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TRIBOELECTRIC DUST COLLECTOR

Kuznietsov S.I.
Kherson National Technical University
Beryslavske highway, 24, 73008, Kherson
ksieko@rambler.ru

Many production processes are associated with the formation of dust. The main danger to the human body is small solid particles, which are not retained by the upper respiratory tract and freely penetrate into the lungs. Therefore, the problem of trapping fine dust is given special attention. For highly efficient air purification, a triboelectrostatic dust collector design has been developed that is capable of capturing finely dispersed (aerosol) dust of any origin. The mathematical dependences for the optimal geometric dimensions and the ratios of the apparatus are determined. *Key words:* triboelectrostatic dust collector, very fine dust, air cleaning.

Трибоелектростатичний пиловловлювач. Кузнєцов С.І. Велика кількість виробничих процесів у промисловості пов'язана з утворенням пилу. Основну небезпеку для організму людини представляє дрібнодисперсний пил, який не затримується у верхніх дихальних шляхах і безперешкодно проникає у легені. Тому проблемі уловлювання дрібного пилу приділяється особлива увага. Для високоефективного очищення повітря розроблено конструкцію трибоелектростатичного пиловловлювача, здатного вловлювати дрібнодисперсний (аерозольний) пил будь-якого походження. Визначено математичні залежності для оптимальних геометричних розмірів і співвідношень апарату. *Ключові слова:* трибоелектростатичний пиловловлювач, дрібнодисперсний пил, очищення повітря.

Трибоэлектростатический пылеуловитель. Кузнецов С.И. Многие производственные процессы связаны с образованием пыли. Но основную опасность для организма человека представляет мелкодисперсная пыль, которая не задерживается верхними дыхательными путями и беспрепятственно проникает в легкие. Этой проблеме уделяется особое внимание. Для высокоэффективной очистки воздуха разработана конструкция трибоэлектростатического пылеуловителя, способного улавливать мелкодисперсную (аэрозольную) пыль любого происхождения. Определены математические зависимости для оптимальных геометрических размеров и соотношений аппарата. *Ключевые слова:* трибоэлектростатический пылеуловитель, мелкодисперсная пыль, очистка воздуха.

All human life is in the air environment. Atmospheric air is a vital component of the environment, an integral part of the human habitat.

A large number of industrial processes in the industry is associated with the formation of dust, which pollutes the air of the working zone and far beyond the enterprises that emit dust.

Dust particles larger than 8-10 microns when inhaled in the lungs do not get through the natural self-defense of the respiratory organs of a person. The main danger to the human body is the size of solid particles, which is less than 8 microns. Therefore, the problem of catching fine dust is paid special attention.

Purification of gases leaving from suspended solid particles before entering the atmosphere prevents air pollution, allows the return to production of useful substances and dispose of harmless and hazardous dust without harm to the environment.

The developed equipment can be used in chemical, textile, metallurgical and other branches of industry, which throws gases containing small dust into the air pool.

Known designs of electrofilters for capturing solid or liquid particles. The design of the electrofilter is quite complex, it consists of a number of corona and precipitating electrodes, located in an isolated case. To ensure the operation of a high-voltage DC source. As practice shows, the efficiency of electric filters is 92-96% and the higher it is, the larger overall dimensions should be in the equipment. For example, if you want to capture small particles with an efficiency of more than 95%, the height of the device should not exceed 3 meters [1].

The disadvantages of electrofilters should also include their high cost, cumbersome, complexity of manufacture, as well as the need for periodic restoration of their filtering properties [2]. In addition, it is not possible to capture particles of flammable materials in the electrostatic cells due to the danger of their ignition.

Known designs of electrostatic filters, the principle of which is based on the capture of solid particles by the surface of electrodes, with electrostatic charge. The disadvantage of electrostatic filters is the need to install high voltage power supply, the complexity of manufacturing.

The aim of the research is to develop a design for a triboelectrostatic dust collector capable of effectively capturing fine particles of any origin.

The design of a multi-disc triboelectrostatic dust collector [3], (Fig. 1), has high productivity, high efficiency and low cost. To create an electric field in a filter, a tribo effect that occurs due to friction of dielectrics is used, and eliminates the need to use a high-voltage power supply.

The design of a triboelectrostatic dust collector consists of a number of parallel disks – electrodes 2, fixed on a common shaft 3. A shaft with drives mounted on it is driven to rotate from an electric motor 7 through reducer 6. Disks are in contact with fixed brushes 4. The system of rotating discs with brushes may have open

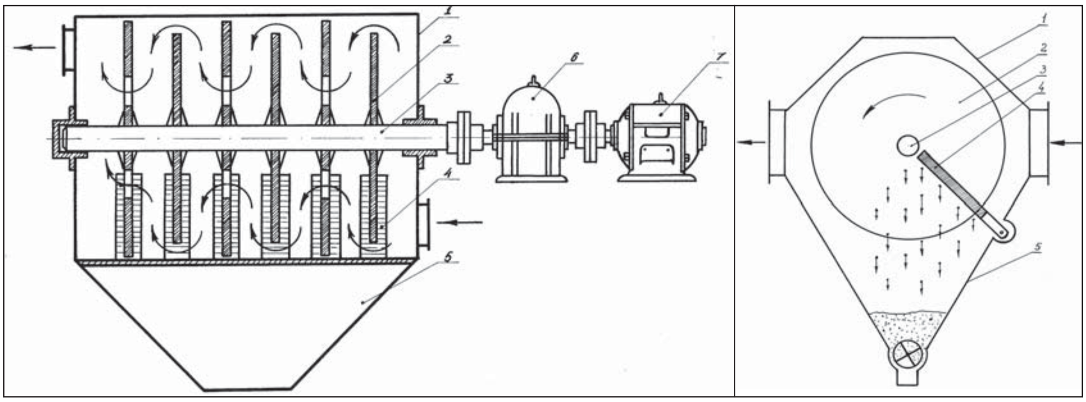

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Fig. 1. Multi-disc triboelectrostatic dust collector:
1 – case, 2 – disks electrodes, 3 – shaft, 4 – brushes, 5 – dust bin, 6 – reducer, 7 electric motors

performance when contaminated gas is forced into the electrostatic filter. In any case, the bottom of the filter is installed bunker 5 to collect the caught dust.

Any dielectrics can serve as material for the production of disks. The most suitable for this purpose are polystyrene, organic glass, polyvinyl chloride, fiberglass, fluoro-layer and other materials that have a high ability to electrify from friction. Brushes can be made of felt, nylon yarn, fiberglass, bristle, cloth, fur and other materials.

When rotating the discs and rubbing them around the stationary brushes, static electricity occurs on the disk surface, and electrostatic field between the disks. The dust particles are forced to or freely enter the apparatus and fall into the electric field. Due to the effect of polarization and charging, the dust is attracted by the surface of oppositely charged disks, deposited on them, and with the help of brushes 4, they are cleaned into a dust collecting hopper 5.

The electrostatic field is created immobile in space and unchanged in time by electric charges, thus electric current is absent. It is a special kind of matter that transmits the actions of charges to each other [4].

Electrostatic discharge occurs at very high voltage and very low current. The voltage of tens of thousands of volts under the current, which is measured by thousands of amperes, can not be felt by the touch [5]. The low current values do not allow static charge to cause harm to a person, which is a great advantage of a tribo electrostatic dust collector.

To prevent the drainage of the charged charges from the disk surface, the shaft must be made of dielectric or insulating devices.

The device can be connected to the gas outlet in two ways. The flow of dusty gas can be: I – perpendicular and II – along the axis of rotation of the disks. In the second case, the supply of polluted gas is carried out through the side connector. The gas passes through the radial gap between the first (in the course of gas) the disk and the casing, and then moves from the periphery to the center between the first and second disk. Then the gas passes through the central openings in the second disk and drives from the center to the periphery between the second and third discs. Thus, the gas passes consecutively between the discs and through the side connector is output from the opposite end of the device. To ensure the flow of gas through a dust collector in all paired disks, in the central part of them, holes for gas passage are made, and the clearance between these discs and the filter housing should be minimal. Odd disks are executed continuously, and the clearance between the disk and the casing should provide unobstructed passage of gas.

With the jacket removed (Fig. 2), the dust collector can be installed in an open drained room or in a dust source. In this case, particles are attracted to disks with a distance of 3 – 5 m.

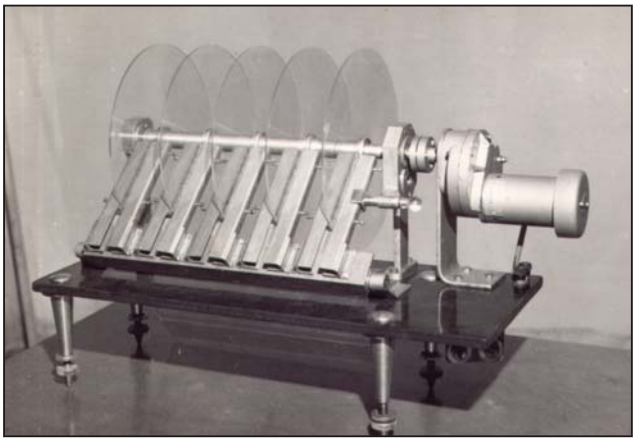

Fig. 2. Ttriboelectrostatic dust collector of open type

The performed tests showed that the apparatus of the described design intensively traps dust of various substances of organic and inorganic origin: coal dust, ash, cement, carbon black, sodium chloride, potassium chloride, sulfite and sodium sulfate, quartz, phosphorites, superphosphates, gypsum, phosphorous flour, ammonia nitrate, ammonium sulfate, chalk, limestone, meadow and many other substances. From organic substances, cotton, hemp and jute dust, particles of other textile

Table 1

Results of filter testing at cleaning (100 m^3) air from some impurities

	The name of the dust	Air trapping, g/m^3		Degree of air purification
		Exit	Entrance	
1	Cement	1,5	0,013	99,8
2	Cooking salt	2,3	0,01	99,6
3	Urea	3,2	0,01	99,8
4	Cotton dust	0,8	0,00	100,0
5	Superphosphate	1,4	0,006	99,6
6	Ammonium nitrate	2,8	0,006	96,8

fibrous materials, as well as flour, sugar, oxalic acid, urea, sulfosal, etc. are well captured.

Mathematical dependencies for determining the optimal geometric sizes and ratios of dust collector.

1. The diameter of the disc depends on the performance of the dust collector and can be determined by the empirical formula:

$$D = \sqrt{\frac{Q}{3600 \cdot V}} \text{ m},$$

where: Q – amount of cleaned air, $м^3/h$;

V – air speed in the machine, м/s; V = 0,5 – 2,0 m/s.

2. The distance between the disks is:

$$l = 0,2 \cdot D$$

3. The number of disks is calculated by the formula:

$$K = \frac{D}{l} \text{ pcs},$$

4. The speed of the disk rotation is determined by the formula:

$$n = \frac{60 \cdot \omega}{\pi \cdot D}, \text{ min}^{-1}$$

where: ω – Circular disk speed (according to research data ω = 1-5 м/s).

When installing a dust collector in open spaces, the number of discs is not limited.

Based on the derived formulas, the optimal geometric dimensions of the apparatus are calculated. To clean 100 m^3/h of gas containing various impurities, a laboratory prototype has been designed that has the following dimensions:

Drive diameter:

$$D = \sqrt{\frac{100}{3600 \cdot 0,5}} = 0,246 \text{ m}$$

Accepted D = 0,25m.

Distance between drives:

l = 0,2 ·0,25 = 0,05m

Quantity of disks:

$$K = \frac{0,25}{0,05} = 5$$

Speed of rotation of disks:

$$n = \frac{60 \cdot 1}{3,14 \cdot 0,25} = 77 \text{ min}^{-1}.$$

The triboelectrostatic dust collector consists of 5 disks made of organic glass with a thickness of 5 mm and a diameter of 250 mm. The distance between the disks on the shaft is 50 mm. Speed of rotation of disks 77min^{-1}. Material of brushes – felt. An engine 30W is installed to rotate the rotor. The results of the test of the filter when purifying the air from some impurities are shown in table 1.

Conclusions.

The triboelectrostatic dust collector is able to effectively clean gases from extremely light and small particles, the size of which may be less than 0.01 μm, to safely capture flammable, explosive, conductive dust at low gas pressure.

The working parts of the dust collector are not susceptible to corrosion from the action of acids, alkalis and other aggressive media, since they are made of nonmetallic materials, and there are no electromagnetic fields dangerous to human health.

The cost and operation of the triboelectrostatic dust collector is lower than that of the electrofilter, the design of the apparatus is easy to manufacture, durable, reliable, safe in operation, does not require installation of a high-voltage power supply, the use of scarce materials, easy to maintain.

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