THEORETICAL SUBSTITUTION OF THE IMPACT OF AN IMPROVED COMB SEGMENT OF ARE-COMBING MACHINE ON FIBER FLOW

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АННОТАЦИЯ

В статье изложены теоретические основы влияния усовершенствованного гребнечесального сегмента гребнечесальной машины на поток волокон. Приведены данные о том, что форма и плотность зубьев сегмента изменяются в зависимости от направления вращения гребнечесального барабана, что позволяет повысить эффективность гребнечесания.

ABSTRACT

This article presents the theoretical basis for the effect of an improved combing segment on fiber flow. It also demonstrates that the shape and tooth density of the segment vary depending on the direction of rotation of the combing drum, thereby improving combing efficiency.

Keywords: Comb, tuft, comb segment, plank, canvas.

The effect of the combing drum gear set on the combing fibers plays an important role in obtaining a high-quality re-carded sliver. During the re-carding process, the combing drum separates the fiber bundle in the sliver into separate slivers, and the increasing number of sawtooth teeth in the combing drum segments ensures that the amount of fiber in the sliver gradually decreases as a result of carding, and that short fibers and knots in the sliver are removed into the sliver.

Although current re-carding machines are aimed at improving the carding process, the angular velocity of the combing drum segments remains unchanged and production difficulties and problems remain unresolved. Due to the fact that the angular velocity of the combing segments during the re-carding process does not change, the ability to effectively separate the fibers and straighten the fiber ends is limited.

Taking into account the nature and elasticity of the fibers, new solutions are required that dynamically control the combing intensity.

Under the influence of friction forces between the fiber bundle and the drum teeth, the fibers are stretched, as a result of which they are straightened and straightened, arranged parallel to each other.

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The main element of the re-combing drum is the comb segments, which are located perpendicular to the axis of rotation of the drum. The comb segments are arranged sequentially in the direction of rotation of the comb drum.

Each comb segment consists of several comb slats. The comb slats are arranged in the direction of rotation of the comb drum.

The shape and density of the segment teeth change in the direction of rotation of the comb drum, which allows to increase the combing efficiency.

One reason for the increase in the amount of lint is that when the fiber bundle is combed with the combing drum and the upper comb, some long fibers break off and become incorporated into the short fibers.

This is because the comb drum combs the front ends of the fiber bundle in the skein, that is, it contains a certain amount of tangled fibers, impurities, which are trapped in the bundle when combed by the upper comb in the previous cycle [1. pp 18-23].

The improved comb segment is divided into four sections. A theoretical analysis of the effect of rubber shock absorbers installed in each segment on the fiber flow was presented, in which the cases resulting from the change in elastic force using rubber covers installed at different heights were considered. The arc lengths of each segment are selected as follows: $\overbrace{AB}=S_1$; $\overbrace{BC}=S_2$; $\overbrace{CD}=S_3$; $\overbrace{DE}=S_4$ and the coverage angles for each arc accordingly φ_1; φ_2; φ_3; φ_4 these parameters are presented in (Figure 1).
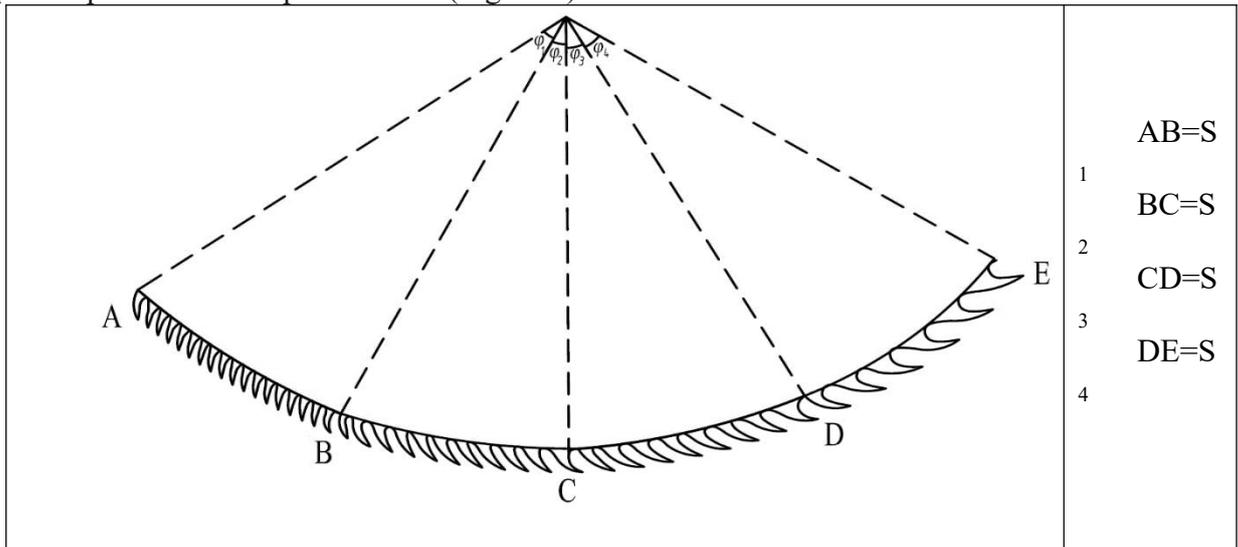

Figure 1. Schematic diagram of an improved comb divided into segments

Suppose that initially A_0B_0 (AB) the position of the fibers on the tooth surface at time t = 0 is $A_0B_0C_0$. In this case, a Cartesian coordinate system is introduced. Then the mass fiber from the triangle M_0 $\Delta A_0B_0C_0$ will be in the initial coordinate system as shown in Figure 2.
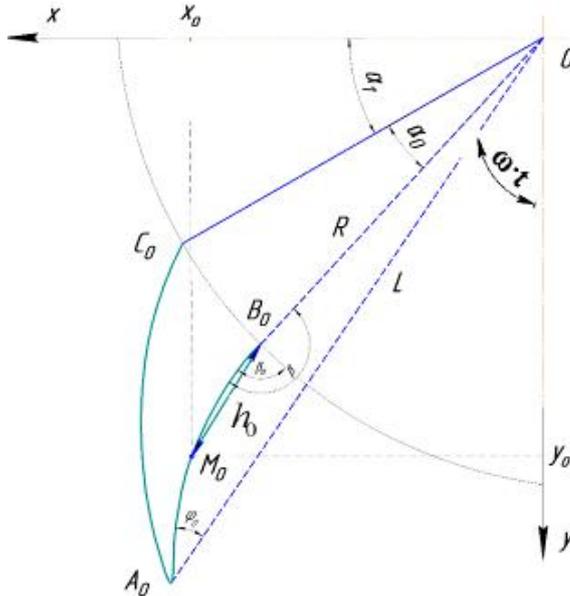
Figure 2. Initial movement of fibers at the base of the recombing drum tooth

Here, $C_0O=B_0O=R$, $A_0O=l$, $M_0B_0=r_0$, $<C_0OB_0=\alpha_0$, $<A_0B_0O=\beta$,

From Figure 2, the following equation is derived from the equation of the initial trajectory of the fibers. [2. p. 341-367].

$$x_0=R\cdot\cos(\alpha_0+\alpha_1)+r_0\cdot\sin\beta_0$$
$$y_0=R\cdot\sin(\alpha_0+\alpha_1)+r_0\cdot\cos\beta_0$$

φ_0 and β_0 The angles are taken depending on the bevel angle of the saw tooth:

$$\varphi_0=\frac{\pi}{2}+\alpha_0+\alpha_1+\omega\cdot t-\beta,\ \beta_0=\beta-\alpha_0-\alpha_1-\omega\cdot t$$

Using the theorem of sines, the following equality is derived:

$\frac{L}{\sin\beta}=\frac{R}{\sin\varphi_0}$, from this $\sin\beta=\frac{L}{R}\cdot\sin\varphi_0$, or $\beta=\arcsin\left[\frac{l}{R}\sin\varphi_0\right]\cdot t>0$ at the time. If it is an angle $\beta>0$, β_0 it will be as follows:

$$\beta_0=\beta-\alpha_0-\alpha_1-\omega\cdot t$$

Thus, the fiber motion is determined by $M(X,Y)$.

$$x_1=R\cdot\cos(\alpha_0+\alpha_1+\omega\cdot t)-r\cdot\cos(\beta-\alpha_0-\alpha_1-\omega\cdot t)$$
$$y_1=R\cdot\sin(\alpha_0+\alpha_1+\omega\cdot t)+r\cdot\sin(\beta-\alpha_0-\alpha_1-\omega\cdot t)$$

Using the equation of motion, the velocity of the fiber along the Cartesian coordinate system is determined. To do this, the first-order derivative with respect to time is taken from the equations of motion, resulting in the following equation.

$$\dot{x}_1=R\cdot\omega\cdot\sin(\alpha_0+\alpha_1+\omega\cdot t)-\dot{r}\cdot\cos(\beta-\alpha_0-\alpha_1-\omega\cdot t)-$$
$$-r\cdot\omega\cdot\sin(\beta-\alpha_0-\alpha_1-\omega\cdot t)$$
$$\dot{y}_1=R\cdot\omega\cdot\cos(\alpha_0+\alpha_1+\omega\cdot t)+\dot{r}\cdot\sin(\beta-\alpha_0-\alpha_1-\omega\cdot t)-$$

$$-r\cdot\omega\cdot\cos(\beta-\alpha_0-\alpha_1-\omega\cdot t)\qquad(1.3)$$

The degrees of freedom of the system are determined and the generalized coordinates are chosen to calculate the generalized forces acting on the fibers. The kinetic energy of the fibers is determined as a function of the generalized coordinates and generalized velocities. [3; pp. 89-114, 4; pp. 109-136]

The external forces acting on the fibers moving on the subgingival basis are presented in Figure 3. The external forces acting on the fibers are taken Q_r as the generalized force, and the sum of their projections $AB=\breve{S}_1$ on the cross section is determined as .
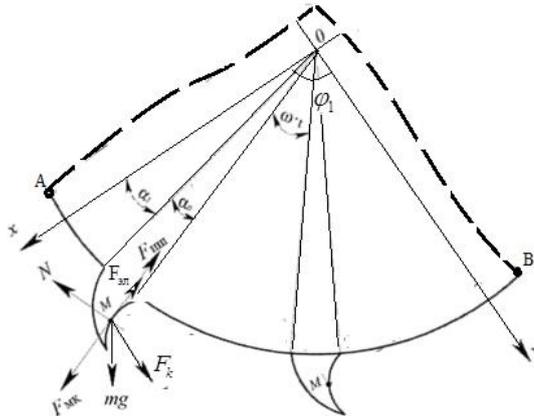
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Figure 3. The movement of fibers on the basis of the tooth of the comb drum

A system of forces was determined that summarizes the external forces acting on the fibers on the sawtooth surface of the comb drum.

$$Q_r = mg \sin \beta_0$$

$$Q_r = f F_k \cos (\beta - \beta_0)$$

$$F_k = F_{m.k} + F_{ish} + F_{el1} = m \cdot \omega^2 \cdot r + f \cdot N + k_1 \cdot \Delta h_1 \qquad (1.4)$$

Here, the external forces acting on the fibers are the Coriolis F_k force, the centrifugal $F_{m.k}$ force, the friction F_{ish} force, the elastic F_{el1} force, and the normal pressure N force, the direction of $F_k = F_{m.k} + F_{ish} = m \cdot \omega^2 \cdot r + f \cdot N$ which is perpendicular to the cross section [5, 6, 7, 8].

$$F_k = 2 \cdot m \cdot \omega \cdot \dot{r} \cdot \cos (\beta - \beta_0)$$

Where, ω– angular velocity of the fibers, $\dot{r}$– relative velocity. From these connections, Q_r for generalized forces

$$Q_r = m \cdot g \cdot \sin \beta_0 - 2 \cdot \omega \cdot m \cdot \dot{r} \cdot f \cdot \cos (\beta - \beta_0)$$

Where f- is the coefficient of friction between the fiber and the tooth.

Scientific research on re-combing technology in yarn production aims to enhance yarn quality, strength, and uniformity, especially when processing medium-fiber cotton. Re-combing removes additional short fibers, neps, and impurities, leading to superior, smoother, and stronger yarn. Studies optimize combing machine parameters (e.g., 400 min⁻¹ comb drum speed, specific settings) for better results, often yielding improved yarn, such as 14.8 tex (36 Ne)) yarn produced on Rieter machines.

In conclusion, it can be said that in the study of the fiber portion in the re-combing process, the parameters were analyzed at different values, and it is clear that the angle of inclination of the tooth, linear speed, and rotation frequency are of great importance in the uniform transmission of the movement of the fibers separately. It was found that the fiber portion cleaned of short fibers and knots is one of the conditions for the production of high-quality yarn.

The improved comb drum segments of the re-combing machine (the segment of the Primocomb Graf company was taken as a prototype) consist of trapezoidal fingers, each finger consists of upper and lower parts, and due to the installation of rubber shock-absorbing gaskets between them in the direction of rotation of the drum, the comb saw provides the possibility of small angular oscillations in the toothed segments, which, due to the resulting deformations, create additional forces for the separation and straightening of the fibers.

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