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Electrophysical processes in an electroterminator (with an intelligent system) with sliding contacts in the power circuit

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Electrophysical processes in an electroterminator (with an intelligent system) with sliding contacts in the power circuit

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Abstract. This article presents data on the properties of sliding contacts during the rotation of the axis of a device for pre-sowing treatment of crop seeds, considers the issues of automation of intermittent power supply and measurement of electrical conductivity and temperature parameters of seed material in the process of electrotechnology. At the same time, the contact resistance of the power circuit, normalized moistening of sowing seeds, depending on the type of plants, was taken as the basis of the physical model. Smart system takes into account soil parameters (type, density, moisture content). In the initial period of seed treatment, moisture penetrates into the seed from the outside. therefore, the time of humidification and electrical treatment are the main factors. Depending on the seed variety, it will be possible to change the operating parameters of the electrical treatment of crop seeds. The work also carried out a review of the literature and mathematical calculations.

1. Introduction

Electrical energy and signals are transmitted through sliding contacts through the rotating part of a device for electrocurrent treatment of moistened crop seeds [1]. For optimal control of complex technological processes, it is convenient to use parametric structural schemes [2].
In the implementation of electrotechnological processes of electrical processing, fixed and movable (sliding) electrical contacts are used. However, in many of the works studied, researchers did little to study the contacts and the electrophysical processes occurring on them. Below is a review of some works on the study of contact phenomena.
The electrical contacts in switches come in a variety of configurations depending on factors such as usage and power. All Alps Alpine detector switches use sliding contacts. Sliding contacts are designed in such a way that contact occurs when the moving contact slides over the fixed contact. When contact occurs, any tiny particles of foreign matter or film trapped between the contacts are removed (self-cleaning), resulting in high contact reliability when used with very low currents. Sliding contacts with a moving contact clamping the fixed contact on both sides are called double-sided sliding contacts and are even more reliable.
In addition to sliding contacts, there are also contact structures where the contacts collide with each other, such as butt contacts, bottom these are mainly used, for example, in medium and high current circuit breakers, where electricity can break through the surface film [3].
When electrical energy is transmitted through sliding contacts, the temperature increases due to friction. When the network breaks, the error in determining the conductivity and temperature of the seeds in the drum exceeds the norm due to the resistance in the contacts. The problem of sliding

contact of a rigid part with an elastic body at a constant temperature difference was studied by the finite element method, taking into account thermal resistance depending on the contact pressure.
In the analyzed [4] article, the authors investigated liquid voltage dividers, and also developed the corresponding electronic models on Multisim software (version 10.0) and SolidWorks. It is indicated here that the measuring equipment during the experiment gave positive results, indicating the quality of measurements, the correctness of the process of electropulse seed treatment.
In the scientific work [1] in particular, a model of a cotton seed was created, consisting of three parts: a chalazal part, a lateral part and a micropyle. Illustrative materials are presented, modern methods are presented, calculation and modeling with the help of computer programs are studied and applied. The necessary conditions for the detection of calculated errors have been created.
In [5], the error in the slope of the electrode was studied in detail. In this case, the electrode was moistened with a solution with a pH of 7. After calibrating the zero point, the researchers obtained the situation depicted in Figure 1. Zero is determined exactly, but the measured value still has a significant error because the slope point has not yet been determined. Now a calibration solution is selected whose pH value is different from 7. Most buffer solutions are used in the pH range from 4 to 9. The electrode is immersed in a second buffer solution and using a potentiometer, the deviation of the slope from the nominal (standard) value is found. And only now the measurement curve coincides with the required curve; instrument is calibrated.

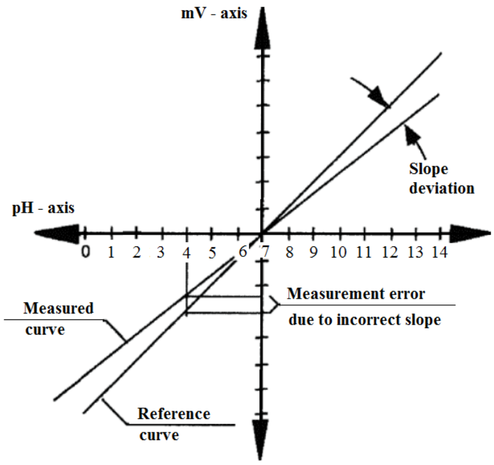


Figure 1. Measurement curves during calibration [5]

The researchers [3] examined the impact and expressiveness of key aspects of statistical contact modeling, including contact model selection, surface estimation method, and scaling during surface data acquisition. For this, friction experiments were carried out using two combinations of materials, which were compared with numerical results obtained using a newly developed numerical system in a commercial simulation program. The results show the relevance of the numerical basis and show the impact of inappropriate surface registration, the expressiveness of the studied estimation methods and communication models, respectively.
In this paper [6], two austenitic ductile irons, ADI1 and ADI2, were subjected to lubricated sliding tests under various normal loads. In this article, the corrosion resistant properties of materials, the influence of the microstructure and mechanical properties of which have been studied, are considered, and an assessment of their corrosion resistance is given. As a result, the following conclusions were drawn: it was noted that both materials showed similar friction characteristics when tested at low temperatures, with normal loads from 50 N to 100 N. When the normal loads were increased from 200 to 300 N, ADI2 showed less friction, because at higher loads, the greater accumulation of graphite on the contact surface of the ADI2 reduces friction.
The article presents a model developed to describe the accumulation of fatigue damage and surface and subsurface damage (separation), wear under conditions of frictional interaction of elastic bodies. Sliding and rotating contacts, as well as the coefficient of sliding friction, relative slip and strength

properties of elastic bodies are considered. Materials of elastic bodies were used as variable parameters [7].

The assessment of the conductivity of single seeds was proposed as an assessment of seed viability, following the development of an instrument to measure the conductivity of the leachate of 100 single seeds simultaneously. Studies with pea, soyabean, cotton, Phaseolus bean, maize and small- seeded crops provided evidence that analysis of the single seed leachate conductivity, could indicate both standard germination and seed vigour. The instrument does not however adjust readings to take account of seed weight. It is therefore recommended that each of the 100 seeds be weighed prior to testing so that the average reading can be recorded per gram individual seed weight, i.e. as μamps cm-1 g-1 or μS cm-1 g-1, depending on the instrument used [8].

The researchers studied the influence and expressiveness of the main aspects of statistical contact modeling, including the choice of contact model, the surface estimation method, and the increase in the surface acquisition process [9]. To do this, the researchers ran friction experiments involving two combinations of materials and made comparisons with numerical results obtained from a newly developed numerical framework in commercial simulation software.

Below is a diagram of the operation of a drum electric seed humidifier. An improved scheme of this installation using a parametric block diagram is considered in [2] (Figure 2).

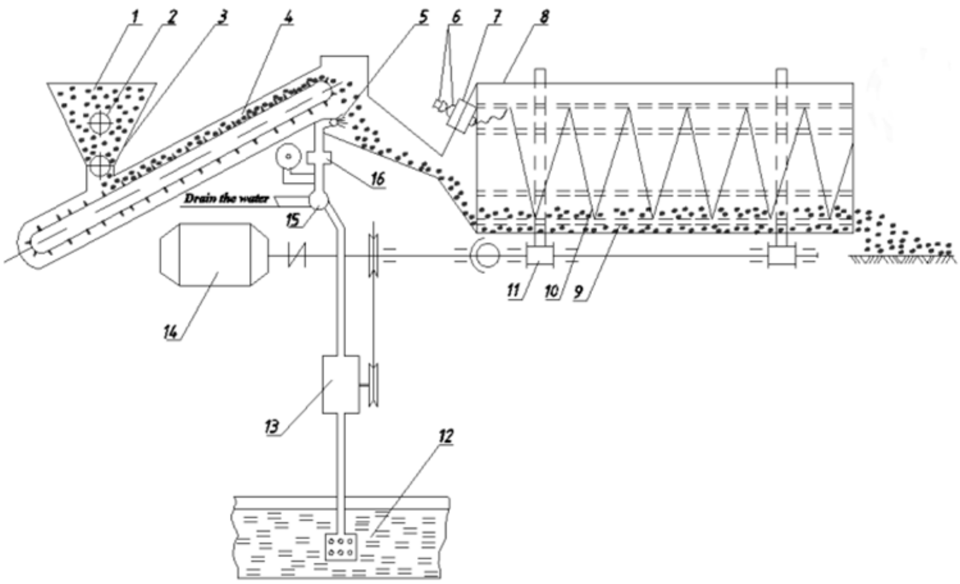


Figure 2. Cotton seed electric humidifier: 1-hopper, 2-turner, 3-feeder, 4-conveyor (conveyor belt), 5-irrigator-moisturizer, 6-discharge electrode, 7-input insulation (high-voltage cable wires, source of electric spark discharges - on not shown in the figure), 8-metal drum (working part), 9-dielectric insulating blades, 10-helix copper conductor electrode, 11-rotating mechanism, 12-reservoir (water tank), 13-pump, 14-electric motor, 15 - water control unit (usually distributor), 16 - branching device

Electrical conductivity can be used as an indicator of seed viability and has two advantages: provide fast and reliable results, and the technique is non-destructive, and seedlings can be used for seedlings after the electrical conductivity test [10].

Researchers have created a program for an intelligent sensor for measuring and controlling the temperature of various objects, which allows adaptive measurement of the temperature of seeds [11]. Figure 3 shows the process of setting the temperature sensor.

Figure 3. Temperature sensor setup process

Figure 4. General view and process of setting the frequency controller [12]

The temperature sensor settings are carried out using the modern Arduino MEGA R3 platform and a microprocessor system that provides constant temperature control using a C ++ computer program[11].

In our work, Altivar ATV11...A VFD / VSD is used - a variable frequency drive controller for asynchronous motors. The Altivar ATV11...A VFD / VSD instruction manual provides information on: setting up the drive, connections, configurations, start-up. The manual also includes dimensions, actuator mounting, wiring diagrams, keypad functions, menu logic, and troubleshooting [12]. The general view and the process of setting up the device is shown in Figure 4.

In the work of the authors [13], the issues of reliability and accuracy of the needle ground thermocouple method were considered, they were experimentally studied for friction materials of various classes, including copper, brake pad material and polyamide. At the same time, these materials in the form of pin samples were tested on steel disk samples in a stationary mode and three transient modes: jump, acceleration and deceleration. The measurement accuracy of a needle thermocouple was also evaluated in the work.

2. Methods

In general, uncertainty is easy to assess. In the device, the accuracy of the value of physical parameters is considered important. Due to the high internal resistance of the contacts and the increase in temperature, it is necessary to calibrate the error in the temperature difference and the electrical conductivity of the processed seed or take the measured values directly from the processing chamber without passing them through the sliding contacts.

Before using the electrodes for the first time, they must be calibrated. For this purpose, special calibration solutions buffered to specific pH values are available. Buffering works in such a way that a small amount of water entering when the electrode is immersed in water does not interfere with the calibration process. The point of calibration is to correct the electrode error associated with production and use to certain values. In this case, two errors must be taken into account: the deviation of the zero point and the "steepness" of the error.

When the source is turned off, the physical parameter of the seed must be measured with the network turned off in the working chamber of the device. It can be used to separate the mains current by the conductivity of the processed seed. The processing time depends on the humidity, the type and temperature of the seed, and the type of soil layer on which the planting is carried out is important in determining its physical parameters.

During the processing of soaked agricultural seeds, when the set value (temperature, electrical conductivity) is reached, the device will automatically stop processing and start measuring and once again confirm that the set value has been reached.

The sliding contact is configured as a three-phase circuit in Figure 5, and we can use it for a single phase as well.

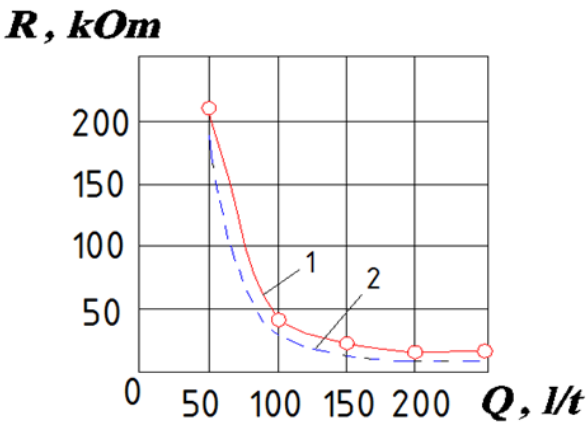


Figure 5. Graph of the dependence of electrical resistance on water flow for a layer of moistened cotton seeds [1,2]

It can be concluded that the level of humidity significantly affects the electrical properties of seeds. Electrical properties can be used to measure the level, which is directly related to both seed germination and viability. Therefore, it can be said that dielectric properties can be used to determine seed quality and germination period [14].

Researchers considered sliding length divided into three modes depending on the size of the contact [15], optimization of a low-power nanogenerator for industrial detection and warning of mechanical damage [16], and contact phenomena in the field of medicine [17].

3. Results and Discussions

Figure 6 shows the duration of electric current treatment of moistened seeds is regulated by a time relay. Information was obtained on the parameters of changes in the physical properties of processed seeds when disconnected from the network. If data is obtained after sliding contacts, the error is greater; if obtained from a seed chamber, the degree of accuracy is higher.

The rotating part of the device has a chamber in which the seeds are placed, symmetrically, each pair is placed in one phase. When the drums rotate, moisture is evenly distributed over the seeds and ensures that the seeds receive the same charge during processing. Depending on the level of humidity and temperature, the source is connected to the network and treated with electric current or stopped.

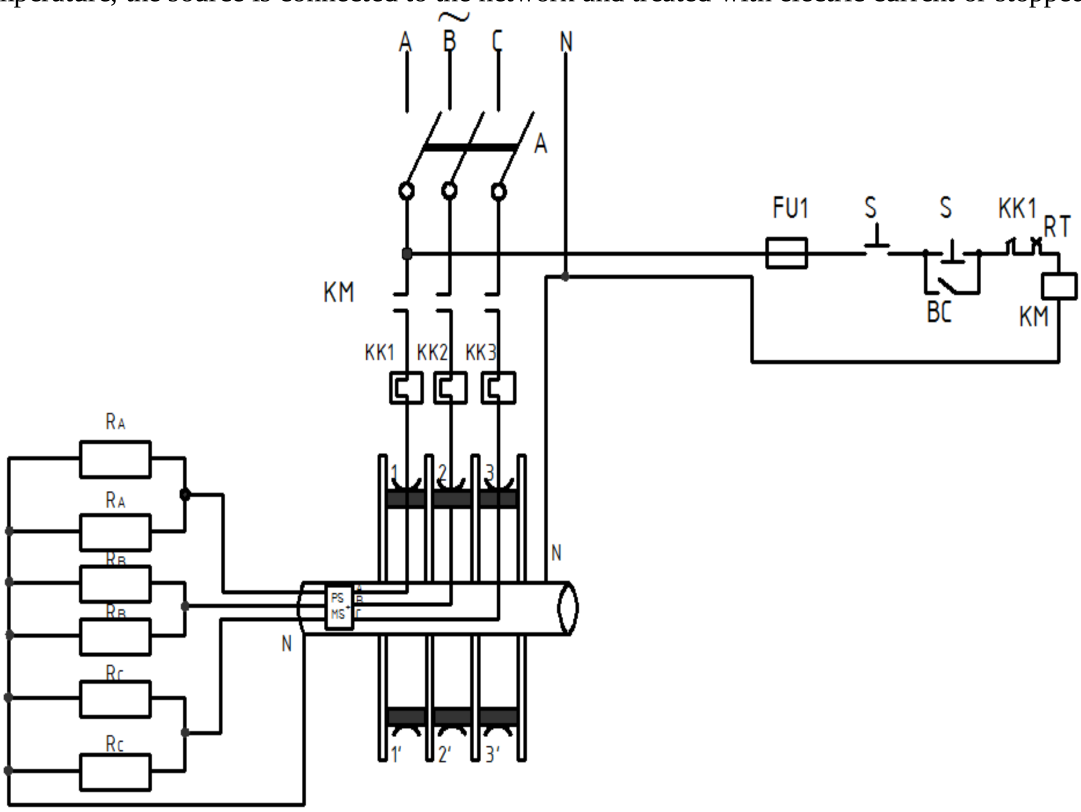


Figure 6. Schematic diagram of the device for the treatment of seeds with sliding contacts

The procedure for measuring the contact resistance of the circuit:
- the circuit shown in Figure 7 is assembled;
- switch SA1 is turned on;
- the adjusting resistor sets the current in the circuit according to the pA ammeter and within the limits of up to 20% of the rated motor current. The current turn-on time for each measurement should not exceed 1 min. Measurements at a current greater than 20% of the nominal current may lead to distortion of the results due to heating of the measured resistance;
- at a steady current value, the SA2 switch is turned on (in this case, it will be possible to take the reading of the pV voltmeter);
- readings of the ammeter and voltmeter for DC and AC circuits are shown in Figure 7 (position b and c).

When measuring the load resistance of one phase

Calculations are carried out taking into account the following ratios (Eq. 1):

$$R_x = \frac{U}{(I - \frac{U}{R_V})} \tag{1}$$

where R_X is the desired load resistance; U is the current source voltage, V; I total circuit current, A; R_V is the internal resistance of the voltmeter, Ohm;

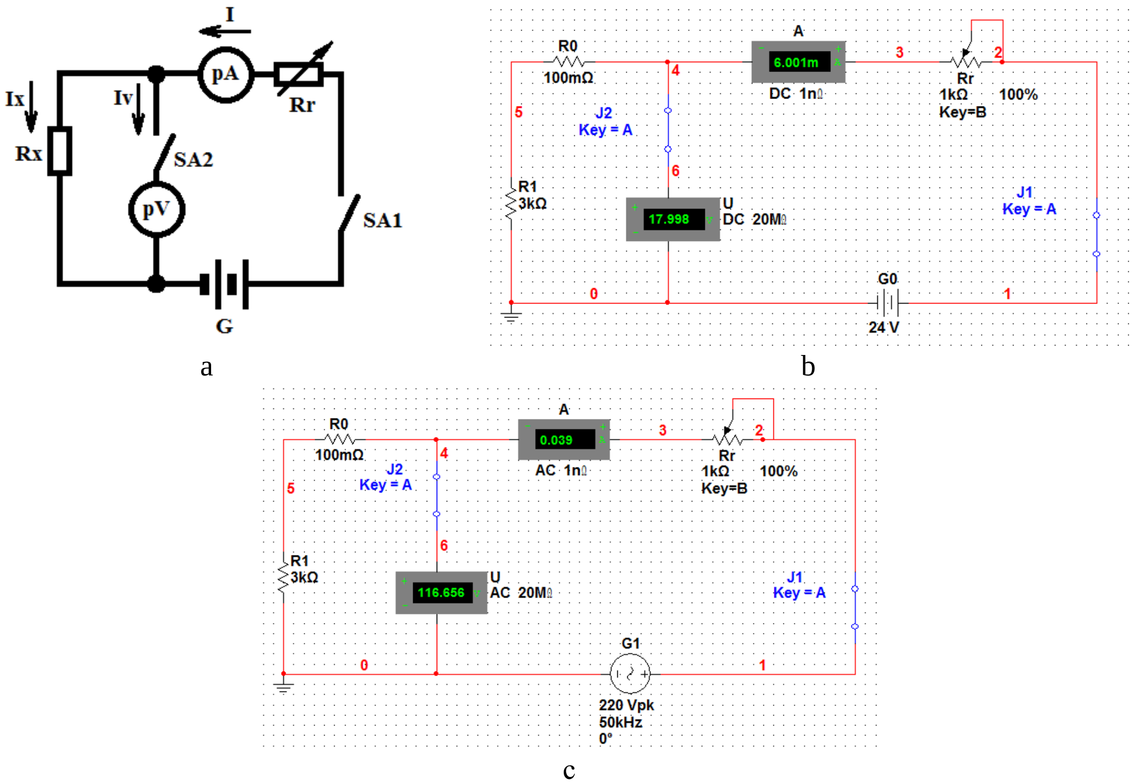


Figure 7. Wiring diagram for measuring resistance

When measuring the load resistance of three phases

If three ends of the load are brought out (blind connection), three measurements should be repeated between each pair of output ends ($R_{1,2}$, $R_{2,3,}$ $R_{3,1}$). If these resistances are equal, then the resistances of each phase (R_{X1}, $R_{X2,}$ R_{X3}) make up (Eq. 2): when connected to a triangle (Figure 8):

$$R_{x1} = R_{x2} = R_{x3} = \frac{3}{2}R_{1.2} = \frac{3}{2}R_{2.3} = \frac{3}{2}R_{3.1} \tag{2}$$

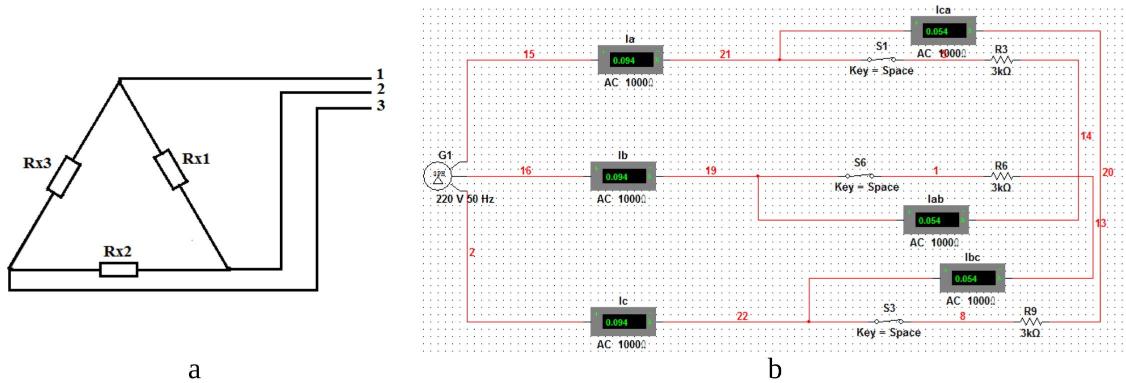
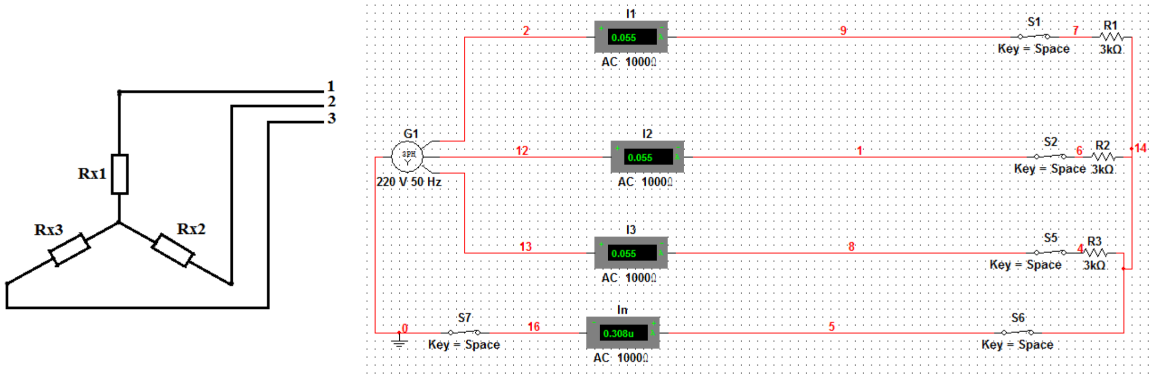


Figure 8. Wiring diagram for measuring resistance windings when connecting phases into a triangle: a - single-line diagram; b - electronic circuit

when connected to a star (Figure 9) (Eq. 3):

$$R_{x1} = R_{x2} = R_{x3} = \frac{1}{2}R_{1.2} = \frac{1}{2}R_{2.3} = \frac{1}{2}R_{3.1} \tag{3}$$



a b

Figure 9. Wiring diagram for measuring resistance windings when connecting phases to a star: a - single-line diagram; b – electronic circuit

If the measured resistances at the terminals differ from each other, then the resistance of each phase is shown in equations (4), (5), and (6) when connected in a triangle

$$R_{x1} = \frac{2(R_{2.3} \cdot R_{3.1})}{(R_{2.3}+R_{3.1}-R_{1.2})} - \frac{1}{2}(R_{2.3} + R_{3.1} - R_{1.2}) \,, \tag{4}$$

$$R_{x2} = \frac{2(R_{3.1} \cdot R_{1.2})}{(R_{3.1}+R_{1.2}-R_{2.3})} - \frac{1}{2}(R_{3.1} + R_{1.2} - R_{2.3}) \,, \tag{5}$$

$$R_{x3} = \frac{2(R_{1.2} \cdot R_{2.3})}{(R_{1.2}+R_{2.3}-R_{3.1})} - \frac{1}{2}(R_{1.2} + R_{2.3} - R_{3.1}) \,, \tag{6}$$

when connected to a star (Eq. 7, 8 and 9):

$$R_{x1} = \frac{1}{2}(R_{1.2} + R_{1.3} - R_{2.3}), \tag{7}$$

$$R_{x2} = \frac{1}{2}(R_{1.2} + R_{2.3} - R_{3.1}), \tag{8}$$

$$R_{x3} = \frac{1}{2}(R_{1.3} + R_{2.3} - R_{1.2}), \tag{9}$$

Intelligent systems are increasingly being used in the agricultural sector. In particular, the authors of [11] used an intelligent system to control and control gates in open channels of irrigation networks. It also proposes a control algorithm for the program.

The algorithm for controlling physical processes for use in research work was also developed by other authors [18, 19, 20].

An algorithm for the treatment of moistened seeds of agricultural plants with electric current has been developed (Figure 10). In this case, first of all, it is necessary to develop an information base based on the results of calculation and measurement of which electrophysical and mechanical processing parameters are of paramount importance for the system and whose values are calculated and measured for each plant species.

For these values, it is necessary to ensure the speed of rotation of the working chamber, that is, during rotation, the seeds are not physically damaged and moisture is saturated throughout the entire length of the same seed.

Two more physical parameters of the processed seed are considered important. These are the electrical conductivity of the seeds and the temperature of the seeds during processing. If the temperature exceeds the specified norm, it is possible to reduce the germination of seeds.

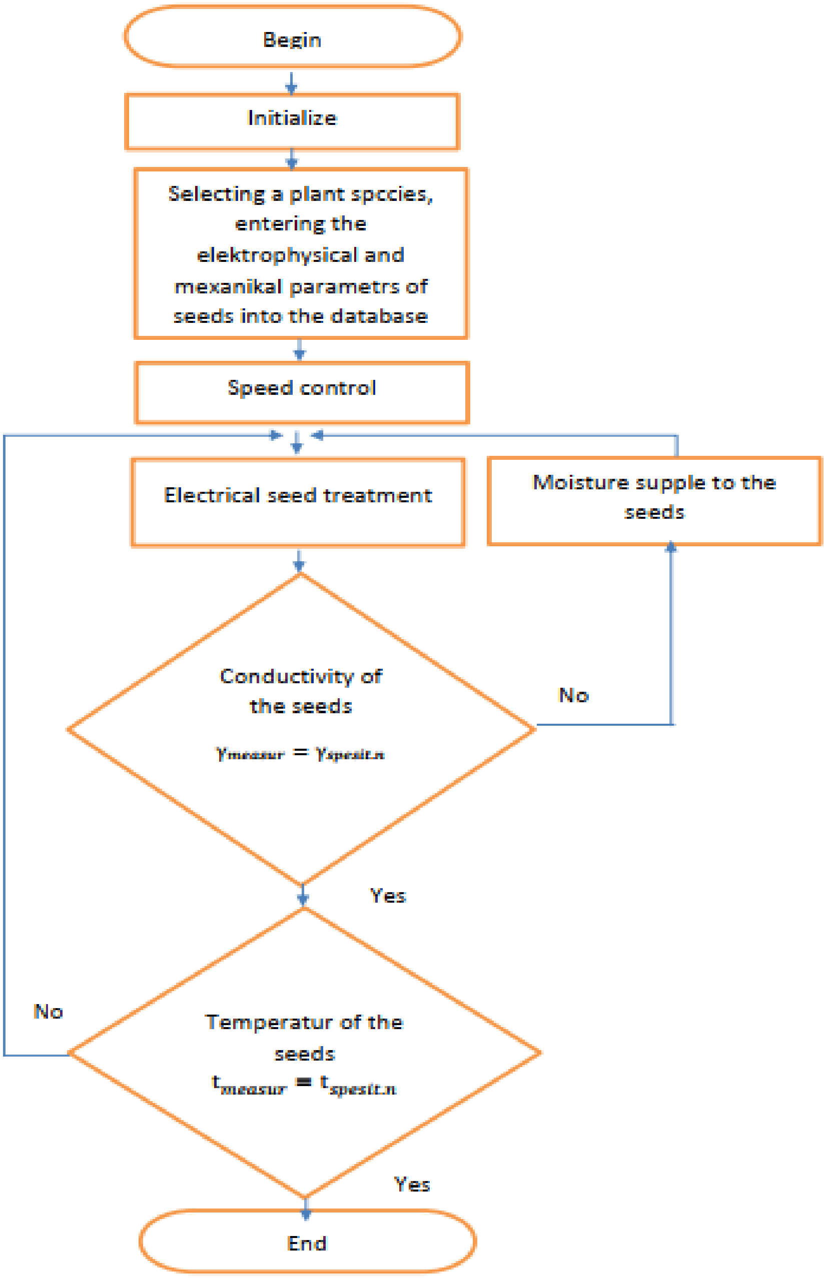


Figure 10. Algorithm of operation of the electric terminator of moistened seeds with an intelligent control system

According to the established algorithm, when the system is started, first of all, the type of plant and some of its physical parameters are taken. At the next stage, the speed of rotation of the working chamber is regulated. When the speed reaches the set value, the seeds are treated with electric current. As a result, the electrical conductivity of the seeds begins to reach a certain (limiting) value from some initial value. During this process, when the temperature of the treated seeds reaches the set value, the system stops the seed treatment process completely. Otherwise, processing will continue. Since the electrical conductivity of seeds is directly related to the moisture level of the treated seeds, additional moisture is added to the seeds to control the conductivity. The system stops working when the temperature of the treated seeds returns to normal.

Temperature information should be obtained from two temperature sensors: the first temperature sensor is activated by the measuring system in the event of a temporary interruption in the supply of electric current to moistened seeds, and the second temperature sensor is placed inside the chamber and provides continuous temperature measurement.

4. Conclusions

The article deals with issues related to electrophysical processes in an electroterminator (with an intelligent system) with sliding contacts in the power circuit. At the same time, the contact resistance of the power circuit, normalized to the moisture content of sowing seeds, depending on the type of plants, was taken as the basis of the physical model. The intelligent system adaptively takes into account the following seed parameters such as temperature, importance, electrical conductivity. In the initial period of seed treatment, moisture penetrates the seeds from the outside. Therefore, the time of moistening and electrical treatment of seeds in the Smart electrotreminator are the main influencing factors. Depending on the variety of seeds, it will be possible to change the operating parameters of the electrical treatment of seeds of agricultural crops with frequency regulation of engine speed. The paper also analyzed the literature, electrical circuits are accompanied by electronic models on the EWB.

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