New universal inlet chamber for vertical and horizontal spindle cotton pickers

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Abstract. This article provides a versatile suction air intake chamber for vertical and horizontal spindle cotton pickers. The results of field tests using the new universal receiving chambers are presented. The results of field tests showed that the use of the new universal intake chambers reduced the power loss on the fan drive by 1.8 ... 2 times compared to the Case-2022 horizontal spindle machine. For the MX-1.8 vertical cotton picker, the weediness of raw cotton was reduced by 1.0-3.0% and crushed seeds by 1.35 times compared to serial receiving chambers.

1. Introduction
It is known that vertically and horizontally spindle cotton pickers are used to harvest raw cotton [1-3]. One of the important systems in cotton pickers is the pneumatic transport system, which is used to transport raw cotton collected by the harvesting machines to the hopper.

The pneumatic transport system of modern semi-trailed cotton pickers of the MX-1.8 (MX-2.4) type consists of four (eight) vertical receiving chambers of rectangular cross-section, rounded from the front side and open from the bottom end. The receiving chambers from the upper side are rigidly connected with special adapters, the ends of which are rigidly connected to telescopic rigid tin (or flexible membrane transparent) pipelines with an inner diameter of 175 mm. These pipelines are connected through an adapter with an air collector connected to the side elliptical inlet of the low pressure centrifugal fan. The fan with a frame is installed in a special frame, welded construction. The latter is rigidly attached to the frame of the cotton picker. The blower outlet of the quadrangular section fan is connected by a trapezoidal pipeline directed to the machine hopper.

The machines are equipped with two fans (left and right), the fan impeller is driven from the transfer gearbox using V-belts through the counter drive.

The operation of pneumatic transport systems of domestic cotton pickers is considered in the works of many scientists, in the works of AN RUz, TsNIHProma, SAIME, TashPI, GSKB AN RUz, TsNIIHProma, SAIME, TashPI, GSKB on machines for cotton growing [4-20].

According to the method of transportation, pneumatic systems are divided into suction, injection and ejection.

Suction pneumatic systems are the simplest in design, but they require devices to prevent damage to seeds and raw cotton fibers when they hit the rotating impeller blades. Allowable damage to seeds should
not exceed 1%. Mechanical damage to cotton seeds is an undesirable defect, since when ginning raw cotton, this leads to an increase in fiber defects.

The pneumatic conveying system of the cotton picker consists of elements characterized by significant local aerodynamic drag. The most critical unit is the receiving chamber. Domestic cotton pickers use receiving chambers with straight, side and slotted entrances [9].

At present, slotted receiving chambers are installed on the serially produced cotton pickers MX-1.8 and MX-2.4, which are a vertical pipe with a slot along the generatrix equal in height to the brush stripper. The stripper is located at the entrance to the slot so that the gap for the passage of raw cotton between the ends of the brush and the wall of the entrance slot is 5...8 mm [10].

To ensure the efficient operation of the pneumatic transport system of a two-row cotton picker, the fan capacity must correspond to \( Q = 2.2 \, \text{m}^3/\text{s} \), the concentration of the mixture \( \mu = 0.2 \, \text{kg/kg} \) according to the recommendations of GSKB for cotton growing machines.

To eliminate damage to raw cotton seeds by the fan impeller in the GSKB for cotton growing machines, a receiving chamber has been developed and created, from where cotton is transported from the working apparatus to the hopper by the forced air flow [11]. The inlet chamber is a V-shaped rectangular pipe and is an ejector hopper. On the basis of this design, an inlet chamber was designed for machines for belt picking of raw cotton, which is a combination of two conventional V-shaped chambers.

The main requirement for the receiving chamber is the absence of air blowing out through the slotted hole towards the cleaning device. According to [11], due to the absence of a sluice valve in a pneumatic transport system with a pressure receiving chamber, air should be sucked along the entire height of the slotted hole through which the harvested raw cotton enters the chamber. In other words, for normal operation of the chamber along its entire height, it is necessary to create negative static pressure. Otherwise, in the upper part of the slotted hole, air is blown out of the chamber into the apparatus and, capturing weakly picked cotton slices, moves them to the periphery of the rotating stripper or to the upper drive part of the apparatus. As a result, a part of the collected cotton falls to the ground, and the other, falling on the gearing of the drive gears and between the belts of the spindle reverse rotation pads, causes damage, wear and breakdown of the apparatus elements. It has been experimentally determined that the aerodynamic resistance of such chambers is 1530 Pa, which is much higher than that of serial suction chambers. Therefore, the power consumed by the pneumatic conveying system is twice the power of the pneumatic systems with suction air flow. In addition, a larger number of pipes increases the metal consumption of the machine [7].

In [17], the influence of the peripheral speed of a centrifugal fan on the damageability of cotton seeds was studied and it was experimentally determined that the mechanical damage of cotton seeds does not occur at \( \omega \leq 34 \, \text{m/s} \) or the fan speed is less than \( n \leq 1270 \, \text{rpm} \). This speed does not ensure the operation of the MX-1.8 and MX-2.4 cotton pickers, which are produced today by factories according to the existing pneumatic transport system schemes.

The authors of [18] studied the dynamics of the interaction of cotton slices with elements of pneumatic transport systems of cotton pickers. In order to reduce damage to cotton seeds, i.e. ensuring the directional movement of cotton seeds and limiting their contact with the fan blades, it was proposed to shift the inlet pipe of the air duct relative to the rotation axis of the fan impeller 75-100 mm. However, this leads to a decrease in fan performance. A decrease in the intake air capacity results in an increase in cotton loss to the ground. Therefore, this proposal has not found practical application.

It is known that in modern American horizontal-spindle cotton pickers, an ejection pneumatic transport system is used, which ensures less damage to cotton seeds. This system consists of a lower intake chamber with a rarefied air flow, a discharge pipe expanding in the middle and upper parts of the pipeline, with the help of which the cotton collected by the device is transported to the machine hopper. The disadvantage is the high-power consumption for the drive of the high-pressure fan.

But, regardless of the method of transporting raw cotton, there are problems of improving the quality of transported cotton and reducing the power consumption of the fan drive in cotton pickers.
The purpose of this work is to develop a new universal receiving chamber for vertical and horizontal spindle cotton pickers, which meets the requirements for the quality of transported cotton with less power consumption for the fan drive.

2. Research method
To achieve this goal a new universal suction chamber of the suction-type U-shape has been developed [21].

The distinctive features of the U-shaped receiving chamber in comparison with the slotted one is that clean air is sucked in during suction, and dirty air is sucked in the slotted chambers. To transport raw cotton from the receiving chamber to the hopper, the U-shaped chamber requires less air volume compared to the slotted chamber.

3. Results and discussion
Based on this, this camera was installed on a horizontal spindle cotton picker of a serial cotton picker MX-1.8 GV [22].

Figure 1 shows a combined cotton picker with horizontal spindle units.

![Figure 1. Cotton picker MX-1.8 GV with horizontal spindle devices.](image-url)

The performance indicators of the machine were compared with the requirements of the organization standard Ts 25272604-017: 2015, registered in the state register on 21.08.2015. Uzbek Agency for Standardization, Metrology and Certification “Cotton picking machine MX-1.8. Technical conditions”.

The cotton picker was aggregated with an LS wheeled tractor with an 80 hp. in field tests The completeness of cotton picking from a machine with horizontal spindle devices at a speed of 4.0 km/h was 91.84%, and at a speed of 5.6 km / h - 87.62%.

As a result of field tests, the high costs for the operation of a horizontal-spindle machine have been confirmed in comparison with a vertical-spindle or combined selective machine (the energy model is a semi-trailed structure plus a horizontal spindle apparatus) 1.8 ... 2 times [23].

Similar tests were carried out on cotton pickers MX-1.8, figure 2 (a, b).
Figure 2. General view of the MX-1.8 cotton picker with serial (a), with experimental (b) receiving chambers.

The operating mode of the MX-1.8 cotton picker for comparative tests is presented in table 1.

Table 1. Operating mode of the cotton picker MX-1.8.

| Engine crankshaft speed, min⁻¹ | Fan speed for serial receiving chamber, min⁻¹ | Fan speed for the test chamber, min⁻¹ |
|--------------------------------|---------------------------------------------|-------------------------------------|
| 2200                           | 1280                                        | 1280                                |

When conducting field trials, the MX-1.8 cotton picker with experimental receiving chambers was used to pick cotton in one bed. The cotton from the second row was harvested in advance, and therefore the width between the drums of the second row was shifted as much as possible.

The results of laboratory tests of changes in cotton contamination using the receiving chambers of the serial and experimental versions, depending on the change in the working gap, are presented in table 2.

Table 2. Test results.

| Indicators               | Serial receiving chamber | Experienced receiving chamber |
|--------------------------|--------------------------|-------------------------------|
| Working slot width (mm)  | 30-28 32-28 34-28        | 30-28 32-28 34-28             |
| Humidity, %              | 8.9 7.6 9.5              | 7.2 7.4 8.2                   |
| Debris, %                | 13.9 11.2 11.5           | 10.9 10.2 10.0                |
| Crushing of cotton seeds % | 0.2 1.0 0.2           | 0.4 0.4 0.21                  |

4. Conclusion

When picking cotton with a combined selective machine MX-1.8 GV with the use of a U-shaped receiving chamber, the completeness of harvesting is P = 91.84% in one pass, providing a decrease in power loss on the fan drive by 1.8 ... 2.0 times compared to the horizontal spindle machine Case-2022.

The data obtained from the results of laboratory and field tests of the MX-1.8 cotton harvester with a new receiving chamber, the contamination of the harvested raw cotton in comparison with the serial one decreases by 1.0-3.0% when the working gap changes from 30-28 mm to 34-28 mm, and the fragmentation of cotton seeds decreases 1.35 times.

References

[1] Matchanov RD 2011 Cotton pickers 1929-2010 (Tashkent) 66
[2] Shoumarova M and Abdillaev T 2002 Agricultural machinery (Tashkent: “Teacher”) p 336
[3] TianJing-shan, ZhangXu-yi, ZhangWang-feng, LiJian-feng, YangYan-long, DongHeng-yi, JiuXing-li, YuYong-chuan, ZhaoZhan, XuShou-zhen and ZuoWen-qing 2018 Fiber damage of machine-harvested cotton before ginning and after lint cleaning Journal of Integrative
Agriculture 17(5) 1120-7

[4] Shpolyanskiy D M, Atamanonov Yu P and Samandarov S A 1971 Improving the quality of cold-water harvesting machines Cotton industry 4

[5] Shvartsman L M 1960 Aerodynamics of cotton pneumatic transport (Tashkent, Ph.D. thesis abstract)

[6] Berezhnov V G 1972 Research and development of removable-transporting devices for a cotton picker using a diametrical fan (Tashkent, Ph.D. thesis abstract)

[7] Artykov N I 1984 Pneumatic transport of easily damaged materials (Tashkent: Fan) p 143

[8] Shamsutdinov T Sh 1960 Some questions of the aerodynamics of cotton (abstract of the dissertation of Ph.D.)

[9] Arzumanyants AG and Pilyuganova EA 1973 On the issue of aerodynamic resistance of the receiving chambers of cotton pickers Mechanization of cotton growing 8-9

[10] Mounted four-row cotton harvester KhN-36 (Moscow: V/O "Traktoroexport") p 124

[11] Slobodkin A A and Arzumanyants A G 1975 On the issue of creating a receiving chamber for a cotton picker with a starting pneumatic transport Mechanization of cotton growing 5 9-10

[12] Grober A D Some features of the shock interaction of cotton materials with the working bodies of cotton processing machines

[13] Ismailov A A 1981 Research and selection of methods for increasing the technological reliability of pneumatic conveying systems for cotton (Kostroma, abstract of the dissertation of Ph.D.)

[14] Burkhanov A 1986 Improvement of the working elements of the pneumatic transport system in order to preserve the natural properties of the processed cotton seeds (Tashkent. Abstract of the dissertation of Ph.D.)

[15] Shpolyanskiy D M et al. 1985 Pneumatic conveying systems of a universal cotton harvesting machine Mechanization of cotton growing 12

[16] Usarov Since 1972 Research and substantiation of the parameters of the mechanical conveyor of cotton-picking machines (Tashkent, Ph.D. thesis abstract)

[17] Ziyaev Kh A 1967 Research and development of a centrifugal fan with blades of a new type for cotton pickers (Tashkent, Ph.D. thesis abstract) p 20

[18] Alimova Z X 1999 Dynamics of interaction of the flat lobes with elements of pneumatic conveying systems of cotton pickers (Tashkent, Ph.D. thesis abstract) p 18

[19] Rizaev A A, Yuldashev A T, Kuldoshev D A and Ashurov N 2020 Effect parameters of vertically spindle cottonpicker machine on the mechanical damage of cotton seeds during machine harvesting IOP Conf. Series: Materials Science and Engineering 883 012166

[20] Mukhammadiev D M 2009 Algorithm development for the pulsator VBFC machine unit simulation Journal of Machinery Manufacture and Reliability 38(1) 82-6

[21] Otajonov N S, Matchanov R F, Rizaev A A, Malikov Z M, Yuldashev A T et al. 2019 Method of transporting raw cotton from the receiving chamber to the bunker of a cotton picking machine and a device for its implementation Application No. IAP 2019 0507 Date submitting an application 12.12.2019

[22] Matchanov R D, Rizaev A A, Yuldashev A T, Kuldoshev D A and Akhmedov Sh A 2020 Pneumatic Transport System of a Cotton Picker International Journal of Innovative Technology and Exploring Engineering (IJITEE) 9(4) 2267-70 ISSN: 2278-3075

[23] Conclusion on the results of tests of imported samples of horizontal-spindle machines of the "Case" company: four-row - model 2155, two-row - model 2022 and two-row horizontal-spindle machine KhMG-01 GSKB on machines for cotton growing in the season 1995 1996 (Tashkent: UzMIS) p 30