The results of the introduction of an automatic system for copying the field profile by harvesting machines into the design of the serial cotton harvesting machine MX-1,8

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Annotation: It was found that with the existing technology of cotton harvesting machines, part of the cotton fiber from the lower cotton boxes on the bushes remains unassembled. The solution to this problem is the creation of an automatic system for copying the field profile by the cotton harvesting machines. The operating principle of the developed system is described. The results of comparative laboratory-field tests of a cotton harvester equipped with this system and a serial cotton harvester are presented. The analysis of the results is presented. In general, according to the results of the work: a schematic diagram is selected for the system of an automatic copying of the field profile by harvesting machines; original components and parts of the system for an automatic copying of the field profile by harvesting machines were manufactured and installed on the experimental machine; a set of field experiments was carried out, the results of which confirm the correctness of the chosen solutions.

1. Introduction

Cotton and grain crops are mainly cultivated on irrigated lands in the Republic of Uzbekistan. As a result of the crop rotation, related crops such as beans, corn, mung beans, buckwheat, etc. are also cultivated.

For all the years of cotton cultivation in Uzbekistan, the most acute issue was high-quality and efficient harvesting of raw cotton. Today, it is quite clear that without mechanization of the cotton picking process, it is impossible to achieve any significant results in this industry [1, 2].

To date, the design of mass-produced domestic cotton picking machines (CPMs) has a number of drawbacks that limit the productivity of the CPMs, the indicators of their reliability, and the quality of the harvested raw cotton. This factor also hinders the growth of CPM exports to countries with similar agricultural techniques of cotton cultivation [3-6].

One of the ways to eliminate the above disadvantages and increase the efficiency of the vertical-spindle semi-mounted cotton harvester is the development and implementation of technology and a mechanism for an automatic copying of the field surface by blocks of harvesting devices.

With the existing technology of cotton picking machines, part of the cotton fiber from the lower boxes on the cotton bushes remains unassembled. This is due to the fact that for high-quality collection of raw cotton from the lower boxes on the bushes, the harvesting devices of the cotton harvesting machine should be as close as possible to the surface of the beds [7-9].
However, with manual control of the CPM, it is difficult for the driver to ensure accurate copying of the relief of the beds and, in order to avoid "burying" the devices in the ground with a local increase in the height of the beds, the driver is forced to install the devices at a greater distance from the surface of the beds. At the same time, the lower boxes remain unassembled, the quality and completeness of the collection decreases.

The absence of a system for automatic copying of the field profile on serial machines does not allow the machines to fully process cotton bushes. As mentioned above, the completeness of the cotton harvest decreases, crop losses to the ground grow, there is no protection of the harvesting devices from breakdowns when hitting a local elevation and when "burying" in the beds.

In the light of the foregoing, it becomes obvious the urgency of creating an automatic system for copying the field profile by the harvesting devices of CPM, which will increase their technical level, productivity and quality of machine picking of raw cotton.

2. Materials and research methods.

It is generally recognized that an effective solution to the tasks set is possible only in the case of an integrated approach to their implementation, combining the efforts and capabilities of scientific, design and production organizations. Taking this into account, the implementation of the project for the development of the copying system was carried out by LLC "Design and Technological Center of Agricultural Engineering" (LLC "DTCAE") with JSC "BMKB-Agromash" and UzSTCTT. The basis for carrying out work on the project was:

- results of the implementation of the innovation project No. -2013-3/4 in 2013 "Manufacturing and introduction into production of 2 MX-1.8 CPMs with resource-saving working bodies and harvesting devices of increased productivity";
- available developments of the Special Design Bureau (SDB) "Tractor" (the legal successor of which is LLC "DTCAE") in 2012-2014 during the implementation of the project under the State Scientific and Technical Program KAZ-025 "Creation and manufacture of a modernized transmission and gearbox for a cotton picking machine (CPM);"
- available developments of SDB "Tractor" in 2015 during the implementation of the project under the State Scientific and Technical Program KAZ-007 "Improving the quality of the vertical spindle cotton picking machine by the introduction of hydraulic drives of fans, harvesting devices, and a system for the automatic copying of the field profile by harvesting machines".

The project was carried out according to the traditional scheme: analysis of existing developments, drawing up and approval of technical specifications, development of design documentation, manufacturing of system components and parts and their installation on the CPM, checking the basic operability of the manufactured system, conducting laboratory and field tests of the CPM with an automatic copying system with harvesting devices field profile, analysis of test results, and design refinement based on the analysis results [7,8].

3. The basic principle of the system.

The developed system is hydraulic and is integrated into the main hydraulic system of the CPM. The schematic diagram of the system is shown in figure 1.

The system is activated from the tractor cab. The handle of the hydraulic distributor of the tractor is transferred to the mode of lowering the devices. When the unit moves, the device copies the relief of the beds. The movement of the copying device through the system of levers and rods is transmitted to the plunger of the hydraulic valve of the system. When moving on a flat surface, the plunger of the hydraulic distributor is in the middle neutral position. The oil from the pressure line “P” passes through the channels of the hydraulic distributor to the drain line “T”. When the height of the beds increases, the mechanism of the copying device 8 moves the plunger through the system of levers and rods inside the body of the hydraulic distributor 4, the passage of oil to the output “A” opens and then through the hydraulic lock 2 to the hydraulic cylinder 1. The oil enters the hydraulic cylinder (in the rod cavity) and the device rises. When the level of the beds is lowered, the mechanism of the copying
device is lowered, pushing the plunger of the hydraulic distributor. The “R” highway connects to the “B” channel. The hydraulic lock opens, and the devices are lowered by their own weight.

**Figure 1.** Schematic diagram of the relief copying system
1 - hydraulic cylinder for lifting devices; 2 - hydraulic lock VBPSL G 1/2"; 3 – reverse valve VPR-1/2-2.5; 4 - hydraulic distributor VM-2/1S-3/18X SLP; 5 - tractor hydraulic distributor control handle; 6 - tractor hydraulic system; 7 - harvesting device; 8 - copier (wheeled bush lifter); 9 – levers and rods of the system.

Lifting devices to the transport position is performed from the tractor cab by moving the handle GR up. The liquid passes to the "T" line and further, through the check valve 3, by passing the hydraulic lock 2, enters the rod cavity of the hydraulic cylinder 1. At the same time, the fluid flow through the "P" line is impossible, since the hydraulic lock 2 blocks the liquid passage to drain. Between the lines P and T, a check valve 3 is installed to protect the GR from possible “peak” pressures in the drain line when lifting the devices from the operator's seat.

A general view of the CPM MX-1.8 with an embedded copying system is shown in figure 2.

**Figure 2.** General view of CPM MX-1.8 with the implemented copying system
4. Results and discussion

In the course of the research, laboratory and field experiments were conducted to test a vertical-spindle cotton picking machine with the equipment of harvesting devices with a model of hydraulic copiers of the field profile and for comparison, CPM without hydraulic copiers. The experiments were carried out on the selected areas of the UzSTCTT, sown with cotton, with a total area of 8 hectares.

The following indicators were selected as criteria for evaluating the results of the conducted research:
- completeness of collection by machine;
- the remains of raw cotton on plants;

Figure 3. Cotton picker MX-1.8 3D (a) and a prototype machine with a system for automatic copying of the field relief (b)
- the amount of raw cotton knocked to the ground;
- humidity of the collected raw cotton;
- contamination of harvested raw cotton;
- the number of downed green boxes on the ground.

To determine the efficiency of the tested cotton picking machines with different indicators of raw cotton opening on cotton bushes, the following variants of laboratory experiments were carried out:

Option 1 - disclosure 50-60%; Option 2 - disclosure 65-75%; Option 3 - disclosure 80-90%.

Vertical-spindle cotton picking machines equipped with harvesting devices with a model of a hydraulic field profile copier system and without a hydrocopier were tested with the required technology for harvesting raw cotton, i.e. on double harvesting of cotton, provided for by the requirements for the agronomic background in accordance with GOST 22587.

The work was carried out in two options.

The first option consists of the following sequence - the first collection at a lower opening (60-70%), and the second collection 10-12 days after the first collection, i.e. with an additional opening of cotton (80-90%) [9,11,12].

### Table 1. Characteristics of the cotton field and phenological indicators of cotton

| Name of indicators                                      | Ts 05781953-003:2013 | Cotton picking machine MX-1,8 with hydrocopiers (experience7) | without hydrocopiers (experience 8) |
|---------------------------------------------------------|-----------------------|---------------------------------------------------------------|-------------------------------------|
| Test Location (cotton field)                           | UzSTCTT test site (8 hectares), Yangiyul district, Tashkent region | C-6524 defoliation                                          |                                     |
| Cotton variety                                          | С-6524               |                                                               |                                     |
| Previous processing                                    |                       |                                                               |                                     |
| Plant height (cotton), cm                              | 80-120               | 90,0                                                          | 90,0                                |
| Plant width (cotton), cm                               | no data              | 51,0                                                          | 36,0                                |
| Number of fruit branches on one plant, pcs, total:     |                       |                                                               |                                     |
| - monopod                                              | 1,0                  | 1,0                                                           |                                     |
| - sympodium                                            | 10,0                 | 9,0                                                           |                                     |
| Number of boxes per plant, pcs, total:                 | no data              | 14,0                                                          | 14,0                                |
| - opened                                               | 12,0                 | 13,0                                                          |                                     |
| - semi-opened                                          | 1,0                  | 1,0                                                           |                                     |
| - closed                                               | 1,0                  |                                                               |                                     |
| Number of opened boxes, %                             | not less than 80-90  | 86,0                                                          | 93,0                                |
| Plant standing density, thousand pcs/ha                | no data              |                                                               | 88888,0                             |
| The height of the lower box arrangement, cm            | not less than 8,0    | 23,0                                                          | 27,0                                |
| The number of leaves on one plant, pcs, total:         |                       |                                                               |                                     |
| Including - dry                                        | no more than 4,0     | 3                                                              | 4                                   |
| - semi-dry                                             | -                    | -                                                             |                                     |
| - green                                                | no more than 3,0     |                                                               |                                     |
| Row spacing width, main rows, cm                       |                       | 90,0                                                          |                                     |
| Depth of irrigation furrows, cm                         | 15,0                 |                                                               |                                     |
| Moisture content of raw cotton on the plant, %         | no more than 11      | 10,4                                                          |                                     |
The second option was an unconventional cotton harvesting technology - two-time cotton harvesting, i.e. the second pass immediately after the first with a large opening of cotton on cotton bushes.

In order to achieve reliability and comparability of the performance indicators of different CPM variants, the characteristics of the cotton field and the phenological indicators of the cotton plants on it were first determined. Table 1 shows experimental data on the characteristics of the cotton field and the phenological parameters of cotton plants with an analysis of their preparation for mechanized cotton harvesting by experimental cotton harvesters equipped with harvesting machines with hydrocopiers of the field relief and without hydrocopiers.

The results of agrotechnical assessments of experimental cotton pickers on the basis of MX-1.8 with hydrocopiers and without hydrocopiers carried out in these fields, on a double harvest using an unconventional cotton harvesting technology (the second harvest immediately after the first) with opening the bolls on the cotton bushes, respectively, 86.0 and 93.0% are shown in table 2.

**Table 2. Results of comparative agrotechnical assessments of CPM MX-1,8**

| Name of indicators                                                                 | Ts 05781953-003:2013; ГОСТ 22587 | MX-1,8 with hydrocopiers | MX-1,8 without hydrocopiers |
|-----------------------------------------------------------------------------------|----------------------------------|--------------------------|-----------------------------|
| Test location (cotton field)                                                      | UzSTCTT test site (8 hectares), Yangiyul district, Tashkent region |
| Speed of movement on the assembly, km/h:                                          | 4,13-5,32                        | 4,5 (1 collection)       | 5,8 (2 collection)          |
| The yield of raw cotton on the accounting plot, q/ha (when opened)                | 34,32                            | 31,58                    |
| Raw cotton collected in the hopper, total, q/ha (%):                               | 31,42(91,55)                     | 29,16(92,34)             |
| including                                                                         | 28,86(84,09)                     | 24,80(78,53)             |
| - I (1 collection)                                                                |                                      |                          |
| - II (2 collection)                                                                |                                      |                          |
| Raw cotton left on plants, q/ha (%):                                               | 1,55(4,52)                       | 1,11(3,51)               |
| Knocked raw cotton to the ground, q/ha (%):                                        | 1,35(3,93)                       | 1,31(4,15)               |
| Moisture content of raw cotton on the plant, %:                                     | no more than 12-13                |
| - I (1 collection)                                                                | 11,00                            | 10,00                    |
| - II (2 collection)                                                                | 10,50                            | 9,70                     |
| Contamination of harvested raw cotton, %:                                          | no more than 10                  |
| - I (1 collection)                                                                | 5,60                             | 5,01                     |
| - II (2 collection)                                                                | 8,8                              | 11,3                     |
| Actual number of open boxes, %                                                    | 86,0                             | 93,0                     |
5. Conclusions
As a result of the research and development work carried out, and on the basis of the results of laboratory and field studies of experimental vertical-spindle cotton pickers equipped with harvesting devices with hydraulic field profile copiers, carried out on the cotton fields of the UzSTCTT testing area, the following conclusions can be drawn:

1. The developed system for copying the field surface profile by the CPM harvesting devices corresponds to the technical task.
2. Experimental cotton picking machines equipped with bush lifters for harvesting devices with hydraulic field profile copiers based on vertical spindle cotton picking machines were tested on the counting fields of the 8 hectares testing area.
3. Experiments carried out on a double harvest, the results showed that for 1 and 2 harvests, CPM with hydrocopiers collected 85.39% of the ripened cotton harvest (Experiments conducted on a double harvest, the results showed that for the 1st and 2nd collections, CPM with hydrocopiers was collected 85.39% of the ripened cotton crop (according to the requirements of the Regulatory Documentation, not less than 85%).
4. Phenological observations showed that with the opening of 92.0% cotton, the yield for the opened raw cotton on the accounting plots of the experiments was 31.58 q/ha, and with the opening of 86.0% - 34.32 q / ha.
5. During two harvests by an experimental machine with hydrocopiers, raw cotton was harvested, respectively, with a yield of 34.32 q / ha - 91.55%.
6. The moisture content of the harvested raw cotton by an experimental machine with hydrocopiers at 1 harvest was, respectively, 11.0%, and 10.5% at 2 harvest.
7. The contamination of the harvested raw cotton by the experimental machine at 1 and 2 harvests was within 5.6-8.8% with hydrocopiers, while according to the requirements of regulatory documents, no more than 10% is allowed.
8. The analysis of the indicators shows that the increase in the opening of raw cotton on cotton plants, which is in the range of 57.0-86.0%, does not affect the quality indicators of the tested cotton harvesters.
9. With different cotton openings, the damage to the seeds of the harvested cotton ranges from 0.1-0.5%, which meets the requirements of the RTD (no more than 1.0%).
10. The grade of the harvested raw cotton belongs to grade 1, and the grade of cotton fiber with different cotton openings is in the range of 1-3, i.e. one sort.
11. The bush lifts of harvesting machines with hydrocopiers do not collect weeds, their roots and soil lumps when working.

In general, according to the results of the work:
- a schematic diagram is selected for the system of an automatic copying of the field profile by harvesting machines;
- original components and parts of the system for an automatic copying of the field profile by harvesting machines were manufactured and installed on the experimental machine.
- a set of field experiments was carried out, the results of which confirm the correctness of the chosen solutions.

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