Parameters of finger stalk lifter cut branches in intensive gardens

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Abstract. In Uzbekistan, the areas of intensive orchards are expanding, in which branches are regularly pruned according to agrotechnical rules.
In intensive orchards, the number of fruit trees is usually greater, so cut branches occupy most of the row-spacing area. They interfere with many operations, so they must be removed. Usually, this work is done manually. True, some rakes collect cut branches and take them out of the field. The parameters of existing rakes do not always meet the requirements, so the authors proposed a branch pick-up that works satisfactorily. This article provides a rationale for its kinematic parameters. This branch pick-up also allows you to pick up short-cut branches in intensive orchards.

1 Introduction

In the article "Features of Tree Pruning in Intensive Orchards", the authors substantiated that a technical tool for directly selecting cut branches from the field surface should work like straw pickers installed on grain harvesters [1].

To clarify the parameters of such a pick-up, the cut branches' dimensions and their relative position on the field surface were studied. In intensive gardens, the length of cut branches can be taken in the range of 300-1200 mm. Short branches usually do not have side shoots, while long branches have side shoots 50–300 mm long. Moreover, the lateral processes are directed in different directions, representing voluminous elements. Depending on the thickness and rigidity of the lateral processes, the branches lying on the field's surface have a height of up to 300 mm. Therefore, the most difficult is the selection of short branches without processes, which, adapting to the microrelief of the field, lie, leaning on lumps of earth, at a height of h = 50-80 mm.

Therefore, the ends of the fingers of the pick-up must pass relative to the field surface at a height *h*. To prevent voluminous branches from being compacted, complicating the selection, the free length of the fingers must be at least l = 400 mm.

The casing diameter D_k, considering l = 400 mm and h = 50 mm, and the radius of the eccentric axis O_1 of the rotation of the fingers E = 180 mm, D_k = 300 mm, is selected. Therefore, to comply with r = 400 mm, h = 50 mm, E = 180 mm, as well as the conditions for the end of the finger to fall into the casing without protruding at the highest point of its position, the total length of the finger relative to O_1 is taken to be L = 350 mm. [2]

Considering the microrelief of the field, the small row spacing in intensive orchards, and the random spread of branches, we believe that the operating speed of the unit should not exceed V_m = 1.2 m/s. The completeness of the selection will depend on the coefficient of the advance of the circumferential speed of the end of the finger $\overrightarrow{V\pi}$ concerning the forward speed of the unit $\overrightarrow{V\text{м}}$. It is clear that there should be K >1.0. With a large value of K, that is, with a high circumferential speed of the finger, $\overrightarrow{V\pi}$ the branches will be intensively thrown far forward, which is not advisable. And also, the energy intensity of the process will be excessive. Therefore, we will carry out a kinematic study for various K. A priori we take K_1 = 1,1. Based on the results of these studies, we will establish the values of the coefficient K when the unit works satisfactorily. The gap between the impacts of adjacent fingers on the field's surface, that is, the overlap of their trajectory, must be comparable to the size of the branches lying on the ground. Based on this overlap, the number of fingers will be determined.

2 Research methodology

Thus, to determine the number of fingers for the pick-up dimensions adopted above, it is necessary to conduct a kinematic study for various coefficients of the unit operating modes.

The peripheral speed of the end of the finger at K_1 will be: $V_{n1}=K_1 \backslash V_M$= 1.1 * 1.2=1.32 m/s, and the angular velocity ω of rotation of the finger around the axis O_1 with a known turning radius r = L = 0,40m will be $\omega_1 = V_{n1}/r$ = 1.32/0.40 = 3.31 s; finger speed per minute: $n_1 = 30*\omega_1/\pi$= 30*3.3/3.14 =32 rpm, the time of one revolution of the finger per second: $t_1 = \pi/n_1$ = 3.14/32 = 0.098 sec, the path traveled by the unit in t seconds: $S_1 = V_M*t_1$ = 1.2*0.098 =0.12 m [5].

Based on these data, we construct the curve of the trajectory of the end of the finger in Fig. 1. Of interest to us is the trajectory of the finger movement in the front half of the pick-up drum, i.e., between the lower and uppermost positions of the pin in the casing. In the lower and upper positions of the pin, the direction of the peripheral speed of the end of the pin $\overrightarrow{Vo}$ and the speed of the unit $\overrightarrow{V\text{м}}$ are horizontal, but in the lower position, their direction coincides, i.e., summed up and in the upper positions$\overrightarrow{Vo}$ is directed against $\overrightarrow{V\text{м}}$, so they differ (Fig. 2). However, to determine the number of fingers, one should study the full trajectory of the finger in Fig. 2. The absolute speed of the branch, if it is captured at point A, is equal to the vector sum of the speed of the unit in the field $\overrightarrow{V\text{м}}$ and the circumferential speed $\overrightarrow{Vo}$, obtained by rotating the branch along with the finger around point O, that is $\overrightarrow{Va}$= $\overrightarrow{V\text{м}}$+ $\overrightarrow{Vo}$. With the $\overrightarrow{Va}$ thumb, it will throw the branches forward and not grab. Therefore, it is advisable to take the smallest K = 1.1. When the branch, together with the finger, is in position B, the end of the finger is already $\overrightarrow{V\text{в}}$ pointing upwards, from which the branch will not come off the finger. For the end of the finger to easily capture branch A, the absolute speed of the end of the finger in positions K, that is, at the height h of the location of the branch relative to the surface of the field, must Vкhave directions relative to from $\overrightarrow{V\pi}$ by an angle α, which is less than the friction angle φ of the branch and the finger. With this condition, the quantity $\overrightarrow{V\pi}$ was also determined $\overrightarrow{V\text{м}}$ [3, 4].

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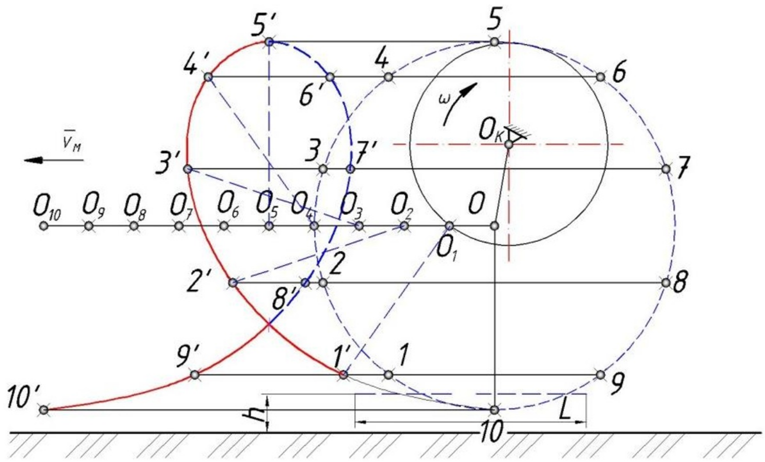

Fig. 1. Finger trajectory at K = 1.1.

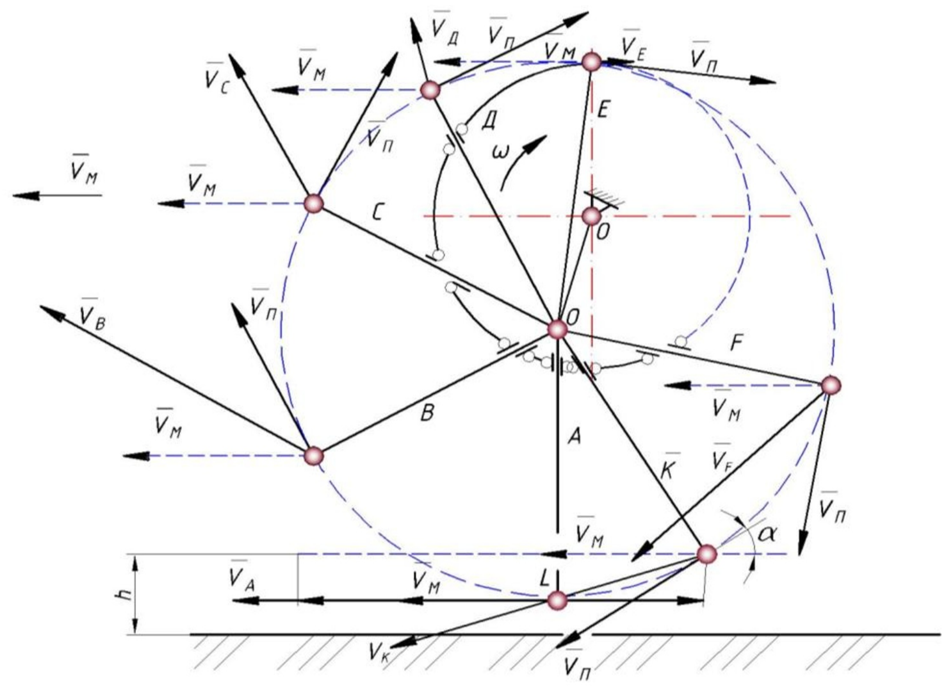

Fig. 2. Finding the absolute speed V $_K$ of the end of the finger in its position K when the angle of inclination V $_K$ to the horizon α is less than the angle φ of friction between the finger and the branch.

However, it is necessary to make a technical decision when even from position A, the finger grabs the branches. To do this, we consider that the end of the finger should not have a radial direction but should be bent forward in the form of a shelf (Fig. 3.) The length of the shelf should be sufficient for laying 2-3 branches. The ledge must be deflected from the radial direction by an angle β, which must be less than the friction angle φ of the branches on the steel pin so that the horizontal ledge of the pin can be inserted under the branches without shifting the branches to capture them. The length of the shelf should be sufficient so that it can accommodate 2-3 branches in diameter. The end of the finger bent in the form of a shelf does not prevent the captured and raised branches from being thrown off the finger in the highest position E. Here, the end of the finger has an absolute speed $\overrightarrow{VaE}$ directed backward along the course of the unit. True, here $\overrightarrow{VaE}$ it turns out to be small. But this is enough since the inertia force helps to throw the branches back so that the other pick-up unit can easily catch the branches and direct them in the right direction [6,7.]

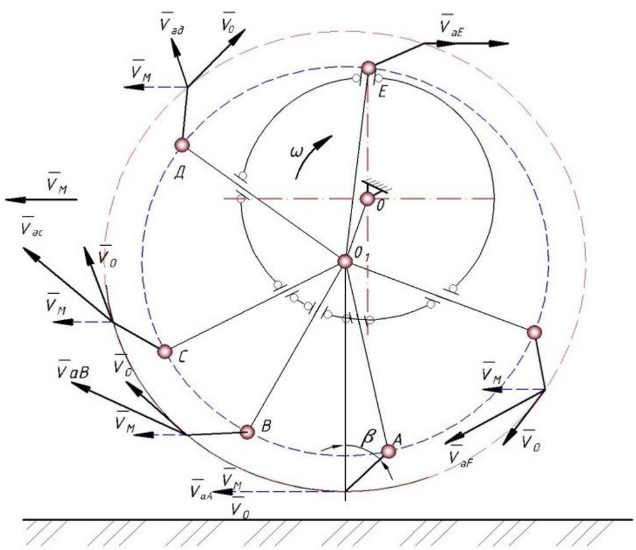

Fig. 3. Changing absolute speed of end of the picking finger as it moves.

For a complete analysis of the selection process, consider the forces acting on the branch T in position B of the finger in Fig. 4. If the branch is considered as a material point T with mass m, then it is affected by:

G is gravity, G = mg,N;

P_{ω} is centrifugal force; $P_{\omega} = mr\omega^2$, N; r is the radius;

P_i is force of inertia; P_i = ma, N; a is acceleration m/s^2 directed against the absolute speed $\vec{V}_{av}$ P_k is the cariolis force, $P_k = 2\ \omega V_{rel} sina$, N ;

P is the resultant of the above forces;

F is the friction force of the branch on the finger, N; F = Pfcosɣ; ɣ is angle of deviation of the resultant P from the normal to the finger; f is the coefficient of friction.

If the projection onto the finger is P_n = Psinɣ will be greater than F_1, then the branch will slip out; if P_k<F, then the branch will be held on the finger. Preliminary experiments show that P_k<F.

If the end of the finger is bent in the form of a shelf, then the effect of the above forces will change, from which the branch will not come off the finger, which is subjected to preliminary experiments.

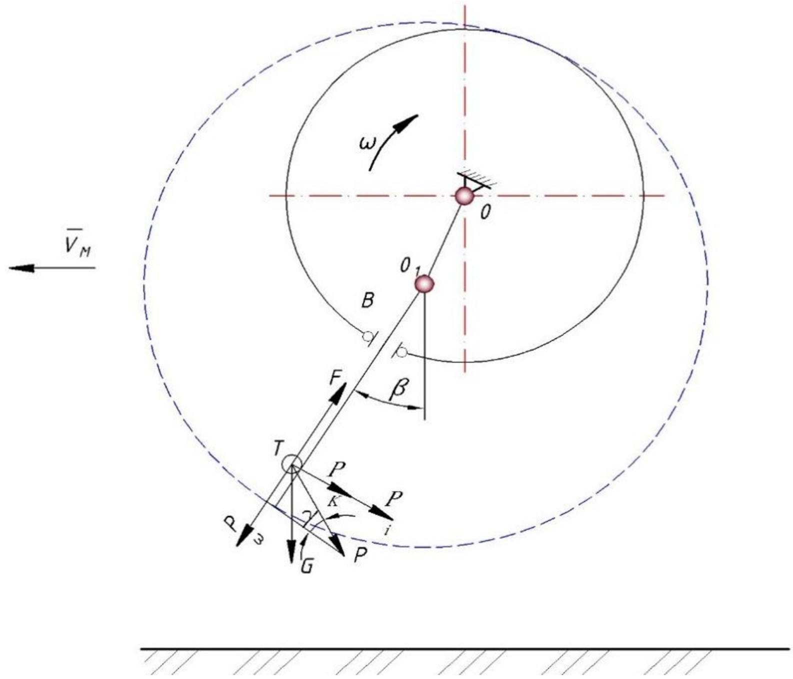

Fig. 4. Forces acting on the branch T.

The number of fingers should ensure the selection of all the branches laid on the field. The distance l_{in} between fruit trees in an intensive garden, depending on their type, according to observations in Uzbekistan, L = 1.2 ... 1.3 m is set. Therefore, we can assume that the distance between branches cut and laid on the ground will be within these limits.

If the pruner (worker) does not randomly scatter the cut branches but lays them according to a predetermined sequence in the middle of the aisle, from which his productivity will not suffer. In such a situation, the selection of branches will be facilitated. The most time-consuming will be the selection when the trees are planted close to each other, for example, at S = 1.2 m. Therefore, during the time t_a spent for the path passage equal to L = 1.2 m, at least one finger must pass the conditional location of the branches. [8].

We have adopted the operating speed of the unit V_a = 1.2 m / s. Therefore, for every S = 1.2 m, at least one finger must pass over the field's surface. At K_1 =1.1, the finger, rotating with the drum every second, will go through the path $L_в = K_1 * V_a = 1.1*1.2 = 1.32$ m. The circumference at the ends of the fingers $Sp = 2\pi R = 6.28*0.4 = 2.51$ m. Dividing S_p by S, we get the number of fingers $Z = S_п/S = 2.51/1.2 = 2.09$ pieces. Therefore, we take Z = 2 pieces.

In Fig.1, the finger's trajectory was built as if K_1 = 1.1. Comparing these trajectories, we can assume that taking K_1 = 1.1 as the main parameter is appropriate because the location of the lower part of this trajectory L at a height h in the possible arrangement of branches turns out to be the largest, i.e., there will be the greatest probability of capturing branches from the field surface, since it is difficult for the worker to cut the branches to lay the cut branches compactly in width so that there is a small spreading width. We believe that the width L of the trajectories at the height h in should be close to in B_p, i.e., $h_в = B_p$.

Figure 3 shows the nature of the change in circumferential speed $\overrightarrow{Vo}$ and absolute speed $\overrightarrow{Va}$ finger tip for several consecutive positions A, B, C, D, EF, and K in the direction of rotation of the finger. The value $\overrightarrow{Va}$ in the lower position of the end of the finger is the largest and is directed forward in the direction of movement of the unit $\overrightarrow{V\text{м}}$. We consider that at the moment the finger meets the branch, the finger has the maximum speed ($\overrightarrow{Va}= \overrightarrow{V\text{м}}+ \overrightarrow{Vo}$). Therefore, the finger acts on the branch as a blow with $\overrightarrow{Va}$. When large $\overrightarrow{Va}$, due to the impact of the finger on the branch, the latter can be thrown forward a long distance because the smooth surface of the finger cannot immediately grasp the branch immediately after the meeting. This situation worsens the completeness of branch selection.

3 Conclusions

1. For a complete selection of branches with the fingers of the pick-up from the field's surface, the pruning workers should lay the cut branches across the direction of movement of the pick-up.

2. If the finger is straight, then part of the branches it captured can come off. Therefore, it is advisable that the end of the finger be bent forward, in the form of a shelf, which becomes horizontal in the lowest position, so that the end of the finger shelf can easily penetrate under the branches.

3. The length of the shelf at the end of the finger should be sufficient to hold 2-3 branches on it.

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