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ИЗВЕСТИЯ

НАЦИОНАЛЬНОЙ АКАДЕМИИ НАУК
РЕСПУБЛИКИ КАЗАХСТАН
Satbayev University

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NAS RK is pleased to announce that News of NAS RK. Series of geology and technical sciences scientific journal has been accepted for indexing in the Emerging Sources Citation Index, a new edition of Web of Science. Content in this index is under consideration by Clarivate Analytics to be accepted in the Science Citation Index Expanded, the Social Sciences Citation Index, and the Arts & Humanities Citation Index. The quality and depth of content Web of Science offers to researchers, authors, publishers, and institutions sets it apart from other research databases. The inclusion of News of NAS RK. Series of geology and technical sciences in the Emerging Sources Citation Index demonstrates our dedication to providing the most relevant and influential content of geology and engineering sciences to our community.

Қазақстан Республикасы Ұлттық ғылым академиясы «ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы» ғылыми журналының Web of Science-тің жаңаланған нұсқасы Emerging Sources Citation Index-те индекстелуге қабылданғанын хабарлайды. Бұл индекстелу барысында Clarivate Analytics компаниясы журналды одан әрі the Science Citation Index Expanded, the Social Sciences Citation Index және the Arts & Humanities Citation Index-ке қабылдау мәселесін қарастыруда. Web of Science зерттеушілер, авторлар, баспашылар мен мекемелерге контент тереңдігі мен сапасын ұсынады. ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы Emerging Sources Citation Index-ке енуі біздің қоғамдастық үшін ең өзекті және беделді геология және техникалық ғылымдар бойынша контентке адалдығымызды білдіреді.

НАН РК сообщает, что научный журнал «Известия НАН РК. Серия геологии и технических наук» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАН РК. Серия геологии и технических наук в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по геологии и техническим наукам для нашего сообщества.

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A.S. Abishova¹, A.A. Bokanova², A.I. Kamardin³, U. M. Mataev², T.Y. Meshcheryakova⁴

¹Almaty Technological University, Department of Textile production technology

²Eurasian Technological University, Educational program "Engineering"

³National Academy of Sciences of the Republic of Uzbekistan, Scientific and technical center
with design bureaus and experimental production

⁴Kazakh-German University, Department of Electric Power Engineering

E-mail: aigul_slanbekovna@mail.ru

**DEVELOPMENT OF OPTIMAL CONDITIONS FOR OBTAINING
OZONE FOR DECONTAMINATION OF WAREHOUSE AIR**

Abstract. The object of the research is the development of optimal conditions for the creation of the ozone elements. He provides decontamination of warehouse air. The aim of the work is the safety of food and non-food products when treated with ozone. This article presents the calculations and development of a mathematical model of the optimal characteristics of innovative technical means for producing ozone. Ozone is designed to neutralize mold fungi, harmful and toxic waste in various industries of the Republic of Kazakhstan. All over the world, both in the near and far abroad, a consumer use of the ozone elements for cleaning and decontamination air, water and food products. Ozone has an oxide ability, a powerful bactericidal effect, neutralizes various types of mold fungi and yeast, toxic components, etc. This article discusses the optimal conditions for the production of ozone in ozone devices. The authors develop small-sized ozone devices that will reduce energy and capital costs for the technological line by 5-10 times compared to foreign analogues. The creation of small-sized ozone devices is achieved due to the production of ozone as a result of a corona discharge from a micro wire whose diameter does not exceed 100 microns. The material for the article on the use of ozone in the agricultural sector, light industry and other industries that ensure the safety of food and non-food products was the research of scientists from near and far abroad, as the work of the authors. The article includes the results of calculations for obtaining the optimal dimensions of corona wires. Depending on the demand for ozone, not only the size, but also the number of ozone cells devices calculated. To vary the size and other parameters of the ozone cells, a mathematical modeling technique was used, which allowed us to obtain the current-voltage characteristics of the ozone cell. To control the mode of the ozonator, a circuit with a control unit is developed.

Key words: ozone, corona discharge, air, room, characteristics, model.

Introduction. All over the world, people are concerned about the microbiological purity of the air in industrial and warehouse premises, such as the textile, woodworking, agricultural sector, etc. In concentrations exceeding the recommended norms, bacteria and mold fungi contribute to the development of many infectious diseases, various mycoses, and provoke allergic reactions [1-3].

The volume of production and consumption of food products by the world's population is growing every year. The Republic of Kazakhstan is one of the countries with a developed system of agro-industrial complex, where there is an annual increase in the number of farm animals and the volume of seed produced [3-5].

As for the production and storage facilities of textile, woodworking and other industries, their processing is of great importance for human health. Issues of labor protection at modern enterprises,

including textile ones, are one of the most important problems today, where the main direction is to clean the air from dust and toxic components. Dust is formed during sorting, machining and transportation of various fibrous materials: cotton, flax, hemp, wool, synthetic fibers, etc. [6-9].

Food safety is a public health issue that continues to grow in importance. Governments around the world are stepping up efforts to improve food safety [6]. Therefore, the issues of microbiological cleanliness of the air at various enterprises, processing of products are very relevant.

Novelty. In Kazakhstan, a group of scientists has been engaged in the use of ozone for a long time, which together with colleagues from Uzbekistan conducts research in four areas: air purification of premises of various industries, purification of drinking and waste water, treatment and disinfection of textile materials and food products, as well as storage facilities manufactured goods.

To determine the effect of ozone on the improving safety of industrial premises and warehouses of finished products, the study was carried out using the OAC-1 air ozone device developed by the authors.

Studies have found that a decrease in air pressure in the discharge gap does not affect the process of come out ozone format, on the contrary, it leads to an increase in ozone output at low energy consumption [3-6].

The small dimensions of the corona electrodes, the diameter of which does not exceed 100 microns, will significantly reduce the metal consumption of the device, the capital costs of the plant for processing agricultural products, the costs of the technological line will be 5-10 times lower compared to analogues [7].

One of the important advantages of the ozone device is the absence of air treatment, which significantly reduces the cost of processing products [10]. One of the types of the developed model is an ozone device element for the treatment of atmospheric air and can be used for disinfection and sanitation of air in industrial and office premises, as well as for disinfection of drinking and wastewater. Figure 1 shows a diagram of the model. Ozone device element contains the frame of fluoric, (fluorine) plastic 1 with windows 2 for free access of air, the rod of fluoric plastic 3 coaxially disposed in the housing, the coil of copper wire 4 is wound on the rod, corona wire of tungsten or molybdenum in the form of helix 5, located on top of the first winding 4 and terminals K1, K2, K3 to connect ozone device item with a power source [11-16].

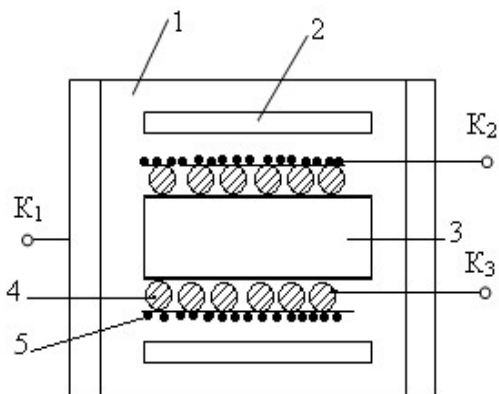


Figure 1-Ozonating element

An alternating voltage of sufficient magnitude is applied to the terminals K2, K3 of the ozone element, after which a corona-barrier discharge occurs in the gaps between the turns of the first winding, leading to the formation of ozone in the atmospheric air [16-18].

Methods. To select the optimal operating conditions of the ozone element, a mathematical model was developed for selecting the diameter of the corona wire, step and inter-turn distance.

The description of the model [14-16]:

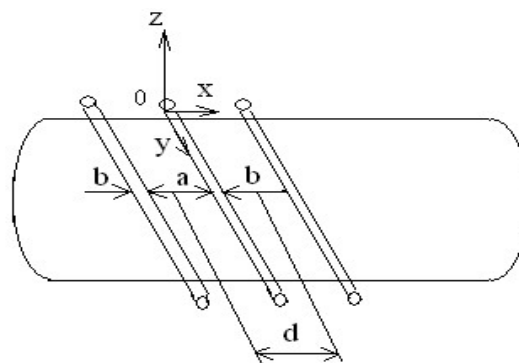


Figure 2 – Section of the ozone cell

1. Analysis of the results of theoretical calculations of the functions $E_x = f(z, x, \tau, a, b, d)$; $E_z = f(z, x, \tau, a, b, d)$ of the corona-barrier discharge fields, here $E_x, E_z, z, x, \tau, a, b, d$ – respectively x and z components of the field strength; components of the radius of the equipotential line, where the potential is sought; the charge per unit length of the charged wire τ ; the inter-turn distance a ; the diameter of the corona electrode b ; the step of the spiral d (figure 2) [14].

2. Planning of a multi-factor element for a preliminary assessment of the mechanical and electrical values of the design of the proposed ozone element on the corona and corona-barrier discharge.

3. Identification and restriction as a result of a multivariate experiment of the range of changes in variables and constants that characterize the working version of the model.

4. Determination of the calculated analytical dependencies taking into account the multivariate experiment and the identified limitations in order to eliminate a number of parameters appearing in the theoretical formula.

5. Finding the analytical dependences of the calculated values through the main varying parameters.

6. Introduction of the found analytical dependences and constants into the theoretical formula, its transformation into an engineering formula, and comparison of the calculation results, error estimation.

$$E_x = 2\tau C + \tau B \left\{ e^{-S} \frac{2\pi \sin G}{d \sin G} + e^{-2S} \frac{4\pi \sin 2G}{d \sin 2G} \right\},$$

$$E_z = 2\tau F + \tau B (e^{-S} 2\pi ctg G + e^{-2S} 4\pi ctg 2G), \quad (1)$$

where: $B = \frac{4\pi a(1-2\ln \frac{a}{b})}{d}$; $C = \frac{x}{z^2+x^2}$; $G = \frac{2\pi x}{d}$; $F = \frac{z}{z^2+x^2}$; $S = \frac{2\pi|z|}{d}$; $x = r_0$; $z = r$.

where: $\tau = \frac{2\pi \epsilon U_0}{\ln \frac{d}{r_0}} = 27.3$ – the charge per unit length of the wire.

Substituting the values E_x, E_z of the field strength:

$$E_{xz} = \sqrt{E_x^2 + E_z^2} = 163.75 \text{ V.}$$

$$E_x = 2 \cdot 0.071 \cdot \tau + (-17.8) \left(0.04 \cdot \frac{2\pi}{a} + 0.0025 \cdot \frac{4\pi}{a} \right),$$

$$E_z = 2 \cdot 0.37 \cdot \tau + \tau(-17.8) \left\{ 0.04 \cdot \frac{2\pi}{a} ctg \frac{\pi a}{a} + 0.0025 \cdot \frac{4\pi}{a} ctg \frac{2\pi a}{a} \right\} \quad (2)$$

where: $\tau = \frac{2\pi\epsilon U_0}{\ln \frac{d}{r_0}} = 27.3$ the charge per unit length of the wire.

Substituting the values EX ,EZof the field strength: $E_{xz} = \sqrt{E_x^2 + E_z^2} = 163.75$ V.

Conclusions. As a result of the simulation, the block diagram shown in Figure 3 was compiled [14].

The above theoretical studies of the function E for the design of the OKR type us to establish the intervals of change in the main electrical parameters of the field: for $U_0 = -1$ kV; $x = 0.005$ cm; $z = 0.026$ cm; $E_x = -88.57$ kV/cm; $E_z = -137.7$ kV/cm; $E = 163.75$ kV / cm[14-23].

The digital values of the fixed and calculated values are entered into an intermediate formula for determining the components of the electric field strength, the main varying factors in which are the initial values of the diameter, the inter-turn distance, the spiral step, the radius of the equipotent line, where the potential is sought, the radius of the wire, the potential on the surface of the wire, the charge per unit length of the charged wire(Figure 3) [14].

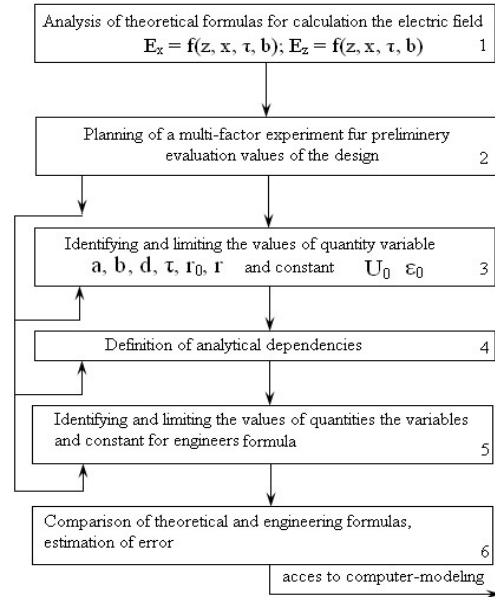


Figure 3 - Structure of the mathematical model

Result. Based on the simulation results, an algorithm and a program for calculating the operating parameters and modes (table).

Current-voltage characteristics of the corona-discharge system depending on the number of tubes

U _{ламп.} B		0	20	40	60	80	100	120	150
1 tube	U _{1.} B	0	1	2,2	3,8	5	5,2	5,80	6,4
	I _{1к.} МКA	0	9	20	34	45	47,27	52,72	58,18
2 Tubes	U _{2.} B	0	0,8	3	4,8	6,40	8	10	12
	I _{2к.} МКA	0	7,27	27	43	58	72	90	109
3 Tubes	U _{3.} B	0	1	3,2	5	7	8,2	10,3	12,5
	I _{3к.} МКA	0	9	29	45	63	75	93,6	113
4 Tubes	U _{4.} B	0	1,3	3,7	5,2	7,7	8,2	10,3	12,6
	I _{4к.} МКA	0	11,82	33,64	47,27	70	74,54	93,64	114,54

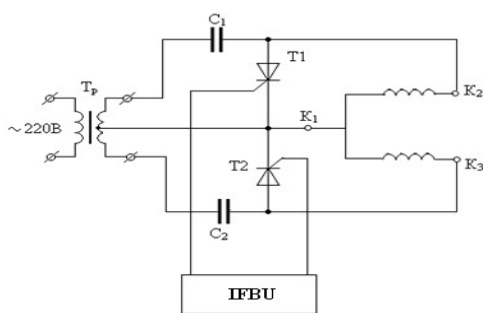


Figure 4 – The scheme of automatic control of the ozone device

The current-voltage characteristics of the ozone device depending on the external conditions and the parameters of the discharge gap are obtained experimentally (figure 5) [16-23].

The scheme of automatic control of the ozonator is shown in Figure 4, where the data obtained as a result of modeling and calculation are set in the pulse-phase control unit of the IFBU, controlled

thyristors T1 and T2 are used for voltage conversion. The pulse to the control electrodes of the thyristors is supplied from the control unit and the IFBU.

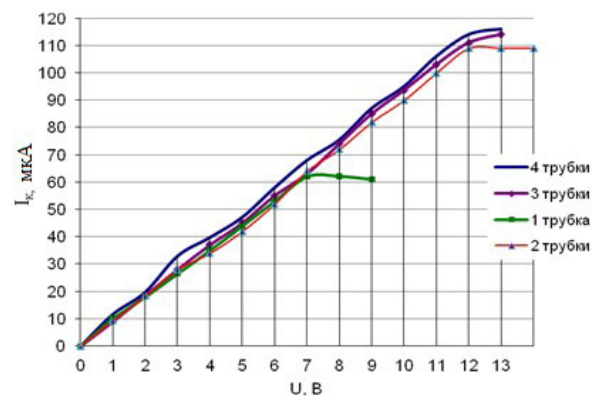


Figure 5- Current-voltage characteristics of corona-discharge devices

Tests of the prototype OAC-1 were performed in the laboratory conditions of the Kazakh Republican Sanitary and Epidemiological Station (KRSES).

А.С. Абишова¹, А.А. Боканова², А.И. Камардин³, У.М. Матаев², Т.Ю. Мещерякова⁴

¹Алматы технологиялық университеті, Тоқыма өндірісінің технологиялық кафедрасы, Алматы, Қазақстан;

²Еуразиялық технологиялық университет, «Инжиниринг» білім беру бағдарламасы, Алматы, Қазақстан;

³Өзбекістан Республикасының Ғылым академиясы, құрастыру және тәжірибелік өндірістің ғылыми-техникалық орталығы, Ташкент, Өзбекстан;

⁴Қазақстан-неміс университеті, Электр энергетика кафедрасы, Алматы, Қазақстан.
E-mail: aigul_slanbekovna@mail.ru

ҚОЙМАЛАРДЫҢ АУАСЫН ЗАЛАЛСЫЗДАНДЫРУ ҮШІН ОЗОН АЛУДЫҢ ОҢТАЙЛЫ ШАРТТАРЫН ӘЗІРЛЕУ

Аннотация. Зерттеу нысаны-сақтау бөлмелерінің ауасын зарарсыздандыруды қамтамасыз ететін озон элементін құру үшін оңтайлы жағдайларды жасау. Жұмыстың мақсаты-озонмен өңдеу кезінде азық-түлік және азық-түлік емес өнімдердің қауіпсіздігі. Бұл мақалада озон алуға арналған инновациялық техникалық құралдардың оңтайлы сипаттамаларының математикалық моделін есептеу және дамыту келтірілген. Озон Қазақстан Республикасының әр түрлі өнеркәсіп салаларындағы зең саңырауқұлақтарын, зиянды және уытты қалдықтарды бейтараптандыруға арналған. Бүкіл әлемде, жақын және алыс шетелде, озонаторлар ауаны, суды және тамақ өнімдерін тазарту және зарарсыздандыру үшін қолданылады. Озон күшті тотығу қабілетіне ие, күшті бактерицидтік әсерге ие, зең мен ашытқының әртүрлі түрлерін, улы компоненттерді және т. б. бейтараптандырады. Авторлар шетелдік аналогтармен салыстырғанда технологиялық желінің энергетикалық және күрделі шығындарын 5-10 есе азайтуға мүмкіндік беретін шағын озонаторларды жасайды. Шағын өлшемді озонатор құрылғыларын құру диаметрі 100 микроннан аспайтын микро сымнан тәждік разряд нәтижесінде озонды алу нәтижесінде қол жеткізіледі. Озонды аграрлық секторда, жеңіл өнеркәсіпте және азық-түлік және азық-түлік емес өнімдердің қауіпсіздігін қамтамасыз ететін басқа салаларда қолдану туралы мақаланың материалы жақын және алыс шетел ғалымдарының зерттеулері, сондай-ақ авторлардың жұмыстары болды. Мақалада тәж сымдарының оңтайлы мөлшерін алу үшін есептеу нәтижелері келтірілген. Озонның қажеттілігіне байланысты тек мөлшері ғана емес, сонымен қатар озонатор жасушаларының саны да есептеледі. Озон жасушаларының өлшемдері мен басқа параметрлерін өзгерту үшін математикалық модельдеу әдісі қолданылды, бұл озон жасушасының вольт-ампер сипаттамаларын алуға мүмкіндік берді. Озонатор режимін басқару үшін басқару блогы бар схема жасалды.

Түйін сөздер: озон, тәжді разряд, ауа, бөлме, сипаттамалары, моделі.

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А.С. Абишова¹, А.А. Боканова², А.И. Камардин³, У.М. Матаев², Т.Ю. Мещерякова⁴

¹Алматинский технологический университет, кафедра Технология текстильного производства, Алматы, Казахстан;

²Евразийский технологический университет, Образовательная Программа «Инжиниринг», Алматы, Казахстан;

³Академия наук Республики Узбекистан, Научно-технический центр с конструкторским и опытным производством, Ташкент, Узбекистан;

⁴Казахстанско-немецкий университет, кафедра Электроэнергетики, Алматы, Казахстан.
E-mail: aigul_slanbekovna@mail.ru

РАЗРАБОТКА ОПТИМАЛЬНЫХ УСЛОВИЙ ПОЛУЧЕНИЯ ОЗОНА ДЛЯ ОБЕЗЗАРАЖИВАНИЯ ВОЗДУХА СКЛАДОВ

Аннотация. Объектом исследования является разработка оптимальных условий для создания озонирующего элемента, обеспечивающего обеззараживание воздуха складских помещений. Целью работы является безопасность продовольственных и непродовольственных продуктов при обработке озоном. В данной статье приведены расчеты и разработка математической модели оптимальных характеристик инновационных технических средств для получения озона. Озон предназначен для нейтрализации плесневых грибков, вредных и токсичных отходов в различных отраслях промышленности Республики Казахстан. Во всем мире, как в ближнем, так и дальнем зарубежье, для очистки и обеззараживания воздуха, воды и пищевых продуктов используют озонаторы. Озон обладает сильной окислительной способностью, мощным бактерицидным действием, нейтрализует различные

виды плесневых грибов и дрожжей, токсичные компоненты и т.п. В данной статье рассматриваются оптимальные условия для выработки озона в озонирующих устройствах. Авторы разрабатывают малогабаритные озонаторы, которые позволят снизить энергетические и капитальные затраты на технологическую линию в 5-10 раз по сравнению с зарубежными аналогами. Создание озонаторных устройств малых габаритов достигается вследствие получения озона в результате коронного разряда с микропроволоки, диаметр которой не превышает 100 микрон. Материалом для статьи о применении озона в аграрном секторе, легкой промышленности и др. отраслях, обеспечивающего безопасность продовольственных и непродовольственных продуктов явились исследования ученых ближнего и дальнего зарубежья, а также работы авторов. В статью вошли результаты расчетов для получения оптимальных размеров коронирующих проволок. В зависимости от потребности в озоне рассчитаны не только размеры, а также количество озонаторных ячеек. Для вариации размеров и других параметров озонирующих ячеек была применена методика математического моделирования, что позволило получить вольт-амперные характеристики озонирующей ячейки. Для управления режимом озонатора разработана схема с блоком управления.

Ключевые слова: озон, коронный разряд, воздух, помещение, характеристики, модель.

Information about the authors:

Abisheva Aigul Aslanbekovna, Candidate of Technical Sciences, Almaty Technological University, senior lecturer of the Department of Textile Production Technology, aigul_slanbekovna@mail.ru, The original version of the article, <https://orcid.org/0000-0002-1405-7783>

Bokanova Aliya Abylgazievna, Doctor of Technical Sciences, Eurasian Technological University, Professor of OP "Engineering", Associate Professor, bokanova_a@mail.ru. Development of theoretical, <https://orcid.org/0000-0002-3462-5629>

Kamardin Alexey Ivanovich, Candidate of Technical Sciences, Academy of Sciences of the Republic of Uzbekistan, Scientific and Technical Center with Design and Pilot Production, kadmon@bk.ru, experimental research, <https://orcid.org/0000-0002-7972-9798>

Mataev Umirbek Mataevich, Candidate of Technical Sciences, Eurasian Technological University, Associate Professor of OP "Engineering", Associate Professor, u.matayev@etu.edu.kz, research methodology, <https://orcid.org/0000-0003-0902-478>

Meshherjakova Tatyana Yuryevna, Candidate of Technical Sciences, Kazakh-German University, Associate Professor of the Department of Electric Power Engineering, Associate Professor, meshherjakova_tanja_meshherjakova_tanja@rambler.ru, electronics programme, <https://orcid.org/0000-0003-1910-8487>

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