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Mathematical Modeling Of the Technological Processes Original Processing Of Cotton

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ABSTRACT: Republic of Uzbekistan produces more than 3000000 tons of cotton per year, 800000 tons of this harvest is a high quality fiber which is exported to abroad. One of good reason, and global task of production high quality fibre, it is value and request from other countries. A main point of taking high quality fiber depends on previous cultivation. Previous cultivation consists of following technical processes:

1. Cotton transportation from bale with help of air through the pipes. In this process, there is considered three - dimensional transition of various particles of cotton in air streams. In the scientific article, it is theoretically investigated the movement of particles of a cotton in air streams.
2. On factories the cotton is transported through pipelines by means of an air stream. Cotton getting to a stone catcher is exposed to percussive loading. In this technological process**,** problems of preservation of natural quality of cotton and seeds are considered.
3. Squashing air from cotton in separator. In this process, a modification air pressure depends on denseness of a stream of cotton. The movement of cotton and air is considered in the form of two component medium.
4. Cotton getting to the chamber of the gin, through teeth of a saw and kolosnic, received considerable loads. Such loads often damage and break natural qualities of fiber. Here, research is conducted about interaction of cotton with saw cylinder, including dry and viscous friction cotton with saw.

KEYWORDS: Cotton, Clearing, Factor of Proportionality, Fiber, Gin, Linear Speed, movement, Mathematical Model, Friction, MAPLE.

1 INTRODUCTION

Primary processing of cotton consists of four main technological processes such as;

a) Transportation cotton by airstreams in pipe line.

b) Clearing of cotton from different admixtures, by means of stone-catch.

c) Division cotton from air stream in separation to camera.

d) To separate fiber from seed of cotton in gin.

Scientific article considers mathematical models of technological process of separation. Following outcomes are received:

- Optimal value of air speed of cotton transportation;
- Optimal value of elastic elements of quencher during the shock loading;
- Optimal condition of cotton gin with saw;

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1.1 FORMULATION OF THE PROBLEM

Revealing the strict regularities three-dimensional moving the different particles of cotton in airstreams required for increasing its transportation on base of the required mode.

This problem analytically is not solvable. Since moving of the cotton in flow of air has a complex nature.

We shall consider the general case of the moving the particles of cotton in airstreams, when the directing cosines of the air stream's speed is different from directing cosines of the flying particles cotton's absolute speed.

1.2 THE MATHEMATICAL MODEL OF THE PROBLEM

When scheduling the system of the differential equations of the cotton moving in three-dimensional space we shall take the following conditions:

a) The cotton presents itself like a material point with constant factor K_n (coefficient of flying) that insulated in flight;

b) The Resistance of surroundings is pro rata to square relative speed of cotton. The Lifting power that acting on cotton in air stream is perpendicular to its vector of speed is zero;

c) The Air stream in the area of investigation has constant vector of speed by size and direction. The Initial condition $t = 0$, the initial absolute speed of cotton is known;

1.3 THE METHODS OF DECISION OF THE PROBLEM

The Scheme of the cotton's moving in the space of the coordinate's $O^1\mathrm{XYZ}$ .The beginning of $\left(O^1\right)$ which moves together with the airstreams at the speed of - u (fig.1).

The following indications are incorporated:

u -the speed of the air stream; $\cos\theta_B, \cos\delta_B, \cos\gamma_B$ - the directing cosines of the vector of air stream; $u_{\mathrm{X}} = u\cos\theta_B, u_{\mathrm{Y}} = u\cos\delta_{|B}$, $u_{\mathrm{Z}} = u\cos\gamma_B$ -the projections of the vector of speed to the air stream on not rolling axis of the coordinates OXYZ ;

S_a And S_r - absolute and relative cotton, moving of cotton, in coordinate OXYZ and $O^1\mathrm{XYZ}$;

v_a And v_r - absolute and relative velocity of cotton tangent to cottons S_a and S_r ;

The Equation of the moving of cotton in vector form, on principle Dalambera has a following type:

$$m\vec{a} + \vec{G} + \vec{R} = 0 \quad (1)$$

Let's write this equation in projection on axis still coordinate OXYZ system has following type:

$$-m\ddot{\mathrm{X}} + R_{\mathrm{X}} = 0,$$

$$-m\ddot{\mathrm{Y}} + mg + R_{\mathrm{Y}} = 0 \ , \quad (2)$$

$$-m\ddot{\mathrm{Z}} + R_{\mathrm{Z}} = 0$$

Here; $R_{\mathrm{X}} = -R\cos(v_r, \mathrm{X}),\ R_{\mathrm{Y}} = -R\cos(v_r, \mathrm{Y}),\ R_{\mathrm{Z}} = -R\cos(v_r, \mathrm{Z}).$

$R = mK_n|v_r|^2$ - a reactions of the air ambience on moving cotton.

If begin mobile rolling coordinates point O^1 moves in longitudes vertical plane XOY at the speed of u, that absolute and relative motion flying cotton are bound by following expressions:

$$\mathrm{X} = ut\cos\theta_B - \mathrm{X} \ ; \qquad \ddot{X} = - \ddot{x}$$

$$\mathrm{Y} = ut\sin\theta_B - \mathrm{Y} \ ; \quad \ddot{Y} = - \ddot{y} \qquad (3)$$

$$\mathrm{Z} = z \ ; \qquad \ddot{Z} = \ddot{z}$$

Then: $v_{rx} = -\dot{x}$, $v_{ry} = -\dot{y}$, $v_{rz} = \dot{z}$. (4)

Equation (2) is converted to type:

$$\ddot{\mathrm{X}} = -K_n v_r \dot{x}$$

$$\ddot{\mathrm{Y}} = g - K_n v_r \dot{y} \qquad (5)$$

$$\ddot{\mathrm{Z}} = -K_n v_r \dot{z}$$

1.4 THE ANALYSIS'S DECISION

The System equation (5) with corresponding to initial condition, presents the problem Koshi . (5) - a system differential equation is solved numerically on program MAPLE - 9.5. They are received corresponding to graphs. On the **graphs** are shown change moving and speeds of cotton on directions OX, OY, OZ. In stream air, change of relative movement of cotton $x(t), y(t), z(t)$ and also speeds are result in Fig1.2 and Fig1.3 (where t-time).

Character of change value moving on a direction – $x(t)$, trial to schedules 2, 3 times expired from value at (t) and $z(t)$.

Such change value of relative movement of a clap(cotton), is observed in real physical processes. At $t > 1$ second, relative moving on all directions becomes stationary. That is not dependent on time-t. if to analyze character change relative speeds of a clap(cotton) $V_x(t), V_y(t), V_z(t)$ to awake it is visible, those are a) Values relative speeds $V_x(t)$ confluence of time- t, decreases. Equal to zero, it means that at $t > 1$ sec. differences value absolute speeds of air and a cotton finds room. Movement of a cotton in streams of air to pass to a stationary mode.

b) It is similar to $V_x(t)$ change relative speeds- $V_x(t)$ eventually-t aspire to zero.

c) Value relative speeds – $V_y(t)$ up to 1 sec. Increases, to pass to a stationary mode further. This procession in more full really reflects movements of cotton in streams of air.

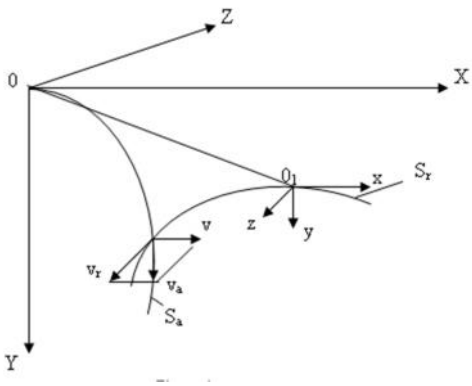

Figure 1.1

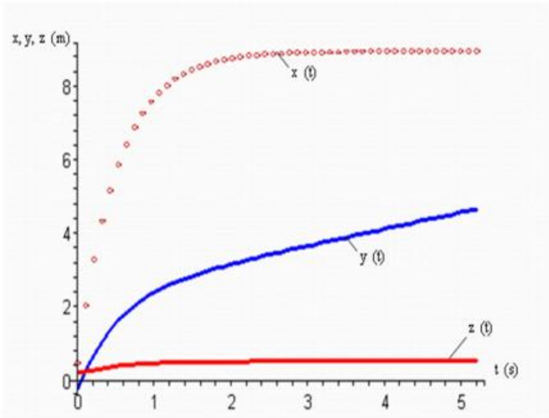

Figure 1.2

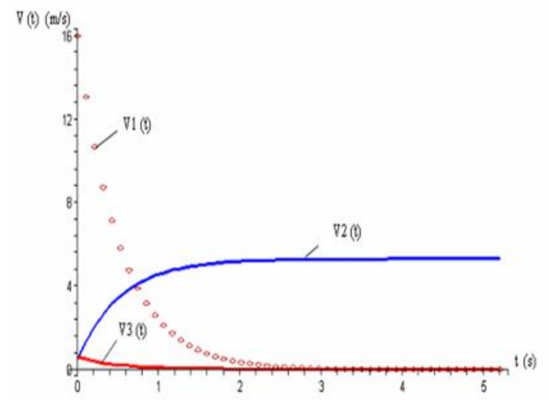

Figure 1.3

2 THE WAYS OF THE DETERMINATION STRIKING POWER, ON COTTON, STONE-CATCH

2.1 FORMULATION OF THE PROBLEM

On the plants of cotton, the cotton is transported through pipe line by means of air stream.

Here different external impurities (small and bigger impurities, small stone and external belongings) together with cotton moves with help of airstream. Heavier impurities are separated from cotton and got into stone-catcher.(fig.2.1).

The Cotton, falling into camera stone-catch, is subjected to striking load in point A.

As a result of blow cotton is recoiled from point B and rises upwards on camera. Under the action of striking load, the qualities of the cotton falls, as well as partly occur the damages of the seed.

In this technological process, conservation natural quality of the cotton and seed of cotton are actual problem. So in camera stone-catch is installed plate arts, absorb striking load. The Plate arts have in point "C" has springs of the extinguisher of striking power.

2.2 THE MATHEMATICAL MODEL OF THE PROBLEM

Let cotton by stranger's primate with weight $-m_0$ at the speed of - v, strikes in point B on internal wall stone-catch. Because of elastic of the cotton, in point to occur the recoil, and under the action of aerodynamic power of the air cotton having determined volume, comparatively point of the osculation "B", revolves to account of the rotation, in cotton to occur the process a loosening. As a result, different admixture heavier than cotton is lowered downwards pocket of stone-catcher. The cotton under action of aerodynamic power moves in stone-catcher's chambers.

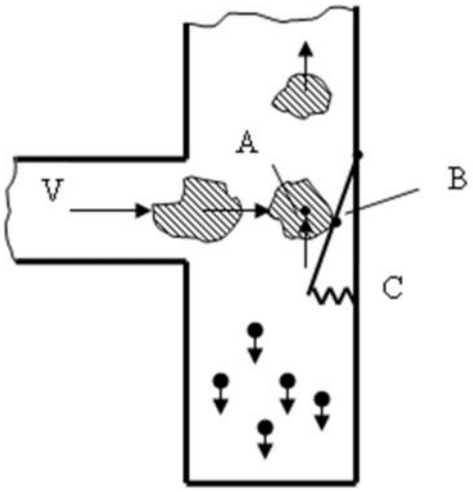

Figure 2.1

2.3 THE METHODS OF THE DETERMINATION OF DYNAMIC POWER

In the first approximations, the striking load is considered as a dynamic power, appearing between cotton and surfaces of the camera.

Then

$$P_d = K_d P_{st} \qquad (1)$$

K_d - a dynamic coefficient of the cotton, P_{st} - a steady-state load, acting on cotton in airstreams.

The Dynamic coefficient of the cotton - K_d -is defined under the law conservations to energy by following formula:

$$K_d = 1 + \sqrt{1 + \frac{v_h}{g\Delta_{st}\left(1 + \frac{m_1}{m_2}\right)}} \qquad (2)$$

Here: v_h - a velocity of the cotton (m/s);

g- Velocity of the free fall (m/s^2);

m_1 - a weight of the cotton (kg);

m_2- weight of the extinguisher (kg);

Δ_{st} - a steady-state deformation (m).

Steady-state deformation consists of two composed: Δ_1 - a Steady-state deforms the spring and Δ_2 - a Steady-state deforming the plate.

They are defined by following formula:

$$\Delta_1 = \frac{8D^3 n}{cd^4}; \ \Delta_2 = \frac{pl^3}{48EI_y}; \qquad (3)$$

Here: D- big diameter of the spring; d- diameter of the material of the spring; n- number whorl springs; resilience coefficient of the material of the spring; l-length of the plate; l_y the moment to inertias section plates; E- module to elasticity of the material of the plate.

Steady-state power is P_{st} defined by formula:

$$P_{st} = m_1 g + m_2 g \quad (4)$$

m_1 -a weight of the cotton, m_2 - a weight of the plate.

2.4 THE ANALYSIS RESULT

The Analysis studies are brought below in table № 1.

Table 1.

№	D mm	d mm	N	$v_h\ (\frac{m}{s})$	$\Delta_{st}\ \Delta_{pr}$	c	$\Delta\ K_d$	P_d(N)	P_{st}
1	30	3	10	8	0,38	1,5	2,75	31,51	71
2	30	3	10	10	0,38	1,5	3,06	35	71
3	30	3	10	15	0,38	1,5	3,88	44,38	71
4	30	3	10	20	0,38	1,5	4,74	54,23	71

Thereby, at speed v_h =15 m/s.

To account of the extinguisher, dynamic power acting on cotton, 1,5 times decreases, for critical load positively influences upon conservation seed of cotton. From table №1 and under the formula (2) and (3) it is possible to judge; shock force to cotton weights basically depends in the following parameters:

- From weight of cotton and plate seed;
- From speeds of cotton at with pressure;
- From static deformations of a plate.

In tables №1 it is resulted dependents of speed of a clap(cotton) and factor of kg at various their value. At speed $V_x(t) = 15\,m/s$, force static pressure between a clap(cotton) and a plate, it is equal 71 N. force dynamic pressure 44,4 N .

When speeds of a cotton changes $S = 20\,m/s$, force dynamic pressure changes in intervals 31,5-54,2 N . From the formula (2) and (3) it will be chosen optimum parameters of the spring, allowing to reduce values force of impact of a cotton to the plates.

3 THE DETERMINATION PRESSURE AIR, IN SEPARATOR SELECTED FROM COTTON

3.1 FORMULATION OF THE PROBLEM

In separation process air from cotton, as well as change the pressure of the air on length of the separator, has actual importance. Since, change pressure from air, it depends capacity separation cotton from air. When moving the cotton and air, it presents two component of the ambience.

3.2 THE MATHEMATICAL MODEL OF THE PROBLEM

Let velocity of the air when entering to separator has importance –v_0; and pressure –P_0; S_0-area cross-section in point 0-0 entering pipe line to camera of the separator (fig.1).

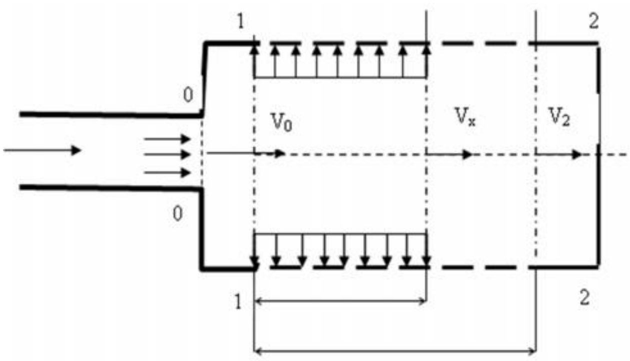

Figure.3.1

The Main parameters of the ambience:

ρ_1 -density of the air, ρ_2 - density of the cotton, l_0 - length worker cameras of the separator, W_1- volume of the cotton, occupying in cameras, W_2-volume of the air, occupying in camera,

$\beta_0 = \frac{w_1}{w_1 + w_2}$ - a three-dimensional coefficient to concentrations of the ambience;

Then density of the ambience - ρ, in worker to camera there is variable value, hanging from coefficient β_0, section- X_1, density ρ_1 and ρ_2; on formulas:

$$\rho_X = \beta\rho_1 + (1-\beta)\rho_2 \quad (1)$$

Here $\beta = \beta_0\left(1 - \frac{X}{l_0}\right)$;

3.3 The Methods decision

In section 1-1 velocity of the air – v_1, area cross-section camera – F_1, consumption of the air - Q, density of the ambience - ρ, pressure of the air –P_1, area useful section netlike part of camera – F_0, Then

$$v_1 = v_0 \frac{S_0}{F_1} \quad (2)$$

The Difference pressure air in this section will:

$$P_1 - P = \rho\, v_1^{\,2} \frac{S_0}{F_1}\left(1 - \frac{S_0}{F_1}\right) \quad (3)$$

The Consumption of the air - Q;

In section $X - X$. The Consumption of the air;

$$Q_x = Q - 2Q_0 \frac{X}{l_0} \quad (4)$$

The Velocity of the air; $v_x = \frac{Q_x}{F_1}$ (5)

Change pressure P_x - is defined on formula;

$$P_x = P_0 + \rho_x {v_0}^2 \left(\frac{S_0}{F_1}\right)^3 \left(1 - \frac{S_0}{F_1}\right) + \frac{\rho_X Q^2}{F_1^2} \left[2\frac{X\alpha}{l_0} - \left(\frac{X\alpha}{l_0}\right)^2\right] \qquad (6)$$

Here $\alpha = \frac{Q_0}{Q}$;

Under the law conservation amount motion is defined dynamic pressure of the ambience.

$$P_x = p_0 + \rho_X {v_0}^2 \left(\frac{S_0}{F_1}\right)^3 \left(1 - \frac{S_0}{F_1}\right) + \rho_X {v_X}^2 \left[2\frac{X\alpha}{l_0} - \left(\frac{X\alpha}{l_0}\right)^2\right]$$

Here: $v_X = \frac{\left(Q - \frac{2Q_0 X}{l_0}\right)}{F}$; the velocity of the ambience in section $x - x$;

$v_m = \frac{Q_0}{F_0}$ - a velocity of the air, leaving on netlike area of the separator.

3.4 THE ANALYSIS RESULT

In graph it is brought nature change the ambience pressure $P(x)$; the consumption of the air- $Q(x)$; the velocities - $v(x)$ on lengths of the camera x; they are received on program MAPLE-9.5.We can see high pressure forces at graphics when consent ration environment of big value. Dynamic pressure force is abated among the separation length in general hyperboles law. This process is suitable to change law of dynamic pressure. In schedules Fig 3.2 reduce change of dynamic pressure – Pd on length of a separator. Schedules correspond (meet) to values of concentration among "a cotton - air" $-b$. Here values b changes in intervals 0.5 -1. Character of change – Pd on length, shows reduction about increase value-e. Pressure $-Pd$ at $b = 0.9 - 1$ values insignificantly, at 0.5-0.7 values is title bit more, when $e < 0.4m$. Start $e < 0.4m$, values Pd, the hand aspires to zero.

It means that cotton are divided from air, to pass to the following process. Such law, proves to be true in schedules Fig 3.5 where speed of air decreases with increase length of a separator. To such images, separation process begins at $e < 0.3$ workers of the chamber.

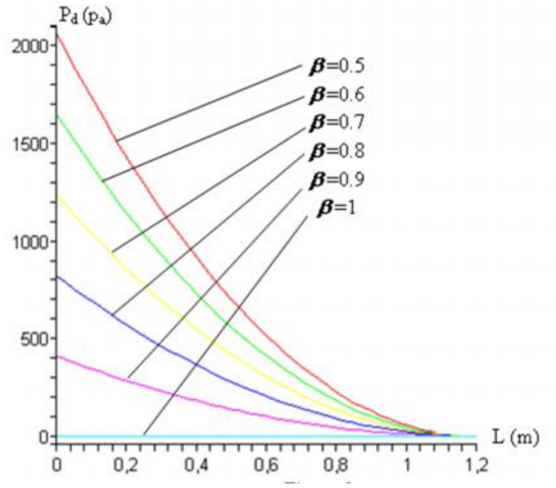

Figure 3.2

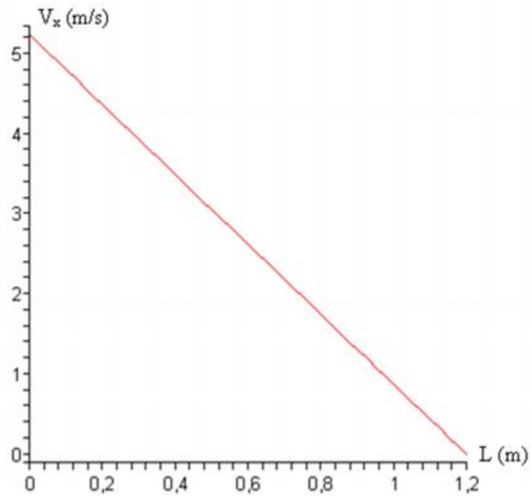

Figure 3.3

4 THE MATHEMATICAL MODELING OF THE STRIKING PROCESS OF THE LEAFLET IN GINNING POINT.

4.1 FORMULATION OF THE PROBLEM

The Cotton leaflets, falling into camera of the din, contiguity saw teeth passion and kolosnic, get the striking loads. Such loads often draws itself damage seed and breach natural quality fibred of cotton.

Sometimes, to account faulty bare seed from fibred, bring about increase short fibre. Such fibred negatively affect influence act to the following technological process knitted material. On this, study of the nature of the striking loads on seed from fibred, has actual importance.

4.2 MATHEMATICAL MODELING OF THE PROBLEM

We Research the striking process of the leaflet, enthralled teeth of dust on surfaces kolosnic (fig.4.1).

Ginning process happens in a point A, where the cotton hits on the surface of kolosnic. [3],[4].

In this process it is considered friction between cotton and kolosnic.

At calculation of such system by count slant blow use two hypotheses, conditionally named: viscous and dry friction at slant blow.

4.3 THE METHODS OF THE DECISION

We shall consider the leaflets of the cotton as material point. It is weight-m, giving under corner - α on still plane kolosnic.

Before striking and after striking to velocities of the leaflet, accordingly v and v_1 .

Then forming on v v_1 axis's $A\mathrm{X}$ and $A\mathrm{Y}$ will:

$$v_{\mathrm{X}} = v\sin\alpha \,,\ v_{1\mathrm{X}} = v_1 \sin\beta$$

$$v_{\mathrm{Y}} = v\cos\alpha \,,\ v_{1\mathrm{Y}} = v_1 \cos\beta \qquad (1)$$

According to both hypothesis (viscous, dry) of the normal component $v_{1\mathrm{X}}$, $v_{1\mathrm{Y}}$ - a velocities before and after the blow are bound by correlation:

$$v_{1\mathrm{Y}} = -kv_{\mathrm{Y}}$$

$$v_{1\mathrm{X}} = (1-\lambda)v_{\mathrm{X}} \qquad (2)$$

Where λ - a coefficient viscous friction blow. The Equation (1) and (2) installs linear relationship between before striking and after striking component of the velocities.

According to (3) tangential formed striking pulse - $m\lambda v_{\mathrm{X}}$ do not hang from value its normal forming, and is defined by coefficient - λ , which hang from characteristic of the surfaces kolosnic and leaflets. Also relative air speed of sides, like that, as power of the resistance under viscous friction, pro rata velocities moving the leaflet.

On hypothesis "conditional viscous friction" corner reflection leaflets from kolosnic - β is defined following dependency.

$$tg\beta = \frac{1-\lambda}{K} tg\alpha \qquad (3)$$

On hypothesis "conditional dry friction" tangential forming striking pulse proportional its normal forming. In this case coefficient to proportions is a coefficient - f dry friction:

$$v_{1x} - v_x = \pm f\left(v_{1y} - v_y\right) \qquad (4)$$

The Sign $\langle + \rangle$ and $\langle - \rangle$ is chosen opposite sign v with provision for that that striking interaction not always bring about reduction of the relative velocity of the moving the leaflet on planes kolosnic.

In this case corner reflections - β is defined by following dependency.

$$tg\beta = \frac{1}{K} tg\alpha - f\left(1 + \frac{1}{K}\right) \qquad (5)$$

If it is executed condition $tg\alpha < f(1+K)$ (6)

That leaflet on planes does not slither but is occurred the recoil of the motion.

In such case gin capacity decreases.

At condition $$tg\alpha > f(1+K) \quad (7)$$

Capacity of the genie increases on first hypothesis tangential and normal forming power of the pulse is defined by dependency:

$$S_T = m(2-\lambda)v\sin\alpha \quad (8)$$
$$S_n = -m(1+K)v\cos\alpha$$

On the second hypothesis:

$$S_T = mv\sin\alpha f\left(K\frac{\cos\beta}{\cos\alpha}-1\right) \quad (9)$$
$$S_n = -mv\cos\alpha f\left(K\frac{\cos\beta}{\cos\alpha}-1\right)$$

4.4 THE ANALYSIS'S RESULT

If will consider the second a hypothesis in formulas (5) it is necessary to accept $V_x = 0$. In that case, cotton does not delete on a surface teeth of saw to occur dirt from a teeth of a saw. And force of friction between a cotton and a tooth is absent. Such case dinning process precedes the second hypothesis cotton hits on teeth of a dust under a corner-1 to horizon. Thus the corner of reflection-b changes depending on. Character of dependence 1 from a corner $-b$ reduce in graphic Fig4.2. Here factor $K = 0.5$.

Speed of a cotton on shock process it equal -$V1$, and after impact $-V$. Their changes depending on a corner -1, reduction in Fig4.3 to mean, on hypothesis conditional “viscous friction”, dining process to occur more accelerated. Branch a fiber from seeds comes faster, then on a hypothesis of “Dry friction”.

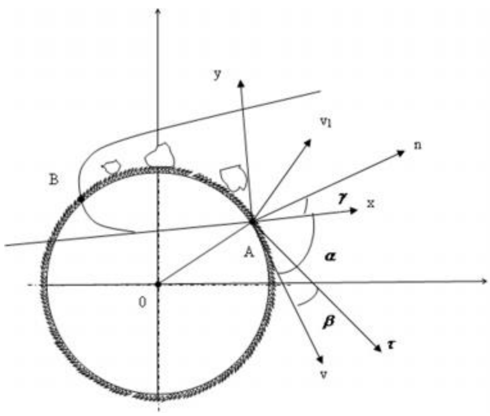

Figure.4.1

On graph are brought change the corner of the reflection β in dependency α under "conditionally viscous" hypothesis's.

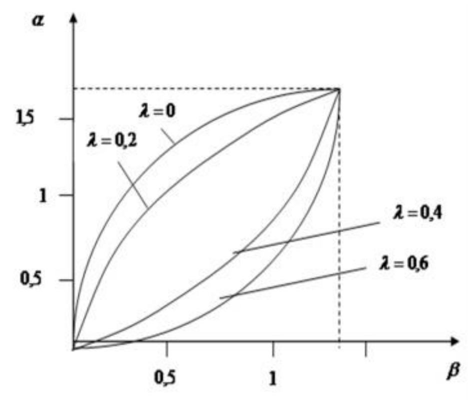

Figure.4.2

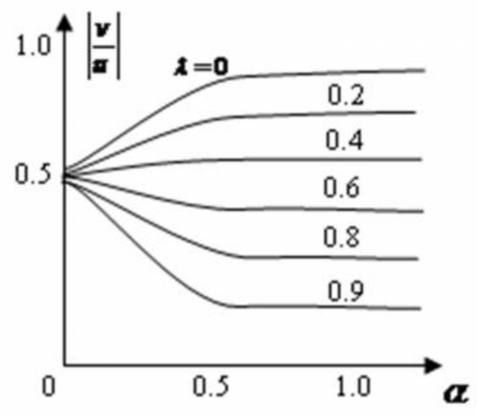

Figure.4.3

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