International Journal on
"Technical and Physical Problems of Engineering"
(IJTPE)
Published by International Organization of IOTPE

ISSN 2077-3528
IJTPE Journal
www.iotpe.com
ijtpe@iotpe.com

March 2019 | Issue 38 | Volume 11 | Number 1 | Pages 35-41

STUDY OF THE MOST ENERGY-EFFICIENT MODES OF GENERATION OF HIGH-VOLTAGE NANOSECOND PULSES AND CHEMICALLY ACTIVE DISCHARGE PRODUCTS FOR ACTIVE DISINFECTION OF FLUID FOOD PRODUCTS

E.J. Gurbanov [1] A.M. Hashimov [2] K.B. Gurbanov [3]

1. Azersu OJSC, Baku, Azerbaijan, kurbanovej_mpei@mail.ru
2. Azerbaijan Research Institute of Energetics and Energy Design, Azerenerji JSC, Baku, Azerbaijan ahashimov@azerenerji.gov.az
3. Institute of Physics, Azerbaijan National Academy of Sciences, Baku, Azerbaijan, arif@physics.ab.az

Abstract- The use of more energy-efficient and environmentally clear technologies for disinfecting flowing liquid food products (without the use of various chemical reagents) is a highly topical task today. At the same time, special attention should be paid to the preservation by the products of their nutritional and biological value. In this article, more energy-efficient methods of treatment products with reactive discharge products (ozone, atomic oxygen), generated in barrier and crown discharges are proposed. To improve the energy efficiency of the installation, a crown discharge reactor with an innovative "wire-cylinder" electrode system and retractable dielectric nozzles on a potential electrode, is proposed. The discharge delay time, the excitation of volume nanosecond discharge in the interelectrode gap, and the extensive generation of chemically active discharge products, which can be directed to the active inactivation of pathogenic microorganisms in food products, are reduced. At the same time, it is necessary to limit the formation of spark discharges in the interelectrode distance that could affect the physico-chemical content of the treated products and achieve maximum branching of the streamer channels (without transition to a spark), ensuring an efficient generation of chemically active discharge products. For generation at the output of a high-voltage pulse generator, an innovative scheme of multi-gap spark discharger is proposed for shortening the front of a pulsed signal up to units of nanoseconds.

Keywords: Barrier Discharge, Crown Discharge, Streamer, Electrography method, Flat plates, Reactor, Multi-Gap Spark Discharger, Nanosecond, Front, Electrode System, Food Products.

I. INTRODUCTION

Over the past few decades, leading scientific schools around the world (USA, Japan, Russia, etc.) have been intensively conducting research on the development of energy-efficient and environmentally clear technologies using high pulse voltage of short (nanosecond) duration. Such explorations are accompanied by study of the high-speed physical processes in discharge gap, commensurate with the duration of the pulsed signal. Continuous improvement of the parameters of high-voltage devices and loads, ensuring the efficient transfer of energy and its useful effect on the research object is a very complex technical task [1-5]. To create such devices, systematic research of various physical processes, discussion of mechanisms and analysis of the results obtained.

The study of the effect of strong electric fields and discharges on various mediums has been devoted to many works by various authors. We can mention works on ecologically clean methods of electron-ion treatment of toxic emissions of harmful industrial productions, water resources, water-containing foods from various pathogenic microorganisms, etc. The latter is of great interest to researchers in the aspect of more effective exposure pathogens and ensuring a longer storage of food products without changes (partial improvement) in their nutritional and biological value.

In works [6-12] the most well-known theories on the inactivation of microorganisms in food products are most fully represented. Existing methods of treatment, such as, thermal pasteurization, high-temperature sterilization, use of various kinds of chemical conservants, etc. have been known for a long time. It should be noted that these methods in the technological process do not always lead to the desired results in the composition and quality of the treated food products and do not guarantee the safety of their use. In addition, they relate to a fairly energy-intensive technology. In this regard, work aimed at the search, development and creation of more energy-efficient installations for electron-ion treatment of food products that do not change, and sometimes improve the nutritional and biological value of flowing food products, is an urgent task for the entire food industry.

Moreover, in addition to conducting research on the development of energy-efficient sources for generating pulse signals of short duration, we paid special attention to studying physical processes in air gaps when exposed to such pulses in the presence of axially located dielectric flat plates in the discharge gap. The interaction of the plate parameters and the characteristics of a nanosecond volume discharge excited in gap allowed us to optimize these parameters to select the most efficient mode for generating active discharge products (ozone, oxygen) with their further use for disinfecting food products.

For carrying out the research, we developed two electrical circuits of the high-voltage installations: with a barrier and crown discharge reactors, based on a high-voltage step-up transformer and a pulse transformer for ozone generation for the treatment of beverages (wines, juice extracts) in order to prolong their storage and improve some organoleptic properties.

II. EXPERIMENTAL PART AND DISCUSSIONS

The barrier discharge reactor was used in the circuit with a high-voltage step-up transformer of the industrial frequency, and the crown pulse discharge reactor in the circuit with a pulse transformer. Both schemes were designed to excite the electric discharge and generate chemically active discharge products for their further use in disinfection purposes.

Figure 1 shows the electrical circuit of the pulse voltage generator based on a pulse transformer. In the circuit, a high-speed thyristor - T is used as a commutating switch with a switching time equal to the duration of the transient characteristic of the pulse transformer - PT (some mcs). It is designed to transform the input voltage of 600 V (thyristor switch-on voltage) to 100 kV on the secondary winding of the transformer.

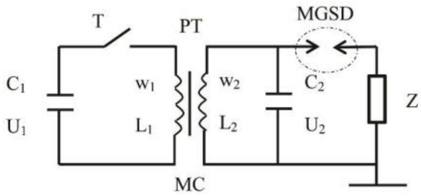


Figure 1. The electrical circuit of a high voltage pulse generator based on a pulsed transformer

To ensure a high amplitude of the output voltage with a possibly short front and a high transformation ratio, special attention should be paid to minimizing inductive losses on the magnetic circuit and the high-voltage winding of the transformer [1]. The shortening of the front of the impulse signal was ensured by the design of a multi-gap spark discharger with a small commutation time (several milliseconds), shown in Figure 2.

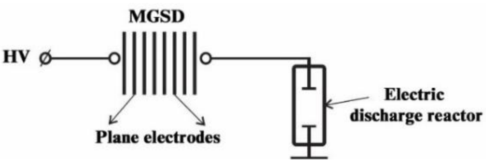


Figure 2. Design of a multi-gap spark discharger

High impulse voltage from the generator output is fed to the multi-gap spark discharger - MGSD, where the front duration is shortened to one nanoseconds. In the design of the discharger a module was used from parallel flat electrodes with a minimum electrode spacing ~ 1 mm. Such a design made it possible to increase the service life of a spark discharger up to 10^9 pulses, to provide a high pulse repetition rate (hundreds Hz), and restoration of the electrical strength of the air gap.

On the other hand, the use of such design with developed surface of the electrodes prevented the process of localization of the spark at one point and ensured its migration over the entire surface of the electrode. All this, ultimately prevented rapid erosion of the surface of electrodes. It should be noted that development of such design became possible as a result of complex studies of physical processes in dense air gaps at small interelectrode distances, including researches of micro explosive processes on the surface of potential electrodes and X-ray radiation during formation of nanosecond pulsed discharge.

It was found, that in overvoltage air gaps with nanosecond high-voltage pulses, a sharp increase in the field strength occurs on micro-inhomogeneities of the electrode, leading to explosive processes on it and formation of micro craters whose dimensions decrease with increasing radius of curvature of the electrodes.

Thus, the most stress-resistant and energy-efficient flat electrode system was proposed, providing turbulent movement of the air flow, cooling the plasma channel, its rapid decay and, accordingly, quick restoration of the electrical strength of the gap providing a high repetition rate of pulses.

As already noted, in a circuit with a high-voltage step-up transformer of the industrial frequency, a barrier discharge reactor was used to generate chemically active discharge products. The laboratory version of the reactor is shown in Figure 3.

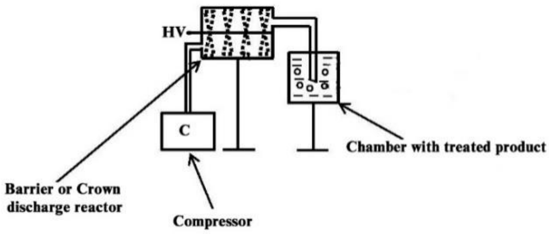


Figure 3. Sketch of a barrier discharge reactor

Reactor of the barrier discharge (Figure 3) contains a coaxial electrode system, consisting of an internal axial conductor - a rod by length L ~ 500 mm (Ø ~ 1 mm), a glass tube (dielectric barrier) by thickness Δ ~ 1.5 mm and steel pipe – electrode by diameter Ø ~ 10 mm. The length of the discharge gap varies within - dg = 1-8 mm. The electric field in the gas gap is homogeneous or slightly inhomogeneous [2]. The voltage range was 6-12 kV of industrial frequency. It should also be noted that the barrier discharge is excited only at an alternating voltage.

In order to increase the energy efficiency of high-voltage installations for the generation of chemically active discharge products, a nanosecond crown discharge reactor design was developed in a "wire-cylinder" electrode system. It was used in the scheme of electro pulse installation developed on the basis of pulse transformer. The output voltage of the pulse generator was 100 kV, the pulse front was ~ tens ns, and pulse duration ~ hundreds ns through developed-multi-gap spark discharger at the output of generator. Figure 4 shows a sketch of pulsed crown discharge reactor.

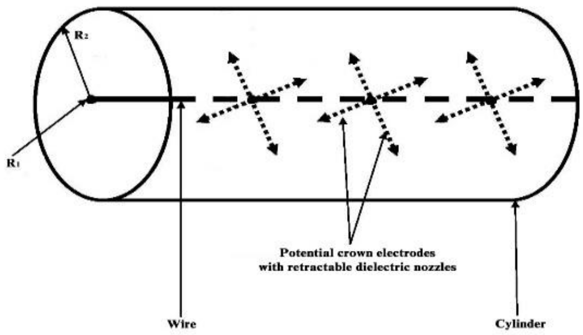


Figure 4. Sketch of a crown discharge reactor

During the development of a crown discharge reactor, the results of researches on long and small air gaps, conducted by us, were used [3].

So, in order to reduce the delay time of nanosecond pulse discharge and create conditions for formation of the volume discharge, we proposed innovative designs of potential electrode using retractable dielectric nozzles. On the central conductor - steel wire screwed crown "pin" electrodes, which were worn hydrophilic (porcelain tube) and hydrophobic (fluoroplastic, plexiglass) nozzles, depending on radius of curvature of the "pin" electrode. At a radius of curvature of potential "pin" electrode ~1 mm, a fluoroplastic nozzle was put on the porcelain tube, and with radius ~ 4 mm - a plexiglas nozzle.

Varying the position relative to each other and the edge of "pin" electrode, formation of volume nanosecond discharge and its delay time were investigated. It was found, that when potential electrode is deepened inside the porcelain nozzle by ~ 5 mm and with simultaneous use of several nozzles, it is possible to increase discharge zone to tens mm and reduce discharge delay time to 20-30 ns. Decrease in discharge delay time and formation of volume discharge in reactor was ensured by formation of negative oxygen and ozone ions, as a result of partial discharges in area "pin electrode-porcelain tube", their accumulation on the surface of hydrophobic fluoroplastic nozzle and their subsequent decay in a strong electric field with generation of free electrons, participating in ionization of molecules away from primary ionization zone.

Another important condition in development of nanosecond crown discharge reactor was to ensure the maximum level of branching of the leader channels in interelectrode distance and determine the limiting minimum value of electric field strength at any point in the interval at which branching takes place.

Due to the fact that when designing a reactor, dielectric materials are used to ensure its mechanical and electrical strength, the problem of limiting the possible influence of the parameters of insulating structures on the characteristics and formation processes of electrical discharges excited in the reactor (in particular, a crown nanosecond discharge) is important. For this purpose, studies were conducted on the excitation of a nanosecond volume discharge in a "pin-plane" electrode system when a gap of dielectric plates of different thickness was established parallel to the axial line. Moving the plates at different distances from the potential electrode, the position was fixed according to the minimal influence of the plate parameters on the discharge characteristics (discharge current, parameters of the streamer channel, streamer speed, etc.). Samples of seatall, polycore and ceramics by 1-9 mm thickness and with different surface conditions were used as dielectric plates (Table 1).

Particular attention was paid to the study of the optimal modes of formation and branching of the streamer channels in the whole volume, preventing their transition to a spark. These researches were aimed at developing the ultimate energy-efficient nanosecond discharge reactors with the maximum generation of reactive discharge products shown in the fig.4. We investigated the parameters of the streamer channel (length, width, head size) depending on the electrical parameters of the pulse generator and the determination of the minimum average value of the field strength in the gap, which ensures the formation and branching of the streamers. To register the discharge current, the voltage drop across the measuring resistance (shunt) [13] included in the discharge circuit was measured. It was found, that with a minimum average electric field strength ~8 kV/cm, the branching process of the leader channels is ensured at any point in space.

Table 1. The results of research of influence of the parameters of flat dielectric plates and discharge gaps on characteristics of crown nanosecond discharge.

Material	Thickness, mm	Interelectrode distance, mm	Distance from "pin" electrode, mm	Current, A	Scan, ns/div	Sensitivity, mV/div
Air		116	2	0.25	100	500
Ceramics	0.5	116	2	0.3	100	500
Ceramics	0.96	116	2	0.35	100	500
Seatall rough	0.98	116	2	0.25	100	500
Smooth polycore	1	116	2	0.28	100	500
Seatall smooth	0.5	116	2	0.26	100	500
Ceramics smooth	1	116	2	0.4	50	500
Ceramics brown	1	116	2	0.3	50	500

As can be seen from the table, in the presence of dielectric plates in the gap, the discharge current amplitude slightly increases to 0.3-0.4 A, depending on the surface structure of the dielectric and its thickness.

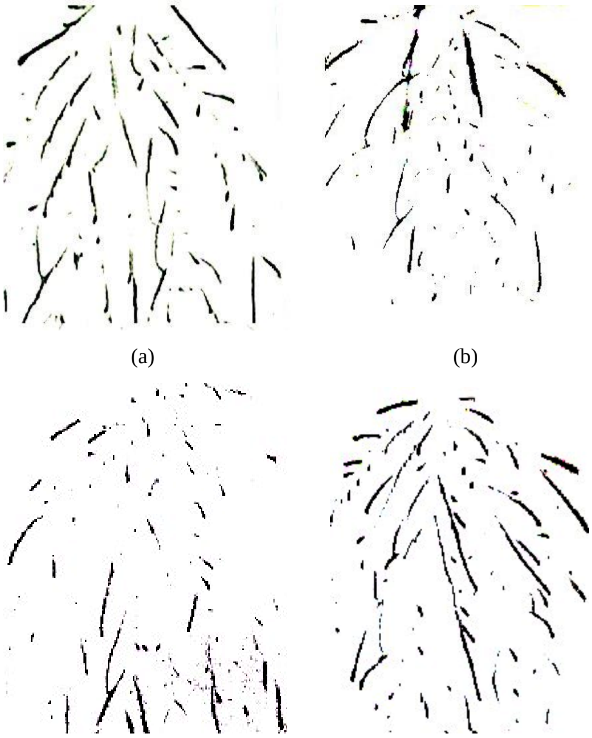
Therefore, observance of these important conditions and application of the obtained results allowed us to develop an energy-efficient nanosecond crown discharge reactor that provides the maximum level of generation of chemically active discharge products in both longitudinal and radial directions.

As can be seen from the table, the amplitude of the discharge current when establishing dielectric plates increases by 10-30%. The peak of the discharge current is caused by the movement of the heads of the first streamers in area with the maximum field strength. After some ns, streamer heads fall into the field of less than 8 kV/cm, which leads to a sharp decrease in current. It can be noted that with a slight increase in the thickness of the dielectric up to 1 mm, the amplitude of the discharge current increases to 0.3 A. We believe that an increase in the dielectric thickness not only leads to field growth at the crown electrode, but also to an enhancement of polarization field of the plate and, accordingly, to streamers developing along its surface.

The presence of plates of different thickness leads to a certain distortion of the field near the "pin" electrode, as a result of which the maximum tension on its surface shifts from the gap axis towards the dielectric plate. Moreover, this occurs in all cases, regardless of the distance of the barrier relative to "pin" electrode. For dielectrics with thickness > 2 cm, the field lines are strongly distorted and directed towards the barrier, and the discharge develops only along the surface of the dielectric (without volume part). It should be noted that with a decrease in the distance between the needle and the dielectric or an increase in its thickness, the field intensity at the tip increases greatly.

It should also be noted that the growth of the discharge current amplitude depends not only on the increase in the field at crown electrode, but also due to increased capacity of the streamer channels and additional ionization and sticking processes involving the dielectric material, its chemical composition and surface structure. In order to study the structure of the discharge, electrograms were developed, which allow us to compare the picture of the charge deposited on the plate and estimate the differences in the structure of the surface part of the discharge for different dielectric barriers. One of the first works on the application of electrography in the study of a pulsed streamer crown is article [14]. However, the effect of a dielectric on the characteristics of a discharge is not sufficiently developed there. As can be seen from the electrogram in Figure 5, on thicker plates, the discharge trace has large dimensions and the plate surface is more densely filled with channels and heads of streamers, especially along perimeter of streamer zone.

It should be noted that the streamer channels on ceramic plates appear very clearly. According to the received electrograms it is also possible to determine the size of the streamer zone (length and width), the sizes of the heads and channels of streamers. In [15], these measurements were carried out on plexiglas and ceramic plates with thickness of 1.5 mm and their dependence on the average field strength in the gap.



(a) (b) (c) (d)

Figure 5. Discharge electrograms for the gap "pin"- "plane": a - seatall (0.5 mm), b - seatall (1 mm), c - ceramics (1 mm), d - polycor (1 mm)

It was shown that with growth of average field intensity - E_{aver} the length and width of the streamer zone is also increased. From the electrograms it can be seen that on different materials the nature of streamers branching in radial direction and along the field line is different. Also vary the size of the heads and streamer channels at different distances from the crown electrode. The branching intensity along the entire length of gap is not same: it is maximum in area of "pin" electrode and is decreased with from it. You can also see that the main channel is curving, which indicates branching on the head of streamer.

The development of streamer zone is not only along the axis of gap, but also in radial direction. Moreover, on the border of streamer zone, there are separate streamers that develop almost perpendicular to the axis of the gap. This indicates a high density of streamer channels and an excessive charge of heads, which leads to their considerable repulsion. An increase in the length of the streamer zone is also observed compared to its width. Thus, electrography provides a clear image of streamers heads and a variety of short branches. In all cases, there is a curvature of the main channel of the streamer in branching places. This happens regardless of where the streamer under consideration develops: at the front of streamer zone, on side of or near the crown electrode. This suggests that branching of streamer occurs at its head and the charge field of the head of the branched streamer bends the trajectory of the main streamer.

Using the developed electrograms, it was revealed that when installing dielectric barriers, intense branching of streamers is observed in area of maximum field strength and less intense in the rest of the gap. It is noted that the branching process is observed when the field strength in the gap is > 10 kV/cm. Given electrograms indicate a change in size of heads and streamer channels in presence of dielectric plates in discharge gap.

In both schemes of a high-voltage electro pulse installation, as in the case of barrier reactor and crown discharge, comparison of the specific energy inputs for ozone generation was made. In both schemes a multi-gap design of the spark discharger was used. In the case of barrier reactor, a multi-gap spark dischargers consisted of 5 interelectrode gaps, and in the case of a crown reactor, of 10 gaps with a distance between planar electrodes ~ 1 mm. In both cases, normal (non-dried) air was used as the working gas.

It was found, that with same consumption of the initial working gas, specific energy consumption per unit of mass of ozone is several times smaller in case of using reactor with nanosecond crown discharge than in the case of barrier one. On the other hand, in the electrode system of the barrier discharge reactor, in contrast to the crown one, because of the presence of dielectric, some loss of energy and heating of the electrode system occur at same input power and flow rate of the working gas. Ozone concentration was measured with a gas analyzer.

As objects of research, samples of apple juice extracts and semi-dry red wine were used. Samples were divided into 2 types: a control sample not exposed to ozone and an experimental (treated) one. Tables 2 and 3 show quality indicators of these products before and after ozone treatment.

Table 2. Results of analysis of physicochemical and bacteriological parameters of semi-dry red wines before and after ozone treatment

Physicochemical and bacteriological parameters	Measure unit	Control sample	Experimental sample
Ethanol	% ob.	9.2	9.2
Reducing Sugars	g/dm^3	2.4	2.4
Titrated acids	g/dm^3	6.4	6.4
Volatile acids	g/dm^3	0.5	0.52
PH		3.2	3.3
Iron	mg/dm^3	4	5
Phenolic substances	mg/dm^3	1150	1150
Anthocyanins	mg/dm^3	85	80
Intensity		0.3	0.28
Shade		0.7	0.8
Number of microorganisms	cell/cm^3	40000	100

Table 3. Results of analysis of physicochemical parameters of apple juice extracts before and after ozone treatment

Indicator name	Results	
	Control sample	Experimental sample
lactose, g/100g	12.7	13.0
glucose	1.45	1.5
niacin mg/100g	0.1	0.08
Vitamin C, mg/100g	4.0	3.5
Phosphorus, mg/100g	4.55	4.6
Potassium, mg/100g	106.3	105.0
Calcium, mg/100g	10.2	10.7
Magnesium, mg/100g	4.9	4.7
Iron, mg/100g	1200	1180

As can be seen from the tables, ozone treatment does not lead to change in physicochemical composition and biological value of the food products examined. On the other hand, microbiological analyzes of treated products show the maximum inactivation degree of pathogenic microorganisms contained there [16-18]. It should also be noted that the organoleptic properties of products (color, bunch and taste) are improved compared to the control samples. In the work, researches were also carried out on the effect of ozone on presence and amount of oxidized forms of useful polyphenolic compounds in apple juice. By spectrophotometer, optical densities of D-ethanol extracts of juice were measured in the wavelength range 200-250 nm.

Results of measurements showed, that after ozone treatment amount of carboxylic acids is decreased significantly, approaching their quantity in control samples, and is D = 0.9, which is a proof of effectiveness of this technology for preservation of polyphenolic fruit complexes in comparison with heat sterilization (pasteurization), at which it is much higher. As a result of ozone treatment of the juice extracts examined, their maximum shelf life was ~ 2 years when stored in light at room temperature.

Thus, the article presents results of research on improving design of components and parameters of high voltage electric pulse installations directed at energy-efficient application of the source energy for generation of reactive products of electrical discharges in order to disinfect liquid food products by environmentally friendly methods instead of energy-intensive ones (pasteurization, sterilization and use of various a kind of conservants).

III. CONCLUSIONS

The presented article explores possibilities of development of relatively new scientific direction - impulse power engineering by developing and improving design and parameters of its individual components. On the basis of numerous experiments carried out to research physical processes in small and long air gaps, original designs of potential electrodes with the use of retractable dielectric nozzles were developed.

Results of the conducted researches made it possible to develop a new design of multi-gap spark dischargers using a planar-parallel system of flat electrodes that ensure a high service life of the discharger without eroding surface of the electrodes, rapid restoration of electrical strength of air gaps, and high pulse repetition rate. At the same time, such design of the spark gap served as a sharpening of the pulse front, with help of which it was possible to reduce its value to one nanoseconds.

Results of researches contributed to development of energy-efficient crown and barrier discharge reactors for generation of chemically active discharge products. By developed reactors, effective disinfection of liquid food products (apple juice and red wines) from pathogenic microorganisms was carried out in order to ensure their long-term storage in an environmentally friendly manner.

By effective ozone treatment of investigated products, it was possible to disinfect them, as much as possible, from pathogenic microorganisms, improve organoleptic properties of the products, without changing their physicochemical composition and biological value.

REFERENCES

[1] E.J. Gurbanov, "Development of the Main Units of High-Frequency High-Voltage Pulse Installations", News of Azerbaijan Engineering Academy, Baku, Azerbaijan, Vol. 8, No. 1, pp. 110-121, 2016.

[2] V. Mamedov, A.M. Hashimov, K.B. Gurbanov, E.J. Gurbanov, "Technological Installation with Barrier Discharge Reactor for Treatment of the Fluid Foodstuff", Journal of Power Engineering Problems, Baku, Azerbaijan, No. 3, pp. 65-72, 2015.

[3] E.J. Gurbanov, "Influence of Parameters of the Electrode Design on a Luminescence form of the Pulsed Discharges in Overvoltage Gaps", International Journal on Technical and Physical Problems of Engineering (IJTPE), Issue 23, Vol. 7, No. 2, pp. 49-54, June 2015.

[4] A.M. Hashimov, E.J. Gurbanov, "The Influence of High-Voltage Impulse Treatments on Biological Cells", Surface Engineering and Applied Electrochemistry, Vol. 45, No. 5, pp. 411-414, 2009.

[5] E.J. Gurbanov, "Environmentally Clear Methods of Water Disinfection", International Journal on Technical and Physical Problems of Engineering (IJTPE), Issue 18, Vol. 6, No. 1, pp. 34-38, March 2014.

[6] V.N. Golubev, I.N. Jiganov, "Food Biotechnology", M., p. 123, 2001.

[7] L. Leystner, "The Importance of Barrier Technology while Preserving the Quality of Food Products", Meat Industry, No. 2, pp. 23-25, 1998.

[8] B.L. Flaumenbaum, "Fundamentals of Food Canning", Easy Food Industry, Moscow, Russia, p. 272, 1982.

[9] I.L. Rabotnova, "The role of Physicochemical Conditions of the Environment in the Vital Functions of Microorganisms", M: Academy of Sciences, USSR, p. 275, 1957.

[10] G.V. Barbosa Canovas, M.M. Gongora Nieto, U.R. Pothakamury, B.G. Swansson, "Preservation of Foods with Pulsed Electric Fields", Academic Press, Washington, San Diego, p. 200, 1999.

[11] T.Y. Tsong, "Review: On Electroporation of Cell Membranes and Some Related Phenomena", Bioelectrochem, Bioenergetics, Vol. 24, pp. 271-295, 1990.

[12] S.L. Harrison, G.V. Barbosa Canovas, B.G. Swanson, "Sacchromyces Cerevisiae Structural Changes Induced by Pulsed Electric Field Treatment", Lebensm. Wiss. Technol., Vol. 30, pp. 236-240, 1997.

[13] A. Schwab, "High-Voltage Measurements: Measuring Instruments and Methods of Measurement", 2nd Ed., M. Energy Atomization, p. 264, 1986.

[14] A.V. Ivanov, "The Use of Electrography for the Study of Bulk and Surface Charges", Abstract of Dissertation for the Degree of Ph.D., Moscow, Russia, 1971.

[15] V.V. Timatkov, "Study of the Structural Characteristics of a Nanosecond Pulsed Crown Discharge in Electrode Systems of Various Configurations", M. Moscow Energy Institute (Technical University), Moscow, Russia, 2005.

[16] E.J. Gurbanov, "Plasma Processes in Water under Effect of Short Duration Pulse Discharges", 66th Annual Gaseous Electronics Conference (GEC-2013), Princeton, USA, Vol. 58, No. 8, p. 47, 2013.

[17] E.J. Gurbanov, "Power Effective Methods of Water Purification", 2nd International Conference on Caspian Aqua Technologies, Baku, Azerbaijan, pp. 209-212, 2014.

[18] E.J. Gurbanov, "Environmentally Clear Methods of Treatment of the Liquid Foodstuff", News of the Azerbaijan National Aerospace Agency, Baku, Azerbaijan, Vol. 19, No. 1, pp. 46-54, 2016.

BIOGRAPHIES

Elchin Jalal Gurbanov was born in Kurdamir, Azerbaijan on 12.02.1963. In 1980, he graduated from school No. 151 in Baku, Azerbaijan and entered in Faculty of Electronic Equipment, Moscow Power Engineering Institute, Moscow, Russia. In 1986, he successfully graduated that institute by specialty "Electronic devices" and start to work in High Voltage Laboratory in Physics Institute, Azerbaijan National Academy of Sciences, Baku, Azerbaijan. In 1995, he successfully defended a candidate dissertation regarding the high voltage treatment of compositional materials and received a scientific Ph.D. degree in physics and mathematics sciences. In 2006-2010, he studied in doctorate level in high voltage department of Moscow Power Engineering Institute (Technical University). In 2018 he defended his doctoral thesis, after which it was received a scientific degree of Doctor of Technological Sciences. From 2013, he works in Science Department of "Azersu" Open Joint Stock Company, Baku, Azerbaijan. He published more than 95 scientific articles in different journals, 1 author certificate and 2 patents.

Arif Mamed Hashimov was born in Shahbuz, Nakhchivan, Azerbaijan on September 28, 1949. He is a Professor of Power Engineering (1993); Chief Editor of Scientific Journal of "Power Engineering Problems" from 2000; Director of Institute of Physics of Azerbaijan National Academy of Sciences (Baku, Azerbaijan) from 2002 up to 2009; Academician from 2007; the First Vice-President of Azerbaijan National Academy of Sciences from 2007 up to 2013; and Director of Azerbaijan

Research Institute of Energetics and Energy Design from 2014 till now. He is laureate of Azerbaijan State Prize (1978); Honored Scientist of Azerbaijan (2005); Cochairman of International Conferences on "Technical and Physical Problems of Power Engineering" (ICTPE) and Editor in Chief of International Journal on "Technical and Physical Problems of Engineering" (IJTPE). Now he is a High Consultant in "Azerenerji" JSC, Baku, Azerbaijan. His research areas are theory of non-linear electrical Networks with distributed parameters, neutral earthing and ferroresonant processes, alternative energy sources, high voltage physics and techniques, electrical physics. His publications are 310 articles and patents and 5 monographs.

Kamil Bakhtyar Gurbanov is Candidate of Physical-Mathematical Sciences in the field of "physical-mathematical sciences of polymers". He defended his dissertation at the Scientific Council of Institute of High Molecular Compounds, Academy of Sciences of RF, St.-Petersburg, Russia in 1974. He is a Leading Researcher and Vice-Director of the Institute on Physics, Azerbaijan National Academy of Sciences, Baku, Azerbaijan. He is a specialist on investigation of the physical-chemical processes in the conditions of action of the electrical discharges. Under his supervision the investigations on study of the processes of oxidation and modification of materials with the use of actions of the electrical discharges are carried out and also the high effective methods of solution of the ecological problems are developed.