THEORETICAL ANALYSIS OF FLUFF SEPARATION FROM SEED UNDER THE INFLUENCE OF SAW TEETH

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Abstract. *In this article, during the lintering process, which supplied the blower air to the air chamber, a stream of which provided complete removal of the torque from the saw teeth, a small size ventilator design was developed; in the technological process of lintering, the effect of each linter on the complete removal of the amount, speed and uniformity of the blowing air from the flue chamber soplos has been determined; in the process of lintering technology, the parameters of the installation of the air blower fan in the air chamber, which will be installed in the air Chamber of each Linter, are determined; in the technological process of linterization, the design, basic parameters and aerodynamic operating modes of the air blower fan, which is installed in the air Chamber of each Linter, are determined.*

Keywords: *saw angle, nozzle, experimental movement, tow, air, flow velocity, aerodynamic force, linter, supercharger, fan, pressure, pipe, aerodynamic system, saw cylinder, working chamber, exhaust pipe, seed comb, grate, drum, feed roller, linter, fluff, air chamber, aerodynamics, dynamic pressure, stand, air density fan, condenser, static pressure, grasshopper speed, seed mixer.*

Main Part

After the ginning process, the fiber coating remains on the cotton seed, which consists of relatively short fibers, the number of which depends on the selection of cotton raw material and the type of industry. So, for medium-fiber varieties, the amount of fiber covering in seeds is 11...16%, and for thin fibers - 3...5% by weight of seeds [1]. The fibrous coating remaining in the cotton seed consists of fibers with a length of 1...1.5 mm to 25...26 mm. At the same time, the fibers with a length of 6 mm and more belong to fluff (lint), and the fiber with a length of less than 6 mm belongs to the delint type. The total fluff weight is expressed as a percentage of the initial seed weight in the total or total determination of the fluff quality of the seed. Linters are cotton processing machines designed for mechanical removal of lint from cotton seeds and under the influence of force and processed during a continuous cycle of work [2]. One such machine is the 5LP aggregate with a working body in the form of a saw cylinder consisting of discs of the same type.

During the linting process, saw disc teeth scrape the fluff from the continuously rotating seed roller. At the next stage, as a result of the contact interaction, the fluff is removed from the fiber coating remaining in the cotton seed after ginning. Taking into account the value of fluff as a raw material in various industries, the issue of accelerating the linting process is urgent, and at the same time, maintaining the quality indicators of fluff is an important task in the modern cotton ginning industry.

In recent years, extensive efforts have been made in the cotton ginning industry to reduce linter battery air consumption and create a level playing field for battery operated linters. Experimental and theoretical studies allowed to recommend the inclusion of a number of improved elements of the linter battery.

There are several known methods of removing lint from saw teeth [5].

1. Mechanical, fluff removal is carried out by brush drums and other similar methods (used in the construction of the first manufactured linters). Its use significantly complicates the linter construction, but does not reduce energy consumption.

2. A method of fluff removal with a high-speed air stream from the nozzle of the air chamber in the direction of movement of the saw teeth. This method is used in modern linter designs, and its disadvantage is the uneven distribution of air through the air chambers of all the linters in the battery.

3. The method of removing lint from each saw tooth using separate air streams. This solution requires little energy, but it is very complicated to manufacture and use.

4. The method of self-dissolving when the angle of inclination of the front surface of the saw teeth to the radius of the saw is equal to or less than the angle of self-dissolving of the fluff. In this case, the energy costs are minimal, because the fluff comes out of the saw tooth without additional effort, and a small amount of air is enough to shed them. However, as the angle of inclination of the tooth decreases, the quality of fluff deteriorates, as a result, this method cannot be used to remove fluff from the saw tooth.

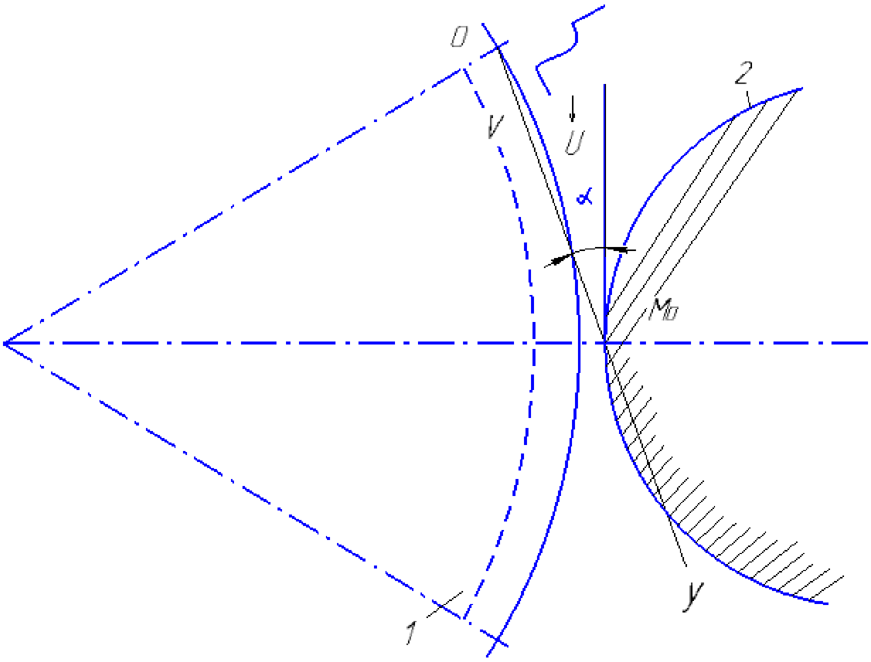
5. The combined method consists in reducing the angle of inclination of the tooth (without causing it to drop by itself) and using a less expensive air flow. A slight reduction in energy consumption can be achieved with this method, but the maintenance of an air chamber makes it difficult to create a level playing field for battery-powered linters.

6. The method of removing fluff with a suction air stream. In this way, by increasing the width of the suction channel, the air consumption is doubled and, as a result, the energy consumption also increases.

Based on the analysis of the above methods of removing fluff from saw teeth, the second method, which is widely used in modern linter constructions currently used in seed linting workshops of cotton ginning enterprises, was selected for further studies.
This means that fluff is removed from the saw teeth by a high-speed air stream from the air chamber's narrow slot-shaped nozzle. The efficiency and energy costs of this process depend on the static pressure in the air chamber and the speed at which the air is expelled from the slit-shaped nozzle. Let's look at the behavior during the initial removal of the tuft of fluff.

Aerodynamic studies carried out at the "Cotton Industry Scientific Center" have shown that the air stream flowing from the narrow slit-shaped nozzle of the air chamber also adds a certain amount of air from the environment. The velocity of entrained air increases as it approaches the active medium [7].

We designate the point where the added air flow and the speed of the saw tooth are equal to each other by the letter O, and the point of the maximum speed of the active air flow by Mo (Fig. 1.1). If the width of the slit-shaped nozzle is h, the distance from the edge of the slit-shaped nozzle to the point Mo is approximately 6 h. Let us pass the axis U through the points O and Mo and consider the behavior of the fluff in the section OM.



1 saw; 2nd air chamber nozzle guide plane.
Figure 1.1. Diagram of air flow and fluff tuft velocity during saw tooth removal

At the point O, which is taken as the origin of the coordinate axis, the speed of the tuft of fluff is equal to the linear speed of the saw tooth. When the tuft of fluff moves from point O to Mo, its speed is equal to the maximum speed of the stream flowing out of the nozzle in the form of a narrow slit. Under the influence of the aerodynamic force of the air flow, the tuft of fluff is removed from the saw tooth.

In order to determine the behavior of the tuft of fluff during removal from the saw teeth, a differential equation of its movement in the OMo section was created. The solution of this equation allowed us to obtain an expression for determining the trajectory of the tuft of fluff [2, 1].

$$У_{п} = Ut - 26{,}5\frac{m}{S_{м}}\, l_{n}\left[0{,}377\,\frac{S_{м}}{m}\,(U\sin\alpha - V)t + 1\right] \qquad (2.1)$$

And to determine the time ts to remove the tuft of fluff from the saw tooth, the following equation was obtained:

$$t_{c} = \frac{m}{0{,}43\,S_{м}\,(U) - V)} \qquad (2.2)$$

where: Ut is the coordinate of the moving tuft of fluff;
U and V- speed of air flow and tuft of fluff, m/s, respectively;
m- the weight of the tuft of fluff, kg;
S_m- the average section of the tuft of fluff, m^2;
α– the angle between the speed of the tuft of fluff and the direction of the air flow;
t_c - the time of movement of the tuft of fluff from point O, sec.

It follows from equation (2.2) that, all other conditions being equal, fluff removal time increases with fluff weight at the same average cross section.

The position of the seed chamber relative to the saw cylinder affects the linting process of the seed and is also known to depend on the residual hairiness of the seed [9].

In existing linter equipment designs, when the diameter of the saw cylinder decreases (due to the opening of the back tooth on the saw), the position of the working chamber changes and, as a result, the angle also changes.

Based on the above, when determining the aerodynamic mode with the proposed separately installed fan, it is necessary to conduct experimental studies using only new saws with a diameter of 320 mm in order to take into account the actual indicators of fluff removal. In addition, attention should be paid to the dirtiness of the obtained fluff, because the increase in the dirtiness of the fluff leads to an increase in the mass of the resulting fluff.

It should be noted that the basis of lintering is that the saw scrapes the fluff from the seed with the upper part of the tooth, and the lintering performance is related only to the geometrical parameters of the teeth of the saw disc. The linting process generally depends on the extent to which the front surface of the designated saw tooth covers the lint and then removes it.

In order to study the process of separating fluff from the surface of the saw in the fluff separator with an additional fan installed on the air pipe, the movement of the air flow along the curve as a module formed in the concentric arc of the circular pipe was considered.

We assume that the air is drawn through the duct with the consumption Q, and of course the air coming from the air duct is also affected. The behavior of the air flow in the circuit, where the ideal consumption of incompressible air is assumed, is as follows:

$$Q = \rho_0 \cdot S \cdot (\vartheta + \vartheta_0) \tag{2.3}$$

here: - ρ_0 -air density $\rho_0 \approx 1{,}1\,\text{kg}/\text{m}^3$.

S- in the case under consideration, the transverse cut will be equal to:

$$S = h \cdot L \tag{2.4}$$

L-channel width (1520mm), - channel height (5mm).

Thus, the airspeed is calculated from the following formula:

$$\vartheta = \frac{Q}{\rho_0 \cdot L \cdot h} - \vartheta_0 \tag{2.5}$$

When determining the speed, we assume that there will be no friction of air in the internal channel. It is possible to consider the effect of cylinder circulation on the movement of air flow, taking into account the non-compressibility of air.

Let's look at the movement of torque with which the Saw tooth is hooked: we determine the position of the teeth on the surface of the cylinder with certain indicators: the location of the teeth *B* or B_1, *OB*=*R* in the scheme, the height of the tooth $BC = h_0$ and the angle of deviation of the tooth *OBC* (figure 2.4).

The torque is influenced by weight and friction force. Under the influence of the pressure of the force of Gravity, The Force is conditioned. Taking the distance as a generalized coordinate, we use Lagrange's type II equation to determine the motion of the moment along the tooth *BA*=*r*.

Let the teeth *t=0* be in position $r=r_0$ when the rotation time is, in which lie a radius along the horizontally oriented axis *OX*, let's imagine that the axis is perpendicular to it *OB*. The center *OY* of the saw cylinder is defined as the head of coordinates [3].

We write the coordinate position of the mass of the torque on the Saw tooth as follows:

$$\begin{aligned} x &= R\cos\omega t + r\cos(\alpha - \omega t) \\ y &= R\sin\omega t + r\sin(\alpha - \omega t) \end{aligned} \tag{2.6}$$

to determine the kinetic energy of the M-mass moment, we can from the equation of motion in time from the equation (2.6) and equal to:

$$T = \frac{m}{2}(\dot{x}^2 + \dot{y}^2) = \frac{m}{r}(R^2\omega^2 + r^2 + r^2\omega^2 + 2R\omega\dot{r}\sin\alpha - 2R\omega^2 r Cos\alpha)$$

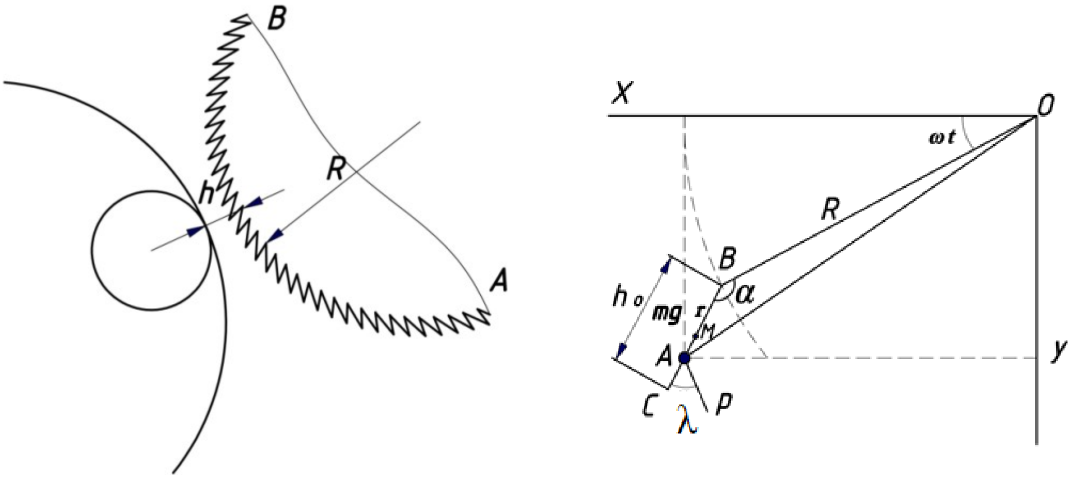


Figure 2. Movement of torque along the saw cylinder tooth

(2.7)

Using LaGrange's equation of Type II (2.7), a private dressing is obtained from the equation:

$$\frac{d}{dt}\left(\frac{\partial T}{\partial \dot{r}}\right) - \frac{\partial T}{\partial r} = Q_r \qquad (2.8)$$

(2.8) from equality, the generalized forces of the external forces acting on the flow of torque on the surface of the Saw tooth are determined and are general and private solutions to the unisexual equation.

$$m\ddot{r} = m\omega^2(r - R\cos\alpha) + Q_r \qquad (2.9)$$

here: - Q_r the generalized force is found by the formula:

$$Q_r = \sum X_i \frac{\partial x}{\partial r} + \sum Y_i \frac{\partial y}{\partial r} \qquad (2.10)$$

X_i, Y_i-,-OX and OY the projection of external forces on the axes is equivalent to:

$Y_i = mg\sin(\alpha - \omega t)$ $X_i = 0$ we form a connection hearing of the force of gravity of the torque, the force of friction on the weight with the force of the Cariolis.

$$F_{TP} = -f \cdot m \cdot g\cos(\alpha - \omega \cdot t) + f \cdot F_{кор} \qquad (2.11)$$

here, the Coriolis force is formed in the separation of the fluff from the Saw tooth.

$$F_{кор} = -2 \cdot \omega_e \cdot \dot{r}_r \cdot \sin\alpha \qquad (2.12)$$

Here α - is the angle-the angle between the displacement acceleration of the torque and the relative speed of the absorption force P of air at pressure the equation of the angular relationship between the strength of the torque and the λ surface of the Sawtooth is presented in Figure 2.2 [8].

$$P = S \cdot p\sin\lambda \qquad (2.13)$$

here: - S-the surface of the tooth contact of the bruise;

λ - the angle between the surface of the Saw tooth by the force of gravity.

$$\lambda = \arcsin\frac{R\sin\alpha}{\sqrt{R^2 + h_0^2 - 2Rh_0\cos\alpha}} \qquad (2.14)$$

Taking into account these, the total bonding strength of the torque with the tooth is determined by the following formula:

$$Q_r = -mg\sin(\alpha-\omega t) + fmg\cos(\alpha-\omega t) + 2mfr\omega\cos\alpha + P\sin\lambda \; (\frac{\pi}{2} < \alpha < \pi) \qquad (2.15)$$

The second-order non-homogeneous differential equation in determining the motion of the torque affected by the cylinder saw tooth is expressed as follows:

$$\ddot{r} - \omega^2\cdot r + 2\cdot f\cdot\dot{r}\omega\cdot\cos\alpha = -\omega^2\cdot R\cdot\cos\alpha - g[\sin(\alpha-\omega t) - f\cos(\alpha-\omega t)] + (\frac{Q}{\rho\cdot\vartheta} - \vartheta_0)\cdot P\cdot\sin\lambda \qquad (2.16)$$

In this: *t=0* taking that $r = r_0$ $\dot{r} = 0$ when we have, we find the initial condition for the movement of the fluff along the tooth.

$\ddot{r}(0) > 0$ the condition must be fulfilled and give:

$$\omega^2 r_0 - \omega^2 R\cos\alpha - g(\sin\alpha - f\cos\alpha) + \overline{P}\sin\lambda > 0 \qquad (2.17)$$

From this, it is possible to choose an angle that fulfills *t=0* the condition of the movement α of the muzzle along the tooth. We estimate the momentum $\overline{P} >> 1$ at a small mass, and *t=0* the momentum at corresponds to the inequality $\sin\lambda > 0$ of the motion condition.

In this case, $0 < \lambda < \pi$ the condition is fulfilled. $h_0 << R$ while $\lambda \approx \alpha$ can be assumed. Then assuming the equation (2.26) is, $\alpha = \pi - \overline{\alpha}$ we obtain:

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

$$\omega^2 r_0 + (\omega^2 R + fg)\cos\overline{\alpha} + (\omega^2 R - \overline{P})Sin\alpha > 0 \; (2.18)$$

In this equation we introduce the following definitions.

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

$$q = \frac{\omega^2 r_0}{\sqrt{(\overline{P}-g)^2 + (\omega^2 R - fg)^2}} \qquad (2.19)$$

$r_0 < R$ if we get the equation with respect to α

$$\sin\overline{\alpha}\cos\beta - \cos\overline{\alpha}\sin\beta < q \qquad (2.20)$$

(2.29) using the inequality of the slope angle of the Saw tooth from this inequality:

$\sin(\overline{\alpha} - \beta) < q$ from this $\overline{\alpha} < \beta + \arcsin q$ or:

$$\overline{\alpha} < \overline{\alpha}_0 = \arccos\frac{\overline{P} - g}{\sqrt{(\overline{P}-g)^2 + (\omega^2 R - fg)^2}} + \arcsin\frac{\omega^2 r_0}{\sqrt{(\overline{P}-g)^2 + (\omega^2 R - fg)^2}} \qquad (2.21)$$

$\alpha = \pi - \overline{\alpha}$ considering the connection $\alpha > \alpha_0 = \pi - \overline{\alpha}_0$.

$1 - \omega \approx 78.5c^{-1}$, $2 - \omega \approx 104.67c^{-1}$, $3 - \omega \approx 157c^{-1}$,

$4 - \omega \approx 314c^{-1}$, $\alpha_0 -$ saw tooth slope angle

Figure 3 lists α_0 for two different exponents of radius R (m) with respect to $\overline{P} = P/mg$, the bond taken when considering $f = 0.3$ $r_0 = 1$мм at different exponents of angular velocity $\omega(c^{-1})$ *of R=140, R=160.*

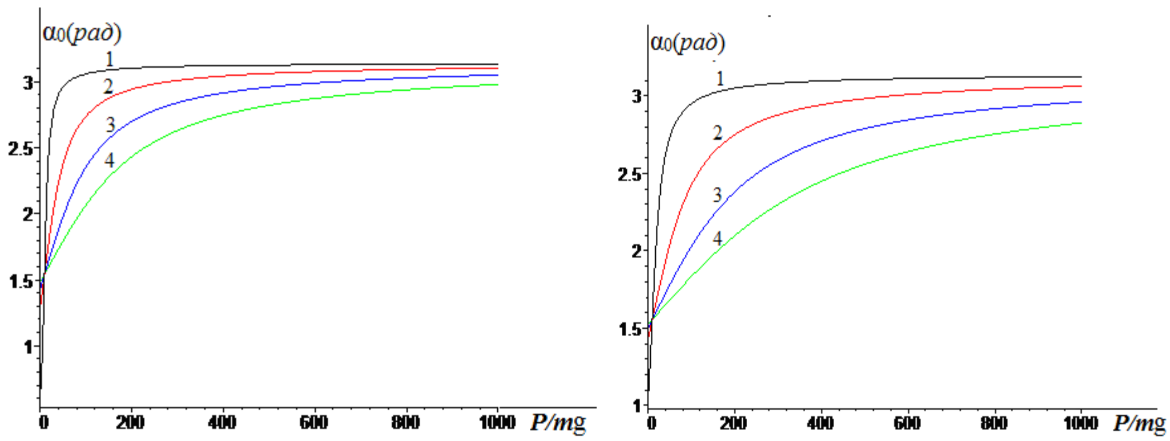


Figure 3. The impact of the Saw tooth on the torque at various indicators of angular speed:

It has been observed that as the absorption of air from the graph increases, it approaches a rapid increase in small values of R and a constant in its short values. When the Radius *R* increases, *α* the growth intensity of the decreases. (2.16) the equation states that the law of change in the airspeed being given by a ventilator in terms of pressure is defined.

From this link, it is possible to select the torque separator saw cylinder speed indicators and the angle of the Saw tooth, as well as the rational values of the dimensions of the torque removal pipe, from which an additional winch is mounted.

(2.16) using the equation the dependence of the movement of the air velocity being given through the ventilator on pressure is shown in Figure 3.

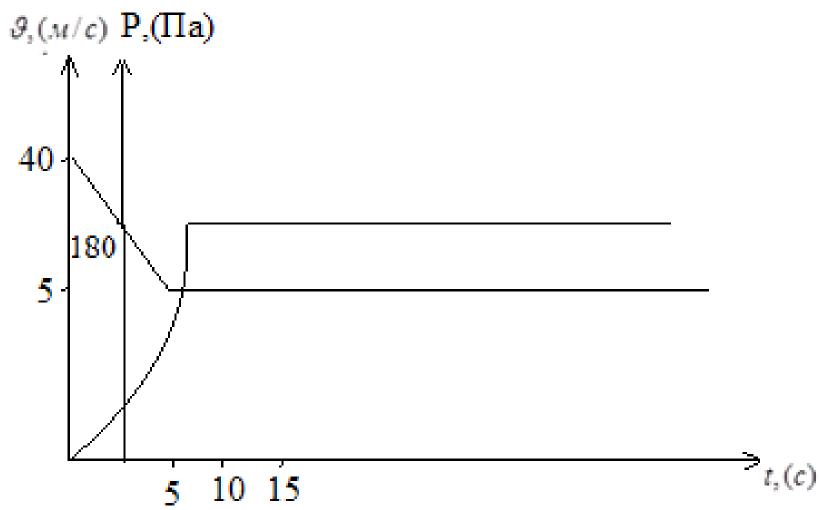
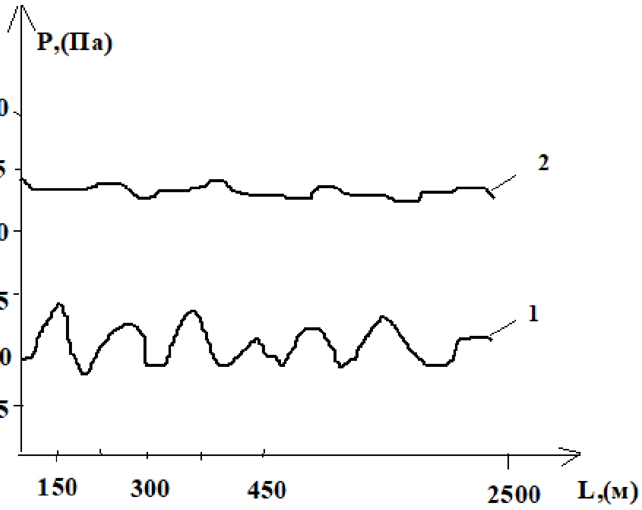


Figure 4. Dependence graph of air velocity and pressure being supplied to the linter via a ventilator

We can see in the results of a scientific study conducted that the air velocity given to the linter by the fan is variable in time, ensuring that this figure 4 shows the consistency of the pressure distribution over the length of the soplo. Because in the aerodynamic system proposed for the length of the soplo on each linter, the static pressure increases.



1-current aerodynamic Mode, 2-proposed aerodynamic mode

Figure 5. Distribution graph of the pressure of air on the length of the nozzle, which is supplied to the linter through the Winteler

Using the additional fans being recommended, the stream of air in front of one linter allows you to send the fluxes separated from the pollen in the linter to the suction pipe by completely removing them from the Saw tooth (figure 5).

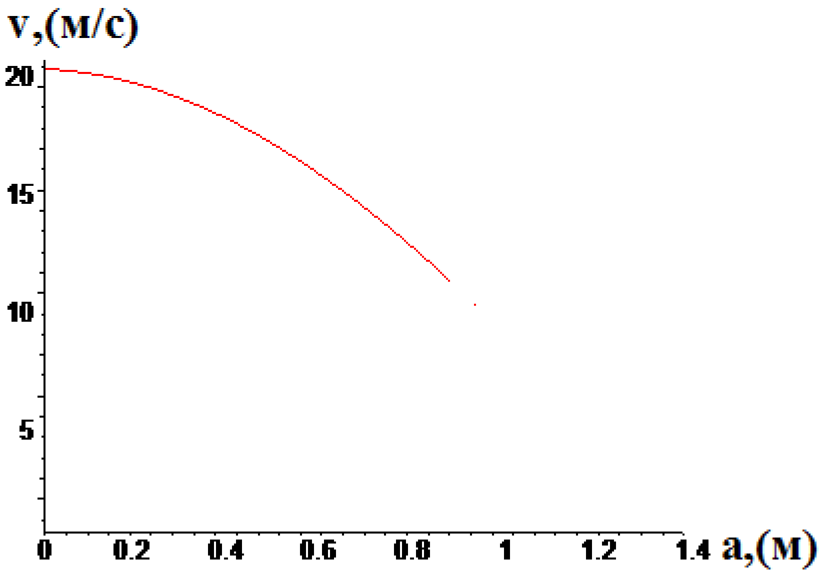


Figure 6. A graph of the speed of the air pipe at its value *V=20m/s* using a fan on a single linter

The graph in Figure 6 shows the proposed aerodynamic mode, i.e. a fan is mounted on an aloxis to a Har one linter, and the hole in the chamber is planked. From the graph, it can be seen that the speed of the Xava will not have a fixed value, but the main thing is that the static pressure in the air chamber will remain the same amount over the entire length of the chamber.

REFERENCES

1. Д.У. Мадрахимов, Ф.З.Мамадалиев Линтерлаш жараёнида момиқни арра тишидан ечиб олиш ва пневматик қувурларда ташиш тизимларини такомиллаштириш бўйича изланишларни таҳлили.
2. Mamadaliev Farkhodbek-Methodical methods of preparing and conducting experiments with an improved device for removing and transporting fluff in a linter machine
3. Паспорт пильного линтера 5ЛП. Ташкент. ТГСКБ по хлопкоочистке. 1981.- 18 с.
4. Ракипов В.Г., Назиров Р.Р. Пахтани қуритиш учун қуёш нури энергиясидан фойдаланиш усулини илмий ўрганиш. Мавзу 0902. ИТҲ. “Пахтасаноат илмий маркази” ОАЖ”. Тошкент. 2010 28 б.
5. “Paxtasanoatilm” ОАЖ, “Жин-тола тозалагич ва линтер батареялари комплексларини оптимал аэродинамик режимларига тавсиянома ”, Тошкент, 2002. 25 б.
6. O’zDst 596:2016. Семена хлопчатника технические. Технические условия.- Ташкент, 2016.- 6 с.
7. Покрас В.М., Максудов И.Т., Кордуб Н.В. //Хлопковая промышленность. №3. 1976. Ташкент. 16-18 с.
8. Максудов И.Т. и др. Изыскание путей уменьшения количества воздуха в существующих системах пневматического транспортирования линта с выдачей рекомендации. НТО ЦНИИХпрома. Ташкент. 1977. 81 с.
9. Расулов А. ва бошқалар.Жин-тола тозалагич ва линтер батареялари комплексларини аэродинамик режимларини ўрганиб чиқиш ва такомиллаштириш бўйича амалий тавсиянома бериш. ИТХ. “PAXTASANOATILM” ОАЖ. Тошкент. 2002. 48 б.
10. Жин-тола тозалагич ва линтер батареялари комплексларини оптимал аэродинамик режимларига тавсиянома. “PAXTASANOATILM” ОАЖ. “Ўзпахтасаноат” уюшмасини бошқарув раисининг биринчи муовини Дьячков В.В. томонидан тасдиқланган. Тошкент. 2002. 25 б.