.

At the decision on a problem of the equation of movement of a short meeting on a grid we will look a cotton as elastic.

At equation creation it is necessary to add variable inertial forces Ф, we will consider that the cotton bunch will be vibrated in vertical direction Y then the equation will become one-sedate degree compelled fluctuation and will assume the following air. As stated in [2], [3]:

$$y'' + 2ny' + k^2 y = \frac{1}{m}\Phi_e; \quad (10)$$

Here, Φ_e– variable inertial forces, n–factor of attenuation, $k = \sqrt{\frac{c}{m}}$- frequency of free vibration. C–stability to elasticity of a fiber of cotton.

If frequency of fluctuation is equal on $\omega = \upsilon t$; then, variable inertial forces the following kind. As stated in [2], [3] is trampled down:

$$\Phi_e = -m\frac{2\pi^2\vartheta^2 A_{max}}{L^2\cos\frac{2\pi\vartheta t}{L}} \qquad (11)$$

If it to put on initial equation positions then will assume the following air:

$$y'' + 2ny' + k^2 y = -h\cos p\,t; \quad (12)$$

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Where $p = \frac{2\pi\vartheta}{L}$; $h = \frac{A2_{max}}{2}$;

Then, the differential equation compelled fluctuation will assume the following air:

$$y = e^{-nt}(C_1 \cos k^* t + C_2 \sin k^* t) - A_d \cos(pt - \varepsilon); \quad (13)$$

Here: $k^* = \sqrt{k^2 - n^2}$- frequency fading the fluctuation, the p-compelled frequency of fluctuation,

A_B- amplitude compelled fluctuation $A_B = \frac{h}{\sqrt{(k^2-p^2)^2+4n^2p^2}}$; $C_1 = A_B \cos\varepsilon$;$C_2 = \frac{A_B}{k^*}(n \cos\varepsilon + p \sin\varepsilon)$;

$$y = A_B e^{-nt}\left\{\cos\varepsilon \cos k^* t + \frac{1}{k^*}(n \cos\varepsilon + p \sin\varepsilon) \sin k^* t\right\} - A_B \cos(pt - \varepsilon); \quad (14)$$

The first part of party right the equations, the disappearing fluctuation, the second right of a part

Plural parties the equations a part, has forced fluctuation. Except for force of resistance$n = 0$, $\varepsilon = 0$,$k^* = k$,

the equations will be assumed by the following an air:

$$y = \frac{h}{k^2-p^2}(\cos k\,t - \cos p\,t); \quad (15)$$

At a resonance - $p = k$; $\varepsilon = \frac{\pi}{2}$; $n \neq 0$;

$$y = \frac{h}{k^2}\left(\frac{ke^{-nt}}{k^*} \sin k^* t - \sin k\,t\right); \quad (16)$$

Amplitude compelled fluctuation$A_M = \frac{h}{2nk} = \frac{kA_{max}}{4n}$; coefficient attenuations$n = 0{,}1k$, then$A_M = 2{,}5A_{Max}$, critical speed at a resonance $\upsilon_к = \frac{L}{T}$; T – cycle free fluctuation.

The equations at a resonance:

$$\digamma y = -\frac{kA_{max}}{4 \sin k} \quad (17)$$

Thus the amplitude compelled fluctuation grows in due course - $A_M = \frac{kA_{max}}{4n}$;

With aforementioned, specified the equation, it is visible, which in distinction of phases on 90^0 sheaves of a cotton (at the free and compelled fluctuation) falls in a resonant situation.

It was decisions for radially connected among themselves horizontal and vertical the parties of the mechanism. The second situation in the angular has connected among themselves the parties of the mechanism. As stated in [1], [3], [7], [8]:

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If we will conditionally tear up that all fibers of a bunch round a seed as one elastic core, vibrating movement of a bunch it will be connected from stability to elasticity of a core. Also, we will accept a bunch oscillate motion bilateral and frequencies the identical:

Conditionally we take core bending's in two directionsxy.

Then differential the equations of system of free fluctuation will be assumed by the following ail:

$$\left.\begin{matrix} mx'' + cx = 0 \\ my'' + cy = 0 \end{matrix}\right\} \quad (18)$$

From this we will find

$$k_1 = k_2 = \sqrt{\frac{c}{m}};$$

From this equation of movement of system in coordinates will assume the following air:

$$\left.\begin{matrix} x = C_1\, sin(\,kt + \alpha_1) \\ y = C_1\, sin(\,kt + \alpha_2) \end{matrix}\right\} \quad (19)$$

On initial parameters the bunch trajectory will accept various forms. It is a situation for a bunch which moves on a surface without coming off it.

At an inequality $m\omega^2 < my''$the cotton bunch will lose contact with bottom grill of crate.

V. EXPERIMENTAL RESEARCHES OF CALCULATION OF THE SIZES TO DIRECT OF THE MECHANISM

At actions the mechanism of a management the sizes of the mechanism of a management of the difficult harmonious equipment also play speed of the equipment the big role. From these communications we will find the sizes of the mechanism of a direction. Shown in fig. 3, and speed of the equipment.

At cotton movement a short meeting in the inclined vibrating mechanism force of equal speed strikes the equipment.

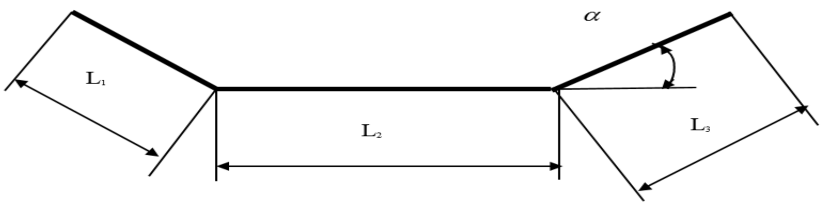

Fig 3: The mechanism of a direction of a mesh plane. α −Angle of slope, L_1, L_3 – the inclined parties of the directing mechanism, L_2 – the horizontal party of the directing mechanism

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Thus, the sheaf of action of a cotton of inertial force changes a direction vertically to the equipment. As sheaf division at most the inertia equipment should exceed forces of blow. With that end in view it is necessary to lift speed of the equipment on a mechanism direction. Also, the design of the equipment should be very steady.

As stated in [2],[3],[5] on it initial calculations we will spend at small speeds, in a range- $v_a = 1.....5(м/s)$;

With step 1 $(м/s)$; the second blow of the equipment occurs at transition of movement of a wheel of a grid from a horizontal plane of the mechanism of a direction on the inclined. Here there will be a communication between inertial force of a cotton with speed of a grid. On small speeds the cotton will be vibrated without a grid separation.

The grid by means of wheels after blow will raise on vertical on an inclined plane of the mechanism of a direction and in descent, division of a cotton from a grid will be connected with speed of a grid.

Blow of the second will arise at transition of movement of a wheel of a grid from an inclined plane of the mechanism of a direction on the horizontal. It should make attacks when the cotton will already come back to a grid, it will be connected with length of an inclined plane. From it probably to draw a conclusion that the length of the mechanism of a direction is connected with speed of a grid.

This situation we will check up having created differential the equations of movement of a bunch from the equation of forces operating on a bunch. As stated in [4]:

$$\left.\begin{aligned} y' &= v - gt + c_1 \\ y &= vt - g\frac{t^2}{2} + c_1 t + c_2 \end{aligned}\right\} \qquad (20)$$

In detail inclined plane of the mechanism of the direction equal on y = 0,02 meter, we find time of blow of a wheel for the horizontal plane directing the mechanism (**the Fig 4**): in the schedule on vertical time of an axis of blow of a short meeting for

a grid - the presented speed of a grid on a horizontal axis.

From this it is possible to calculate length of an inclined plane directing the mechanism from the following formula $s = vt$;

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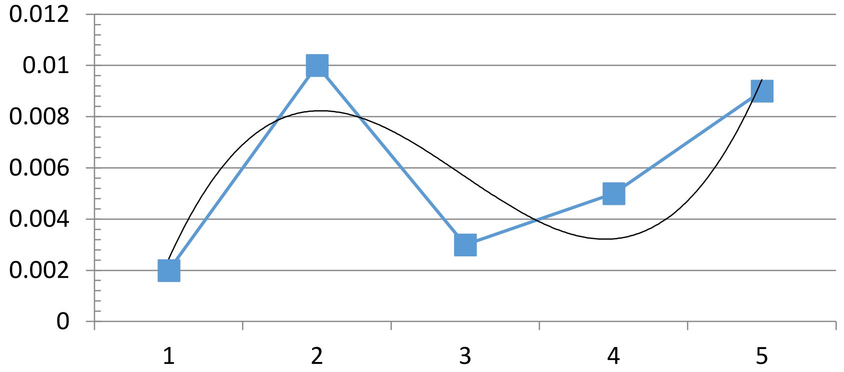

Fig 4: Time of blow of a wheel for a horizontal plane of the mechanism of a direction. Across time-(s), on a vertical speed of–(m/s)

From this follows that at reduction of speed of a grid down and length of an inclined plane directing mechanism. Also, from calculations it is possible calculation length of horizontal and inclined planes the directing mechanism. At a correct choice of parameters of length and the form the directing mechanism, action of forces on a bunch will be next and will promote also to bunch vibrating in a horizontal and vertical direction.

The diagram of movement of cotton at failure of cotton from a grid it is connected with propensity of a grid. As is more than propensity of a grid so the schedule to come nearer to a parabola in reduction of propensity the schedule, to come nearer to a hyperbole.

VI. RESULTS

As a result of the decision lower specified parameters of the eater difficult harmonious vibrating movement of the equipment are calculated:

1. The optimum form of the eater of movement – the direction mechanism.

$\alpha = 22^0 = \frac{1}{8}$; One part from eighty total length of the directing mechanism;

$\beta = 68^0 = \frac{1}{4}$; One part from four total lengths of the directing mechanism;

The angle α changes at change of a grade of a cotton as more low a grade cotton clarification worsens, therefore to rise clearing a corner raises - for increase of force of inertia, the corner changes with 22^0 to 37^0. Communication of change of a corner with a cotton grade is shown on **(Fig. 5).**

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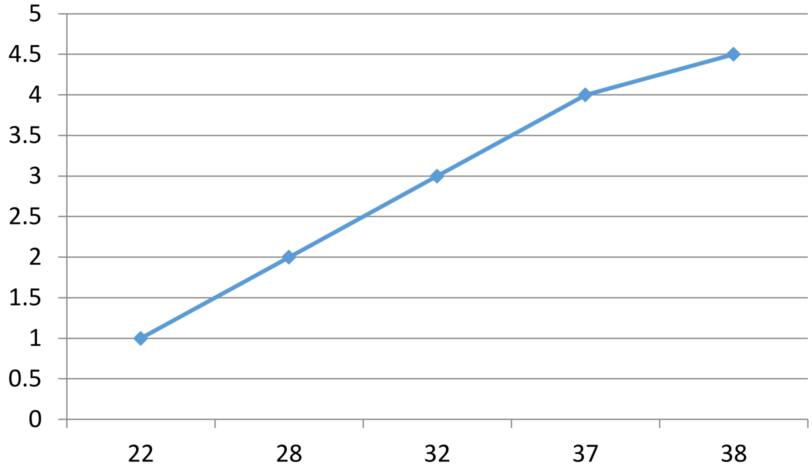

Fig 5: The dependency of change of an angle of slope (x) with change of a percentage of waste in cotton. On a vertical axis is plotted cotton quality grade, on a horizontal axis an angle of slope.

Length of parts of the directing mechanism. Shown in **Fig.3:**

Length of an inclined part –

$$L_1 = L_3;$$

Length of a flat part -

$$L_2 = 2L_3;$$

Difference of phases of oscillatory forces:

in $\frac{\pi}{4}$-at-$\frac{\pi}{8}$;

2. Parameters of acceleration of the equipment;

Distinction of amplitudes of perpendicular oscillatory forces:

Horizontal amplitude of fluctuation –

$$\text{A} = \frac{1}{2}\text{B};$$

Vertical amplitude of fluctuation –

$$B = 2A;$$

Optimum speed of vibrating cotton -

In a range:

$v_a = 1.....5(м/s)$; c step $1\ (м/s)$;

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Communication with time of blow of a wheel on a horizontal plane of the directing mechanism with speed of a wheel. As stated in shown in **fig.4**.

Angular frequency of the compelled forces:

$$\omega = 0.5 - 1.5\frac{rad}{s};$$

Change of communications with length of an inclined plane of the mechanism of a direction with change of speed of the equipment:

3. Action vibrating grids on a cotton a short meeting:

Differential of the equation of movement of a cotton a short meeting. As stated in (formula 14)

Practical results

For research of the vibrating mechanical action developed in installation. Shown in the **Fig 6**, as stated in [7], [8]. In experimental it has been had the given satisfaction of theoretical researches of a problem.

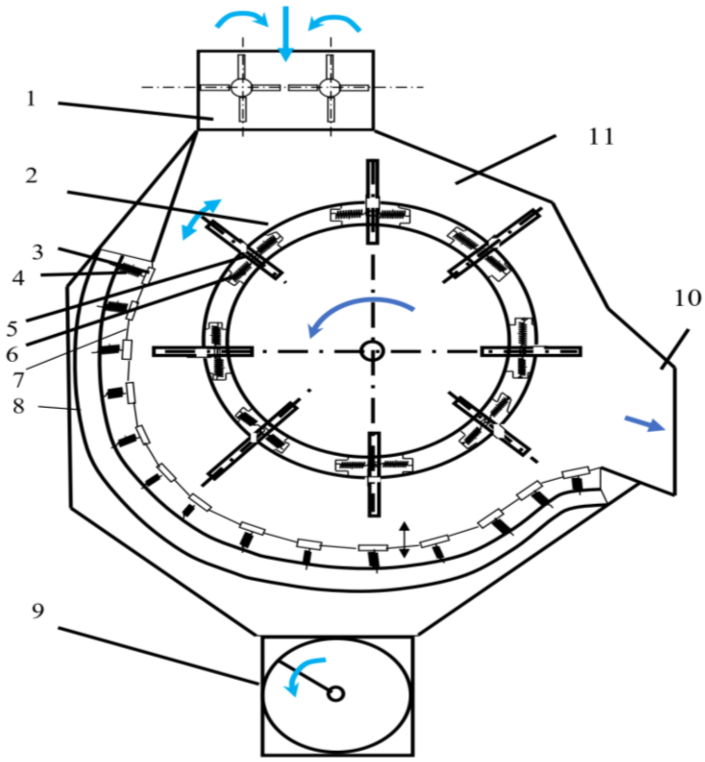

Fig 6: Laboratory vibrating cleaner. Here: 1-entrance channel with a feeder, the 2-feeder on shaft of a feeder, the 3-elastic element, 4-the drum, 5-elastic element, the 6-vibration mechanism, 7-a colosnic,8- fundament of colosnic.,9-shnek, 10-exit fiber, 11-work camera.

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Results of experimental research

No.	Extraneous impurity before clearing, %	Defects before clearing, %	Extraneous impurity after clearing, %	Mechanical defects after clearing, %	
				With great dispatch-mechanical influence	Vibrating mechanical influence
1.	2,5	0,5	1,5	1,2	0,54

From the table it is visible, which, efficiency at vibrating mechanical explanations lifts to 15 %, occurrence pollution down comes over to the side of 45 %.

This experimental proves that vibrating action on a cotton raise effect of clearing.

Experiment has been spent on Experimental to installation, in experimental there was it, the grade of a choice of cotton C-6524, first a grade, 1ro, a class, with humidity of 9 % is used at pollution of 2,5 %. Amplitude of fluctuation 4-8 mm, Optimum frequency 8 sek-1. For comparison it was used ICC-10.

VII. Offers scientific research After research some variants of a design of cleaners have been offered and demands for inventions and for useful models from them for today of 10 patents have been submitted is received, 3 on inventions, 7 on useful models. Patent researches proceed till now.

For introduction in manufactures the optimum variant of a design the Universal cotton cleaner c by a difficult harmonious oscillation motion of cotton and with some adaptations has been chosen.

VIII. CONCLUSIONS

Existing cotton cleaning equipment doesn't satisfy the requirement of manufacturers because of cleaning process efficiency. Influences of mechanical intact worsening quality of cotton fibers blow by cutting them, so overall quality descend and losses of cotton during further processing increases. Vibrational methods for cotton cleaning is not implemented at full scale and they claimed to be not enough efficient.

Proposed method and equipment proves own efficiency in laboratory conditions and have chance to be implemented in industry. Performed experimental research revealed properties of such method and bring these conclusions:

- Cleaning process and percentage of waste in cotton are influenced by path of vibration and amount of moisture in cotton material;
- Vibrational method broke less fibers than mechanical cleaning through grill;
- Seeds are less damaged in comparison with mechanical cleaning.

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