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RESEARCH OF THE SYSTEM OF CORONA ELECTRODES OF RECIRCULATION FILTERS FOR THE REMOVAL OF SMOKE

(presented DSc Krivtsova V.I.)

Based on the results of experimental studies of the electrical and aerodynamic characteristics of laboratory samples of the recirculation filter on the principle of electric wind with needle corona electrodes, the optimal geometric parameters of the latter have been determined and recommendations for their use have been developed for cleaning from dangerous aerosol contamination in foci of emergency situations.

Keywords: emergency situation, aerosol pollution, recirculation electric filter, needle corona electrode.

Problem statement. The promising methods for purifying the Emergency situation (ES) from hazardous aerosol contamination in closed structures include the method of electrical deposition, which can be implemented by using a recirculation filter on the principle of electric wind (REF) [1,2]. These devices allow to significantly reduce the concentration of smoke in the cells of the fire in the premises, do not violate the mass balance of air during the fire, do not pollute the environment, precipitate aerosols with particle size (0,01-100) microns, have a minimum power consumption. At the same time, new measures are being introduced to the means of electric cleaning, especially as regards the issues of increasing their reliability, efficiency and economy [3].

In connection with this, an important scientific and technical problem arises regarding the creation of modern means of cleaning the cells of ES from the dangerous contamination of products of combustion and explosions, and research on the improvement of the efficiency of cleaners and the substantiation of their design parameters using electrodeposition methods are very relevant.

Analysis of recent researches and publications. In the means of electric cleaning, as the main physical phenomenon, which determines their function as intended, there is a crown discharge [4]. It should be noted that despite the high level and considerable amount of work done both in theory and in the practice of electric cleaning, many issues remain, without which it is impossible to further improve the designs of electric cleaners.

The key elements of each electric cleaner, which determine its performance, are precipitating and crowning electrodes. At the same time the following requirements are presented to the latter [5]:

- the exact form for creating an intense and fairly homogeneous discharge;

- mechanical strength and stiffness to provide long-term operation of electrodes under conditions of vibration and rocking under the influence of electric field forces, air flows, etc.;

- Easy manufacturing and low cost.

According to the principle of existing structures, crowning electrodes can be divided into two groups [6].

The first group includes electrodes that do not have fixed bit points when discharge points are located along the electrode at different distances from each other, depending on the mode of operation of the electrofilter and the state of the electrode surface.

The crowning electrodes of this group may be round (sometimes twisted in a spiral), square (sometimes screw-like), stellate with a different number of vertices and a strip (strip metal) form of a cross-section. The value of the cross-section of such electrodes is designed to provide the necessary mechanical strength, and the radiation emitting surfaces have a small radius of curvature and provide the creation of an intense corona discharge.

The second group includes electrodes with fixed points of discharge along their length. As fixed discharge points on the surface of the electrode at a certain distance from each other there are nodes or spikes taking into account the requirements for mechanical strength.

A typical crowning electrode with fixed discharge points is a barbed wire. Corrosion electrodes are also used from the section of the tape, with stamping or teeth stamped on it. Sometimes thorns are located on square or other profile electrodes.

The most common designs of crowning systems in electrofilter are needle and wire electrodes. However, needle electrodes with the same voltages create more powerful electric fields than wires. In addition, there is a good localization of the spatial charge at the edge for the electrode blank.

In view of the above, the purpose of the work is to develop and study the system of crowning electrodes to improve the efficiency of cleaning and the reliability of the recirculation filter on the principle of electric wind when used in cells of emergency situations.

Statement of the problem and its solution. To achieve the goal in the work solved the following tasks:

- to carry out the analysis of existing design systems of recirculation electric filters;

- to propose the construction of the crowning system and to determine its optimal geometric parameters for a recirculation electric filter on the principle of electric wind and carry out theoretical and experimental studies showed the proposed REF with a needle system of corona electrodes.

Improving the efficiency of cleaning and reliability of the recirculation filter on the principle of electric wind can be achieved by optimizing the

geometric characteristics of the crowning electrodes. A large number of factors and the complexity of phenomena in the electric field of corona discharge determine the use for the study of the characteristics of electric filters, mainly experimental methods. In work to achieve the goal, a laboratory sample of REF was developed consisting of several consecutive united single-band systems, «needle-shaped crowning electrode-depositing plates», which were placed in a vinyl-plated housing 3, which was made in the form of a parallelepiped (Fig. 1).

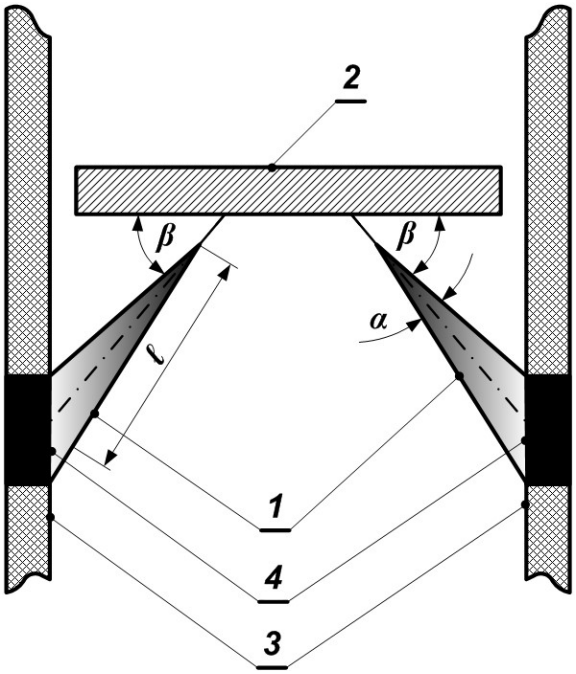

Fig. 1. System crowning chalk electrodes: 1 – crowning needle electrodes; 2 – precipitation plates; 3 – side walls of the filter housing; 4 – mounting knob

The needles crowning electrodes 1 are made in the form of a tip of sheet brass in the thickness of 0,2 mm. The sedimentation zone 2 consisted of two metal plates located parallel to each other at a distance of $2{,}5\times10^{-3}$ m. Power system of electrodes was carried out from the source of direct current, which was regulated in the range from 0 to 25 kV. The system of electrodes was characterized by the following geometric parameters: ℓ – length of the crown electrode; α – angle of the cone of the crowning electrode; β – angle between the crowning and precipitating electrodes.

Before proceeding with experimental research, the input factors and the initial parameters of the object of research were determined. The main parameters that determine the efficiency of the REF are the maximum amount of purified air Q and the degree of purification from dangerous aerosol particles η [7]. In the work, the efficiency of the REF Q was determined by the formula

$$Q = FV, \text{ m}^3/\text{h}, \quad (1)$$

where F – area of the living section of the cleaner, m²; V – air velocity at the outlet of the electrofilter, m/s.

The efficiency of the REF η of the relative dispersion of the deposited particles is determined by the ratio

$$\eta = (1 - n / n_o) \times 100, \%, \quad (2)$$

where n_o and n – number of particles of the indicated dispersion at the inlet and outlet of the electro filter, respectively, particles / liter.

In connection with this, in the experiment, the following dependencies were investigated

$$Q = f(U), m^3/h; \qquad \eta = f(U), \%.$$

In the experiment, the kinetics of reducing the average concentration of smoke in an experimental chamber in a volume of 1 m^3 was investigated. The scheme of the laboratory installation is shown in Fig. 2.

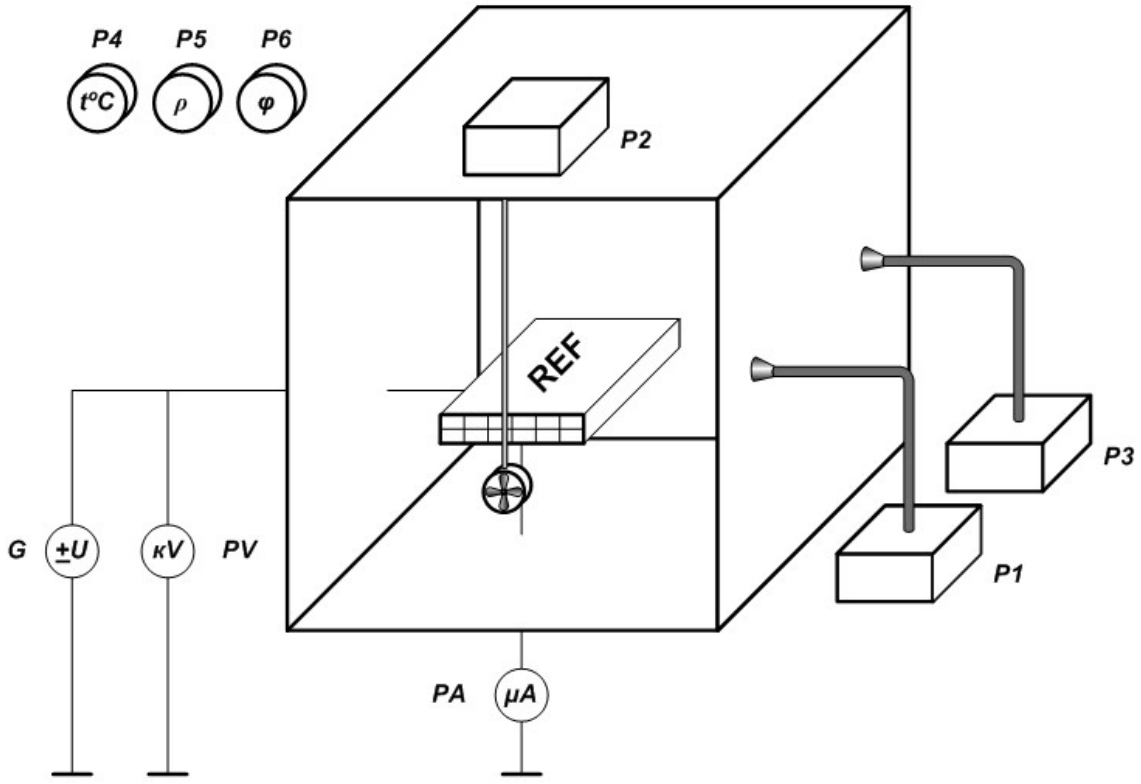

Fig. 2. Scheme of laboratory installation: G – high-voltage source of positive and negative voltage AKI-50; REF – module of recirculation electro filter; PV – kilo voltmeter C196; PA – micro-ammeter M-906; P1 – analyzer of aerosols AZ-5; P2 – anemometer AP-1; P3 – smoke generator; P4 – thermometer; P5 – barometer; P6 – psychrometer

The laboratory unit consisted of: laboratory sample REF, high-voltage voltage source AKI-50 (G), electrostatic kilo voltmeter C196 (PV),

microampermetric M906 (RA), aerosol recorder AZ-5 (P1), anomometer AP-1 (P2) and smoke generator (P3). In addition, a combined device BM-2 (P4-6) was used to measure temperature T, relative humidity φ, and air pressure ρ. During the experiments, these parameters changed in the following ranges: T – 20...24°C, φ – 50...70%, ρ – 715...738 millimeters of mercury pillar. It is established that the change in temperature, humidity and air pressure in these ranges does not significantly affect the work of REF. Therefore, in the research methods, the values T, φ and ρ were not used.

The dependence of the velocity of the electric wind in the REF and the dependence of the degree of air purification on the stress of the corona discharge are given in Fig. 3 and 4 respectively.

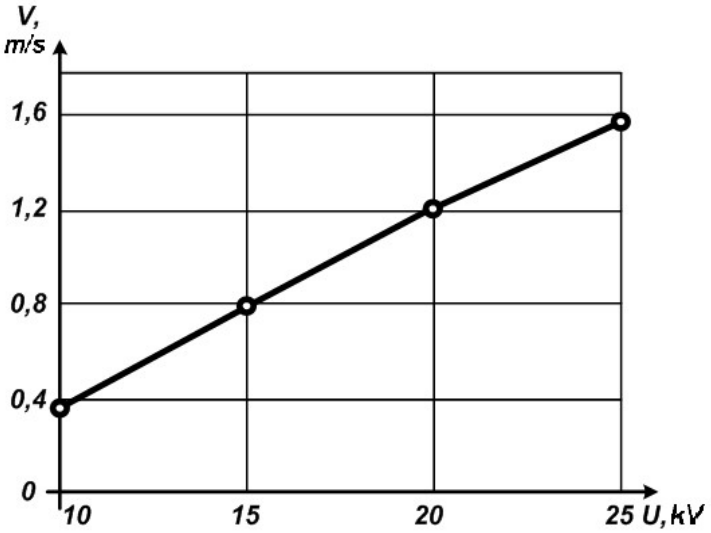

Fig. 3. The dependence of the speed of electric wind on the voltage of the corona discharge

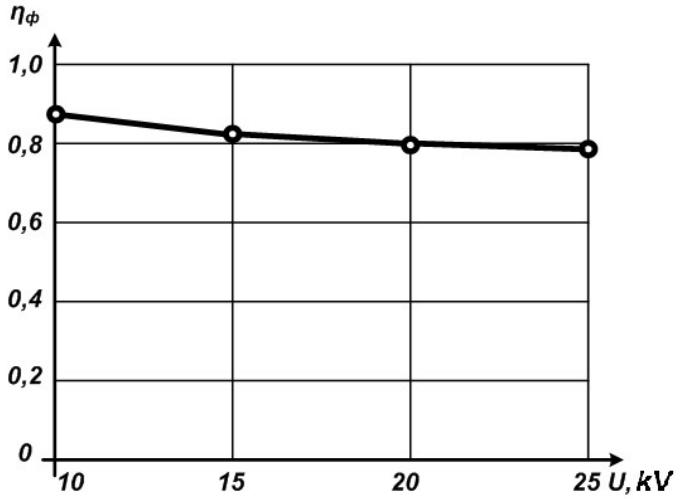

Fig. 4. Dependence of the degree of air purification in the REF from the voltage of the corona discharge

To evaluate this or that type of corrosion electrodes, it is necessary to have data on the efficiency of a cleaner that uses one or another crowning system. At

the same time, the type of corona electrodes is the best, which provides the maximum amount of purified air while preserving the degree of its purification.

In this regard, the following dependencies were investigated in the work for the assessment of the quality of needle crowning electrodes

$$Q = f\ (\ell, \alpha, U, \beta - \text{const}); \quad Q = f\ (\alpha, \ell, U, \beta - \text{const});$$

$$Q = f\ (U, \alpha, \beta, \ell - \text{const}); \quad Q = f\ (\beta, \alpha, \ell, U - \text{const}).$$

Experimental studies have found that, with increasing length ℓ of the vertex to certain values, the current of the corona discharge I_k reaches saturation, and the subsequent increase in the length of the tip practically does not affect its magnitude. At the same time, with an increase in the angle of the taper α of the edge, the minimum coronation voltage increases and the current I_k of the corona discharge decreases. In this regard, when choosing the length of the needle crowning electrodes as a criterion, it is advisable to take the optimum ratio between the productivity of the Q filter and its mass-dimensional characteristics. So, for this design of the filter and its modes, the optimal length is optimal. Sacrificial crowning electrodes should be within 30 ± 5 mm. Taking into account the technology of making the needle crowning electrodes, the optimal angle is α_{opt}. The conicity of the edge, within which there is observed the maximum productivity Q at the minimum voltage on the crowning electrodes, must be within the range of 20 ± 3°, and the optimal angle β_{opt}. between electrodes in each section of the filter – 25 ± 5°.

Conclusions. Studies have shown preference to use REF needle corona electrodes are compared to provide a wired high speed electric wind that corresponds to the higher productivity cleaner. This can increase the stability of output parameters and operational reliability REF while maintaining the established degree of purification allege in cells emergencies.

The design of crowning system with needle corona electrodes and the optimum geometrical parameters for the last recirculating filter on the principle of electrical wind.

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Дослідження системи коронуючих електродів рециркуляційних фільтрів для видалення диму

На основі результатів експериментальних досліджень електричних та аеродинамічних характеристик лабораторних зразків рециркуляційного фільтру на принципі електричного вітру з голчатими коронуючими електродами, визначені оптимальні геометричні параметри останніх та розроблені рекомендації щодо їх використання для очистки від небезпечного аерозольного забруднення в осередках надзвичайних ситуацій.

Ключові слова: надзвичайна ситуація, аерозольне забруднення, рециркуляційний електричний фільтр, гольчатий коронуючий електрод.

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Исследование системы коронирующих электродов рециркуляционных фильтров для удаления дыма

На основе результатов экспериментальных исследований электрических и аэродинамических характеристик лабораторных образцов рециркуляционного фильтра на принципе электрического ветра с игольчатыми коронирующими электродами, определены оптимальные геометрические параметры последних и разработаны рекомендации по их использованию для очистки от опасного аэрозольного загрязнения в очагах чрезвычайных ситуаций.

Ключевые слова: чрезвычайная ситуация, аэрозольное загрязнение, рециркуляционный электрический фильтр, игольчатый коронирующий электрод.