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Қ. И. Сәтпаев атындағы Қазақ ұлттық техникалық зерттеу университеті

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ИЗВЕСТИЯ

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INSTALLATIONS FOR COMPLEX INFLUENCE OF ELECTROPHYSICAL FACTORS ON RAW MATERIALS

Abstract. Two microwave installations have been developed with quasi-stationary resonators with rectangular and circular torus sections. In both installations in the condensing part of the resonator, there is an electro-gas-discharge lamp connected to the source of kilohertz frequency according to the D'Arsonval principle. Therefore, the installations provide a complex effect of electrophysical factors on raw materials, including the potato tubers and onion sets during preplant treatment.*In the first installation* with a quasistationary toroidal resonator of rectangularcross section in the condensing part, the distance between the walls is less than at the edges and not less than a quarter of the wavelength. The resonator is designed as coaxially arranged non-ferromagnetic cylinders, the lower bases of which form its condensing part, and the arrangement of the internal cylinder is adjustable in height.

The annular space between the side walls of the cylinders on the top is closed with a non-ferromagnetic surface containing the nodes of the threaded height regulator of the internal cylinder. Inside the annular space, there is a cylinder, an air offtake and an electro-gas-discharge lamp connected to kilohertz frequency source. In the condensing part, there is a batcher. The emitters from magnetrons located on the side surface of the outer cylinder with a shift of 120 degrees are directed to the condensing part of the resonator.

In the second installation, the toroidal resonator is represented in the form of a torus with a circular cross section and docked plane-parallel circular surfaces in the central part. Inside the torus is a dielectric grid conveyor. In the central part of the resonator, there is a rotating disk, over which a dielectric distributor is mounted.Emitters are directed into the torus, and electro-gas-discharge lamps connected to kilohertz frequency sources are directed into the condensing space. At the center of the resonator, a feed hopper is installed, and under the torus - an induction heater is mounted so that the segment of the bottom of the torus surface is its secondary winding.

Keywords: ultrahigh frequency generator, quasi-stationary toroidal resonator, electro-gas-discharge lamps, kilohertz frequency source, induction heater.

Introduction. It is known that the treatment of onion sets before planting is carried out in order to avoid low germination, bacterial damage, and intensive “shooting”. Immediately before planting, onions are heated at a temperature of 35-40 °C for 10-12 hours. Further, phytosporinis used to suppress the development of pathogenic soil microflora. There is a way to warm the onion sets in hot water (45-50 °C) for 10-12 minutes and then in cold water, also 10-12 minutes, then treatment with pests and nutrient solutions. At the same time for uniform heating and cooling of onion sets in farms, it is necessary to have water heaters and additional mechanisms for mixing.

There is a method of preplanting treatment of onion sets in an electromagnetichigh-frequency field [1]. At the same time, high-frequency installations of *periodic action* and with fixed frequencies (27.12 MHz, 40.68 MHz) were used, where the working chamber is a condenser made of two parallel-arranged plates. Long-term laboratory and field studies of these authors on the application of electromagnetic high-frequency fields for preplanting treatment of onion-seed showed that there is an increase in sowing and productive indicators, improving product quality.

In the Federal State Budgetary Educational Institution of Higher Education "Stavropol State Agrarian University", there were received positive results of research on the preplanting treatment of onions with a pulsed electric field to improve their sowing qualities [2].

It is known that the yield of potatoes depends largely on the quality of sown tubers. Today, preplanting treatment is carried out with agricultural preparations for the prevention of diseases, pests, growth stimulation. Most often for disinfection these drugs are used: Maxim, Phytosporin-M, they are combined with other fungicides and growth stimulants. They protect the crop from diseases at all stages of growth, but do not exclude side effects on humans [3].

The positive results of electrophysical methods of processing products are known [4-7]. For example, the electrophysical factors processing technology of potato tubers prevents the contamination of agricultural land and, without chemical intervention, makes more efficient the use of the capabilities of the potato tuber itself. Known methods of preplanting treatment of potato tubers with low-frequency (8-19 Hz) magnetic fields [8]. The installation contains an inductor, but the processing time at a frequency of 16 Hz reaches up to 15-20 min, which is a disadvantage.

Conditions, materials, and research methods. The development of constructional design of cavity resonators was carried out on the basis of the analysis of electrophysical factors influencing the raw materials, based on the theory of the electromagnetic ultrahigh frequency field, induction heating and d'arsonvalization [9].

The object of the research is technological processes that ensure the prevention of potato tubers and onion sets from pests and growth stimulation; experimental samples of installations that implement the complex effect of electrophysical factors on raw materials in a continuous mode.

The aim of preventive treatment of potato tubers and onion sets before planting by the complex effect of electrophysical factors is disinfection from a number of pests, activation of potato tuber cells to accelerate and promote their germination, with the exception of side effects on the physico-chemical composition of grown potatoes.

Results and discussion. Below are described two developed microwave installations with toroidal resonators, providing complex effect of electrophysical factors on raw materials in continuous mode.

The first installation. For disinfection from a number of pests, for activation of onion sets germination and potato tubers in continuous mode in order to increase productive indicators, we suggest processing them before planting with a complex effect of the electromagnetic ultrahigh frequency field (EMUGFF) and corona discharge, which provides air ionization and ozonation. The implementation of the complex effect of these electrophysical factors is possible in the microwave installation with the quasistationary toroidal resonator [1, 2] of rectangularcross section, containing below-cutoff waveguides that ensure the observance of electromagnetic safety when moving onion sets through the resonator.An electro-gas-discharge lamp connected to kilohertz frequency source according to the D'Arsonval principle [12, 14] provides a corona discharge and radiation of a bactericidal flux of ultraviolet rays, moreover, this lamp filled with argon or neon and located in the electromagnetic ultrahigh frequency field coronates more powerfully.

The technological task of development is the preplanting treatment of vegetable crops in order to increase their sowing and productive indicators by the complex effect of electrophysical factors in continuous mode with the provision of high electric field intensity and ozonation for decontamination of raw materials and compliance with electromagnetic safety.

The microwave installation (figure 1) for preplanting processing of vegetable crops consists of the vertically located quasistationary toroidal resonator 1 with a rectangular cross section.

It is known that the shape of the profile of the toroidal resonator determines the structure of the excitable electromagnetic fields. The electric field is mainly concentrated in the condensing part of the resonator, where the distance between the walls is small, i.e. this part of the resonator is capacitive in effect. The magnetic field energy is concentrated in the periphery part of the resonator (in the torus) [10].

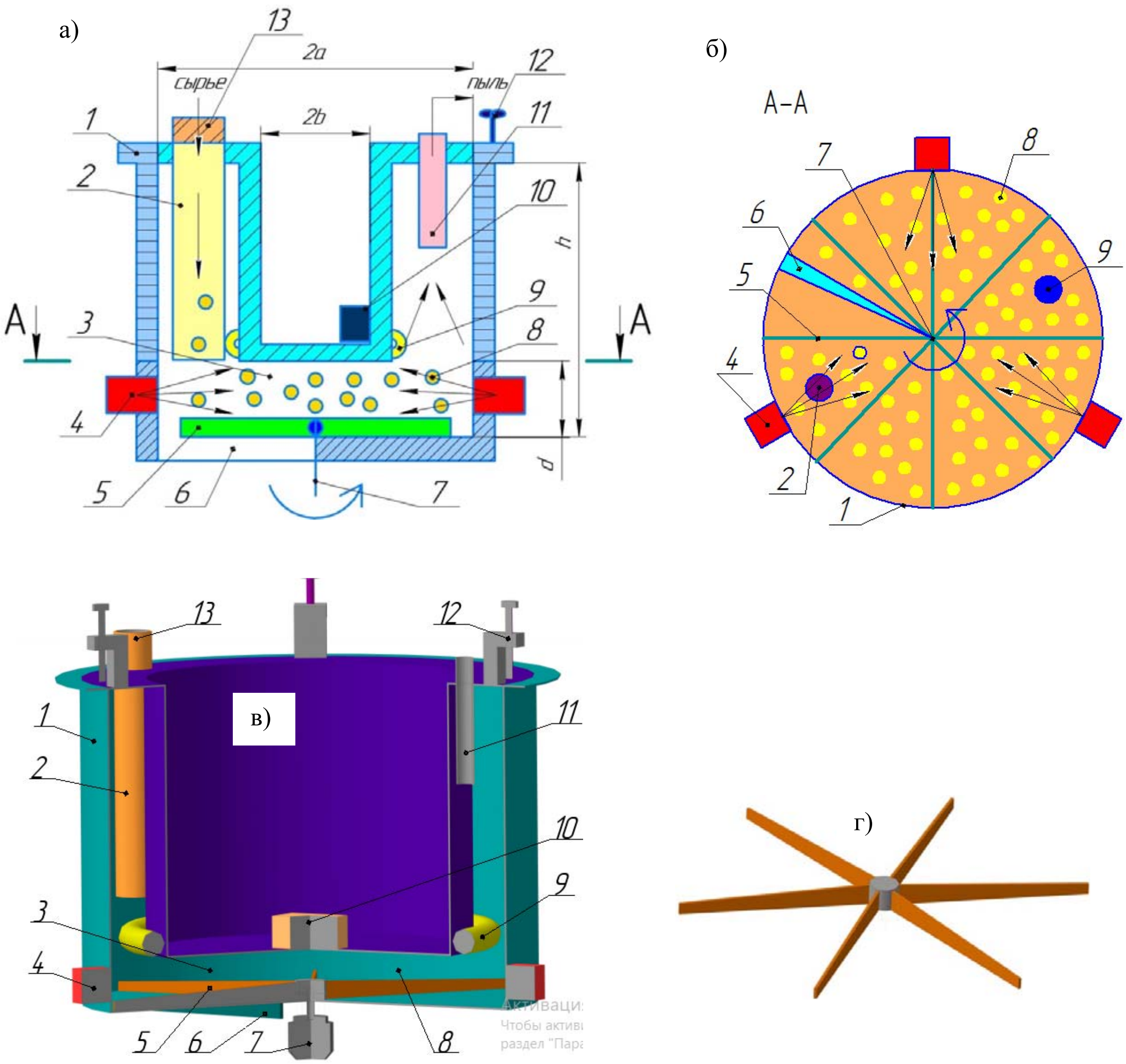

Figure 1 – Microwave installation for preplanting processing of onion sets in continuous mode: а, б) schematic illustration of the front view andA-A; в, г) space image of the installation in the section and batcher; 1 – quasistationary toroidal resonator; 2 – dielectric cylinder for feeding raw materials; 3 – condensing part of the quasistationary toroidal resonator; 4 – magnetrons with emitters; 5 – batcher with radially located dielectric scrapers; 6 – discharge opening with the below-cutoff waveguide in the form of a regular triangular prism;7 – drive shaft of the scraper batcher; 8 – raw material; 9 – circular electro-gas-discharge lamp; 10 – kilohertz frequency source; 11 – dielectric air offtake; 12 – threaded height regulator of the internal cylinder; 13 – below-cutoff waveguide of circular section

The annular space between the side walls of the cylinders is on top closed with a flat surface, where there are openings for the dielectric air offtake 11 and for the below-cutoff waveguide 13 joined with the dielectric cylinder 2. Inside the annular space, there is the dielectric cylinder 2, the dielectric air offtake 11 and the circular electro-gas-discharge lamp 9. This lamp has the ring form is put on the inner cylinder with a gap between them at the level of its base. The electro-gas-discharge lamp 9 is connected to kilohertz frequency source 10, located on the side surface of the inner cylinder, from the inside. In the condensing part, there is the batcher 5 with radially located scrapers, mounted on the shaft 7 of the electric motor coaxially with the base of the outer cylinder, where there is the discharge opening 6 in the form of a sector. The below-cutoff waveguide in the form of the regular triangular prism is docked to the discharge opening.

The emitters from magnetrons 4, located on the side surface of the outer cylinder with a shift of 120 degrees, are directed to the condensing part of the resonator, where there is raw material 8. The capacity of the condensing part of the resonator is regulated by changing the vertical position of the internal cylinder. For this, there is a threaded height regulator for the lift of the inner cylinder 12. In this case, the electric field intensity is adjusted by changing the distance between the bases of the non-ferromagnetic cylinders.

The technical process of preplanting processing of potato tubers or onion sets is as follows. Turn on the drive of the air offtake 11 and the batcher 5 with dielectric scrapers. Set a certain distance between the bases of the cylinders, calibrated to the required value of the electric field intensity, sufficient for disinfecting onion sets or potato tubers.Turn on the kilohertz frequency source 10, after which due to the occurrence of corona discharge between the side surface of the inner cylinder and the electro-gas-discharge lamp 9, the air ionization occurs, ozonation, the lamp will be a source of ultraviolet rays of the "C" area. Next, turn on the conveyor to feed the raw material into the dielectric cylinder 2 through the below-cutoff waveguide 13 of circularcross section. Turn on the ultrahigh frequency generators 4.When the raw material enters the condensing part 3 of the quasi-stationary resonator 1, it is exposed to the electromagnetic ultrahigh frequency field in the process of moving with the scraper batcher, it is heated (up to 35-40 °C), disinfected due to the high electric field intensity (above 1.5 kV/cm), as well as ozonization and bactericidal action of ultraviolet rays.

Moreover, the electric field intensity is adjusted by changing the distance between the bases of non-ferromagnetic cylinders using a threaded height regulator of the inner cylinder lift 12. After one turn of the shaft of the electric drive 7 of the scraper batcher, the processed raw material 8 is poured out through the discharge opening 6 and the below-cutoff waveguide in the form of the triangular prism. Through the air offtake 11, dust, husks, others are removed. The technical process of preplanting treatment of onion sets or tubers of seed potatoes goes is underway in continuous mode.

During the operation of the kilohertz frequency source (by D'Arsonval principle), impulse high voltage and low power currents affect the raw materials. The current passes through the electro-gas-discharge lamp. Between the lamp and the side surface of the inner cylinder, there is a corona discharge of different intensity depending on the gap between them (0.5-2 cm). Herewith, there is a release of ozone and air ionization, a formation of ultraviolet rays. The current on the electro-gas-discharge lamp is not more than 0.2 mA, the voltage is 12-15 kV, the pulse frequency is 110 kHz [14]. The released ozone and ultraviolet rays of the "C" area have a bactericidal effect. Bacteria and microorganisms present in the treated seeds die. With the complex effect of various electrophysical factors, the cells of potato tubers and onion sets are activated, which increases the germination energy, germination, growth force and yield.When designing the quasistationary toroidal resonator for operation in continuous mode, it is necessary to strive to reduce the equivalent capacitance at a given resonant frequency and increase the equivalent inductance (toroidal surface). In this case, the loss of microwave energy in the toroidal resonator is reduced, and the efficiency increases [10].

Low radiation losses due to the presence of below-cutoff waveguides and losses in the walls of the quasi-stationary toroidal resonator made of aluminum lead to the fact that this resonator in the microwave range has a high-quality factor of its own.

The second installation for preplanting treatment of potato tubers or onion sets by electrophysical factors (figure 2) consists of the toroidal resonator 1, made in the form of the circular torus, the average perimeter of which is a multiple of half the wavelength. The middle part of the toroidal resonator is made of two plane-parallel circular planes, forming the condensing space 13**.**In this space, the disk 5 is installed coaxially with the resonator, which is driven by the electric motor. Above the disk 5 is rigidly installed dielectric distributor of tubers 6 in the form of a streamlined surface. Through the upper circular plane, detachable electro-gas-discharge lamps fed from the kilohertz frequency sources 12 are directed uniformly around the perimeter into the condensing space.

Electro-gas-discharge lamps are surrounded by the grid that protects from the impact of tubers. In the center of the same circular plane, the filling hopper 14 is installed. Microwave energy emitters 2 from magnetrons are directed through the surface of the torus. They are located with a shift of 120 degrees in order not to disrupt the operation of neighboring magnetrons. Inside the torus, the conveyor 4 and the scrapers 9 move by means of the driven pulley 8 and the drive gear mounted on the shaft.The discharge dielectric limiter 11 is rigidly fixed above the conveyor, directing the potato tubers to the window 10 with the below-cutoff waveguide. The fluoroplastic scrapers 9 mounted under the conveyor move with it, and

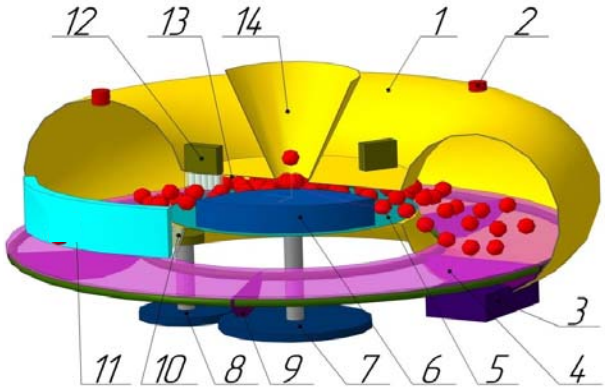

Figure 2 – Installation for preplanting treatment of potato tubers with exposure by electrophysical factors:
1 – toroidal resonator; 2 – microwave energy emitters; 3 – induction heater; 4 – dielectric grid conveyor;5 – rotating disk;
6 – dielectric distributor of tubers;7 – driving pulley; 8 – driven pulley for the grid conveyor drive;
9 – dielectric scrapers for waste unloading; 10 – unloading window for tubers;11 – discharge dielectric limiter;
12 – kilohertz frequency sources;13 – condensing space; 14 – filling hopper;15 – window for discharging waste

they are intended for discharging waste from the torus through the window 15 and the below-cutoff waveguide. The induction heater 3 is installed under the torus, and the torus segment above it performs the secondary winding of the inductor [11].

So, the installation contains three different sources of electromagnetic radiation:

- ultrahigh frequency generators (main nodes - magnetron, emitter);
- induction heater (primary winding and torus segment);
- kilohertz frequency sources (generator and electro-gas-discharge lamps) that generate high-frequency alternating impulse current with high voltage, the value of which is in the range of 2-15 kV, current frequency - 110 kHz [12].

The technical process of preplanting processing of potato tubers is as follows. Load the potato tubers into the hopper 14. Turn on the electric drive of the disk 5, then the driven pulley 8 rotates by means of the driving pulley, driving the conveyor 4 and the scrapers 9. Turn on the kilohertz frequency sources 12 and induction heater 3, then ultrahigh frequency generators, emitters 2 of which excite in the EMUHFF toroidal resonator.

A traveling wave with the 2450 MHz frequency is excited *in the toroidal resonator*, and under the influence of the EMUHFF, the potato tubers endogenously heat up to 35 °C, which accelerates the enzymatic activity of the tubers, thereby increasing their germination. In the condensing space, the electric field intensity is high enough (more than 2 kV/cm), which ensures the prevention of potato tuber from diseases and pests.

Electro-gas-discharge lamps 12 are at a distance of several millimeters (3-5 mm) from the tubers. In this case, a small electrical discharge arises between the lamps and tubers, which accelerates biochemical reactions, saturates the tubers with oxygen, increases the elasticity of the tuber's jacket and its permeability [2]. The electric discharge has a bactericidal and bacteriostatic (delayed multiplication of bacteria) action. Discharges produce ozone with a disinfecting effect.The conversion of high-voltage voltage to the corona discharge of the required force is due to the electro-gas-discharge lamps. Complex physical and electrochemical processes with the participation of inert gases in the lamp can produce several factors. Inert gas acquires the properties of the electrical conductor, then through a layer of air between the lamp and the tubers of potatoes, through the potatoes and the disk 5 is closed to the ground. As a result, the corona discharge occurs, therefore, ozone, heat and ultraviolet radiation are released in the condensing space 13. This whole complex of factors contributes to the activation of potato tuber cells, which allows them to accelerate and increase their germination.

Because of the fact that *induction heaters* are installed under the torus bottom segment, the electromagnetic coil (primary winding) generates a magnetic field, and the torus surface bottom segment made of ferromagnetic material with a size of at least 70% of the surface of the induction cooker is heated by eddy currents. When there are pests, separated by the conveyor grid 4, by means of mobile fluoroplastic scrapers 9 to the heated torus segment, they are destroyed by a thermal burn and are output through the discharge window 15 and the below-cutoff waveguide.

The choice of modes of factors influence depends on the type and maturity of potatoes or onion sets. The use of such an installation with different electrophysical factors will allow to obtain environmentally friendly products that meet all the requirements of the standards. This installation is recommended for preplanting processing of potato tubers no larger than 6 cm. This is connected with the provision of the high electric field intensity in the condensing space, the depth of a centimeter wave penetration into the potato tubers, and also the simplification of the design of the below-cutoff waveguides. They are provided in the unloading windows 10 and 15. Uniform heating of the tubers and continuous operation of the installation is ensured by transporting in the torus with the help of the grid conveyor.

The technical specifications of the installation for preplanting treatment of potato tubers by the complex effect of electrophysical factors are given in table.

Installation specifications

Item	
Capacity, kg/h	250-300
Microwave generator power, kW	3.6
kilohertz frequency sources power, kW	0.225
Induction heater power at a heating temperature of 150 °C, kW	1.0
Power of motor reducer ESTA -6.3/12.5 for the conveyor drive, 2.4/4.8 r/min	0.043
Installation capacity, kW	4.9
Specific energy costs, kW·h/kg	0.015-0.2

Conclusions. Using the proposed installation, with the capacity of up to 300 kg/h,it is possible to handle the entire volume of potato tubers in farms before planting. Studies show that the duration of the effect from the complex impact of electrophysical factors is up to 6 days. Consequently, it is possible to carry out preplanting treatment of up to 20 tons of potato tubers, no larger than 6 cm in size, using one such installation, at specific energy costs of up to 0.2 kW·h/kg.

The developed installations contain various sources of electromagnetic radiation.:

- ultrahigh frequency generators, providing endogenous heating of planting material and prevention of diseases and pests; induction heater for the destruction of pests by means of thermal burns; high-frequency (110 kHz) alternating impulse current generators with high voltage (up to 15 kV) and electro-gas-discharge lamps, which accelerate biochemical reactions and disinfect the raw material due to ozonation.

This whole complex of energy sources contributes to the activation of sown and productive indicators of vegetables. Using a new method of preplanting treatment of onion sets and potato tubers can increase crop yields by up to 15% and improve product quality, increase hygienic safety requirements of the product, therefore, the developed installations are recommended for use in farms.

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ШИКІЗАТҚА КЕШЕНДІ ӘСЕР ЕТЕТІН ЭЛЕКТРОФИЗИКАЛЫҚ ФАКТОРЛАРЫ БАР ҚОНДЫРҒЫЛАР

Аннотация. Төрт бұрышты және дөңгелек қимасы бар квази стационарлық резонаторлармен екі микротолқынды қондырғылар әзірленді. Екі қондырғыда да резонатордың конденсатор бөлігінде Дарсонваль қағидасына сәйкес килогерц жиілігінің көзіне қосылған электр разряд шамдары бар. Сондықтан, өсімдіктер алдын ала отырғызу кезінде электрофизикалық факторлардың шикізатқа, оның ішінде картоп пен пияз түйнекіне кешенді әсерін қамтамасыз етеді. Конденсатордың бөлігінде тікбұрышты көлденең қиманың квазистациялық тороидальды резонаторы бар алғашқы қондырғыда қабырғалардың арасындағы қашықтық шеттерге қарағанда аз және толқын ұзындығының төрттен бірінен кем емес. Резонатор коаксиалды ферромагниттік цилиндрлер ретінде құрастырылған, оның төменгі негіздері оның конденсатор бөлігін құрайды және ішкі цилиндрдің биіктігі реттеледі. Цилиндрлердің бүйірлік қабырғалары арасындағы сақиналық кеңістік феромагниттік емес беткі қабатпен жабылады, ішкі цилиндрдің көтеру биіктігінің бұрандалы реттегішінің түйіндері бар. Сақиналық кеңістікте цилиндр, ауа ағыны және килогерц жиілігінің көзіне қосылған электр қуатын шығару шамы бар. Конденсатор бөлімінде дозатор бар. Сыртқы цилиндрдің бүйір бетінде 120 градусқа жылжуы бар магнетроннан шыққан сәуле таратқыш резонатордың конденсатор бөлігіне жіберіледі. Екінші қондырғыда тороидальды резонатор орталық бөлікте дөңгелек көлденең қимасы бар және торға параллельді дөңгелек беттермен тор түрінде ұсынылған. Тора ішінде диэлектрлік тор конвейері бар. Резонатордың орталық бөлігінде диэлектрлік бөлуші орнатылатын айналмалы диск бар. сәуле таратқыштар торға бағытталады және килогерц жиіліктер көздеріне қосылған электрогазоразрядты шамдар конденсатор кеңістігіне бағытталады. Резонатордың ортасында арна шұңқыры орнатылған, ал тор астында - тор бетінің төменгі бөлігінің екінші орамасы болатын индукциялық жылытқыш.

Түйін сөздер: жоғарытолқынды генератор, квазистационарлық тороидальды резонатор, электр разряд шамдары, килогерц жиілік көзі, индукциялық жылытқыш.

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УСТАНОВКИ ДЛЯ КОМПЛЕКСНОГО ВОЗДЕЙСТВИЯ ЭЛЕКТРОФИЗИЧЕСКИХ ФАКТОРОВ НА СЫРЬЕ

Аннотация. Разработаны две сверхвысокочастотные установки с квазистационарными резонаторами с прямоугольным и круглым сечением тора. В обеих установках в конденсаторной части резонатора предусмотрена электрогазоразрядная лампа, подключенная к источнику килогерцовой частоты по принципу Дарсонваля. Поэтому установки обеспечивают комплексное воздействие электрофизических факторов на сырье, в том числе на клубни картофеля и лука-севка при предпосадочной обработке. В первой установке с квазистационарным тороидальным резонатором прямоугольного сечения в конденсаторной части расстояние между стенками меньше, чем по краям, и не менее четверти длины волны. Резонатор выполнен как соосно расположенные неферромагнитные цилиндры, нижние основания которых образуют его конденсаторную часть, и расположение внутреннего цилиндра по высоте регулируется.Кольцевое пространство между боковыми стенками цилиндров сверху закрыто неферромагнитной поверхностью, содержащей узлы резьбового регулятора высоты подъема внутреннего цилиндра. Внутри кольцевого пространства установлены цилиндр, воздухоотвод и лампа электрогазоразрядная, подключенная к источнику килогерцовой частоты. В конденсаторной части имеется дозатор. Излучатели от магнетронов, расположенных на боковой поверхности наружного цилиндра со сдвигом на 120 градусов, направлены в конденсаторную часть резонатора. Во второй установке тороидальный резонатор представлен в виде тора с круглым сечением и состыкованных плоскопараллельных круглых поверхностей в центральной части. Внутри тора расположен диэлектрический сеточный транспортер. В центральной части резонатора расположен вращающийся диск, над которым установлен диэлектрический распределитель. В тор направлены излучатели, а в конденсаторное пространство – электрогазоразрядные лампы, подключенные к источникам килогерцовой частоты. По центру резонатора установлена загрузочная воронка, а под тором – индукционный нагреватель так, что сегмент дна поверхности тора является вторичной его обмоткой.

Ключевые слова: сверхвысокочастотный генератор, квазистационарный тороидальный резонатор, электрогазоразрядные лампы, источник килогерцовой частоты, индукционный нагреватель.

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