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PRE-SOWING SEED TREATMENT IN ELECTRIC AEROSOL CLOUD

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ABSTRACT

The efficiency of the existing technologies for pre-sowing seed treatment, ensuring the high quality of seed material along with its proper clearing and sorting, has been analysed. One effective solution is the introduction of electrical technologies, the complexity of which lies in

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ABSTRACT

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the scientific sophistication and the variety of tasks they address. The authors propose an electrotechnological complex (ETC) for pre-sowing seed treatment, which includes a working chamber, where charged grain is fed, while aerosol is delivered through adjustable sprinklers directed toward the seed flow, allowing for control over the spray stroke length. When the freely falling charged seeds enter the cloud of oppositely charged aerosol, they become intensively coated with the working solution. The degree of coverage depends on the length of the working chamber, the potential difference between the grain flow and the sprinklers, and the concentration of the aerosol cloud. Given the relative complexity of the process and the presence of multiple disturbances, optimisation can only be achieved through automation. The main objective of the paper is to study the stability and functional quality of the automated ETC for pre-sowing grain treatment with aerosol. To achieve this, a structural and functional algorithmic scheme has been developed, outlining the composition of its elements, signal direction, and the functional purpose of each component. This scheme facilitated the development of a system simulation model. The paper presents calculated results for key performance indicators of the ETC, with values aligning with those typical for this class of systems. A key advantage of this research is the proposed system for optimal correlation of all element characteristics and parameters of the automated object, ensuring stability and high performance.

Introduction

The agricultural sector plays a vital role in ensuring Ukraine’s food security and independence. It contributes 17% of the country’s GDP and accounts for approximately 60% of the population’s consumer fund (Bioinvest-Agro, 2025; Trymbach and Vechera, 2011). It is a key revenue-generating sector, which supplies 8-9% of the state budget and ranks second in export commodity structure (On Pesticides, 1995; Tymoshenko and Vechera, 2010). Improving crop yields and reducing production costs in grain farming depends significantly on seed quality, which is directly influenced by cleaning, sorting, and pre-sowing treatment methods (Chekman et al., 2013; Sprinkler GMD-6014, 2022).

In modern agriculture, high-quality seed material is of paramount importance as a means of production for achieving high crop yields. However, even healthy seeds do not always possess optimal sowing properties, as they are rich in nutrients and thus provide an ideal substrate for the development and preservation of phytopathogenic bacteria. Seeds can spread numerous diseases, which significantly reduce yield and compromise quality. In addition to pathogenic microorganisms, saprophytic (mould) bacteria colonise seeds, leading to mould growth and seedling mortality. One effective method to neutralise these pathogens, protect seeds from mould contamination, and mitigate the effects of root rot is pre-sowing seed treatment. The active cycle of the plant’s growth begins with seed germination, making the initial stage of crop cultivation critical. Therefore, agricultural practices must include measures to enhance seed viability and field emergence rates. This involves treating seeds with insecticidal and fungicidal preparations to prevent disease and control pests. According to the World Health Organisation (WHO), mycotoxin contamination affects up to 25% of all grain stored.

Contamination of seed material with pathogenic microflora can occur at various stages: during the vegetation period; at harvest (particularly under high humidity conditions); during threshing or post-harvest processing; in storage, when storage conditions are compromised, especially with seeds of high moisture content. Pre-sowing processing of seeds with microelements represents an economically efficient approach, as it enhances germination vigour, field emergence rates, boosts disease resistance and increases tolerance to adverse weather conditions. The application of seed protectants, when combined with optimal sowing practices, serves as a critical determinant in achieving healthy crop establishment and maximised yield potential.

A fundamentally distinct disinfection mechanism is employed by electrophysical methods. Exposure to high-frequency electromagnetic waves induces non-thermal structural modifications at the cellular level, which significantly disrupt the biological activity of pathogens. The electrical method of pre-sowing seed treatment is a viable alternative to chemical pre-sowing treatment. Current research demonstrates that the physical method of seed infection control achieves comparable efficiency to the chemical method. This equivalence is currently only established for controlling common bunt (Tilletia caries) in wheat and rye. However, these methods demonstrate limited effectiveness against loose smut (Ustilago nuda) and soil-borne pathogens.

It should be emphasised that the advantages of electrotechnical applications in both pre-sowing and post-harvest operations include environmental safety, absence of microbial adaptive mechanisms, increased crop yields, and effective grain drying. However, chemical pre-sowing treatment provides better neutralisation of parasitic microflora. In practice, bacterial and fungal infection rates in seed material frequently exceed 50%. Pathogen-induced yield losses in cereal crops (common bunt and loose smut, Helminthosporium blight and Fusarium blight, seed moulding) can reach 15-30%. For example, Fusarium infection significantly reduces field emergence rates, thousand-grain weight, and the number of grains per ear.

Protection of plants from pests, which target various growth stages including stored seeds, seedlings, foliage, root systems, and mature grains, is a critical factor in grain production intensification. When pest damage reaches 15-20% of the grain stock, the majority of seeds lose all field germination capacity, and seedlings that do develop typically perish before emergence. In the context of the above-mentioned, an integrated approach combining the use of modern seed treatment stimulants and protectants and advanced electrical methods should be considered for comprehensive crop protection.

The challenge in implementing electrical technologies in the agro-industrial sector lies in the use of scientifically advanced solutions, the variety of operational tasks, and the prevalence of system disturbances. Thus, substantiation and development of methods for calculating the parameters of ETCs remains a relevant task.

Current research (Szafraniec et al., 2021) demonstrates that hybrid energy systems combining conventional fossil-based networks and renewable energy sources offer a viable solution. This solution requires a scientific approach, since advanced mathematical modelling of closed microrids and open grids will optimise system efficiency (Pentoś et al., 2022; Mahajan et al., 2023). The proposed electrotechnological complex enables low-impact pre-sowing treatment of wheat, barley, rye, as well as oilseed crops, leguminous plants and other agricultural species (Diordiiev et al., 2015; Diordiiev et al., 2014). Implementation of the proposed technology requires new technological equipment. A combined functional circuit must be developed to identify and control both the basic operating modes of the technological machines and the stages of the technological process. Additionally, automated technical means must be selected to ensure stable operation of the control system across a wide range of input parameter fluctuations.

The proposed technological equipment (Fig. 1) comprises a grain bucket elevator, a charged grain generator and aerosol, the working chamber, a charged grain conveyor-dispenser, an electrified aerosol delivery system, an unloading conveyor, a condensate drainage system for the working chamber, and a treated grain storage tank.

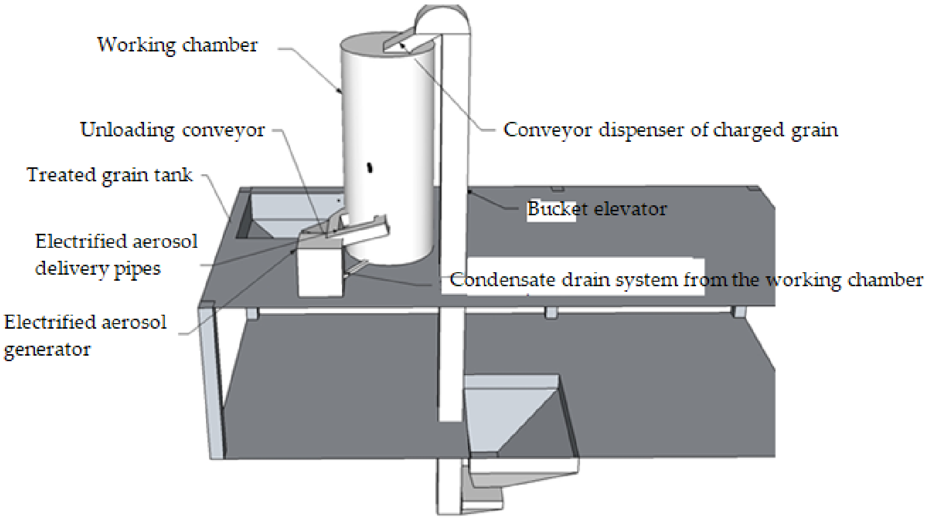

Figure 1. Electrotechnological complex for pre-sowing seed treatment with an electrified aerosol cloud

The operational principle of the working chamber is illustrated in Figure 2. The throughput capacity of the working chamber in the seed treatment line, operating with an electrified aerosol cloud in a 1 m^3 chamber volume, reaches up to 1 tonne per hour.

The grain flows from the storage tank (1), through the dispenser (2), which delivers seeds to the dielectric treatment chamber (3), via the flow distributor (4). The distributor applies an opposite electrical potential to that of the charged aerosol, delivered by the sprinklers (5), creating an electrostatic field across the seed flow. This system features adjustable spray stroke length control, where seeds enter the treatment chamber without mechanical acceleration, undergoing treatment during free-fall through the electrified aerosol cloud before exiting through the discharge outlet (6). When electrically charged seeds from the distributor encounter the oppositely charged aerosol cloud (Fig. 2), they become intensively coated with working solution. The coating efficiency depends on three key parameters, including working chamber length, potential difference between the distributor and the sprinklers and aerosol cloud concentration.

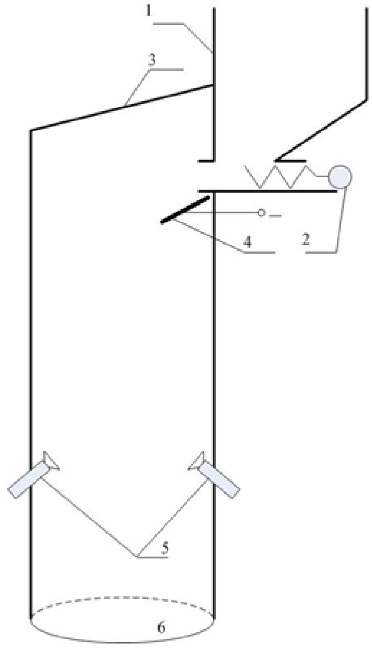

Figure 2. Operational principle of the working chamber in the seed treatment line with an electrified aerosol cloud: 1 – grain storage tank; 2 – dispenser; 3 – dielectric seed treatment chamber; 4 – seed flow distributor; 5 – aerosol sprinklers; 6 – treated seed discharge outlet

The system architecture utilises the ES-ForthLogic controllers manufactured by PE “Electrosvit” (specifications are detailed in Table 1). This engineering solution enables modular automation architecture, incorporating relay-based control components, programmable logic controllers, and standardised physical quantity sensors with unified signalling. The system also provides cross-platform interoperability through compatibility with third-party automation systems, integration with standard GSM/GPRS controller networks, and centralised dispatch, monitoring and control capabilities.

The seed treatment working chamber is constructed from dielectric material, specifically monolithic polycarbonate, to ensure operational safety for personnel. Monolithic polycarbonate is a thermoplastic material manufactured through phenol and acetone condensation, producing a void-free sheet material. The key advantage of the material is its exceptional mechanical strength. It substantially outperforms glass and conventional materials in impact resistance, making it optimal for applications requiring structural durability. Other advantages include significant weight reduction compared to conventional materials and thermal stability, as it maintains all mechanical characteristics at temperatures up to 180°C.

To prevent electric shock in case of chamber insulation failure, the following combined protective measures are implemented: protective earthing, automatic power disconnection, equipotential bonding (potential equalisation), and protective (electrical) separation (circuit isolation). For protection against aerosolised chemicals, the system requires the use of respiratory protection and personal protective equipment, including respirators, gas masks, chemical-resistant clothing, and skin protection products. Respirators provide air purification, whereas protective clothing and gloves prevent skin contact with substances.

Table 1.
Automation tools

Control parameter, functions	**Equipment type**
Air pressure sensor	PD100-DI.1,0.1
Position sensor: valve/damper	ME8111 / ME8108
Humidity sensor	ES-DH-1M
Exposure sensor	FR-7E
Programmable logic complex	ES-ForthLogic
Electromagnetic relay	PE-4PP
Power supply	BZH-I
Discrete extension module	ES-DIO-1M
Analogue extension module	ES-AI-1M / ES-PT-1M

Materials and Methods

The temperature of the aerosol cloud in the pre-sowing seed treatment chamber is automatically maintained at 48-55°C. Chamber humidity must be strictly regulated, and moisture content should not exceed the conditioned humidity by more than 1%. For optimal conditions of pre-sowing seed treatment in an aerosol cloud, a relative air humidity of 80% is maintained.

The main objective of the present research is to study the stability and performance of the automated ETC for pre-sowing seed treatment with aerosol. For this purpose, structural schemes must be developed to derive corresponding mathematical models, the analysis of which will determine the system's efficiency.

To investigate both static and dynamic system properties, Figure 3 presents the structural and functional algorithmic scheme of the electrotechnical complex for pre-sowing seed treatment with aerosol. The schematic representation illustrates the component configuration, signal flow directions, and operational functions of all system elements.

The system architecture consists of three control loops. The first loop regulates the formation of a controlled seed flow and its subsequent high-voltage charging, incorporating continuous monitoring and control of the mass flow rate. The second loop controls the generation of high voltage with opposite polarity for the simultaneous charging of seeds and aerosol particles. In this loop, a generator and voltage multiplier operate under closed-loop control, with the output voltage regulated through feedback from a voltage sensor. The third loop governs the liquid delivery system, enabling aerosol generation and its high-voltage charging with polarity opposite to that of the seeds.

In the scheme, transfer functions $W_1(P)$ through $W_4(P)$ represent the grain flow control loop, with the flowmeter $W_4(P)$ positioned within the feedback loop. In order to optimise the performance of the actuating motors, advanced control algorithms particularly those focused on energy efficiency (Bredykhin et al., 2024; Al-Quraan et al., 2022) and resource-saving strategies that account for thermal wear (Bazaluk et al., 2022a; Bazaluk et al., 2022b) are widely employed. In our case, system performance is enhanced by implementing an automated control system, where optimisation criteria are integrated directly into the control algorithm (Kravchuk and Voitiuk, 2010; Electrostatic, 2022; Judickaitė et al., 2022; Bednařík et al., 2022). This approach is applicable to both existing machinery and equipment under development (Klimek-Kopyra et al., 2022; Cecchetti et al. 2022; Lezhenkin et al., 2021).

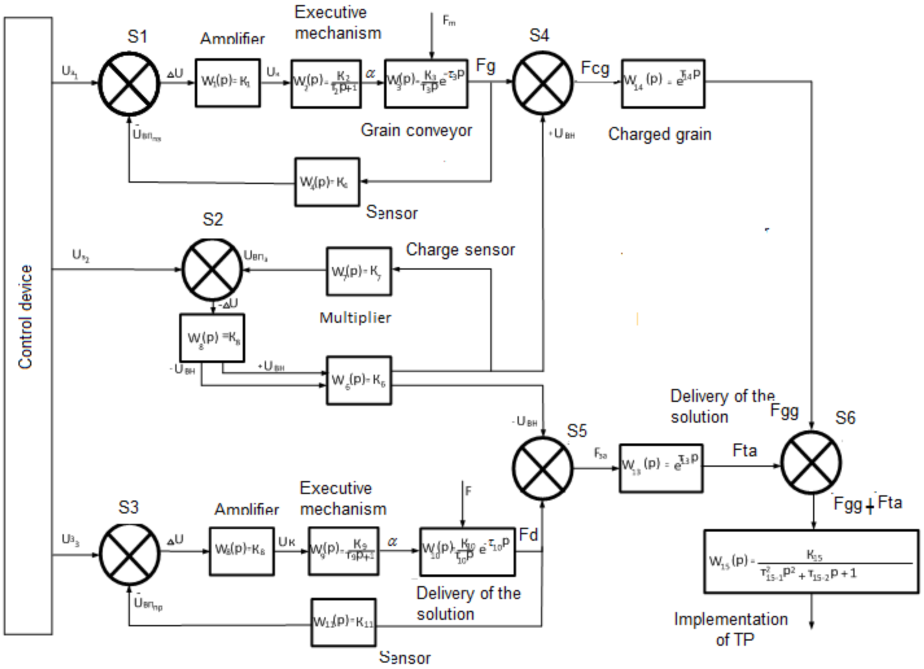

Figure 3. Structural and functional algorithmic scheme of the ETC for pre-sowing seed treatment with aerosol

The high-voltage control loop is implemented through transfer functions $W_5(P)$-$W_7(P)$ with voltage regulation achieved via a voltage sensor $W_7(P)$. The liquid flow loop, which subsequently facilitates aerosol generation, is represented by transfer functions $W_8(P)$-$W_{11}(P)$. Designating these loops as $W_{e1}(P)$-$W_{e3}(P)$, respectively, and applying the fundamental transformation rules of structural algorithmic schemes, we obtain:

$$W_{e1}(P) = \frac{W_1(P)\cdot W_2(P)\cdot W_3(P)}{1+W_1(P)\cdot W_2(P)\cdot W_3(P)\cdot W_4(P)} \tag{1}$$

$$W_{e2}(P) = \frac{W_5(P)\cdot W_6(P)}{1+W_5(P)\cdot W_6(P)\cdot W_7(P)} \tag{2}$$

$$W_{e3}(P) = \frac{W_8(P)\cdot W_9(P)\cdot W_{10}(P)\cdot W_{12}(P)}{1+W_8(P)\cdot W_9(P)\cdot W_{10}(P)\cdot W_{11}(P)} \tag{3}$$

The grain is charged with a high positive polarity as it is delivered to the working chamber (summing node S_4, transfer function $W_{14}(P)$). The charging process of the aerosol is reflected by the summing node S_5 and the transfer function $W_{13}(P)$, respectively. These control loops can be described as follows:

Charged seeds supply loop

$$W_{char.gr.}(\mathrm{P}) = [W_{\mathrm{e}1}(\mathrm{P}) + W_{\mathrm{e}2}(\mathrm{P})] \cdot W_{14}(\mathrm{P}) \tag{4}$$

Charged aerosol supply loop

$$W_{char.aer.}(\mathrm{P}) = [W_{\mathrm{e}3}(\mathrm{P}) + W_{\mathrm{e}2}(\mathrm{P})] \cdot W_{13}(\mathrm{P}) \tag{5}$$

Aerosol treatment of seeds loop

$$W_{aer.treat.gr.}(\mathrm{P}) = [W_{char.gr.}(\mathrm{P}) + W_{char.aer.}(\mathrm{P})] \cdot W_{15}(\mathrm{P}) \tag{6}$$

Results and Discussion

According to the obtained structural and functional scheme, a simulation model has been developed (Fig. 4), which allows obtaining the transfer characteristics of the control system of the ETC. For modelling and investigating the developed simulation model, the MATLAB/Simulink software platform was used.

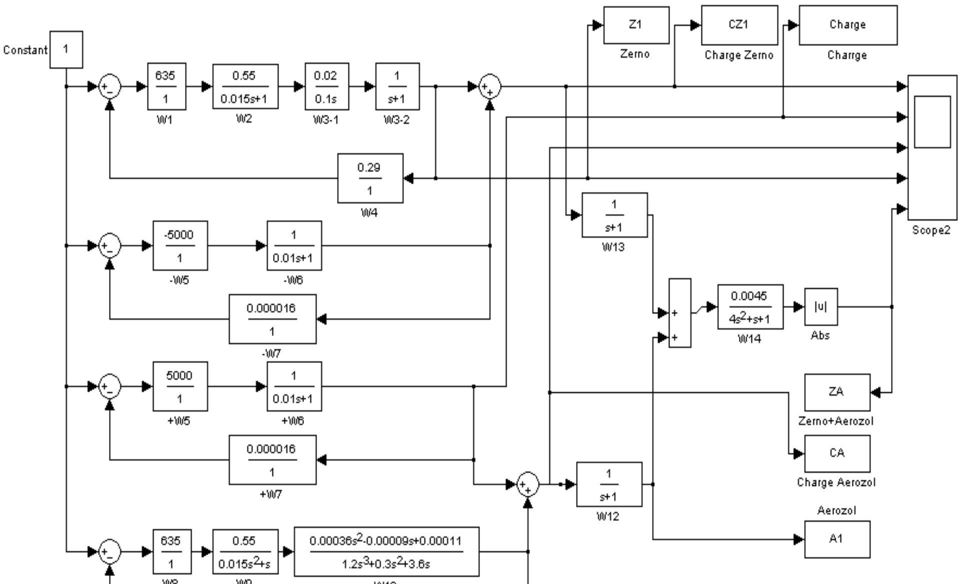

Figure 4. Simulation model for the control system analysis of the ETC

From the simulation model, we obtained the transient processes of the loops (Fig. 5): aerosol charge, wheat seed charge, and the interaction between the charged wheat seed and the electrified aerosol. The regulation time was $T_{reg.}$ = 42 s. Based on the transfer characteristics, the following parameters were determined: first peak time, Tmax1 = 8 s, second peak time, T_{max2} = 15 s, attenuation decrement Δ = 0.57. The transient processes of the control system at different stages of seed treatment, shown in Figure 5, were obtained from the simulation results. The next step will be to develop an experimental setup to validate these findings. The results of this experimental validation will be presented in a separate article.

The developed simulation model enables assessment of the impact of external and internal disturbances on various operating modes of the ETC.

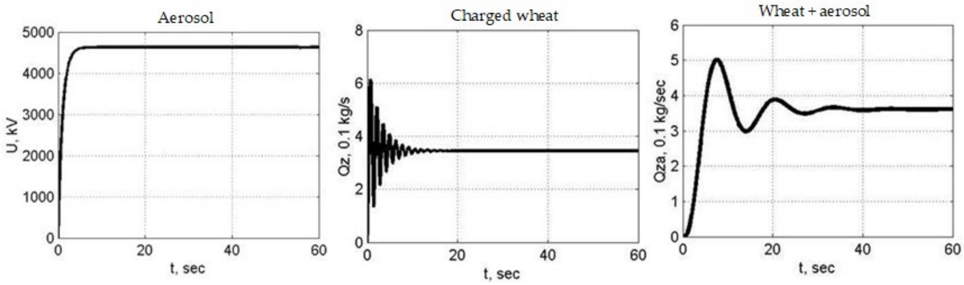

Figure 5. Transient processes of the control system at various stages of seed treatment

To implement the process of pre-sowing treatment of grain materials in an aerosol cloud, technological equipment can be installed on an operating grain cleaning complex. To ensure etching productivity of 5 $t\cdot h^{-1}$ and consumption of working solution 10 $L\cdot t^{-1}$, the equipment must have a high-voltage power supply unit with constant voltage outputs of at least +5 kV and -5 kV with an installed power of 50 W, the size of the spraying droplets must be up to 30 μm.

The effect of using the proposed equipment will reduce crop losses from the planned to 20%. Increasing the efficiency of application of the working solution due to ensuring uniformity of processing up to 95-98%.

Physical Principles for Modelling of Grain Treatment in the Electrified Aerosol Cloud

Today, various chemical preparations are widely used for crop protection, primarily synthetic organic compounds commonly referred to as pesticides.

In general, despite their major disadvantages, chemical methods remain the primary means of plant protection and are expected to continue to be so in the near future. The global assortment of pesticides includes a wide range of formulations designed to be ultimately safe for humans and beneficial animals, ensuring no pesticide residues remain in the environment, products, or food chains, and preventing the emergence of resistant pests. The spraying method involves applying pesticides to the treated surface as a liquid spray, in the form of solutions, emulsions, or suspensions. Depending on the volume of the liquid used, spraying is classified as follows: high-volume – 400...2000 $L\cdot ha^{-1}$, medium-volume – 100...400 $L\cdot ha^{-1}$, and low-volume – 10... 100 L·ha^{-1}. The main disadvantages of the spraying method are associated with the use of bulky equipment, excessive pesticide waste, and significant environmental pollution.

Electrification of the working solution aerosol promotes more uniform coverage of the treated surfaces, resulting in a higher disinfecting effect. Additionally, the disinfectant remains on the treated surfaces longer compared to applications using uncharged aerosols. The charged pesticide particles settle significantly more evenly, leading to a considerable reduction in pesticide costs.

Since the trajectory of the particles is determined by the shape of the electric field, which in turn depends on the profile of the treated object, particle deposition can occur over the entire surface of the object. When charged aerosol particles settle on the grain, the primary force involved is the electric attraction, which is proportional to the product of the field intensity and the particle's charge. Therefore, the use of electric aerosols contributes to better pre-sowing seed treatment.

If two charged material points are fixed in a vacuum and separated by some distance, an interaction force arises between them, directed along the line connecting the two points. This force is described by Coulomb's Law – the fundamental law governing electrical interactions between bodies:

$$F = \frac{k_1 q_1 q_2}{r_{12}^2} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1 q_2}{r_{12}^2} \qquad (7)$$

where:

k_1 – constant, $k_1=1\cdot[(4\cdot\varepsilon_0\pi)=9\cdot10^9\ C^2\cdot N\cdot m^2]^{-1}$;
q_1 and q_2 – charges of material points, C;
r_{12} – distance between the points, m;
ε_0 – vacuum permittivity, $\varepsilon_0=8.854\cdot10^{-12}\ C^2\cdot N\cdot m^2$.

Since electrical forces act between charged bodies, a charged body creates an electric field around itself. When a point charge (a body with a small, concentrated charge) enters this electric field, a force is exerted on it:

$$\bar{F} = q_n \bar{E}, \qquad (8)$$

where:

q_n – point charge.

The field intensity of a point charge in a vacuum is determined as follows:

1. In vector form

$$\bar{E} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{r} \cdot \bar{r}_0, \qquad (9)$$

where:

$\bar{r}_0$ – unit vector, m;

In scalar form

$$E = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{r^2}. \qquad (10)$$

The interaction force between charges in a homogeneous and isotropic medium is reduced by a factor of ε compared to the force in a vacuum, where $\varepsilon = F_0 \cdot F^{-1}$ is the permittivity of the medium.

Sources of high voltage

The basic principle behind impulse high-voltage sources is the accumulation of electromagnetic energy in storage devices – either capacitive (low-inductance capacitors and pulse-forming lines) or inductive – followed by the rapid transfer of this energy to the load.

The most common method is the storage of electrical energy in capacitive storage devices, specifically capacitor banks. This principle is relatively straightforward: energy is accumulated slowly in a storage device and then quickly transferred to the load via a switching device. As a result, even with a short pulse duration and relatively low energy, a considerable power output can be achieved.

The principle of using inductive storage devices is applied when generating high-voltage pulses for powerful pulse technologies. The energy density stored in inductive storage is approximately two orders of magnitude higher than that in capacitive storage, making inductive devices more cost-effective. The pulsed voltage generated at current interruption can be significantly higher than the voltage at the preceding stage of pulse formation. However, it should be kept in mind that at megavolt voltage level, interrupting a current in the kiloampere range is considerably more challenging than rapidly closing the switch.

The pulse voltage source consists of a system of resistor-capacitor circuits and switching elements (dischargers or semiconductors), the diagram of which is shown in Figure 6. The principle of voltage increase (multiplication) involves charging the storage capacitors (C_1) through charging resistors (R_a, R_2) from the voltage source (E), followed by their sequential connection into a discharge circuit using the switching elements (VS_1) to form the voltage pulse. As a result, the output voltage is effectively added (multiplied) and depends on the number of storage capacitors. The output voltage $U = n \cdot U_1$ (where U_1 is the charge voltage on a single capacitor) can reach the megavolt range, while the current can reach up to one kiloampere, and the pulse repetition rate can be as high as 10 Hz.

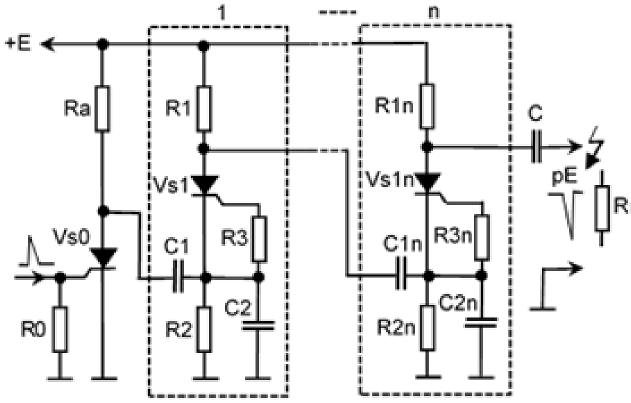

Figure 6. Circuit of the Arkadiev-Marx pulsed voltage source using semiconductor elements

The typical voltage waveform at the output of this pulsed voltage source is shown in Figure 7.

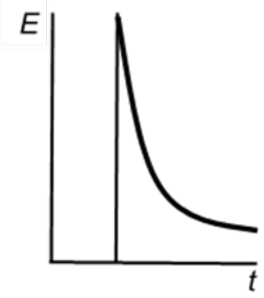

Figure 7. Voltage waveform at the output of the Arkadiev-Marx pulsed voltage source using semiconductor elements

The high voltage device based on variable capacitors ($C_i > C_{i+1}$) consists of a series of connected capacitors with different capacitances, separated by diodes (*VD*). The circuit of the device is shown in Figure 8. When the storage capacitors *C* are charged from the variable voltage source U_1, energy is transferred through the series circuit, gradually increasing the output voltage. The output voltage depends on the ratio of the maximum capacitance C_{max} to the minimum capacitance C_{min} of the capacitors:

$$U_2 = U_1 \frac{C_{max}}{C_{min}}. \tag{11}$$

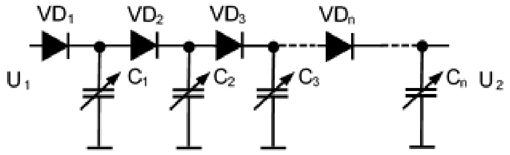

Figure 8. Circuit of a high-voltage source based on variable capacitors

The output voltage waveform is shown in Figure 9. The maximum voltage for this circuit is 100 kV, with a current of 10^{-3}A.

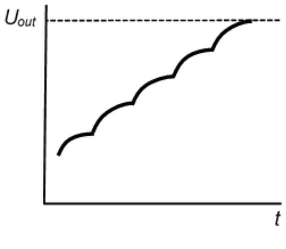

Figure 9. Output voltage waveform of the source based on variable capacitors

If the capacitor in this circuit is simultaneously connected to the *FV1* switch, when the voltage across the capacitor exceeds the switch's breakdown voltage, the energy is transferred to the load R_H (Figure 10). Subsequently, a new portion of energy from the source *E* is supplied, and the process repeats. The frequency of these pulses is 0.1 Hz. The output voltage waveform is shown in Figure 11.

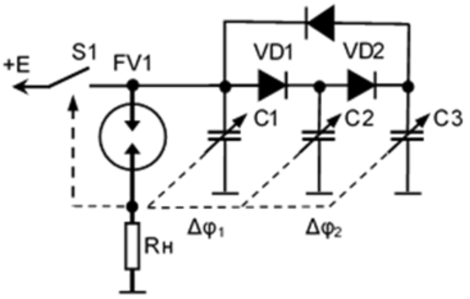

Figure 10. High-voltage supply circuit based on variable capacitors with an arrester

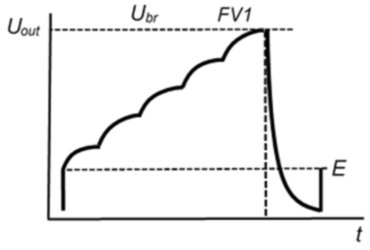

Figure 11. Output voltage shape of a high-voltage source based on variable capacitors with an arrester

Conclusions

A technological scheme for the ETC of pre-sowing seed treatment with minimal grain damage has been proposed. The implementation of this technology is feasible using new technological equipment. A functional integrated scheme has been developed, enabling identification and control of the key operating modes of the machinery and stages of the technological process, as well as ensuring a controlled sequence of power element activation based on sensor inputs.

The selected technical automation tools potentially enable effective control of the pre-sowing treatment of wheat seeds in the electrified aerosol field of the chemical solution.

The selected technical automation tools provide stable operation of the control system in a wide range of fluctuations of input control parameters. The quality of process control is characterised by the following indicators: regulation time, $T_{reg.} = 42$ s, first and second peak times $T_{max1} = 8$ s and $T_{max2} = 15$ s, respectively, and attenuation decrement $\Delta = 0.57$, all within the acceptable limits for this class of system.

The effect of using the proposed equipment will reduce crop losses from the planned to 20%. Increasing the efficiency of application of the working solution due to ensuring uniformity of processing up to 95-98%.

Author Contributions: Conceptualization, V.D. and S.H.; methodology, O.M., V.D. and T.S.; project administration, S.H., A.M., and T.W.; validation, O.M., O.S. and S.N.; investigation, S.H. and O.M.; data curation, S.H., O.S. and O.M.; writing–original draft preparation, A.M., V.D. and T.S.; writing–review and editing, O.S., S.H. and T.S.; visualization, S.N., T.W. and T.S.; supervision, O.S. and T.S.; funding acquisition, S.H. All authors have read and agreed to the published version of the manuscript.

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ZAPRAWIANIE NASION PRZED SIEWEM W ELEKTRYCZNEJ CHMURZE AEROZOLOWEJ

Streszczenie. W pracy przeanalizowano efektywność istniejących technologii zaprawiania nasion przed siewem, aby zapewnić wysoką jakości materiału siewnego, w tym jego odpowiednie oczyszczenie i sortowanie. Jednym ze skutecznych rozwiązań są technologie elektryczne, których złożoność wynika z naukowego zaawansowania oraz różnorodności realizowanych zadań. Autorzy proponują kompleks elektrotechnologiczny (ETC) do zaprawiania nasion przed siewem, który obejmuje komorę roboczą, do której trafia naładowane ziarno, i do którego aerozol dostarczany jest przez regulowane dysze skierowane na strumień nasion. Umożliwia to kontrolę długości skoku oprysku. Gdy naładowane ziarna, swobodnie spadając, wchodzą w chmurę aerozolu o przeciwnym ładunku, intensywnie pokrywają się roztworem roboczym. Stopień ich pokrycia zależy od długości komory roboczej, różnicy potencjałów między strumieniem ziarna a dyszami oraz stężenia chmury aerozolu. Ze względu na względną złożoność procesu i obecność wielu zakłóceń, zaprawianie można zoptymalizować wyłącznie poprzez automatyzację. Aby zrealizować główny cel przedstawionych badań – zbadanie stabilności i jakości funkcjonalnej zautomatyzowanego kompleksu ETC do zaprawiania ziarna przed siewem przy użyciu aerozolu – opracowano strukturalny i funkcjonalny schemat algorytmiczny. Przedstawia on skład elementów, kierunki sygnałów oraz funkcjonalne przeznaczenie każdego komponentu. Schemat ten umożliwił opracowanie modelu symulacyjnego systemu. W artykule przedstawiono obliczone wyniki kluczowych wskaźników wydajności ETC, których wartości są zgodne z typowymi dla tego typu systemów. Kluczową zaletą przeprowadzonych badań jest zaproponowany system optymalnego skorelowania wszystkich cech elementów oraz parametrów obiektu zautomatyzowanego, co zapewnia jego stabilność i wysoką wydajność.

Słowa kluczowe: kompleks elektrotechnologiczny; zaprawianie nasion przed siewem; naładowany aerozol; komora dezynfekcyjna; zautomatyzowany system sterowania; inżynieria; rozwiązania modułowe