Justification of commercialization of export-oriented harvesting apparatus for intensive processing of cotton boxes

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Abstract. In the conditions of operation of cotton harvesters with apparatus a two-time bush processing, such agrotechnical indicators as the loss of raw cotton and the dependence of the completeness of its collection on the degree of ripening of the crop do not meet the requirements of state standards. With a single pass of the machine, the completeness of cotton harvesting ranges from 75-83%, losses on bushes reach 15-10%, and with a two-time bush harvest – respectively 78-86% and 12-7%. In high-yielding fields (40 kg / ha and more), these indicators are too greatly deteriorating. The low cotton harvest and its high losses are largely explained by the high sensitivity of such apparats to the readiness plants of cotton plants and the agrophone of the cotton field for machine harvesting, the extensive nature of the processing of the opened boxes and the insufficient duration of the time the interaction of the latter with the working organs of the apparatus. One of the ways to intensify the impact of the working organs on the opened boxes and increase the time of interaction of the latter in the technological cycle working of the apparatus is to increase the multiplicity of processing cotton boxes. Therefore, the development of design documentation, the manufacture of industrial samples, trialing, preparation for commercialization and the organization of serial production of a cotton harvesting apparatus for intensive processing of cotton boxes (IPCB) is an important innovative task.

1 Introduction

Cotton harvesting apparatus with an intensive nature of processing boxes will be economically advantageous if a compromise is established between the main indicators of the quality work of the cotton harvesting machine (CHM) – the completeness of cotton harvesting and the preservation of the natural qualities of raw and fiber [1-8].

The problem of creating a cotton harvesting apparatus (HA) with a technological process of work that has such a compromise is an important scientific and technical problem that requires the development and implementation of advanced technological methods and technical solutions.

One of such methods of intensive processing of boxes [9] is a method that differs from the known methods in that an increase in the completeness of cotton removal from bushes is achieved by sparing (non-forced) by the loads of the processing modes of boxes.

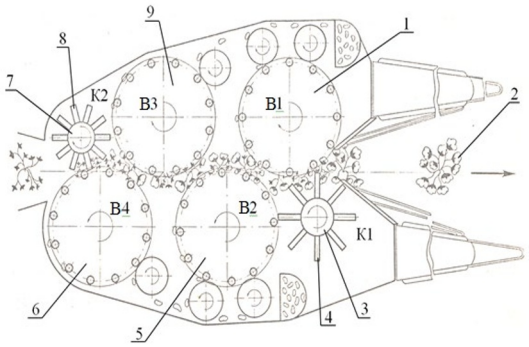

Fig. 1. The construction and technological process of working the cotton harvesting apparatus during multiple processing of cotton bushes: *1, 5, 6, 9 – spindle drums; 3, 7 – front and rear spikes drums; 4, 8 – elastic spikes; 2 – cotton bush with open boxes.*

Technical providing for such a method of intensive processing of boxes can be carried out HA (Fig. 1), where four staggered spindle drums 1, 5, 6, 9 and two spikes 3, 7 pegs with elastic spikes 4,8 are provided for each processed row of cotton [10].

The basis for the development of a model of intensive processing of the box by the working organs of this HA is its technological process of work. When the cotton harvesting apparatus moves across the field, the elastic spikes of the drum K 1 introduce cotton bushes into the working slot of the apparatus, pushing out the boxes and pressing them to the surface of the spindles of the drum B

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(Fig. 1). This means that the boxes between these drums are subjected to a single treatment. As the cotton harvesting apparatus moves forward, the box is sequentially processed on both sides by spindles, a pair of drums B1-B2, B2-B3 and B3-B4, as a result, the processing multiplicity reaches four. The last, one-time (and in total fivefold) impact on the box, is carried out by a pair of drums B4-K2. At the same time, the elastic spikes of the K2 drum press the remaining cotton slices to the surface of the B4 drum, and then, at the exit from the working slot, ensure the with drawl of bushes without shaking [11, 12].

Advantages of the cotton harvesting apparatus over the well-known constructions of vertical spindle harvesting apparatus:

- achieved fivefold processing of cotton boxes with staggered four spindle and two auxiliary spike drums;
- undulating, along the length of the working chamber of the apparatus, a working slot that promotes the reformation of cotton bushes and improves the access of spindles to cotton boxes;
- not a stepwise, but a smooth change in the value of the working slot between the spindle drums along the entire length of the apparatus, which eliminates the need to adjust the width of the slot when switching CHM from the first cotton harvest to the second;
- the entrance of cotton bushes into the working chamber of the apparatus without tilting and exiting it without shaking, which is ensured by the selection of rational kinematic parameters of the front and rear spikes drums;
- preservation of the natural qualities of raw cotton due to the processing of cotton boxes in sparing (non-forced) modes of the apparatus, which positively affects the percentage of cotton fiber output raw materials from machine-harvested.

2 Material and method

It should be noted that the high percentages of cotton leaves falling after defoliation and opening of the boxes (90-94%) and the location of the lower boxes from the ridge of the bed (20-25 cm instead of the required 8 cm) contributes to the free access of the spindles to the slices of the boxes, the complete processing of the latter and, consequently, the increase in the completeness of cotton removal from cotton bushes.

Agro technical indicators of apparatus for intensive processing of cotton boxes (IPCB) and serial are summarized in Table 1. The table shows that on the apparatus (IPCB) due to the five-fold processing of the boxes in two passes of the machine, the completeness of cotton collection into the hopper reaches 93.58-96.88%. This is 3.40-2.37% more than the completeness of collection achieved by the serial device (90.18-94.51%) and 3.58-6.88% more than the indicator required by the Ts05781953-003:2013 standard (at least 90%).

The expediency of picking up the cotton left on the bushes (0.68-2.76%) is determined by the cotton producer (farmer or cluster) according to economic criteria.

Thus, the development by machine-building enterprises of serial production of harvesting apparatus for IPCB and equipping the existing fleet of cotton harvesting apparatus with such devices contributes to the exclusion of manual cotton harvesting in the republic.

In 2021, cotton sowing with a row spacing of 76 cm reached 200 thousand hectares. There is a tendency to expand the volume of such sowing.

Table 1. The agro technical indicators of the CHM-1,8 cotton harvesting machine, equipped with an IPCB harvesting apparatus (numerator) and a serial apparatus (denominator) achieved during two collections according to the results of four-year state tests.

Name of indicators	**Values of indicators**			
Year and test protocol	2013 y. protocol №8-2013	2014 y. protocol №8-2014	2020 y. Act №8-2020	2021 y. report №5-2021
Completeness of collection in the bunker, %	96,88 / 90,70	95,14 / 94,51	95,67 / 92,04	93,58 / 90,18
Left cotton on the bushes, %	0,68 / 4,18	1,5 / 1,23	1,72 / 3,31	2,76 / 5,11
Knocked the cotton to the ground, %	2,44 / 5,12	3,36 / 4,26	2,61 / 4,65	3,66 / 4,71
Humidity of bunker cotton, %	9,4 / 8,9	12,2 / 11,18	8,8 / 8,2	8,5 / 8,4
Clogging of bunker cotton, %	17,75 / 14,74	9,6 / 9,4	17,6 / 12,6	16 / 13

In order to mechanize the cotton harvest from the fields with row spacing of 76 cm, the following works were carried out by the joint efforts of technologist-engineers of JSC “Technologist” and scientists of the Research Institute of Agricultural Mechanization (Fig. 2).

Fig. 2. Two-row harvesting apparatus for intensive processing of cotton boxes (IPCB) with row spacing 76 cm, prepared for attachment to the machine CHM-3.04H.

- the layout scheme has been developed and industrial samples of apparatus for intensive processing of cotton boxes (IPCB) and serial devices have been manufactured;
- the track of the controlled wheels, the mechanisms of hitching apparatus, the longitudinal frames of the

cotton harvesting unit have been improved taking into account the row spacing with a width of 76 cm;

- the corresponding track of the driving wheels of the tractor MTF-80 "Belarus" was selected by replacing the wheel disks;

- reducing gear is installed on the rear power take-off shaft of the tractor;

- the assembly of the machine has been carried out. The machine is indicated by the symbol CHM-3.04H, where CHM is "cotton harvesting machine", 3.04 m is the width of the four–row machine (4x76 cm); H is a hybrid machine (the left devices are serial, the right ones are IPCB);

- the machine passed preliminary tests in the fields of the “Ahmad Yasavi FIELD” farm during the second cotton harvest.

In the process of approbation, the fit of tractor driving wheels, steerable wheels and harvesting machines into cotton beds and the functionality of the machine in fields with row spacing of 76 cm were tested and evaluated.

The identified shortcomings will be eliminated. For the cotton harvesting season of 2022, a batch of industrial samples of the CHM-3.04H machine will be produced (Fig. 3).

Thus, the four-row cotton harvesting machine CHM-3.04H accelerates the process of commercialization of harvesting machines and agricultural machinery.

Fig. 3. Semi-mounted cotton harvesting machine CHM-1,8 based on the tractor MTF-80 "Belarus", equipped with a harvesting apparatus for IPCB-№1, manufactured under project №T-KX-2021-176.

3 Results and discussion

1. Ensuring the collection of the maximum part of the opened cotton from cotton bushes in high-yielding fields in one pass by vertical spindle cotton harvesters is an important scientific and technical task. This problem can be solved by using cotton harvesting apparatus with intensive processing of cotton boxes (IPCB).

2. Two industrial samples of IPCB harvesting apparatus for row spacing of 90 cm were manufactured and tested in the cotton harvesting seasons of 2020 and 2021. In the IPCB apparatus, for staggered spindle drums and two spikes with elastic spikes are provided for each processed row of cotton.

3. As a result of the staggered arrangement of spindle and spike drums in the working chamber of the apparatus, the multiplicity of processing cotton boxes with spindles increases to five, the length of the working chamber of the apparatus and the number of working spindles increases, an undulating gap between the drums is formed. The wave-shaped gap promotes the reshaping of bushes during the passage through the working chamber and improves the access of the spindles to the boxes. These design and layout features of the apparatus the growth of agro technical indicators of the cotton harvesting machine.

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