RF INSTALLATION FOR THE GRAIN DISINFESTATION

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The ecologically pure method of grain product disinfestations through the grain treatment with the RF electric field is described. The experimental data obtained showed that with strengths of the electrical RF field of E=5 kV/cm and frequency of 80 MHz the relative death rate is 100%. The time of the grain treatment in this case is 1 sec. The pulses with a duration of 600 μs and repetition rate of 2 Hz were used, the duration of the front was 10 μs. The schematic layout of installation with a productivity of 50 tones/h and power of 10 kW is given.
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The most common method for combating grain pests is currently a chemical treatment with poisoning substances. First of all, this method is harmful for personnel maintenance. Moreover, a part of poisoning substances remains in the treated grain and enters the human and animals' bodies.

A method of the grain treatment with hard gamma rays is known. However, in this case the personnel also undergo the harmful influence of the gamma rays. Besides, this method had not received wide recognition because of high cost of equipment, high power consumption, and because of large weight and overall sizes of the installation, which does not permit to made a movable installation.

A new, most promising method of the grain and grain product treatment is the method, in which the grain containing the pests is subjected to the RF electric field. There are two approaches to the application of the RF field. With the first the RF field influence on the treated stuff causes considerable heating of the living things that causes their death. As the grain itself possesses the less dielectric constant than that of insects [1] it is not heated considerably.

The second method is of a great interest as it does not cause the heating of the biologic object in such extent, and does not lead to the death of the living thing. For example, the application of the RF fields of $5\cdot10^7$-10^8 Hz, which satisfy the relationship $h\nu < kT$, where $h\nu$ is the energy of the RF field quantum, and T is the absolute temperature of the treated body, has a specific effect on the biologic objects that cannot be explained only from the thermal influence of the RF field. The influence occurs at the energy levels several orders lower than those where the heat causing the destruction of the living thing is generated. It is clear that in this case some nonthermal mechanism works of the RF field influence on the organic matter. As for the essential difference between thermal and nonthermal mechanisms of the RF influence there is presently no consistent theory, which would explain the nonthermal effect of the pulsed electric field on the pests; however, there are several hypotheses for explanation of this phenomenon [2, 3, 4, 5]. The supposition exists that in this case the irreversible changes in the biologic object, which lead to its destruction, occur at the cell level (or at the molecular level), and depend on the RF field frequency and amplitude. In the given paper the experimental results obtained with the RF equipment of the linear ion accelerator (LUMZI) at the NSC KIPT together with the Institute of the Veterinary Medicine are presented. The specialists from the Institute of the Veterinary Medicine carried out experiments to evaluate the efficiency of this method. As it was mentioned above, in the experiment the pulse (nonthermal) nature of the RF field influence on insects was studied.

Preliminary experiments were performed on the feeder channel of the RF supply generator of the LUMZI. All experimental batches of the grain infested with pests were prepared at the Institute of the Veterinary Medicine, and after irradiation at the installation were studied and compared with the control samples.

The samples of the infested grain packed in small dielectric containers (about 20-30 grams each) were placed inside the feeder channel of the RF generator working on the active load. The generator operated in the pulsed mode. The pulse duration was 600 μs, the front length was 10 μs. The range of the pulse frequency was 1-5 Hz. The amplitude of the RF field acting on the sample could be changed with the irradiating sample shift between the central and external feeder wire along the radius. The field amplitude at the point of the sample location was calculated. The operating generator frequency in these experiments was 47 MHz. In the Table I the data obtained in the experiments are given.

Table I. f = 75 MHz , 2 pulses/s

E,kv/cm	3.5	5.0	10.0	20.0	30,0
Mortalitu (%)	92	100	100	100	100

The mortality of insects in the treated grain samples was determined as a function of the exposition and amplitude of the acting RF field. From the Table I one can see that the mortality increases with the RF field strength and has a maximum value (~60-70%) with the field strength about E = 4 kV/cm (the averaged value of E along the length of the sample is given). Increase in the generator power (the flux of the RF energy through the sample) does not cause increase in the mortality of insects.

As the RF field strength in the coaxial feeder varies from E_{max} at the central wire to E_{min} at the external wire it is impossible to provide the uniform irradiation of the

infested grain with the coaxial feeder. For the uniform irradiation of the grain and for the examination of the insects' mortality with further increase of the RF field strength in the region of the irradiation, the authors designed an irradiating chamber where the goal was achieved using the physical properties of RF cavities. The schematic layout of the chamber at which the following experiments were carried out is given in the Fig. 1.

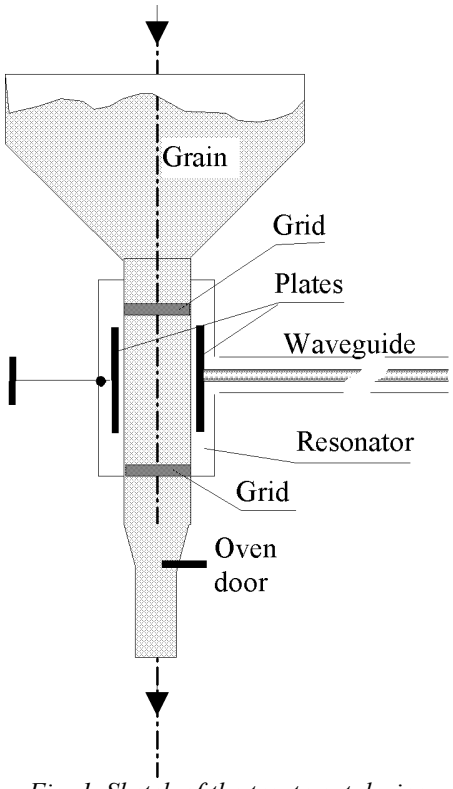

Fig. 1. Sketch of the treatment device.

In the experiments the irradiated sample was placed between the plates of the capacitor that was a load for a quarter-wave coaxial resonator. The application of the coaxial resonator with a plate capacitor as a resonance load of the RF generator enabled obtaining the RF field strength from 0 to 30 kV/cm in the region of the grain irradiation. With that, taking into account the resonance nature of the generator load the power consumption was essentially less than in the experiments with the coaxial feeder. In the Table II the experimental data obtained at the installation with the plate capacitor are presented.

Table II, f = 47.7 MHz, τ_p = 600 μs

Exposition, sec	5	10	20	60	60	60
Voltage, kV	10	10	10	10	8	5
E, kV/cm	3.2	3.2	3.2	3.2	2.6	1.7
P_{pulse}, kW/cm^2	138	277	554	1162		456
Mortality	93.5	98.9	98.2	83.1	58.1	71.4

The RF field strength in the region of the irradiation was calculated similarly to the experiments on the first installation. One can see that as the field energy increases the rise in the relative mortality of the insects occurs, and with the field strength of 5-5.5 kV/cm becomes 100%. To obtain such an effect only 2-3 pulses is sufficient.

With that the increase in the generator power does not result in the essential changes in the relative mortality of the insects. The functions obtained in experiments are shown in Fig. 2 and 3.

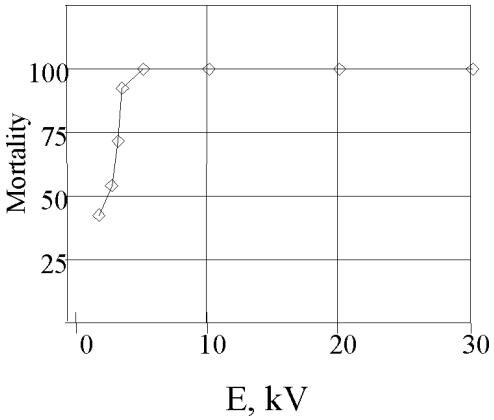

Fig. 2. The weevil mortality dependence on electric field intensity.

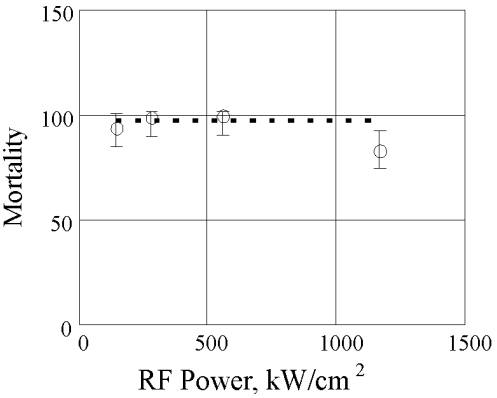

Fig. 3. The weevil mortality dependence on RF Power.

As the pulse duration of the RF field was 600 μs and was not regulated, it can be assumed from the results in Figure 3 that to obtain the 100 % death of the insects the pulse duration may be reduced, i.e. the power consumption may be decreased.

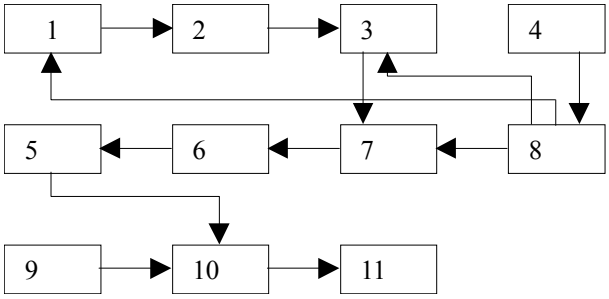

Fig. 4. The simplified block-diagram of the installation: 1 - power transformer, 2 - AC/DC convertor, 3 - timing device, 4 - RF generator, 5 - pulse output transformer, 6 - artifical line, 7 - signalling and interlock, 8 - reception facility, 9 - device of a grain treatment, 10 - grain reception.

The performed experiments showed that the described method of the RF treatment of the grain aimed to its disinfestation is competitive with traditional methods, and after a number of experiments on the optimization of the parameters of the irradiating installation and the RF generator may form a basis for the development of a commercial installation. The authors calculated the RF installation for the grain disinfestation with capacity of 50 tones/hour and power consumption of 10 kW. In the Figure 4 the simplified diagram of the installation is given.

The estimated cost of the installation is $40,000. The treatment of the 1 tone of the grain is about $2.

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