Justification of the Scheme of the Automated System of Control and Management of Seeding in Rowed Seed Drills

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Abstract. The article considers the issues of the need to improve the quality of the technological process of sowing seeds of row crops with precision seeding drills and the main trends of their improvement from the point of view of the possibility of introducing seed lines with control and control systems for the technological processes of sowing row crops into the design of a serial row seed drill, and also presents a new design of a sowing apparatus with an automated system for monitoring and controlling the process of sowing row crops cultures, the scheme of the seeding control system and the advantages of using the new system are developed and described. (Purpose of the study) Substantiation of the scheme of the automated system of control and management of seeding in rowed seed drills (Materials and methods) The research is based on a systematic analysis of the designs of seeding machines of precision seeding drills, monitoring and synthesis of the best technical solutions for creating a design of a seeding machine with a system of automated control and management of the technological processes of seed sowing at the stage of transporting them to the bottom of the furrow. (Results and discussion) The result of the synthesis of the best ideas and constructive solutions evaluated based on the analysis of the main trends of manufactured agricultural machinery for the cultivation of row crops is presented. The main disadvantages of precision seeding drills are described and ways to improve their designs are presented. The analysis of seed sowing control devices and primary converters used in them at all stages of the technological seeding process by the dosing system is given. The evaluation of serial seeding control systems and the parameters controlled by them is presented and it is established that none of them controls the seeding process, respectively, and it is impossible to talk about seeding quality management in general. To ensure accurate sowing of seeds of row crops, a design of a pneumatic seeding apparatus with a seed blower with an automated system for monitoring and controlling the process of sowing seeds of row crops has been developed, the scheme of which is also presented in this work. (Conclusions) Based on the patent search, monitoring and synthesis of existing serial precision seeding drills and automated systems for monitoring technological seeding processes, the necessity of developing a seeding apparatus with seed blowers and including an automated system for monitoring and managing the quality of sowing seeds of row crops at the stage of seed movement to the bottom of the furrow in

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their design is justified. Keywords: row crops, seed sowing, automated seeding control system, seeding process control, seeding sensor, control system, seeding quality.

Based on the analysis of the main trends of agricultural machinery produced for the cultivation of row crops, we have identified the problems facing researchers in choosing the optimal model of a seeder on the market of serial rowed seeders as a result of the synthesis of the best ideas and constructive solutions [1,2]. Earlier, we proposed a new classification feature in the development of precision seeding drill designs – this is the level of placement of the seeding apparatus from the bottom of the furrow [1,2]. Based on the monitoring and analysis of the designs of serial rowed seeders of Russian and foreign production, all the pros and cons of each design were identified (free flight of the seeder (probabilistic process); oblique impact and seed inversion (especially at high speeds); transportation of seeds to the bottom of the furrow; "uneven" distribution of seeds in a row; seeding speed limit (up to 10 km/h); lack of a system of controlling the seeding process after the seeds are removed from the disk) [1,2], which made it possible to justify the need to improve the technological process of sowing seeds of rowed crops with serial pneumatic seeders and also to improve the structural elements of these seeders (Figure 1). In the rowed seeders available in mass production with a low location of sowing machines, the absence of automation elements in controlling the process of precise seeding during the operation of the seeders was revealed, and based on this, we proposed a functional scheme and design of a sowing machine with a seed duct [2], which was improved during laboratory studies and has already been proposed in the form of an inflated sowing machine air in the seed duct, which has an accelerating section of seeds. This design allows ensuring the speed of the seed at the outlet of the seed duct, equal to the speed of movement of the unit. We have also patented the functional scheme and design of an upgraded sowing machine with a system for automatic measurement of seed velocity at the outlet of the seed pipeline [3-5]. Such modernization will make it possible to automate the process of seed sowing quality management in dosing systems.

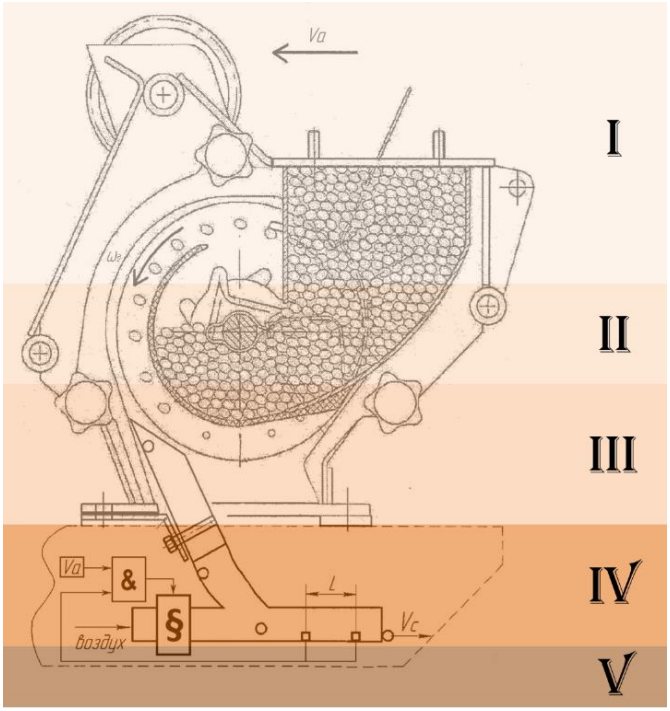

Fig. 1. Stages (levels) of seed movement in the sowing apparatus during sowing.

The following components of the project can be attributed to the fundamental innovation of the proposed design of the seeding apparatus:

- presence of a seed line in the design of the seed drill, which allows changing the trajectory of the seed from the sowing disk to the bottom of the furrow, as well as changing the velocity vector and its value;
- presence of a system for measuring the speed of seeds at the outlet of the seed pipeline;
- new approach in the quality management of sowing of row crops based on the automatic matching of the speed of the sowing unit and the speed of seeds at the exit of the seed pipeline;
- presence of an automated control unit for the seeding process and the introduction of an information and analytical system [5,6].

The issue of automation and quality management of processes in agricultural production is relevant [1,7]. Therefore, we have analyzed the main stages and parameters that are subject to automatic control in seed drills, when seeds move from the hopper to their distribution in the furrow. The path that the seed makes in the seeder from the seed hopper to the bottom of the furrow can be divided into 5 stages: in the hopper (I); in the sowing apparatus (II); in the seed line (III); in the coulter (IV) (if available, but in our design in the accelerator coulter); in the furrow (V) opened and prepared by the coulter (Figure 1) [7].

As a result of the analysis, it was revealed that the stage "movement in the coulter" (IV) can be considered problematic, due to the lack of sensors that determine the speed (movement) of seeds in the coulter.

At each stage of the technological process of sowing seeds with rowed seeders, control of the operation of the elements of the sowing apparatus and compliance with the specified parameters is required, for which various electrical sensors are used, which in turn constitute an automated seed sowing control system (ASSS).

In the Russian market, automated control systems are presented by Russian and foreign

manufacturers and determine the parameters of the dosing systems and control individual parameters at each stage of the process: the level of seed in the hopper of the seeder; control of the rotation of the dispenser shafts; the speed of the seeder sowing unit, the flight of seeds through the coulters, etc.

Based on the analysis of a priori information about seed sowing control devices and primary information converters used in them, we have proposed a generalized scheme of sensors used at the stages of the seed seeding technological process (Table 1) [7].

Table 1. Types and means of control at each stage of the technological process of sowing seeds with pneumatic sowing machines

Seed level control in the hopper						**Rotation of the seeding devices of the apparatus and their feeding of seeds into the furrow (II, III)**			**Passage of seeds in coulters and depth of seeding (IV,V)**				
Visual			**Signal-informative method**			**contact**	**contactless**						
Float type	Use of transparent materials	Using a glow discharge lamp	Electromechanical (membrane) type sensors	Electromechanical type sensor	Photoelectric type sensor	electromechanical, acoustic and piezoelectric	Piezoelectric, photovoltaic and pneumoelectric	electromechanical sensors (closing and opening of electrical contacts)	Piezoelectric contact type sensors	Photoelectric type sensors	Ultrasonic seed counter	Electromechanical type sensors	Pneumoelectric sensors

Analysis of 11 seed sowing control systems for 11 main parameters of the drill operation (Table 2) showed that absolutely all parameters of the seeding apparatus are not controlled by any of the systems considered. All control systems monitor 3 parameters:

1. Display of the number of the faulty coulter;
2. Serviceability of sensors and power supply voltage of the on-board system in the tractor cab;
3. The flight of seeds through the coulter.

The maximum number of fixed parameters, namely 10, was found in Seed Master Integra and 9 in Kuzbass. The minimum of parameters monitored by SLE was found in Darina U, the number of which was 4. We also found that all systems monitor and tracking the seeding process, but none of them controls it, respectively, and it is impossible to talk about seeding quality management in general [7].

Table 2. Evaluation of seeding control systems and the parameters controlled by them

Parameters	Seeding control systems for serial row drills										
	Skif -17	Skif T04	Sar mat	Mo nad a	Dari a U	Ves na - 8	Kuz nass	Aria	Niv a 23	Agr o -8	Seed Mast er Integr a
Control of rotation of the dispenser shafts	+	+	+	-	-	-	+	+	-	-	+
The level of seed material in the seeder bunkers	+	-	+	+	-	+	+	+	+	-	+
Seeding rate (pcs) in each seeding section	+	+	+	+	+	+	+	+	+	+	+
The time of the seeder operation and the sown area of the field	-	+	-	+	-	+	+	-	+	-	+
Number of revolutions of the drill fan	-	-	-	-	-	-	+	+	-	-	+
The speed of the sowing complex	-	-	-	+	-	+	+	-	+	+	+
Seed flight through the coulter	+	+	-	+	+	+	+	+	+	+	+
Percentage of doubles and omissions in each seeding section	-	+	-	+	-	+	-	-	+	+	-
Reference and actual seeding rate	-	+	-	+	+	+	-	+	+	+	+
Displaying the number of the faulty coulter	+	+	+	+	+	+	+	+	+	+	+
Serviceability of sensors and the power supply voltage of the tractor's on-board network	+	+	+	+	+	+	+	+	+	+	+

To ensure accurate seed sowing, we have developed a design of a pneumatic seeding machine with an automated system for monitoring and controlling the process of sowing seeds of row crops, which includes the following elements [3]: indication unit and data

acquisition unit (IU and DAU), wheel rotation sensor (WRS), electro-servo drive (ESD), signal processing unit (SPU), speed sensor (SS) consisting of sensors for the flight of the seed 1,2 (DPS), set of connecting cables located on the dashboard of the tractor, a system switch with a connecting cable (Figure 2).

The workflow of the seeding control system (SCS) is described in previously published works [8]. The system of control and management of seed sowing of row crops is a new solution for sowing row crops and does not require adjustments, makes it possible to control the sowing process in many parameters, which increases production efficiency.

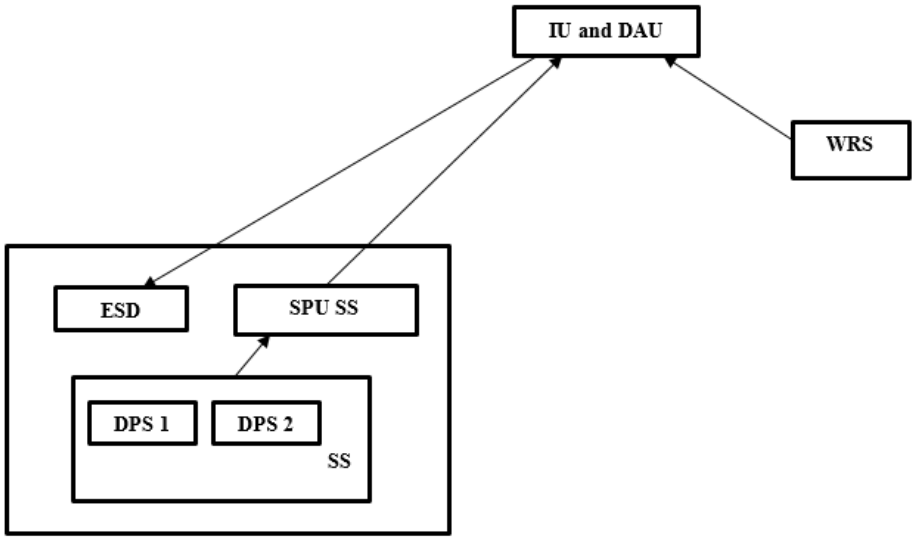

Fig. 2. Block diagram of the interaction of elements of the control and management system for sowing seeds of row crops

To create a uniform flow by the seeding apparatus and ensure uniform seeding, it is necessary that the speed of seed movement at various stages remains constant [2,4,5] and controlled at the site of seed exit from the disk and movement to the bottom of the furrow, therefore, the above, patented design of the seeding apparatus with an automated system for monitoring and controlling the process of sowing seeds of row crops, allows performing technological control of the operation of the sowing unit during sowing, monitors the speed of movement of the sowing unit and the speed of seed departure from the seedpipe, with the possibility of equalizing these speeds, which ensures shockless laying of the seed in the furrow and eliminates the phenomenon of redistribution of seeds of row crops in a row during sowing, which increases the uniformity of the distribution of seeds of row crops in a row during sowing [1,2,4,5].

The introduction of this design will lead to the expected economic effect of increasing the productivity of the seeder, reducing the time of sowing and increasing the yield of row crops.

Conclusions

Based on the patent search, monitoring and synthesis of existing serial precision seeding drills and automated systems for monitoring technological seeding processes, the necessity of developing a seeding apparatus with seed blowers and including in their design an automated system for monitoring and managing the quality of sowing seeds of row crops at the stage of seed movement to the bottom of the furrow is justified.

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