Problems in the air transport systems of cotton harvesting machines

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Abstract. The article describes the analysis regarding the shortcomings of the horizontal and vertical spindle cotton picking machines manufactured in the country, based on the principles of operation and experiments of air transport systems that transfer cotton from the picking machines to the bunker. On the examples of JX-220 horizontal and semi-trailer vertical spindle machines with suspended structures, the moving air velocities in the air transport pipelines were measured using a Kanomax Anermomaster 6112 instrument and the results were interpreted. In high-yield fields, the decline in the harvesting qualities of machines of both constructions is to some extent characterized by defects in the air transport system. During the operation of the JX-220, the cotton collected and stuck in the front drum of the harvester is collected in the receiving chamber of the system due to the low air flow rate. The four-row MX-2.4 semi-trailer with a vertical spindle has a stairwell behind the tractor to facilitate maintenance, complicating the design of the air transport system. The experiments have shown that due to the increase in local aerodynamic resistance in the system pipes, the flow rate to transport the cotton to the bunker is insufficient. The results of analyses and experiments require research on the reduction of aerodynamic resistance in machine air transport systems.

1. Introduction

According to the annual report of the International Cotton Advisory Committee (ICAC), the demand for environmentally friendly raw cotton and its products is increasing year by year [1].

Uzbekistan is one of the leading countries in the world in terms of cotton cultivation and processing, and the harvesting on the basis of mechanization is being carried out with modern horizontal and vertical spindle machines. In this process, when picking raw cotton, which is picked up by the plantations, into the bunker, an air transport system is used which has a low negative effect on the natural qualities of fiber and seeds. Horizontal spindle cotton machines are equipped with a “Jet er trole” system based on the ejection print, while vertical spindle machines have a system of sucking air from the apparatus and directing the harvested cotton to the bunker using a ventilator of low energy efficiency [2-4]. Some research and experimental design studies are being carried out in the USA and
Uzbekistan based on the above-mentioned principles, and a number of organizations are working in this direction [5-14].

The article covers the problems of modern cotton-making machines based on the analysis of air transport systems and the necessary experience.

Leading companies from the USA, Italy, China, India and other countries John Deere, New Holland Case, Guanda, Huangxin and Tashkent Agricultural Machinery Plant (TAMP) use Case C® as an example of horizontal spindle machines in analyzing the main principal aspects of air transport system in them. John Deere's two-row high-performance machines (1,417 M³/s), with high speed and high pressure (5.5 KPA), requiring great power (at least 30 ... 40 kW) were equipped with centrifugal ventilator at some time in the past [3, 4, 9]. Such constructions are being used in modern multi-lane (3-6 lanes) machines as well.

2. Research method

The processes in air transport systems, the working element of the construction of two types of cotton picking machines, are explained in a theoretical (analytical) way. Static and working conditions of constructions are considered. The experimental aerodynamics method, the special modern instrument Kanomax Anemomaster 6112, measuring the air flow velocities in the secondary system pipes by the repetition method are used; the results are processed by mathematical statistical methods and shown as graphs and tables. The experiments and analyses revealed the problems in the air transport systems of machines and became the basis for their further solution.

3. Results and discussion

Figure 1 shows the examples of Case-2022 and JX-220 machines including the case in which cotton is being transmitted by air from the term apparatus (two-row) to the bunker and the observations of the receiving camera of the JX-220 machine [1, 9]. The harvesting machine 1 consists of (Figure-1a), high-performance centrifugal ventilator 2, a pipe 3, which transmits the air from the ventilator to the receiving chamber 5 by means of a high-speed “U” Simon slit, a pipe 4, which transmits the cotton to the bunker and other parts that carry out the harvesting process.

![Figure 1. Horizontal spindle Cotton Machine: a–Case-2022 air transport system, b – JX– 220 receiving camera of machine](image-url)

The process in the air transport system is carried out as follows: the air flow that moves the cotton is absorbed from the outside as a result of the rotation of the propellers of ventilator 4 at a large angular velocity (Nv=4000 min⁻¹) and the pipe is directed to 3, at the exit from it the air cross-section is transmitted to transport pipe 4 on one side of the receiving chamber 5 by means of a small “U” shaped slit. From the second side of the receiving chamber, cotton wool is transmitted to it through the disc separator at a certain initial speed, and the “U” connected to the camera is directed upwards from
the Simon slit and sent to the bunker through pipe 4, joining the negative pressure-absorbing current around it.

According to the rules of aero-hydrodynamics, if a continuous environment moves at a greater speed than any narrow surface, negative pressure (absorbing current) appears around it, attracting the surrounding environment. Because the air transportation systems of horizontal spindle machines are based on that same principle, harvested cotton falls into the bunker directly through pipe 3 (Figure 1), not from the ventilator. This means that the speed of air passing through the "U" shaped slit, its volume in every moment and pressure are of great importance in the impeccable process of cotton transport. As a result of the experiments conducted with the permission of the TQXTZ leadership, the air velocity outflowing from the slit was recorded to be approximately 35 m per sec, using the Kanomax Anemomaster 6112 instrument [15].

The “N” distance in the receiving camera 5 in Figure 1 and its cross-section surface are of great importance for the reliable operation of the system. This issue is being expected to be solved on the JX-220 machine, since in high-yield fields there are cases when the camera is filled with cotton. As a result of the experiments and tests conducted in the Certification and Testing Center of Agricultural Machinery and Technologies (QXTTSM) and BMKB-Agronash JSC, construction combines (Case-2022, Case-2155, DD-9930, DD-9940, etc.) and power and collar lubricants for horizontal spindle machines in the hanging form (JX-220) 1.6 compared to vertical spindle machines of the same classis 2, 3 times higher it is noted that the power consumption for the air transport system is two times higher [4, 9, 13].

In this regard, it is worth noting that the costs of semi-trailer cotton machines created in Uzbekistan are several times less: for production (2-4 times), for use (up to 2 times). At the same time, an increase in the reliability of machines is still urgent. Especially, the practical importance of carrying out research on the air transport system and improving it [12] are of great importance.

Figure 2. The semi-trailer MX-2,4 cotton mill and its air transport system.

Figure 2 shows the MX-2, 4 semi-trailer vertical cotton harvesting machine designed for a four-row 60 cm range. The machine consists of an air transport system and a bunker based on a suction-
compression printing system, consisting of 4 two-sided spindle drums of the same construction on each side and 6 brushless separators on each nozzle, a transfer from the ventilator through the pipes of the sought cotton to the bunker through which the bunker is transferred. Since the process in the terminology apparatus is widely covered in the literature, it is preferable not to go into it in detail [1, 4, 12,16-19]. The air transport system, which transmits the cotton harvest to the bunker in the spindle unit, is configured as follows: all parts of the machine are frames-1 that can be installed, the receiving camera installed on the harvesting apparatus-2, the pipes that can enter each other transmitting the cotton to the ventilator-3, the inlet part is a pyramidal outlet part, the air collector connected to the fan body -4, the centrifugal low-pressure fan-5, the belt drive moving the fan blades-6, the cardan shaft-7. The working process of machine air transport system: the rear power draw of the tractor transmits the connected reducer by the governor to the valve 7 by the second outgoing governor Mufta coupling to the valve with the valve card, the second side of the Val provides movement through the cone-wheel reducer to the valve Guide Pulley, then the motion is transmitted to the drive pulley on the fan shaft, from which the motion begins to rotate the blades. As a result, the air moves through the elliptical hole on the side of the ventilator housing, sliding through the outside and the hardware side slit through the lower and side holes of the muffler 4, the transmitter tube 3, and the receiving Chambers 2. The cotton, which received the initial acceleration from the separator with a brush inside, falls into the cotton receiving chamber through the suction stream and reaches the bunker having passed through the ventilator. Semi-trailer creates conditions of wide use in work other than tractor due to the possibility of easy separation of the tractor from the cotton harvesting unit in the car. At the same time, the location of the harvesting apparatus on the stairs in the machine has made the design of the air transport system to some extent more complicated. An additional twist in the geometrical forms of the transmission pipes caused a decrease in the volume of air in the receiving chamber, sucking additional air from the outside at the places of entry of the pipes into each other. As a result, the structures of the transmission pipes as well as clamps are complicated and cause an increase several times local aerodynamic resistance to increase several times in them [19, 20]. Therefore, the shortcomings in the air transportation system of the MX-2,4 machine negatively affect the completeness of harvesting, one of its main indicators. To solve this problem, it is of practical importance to study the air velocity, which is one of the main indicators in the system. In this case, we performed the air velocity using the Kanomax Anemomaster 6112, measuring instrument at three locations (A, V, S) in the system shown in Figure 2 and four air-absorbing pipes at the point where they are connected to the mast [15].

This measuring instrument is made in Japan and has a special display screen, with the possibility of recording the speed, pressure and temperature of the air in the object being studied [13]. In the process of measuring the air velocity, when the Velocity value of the accuracy level is 0,1 of ... 19,9 m/s it is 2% , when it is 20 ...50 m/s it equals to 3% . The experiments were carried out on the MX - 100 machine, which was aggregated with the TTZ-LS 2,4n tractor, and in each of the above positions (mainly A and C cross-sections), the results obtained were shown in the table with their average values after three repetitions.

Air flow rate in the air transport system of MX-2,4, cotton picking machine (based on air collector types)

| Name of the manufacturing company | TAMP* / Technolog JSC** |
|----------------------------------|-------------------------|
| Measuring points in the pipes that transmit cotton to the bunker | By System height | A | B | C |
| According to the order of the pipes | I | II | III | IV | I | II | III | IV |
| Air flow rate**, M/s | 20,8/21,3 | 20,8/21,4 | 19,7/20,2 | 18,0/24,3 | 7,5/7,9 | 5,0/5,5 | 5,1/7,7 | 6,2/6,3 |

* - TAMP construction in the numerator
According to the table, the air flow rates in air transport systems, equipped with hoods, which are produced in both enterprises, are close to each other. At the same time, the flow rate at the entry point A of the coupler, which is located at the farthest edge of the technologist AJ, is due to the characteristic of the construction, which is the excess of the coupler to 6.3 m/s, that is, the pyramidal construction of the coupler has a symmetrical shape, which reduces the local aerodynamic resistance up to 3 m/s. But flow rate under the receiving camera of the hardware associated with this point is equated with the TQXTZ construction. The reason for this is the abundance of local resistance in the transmission pipe and the excess of air flow, which is absorbed by the side of the receiving chamber.

From the results of the research conducted, it is known that local aerodynamic resistance in the pipeline increases when the bendings in the transmission pipes (the number of them is more than two) are as many as possible and their value approaches 90° [20].

From the experiments conducted on TAMP fields it is known that the air-transport systems of the MX-1,8, MX-2,4 semi-trailer machines adversely affect the quality of the harvest in fertile fields and the amount of cotton spilled on the ground increases, as the velocity of air flow in the receiving chamber of the harvesting apparatus is less than the rate of suspension of cotton pieces and stalks (6.3... 7.0 m/s) (see table) [12, 20].

4. Conclusion
1. Based on the above-mentioned analysis and conducted experiments, the improvement of air traffic systems of cotton machines JX-220 suspended and semi-trailer structures is one of the pressing problems and needs solving.
2. The analysis of the structures of air transport systems of cotton-making machines in production and their working processes was conducted, and shortcomings in the system were covered.
3. As a result of the experiments conducted on the example of a four-row semi-trailer cotton-harvesting machine, it was determined that the air velocity in the hardware receiving chamber is not enough to transfer cotton to the bunker.

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