Theoretical study of the fiber separation process in the working area of the sawdust fiber separation machine(gin)

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Annotation
In this article, a theoretical study of the process of fiber separation in the working area of the colossal grid of a sawed seed fiber separation machine, the fact that the process of saw fiber separation differs from other methods due to its high productivity, the occurrence of defects in the fiber structure as a result of mechanical damage to the cotton seed, cutting, breaking and damage of the fiber increase, decrease in the average staple length of the fiber leads to a decrease in the quality indicators of the produced fiber and seed, and the reduction of the front angle of the saw tooth to 15 ÷ 20 ° allows to extract the fiber from the saw teeth at the minimum speed of the air flow, and to reduce the energy consumption for this, and to separate the fiber ideas and considerations are given for further research to optimize the bevel angle of the front edge of the saw tooth in terms of ease of extraction and reduction of seed damage.

Keywords: sawdust, cottonseed, fiber, energy consumption, fiber packaging, impact force impulse, raw material, mechanical damage.

Introduction

In our republic, special attention is paid to the issues of deep processing of raw materials and production of finished products with high added value, as well as promotion of their export in textile and sewing-knitting enterprises. In this regard, comprehensive measures are being implemented to increase the range of finished products, increase profitability, and ensure product competitiveness through the cluster method of cotton cultivation and deep processing, modernization of enterprises and technical re-equipment. In ensuring the performance of these tasks, issues of improving the quality and quantity of the cotton industry, supplying high-quality, competitive cotton fiber to the textile industry, and increasing the efficiency of the production of cotton products by reducing material and energy costs at all stages of production have a special place.

Analysis and results

Process of separation of sawdust and factors affecting it. The development of new technical solutions that save resources, increase the efficiency of the process, and preserve the natural properties of the seed and fiber to the maximum extent, is one of the important issues facing the country's cotton industry today. Saw fiber separation process is distinguished from other methods by its high productivity. However, defects such as mechanical damage to the cotton seed in the fiber separation process, increase of defects in the fiber structure as a result of fiber cutting, breaking and damage, and a decrease in the average staple length of the fiber lead to a decrease in the quality and quantity of the produced fiber and seed. In particular, during the processing of seed cotton, damage to the seed leads to negative consequences such as its death due to splitting and crushing, decrease in germination, disease of sprouted cotton seedlings. From this point of view, a more in-depth study of the process of separating cotton fiber from the seed using theoretical and practical research methods, identifying and eliminating factors that negatively affect the quality and quantity of the product in the process are among the urgent issues facing the country's cotton industry and scientists today. In these studies, issues of prevention of these consequences are considered by identifying and analyzing the causes of seed damage and decrease in fiber quality through the theoretical analysis of cotton ginning process and the factors affecting it.

Theoretical basis of sawdust separation process. In the sawdust separation process, there are factors that resist the movement of the raw material roller in the working area of the colosnik grid. As a result of the circular movement of the saw cylinder, the cotton fibers caught by the saw teeth hit the colosnik grid with a certain force, are separated from the seed, and change the speed and direction of movement (Fig. 1).

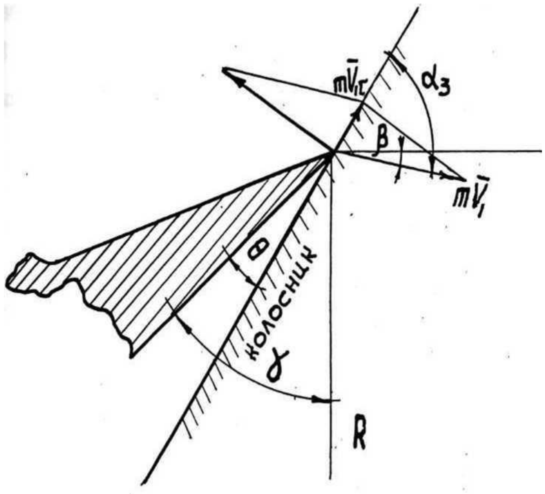

Fig. 1 Kolosnik zone

A single seed cotton in this zone is affected by the following forces:

$m\bar{v}_n$ - the normal of the impact force pulse is directed along the radius of the raw material shaft, under its influence the raw material shaft is compressed;

$m\bar{v}_\tau$ - the tangential impulse of the shock force, which helps the raw material shaft to rise up through the colossal grid and the front brush.

When studying the forces acting on single-seeded cotton, the column grid should be positioned so that the force is tangential to $m\bar{V}_\tau$ should be as large as possible.

According to the scheme (Fig. 1).

$$m\bar{v}_\tau = mv_1 \cos\alpha_3$$

in this α_3 – the exit angle of the saw from the working chamber.

The angle at which the front of the tooth meets the grill

$$\theta = \gamma - \left(\frac{\pi}{2} - \alpha_3\right)$$

Here γ- front slope angle of the saw tooth;

β – the angle of inclination in relation to the saw, it is usually accepted in the amount of 4 ÷ 9°. β>9° damage to the seed, especially the seed seed, increases and the energy consumption for the movement of the raw material roller increases. β < 4° The productivity decreases as a result of the fibers slipping between the colosnik grid and the saw tooth.

The rational profile of the saw tooth and its gripping ability. Mechanical separation of the fibers from the seed occurs when the saw teeth interact with the raw material shaft and the koldosnik grids in the working chamber.

B.A. Levkovich, N.G. Gulidov and G.I. at the Tashkent Institute of Textile and Light Industry and Scientific Center of Cotton

Industry. Boldinsky [1,2,3] studied the elements of the saw tooth profile and their ability to retain fiber through theoretical and experimental studies. Figure 2 shows the scheme of the meeting of the saw teeth with the raw material in the zone of contact with the fiber [3].

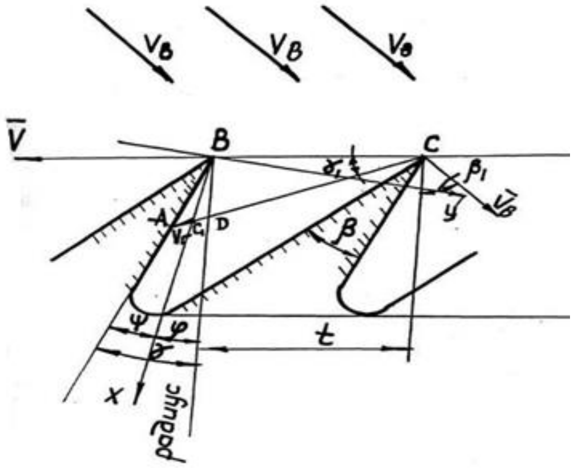

Figure 2. According to G. I. Boldinsky, the scheme of meeting the saw teeth with the grain in the area of separating the fiber from the seed.

Centrifugal force acts on the fibers held by the saw teeth, which causes it to separate the fiber from the saw teeth, while frictional force acts to hold the fibers at the front of the tooth.

The angle φ between the radial plane of the saw blade and the plane of fiber thrust is found as follows:

$$\varphi = \gamma - \psi$$

$$\varphi = arctg\frac{m\mathcal{V}^2 - \mu cR\mathcal{V}^2}{cR\mathcal{V}^2 + \mu m\mathcal{V}^2}$$

φ- the angle of retention of the fiber in the saw teeth;

γ- front corner of the tooth;

m- fiber roll mass;

c - proportionality coefficient;

$\mathcal{V}$- saw tooth speed;

p - saw radius;

μ- the coefficient of internal friction of the fiber.

The ability of the tooth to retain fiber ABC_1, is proportional to the area of the triangle and is defined as:

$$S_{\Delta ABC_1} = S_{\Delta ABC} - S_{CBC_1}$$

In this $S_{\Delta ABC}$ – Area of triangle ABC (see Figure 2).

Fiber capture ability:

$$S_{\Delta ABC} = \frac{t^2 sin\gamma}{2} \cdot \frac{\sin(\gamma - \varphi)}{\cos(\gamma + \gamma_1) \cdot \cos(\varphi + \varphi_1)}$$

here t – pitch of teeth;

γ_1 – the angle between the relative velocity vectors and the circular velocity.

$\gamma \leq \varphi$ the ability of the saw tooth to hold the fiber will be zero, so the best conditions will appear for the fibers to separate from the tooth by themselves.

γ with an increase in the angle, the area of the AVC triangle increases, as a result, the ability of the teeth to retain the fiber also increases. At the same time, γ an excessive increase in the angle can lead to a decrease in the sharpness of the tooth and a decrease in the strength of its base.

The angles in the saw teeth used have the following values γ =38 ÷ 40° га эга; $\beta = 20°$; $\beta_1 = 30°$.

The optimal value of the anterior inclination angle of the tooth:

$$\gamma_{опт} \cong arctg\frac{t + \sqrt{t^2 - 4h(h - \frac{t}{tg\beta})}}{2h_{опт}}$$

$h_{опт}$ – the optimal value of the tooth height.

Saw blade geometry also significantly affects ginning machine performance, seed cotton seed damage, and fiber extraction. In particular, the front angle of the tooth has a significant effect on the separation of fiber from the saw teeth and the impact force on the seed.

γ with the decrease of the angle to 15 ÷ 20°, it is possible to ensure easier separation of the fiber from the saw teeth at the minimum speed of the air flow [4,5,3]. Due to this simplification of the structure of the saw fiber separation machines, it is possible to reduce the consumption of electricity, to separate the fiber from the saw teeth without air separation devices, and to reduce the level of damage to the seeds. But, on the other hand, we reduce the problem of easy fiber separation from the saw teeth, the damage to the seed, as well as the ability of the teeth to retain the fiber, and as a result, the productivity of the technological machine also decreases.

We will consider the problem of improving the process of separating cotton fiber from seeds.

In the working chamber, the separation of the fiber from the seed starts from the seed comb zone and goes to the working zone of the colosnik grid. The fibers are partially separated from the fiber seed caught by the saw teeth in the area of the seed combs and pulled into the slot of the colosnik bars, where the fiber is completely separated from the seed. In this zone, with the reduction of the angle of the front edge of the saw tooth, the angle of meeting the front edge of the tooth with the colossal grid also decreases, this angle should be 9 °. In order to keep the angle of meeting the saw tooth with the colossal grid equal to 9°, we change the direction of the tangential component of the pulse $m\bar{V}_{1t}$ by changing the position of the colossal grid in order to maintain the ability of the saw teeth to catch the fiber and the productivity, to prevent damage to the seed cotton seed.

These issues N.G. Gulidov [4], B.I. Roganov [6], H. Saidov [7], P.N. Tyutin [8], G.I. Miroshnichenko [9], G.I. Boldinsky [3] and others and studied in detail in our works [11,12].

According to these studies, only the upper part of the tooth, approximately 0.7 mm high, is involved in the process of hanging the fiber. However, later B.A. Levkovich, G.I. Boldinsky and P.N. Tyutin [10] found that the entire height of a standard tooth is involved in fiber attachment, not just the upper part as previously thought. These conflicting results regarding the ability of defibering saw teeth to retain fiber call for further research to investigate the issue of defibering from teeth. It will be necessary to find ways to optimize the bevel angle of the leading edge of the saw tooth in terms of facilitating fiber extraction and reducing seed damage. If this problem is solved, the energy consumption in separating the fibers can be significantly reduced.

Conclusion/Recommendations

Saw fiber separation process is distinguished from other methods by its high productivity. However, as a result of mechanical damage to the cotton seed, cutting, breaking and damage of the fiber, the increase of defects in the composition of the fiber, the decrease of the average staple length of the fiber leads to a decrease in the quality indicators of the produced fiber and seed.

Decreasing the front inclination angle of the saw tooth to 15 ÷ 20° allows easier separation of fiber from the saw teeth at the minimum air flow speed and reduces the energy consumption, however, it reduces the ability of the saw teeth to hold the fiber and, as a result, the productivity of the technological machine.

Further research is needed to optimize the bevel angle of the leading edge of the saw tooth in terms of facilitating fiber separation and reducing seed damage.

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