Evaluation of the degree of processing of the stalks on the basis of the analysis of the trajectory of the spindle of the horizontal spindle cotton harvesting machine

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Abstract. This article describes the work on the study of horizontal spindle cotton harvesting machine, the current tasks to be performed in this study, the relevant parameters for the graph analytic construction of spindle trajectory, the size of zoning and prospective cotton varieties in the country and the law of distribution of these dimensions details such as the elongated cycloid of the ridge, the machining boundaries of the spindle, the determination of the degree of machining of the cotton row, and the significance of the results obtained from this study are given.

1. Introduction
Currently, the agro-industry in the Republic of Uzbekistan is gradually transitioning to a system of growing products on a cluster basis (livestock, cotton, grain, fruits, vegetables, melons, etc.). This situation requires research in promising areas of design, production and operation of competitive modern agricultural machinery of different models and technical capabilities, meeting the requirements of clusters, high productivity and reliability. In particular, given the use of different types and models of cotton harvesting machines (CHM) in the harvesting of cotton in the Uzbekistan [1-4], one of the urgent tasks is to assess the suitability of cotton for harvesting in a particular type of machine [5, 6].

At present, it is known that a number of cotton varieties have been introduced in the country. The physical and mechanical properties of cotton stalks and stalks, size, yield, degree of opening, location of stalks in cotton are different. Based on the characteristics of the introduced cotton varieties, it is advisable to design a CHM and develop recommendations. The structure of the tubers of cotton varieties and the physical and mechanical properties of its elements plays an important role in the selection of kinematic, dynamic and geometric parameters of CHM based on the results of research. For example, cotton height and width, opened and unopened bowl sizes determine the optimal working chamber width of the CHM, the number and size of spindles, the pulling force of the cotton from the bowl, the binding strength of the fiber determine the linear and angular velocity of the spindle [7].

From the analysis of the studies conducted so far, it is clear that the movement of the CHM spindle with a vertical spindle (VS) in the working chamber determines the basis of the quality indicators of machine operation. For this reason, researchers have considered this issue as a major problem. The same problem can be called in the horizontal spindle (HS) CHM [6, 8].
To study the physical and mechanical properties and parameters of new zoning and promising cotton varieties in Uzbekistan on the basis of in-depth study of HS CHM work process is seen as a key factor in determining the measures to be taken [9].

Based on this, in this work the purpose is to study the laws of motion of the horizontal spindle in the working chamber and the interaction of the cotton with the open stalk, and on their basis to develop methods for calculating the optimal parameters of HS CHA for Uzbekistan. The trajectory of the HS CHM spindle determines its performance indicators. For this reason, trajectory construction and analysis are of great importance in determining the basic kinematic mode of the machine and its parameters during design. It is also the most effective method in the initial stages of the study of HS CHM in the construction of the equations of motion of the spindle, in the study of its interaction with the cotton ball, the cause of which is clearly visible. There is no substitute for the graph analytic method of constructing trajectories in the construction and verification of the equations of motion of the HS CHM [9-14].

2. Materials and methods

The US Company “Case-Cotton” processes spindle drums on two opposite sides in a row of cotton. The HS CHM spindle is in four elementary motions, i.e., forward with the machine, rotating with the spindle drum, rotating the crank cassette and the spindle attached to it according to a certain law, and the spindle is rotating around its own axis.

Taking into account all of the movements listed above, we construct the spindle trajectory of the HS CHM in a graph analytic manner. The following parameters of HS CHM “Keys-2022” were taken as initial data [9, 15]:

- machine speed \(V_1=6.19 \text{ km/hour}\);
- the number of revolution of the spindle drum - \(n_d=158 \text{ min}^{-1}\);
- radius of spindle drum - \(R_d=128.27 \text{ mm}\);
- minimum radius of conical spindle - \(r_{\min}=2.63 \text{ mm}\);
- maximum radius of conical spindle - \(r_{\max}=5.325 \text{ mm}\);
- the number of revolutions of the spindle - \(n_{sp}=4125 \text{ min}^{-1}\).

- determine the angle of rotation of the spindle:

\[
\theta_d = \arccos \left( \frac{l_{\min} - l_{\max}}{R_d} \right);
\]

\[
\Delta \theta_d = 15^0 = 0.26 \text{ mm} ;
\]

- determine the angular velocity of the drum:

\[
\omega_d = \frac{\pi \cdot n_d}{30} = 16.53 \text{ rad/s}.
\]

We determine the state after \(\Delta t\) time elapsed from the initial state.

- determine the time taken for the angle step:

\[
\Delta t = \frac{\Delta \theta_d}{\omega_d} = 0.015729 \text{ s};
\]

- we determine the displacement of the spindle \(S_n\) at a distance:

\[
S_n = V_1 \cdot \Delta t = 97 \text{ mm}.
\]

The coordinate system was chosen as follows:

- the abscissa axis is parallel to the forward motion of the machine and passes a distance equal to \(R_d\) from the center of the spindle drum;
- the ordinate axis passes through the spindle drum axis at \(t = 0\).
To construct the initial state, we draw the center of the drum $\theta^K_d K^K = R$ at a distance of 3S1 from the point of intersection of this straight line with the OY axis by passing LL parallel to the axis OX at a distance $R_0=128.27$ mm from it. We move the center of the $K'$ cassette perpendicular to the row of cotton from the point $K_I$, and this is the case for a $T'$ point $\theta_d = 15^0$ at a distance $l_1 = 121.87$ mm from the $KI$ in a straight line. We define the point $KI$ at a distance $S_1$ from the point and draw a straight line at length $15^0 + 5^0$, i.e., $20^0$, take the cross section of the straight line in length and determine the point $KI$ (Fig. 1). At point $\theta^K_1$ we define point $\theta^K_1$ at a distance $S_1$ and determine the point $K_I$ by drawing a straight-line section of length $R_d = \theta^K_1 K_I$ by drawing a straight line at $15^0 + 5^0$, i.e., $20^0$ (Fig. 1).

In this way, by adding $\theta_d = 5^0$, we define $K_I$ points up to $\theta^K_2 = 150^0$ and combine the $K_I$ points. The result is an elongated cycloid with a ridge.

The machining surfaces of the spindle row of cotton are given longitudinal (A, B, C, D) and transverse (L, V) shears, and the general machining boundaries are defined (Fig. 1).

Due to the high rotational frequency of the spindle and the small radius of the spindle, as it enters the working chamber, its teeth pick up the cotton in the cocoon; the blue cocoons burst into and fall to the ground, which has been observed in field experiments. When the spindle picker returns from the working chamber, the spindle tooth cannot pick up the cotton because the spindle tooth works to get out, not to stick to the cotton in the cocoon.
3. Results and Discussions
According to the obtained results, HS CHM allowed determining the design parameters of the dial drum, namely the number of cassettes, the number of spindles in the cassette and the distance between them, the geometric parameters of the spindle - diameters, cones, tooth orientation, correct selection or synthesis of tooth angles.

The distance between the spines of the spindle trajectory of the HS CHM generated graph analytically - \( L_s \) and the width of the spindle \( B_s \) are determined. As a measure of the degree of row processing, we assume the ratio of the width of the loop \( B_s \) to the distance \( L_s \) between the bars:

\[
K_{\text{proc}} = \frac{B_s}{L_s}
\]

Where: \( L_s \) - the distance between the spindles of the spindle trajectory;

\( B_s \) - lattice width.

We accept the expression for the optimal value of the degree of processing of cotton:

\[
L_{s, \text{opt}} = B_s + D_{\text{min}}
\]

Where \( D_{\text{min}} \) is the statistically determined minimum diameter of the open cocoon, which is 40 rayon 72 mm in regionalized and promising cotton varieties.

Where \( D_{\text{min}} \) is the statistically determined minimum diameter of the open cocoon, this figure is regionalized in the republic and is observed to be 40-72 mm in promising cotton varieties.

\[
K_{\text{proc}} = \frac{B_s}{L_{s, \text{opt}}} = \frac{B_s}{B_s + D_{\text{min}}}
\]

4. Conclusion
In a graph analytically constructed spindle trajectory, the distances between the axes of symmetry of the ridges are compared to the diameters of the opened and unopened grooves. The size of cotton stalks of regionalized and promising varieties in the country and the law of distribution of these sizes determine the trajectory of the typewriter HS. It allows determining which of the regionalized and promising varieties in our country is suitable or not suitable for the HS CHM harvest.

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