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THEORETICAL FOUNDATIONS OF THE TECHNOLOGICAL PARAMETERS OF A STRAIGHT-FLOW FIBER SEPARATION DEVICE

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Abstract: The article discusses theoretical studies including the investigation of the fiber separation process from the seed during ginning depending on the density of the seed and fiber and the change in the inclination angle of the ginning rollers over a unit of time, the development of a mathematical model of the straight-flow fiber separation process, and the statistical analysis of the technological process in a straight-flow fiber separation device.

Keywords: Seed cotton, straight-flow fiber separation, inclination angle, theoretical study, roller, mathematical modeling.

Introduction. To study the theoretical investigation of the fiber separation process from the seed on the ginning rollers depending on the change in the inclination angle over a unit of time, the following figure is used (Figure 1).

1. To study the theoretical aspects of this process based on the schematic diagram presented below. For this purpose, we formulate the equations of motion of the cotton particles moving between the pairs of ginning rollers.

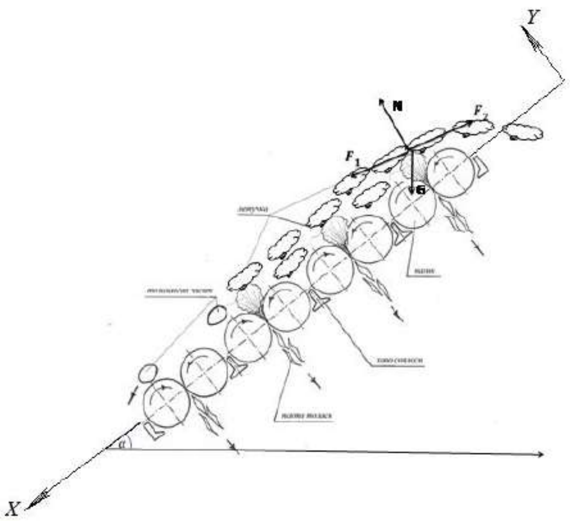

Figure 1. Technological schematic of fiber separation in a straight-flow fiber separation device

α – inclination angle, g – acceleration due to gravity, v_0 – initial velocity of cotton movement. In this case, the differential equation of motion of cotton particles on the ginning rollers can be written as follows:

$$m\ddot{x} = mg\sin\alpha - f_0 mg\cos\alpha$$

Initial conditions:

$$v(0) = v_0$$

$$x(0) = 0$$

The solution of the equation under the given initial conditions is as follows.

$$x = v_0 t + \frac{g(\sin\alpha - f_0 \cos\alpha)t^2}{2}$$

From this, the following graph was obtained. Based on the graphs, we can draw the following conclusion:

The change in the inclination angle (with constant cotton velocity) affects the cleaning of cotton particles on the first roller and the delivery of cotton flow to the subsequent rollers. When the inclination angle varies from 45° to 65°, cotton is supplied to the first, second, and third pairs of rollers over a period of 3 seconds.

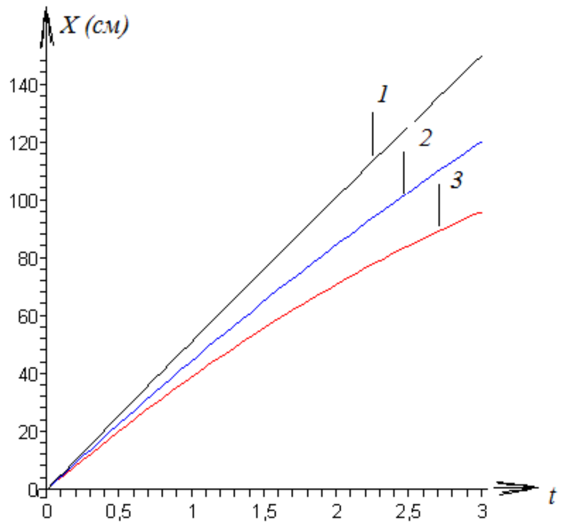

Figure 2. Graph showing the relationship between the inclination angle of the ginning rollers and the fiber separation process from the seed over a unit of time.

The law of motion of cotton particles along the 0x-at the following inclination angles of the rollers: 1st inclination angle: α = 65°

2nd inclination angle: α = 55° 3rd inclination angle: α = 45°.

Here, the seeds separated from the fiber fall under the influence of their own weight because their density is higher than that of the cotton particles and the resistance forces from the equipment are small.

In the fiber separation process from the seed, when the cotton flow velocity is 12 cm/s and the inclination angle is 55°, the three-section rollers are fully supplied with cotton, which leads to increased operational efficiency.

2. Development of a mathematical model for the fiber separation process from seeds on the ginning rollers.

To theoretically study the process of separating fiber from individual seeds, we accept the following initial conditions:

The mass of the fibers separated from the seed is considered as a continuous medium;

In the separation zone, seed cotton comes into contact with separating elements (rollers) in the form of a cylindrical surface;

During deformation of the fiber mass, there is a relationship between the tensile (stretching) force and deformation;

The forces between the rollers and the seeds being separated from the fiber obey Winkler-Voigt law at initial displacements and Coulomb's friction law at large displacements;

The process of fiber separation from the seed surface occurs in a one-dimensional direction.

Under such conditions, the tensile stress is determined $\varepsilon_0 = \frac{l_0 - l}{l}$ is the tensile (stretching) force and is the cross-sectional area. The tensile strain is calculated using the formula: is the current length. This relationship is widely used to determine the mechanical properties of materials.

In many cases l_0, this relationship is linear and is expressed as σ=Ey ε is the Young's modulus. In the theory of fibers σ=Yeε, this relationship is represented as is the fiber's Ye modulus of elasticity.

In this case, *Ye1* is considered the modulus of elasticity. The relationship between *Ye*-*Ye1* and is given by $Ye=Ye_1/S$. During the process of fiber separation from the seed, this relationship is generally nonlinear (Figure 3) and is denoted as σ=Ey(ε).

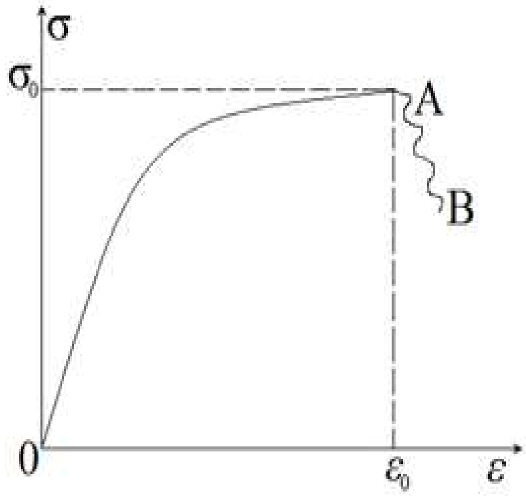

Figure 3. Scheme of fiber deformation

Its characteristic feature is that at the initial values of the force, the resistance is weak (low), but later, as the fiber mass opposes the external force, the resistance increases. As the tensile force grows, some fibers begin to break, causing the resistance to decrease while deformation continues to increase. Once the proportion of broken fibers reaches a certain value, the fiber mass can instantaneously separate from the seed surface. This behavior is also observed in individual threads. In threads, this process depends on their structural composition; the rupture and the corresponding strain depend on the formation and structure of the thread.

Based on the above assumptions, the mechanics of fiber separation from the seed were theoretically studied. In particular, Figures 4(a, b) show the schematic of separating fiber from an individual seed.

Since the seed cotton is symmetrically positioned on the roller surface, we consider the separation process for the roller on the right side. In the figure, the seed is represented as a rigid cylindrical body with radius R1R_1R1, and the roller has a radius R2R_2R2 and rotates around its axis with angular velocity ω. In practice, $R_2=4R_1$.

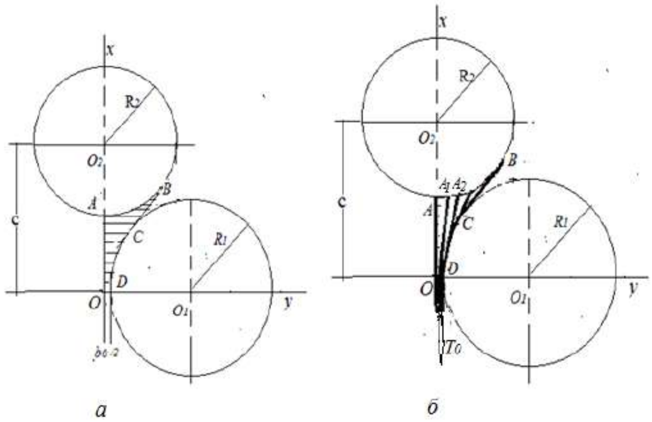

Figure 4. Scheme of the distribution of seed cotton mass along the surface of the right-side roller.

When the seed is positioned relative to the roller at time t=0, a region filled with fiber in the shape of ABCDO is formed between them. At t>0t under the influence of the rollers, the fibers begin to separate from the seed.

Once the amount of separated fiber reaches a critical value, the contact (adhesion) force between the seed and the roller decreases relative to the seed's weight, causing the seed to detach from the rollers and move freely.

If τ and q represent the frictional and normal forces per unit length between the fiber and the roller, the equation of motion for a weightless fiber along the contour can be written as follows:

$$\vec{e}_1 \frac{\partial (T-\mu v_r^2)}{\partial s} + \frac{T-\mu v_r^2}{R}\vec{e}_2 + \vec{\omega}_1 - q\vec{e}_2 - \mu \dot{v}_e \vec{e}_1 = 0 \qquad (1)$$

Here, mmm is the linear mass of the fiber. We assume that the fiber moves along the contour and use the following conditions:

Assuming R_1+R_2 and performing the necessary operations, the solution of the equation can be obtained.

$$\tau=-fq\ v_r<v_e,\ \tau=fq,\ v_r=v_e\ \ -fN<\tau fN,\ v_r>v_e,\ s=R\varphi$$

and the distance c between their horizontal axes is calculated using the following formula:

$$c = c_0 = (R_1 + R_2)\sin\alpha_{00} \tag{2}$$

Here, α_{00} is the wrap angle, which is expressed by the following equation:

$$\alpha_{00} = \arccos\frac{b_0 + R_2}{R_1 + R_2} \tag{3}$$

The distance between the roller and the vertical axis. If the center of the roller moves a distance h in the vertical direction, then the distance *s* is determined as follows:

$$c = c_0 + h = (R_1 + R_2)\sin\alpha_{00} + h. \tag{4}$$

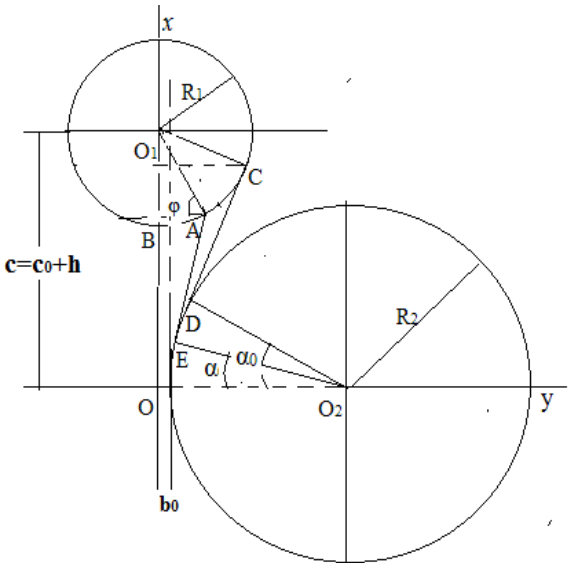

Figure 5. Geometry of the relative positioning between the seed and the roller

According to Figure 5, by determining the coordinates of points C and D, we can calculate the wrap angle α_0

$$\alpha_0 = \gamma - \beta \tag{5}$$

Here $\gamma = \arcsin\dfrac{R_1 + R_2}{\sqrt{(b_0 + R_2)^2 + c^2}}$; $\beta = \arcsin\dfrac{b_0 + R_2}{\sqrt{(b_0 + R_2)^2 + c^2}}$.

By solving the equation under the given initial conditions, the following graphs are obtained (Figure 6).

Analysis of the graphs shows that as the distance h between the centers of the seed and the roller, as well as the distance b_0 between the rollers, increases, the wrap angle $\alpha 0$ decreases. In addition b_0, increasing leads to a sharp reduction in the wrap angle.

The following values were used in the calculations: R_2=0.0055m, R_1=0.02m, b_0=0.002÷0.003mm, $R_1 \approx 4R_2$, R_2=0.005m.

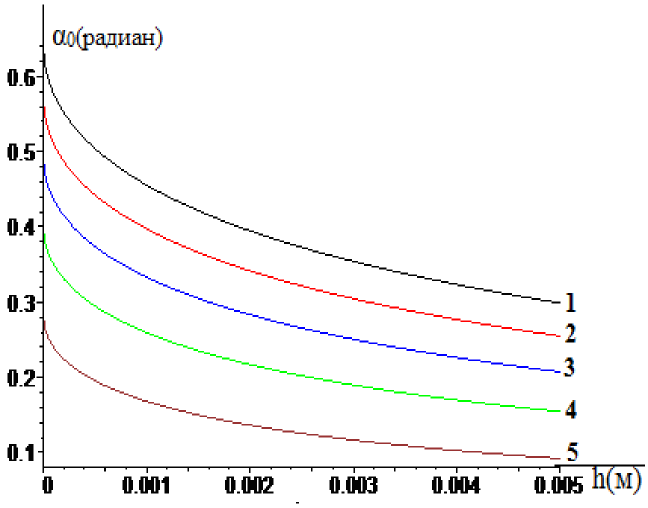

Figure 6. Graph of the variation of the wrap angle α with respect to h for different values of the distance

$h = 0.002м, \ \ b_0 = 0$ $\qquad$ $h = 0.002м, \ \ b_0 = 0.002м$

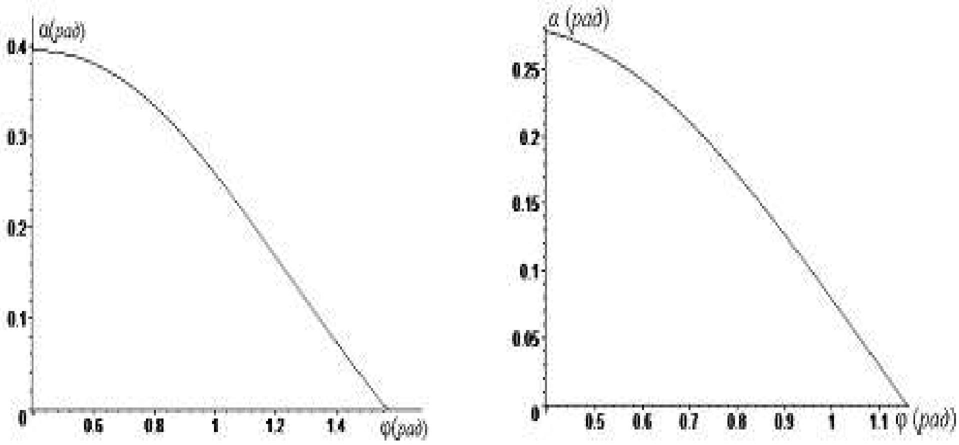

Figure 7. Graphs of the variable wrap angle α (rad) versus (rad) for different values of h=0.002 mh = 0.002, {m}h=0.002m

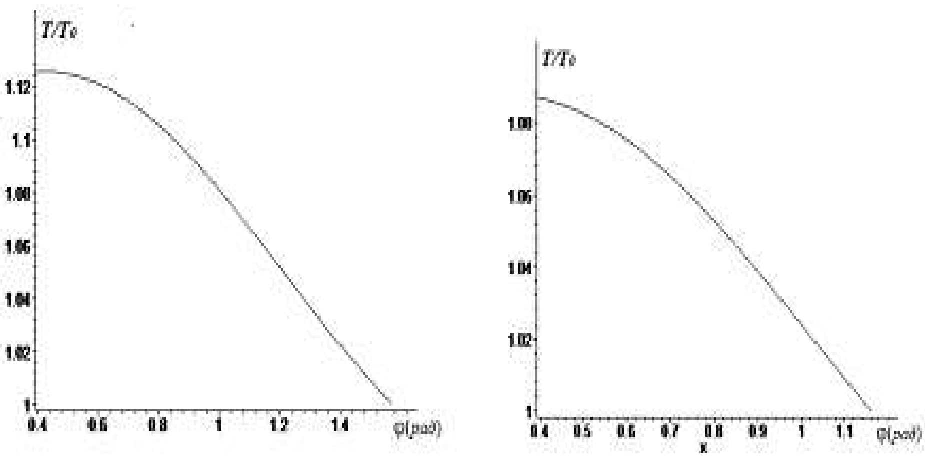

Figure 8. Variation of fiber tension T (N) with wrap angle α (rad) versus (rad) for different values of h=0.002 mh = 0.002, {m}h=0.002m

3. Statistical Analysis of Experimental Results on Fiber Separation from Seeds in Ginning Rollers.

Based on the obtained experimental results, $k = 2$ we construct regression equations for the fractions. Initially, a two-level, three-factor experimental design is developed.

In this design: The first factor is the coded roller speed; The second factor is the coded distance between the rollers; The third factor is the coded deviation angle of the rollers along the horizontal alignment.

Table 1. In the first experiment $p = 1$, the amount of separated fiber is M (kg)

Roller speed, mm/s	x_{max}	x_{min}	Δ	x_0
Distance between rollers, mm	0,005	0,025	0,00375	0,00125
Roller deviation angle along the horizontal alignment, degrees	0,5	0,025	0,2875	0,125
Roller speed, mm/s	60	40	50	10

Table 2. In the second experiment $p = 2$, the amount of separated fiber is M (kg)

Roller speed, mm/s	$x_{i\,max}$	$x_{i\,min}$	Δ_i	x_{i0}
Distance between rollers, mm	0,005	0,025	0,00375	0,00125
Deviation angle of rollers along the horizontal alignment, degrees	0,5	0,075	0,2875	0,125
Roller speed, mm/s	70	50	60	10

Table 3. The average amount of separated fiber in both experiments is M (kg).

Roller speed, mm/s	$\vec{x}_{i\,max}$	$\bar{x}_{i\,min}$	$\bar{\Delta}_i$	$\bar{x}_{i0}$
Distance between rollers, mm	0,005	0,025	0,00375	0,00125
Roller deviation angle along the horizontal alignment, degrees	0,5	0,025	0,2875	0,125
Roller speed, mm/s	65	45	55	10

References

1. Cotton: World Statistics. http://www.ICAC.org; http://www.statica.com.

2. Болдинский Г.И. и др. О профиле фартука сырцовой камеры джина в зоне входа в нее хлопка-сырца // - Ж. Реф. сб. Хлопковая промышленность. 1975. №1. 9 с.

3. Мирошниченко Г.И. и др. Оборудование и технология производствапервичной обработки хлопка. – Т., “Ўқитувчи”, 1980. – 328 с.

4. Anthony W. S. Production and Ginning of Cotton. // Textile Goods Industry More in this category:«Global Trends in the Textile Industry Cotton Yarn Manufacturing».05 September 2011

5. Hardin R.G., Barnes E.M.,Valco T.D.,Martin V.B.,Clapp D.M. Engineering and ginning: Effects of gin machinery on cotton quality. Journal of Cotton Science.2018, Pages 36-46. https://www.researchgate.net/publication/325809801

6. Anthony W. S.and William D. Mayfield. Cotton Ginners Handbook. // Agricultural handbook. № 503. U.S. Department of Agriculture. December 1994.

7. Эргашев Ж.С. Совершенствование технологии пильного джинирования с целью повышения количественных и качественных показателей. Диссертация на соискание учёной степени кандидата технических наук. Ташкент. – 1991 г.

8. Сафаров Н.М. Разработка методики определения динамических и технологических показателей пильного джинирования при различных плотностях хлопка-сырца. Диссертация на соискание ученой степени кандидата технических наук. Ташкент, 1997.

9. Agzamov M. Jinlash jarayonida mahsulot sifati yaxshilanadigan yangi tejamkor texnologik jarayon koʻrsatgichlarini aniqlash. Fan doktori (DSc) ilmiy darajasini berish boʻyicha taqdimnoma. Toshkent. – 2018 y.

10. R.Muradov, A.Karimov, A.Sarimsakov Jin mashinasi konstruksiyasini takomillashtirish yoʻllari. Monografiya. Namangan nashriyoti. Namangan. 2016 y.11. Тихомиров В.Б. Планирование и анализ. - М., ЛИ, -М. Лег. инд. 1969. - 269 с.

12. Oʻrozboyev M.T. Materiallar qarshiligi, Toshkent, “Oʻqituvchi”, 1973 yil, 491 b.

13. Потураев ВТ., Дырда В.И. Резиновые детали машин. М. Машиностроение.1977г.

14. Мэнли Р. Анализ и обработка записей колебаний. Машиностроение, М.,1974 г.

15. Юнусов С., Махманазаров З. Исследование влияния параметров машинного агрегата с механизмом ворошителя семенного валика линтерной машины на режимы движения и нагруженность системы // Журнал“Проблемы текстиля”, №1, 2016 г.

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