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ACTIVATION METHOD OF CLEANING PROCESS GAS

Abstract. This article presents the results of joint research of "ABsalut Ecology" LLP with Karstu of industrial electrochemical aeroion plants B30-500 and AP-21, capable of cleaning technological gas emissions from toxic impurities SO_2 (at least 90%), NO_x (at least 80%), CO_2 (at least 90%) and dust particles (99.9%); with the return to production of part of the burned carbon (in the form of fine soot).

It was found that in the discharge zone of the V30-500 and AP-21 installations, the active factors affecting the chemical process are: high voltage of the electric field ; secondary ionization of substances; polarization of molecules; high temperature; photoionization; microwave radiation; shock wave. Two processes take place simultaneously in the reaction zone of the plants: activation and reduction of CO_2, CO, NO_x, and SO_2 oxides to elementary substances in the core of the electronic injector.

Reduction of CO_2, CO, NO_x, and SO_2 oxides in the reaction zone proceeds simultaneously by various mechanisms: catalytic reduction and dissociation. It is established that the catalytic system in the installation is an electronic injector, which serves as a source of active particles that determine the rate of chemical reactions. Reducing agents CO, NH_3 are present in the gas to be treated , and are also formed in the reaction zone of the plant.

As a result of the reactions, elementary substances are formed. The speed constants of elementary processes in a discharge strongly depend on the electric field strength, and the speed of individual processes may depend in a non-linear way on the current density, so by changing these parameters, you can change the selectivity and speed of recovery processes in the installation.

It is shown that ionization and dissociative processes with the formation of various radicals and ions are feasible in non-equilibrium weakly ionized plasma. The degree of capture of aerosols and dust increases with a decrease in the size of dust-like particles, and in dry electric filters, on the contrary, falls to zero.

The ways of increasing the efficiency of technological gas treatment plants (geometric parameters of new plants, increasing their productivity, using new high-voltage power sources, flotation and filtration devices, and dispatching control systems) were determined.

The efficiency of the gas treatment plant does not decrease when the particle size of the captured aerosols decreases, starting from the size of about 5 microns and lower, the cleaning efficiency approaches 100%.

The research results are shown as graphs that show the concentration of gas before and after treatment. The degree of air purification from dust particles and aerosol impurities ranges from 60% to 99%.

Keywords: soot, activation, electrochemical installations, air ionization, atmospheric pollution, ecology, initiation, carbon conversion, aeroionizers, cyclones, scrubbers, electrofilters.

Introduction. Nowadays the issue of solving environmental problems is acute throughout the world. The scientific and technological revolution, the intensive growth of production are the basis of negative changes in the environment, these include: air pollution; destruction of the fertile layer of the earth; poisoning and pollution of the rivers, lakes, oceans, etc. As a result of human and industrial activities of the people more than 200 million tons of carbon monoxide, 151 million tons of sulfur (IV) oxide, and over 50 million tons of oxides nitrogen, more than 50 million tons of various hydrocarbons, more than 250 million tons of fine aerosols are annually emitted into the Earth's atmosphere [1].

The relevance of this article is caused by the alarming situation in the ecology of the Republic of Kazakhstan. The highest level of air pollution is observed in the cities of Ust-Kamenogorsk, Shymkent, Aktobe, Balkhash, Temirtau.

This problem makes the young generation think about how to return the human environment, our Earth, to that perfect natural balance that existed earlier. By lowering the air pollution levels, countries can reduce the burden of diseases such as stroke, heart disease, and lung cancer, as well as chronic and acute respiratory diseases, including asthma. In 2012, an estimated 3.7 million premature deaths occurred in urban and rural areas worldwide due to the air pollution. According to the recent WHO estimates of the total global burden of disease, approximately 7 million cases of premature death are caused by the air pollution and the indoor air [2].

The main causes of the high level of air pollution in the cities of Kazakhstan are as follows:

- outdated production technologies,
- inefficient gas cleaning equipment,
- mismatch of coal fuel to boiler units,
- a huge amount of accumulated and new dumped waste (billions of tons).

From the above-said it follows that the enterprises of Kazakhstan need comprehensive purification, which will not only clean up gas emissions, but also make it possible to obtain carbon black products in the form of environmentally friendly compounds.

A scientific-engineering group of the ABsalut Ecology LLP headed by A. Borissenko, Doctor of Chemistry, Professor, Academician, developed and introduced into production new electrochemical plants of the B30-500 and AP-21 models that not only clean technological gas emissions from toxic impurities (CO_x, NO_x, SO_2, H_2S, etc.), return to production a part of the burned carbon (in the form of fine soot), but also purify the air in residential premises saturating it with negative air ions and enriching it with oxygen.

In the discharge zone of the B 30-500 and AP-21 plants, the active factors affecting the chemical process are as follows:

- high voltage of the electric field;
- secondary ionization of substances;
- polarization of molecules, excitation of molecules and atoms;
- high temperature;
- photoionization;
- microwave radiation (electromagnetic waves);
- shock wave.

Process gases entering the B 30-500 and AP-21 units have the following component composition: CO_2, CO, SO_2, CH_4, N_2, O_2, H_2O.

Experimental part. In the reaction (discharge) zone, in the presence of the active factors described above, there can take place the reactions of all components with the formation of elementary substances and various compounds, i.e. taking into account the experimental data obtained in the laboratory of the ABsalut Ecology LLP, it follows that in the near-cathode unipolar charged region of the B 30-500 and AP-21 plants, in the conditions of a non-equilibrium weakly ionized plasma, ionization and dissociative processes can occur with the formation of various radicals and ions [3].

In the aggregate, all these processes can lead to the reduction of carbon oxides (CO_2), sulfur dioxide (SO_2) and nitrogen oxides (II, IV).

- CO_2

a) occurrence of complete or partial dissociation of carbon oxides:

$$CO_2 \rightarrow C + O_2$$

$$CO_2 \rightarrow CO + \frac{1}{2} O_2$$

$$CO \rightarrow C + \frac{1}{2} O_2$$

$$CO^* + CO^* \leftrightarrow C + CO_2$$

$$CO_2{}^*{}_{(г)} + C_{(т)} \rightarrow C_{(о)} + CO_{(г)}$$

b) processes of reducing by atomic hydrogen:

$$CO_2 + H \rightarrow C + HO_2$$
$$CO + 2H \rightarrow C + H_2O$$

c) carbon oxides interaction with atomic oxygen:

$$CO_2^* + O \leftrightarrow CO + O_2$$

d) carbon oxides interaction with forming methane, other hydrocarbons and elemental carbon:

$$8H + CO_2 \rightarrow CH_4 + 2H_2O$$
$$CO + 3H_2 \leftrightarrow CH_4 + H_2O$$

$CH_4 \rightarrow C_2H_2$, C_2H_4, C_2H_3 and others $\rightarrow$ solid products.

Thus, in the unipolar (negative) charged zone, carbon dioxide dissociation and reduction reactions are possible.

- **SO_2** - the mechanism of electrochemical transformations is also possible, leading to the reduction of sulfur dioxide molecules to elemental sulfur in the dark discharge zone in the solid needle electrode – gas – liquid anode system [4].

a) complete or partial dissociation of sulfur dioxide molecules

$$SO_2 \rightarrow S\downarrow + O_2$$

b) reducing sulfur dioxide by atomic hydrogen

$$SO_2 + 4H^* = S\downarrow + 2H_2O$$

c) reducing by hydrogen sulfide with forming elemental sulfur (hydrogen sulfide is one of the intermediate products that are formed when reducing sulfur dioxide):

$$6H^* + SO_2 = H_2S + 2H_2O$$
$$SO_2 + H_2S = 3S\downarrow + 2H_2O$$

d) in the reducing gas discharge medium there is also possible the reaction of hydrogen sulfide H_2S dissociation to free sulfur:

$$H_2S \rightarrow S + H_2 \text{ [5]}$$

- **N_xO_y** – here there are also possible electrochemical transformations of nitrogen oxides to the elemental composition (nitrogen).

$$N + NO \rightarrow N_2 + O$$
$$N + NO_2 \rightarrow 2NO$$
$$N + NO_2 \rightarrow N_2 + 2O$$
$$O + NO_2 - O_2 + NO$$
$$N_2O \rightarrow 2N_2 + O_2$$
$$2NO_2 \rightarrow N_2 + 2O_2 \text{ [6]}$$

Today, as a result of tremendous work, the industrial unit B 30-500 provides the degree of purification of process gases of at least: an integrated one 99.7%; from carbon monoxide (CO) 97%; from sulfur dioxide (SO_2) 95%; from nitric oxide (NO_2) 80%; from dust and aerosol particles 99.5%. The data has been repeatedly confirmed:

1) by specialists of the ABsalut Ecology LLP company on German Testo 350 instruments. Using this device, there can be monitored the operation of an industrial gas treatment plant and recorded the cleaning changes in real time.

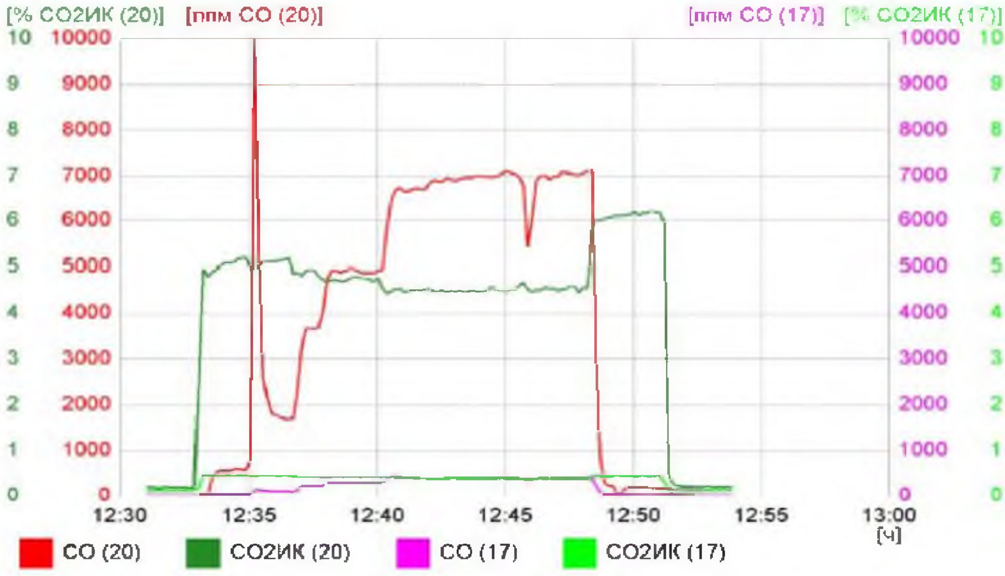


Figure 1 - Gas measurements in the reaction zone of the industrial gas cleaning plant

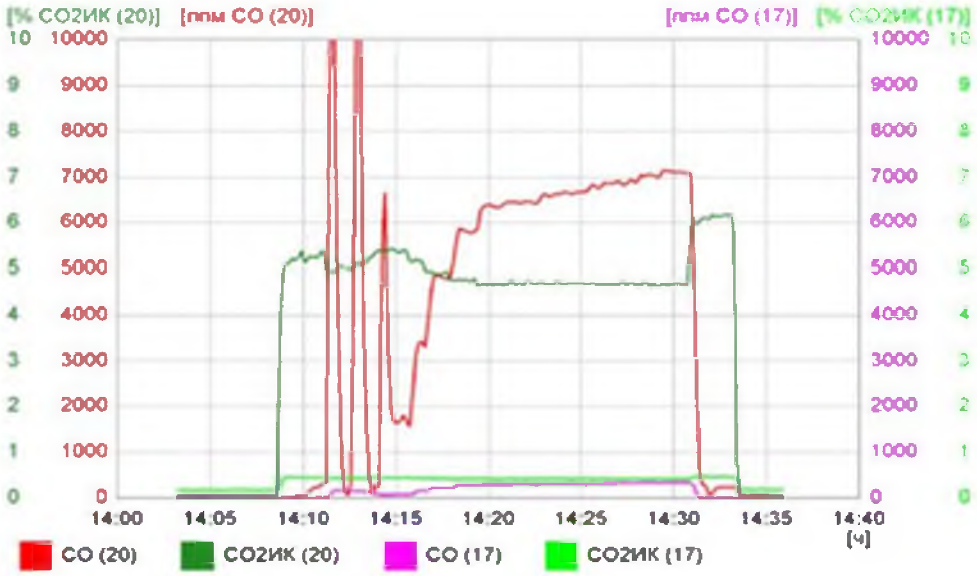


Figure 2 - Gas measurements in the reaction zone of the industrial gas cleaning plant

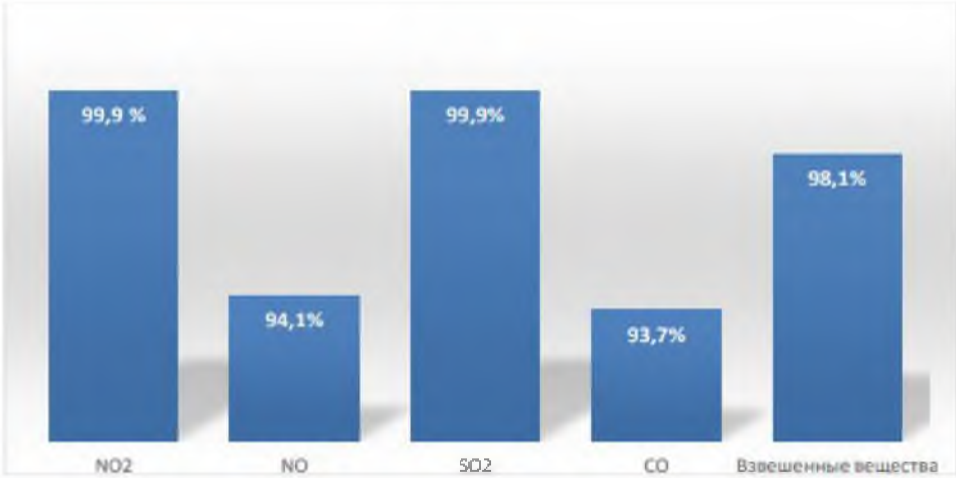
The graphs are plotted using two Testo 350 instruments: one instrument measures gas at the inlet to the gas treatment plant, the other one at the outlet. The graphs show 4 lines of different colors:

- CO (20) - red line, CO2IK (20) - dark green line show the amount of gas at the inlet to the gas treatment plant, i.e. gas concentration before cleaning;
- CO (17) - pink line, COIK (17) - light green line show the amount of gas at the outlet of the gas treatment plant, i.e. gas concentration after cleaning.

To the left and right of the graphs there are scales of the CO_2 range in percent and CO in ppm.

1) Results obtained by the independent laboratory of the Tsentrgeolanalit LLP.

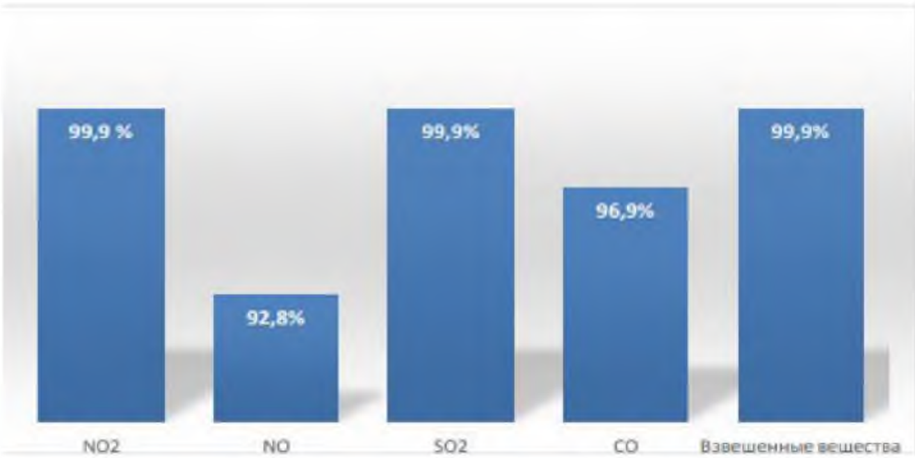
Minutes No. EC050517/1. Meteorological conditions: T +3°C, pressure 718 mm Hg, humidity 70%. Sampling equipment: Aspirator ABA-180, Gas analyzer DAG-500.



Suspended matters

Figure 3 - Gas measurements in the process of operation of the industrial gas cleaning plant. Minutes No. EC050517/1

Minutes No. EC061117/1. Meteorological conditions: T +24°C, pressure 707 mm Hg, humidity 20%. Sampling equipment: Aspirator ABA-180, Gas analyzer DAG-500.



Suspended matters

Figure 4 - Gas measurements in the process of operation of the industrial gas cleaning plant. Minutes No. EC061117/1

The introduction and use of the results of these studies allows preparing for the implementation of an integrated quality and environmental management system (ISO 9001: 2015, ISO 14001: 2015) at the ABsalut Ecology LLP, increasing the efficiency of process gas purification processes, as well as preparing a draft program for the use of the materials, obtained as related materials (fullerenes, carbon black, etc.) during the operation of the plants. Based on the results of these studies, measures were prepared to further improving the plant for cleaning process gases and atmospheric air, and the technology of cleaning and reducing the purification products.

The plant by A.V. Borissenko is intended not only for purifying nature, but also for obtaining useful substances from harmful wastes.

From all the above-said it follows that the scientific and engineering group of the ABsalut Ecology LLP headed by Dr. of Chemistry, Professor, Academician A.V. Borissenko, has developed and introduced the technology that uses a new activation method of cleaning industrial and utility gases in the unipolar ionized region when exposed to a strong electric field. This technology is patented and has no analogues in the world. With its help there can be solved one of the vital problems of the mankind: atmospheric air pollution.

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ТЕХНОЛОГИЯЛЫҚ ГАЗДЫ ТАЗАЛАУДЫҢ АКТИВАЦИЯЛЫҚ ӘДІСІ

Аннотация. Бұл мақалада технологиялық ғаз шығарындыларын SO2 (кемінде 90%), NOx (кемінде 80%), CO2 (кемінде 90%) және шаң тәріздес бөлшектерден (99,9%) тазартуға қабілетті В30-500 және АП-21 өнеркәсінтік электрохимиялық аэроиондық қондырғылардың ҚарМТУ-мен "ABsalut Ecology" ЖШС бірлескен зерттеулерінің нәтижелері келтірілген.

В30-500 және АП-21 қондырғыларының разрядтық аймағында химиялық процеске әсер ететін белсенді факторлар мыналар болып табылады: электр өрісінің жоғары кернеуі; заттардың қайталама иондалуы; молекулалардың поляризациясы; жоғары температура; фотоионизация; СВЧ-сәулелену; соққы толқыны.

Қондырғының реакциялық аймағында бір уақытта екі процесс өтеді- CO_2, CO, NOx, SO_2 оксидтерін активтендіру және электрондық инжектордың белсенді аймағындағы Элементарлық заттарға дейін қалпына келтіру. Реакциялық аймақта CO_2, CO, NOx, SO_2 оксидтерін қалпына келтіру әр түрлі тетіктер бойынша бір мезгілде өтеді: каталитикалық қалпына келтіру және диссоциация. Каталитикалық жүйе қондырғысында химиялық реакциялардың жылдамдығын анықтайтын белсенді бөлшектердің көзі болып табылатын электрондық инжектор болып табылады. CO, NH_3 қалпына келтіргіштер тазартылатын ғазда болады, сондай-ақ қондырғының реакциялық аймағында құрылады.

Реакциялардың өтуі нәтижесінде қарапайым заттар пайда болады. Электр өрісінің кернеулігіне, сондай-ақ жекелеген процестердің жылдамдығына электр өрісінің кернеулігіне қатты байланысты, токтың тығыздығына байланысты болуы мүмкін, сондықтан осы параметрлерді өзгерте отырып, селективтілікті, қондырғыдағы қалпына келтіру процестерінің жылдамдығын өзгертуге болады.

Әр түрлі радикалдар мен иондардың пайда болуымен ионизациялық және диссоциативтік процестердің өтуі жүзеге асырыла отырып, әлсіз ионизирленген плазма жағдайында көрсетілген. Аэрозольдар мен шаңды ұстау дәрежесі шаң тәріздес бөлшектер мөлшерінің азаюымен артады, ал құрғақ электр сүзгілерінде керісінше нөлге дейін төмендейді.

Технологиялық ғаздарды тазарту бойынша қондырғылардың тиімділігін арттыру жолдары анықталды (жаңа қондырғылардың ғеометриялық параметрлері, олардың өнімділігін арттыру, жаңа жоғары вольтты қоректену көздерін, флотациялық-сүзу құрылғыларын, диспетчерлік бақылау жүйелерін пайдалану және т.б.).

Газ тазарту қондырғысының тиімділігі 5 микрон және одан төмен мөлшерден бастап ауланатын аэрозольдер бөлшектерінің мөлшерін азайтқан кезде төмендетілмейді, тазарту тиімділігі 100%- ға жақындап келеді.

Зерттеу нәтижелері тазартқанға дейін және кейін ғаз концентрациясын көрсететін графиктер түрінде келтірілген. Ауаны шаң тәріздес бөлшектерден және аэрозоль қоспаларынан тазарту дәрежесі 60%-дан 99%-ға дейін ауытқиды.

Түйін сөздер: электрохимиялық қондырғылар, ауаны иондау, атмосфераның ластануы, экологія, бастамашылық жасау, көміртекті конверсиялау, аэроионизаторлар, циклондар, скрубберлер, электр сүзгілері.

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АКТИВАЦИОННЫЙ МЕТОД ОЧИСТКИ ТЕХНОЛОГИЧЕСКОГО ГАЗА

Аннотация. В данной статье приведены результаты совместных исследований ТОО «ABsalut Ecology» с КарГТУ промышленных электрохимических аэроионных установок В30-500 и АП-21, способных очищать технологические ғазовые выбросы от токсичных примесей SO_2 (не менее 90%), NOx (не менее 80%), CO_2 (не менее 90%) и пылевидных частиц (99,9%) с возвращением в производство часть сожжённого уғлерода (в виде мелкодисперсной сажи).

Установлено, что в разрядной зоне установок В30-500 и АП-21 активными факторами, воздействующими на химический процесс, являются: высокое напряжение электрического поля; вторичная ионизация веществ; поляризация молекул; высокая температура; фотоионизация; СВЧ-излучение; ударная волна.

В реакционной зоне установок протекают одновременно два процесса – активация и восстановление оксидов CO_2, CO, NOx, SO_2 до элементарных веществ активной зоне электронного инжектора. Восстановление оксидов CO_2, CO, NOx, SO_2 в реакционной зоне протекают одновременно по различным механизмам: каталитическое восстановление и диссоциация. Установлено, в установке каталитической системой является электронный инжектор, который служит источником активных частиц, определяющих скорость химических реакций. Восстановители CO, NH_3 присутствуют в очищаемом газе, а также образуются в реакционной зоне установки.

В результате протекания реакций образуются элементарные вещества. Константы скоростей элементарных процессов в разряде резко зависят от напряженности электрического поля, а также скорости отдельных процессов, могут нелинейным образом зависеть от плотности тока, поэтому изменяя эти параметры можно изменять селективность, скорость восстановительных процессов в установке.

Показаны в условиях неравновесной слабоионизированной плазмы, осуществимо протекание ионизационных и диссоциативных процессов с образованием различных радикалов и ионов. Степень улавливания аэрозолей и пыли увеличивается с уменьшением размеров пылевидных частиц, а в сухих электрофильтрах, наоборот, падает до нуля.

Определены пути повышения эффективности установок по очистке технологических газов (геометрические параметры новых установок, увеличение их производительности, использование новых высоковольтных источников питания, флотационно-фильтрационных устройств, систем диспетчерского контроля и пр.).

Эффективность газоочистной установки не снижается при уменьшении размера частиц улавливаемых аэрозолей, начиная с размера около 5 микрон и ниже, эффективность очистки приближается к 100%.

Результаты исследований приведены в виде графиков, которые показывают концентрация газа до и после очистки. Степень очистки воздуха от пылевидных частиц и аэрозольных примесей колеблется от 60% до 99%.

Ключевые слова: сажа, активация, электрохимические установки, ионизация воздуха, загрязнение атмосферы, экология, инициирование, конверсия углерода, аэроионизаторы, циклоны, скрубберы, электрофильтры.

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