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The Productivity of The Roller Gin and Ways to Improve It

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Abstract: The article analyzes the process of increasing the efficiency of roller ginning of fine-staple raw cotton. A method for determining the productivity of existing roller gins is described, which shows that productivity depends on the activity of the gripping of the snare drum and the efficiency of pulling the fibers under the knife.

Keywords: Raw cotton, roller gin, frictional forces, bump part.

The development of a theoretical method for assessing the technological productivity of roller gin will allow finding reserves for increasing the efficiency of the roller gin process; to determine the most important design and technological factors affecting the efficiency of the rolling gin in order to further optimize their parameters to increase the productivity of the gin; to establish the influence of technological parameters of raw cotton and fiber on the productivity of gin from the standpoint of preserving their natural qualities.

B.A. Levkovich [1] derived a formula for the productivity of roller gin, which serves as the basis for many other methods for evaluating productivity, developed later. The disadvantages of his method are that the productivity formula does not take into account the factors that determine the gripping and tightening ability of the snare drum and the knife of the roller gin, as well as the most important design parameters of the machine - the stiffness of the knife and elastic properties of the surface of the snare drum, the thickness of the tightened fiber bundles, the degree of attachment of fiber to the seed of the fly.

The productivity formulas developed by P.A.Rogov [2] and B.I.Roganov [3] are similar in structure and physical meaning. They are based on the same performance assessment method developed by B.A.Levkovich.

In later studies, G.I.Boldinsky and A.I.Pavlyak [4] proposed a method for evaluating the performance of a roller gin with an inertial fender, taking into account the separation of the fiber from the seed both by the fender and due to the work of the friction forces of the gin drum.

The method for evaluating the performance of the roller gin botanized by G.I.Boldinsky for the roller gins with an inertial fender is more perfect. The method, along with the design factors - the speed of the fender, the length of the snare drum - takes into account the essential factors that were previously; were ignored. These are the frictional properties of the snare drum along the fiber and of the knife along the fiber, the coefficient of slippage of the snare drum on the pulled fiber, the speed of the ginning snare drum, the strength of the attachment of the fiber to the seed.

Disadvantages of the considered method of assessing performance: the most important design parameters of the machine are not taken into account - the stiffness of the knife, the elastic properties of the surface of the snare drum and the thickness of the tightened beams, on which the tightening and ginning ability of the snare drum depends significantly, and therefore the productivity, as well as the degree of preparedness of the flywheels, served in the ginning area.

The analysis of methods for assessing the productivity of rolling gins showed that the existing methods do not fully reveal all the reserves for increasing the productivity of the machine, improving the design of the main working bodies of rolling gins, ensuring efficient operation of the machine and preserving the natural qualities of fiber and seeds.

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The performance of the roller gin depends on the frictional properties of the coating material of the snare drum, on the completeness of using the moments of the friction area of the snare drum on the knife.

To study the possibilities of increasing the productivity and reliability of the roller gin, opening their reserves, we will consider the operation of the machine from the position of the active use of the friction area of the snare drum on the knife.

The total frictional area of the snare drum when interacting with the knife in 1 s at a drum speed V_o = 2.0 m/s and the working length of the machine L = 1015 mm will be:

$$S_o = V_o L = 2000 * 1015 = 2.03 * 10^6\ mm^2/s$$

It is known from experimental data that the average number of flyers, which can be located along the length of the contact of the knife with the snare drum, is Z_{1av} = 135. Then, taking into account the average value of the stretching of the fibers of the fly when it is ginned to a length of $\bar{l}_l$= 100 mm (in fact, according to our measurements, it fluctuates within 80-120 mm and depends on the period of impact of the fender, the design of the fender, the state of the snare drum, ignition volatility and its moisture content), the friction area occupied by one volute is determined as follows:

$$S_l = \frac{L}{Z_{1cp}} * \bar{l}_l = \frac{1015}{135} * 100 = 752\, mm^2.$$

Knowing the second productivity of the gin and the average mass (weight) of the fibers of the cotton fly g_l = 0.06 g, it is possible to determine the number of the flyers promoted per second. For example, with the hourly productivity of the rolling gin Пs = 60 kg/h (Пs = 16,7 g/s)

$$Z = \frac{\Pi_l}{g_l} = \frac{16{,}7}{0{,}06} = 278\, pieces/s.$$

The frictional area occupied by the fiber of these volatiles will be

$$S_f = S_l Z = 752 * 278 = 0.209 * 10^6\ mm^2/s.$$

Let us introduce the concept of the coefficient of active use of the frictional area, equal to the ratio of the area of the drum occupied by the fiber to the total area of the drum in 1 s:

$$\gamma = \frac{S_f}{S_o} = \frac{S_l Z}{S_o}$$

So, with the productivity of gin ДВ Пs = 60 *kg/h* (Пs = 16.7 *g/s*)

$$\gamma = \frac{0.209 * 10^6}{2.03 * 10^6} = 0.103,$$

that is, with a gin productivity of 60 *kg/h*, the second surface of the snare drum (the frictional area of the snare drum on the knife) is used only by 10.3%. Considering the work of the roller gin from the standpoint of using the friction area of the snare drum, it is possible to write a productivity formula

$$\Pi_s = 3{,}6\gamma\, \frac{V_o L}{S_l} * g_l\ \ kg/h$$

At γ=1.0 and V_o=2.0 *m/s*, the maximum theoretical productivity of the rolling gin will be

$$\Pi_s = 3{,}6 * 1{,}0 * \frac{2000 * 1015}{752} * 0{,}06 = 583{,}2\ \ kg/h,$$

that is, the actual productivity of the rolling gin is 7-10 times less than the theoretically possible one and depends on the value of the coefficient of active use of the friction area γ.

Determination of ways to increase the coefficient of active use of the friction area γ is a task directly related to increasing the reliability of the working gin and its productivity.

To increase the productivity of rolling gin, it is necessary to use more fully the working surface of the drum per unit of time both along the length of the snare drum (across

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the flow of the product ginning) and along the flow. The ginning efficiency and γ coefficient are primarily influenced by the gripping and tightening ability of the snare drum, which depends on the frictional properties of the material, the ability of its adhesion to the fibers of the fly, as well as the best conditions for the adhesion of the fibers to the micro irregularities of the snare drum surface.

The efficiency of roller ginning and the coefficient γ are also determined by the completeness of the use of the contact length of the knife with the snare drum at any given time. The loading of the machine along the length of the knife-drum contact is primarily affected by the ginning ability of the knife-drum pair itself. This ability depends on the preservation of optimal conditions for the capture of fibers by the drum and the stability of the frictional contact between the knife and the drum, since the passing layer of fiber leads to deformation of the knife-drum system. In this regard, we will introduce the concept of "the actual ability of ginning the flies along the length of the contact of the knife with the drum at any time" - P (ps)

The efficiency of using the friction area along the flow is significantly affected by the slip of the snare drum along the pulled fiber, as a result of violation of the ginning condition:

$P_3 > P_H$,

where P_3 - is the fiber pulling force from the side of the drum-knife system; P_H - the force holding the fiber (the force of fixing the fibers on the seed, the friction force against the seed and the knife, the force determined by the strength of the fibers when overwhelming the ulyuk and litter, etc.).

The amount of slippage can be characterized by the slip coefficient

$$\varphi_1 = \frac{V_v}{V_o},$$

where V_o is the circumferential speed of the drum; V_f - average fiber exit speed.

According to the condition of ginning, it can be assumed that an increase in the tightened force P_3 will reduce the value of the relative slippage. Slippage can be reduced by a periodic active violation of the slip condition $P_3 < P$ by the action of a rebound element.

The loading of the snare drum along the contact with the knife is also significantly influenced by the uneven power supply of the ginning zone. It will be taken into account by the coefficient of uneven nutrition and the structural composition of cotton φ_2.

Taking into account the factors considered, the coefficient of active use of the friction area is equal to

$$\gamma = P(n_l)\varphi_1\varphi_2.$$

Then the formula for the productivity of the roller gin will take the form

$$\Pi = 3{,}6P(n_l)\varphi_1\varphi_2 \frac{V_o L}{S_l} g_l.$$

Thus, to increase the productivity of the roll gin, it is first of all necessary to actively use the surface of the drum along the ginned stream of raw cotton and the snare drum. This is due to the active capture of the fibers by the snare drum and the efficiency of pulling them by the knife, which helps to reduce the slip of the snare drum along the fiber, the effectiveness of the impact of the fender on the seeds of the ginned fumes and the perfection of the ginning zone nutrition.

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