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DEVELOPMENT OF A INSTALLATION FOR GENERATING HIGH-VOLTAGE DISCHARGES IN WATER

Discovery Note

Abstract

The relevance of developing technologies to improve the environmental friendliness of agricultural and food products justifies the feasibility of creating technical means for the implementation of these technologies. A plant is being developed for the generation of pulsed high-voltage spark discharges in water, which can be used as nutrient solutions in greenhouses for irrigation or irrigation of crop production. The design features of the installation with respect to operation and maintenance are determined. Experimentally revealed rational operating modes of the installation: power consumption up to 3.5 kW; DC voltage up to 70 kV; capacitance of storage capacitors up to 1 μF.

Keywords: pulse capacitors, nutrient solutions, electrodes.

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РАЗРАБОТКА УСТАНОВКИ ДЛЯ ГЕНЕРАЦИИ ВЫСОКОВОЛЬТНЫХ РАЗРЯДОВ В ВОДЕ

Примечание об открытии

Аннотация

Актуальность разработки технологий повышения экологичности сельскохозяйственных и пищевых продуктов обосновывает целесообразность создания технических средств для реализации этих технологий. Разрабатывается установка для генерации импульсных искровых высоковольтных разрядов в воде, которая может использоваться в качестве питательных растворов в тепличных хозяйствах для полива или орошения продукции растениеводства. Определены конструктивные особенности установки относительно эксплуатации и технического обслуживания. Экспериментальным путем выявлены рациональные режимы работы установки: потребляемая мощность до 3,5 кВт; напряжение постоянного тока до 70 кВ; емкость накопительных конденсаторов до 1 мкФ.

Ключевые слова: импульсные конденсаторы, питательные растворы, электроды.

1. Introduction

In agriculture, various technologies are being developed that make it possible to convert nutrients into a form accessible to plants and, in most cases, to exclude the additional introduction of other fertilizers, returning the soil to its lost fertility. The advantage of these and other technologies, using a high-voltage pulse discharge during the generation of an electromagnetic field, is the high efficiency of the processes and the absence of negative environmental impact [1].

Currently, consumers are turning to organic food [2], [3]. The products of farms that use mainly organic fertilizers of natural origin and sell their products in markets and supermarkets are in great demand [4], [5]. However, due to the limited nature of such fertilizers and the duration of the processes of their formation, the cost of environmentally friendly food is still quite high.

The technology of high-voltage generation of pulsed discharges in water is called to solve this problem to a large extent, which makes it possible to obtain fertilizers much faster from soil pulp by converting the nutrients contained in it into compounds easily assimilated by plants. In many cases, it is more beneficial to cultivate not water but water for irrigation. Water treatment with high-voltage discharges allows increasing the number of nitrogen compounds dissolved in it. Such water can serve as an excellent, environmentally friendly nitrogen fertilizer. Biologically active nitrogen dissolved in irrigation water turns into oxides, thereby increasing the content of nitrate and nitrite ions. The use of high-voltage effects on plant materials significantly increases the release of biologically active substances, trace elements, vitamins, and other substances important for the body of animals from them. These substances, enclosed in a durable hard to digest shell, are poorly served by destruction by traditional mechanical methods [6]. The proposed treatment destroys this shell and releases the nutrients in it. Perhaps the use of EG-processing for disinfection of water and solutions.

For small farms where a large number of fertilizers are not required, it is economically feasible to purchase an energy tool of small power (2.0-2.5 kVA) and several working bodies for working with high voltage supplied, with which it is possible to carry out a range of work in the farm: production fertilizers from peat pulp, water, wastewater disinfection, crushing of organic materials, processing of plant and animal feed and others.

Purpose of work: development of a facility for research on the use of pulsed high-voltage electric discharges inside a fluid volume to implement the technology of producing fertilizers from aqueous solutions.

2. Methods

Methods of research, analysis and calculation of technical means and control systems were applied in relation to high-voltage electrotechnological installations for agricultural purposes.

3. Results

When developing the installation, both previously published works and the results of new studies [7] were taken into account. Experimentally, the electrical parameters necessary for processing various organic structures by high-voltage discharges were established.

It was experimentally established that when processing peat pulp various operating modes of plants are possible depending on the values of voltage and capacity. In hard mode, the voltage is more than 50 kV, and the capacitance is less than 0.1 μF. In the average mode, the voltage is about 20 kV, the capacitance is less than 1 μF. In soft mode, the voltage is 20 kV, the capacitance is more than 1 μF. High-voltage water treatment technology requires little energy and the necessary electrical parameters are in the following ranges: voltage 20-60 kV, capacitance 0.05-0.2 microfarads. Water treatment with high-voltage discharges will have, among other things, the effect of disinfection due to exposure to an electromagnetic field [8]. When crushing organic materials and processing plant and animal feed, it is necessary to provide a voltage of 20-70 kV and a capacity of 0.1-0.6 microfarads.

The processing efficiency of high-voltage discharges is affected not only by the absolute values of the electrical parameters, but also by their ratio. The magnitude of the voltage determines the length of the discharge channel, the capacitance determines the diameter of the channel. An increase in capacitance, at a constant voltage, increases the pulse energy and the amplitude of the current. With increasing voltage, the discharge is shorter, an increase in capacity leads to an increase in the duration of the discharge. With a decrease in the active and inductive resistance of the circuit, the efficiency of the discharge increases. An electric discharge leads to the generation of high pressures, due to which mechanical work can be accomplished [9].

The effect will be better, the greater the voltage level of the pulse current generator and the energy introduced into the working period, the steeper the pulse front, the shorter the pulse duration.

Modeling of high-voltage technology for processing agricultural raw materials will clarify the design features of equipment for the implementation of these processes [10], [11]. Therefore, the main tasks of developing an installation for water treatment technology by generating high-voltage discharges will be:

- The optimal scheme of a high-voltage pulsed current source, providing all the necessary processing modes;
- erosion resistant electrode design;
- independent adjustment of output parameters.

In addition, in the future, it is required to ensure the process flow [12]. The design parameters of the installation include: the composition of the installation, reliability, ease of use. It should have a block design, be easy to maintain, electrically safe and convenient for the staff. The installation should provide the necessary range of electrical parameters for the study.

Structurally, the installation should consist of a housing in which are installed:

- high voltage power supply based on a TVI-50/70 transformer with a rectifier;
- electric energy storage system (pulsed high voltage capacitors);
- arrester designed to form pulses with a steep front;
- controls that allow you to change the settings during the experiments;
- working bodies.

The design of the working bodies is determined by the technological process that is performed by the installation.

It was experimentally established that in liquids with ionic conductivity, a discharge occurs only at very small distances between the electrodes and the resulting pressure from the discharge channel in the liquid is negligible. It was possible to solve the problem of a sharp increase in the action of a spark discharge in ion-conducting liquids by introducing a forming air spark gap into the electrical circuit. To enhance the effect in an ion-conducting fluid and effectively convert electrical energy into mechanical energy, you need to increase the surface of the spark discharge channel through which energy is transferred to the liquid.

It is proposed to minimize the working surface of the positive electrode (tip with a diameter of 2-3 mm). In addition, it is necessary to significantly increase the active surface of the negative electrode to sizes limited by the dimensions of the working chamber, since in the installation the diameter of the negative electrode of the working body will be 20-60 mm. Thus, a significant asymmetry of the electromagnetic field between the electrodes is created. As a result of this, the number of negative ions increases sharply and a negative space charge arises between the electrodes. Ions transfer their electrons to the streamer channel, which grows over considerable distances. In this regard, it is assumed that the duration of the process is reduced [13]. Reducing the time of the technological process of water treatment by generation of high-voltage discharges increases the productivity of this process, and then the productivity of the installation [14]. Thus, water after such an electrical effect on it becomes a source of fertilizer for plants, a nutrient solution. These aqueous solutions can be used for irrigation and irrigation in the vegetable growing of open or closed ground.

The installation consists of separate blocks, easy to maintain, repair, install, dismantle (Figure 1).

Figure 1 – Installation for generating high-voltage discharges in water

The installation provides for the protection of personnel from high voltage, noise due to the placement of equipment in a metal and grounded case, and the working body in a special soundproofing chamber.

A high-voltage power supply based on the TVI-50/70 transformer with a rectifier allows you to receive a rectified voltage for charging high-voltage capacitors from 0 to 70 kV, the power of the transformer is 3.5 kW. Storage capacitors allow you to change the capacitance in the discharge circuit from 0.025 to 1.0 microfarads. Dischargers are designed to form pulses with a steep front. Regulation of the air spark gap allows a wide range to change the modes and parameters of the discharge in solutions. To study the enhancement of the effect in an ion-conducting liquid and the effective conversion of electrical energy into mechanical energy, by increasing the active surface of the negative electrode, several electrodes with diameters from the tip to 60 mm were made. Installation parameters during experiments are changed using controls.

4. Conclusion

The designed and manufactured installation is universal, reliable in operation, safe during operation and allows water treatment due to the generation of pulsed spark discharges. The installation provides a change in electrical parameters in the following limits:

- power consumption up to 3.5 kW;
- DC voltage up to 70 kV;
- capacitance of storage capacitors up to 1 μF.

Conflict of Interest

None declared.

Конфликт интересов

Не указан.

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