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Modernized Linter Machine

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ABSTRACT: One of the departments, which includes the processes of primary processing of cotton, is the department of lintering. The function of the linter department is based on scraping residual short fibers from the surface of the seeds. The design, the principle of operation, its main working bodies, the shortcomings of the linter, the state of the relationship of the working bodies of the operating 5LP linter are given.

The main advantage of the plant is that the seeds separated from the lint are brought out through the net surface located under the agitator. As a result, it is possible to increase the plant productivity by lint and seed. In this regard, the reduction of mechanical damage to seeds is achieved.

KEYWORD: lint, compartment, pressure, equipment, agitator, grate, saw, working chamber, seed comb, air chamber, pulp, seeds, saw teeth, air zone.

I.INTRODUCTION

At modern ginneries, 5LP brand linters are widely used. The working chamber of the linter 5 LP consists of complex parts. The low productivity of this machine for seeds is the reason for the increase in production costs of the enterprise. For this reason, research on the creation of a linter machine with simplified spare parts and the technological process is very relevant. In the new proposed linter machine, the technological process makes it possible to increase the removal of lint.

After separating the fibers from the seeds, a lint remains on the surface of the seeds. Depending on the breeding variety, the quantity of lint is different and 5LP machines are used for its separation from seeds at domestic enterprises of the republic [1].

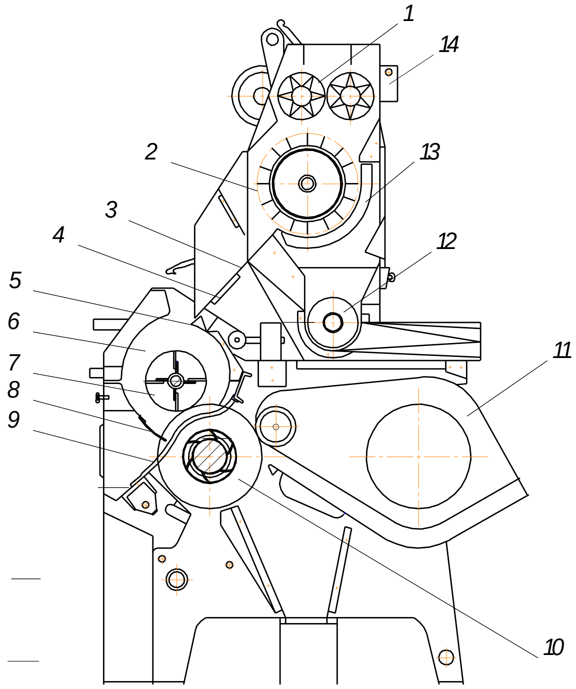
These linter machines are identical to each other and consist of a bounded front and rear apron of the working chamber, seed comb, grate, guard, density valve and chamber sides. Inside the chamber is a tedder. Across the entire width of the chamber, from the upper part of the chamber, seeds are fed by a feeder in a uniform flow through an open tray. Between the gaps in the grate, saws of a rotating saw cylinder pass into the working chamber. Sawing teeth cutting into the mass of the seed roller scrapes the lint from the surface of the seeds and carries them over the grate. From the teeth of the saws, the lint is removed by the pressure of the air flow pumped from the nozzle of the air chamber and through the supply part of the air chamber and by means of a pneumatic transport system is sent to the battery condenser.

The first of the main technological drawbacks of the 5LP brand linter is that with a decrease in the gap between the grate and the seed comb, the density of the seed roller increases, while the lint removal increases and the linter machine's seed throughput decreases. With an increase in this gap, on the contrary, lint removal decreases, and seed throughput increases. It is very difficult to maintain the optimal value between these two indicators.

For optimal operation of the linter machine, it is necessary that the cross-sectional shape of the working chamber should be as close to the circle as possible [2].

The second disadvantage of the 5LP brand inter-engine machine is that, due to the presence of the seed comb, there is no possibility of maximally approximating the cross section of the working chamber to the shape of a circle.

For normal operation of the working chamber, it is necessary that the outer layer of the seed roller has a dense bonded structure and is stable in motion, and its arch, when passing through the upper part of the chamber, is not destroyed, for which a density valve is used.



1- feeding rollers, 2- leveling drum, 3- tray, 4- magnetic coating, 5-vacuum valve, 6-working chamber, 7-agitator, 8-seed comb, 9-grate, 10-saw cylinder, 11- air chamber, 12-auger, 13-mesh surface, 14-regulating load.

Fig 1. Linter 5LP.

For uniform seed feeding into the working chamber of a complex mechanical system consisting of two sprockets, an IVA variator, two levers, a chain and a density valve, which complicates the design of the lindetting machine [3].

The manufacturer of the linter machine is generally proportional to the residence time of the seeds in the working chamber and the number of contacts of the saws with the seeds.

In addition to the state of the position of the seeds between the saws, there is a connection between the separated seed and the possibility of its contact with the saws depending on the distance between them. As the distance between the saws decreases, the likelihood of seed contact with the saws increases

The third drawback of the 5LP linter is that it is impossible to reduce the distance between the saws, since with its reduction, the seeds from the working chamber will not be able to exit through the gaps between the saw blades, but will only exit through the gap between the seed comb and saws, which reduces the performance of the linter

The fourth drawback of the 5LP linter is the complex profile of the grates that make up the grate [4]. On 160-saw linter installed 161 grate. The width of the grate, especially in the workplace, must be observed very strictly, since the gap between adjacent grates in this area is only 2.5-3.1 mm. Inaccurate manufacture of the grate paws leads to their friction against the saws, wear of the edges of the grate and the saws themselves.

To eliminate the above disadvantages, a linter was developed, which is shown in fig. 2. This linter machine consists of a feeder with a roller 1, perforated mesh 2, agitator 3, grate 4, nozzle 5, saw cylinder 6, two casings 7, pneumatic pipe 8.

In this case, the perforated mesh 2 and the grate 4 form the working chamber of the linter machine.

The operation of the linter is as follows: the seeds are fed into the litter with a feed roller 1 and sent to the working chamber, where, due to the rotation of the agitator and the impact of the saws of the saw cylinder 6, a rotating seed roller is formed. Saws, penetrating into the mass of the seed roller, scrap the lint from the surface of the seeds and take them out to the grate 4. The removed lint is carried away into the outlet part of the air chamber and then transported through the pneumatic pipe 8 to the next process.

Seeds, as they remove lint and expose them, are released from the mass of the seed roller and through holes in the perforated mesh and removed from the linter. Due to the increase in the exit zone of bare seeds, by installing a

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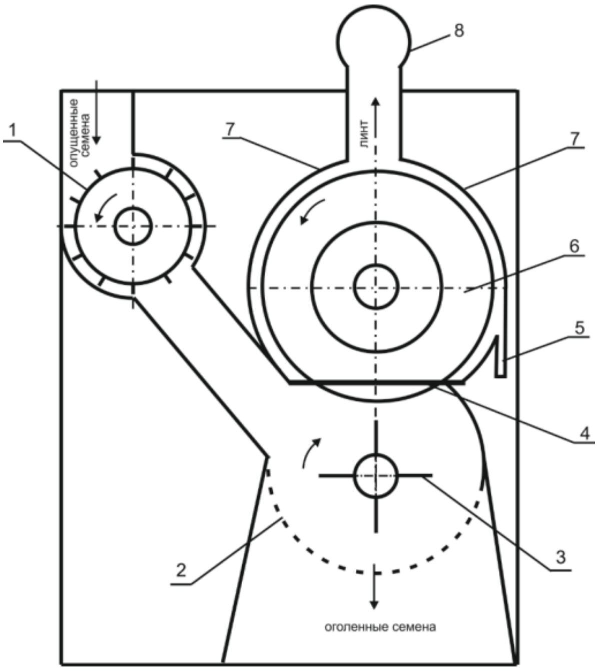
Vol. 6, Issue 11 , November 2019

perforated mesh 2 with a hole size corresponding to the size of normally linter seeds, the rate of their release increases, thereby increasing the productivity of linting and picking up the lint.



1-feed roller, 2-perforated mesh, 3- retractor, 4-grate grilles, 5-air guide, 6-saw cylinder, 7-apron, 8- is transported through the pneumatic line lint.

Fig 2. New linter.

The installation in the lower part of the working chamber of a perforated mesh with calibrated holes to the size of linter seeds and the sequential arrangement of a tiller and a saw cylinder above it, ensure reliable rotation of the raw roller in the working chamber.

The living cross-sectional area of the calibrated perforated mesh is much larger than the cross-sectional area of the gap between the comb and grid-irons in the existing 5LP linter, due to which the release of linter seeds from the working chamber will increase significantly and the productivity of the liner will accordingly increase.

The implementation of the grate rectilinear simplifies the manufacture of grate, assembly and adjustment of the location of the grate relative to the saws, which increases their service life and reliability of the linter.

When introducing this linter in ginneries, due to the increase in the productivity of lintering and lint removal, a significant economic effect will be obtained.

Consider the movement of air flow along a curved channel formed by concentric arcs of a round pipe.

Air is sucked through the channel at a flow rate Q .

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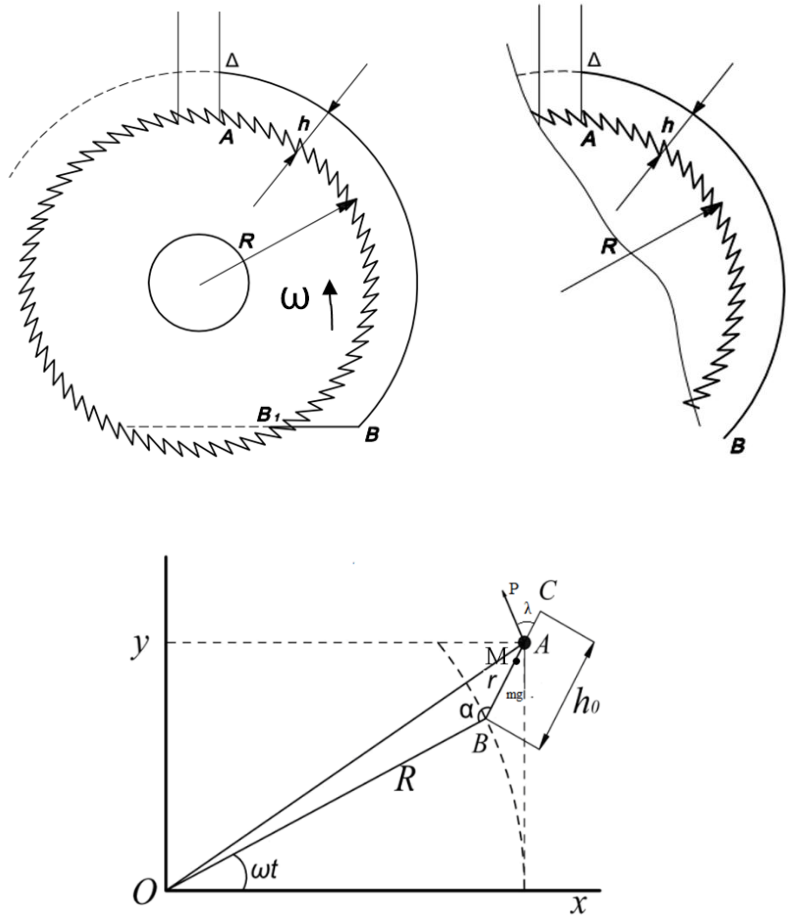

Fig. 3 Lint arrangement diagram (a-c) its movement (d) along the teeth of the saw drum

In accordance with the adopted flow pattern, the ideal incompressible flow rate is calculated by the function:

$$Q = \rho_0 S \cdot v \qquad (1)$$

ρ_0 -where is the air density $\rho_0 \approx 1{,}1$ kg / m3.

S - the cross-sectional area in the considered case will be equal to:

$S = h \cdot L$ (2)

L -width, h -height of the channel. Thus, the air velocity is calculated by the formula:

$$v = \frac{Q}{\rho_0 \cdot L \cdot h} \qquad (3)$$

When determining the speed, it is customary to assume the absence of friction of the internal channel.

Now let the saw drum rotate with a radius at R an angular velocity ω. We can consider the case of the influence of the rotation of the drum during the movement of the air flow, and the air should be considered incompressible. If the fluid is considered ideal, then the rotation of the drum does not affect the movement of the flow, and its speed is determined by the formula (1).

Consider the movement of the lint captured by the teeth of the saw drum.

The position of the teeth on the surface of the drum is determined by the known parameters of the location of the tooth B, in the scheme $OB = R$, the length of the tooth $BC = h_0$ and the angle OBC.

ISSN: 2350-0328
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Vol. 6, Issue 11 , November 2019

The forces of weight act on the lint, the friction is the force due to the action of pressure by the force of weight. To find the lint movement along the teeth, we use the second-order Lagrange equations, $BM = r$ where we take the distance as a generalized coordinate. Suppose that at the moment of rotation the teeth are in a $t = 0$ position where the radius is along $r = r_0$ the axis that is directed horizontally, the axis OB is perpendicular OX to it. The origin is set in the center of the serrated drum OY . The coordinate of the point is written in A the form:

$$x = R\cos\omega t + r\cos(\alpha - \omega t) \quad (5)$$

$$y = R\sin\omega t + rsn(\alpha - \omega t) \quad (6)$$

Kinetic energy of lint mass M will be equal:

$$T = \frac{M}{2}(\dot{x}^2 + \dot{y}^2) = \frac{M}{r}(R^2\omega^2 + r^2 + r^2\omega^2 + 2R\omega\dot{r}\sin\alpha - 2R\omega^2 rCos\alpha) \quad (7)$$

Composing the Lagrange equations IIkind

$$\frac{d}{dt}(\frac{\partial T}{\partial r}) - \frac{\partial T}{\partial r} = Q_r \quad (8)$$

Weget

$$m\ddot{r} = m\omega^2(r - R\cos\alpha) + Q_r \quad (9)$$

Where: Q_r – generalized force is determined by the formula:

$$Q_r = \sum X_i \frac{\partial x}{\partial r} + \sum Y_i \frac{\partial y}{\partial r} \quad (10)$$

X_i , Y_i – projection of external forces along the axis OX and OY that are:

1 –lint weight strength $Y_i = mg\sin(\alpha - \omega t)$, $X_i = 0$

2 –friction force from weight and

$$F_{TP} = -fmg\cos(\alpha - \omega t) + fF_{кор} \quad (11)$$

3 –friction force from Coriolos force

$$F_{кор} = -2\omega rm\cos\alpha \ .$$

Air suction pressure p

$P = S \cdot p\sin\lambda$, S -contact area of lint with tooth

$$\lambda = \arcsin\frac{R\sin\alpha}{\sqrt{R^2 + h_0^2 - 2Rh_0\cos\alpha}}$$

In this case, the generalized force is determined by the contact of the lint according to the formula.

$$Q_r = -mg\sin(\alpha - \omega t) + fmg\cos(\alpha - \omega t) + 2mfr\,\omega\cos\alpha + P\sin\lambda \ (\frac{\pi}{2} < \alpha < \pi)$$

The equation of motion of the lint along the teeth of the drum takes the form.

$$\ddot{r} - \omega^2 r + 2f\dot{r}\omega\cos\alpha = -\omega^2 R\cos\alpha - g[\sin(\alpha - \omega t) - f\cos(\alpha - \omega t)] + \overline{P}\sin\lambda$$

Here $\overline{P} = P/m$

Assuming $r = r_0$ that $\dot{r} = 0$ $t = 0$, we find the condition that the $\ddot{r}(0) > 0$ lint begins to move along the teeth.

$$\omega^2 r_0 - \omega^2 R\cos\alpha - g(\sin\alpha - f\cos\alpha) + \overline{P}\sin\lambda > 0 \quad (12)$$

Where can I set the angle α , under which the conditions of lint movement along the tooth are satisfied from the moment $t = 0$ .With small masses of lint, we can assume $\overline{P} >> 1$, and the condition for the lint to move at a time

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$t = 0$ comes down to inequality $\sin\lambda > 0$,which is performed for $0 < \lambda < \pi$. At $h_0 << R$ can be wet $\lambda \approx \alpha$.

Then setting in the equation (12) $\alpha = \pi - \overline{\alpha}$ we get

$$\omega^2 r_0 + \omega^2 R\cos\overline{\alpha} - g(\sin\overline{\alpha} + f\cos\overline{\alpha}) - \overline{P}\sin\overline{\alpha} > 0$$

Assuming

$$\cos\beta = \frac{\overline{P} - g}{\sqrt{(\overline{P} - g)^2 + (\omega^2 R + fg)^2}} \quad q = \frac{\omega^2 r_0}{\sqrt{(\overline{P} - g)^2 + (\omega^2 R - fg)^2}}$$

when $r_0 < R$ *we get*

$$\sin\overline{\alpha}\cos\beta - \cos\overline{\alpha}\sin\beta < q$$

From this equality we establish

$$\overline{\alpha} < \beta + \arcsin q$$

$$or\ \overline{\alpha} < \overline{\alpha}_0 = \arccos\frac{\overline{P} - g}{\sqrt{(\vec{P} - g)^2 + (\omega^2 R - fg)^2}} + \arcsin\frac{\omega^2 r_0}{\sqrt{(\overline{P} - g)^2 + (\omega^2 R - fg)^2}}$$

Giventheaddiction $\alpha = \pi - \overline{\alpha}$,weget $\alpha > \alpha_0 = \pi - \overline{\alpha}_0$. In fig. 2 shows the dependencies α_0 from attitude $\overline{P} = P/mg$ for two values R (м) at various angular velocity data $\omega(c^{-1})$ where in the calculations $f = 0.3$, $r_0 = 0.001$м

$$R = 0.1\text{м} \quad R = 0.2\text{м}$$

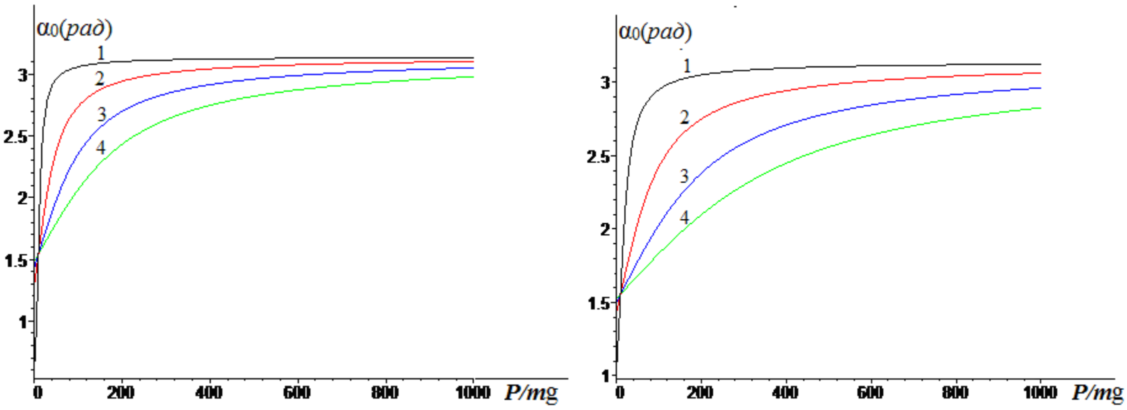

Fig. 2. Dependences α_0 of the angle on the $\overline{P} = P/mg$ ratio for various values of the radius R(м) and angular velocity of the saw drum $\omega(c^{-1})$: $1 - \omega = 10,\ 2 - \omega = 20,\ 3 - \omega = 30,\ 4 - \omega = 40,$ α_0(*рад*)

Assuming $\alpha > \alpha_0 = \pi - \overline{\alpha}_0$ solution of equation (3) satisfaction with the condition $r(0) = r_0\ \dot{r} = 0$ we get in the form

$$r = -A/\omega^2 + A_0\sin(\alpha - \omega t) + B_0\cos(\alpha - \omega t) + A_1\exp(k_1 t) + A_2\exp(k_2 t)$$

где $A = \overline{P}\sin\lambda - \omega^2 R\cos\alpha$, $A_0 = g(1 + f^2\cos\alpha)/2\omega^2(1 + f^2\cos^2\alpha)$,

$B_0 = -g(1 + \cos\alpha)/2\omega^2(1 + f^2\cos^2\alpha)$, $A_1 = (k_2 C_1 - C_2)/(k_2 - k_1)$, $A_2 = (C_2 - C_1 k_1)/(k_2 - k_1)$,

$C_1 = A/\omega^2 + r_0 - A_0\sin\alpha - B_0\cos\alpha$, $C_2 = \omega A_0\cos\alpha - \omega B_0\sin\alpha$

$k_1 = \omega(-f\cos\alpha + \sqrt{f^2\cos^2\alpha + 1})$, $k_2 = \omega(-f\cos\alpha - \sqrt{f^2\cos^2\alpha + 1})$

In fig. Figure 3 shows the dependence of the lint movement along the drum teeth on time (sec) where, in addition, it is customary $\omega = 50c^{-1}$, $\vec{P} = 13$

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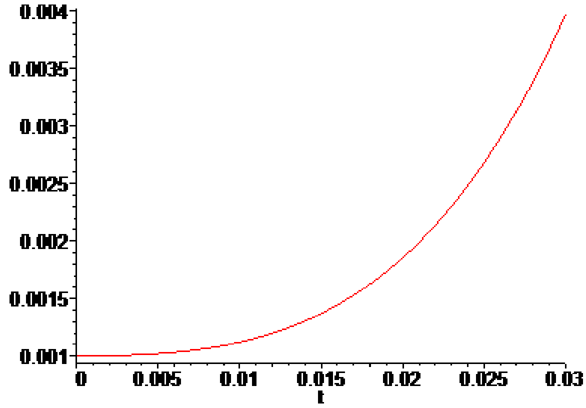

Studies have been carried out to create a technology to increase the efficiency of lint removal from seeds with a reduction in the residence time and removal of bare seeds from the working chamber, to ensure a normal percentage of lint removal and seed fiber.

An opportunity has been created for comparative determination based on proportional calculations of the results of a laboratory sample of a new linter machine with an existing industrial linter machine for seed throughput and lint separation

In a laboratory setup, the influence of the diameter of the working chamber forming the seed roller, the dimensions of the mesh surface for passing bare seeds and the change in the distance between the saws on the lint throughput and mechanical damage to the seeds was studied.

A theoretical calculation of the movement of seeds in the working chamber.

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