

The need for instrumental measurement of the traction force of the friction drive of the vertical spindles of the cotton harvesting machine

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Abstract. An adhesion force measurement device was developed to measure the adhesion force of a friction drive in field conditions. The device consists of a lever with a pin, a dynamometer, and a hook. To measure the adhesion force, the car is stopped on a level area and the cleaning device is raised into the transport position. The movable section of the device is opened up to 30°. The selected spindle is brought closest to the opposite drum manually. The beginning of the serrated tape is inserted into the slot of the spindle rod and bent along the screw shell. A small gap is formed between the surface of the spindle rod and the bent section of the tape, allowing for insertion of the lever pin. When force is applied to turn the lever, it will either form a rigid connection with the spindle or slip along the surface of the belts, depending on whether or not maximum adhesion force has been reached. The dynamometer measures and displays the adhesion force on a certain scale. By knowing the lever arm from the stop to the pull cord and measuring angle between them, calculations can be made to determine adhesion force.

1 Introduction

The spindles of vertical-spindle cotton harvesters are rotated by a friction drive in the form of a planetary mechanism (Figure 1) [1, 2]. When the spindle drum 1 rotates, the spindle 2 is in the working chamber 3, where the cotton bush is strongly compressed by a pair of drums, it rolls over the surface of the bush elements and captures the encountered cotton slice, extracts it from the leaf and winds it around itself. With a rotating drum, the spindle with a skein of cotton is transferred to the removal zone, where its roller is already rolling along the inner belts, and therefore reverses. When the spindle rotation direction changes, centrifugal inertial forces act on the cotton skein, under the influence of which the skein unwinds and leaves the spindle. Such unwinding is called “self- release” of cotton. The overwhelming majority of cotton comes off the spindle by “self-release”. The remaining part of the cotton should be removed by a brush remover. Unfortunately, this puller operates with some drawbacks - it does not have time to remove the remaining part of the cotton completely, which is why the skeins not removed from the spindle are carried into the working chamber.

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This process is called “carrying” the cotton. The amount of adhesion force between the spindle roller and the drive belt plays a big role in ensuring high completeness of cotton collection. The loose bush is pulled by a pair of drums into the working chamber and compressed into a single layer of branches, over the surface of which the spindle rolls, it captures part of the flap, winds it around itself, removing it from the sash. This process occurs quickly (a little more than 0.05 s).

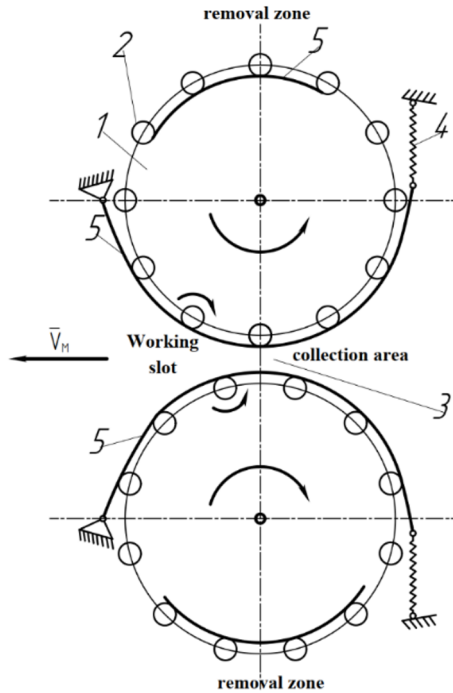


Fig. 1. Diagram of the spindle drive mechanism: 1- spindle drum; 2-spindles; 3-external V-belts in the collection area; 4- tension spring; 5- drive belts.

It has been established that for grabbing cotton, the absolute tooth speed is \vec{V}_T , which is the sum of the operating speed of the machine \vec{V}_M , the peripheral speed of the drum at the centers of the spindles \vec{V}_b and the peripheral speed of the tooth \vec{V}_T relative to the axis of rotation of the spindle. It should have a direction within a small angle β (Figure 2) [3]. The values \vec{V}_M and \vec{V}_b are unchanged. The value of \vec{V}_T depends on the ratio of the force P_p of the adhesion of the roller to the drive belts and the force P_k of the resistance of the bush to the spindle when extracting cotton from the flaps. It must be $P_p > P_k$. The value of P_p depends on the type of material used to manufacture the drive belts and spindle roller, as well as on the tension force P_n of the belts. The value of P_n determines the force of pressure of the belt P_d on the roller. A the adhesion force is $P_p = f P_d$.

We believe that for a satisfactory degree of cotton picking, the value of the P_p force on all drums of the machine should be checked daily before the start of the work shift. If the P_p value is less than the P_{min} value, which is indicated in the service instructions, it is necessary to increase the belt tension. Such control will increase the completeness of cotton harvesting by machine. For this purpose, we propose a diagram of the simplest device for measuring adhesion force P_p .

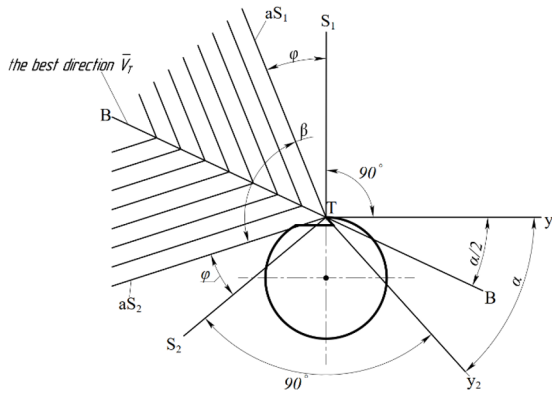


Fig. 2. Scheme for determining the best direction of absolute spindle tooth speed.

The vertical spindle cotton picker consists of four spindle drums 1 with 12 spindles 2 (Figure 1), which have a friction drive. On the field, the apparatus moves at speed \vec{V}_M , the drums, rotating towards each other, pull the cotton bush into the working slot formed between the first pair of drums. Each drum has a friction drive 5, consisting of a set of three conventional V-belts 5, which bend around the spindle rollers from the outside in the working area. When the drum rotates, the spindle rollers roll along the belts and rotate with the tip of their teeth forward.

In the working chamber, the spindles, rolling along a layer of compressed branches of the bush, thread a piece of cotton with their teeth, pull it out of the sash of the box, wrap it around themselves and leave the working chamber. The drum, rotating, transfers the spindle with a skein of cotton to the removal area. Along this path, the spindles rotate by inertia. In the removal zone, the belts are already pressed against the rollers from the inside, causing the spindles to slow down, stop for a moment and accelerate their rotation towards the back of the tooth to facilitate removal. The degree of braking of the spindles when its roller hits the internal belts plays a big role in the process of removing a skein of cotton from it. If the angular acceleration of braking is optimal, then almost 80% of the cotton will come off the spindles by “self-release.” If the angular acceleration is insufficient, most of the cotton skeins will remain on the spindle so that the brush puller can reach them. However, the puller's brushes, unfortunately, do not remove them completely enough. Therefore, part of the skeins of cotton that are not removed from the spindle is carried into the working chamber - a “carry-through” of part of the cotton occurs [4, 5].

If the braking is excessively sharp, the skeins of cotton will lose contact with the tooth and remain in the form of a loose ring. Their puller brushes cannot remove them completely. Therefore, some of the skeins are carried into the working chamber; the “carry-through” will increase sharply, which is why less cotton will be transported to the bunker.

The main indicator is the completeness of cotton harvesting from the bushes, which greatly depends on the functioning of the external belts in the working area of the machine. The adhesion force of the spindle roller P_p with the belts should always be greater than the force P_k of the resistance of the bush to rolling the spindle over it, i.e. $P_p > P_k$. The force P_p depends on the coefficient of adhesion f of the roller surface on the belts, as well as on the force P_d of the normal pressure of the belts on the roller. It is accepted that the angle of the belt wrapping around the roller surface is $\alpha = 360/z$, where z is the number of spindles on the drum (Figure 2). At $z = 12$ it turns out that $\alpha = 360/12 \approx 30^\circ$; however, in reality, V-belts have greater bending rigidity, which is why the angle $\alpha < 30^\circ$. Experiments on installing painted belts in the working area of the drum give an imprint on rollers with an angle of no more than $\alpha = 25 - 26^\circ$. According to M.V. Sablikov therefore, in order to

increase the traction force of the spindle drive belts, it is necessary to increase the angle of wrapping of the rollers with the belts, for which it is necessary to find the possibility of replacing them with more flexible belts [2].

The experience of extensive and long-term operation of vertical spindle cotton picking machines on farms shows that very often the tension of the belts weakens because the springs that tension them “get tired” and reduce their rigidity. Therefore, in fields with more powerful bushes, the completeness of collection by the device is reduced. This is noted by machine operators. Therefore, it is necessary to introduce into the service department of these machines the need to check the tension of the belts [6-8].

The characteristics of these springs (there are three of them) change in different ways, which causes unevenness in the tension of the belts, which causes the adhesion force of the rollers to them. They will also be unequal due to the unevenness of adhesion forces, and geometric sliding on individual belts increases. The belt with the weakest adhesion force causes resistance to the belt with the highest adhesion force, causing them to wear out faster. Therefore, you should often measure either the tension force of each belt or the adhesion force of the P_p rollers with them.

2 Device development

To measure the adhesion force of a friction drive.

When the spindle takes a position when it is closest to the adjacent drum, i.e. when it has penetrated most into the working chamber, the adhesion force of the roller with all three belts should be measured simultaneously because it is in this position that the spindle is most pressed against the cotton bush and experiences the greatest resistance. Naturally, the probability of the spindle teeth meeting the greatest resistance of the compressed branches of the bush. A simple device was developed for measuring P_p in field conditions (Figure 3). For drums equipped with “composite” spindles, the core of which P is covered with a sheath of serrated tape.

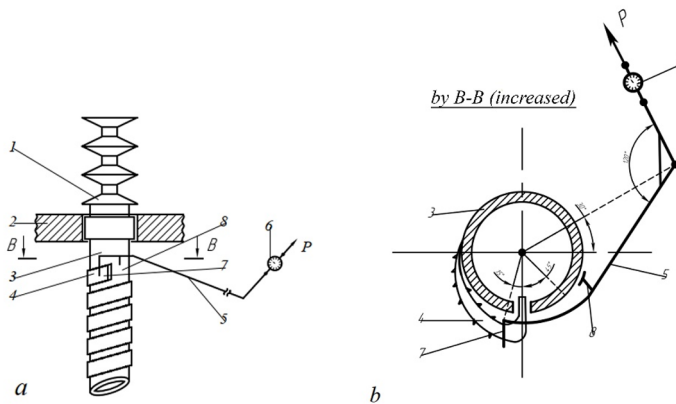


Fig. 3. Scheme of the hook with the lever for the beginning of fastening the serrated tape: 1-spindle roller; 2-upper drum disk; 3-spindle rod; 4-beginning of fastening the serrated tape to the rod; 5-measuring lever with pin; 6-dynamometer; 7-pin; 8-lever stop.

A simple device was made to measure P_p directly on a machine in the field. To measure P_p on milled standard spindles, it is secured using clamp on any part of its rod. This article provides information for measuring P_p on “composite” spindles. A sheath of serrated tape wound along a helical line is put on their rod. Only the upper end of the tape is attached to

the spindle rod so that under the resistance of the elements of the bush it vibrates and self-cleanses itself of greenery.

This version of the device consists of a rod lever 5 with a length of $l = 200 \text{ mm}$ and a diameter of $d = 8.0 \text{ mm}$ (Figure 3, a). Its working end is bent along a circular arc with a radius of $r = 17 \text{ mm}$, which is 5 mm greater than the radius of the spindle rod. Arc length 50 mm. At the beginning of the arc, a pin 7 made of a rod $d = 4.0 \text{ mm}$ and 12 mm long is welded to the lever rod. At the end of the arc, a stop 8 15 mm long is welded to the rod. A hook is welded to the end of the lever 10 at an angle of 120° , to which a dynamometer 6 is attached.

3 Procedure for using the device

The car is stopped on a level area. Raise the cleaning device into the transport position and install the safety stop so that the device is secured. Open the movable section of the device up to 30° . To begin with, take the order of measuring the adhesion force of the roller of any spindle of any drum. By turning the drums manually, bring the selected spindle closest to the opposite drum (Figure 4), i.e. to position A.

The beginning of the serrated tape is embedded in the slot of the spindle rod and bent along the screw shell. Due to the rigidity of the tape, when it bends, a small gap is formed between the surface of the spindle rod and the bent section of the tape, where the lever pin can be freely inserted. If the lever is turned back, its stop will rest against the rod, forming a rigid connection with the spindle. When you try to turn the lever by force to a larger angle, the roller will slip along the surface of the belts, and the spindle will turn at a certain angle. The dynamometer will show the adhesion force of the roller to the belts on a certain scale. The angle between the lever and the traction cord of the dynamometer is fixed at 120° , so the direction of the force P will seem to be parallel to the tangent to the spindle at the stop point. Knowing the lever arm from the stop to the pull cord and the angle between them, the scale of measurements is calculated.

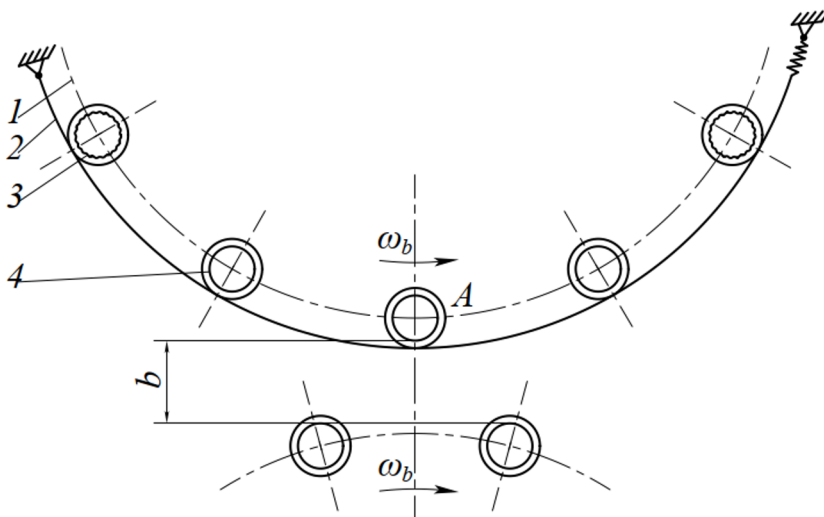


Fig. 4. Scheme for finding location A for measuring the traction force of belts: 1-circumference of the drum along the axes of the spindles; 2-external spindle drive belt; 3-roller rolling circle; 4-spindle rod; b is the width of the working chamber.

4 Research results

The use of the device has shown that it allows one to measure with sufficient accuracy the adhesion force of the roller to the belt. Based on the measurement results, it can be assumed that the adhesion force normally on the pulled internal belts with the spindle roller in position A on the drum should be at least 40 N, because It is in position A that the spindle is subjected to maximum resistance from the cotton bush compressed in the working chamber of the apparatus. It takes no more than 11-12 minutes to prepare the device for measurement, install the device on the four drums of the device and measure. The adhesion force of the roller to the belts must be measured every 40-50 engine hours of the machine in the field. Such quality control will make it possible to maintain satisfactory cotton harvesting throughout the entire harvest season. We believe that inclusion in the list of vertical spindle cotton picking machines performed during maintenance will increase the seasonal completeness of the harvest by 5-6% or more.

5 Conclusions

To measure the adhesion force of a friction drive, a simple device was developed for field conditions. The adhesion force of the roller with all three belts should be measured simultaneously when the spindle is closest to the adjacent drum and has penetrated most into the working chamber. This is when the spindle is most pressed against the cotton bush and experiences the greatest resistance. The device consists of a lever with a pin, a dynamometer, and a hook. For drums equipped with "composite" spindles, which have a serrated tape covering their core, the adhesion force is measured differently.

The device consists of a rod lever with a length of 200 mm and a diameter of 8.0 mm. The working end of the lever is bent along a circular arc with a radius of 17 mm, which is 5 mm greater than the radius of the spindle rod. The arc has a length of 50 mm and has a pin welded at its beginning and a stop welded at its end. A hook is welded to the end of the lever at an angle of 120°, to which a dynamometer is attached.

To use the device, first, stop the car on level ground and raise the cleaning device into transport position. Install the safety stop to secure it. Open the movable section up to 30°. Then, select any spindle on any drum and manually bring it closest to the opposite drum (position A). Insert the beginning of the serrated tape into the slot of the spindle rod and bend it along its screw shell. Insert the lever pin into the gap between the surface of spindle rod and bent section of tape. When trying to turn back or increase angle forcefully, if roller slips along belt surface, it indicates adhesion force. The dynamometer will show this force on its scale.

By fixing an angle between lever and traction cord at 120°, the direction of the force can be determined. The scale of measurements can be calculated by knowing the lever arm from the stop to the pull cord and the angle between them.

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