THEORETICAL ANALYSIS OF PROCESSING OF WOOL FIBERS UNDER THE INFLUENCE OF MOVING ROLLERS

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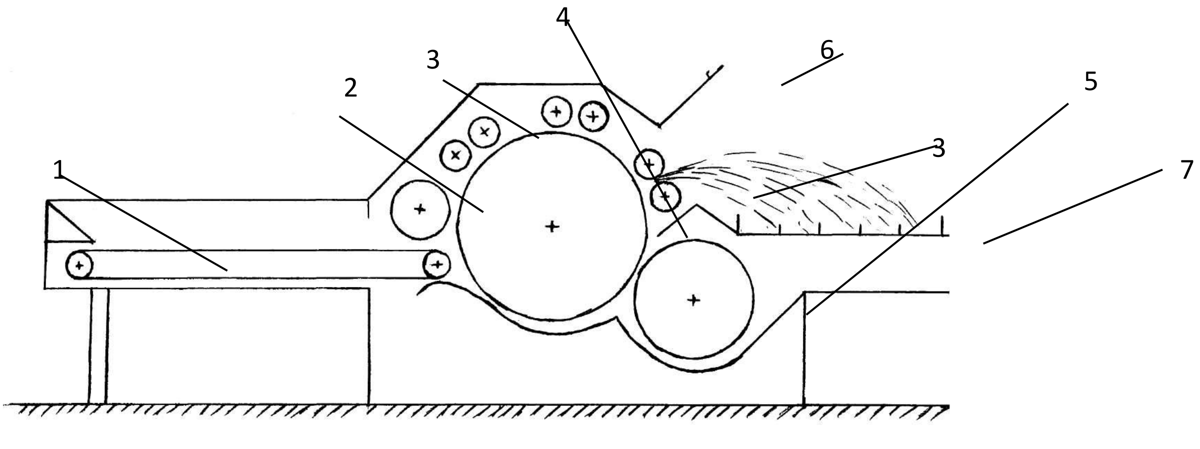
Abstract: *in this article, the analysis of behavior under the influence of pinching rollers of Karakul and Jaydari sheep bred in home and pasture conditions was studied.*

Key words: rollers, plant residues, wool fibers, combing, length of wool fibers, mass, fiber, control chart.

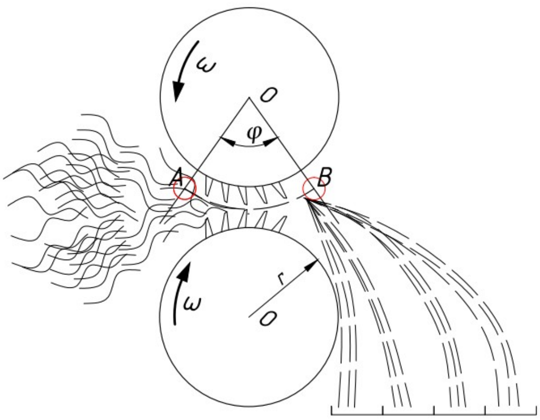
The theoretical analyzes of wool fiber separation under the effect of a pinching roller are presented.



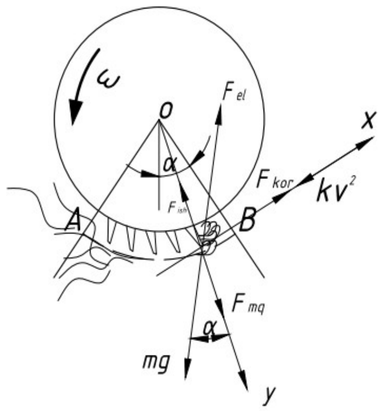
1 – picture. The scheme of the "Pinch Lubrication" machine is shown.

in this case: 1- supply tape, 2- fiber straightening cylinder, 3- pinching rollers, 4- main drum, 5- separation drum, 6- cover, 7- test area.

The issue of correct selection of transmission distances depending on the length and mass of wool fibers under the influence of wool fiber pinching rollers is presented. According to the theory, the role of air in separating the wool fibers along the surface under the influence of the pinching rollers is considered to be important, that is, separation of separated wool fibers under the influence of pinching rollers under the influence of air is aimed at preventing the separation of separated wool fibers into the stream and thereby increasing the efficiency of cleaning. When sorting wool fibers mainly according to their diameters and masses, wool fibers are sorted into the following wool fibers: 1-fine fiber wool, 2-medium wool, 3-half-coarse wool, 4-coarse wool, the lengths of these wools are in the range of 50-100 mm.



2-picture. Scheme of the effect of forces the pinchingroller on wool fibe



3-picture. Scheme of the affecting the separation of wool fibers

$F_{m.q}$ - centrifugal force, $k \cdot \vartheta^2$- air resistance, mg-weight, F_{ish}- friction force. $F_{m.q} = m \cdot \omega^2 \cdot l$; $F_{ish} = f \cdot N = f \cdot m \cdot g$; ω- angular speed of the pinching roller; l- pile length; m- mass of wool fibers, $\mathrm{F}_{кор} = 2 \cdot m \cdot \omega \cdot \dot{x}$- cariolis force, f- coefficient of friction (between wool fibers and pile surface).

From the above given figure-3, φ the angle of coverage of the pile acting along the arc $\breve{AB}$ and we will consider the theory of the transmission of pinching rollers as a result of friction between fibers when separating wool fibers, firstly, we present the differential equation along the OX arc under the influence of a roller that cuts wool fibers. [1]

$$\mathrm{m} \cdot \ddot{\mathrm{x}} = F_{kor} - m \cdot g \cdot \sin\alpha + k \cdot \vartheta^2$$

$$\mathrm{m} \cdot \ddot{\mathrm{x}} - 2 \cdot m \cdot \omega \cdot \dot{x} = k \cdot \vartheta^2 - m \cdot g \cdot \sin\alpha$$

$$\ddot{\mathrm{x}} + 2 \cdot \omega \cdot \dot{x} = \frac{k}{m} \cdot \vartheta^2 - g \cdot \sin\alpha \quad (1)$$

(1) We determine the homogeneous and particular solutions of the second-order homogeneous differential equation.

We look for a homogeneous part in appearance. $\dot{x}_1 = \lambda e^{\lambda t}, \ddot{x}_1 = \lambda^2 \cdot e^{\lambda t}$ we insert this expression into equation (1). $\lambda^2 + 2 \cdot \omega \cdot \lambda = 0$ $\lambda_1 = 0$; $\lambda_2 = -2 \cdot \omega$;

$$x_1 = c_1 \cdot e^{\lambda_1 t} + c_2 \cdot e^{\lambda_2 t}$$

$$x_1 = c_1 + c_2 \cdot e^{-2 \cdot \omega \cdot t} \quad (2)$$

Identical solution

$$x_2 = A \cdot \cos\omega \cdot t + B \cdot \sin\omega \cdot t \quad (3)$$

is found in this way.

$$\dot{x}_2 = -A \cdot \omega \cdot \sin\omega \cdot t + B \cdot \omega \cdot \cos\omega \cdot t;$$

$$\ddot{x}_2 = -A \cdot \omega^2 \cdot \cos\omega \cdot t - B \cdot \omega^2 \cdot \sin\omega \cdot t;$$

we put the determined figures into equation (2). $\alpha = \omega \cdot \mathrm{t}$

$$-A \cdot \omega^2 \cdot \cos\omega \cdot t - B \cdot \omega^2 \cdot \sin\omega \cdot t - 2 \cdot A \cdot \omega^2 \cdot \sin\omega \cdot t + 2 \cdot B \cdot \omega^2 \cdot \cos\omega \cdot t = -g \cdot \sin\alpha \quad (4)$$

(4)we determine immutable A and B figures by equalizing $\sin\omega \cdot t$ and $\cos\omega \cdot t$ coefficients.[2]

$$\begin{cases} -A \cdot \omega^2 + 2 \cdot B \cdot \omega^2 = 0 \\ -A \cdot \omega^2 - 2 \cdot B \cdot \omega^2 = -g \end{cases}$$

$$A = \frac{g}{2 \cdot \omega^2}; \quad B = \frac{g}{4 \cdot \omega^2};$$

We put these outcomes into equation (3).

$$x_2 = \frac{g}{2\cdot\omega^2}\cdot\cos(\omega\cdot t) + \frac{g}{4\cdot\omega^2}\cdot\sin(\omega\cdot t) \quad (5)$$

The general solution of the movement of wool fibers along the OX axis under the influence of a pinching roller is expressed as follows.

$$x = x_1 + x_2 = c_1 + c_2\cdot e^{-2\cdot\omega\cdot t} + \frac{g}{2\cdot\omega^2}\cdot\cos(\omega\cdot t) + \frac{g}{4\cdot\omega^2}\cdot\sin(\omega\cdot t) + \frac{k}{m}\cdot\vartheta^2 \qquad (6)$$

From the expression (6), we use the initial and boundary conditions to determine the constants C1 and C2.

$(x)_{t=0} = 0;\ \ (\dot{x})_{t=0} = 0;$ is used.[3]

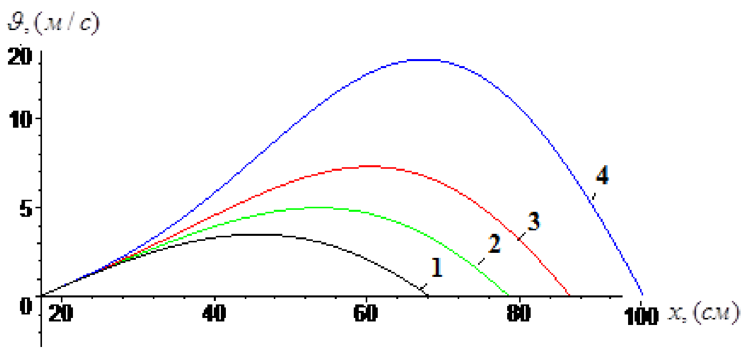
$$\begin{cases} C_1 + C_2 + \frac{g}{5\cdot\omega^2} + \frac{k\cdot\vartheta^2}{m} = 0 \\ -2\cdot\omega\cdot C_2 + \frac{g}{4\cdot\omega} = 0 \end{cases}$$

$$C_2 = \frac{g}{8\cdot\omega^2};\ C_1 = -\frac{5\cdot g}{8\cdot\omega^2} - \frac{k\cdot\vartheta^2}{m}$$

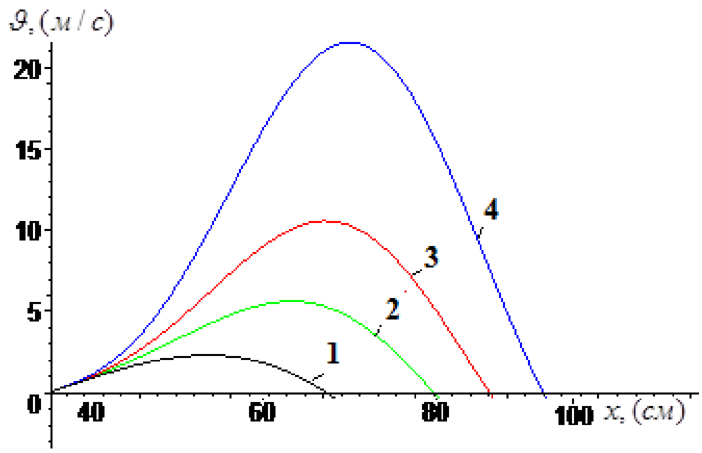
We put the determined C1 and C2 results into equation (6).

$$x = x_1 + x_2 = -\left(\frac{5\cdot g}{8\cdot\omega^2} + \frac{k\cdot\vartheta^2}{m}\right) + \frac{g}{8\cdot\omega^2}\cdot e^{-2\cdot\omega\cdot t} + \frac{g}{2\cdot\omega^2}\cdot\cos(\omega\cdot t) + \frac{g}{4\cdot\omega^2}\cdot\sin(\omega\cdot t) \quad (7)$$

From the equation (7), the dependence of wool fibers on the mass of wool fibers and the angular velocity of the pinching roller during the separation of wool fibers under the influence of the pinching roller was analyzed in graphics using the Maple program. The following parameters are included in the calculation: $g = 9{,}81\, м/c^2$; l=1,8mm; $\varphi = 80^0$; $\omega = 35\, c^{-1}$; m_1=0,023mlgr; m_2=0,023mlgr; m_3=0,014mlgr; $d_1 = 40\, mkm$; $d_2 = 35\, mkm$; $d_3 = 30\, mkm$; $d_4 = 25\, mkm$; ρ_{wool}=1.,28÷1,32gr/sm^3.



4-picture. The graph of transmission distances of masses of wool fibers separated under the effect of pinching roller in different m_1=0,023mlgr; m_2=0,023mlgr; m_3=0,014mlgr; ; m_3=0,008mlgr figures.



5-picture. Graph of distance transmission of wool fiber diametres separated under the effect of pinching roller in $d_1 = 40\,mkm; d_2 = 35\,mkm; d_3 = 30\,mkm; d_4 = 25\,mkm$; figures.

Conclusion: From the analysis of the above graphs, the movement along the OX axis under the influence of the pinching roller during the separation of wool fibers is given. In this case, the problem of sorting the separated wool fibers according to the fall distances under the influence of external forces acting on the wool fibers, the flight distances are given from the equation of dependence on the masses and diameters of the wool fibers.

It should be noted from the graphs that the transmission and sorting trajectories of wool fibers at different values of masses and diameters of their velocities are presented. Values of different masses of wool fibers m_1=0,023mlgr; m_2=0,023mlgr; m_3=0,014mlgr; ; m_3=0,008mlgr; and in different values of diameters $d_1 = 40\,mkm; d_2 = 35\,mkm; d_3 = 30\,mkm; d_4 = 25\,mkm$ values obtained.

We construct the differential equation of motion along the OY axis as a result of the action of the roller that cuts the wool fibers. [3]

$$m\ddot{y} = F_{m.q} + mg \cdot \cos\alpha - F_{is} - F_{e1} \qquad (1)$$

(1) we determine the homogeneous and specific solutions of the second-order inhomogeneous differential equation, the following external forces are generated under the influence of the roller that cuts the wool fibers.

$F_{m.q}$ - centrifugal force, mg-weight, F_{ish} -friction. $F_{m.q} = m \cdot \omega^2 \cdot l;$ $F_{ish} = f \cdot N = f \cdot m \cdot g;$ $F_{el} = k_1 \cdot \Delta x;$ - the elastic strength of the wool between the supply rollers, ω - angular velocity of the idler shaft ; l -pile length; m- mass of wool fibers , f - coefficient of friction [4]

$$m \cdot \ddot{y} = m \cdot \omega^2 \cdot l + m \cdot g \cdot \cos\alpha - m \cdot g \cdot \sin\alpha - \mathrm{k}_1 \cdot \Delta x \qquad (2)$$

(2) divide both sides of the expression by the mass m.

$$\ddot{y} = \omega^2 \cdot l - \frac{k_1 \cdot \Delta x}{\mathrm{m}} + g \cdot \cos\alpha - f \cdot g \cdot \sin\alpha \qquad (3)$$

(3) expression $\vartheta = \omega \cdot l \Rightarrow \omega = \frac{\vartheta}{l} = \frac{\dot{y}}{l}$ we put this equality in the above expression.

$$\ddot{y} - \frac{1}{l} \cdot \dot{y}^2 = -\frac{k_1 \cdot \Delta x}{\mathrm{m}} + g \cdot \cos\alpha - f \cdot g \cdot \sin\alpha \qquad (4)$$

(4) from the same part of the expression $\ddot{y} = \frac{d(\dot{y})^2}{dt} \cdot \frac{2dy}{2dy} = \frac{d(\dot{y})}{2dt}$ we calculate the homogeneous part using this notation.

$$\frac{d(\dot{y})^2}{dt} - \frac{1}{l} \cdot \dot{y}^2 = 0 \qquad (5)$$

(5) the solution of the equation $\dot{y}^2 = z$ and calculate the homogeneous part.

$\frac{dz}{2dt} - \frac{1}{l} \cdot z = 0 \Rightarrow \frac{dz}{2dt} - \frac{1}{l} \cdot z = 0 \Rightarrow \frac{dz}{z} = \frac{2}{l} \cdot dt$ we differentiate the exspression.[5]

$$\ln z = \frac{2}{l} \cdot t \Rightarrow \quad z = e^{\frac{2}{l} \cdot t} \cdot C_1 \qquad (6)$$

to expression $\dot{y}^2 = z$ we express the movement of wool fibers under the influence of a rolling roller along the OY axis $\dot{y}^2 = e^{\frac{2}{l} \cdot t} \cdot C_1 \Rightarrow \dot{y} = e^{\frac{t}{l}} \cdot C_1 \Rightarrow y = l \cdot e^{\frac{t}{l}} \cdot C_1$ we determine the value of the constant C $_1$ using the initial condition . $(y)_{t=0} = l_0$ is equal to $C_1 = \frac{l_0}{l}$

$$\mathrm{y}_1 = l_0 \cdot e^{\frac{t}{l}} \, (7)$$

the particular solution of the expression

$$y_2 = M\cdot\cos\omega\cdot t + N\cdot\sin\omega\cdot t \qquad (8)$$

we look for it in the form, taking derivatives from this expression and putting it into equation (4) we determine the invariants.

$$\dot{y}_2 = -M\cdot\omega\cdot\sin\omega\cdot t + N\cdot\omega\cdot\cos\omega\cdot t$$

$$\ddot{y}_2 = -M\cdot\omega^2\cdot\cos\omega\cdot t - N\cdot\omega^2\cdot\sin\omega\cdot t$$

$$-M\cdot\omega^2\cdot\cos\omega\cdot t - N\cdot\omega^2\cdot\sin\omega\cdot t + \frac{M}{l}\cdot\omega\cdot\sin\omega\cdot t - \frac{N}{l}\cdot\omega\cdot\cos\omega\cdot t = g\cdot\cos\omega\cdot t - f\cdot g\cdot\cos\omega\cdot t \qquad (9)$$

We determine the value of A and V by equating the corresponding coefficients of this equation

$$\begin{cases} -M\cdot\omega^2 - \frac{N}{l}\cdot\omega = g \\ -N\cdot\omega^2 - \frac{M}{l}\cdot\omega = -f\cdot g \end{cases} \qquad (10)$$

(10) from the system of equations

$$M = \frac{l\cdot g\cdot(f - l\cdot\omega)}{\omega\cdot(1 - l\cdot\omega)};\ N = \frac{l\cdot g\cdot(1 + f\cdot l\cdot\omega)}{\omega\cdot(l^2\cdot\omega^2 - 1)}$$

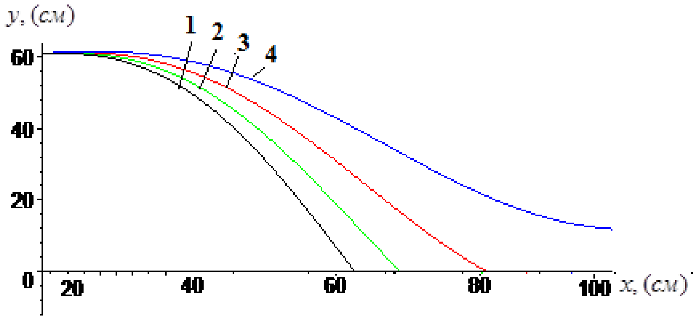
we put the determined values into the equation (8) and determine the specific solution.

$$y_2 = \frac{l\cdot g\cdot(f - l\cdot\omega)}{\omega\cdot(1 - l\cdot\omega)}\cdot\cos\omega\cdot t + \frac{l\cdot g\cdot(1 + f\cdot l\cdot\omega)}{\omega\cdot(l^2\cdot\omega^2 - 1)}\cdot\sin\omega\cdot t \qquad (11)$$

We define the general equation of the trajectory of wool fibers moving along the spinning roller along the OU axis.

$$y = y_1 + y_2 = l_0\cdot e^{\frac{t}{l}} - \frac{k_1\cdot\Delta x}{m} + \frac{l\cdot g\cdot(f - l\cdot\omega)}{\omega\cdot(1 - l\cdot\omega)}\cdot\cos\omega\cdot t + \frac{l\cdot g\cdot(1 + f\cdot l\cdot\omega)}{\omega\cdot(l^2\cdot\omega^2 - 1)}\cdot\sin\omega\cdot t \qquad (12)$$

Expression (12) shows the movement along *the OY* axis under the influence of the rolling roller. This expression is analyzed graphically using the Maple program. The following parameter values are given in the calculation: $g = 9{,}81\, м/c^2$; l=1,8mm; $\varphi = 80^0$; $\omega = 35\, c^{-1}$; m_1=0,023mlgr; m_2=0,023mlgr; m_3=0,014mlgr; $d_1 = 40\, mkm$; $d_2 = 35\, mkm$; $d_3 = 30\, mkm$; $d_4 = 25\, mkm$; ρ_{wool}=1.,28÷1,32gr/sm^3.



6 . Different masses of wool fibers separated on the OU axis under the influence of a rolling roller m_1=0,023mlgr; m_2=0,023mlgr; m_3=0,014mlgr; m_4=0,008mlgr graph depending on the transmission distances in values

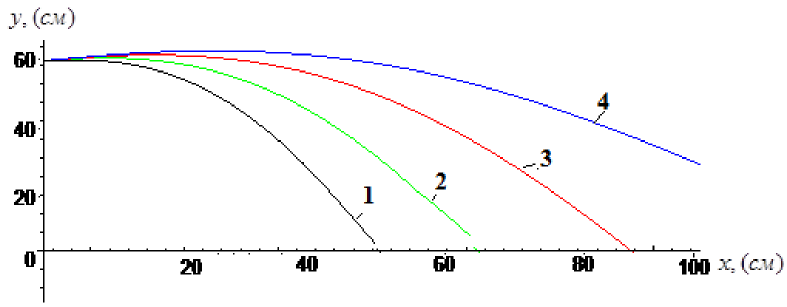


Figure 7. Different diameters of wool fibers separated on the OY axis under the influence of a pinching roller $d_1 = 40\,mkm$; $d_2 = 35\,mkm$; $d_3 = 30\,mkm$; $d_4 = 25\,mkm$; graph depending on the transmission distances in values

Conclusion: The trajectory of movement of separated wool fibers along the OY axis is presented. The angle of coverage of separated wool fibers and its change over time were determined.

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