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Parameters of the stabilizer of the poly-V belts of the drive of vertical spindles for stable cotton harvesting performance

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Abstract. We have in our previous articles that the unstable cotton-picking performance of the vertical spindle cotton picker is mainly due to the instability of the traction force of the V-belts of the friction drive of the spindles. The main reasons for this result were identified. The main reason for the value of the total pulling force of the V-belts in the friction serial drivee, which is why, due to the resistance forces of the cotton bush, the speed of rotation of the spindle often decreases at the time of extraction of the cotton slice from the sash. Therefore, the authors recommended replacing conventional V-belts with poly V-belts, the small wedges of which are installed on one, i.e. a single basis. Our experiments have shown that with the same tension of external belts, the pulling force of a multi-V belt with five wedges is always much greater than a standard set of three conventional V-belts on a serial drive. Consequently, poly-V belts always ensure the optimum angular velocity of the spindle, preventing the reduction of the completeness of the cotton harvest, which is very important. To do this, it was necessary to find some technical solutions for such a drive to function smoothly, in particular, the installation of a spindle speed stabilizer by the time the spindle reversal process was completed before it hit the external belts. Spindle, i.e. its roller, after it leaves the inner belt, rotates by inertia. The stabilizer has a block with an elastic surface, which, pressing against the spindle roller with a certain pressure, slows it down until it stops before the roller hits the beginning of the external belts, i.e. before the start of its reverse rotation. This article describes the design and effects of the stabilizer for the spindle roller to stop it at the right moment.

1. Introduction

The technological process of the vertical-spindle cotton harvester provides for the need to change the direction of rotation of the spindle when it moves from the areas of removal of the device to the working area [1], [2]. Such reversal is ensured by the fact that the belts of the spindle drive 12 in the removal zone cover the rollers 2 spindles from the inside, and in the working area outside the spindle rollers (figure 1).

The spindle 2, from which the cotton wound on it is removed by unwinding in the removal area, rotates in the same direction as the drum 1.

After the spindle roller leaves contact with the inner belts 12, it continues to rotate in the same direction by inertia until it meets the outer belt 7. С At the moment of meeting with the outer belt, the spindle roller slows down, stops for a moment and quickly begins to rotate in the opposite direction, the spindle reverses [3, 4, 5].

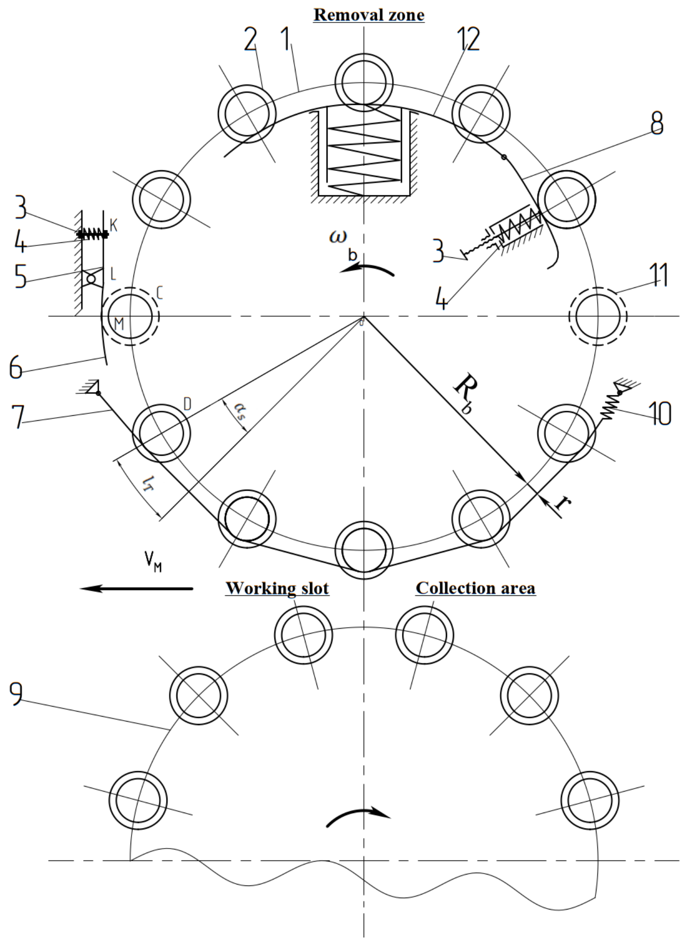

Figure 1. Schematic diagram of installation of the stabilizer of poly-V belts of spindle drive: 1-right spindle drum; 2-roller spindle; 3-adjustable thrust spring; 4-spring tension; 5-lever double-blade; 6-pad external; 7-outer straps; 8-pad internal; 9- left spindle drum; 10-spring of tension of external belts; 11-roller of spindle rotating by inertia; 12-internal belts; C; E and D sequential roller locations; D-start collision of the roller on the outer belt 7.

2. Researched questions

The belt section, where the spindle roller is braked and accelerated, wears out more intensively, which is why over time, as it wears out, the normal calculated rotation speed in the working area comes with some delay. Considering the small size of the wedges 3 of the V-ribbed belt (figure 2), we believe that the orientation of the incoming ribs 4 of the roller 1 into the depressions of the inter-wedge space of the stationary V-ribbed belt will sometimes occur with some displacement. In a small section of the beginning of the belt, its wedges will experience large deformations, which is undesirable. Therefore, to facilitate the process of oriented collision of the roller on a fixed belt, oblique flanges 5 are provided on it. Figure 2 schematically shows the case when the roller ran into the belt in an asymmetric position, when its extreme edge A was on the surface of the flange. B In this case, the upper wedge is A more strongly stretched than the wedge B, so it slides on the surface of the rib to its base and the belt wedges will quickly be in the intercostal space of the roller, the equilibrium normal position of the belt will be restored.

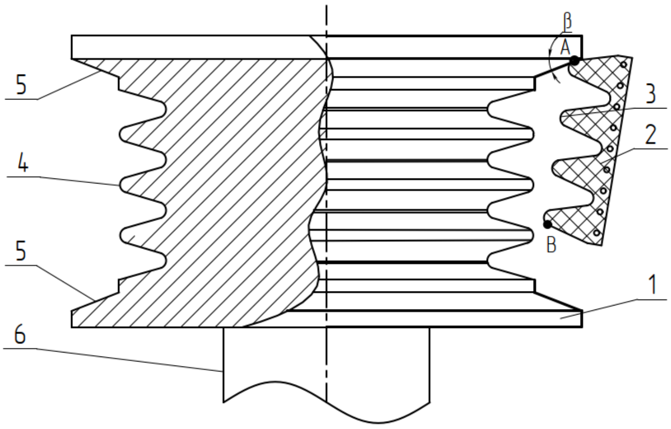

Figure 2. Scheme of a possible variant of hitting the roller on the belt: 1-roller; 2-strap; 3-wedgei belt; 4-rib roller; 5-ribs; 6-spindle.

To reduce the deformation of the elastic wedges, the belt needs to make the roller run over the initial section of the belt with a minimum angular velocity, i.e. with a minimum moment of inertia of rotation. For this purpose, a belt stabilizer is installed (figure 1). It is an external belt pad 6 on a double-shouldered lever 5. Spring 4 constantly presses the pad to the outer surface of the roller, the radius of which $R_b + r$ is. When the spindle roller moves from position to C position, D it is pressed against the pad with silt, which is why it is braked and when approaching the beginning of contact Кwith the outer belt, it stops or at least drastically reduces the speed of rotation in the direction. ω_b The force К can be adjusted using the thrust screw 3, which changes the tension of the spring 4. Knowing the tension force of the spring P_p, as well as the shoulders КL and LM, it is possible to calculate the force of pressing the T pad to the roller.

Long-term observations of specialists at the work of cotton harvesting machines in the field show that the initial part of external belts with a length of 40-50 cm wear out more than the rest, the border of which is marked visually. Therefore, we can assume that on machines with a serial drive, the spindle roller on a belt section about $l_T = 25 - 30\ mm$ long has time to slow down with a negative angular acceleration a_{T}, which can be calculated, and then has time to accelerate, rotating in the opposite direction. The braking $l_T = 25 - 30\ mm$ is the length of the arc with a radius $r_T = R_6 + r_k$, where $R_6 = 146\ mm$ -radius of the drum on the centers of the spindles, and r_k the -radius of rolling the roller along the belts; can be roughly taken $r_k = 11.5\ mm$; $r_{\text{т}} = 146 + 11.5 = 157.5\ mm$.

The value of the central angle of the α_s arc with radius $r_{\text{т}}$ will be $\alpha_s = l_T/r_T = 30/157.5 = 0.19\ radian$. At the speed of rotation of the spindle drum $n_6 = 115\ tur/min$, i.e. at the angular velocity of the drum, $\omega_6 = 11.5\ \ radian/s$, the central angle of the α_s spindle will pass $t = \alpha_s/\omega_6 = 0.19/11.5 = 0.02$ in seconds. Therefore, the spindle rotating in the removal zone with angular velocity $\omega_{\text{c}} = 100.0\ radian/s$ will t stop over time with negative angular acceleration $a_{\text{T}} = \omega_{\text{c}}/t = 100/0.02 = 5000\ radian/s^2$, which is consistent with the data[3, 6, 7, 8], as well as with our theoretical calculations. A spindle having a moment of inertia of rotation J_z 3 and a time t toln stop under the action of braking force pad P_{K}. Therefore, the spring 4 must be stretched by force P_{p}:

$$\text{P}_{\text{p}} = \text{P}_{\text{K}}(LM)/(KL)$$

Therefore, for installation in the stabilizer, a cylindrical extension spring is selected with a characteristic so that the average resistance force is

$$\text{P}_{\text{cp}} = \text{P}_{\text{p}}\,, \qquad \text{N}.$$

3. Results of experiments

A stabilizer sample was made (figure 3). Figure 3 shows its view installed on the stand and its diagram in figure 1.

Figure 3. General view of the stand with a single spindle drum:1-spindle drum; 2-stabilizer for external belts; 3-stand drive electric motor.

As a result of the study of the layout of the serial spindle drum, the dimensions of the stabilizer parts for external belts were adopted. The main elements of the stabilizer are its pads 6 and 8 LM, which are hinged to the drum frame. The length of the pressure part of the outer pad 6 should be greater than the installation step of the combined spindles. Therefore, for constant continuous loading of the pad with spindle rollers, it is customary to $LM = S + 10 = 87\ mm,$ where $S = 78\ mm$ is the step of placing the combined $D = 292\ mm$ rollers on the drum with the number of spindles per $Z = 12$ piece. Shoulder length $KL = 90\ mm.$ The accepted ratio LM and KL facilitates the selection of the spring 4. The point of contact of the shoe 6 with the roller is necessary after the hinge L and it must move to the point M, where the contact of the shoe with the roller closes. The extension spring 4 must have a length $l_p = 40\ mm$ and develop a force $P_c \approx 35\ N$ on average. Screw 4 must be longer than 50 mm in order to be able to adjust the degree of tension of the spring. When the pad pressure on the roller B in position C changes, the spindle rotates by inertia and as it approaches position D, its angular velocity decreases down to zero.

The second stabilizer performs a very important function. It is a small extension of the serial reverse rotation pad, but has not a straight-lined beginning. Its pad 8 must be pressed against the roller with such a pressure that the braking of the spindle gives a negative angular acceleration of the spindle order$\varepsilon_c \approx 5000\ 1/s^2$, so that there is a self-reset of the main part of the cotton wound on the spindle (up to 80%). With greater angular acceleration, part of the cotton can remain in the form of a free ring on the spindle, which will increase the proportion of "carrying" cotton into the working area, which is unacceptable. The dimensions of the internal stabilizer are also selected taking into account the layout dimensions of the drum.

Scrolling the spindle drum on the stand gives, unfortunately, indicative results. After scrolling the drum for 23 hours, the condition of the belts on the stand was examined. The length of the belt sections where the traces of initial wear during braking are shown, can be considered that the stabilizers perform their functions satisfactorily. More accurate results will be obtained when installing a device that registers a change in the angular velocity of the spindle on the desired section of the spindle path. Such a device, to the end of the allows non-contact measurement of the angular velocity of the already developed, its preliminary tests gave the expected positive results, which will be reported in subsequent publications.

4. Conclusions

The small size of the wedges of the poly-V belts caused the need to reduce the angular velocity of the spindle when its roller hits the initial section of both external and internal belts. Therefore, stabilizers for their angular speed were developed.

The spindle rollers that have come off the inner and outer belts and rotate by inertia after contact with the stabilizer reduce the angular velocity, which makes it easier to reverse them in the required mode.

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