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Ionization processes in grain weight under strong electric field

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Abstract. The results of studies depending on the relative intensity characteristics of ionization processes in grain weight of the electric field of high intensity, humidity and established empirically analytical dependence.

Key words: strong electric field, ionization processes, ozone, grain weight, environmentally friendly processing of grain.

INTRODUCTION

Grain sector of Ukraine is a strategic sector of the economy of the state, which determines the volume of supply and cost of main food for the population, including food grain processing and animal products, forms a significant proportion of agricultural incomes, determines the status and trends in rural areas, creates a state for foreign exchange earnings by exports. Grain industry is the basis and source of sustainable development of most sectors of agriculture and the basis for agricultural exports.

Increase of production and improvement of the quality of crop production is possible by reducing crop losses from plant pathogenic microorganisms and utilization of the potential of biological features of seed.

The microflora of grain mass consists almost entirely of anaerobic microorganisms. Mushrooms represented about 85% of pathogens causing the most dangerous diseases of cereals and toxic agents - 80%. Especially rapid was the contamination of grain cereals by the fungi that form the toxins: Fusarium, Alternaria, Repisilium, Mucor, Cladosporium and others. Fighting these fungi can classify the grain commodity to the particular food category, and the presence of toxins formed by these fungi in greater amount than 5 mg per 1 kg makes it unfit even for feeding purposes.

These pathogens alter the biochemical composition of grain and contaminate it with mycotoxins. This creates a serious problem for the food industry. The situation is complicated by the fact that to date there are no biologically acceptable and cost-effective ways to detoxify the grain. During storage (3 to 6 months) in adverse conditions, the surface contamination of grain with fungi can grow by 35 ... 40 times, internal – by 3 ... 4 times. This dramatically increases infestation complex Fusarium, Alternaria, Penicillium. This is an annual loss of 3.2 million tons of grain and a significant reduction in biological value of further millions of tons.

Ozonization is one of the most promising technologies designed to combat the influence of chemical and microbiological nature in agriculture, medicine, ecology and public utilities. Ozonization as a method of disinfection was thoroughly studied with hygiene items and received approval of sanitary and medical facilities of all advanced countries (USA, Germany, Japan, France, etc.) [1]. Significant reduction of cost of production of ozone in relation to other chemicals appropriate for this application, in recent years has also contributed to increasing interest in its wider use in agriculture. Due to the urgent problem, there has been rapid development of such systems.

But modern electroozonators used in agriculture have not found wide use because of their low efficiency. Low productivity has mainly been due to the fact that large losses of ozone occur in the supply network from ozone generators to the product processing units.

MATERIALS AND METHODS

The Department “Electrified Technologies in Agriculture” at the National University of Life and Environmental Sciences of Ukraine has developed a method and device for treatment of seed crops with ozone in an electric field of high voltage direct current. Apparatus

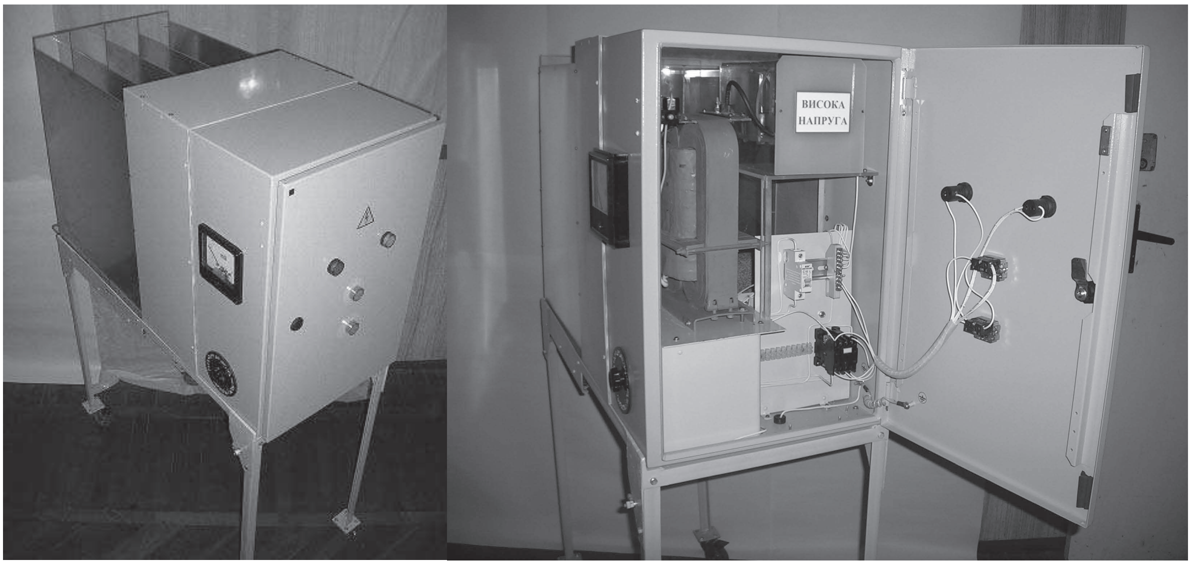


Fig. 1. Apparatus settings for the treatment of seed crops in a strong electric field

settings for curing grain with high voltage electric field are shown in Fig. 1.

When processing the seed crops in high voltage electric fields, when the material is located directly between the plate electrodes, one of the important factors is the mode of processing, electrical discharges, accompanied by ionization processes that occur in air inclusions mixture. The intensity of the ionization process at atmospheric pressure will be determined mainly by voltage applied to electrodes, grain moisture and geometrical form of seeds. At present these electrical processes in the grain mass, under the influence of electric fields of high voltage, were not considered in the scientific work of researchers, so to ensure effective treatment regimes, there is need to explore and establish patterns of change in the intensity discharge processes. For this purpose it was designed in research laboratory settings (Fig. 2).

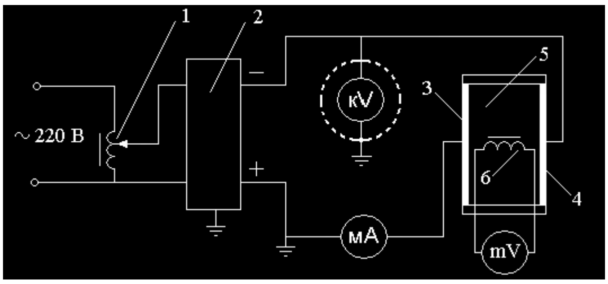


Fig. 2. Circuit diagram for the study of the intensity of ionization processes in vertically arranged electrodes: 1 – autotransformer; 2 - high voltage transformer with a rectifier; 3, 4 - plane-parallel plate electrodes; 5 - chamber for placing seeds; 6 - inductive sensor

There are different methods of registration ionization characteristics in insulating materials [2, 3, 4, 5, 6, 7]. One of the methods used is the method of tangent of dielectric loss angle. This method is based on the principle that with increasing voltage due to the increased intensity of discharge, tg δ is increased. So the point of inflection depending on tgδ (U) is considered at the beginning of discharges, and it is stressed that the initial voltage is responsible for partial discharges.

But these methods have several disadvantages, the main of which is a great sensitivity to external interference and difficulty settings. To investigate the relative characteristics of the ionization processes, the experience withdrawal was used of oscillograms intermittent phenomena in the corona discharge, which was engaged in the research of Loeb School. Researchers at the oscillograph removed currents in voltage at the ends of the resistance, and induced the impulses, Yaki at the "antenna" [8].

RESULTS AND DISCUSSION

Prior to research, grain mixture was filled into the chamber. It was located between two plate electrodes. When the voltage is fed to the plate electrodes, the voltage of primary ionization in the chamber with the grain mixture starts bit processes. As a result, inductance coil 6 having high fluctuations that accompany ionization. As an instrument registering a stable voltage (steady) ionization U_{cm} a switch gear can for example be used. In our case, the voltmeter was used of universal type B7-26. Further, we denote its measurement as U_i. The magnitude of the voltage on the voltmeter connected to the inductor, we will call the relative intensity of characteristic ionization processes, and to characterize the formation of ozone in the mass of seeds under high voltage electric field, the notion was used of the specific characteristics of the intensity of ionization processes $U_{i\,num}$ accommodation experts (мВ·м). $U_{i\,num}$ accommodation experts were determined by the formula:

$$U_{inum} = \frac{U_i \cdot S}{h}, \qquad (1)$$

where: S - area of the electrode is covered with seed mass, m^2. h - distance between the electrodes, m.

As a result of the work the dependence was determined by analytical U_{inum} of the electric field of high voltage and the initial intensity of ionization processes. When considering the ionization processes in the future we will assume their start when $Ui = 0.1$ mB·m. In the above mathematical expression, the calculation of $U_{i\ num}$ accommodation experts begins with the electric field intensity level of initial ionization processes because at lower electric field ionization processes can be neglected.

The resulting mathematical expression that is represented by formula (2) agrees well with the results of experimental studies:

$$U_{inum} = \frac{S}{h} \cdot \left(\exp\left(2,45 \cdot \frac{E - E_{поч}}{E_{поч}} \right) - 0,9 \right), \qquad (2)$$

where: E - electric field, кВ/см, $E_{поч}$ - electric field of primary ionization кВ/cm;

$$E_{поч} = a - в \cdot W, \qquad (3)$$

where: W - moisture content of seeds,% $a, в$ - coefficients that are determined by type of crop (oats $a = 7,33$, $в = 0,423$, barley $a = 6,77$, $в = 0,356$; wheat $a = 9,04$, $в = 0,457$; rye $a = 9,15$, $в = 0,425$).

Experimental studies were performed on barley variety "Scarlet." The research results are cpresented in Tables 1-2 and Fig. 3.

Table 1. Dependence of the specific intensity of ionization processes of barley from the electric field strength at 17,5% moisture barley

$E_{поч}$, кВ/cm	0,96	1.3	1,46	1,86	2,06	2,23
$U_{i\ num.}$, mB·m	0,006	0,099	0,185	0,621	1,075	1,674

Table 2. Dependence of the specific intensity of ionization processes of barley from the electric field strength at 14,9% moisture barley

$E_{поч}$, кВ/cm	1,62	1,83	2	2,46	2,86	3,16	3,3	3.6	3,8
$U_{i\ num.}$, mB·m	0,008	0,035	0,063	0,193	0,408	0,681	0,849	1,379	1,895

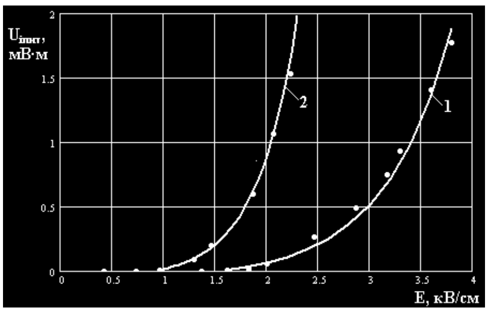


Fig. 3. Dependence of the specific intensity ionization processes in the mass of barley variety "Scarlet" on the electric field: 1 - moisture 14,8%; (2-17,5)% moisture content: - data obtained from materials research; ▬ - graph of the function constructed by empirical formula

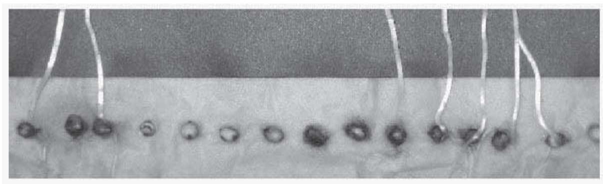
Substituting in the expression 2 values $E_{поч}$ from the expression 3 we get:

$$U_{inum} = \frac{S}{h} \cdot \left(\exp\left(2,45 \cdot \frac{E - a + b \cdot W}{a - b \cdot W} \right) - 0,9 \right) \qquad (4)$$

The resulting empirical formula was evaluated for adequacy by the Fisher criterion. Estimated value of the criterion is Fisher's $\Phi = 1,88$, or less than the critical value at significance level 0.05 is $\Phi_{кр} = 2,01$.

The solution proposed by the Department of Electric and Electro Technology at the National University of Life and Environmental Sciences of Ukraine is a much more effective way in terms of uniformity of treatment and cost-effectiveness, because ozone is formed directly in the grain mass, which in this case plays the role of biological electrode system and an integral electrical complex.

Example results of sorghum seed variety Odessa 302 treatment and buckwheat seed variety Oranta seed treatment are shown in Fig. 4.



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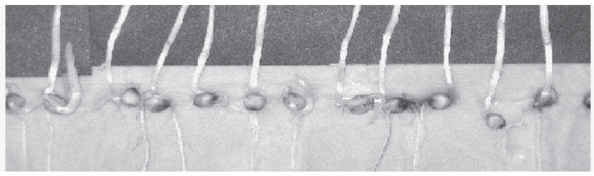

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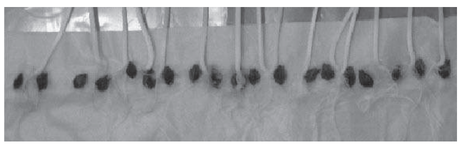

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Fig. 4. Results of treatment of seedlings of sorghum seed variety Odessa 302 (biological method rolls) and buckwheat seed variety Oranta: 1 - control sorghum seeds; 2 - sorghum seeds treated in a strong electric field; 3 - control buckwheat seeds; 4 - buckwheat seeds processed in a strong electric field

Thus the proposed electrotechnic treatment is preffered to the existing ones. It is a low energy and environmentally safe process and allows for a better treatment of grain products.

CONCLUSIONS

1. Analytical dependence was established of the relative intensity of ionization processes characteristic of the electric field of high intensity, taking into account humidity seed mass. The obtained dependence is required for the processing regime.

2. Laboratory studies found out that the proposed method allows for the neutralization of about 90% of hard smut spores. It should be noted that the research was conducted on wheat with an artificial background. The concentration of spores of smut was about 500 units per sample of grain. In the natural background, this figure is considerably smaller (about 10).

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