Intelligent system for managing dynamic processes of seed preparation for sowing – "Must-have" within the concept of digital transformation for crop production

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Abstract. The basic scheme of the work of an intelligent control system for the dynamic processes of seed preparation for sowing, which allows accelerating the transition to progressive technologies of crops cultivation, is considered. The intelligent control system built into the biotech system works proactively in real-time and is designed to make the operator's work easier and faster. The intelligent control system allows timely and effortless control of the preparation and the treated seeds. The use of an intelligent control system reduces the mental and physical stress on the operator during work by 50% or more, without reducing the quality of seed processing; improves the quality of decisions made; reduces the duration of control by more than two times in comparison with the existing methods of control and management of the process of pre-sowing seed treatment.

1. Introduction
Intelligent control systems are classified as cyber-physical systems. In a cyber-physical system, a hybridization of computational and physical processes takes place [1, 2, 3, 4]. The control and management of the technological process of seed processing occur, thanks to an artificial cognitive system (artificial intelligence). An intelligent built-in system allows control of the process using a tablet or smartphone [5, 6].

Organic agriculture requires a stricter attitude to the use of chemicals in crop production technologies, including the pre-sowing treatment of seeds [2, 7]. The use of biological products in seed treatment technology will eliminate the harmful effects of chemistry on the environment and humans. However, for the transition to the organic farming system in the context of digitalization, it is necessary to create and implement new specialized equipment [8, 9, 10]. The introduction and application of intelligent control systems for the dynamic processes of pre-sowing seed treatment will accelerate the transition to progressive technologies for the cultivation of crops [2, 7, 10].

2. Materials and methods
The intelligent control system for seed treatment processes is an intelligent intermediary with artificial intelligence and helps the human operator to automatically regulate and adjust the entire technological process in real-time without difficulties and overloads. The primary purpose of using an intelligent control system is to facilitate, simplify and ensure the safety of the operator's work while maintaining the required quality indicators of the technological process.
Figure 1 shows a block diagram of the technological process of pre-sowing treatment that does not injure seeds in the form of a biotechnical structure with an intelligent control system. The biological system, which is part of the structure of the biotechnical system, includes the seed and the operator. The technical system includes technical means (machines) for seed treatment and an intelligent control system for dynamic processes of seed preparation for sowing.

The process of pre-sowing seed treatment is controlled by a technical system, the operation algorithm of which depends on the input variables: $X_n$ – biological and / or chemical preparation; $X_c$ – seed material; $X_{упр}$ – controlling the operator’s action using artificial intelligence built into the technical system.

The functioning of the biotechnical system is affected by external influences $Z_{тс}$ caused by fluctuations in kinematic parameters, changes in technological characteristics and other influences. These influences are usually random.

In the implementation of the technological process, the technical system must both regulate and control the biological system. Figure 1 shows these impacts are presented in the form of the impacts of the technical system on seeds $U_c$ and the effects of the technical system on the operator $U_о$.

An intelligent control system built into the technical system facilitates and accelerates the operator’s work, allowing timely and effortless control of the preparation $Q_p$ and the treated seeds $Q_c$.

The intelligent control system allows, simultaneously with the listed functions, to monitor changes in the external environment and respond to them $Z_{1}$.
As a result of a complex multilevel interaction of the components of the biotechnical system, an output function of the system \( f(X_n, X_c, X_{imp}, Z_{ts}) \), arises, including the uniformity of the seed coverage with the preparation, the degree of damage to the seeds, the state of the working organs of the machine and other indicators.

2.1. The principle of operation of an intelligent control system for dynamic processes of pre-sowing seed treatment.

The use of an intelligent control system allows increasing the accuracy of all measurements while eliminating time-consuming manual adjustments. The intelligent control system is proactive. At the first stage, the built-in software module reproduces the processing process on a computer (Figure 2).

![Figure 2. Computer model of a drum seed treatment device](image)

The operator selects from the list offered by the system, the type of seeds to be treated and the type of preparation. The system performs processing, after which a video of the processing process (Figure 3) and information about the duration of the process (Figure 4) appear on display. After processing the entered data, the intelligent system informs the operator about the duration of the process and prepares the hardware for operation.

![Figure 3. Visualization of the seedbed preparation process using the built-in simulation program](image)

The operator saves the received image and puts the system into real operation mode if the system has issued a signal ready for the real operation.
The operator switches the system to real operation. If during the process, there is a need to correct the parameters, the system informs the operator in advance, and itself adapts to the changed conditions (seed moisture, contamination, seed weight).

A Mixture Quality Analyzer (MQA) is built into the intelligent control system for dynamic processes of pre-sowing treatment, which allows regulating the intensity of seed coverage with a drug and control the flow of the drug and the productivity of the machine.

3. Conclusion
The built-in artificial intelligent control system is a digital twin of the operator and makes it possible

- to simplify the interaction of the "man – agricultural machine" type,
- to optimize and intensify the process of pre-sowing processing,
- to predict possible errors associated with the human factor,
- to identify and prevent technical failures.

Preliminary laboratory tests have shown that the use of an intelligent control system
- reduces the mental and physical stress on the operator during work by 50% or more, without reducing the quality of seed processing;
- improves the quality of decisions made;
- reduces the duration of control by more than two times in comparison with the existing methods of control and management of the process of pre-sowing seed treatment.

Figure 4. Image of the processing process in real time

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