Study on Ion generators for fruit and vegetable storehouses

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Abstract. The development of food industry and fruit and vegetable production is currently determined not by the amount of production, but by how much of it is preserved. Therefore, the introduction into fruit and vegetable production plan the task of loss reduction of food raw materials at all stages of its transportation, storage and processing was a timely and important step. This paper presents the results from the influence of ionizer structural and operating parameters on the energy performance of the ionized air. The data on optimal modes, that ensure the minimum product losses during long-term storage, are given.

1. Introduction

Recent studies have established that the ionized medium affects the metabolic processes of living organisms and the cellular metabolism of plant raw materials. Among the active factors of such a medium, along with temperature and moisture content, the concentration and density of the space charge of ions in air were considered [1, 2].

Ionization of gases contained in the atmosphere is the main process leading to ion formation [3]. One of the quantities that allows the most complete characterization of various air ions is their mobility $k(m^2 V^{-1} s^{-1})$. It is understood as an average velocity of ion drift in an electric field of unit strength. It is customary to distinguish the following groups of ions in air: light $k \geq 10^{-5}$, mediumk$\sim10^{-6}\ldots10^{-5}$, heavy k$\sim10^{-7}\ldots10^{-6}$, Langevink$\sim2\cdot10^{-8}\ldots10^{-7}$and ultra-heavy k$<2\cdot10^{-8}$ $10^{-9}m^2V^{-1}s^{-1}$. The conductivity of the medium is due not only to the ions mobility, but also to the space charge density in closed rooms. The partial charge density of ions with mobility greater than k_1 and less than k_2 is denoted by $\rho(k_2, k_1)$.The data on the partial charge densities in combination with the mobility characterize the spectrum of ions, and the predominance of ions of any sign is determined by the coefficient of unipolarity φ. Light ions that occur in the ionization zone are considered biologically active. As ions spread over the product storage chamber, they lose their mobility and become medium ions. When air ions reach the surface of the product, they settle on their surface to form an ionic layer of a certain polarity, often a negative one. This layer affects metabolic processes and slows down the mass transfer and product damage.

The ionized medium is used in various technological processes in food industry. It is used to suppress the development of microorganisms and disinfect warehouse premises, in water treatment, including the sterilization of drinks [4, 5]. Air ionization is used for deodorization during dairy products drying, in oil processing. An ionized medium can not only suppress the processes, but under certain conditions it can intensify them [6, 7].

In this aspect, the use of ionized barley processing for the intensification of malting processes is considered. Air ionization helps to improve the technological parameters of citric acid production

process; it increases the productivity of yeast propagator. The influence was established and the processing modes for the yeast activation and preservation were determined.
The requirements for the air purification quality are increasing with the development of food and microbiological industries. Artificial ionization improves the efficiency of filters for "fine" air purification.
The most widespread device of air ionization is anion generator with a corona discharge, free of listed disadvantages. The principle of their operation is based on the charging by neutral air molecules in the corona discharge zone, which occurs in a highly non-uniform electric field. In air ionization devices, corona electrodes of the following design are common: wire-plane (a cylinder), tip-plane (a ring). The formation mechanisms of positive and negative corona differ and are described in detail in a number of publications [8].
An important characteristic of ion generators is the range of variation of its ionization capacity. The use of a direct current corona is characterized by the difficulty of obtaining low ion concentrations, a narrow dynamic range and an increased emission of harmful impurities - air oxides. Ion generators powered by alternate and impulse voltages of 3 ... I0 kV are devoid of these disadvantages. The expediency of using such a voltage is due to a number of reasons:

- the possibility of a combined mode for controlling the ionization capacity of the ion generator through various channels (voltage, phase cutoff angle, frequency);
- prevalence and high reliability of high-voltage transformers;
- the presence of a corresponding transformer in the ionizer power supply unit, etc.

The ionization capacity of ion generators is a function of operating, physical and design parameters. By the latter, we mean the class of parameters that reflect the design of the ionizer. These include structural and geometrical parameters. Physical parameters should be understood as the state of flows (φ, ρ +, ρ-) and the parameters of flow properties (recombination, electrostatic leakage) of ionized gas. The operating parameters include: the type and value of supply voltage of the systems of ion generator corona electrode.
Based on the foregoing, it is expedient to represent the classification scheme of ion generators with a corona discharge in the form shown in Figure 1.

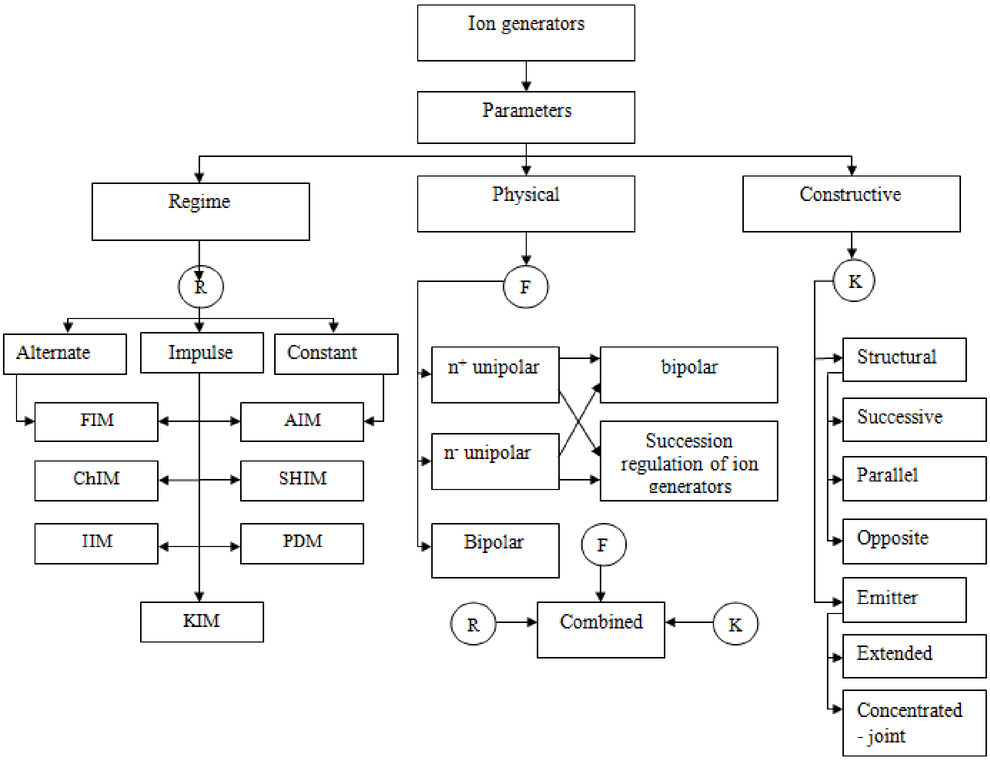


Figure 1. Classification of corona discharge ion generators

2. Methods

Indeed, ionizers can be characterized by a set of three parameters: operating, physical and structural ones, each of which in one way or another affects the ionization capacity of the ion generator. For example, the operating parameters are changed depending on the type of supply voltage of the corona electrode system. Physical parameters characterize the phenomena occurring in the area of corona hood of electric discharge and the conditions for ion loss in the area remote from the point of corona discharge. Structural parameters, in particular the design ones, show the possibility of parallel, successive, opposite (anti-parallel) and combined switching on of ionization devices according to Figure 2. The most acceptable, in our opinion, is the parallel connection of generators, when the maximum ionization effect is obtained at minimum ion losses.

The design of ion generator along with the structural form is characterized by geometrical parameters. So, the execution of the systems of corona electrodes can be distributed (extended), for example, in the form of a thin wire, or concentrated - in the form of a needle. Simultaneous use of both types of emitters is permissible (the needles are attached to the wire). The ionization capacity of ion generator can be changed over a wide range by varying the structure, number, and features of corona devices. Depending on the power supply mode and the design of electrode system, at a sufficient strength of corona discharge electric field, the ionization process is accompanied by the ozone formation. Depending on the technological requirements of fruit and vegetable product storage, the optimal concentration of air ions and ozone in volume can be obtained by varying the power source voltage and the length of the discharge gap.

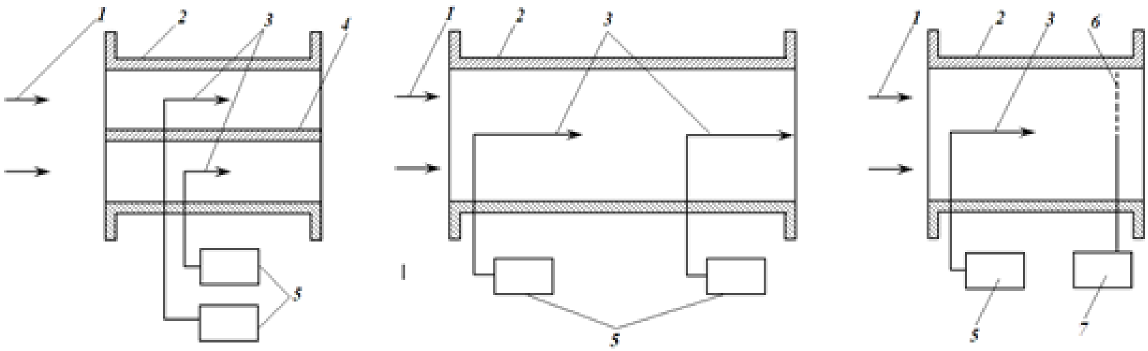


Figure 2. Block diagrams of corona ionizers switching: a) parallel; b) successive; c) opposite 1 - air flow; 2 - air duct element; 3 - corona electrodes; 4 –baffle wall; 5 - high voltage sources; 6 - control grid, ring or filter; 7 - control electrode power supply

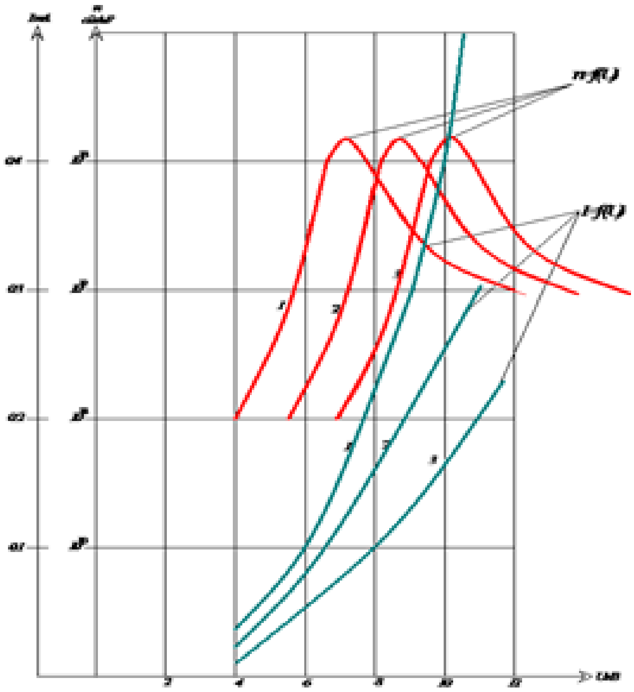
3. Results and Discussions

The studies of the mechanisms of action of the ionized medium and theoretical foundations of its application for storage are given in [8, 9, 10]. Although the results obtained did not allow creating a completely articulate theory, it was proven that the ionized medium has a two-sided nature of action: the stimulating effect of low ion concentrations, and bacteriostatic effect of high ion concentrations. An optimal ion dose, without harming the product surface, protects it from microbiological damage.

To compare various electrode systems and the discharge gap, the volt-ampere characteristics of corona discharge were compared. With different configurations of corona and earthed electrodes, with tip electrodes and the length of discharge gap from 20 to 50 mm, a corona discharge and, as a result, air ionization begins at 2.8 kV and the maximum ionization intensity is observed at 6 - 8 kV (Figure 3).

With further increase in the discharge electrode voltage (in spite of corona current increase), the ionization intensity decreases; this is explained by bilateral screening of electric field of tip electrodes and the transition of corona discharge to another type of discharges. The results obtained are the basis for the development of ion generators for closed rooms. With known parameters of ion generators, it is possible

to select their number and arrangement in the room based on the technological requirements of the storage process.
The efficiency of ion generators depends on the concentration and uniformity of ion distribution in volume. For uniform ionization of large rooms, ion generators are equipped with fans, i.e. the ionizers are installed in the ventilation system [11]. The distance between the generators of air ions is determined by studying the dynamics of ion distribution in the room. With the ionizers described above, the optimum distance between the ionizers was 2.5 meters.



1. H=15 mm
2. H=25 mm
3. H=40 mm

Figure 3. Volt-ampere and volt-ion characteristics of the ion generator at various distances of the discharge gap

4. Conclusions

The recent studies have established that the ionized medium affects the metabolic processes of living organisms and the cellular metabolism of plant raw materials. Among the active factors of such a medium, along with temperature and moisture content, the concentration and density of ion space charge in air were considered.
The ionization capacity of an ion generator is a function of operating, physical and structural parameters. By the latter, we mean the class of parameters that reflect the ionizer design. To compare various electrode systems and the discharge gap, the volt-ampere characteristics of the corona discharge were analyzed. With different configurations of corona and non-corona electrodes, with tip electrodes, the maximum ionization intensity was observed at a voltage of 6 - 8 kV. Depending on the technological requirements of fruit and vegetable product storage, the optimal concentration of air ions and ozone in the volume can be obtained by changing the power source voltage and the length of the discharge gap.
With further increase in the corona electrode voltage (in spite of corona current increase), the air ionization intensity decreases; this is explained, first of all, by bilateral screening of electric field of discharge electrodes and, secondly, by the transition of corona discharge to another type of discharges. The formed air ions could not fly out of the discharge gap into the room volume due to the increase in electric field strength of the ionization zone.

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