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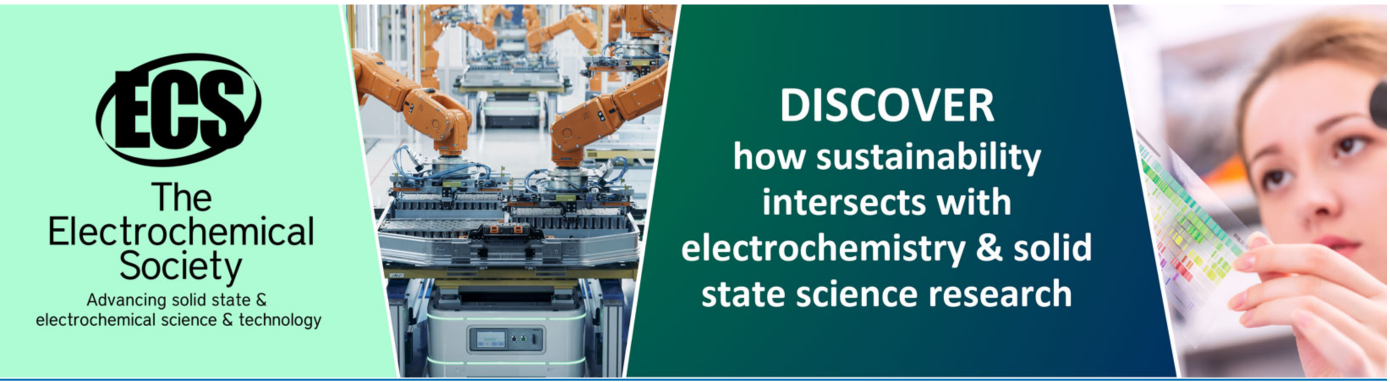

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# Improving the air cleaning devices from Thesolid fine aerosols

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**Abstract.** The industrial processes are noticed to be accompanied by the contaminators' emission inter alia the high-dispersion aerosols. To reduce the amount of the dust emitted into the atmosphere, it is advisable to provide the cleaning devices installation as a part of exhaust ventilation systems. Entrapped substances may be recycled or returned back to production, and it's especially valuable if rare and expensive row materials are used in manufacturing. Trapping aerosols of fine dispersion with simple and reliable mechanical devices with low energy consumption is quite important. The proposed apparatus for the dust particles cleaning emissions is with a dispersion of 0,1 µm. Device operation is based on enlargement and following entrapment of solid fine particles on slabs perforated by the way of chinks and irrigation water contaminated air by the nozzles with the particulate composition of from 2,0 to 10 µm. The chinks width on the first and the second slabs, displacement of chinks hole axes of the first and the second slabs relative to each other and distance between slabs ensure creation of increased coagulation and stable sedimentation of particles are discovered.

## Introduction

Great amount of industrial processes is accompanied by the contaminators emission, thrown out to the atmosphere by vent systems. It promotes not only pollution of air basin, but valuable resources expenditure in case of using expensive row materials. That's why it seems practical to provide cleaning devices as a part of exhaust ventilation systems which may decrease human-induced disturbance on atmosphere and get handy components back to production loop [1-4]. Considering that a part of pollutants is released in the form of fine dispersion aerosols, the trapping of which is accompanied by certain difficulties, the development or improvement of air purification devices is urgent. Moreover, mechanical devices simple in design, installation and maintenance of which are cheaper and more reliable, are preferable to complex technical systems.

There are a sufficient number of devices for air purification from dust, the principle of which is based on the inertial mechanism of deposition [1]. But a significant part of them is used for cleaning from fairly large aerosols (d> 10 µm). The efficiency of the device for air purification from fine dust is low, so the task of creating a simple mechanical device capable of trapping small particles of dust is quite relevant.

## The essential theoretical dependencies used in design

The effectiveness of any device for cleaning air from aerosols is determined by the specific mechanisms of deposition, due to the design features of the device. Particles can be captured due to the effects of diffusion, inertia, contact, sedimentation, electric forces, turbulence, etc.

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In specific devices, one or two precipitation mechanisms are decisive. For the devices, the deposition of particles in which is caused by inertial forces, the mathematical description of this process is based on the Stokes criterion (St), which characterizes the inertial force ratio acting on a particle to the medium hydraulic resistance force [2, 3].

The criterion for the particles inertial deposition similarity, the Stokes criterion is determined by the well-known formula:

$$Stk = \frac{v_g \rho_p d_p^2 C_k}{18\mu_g l}, \qquad (1)$$

where: $v_g$- is flow velocity incident on the obstacle, m/s; $\rho_p$ – is particle density, kg/m$^3$; $d_p$– is a particle diameter, m; $C_к$–is a Cunningham-Millikan amendment; $\mu_g$ – is dynamic viscosity of gas, Pa·s; $l$–is the characteristic dimension of the obstacles, m.

The aerosols inertial deposition is possible when the Stocks criterion outnumbers the “critical” amount $Stk_{lim}$, which is contingent on the type of hindrance.

The aerosol particles deposition efficiency from jets (rectangular and round) incident on the plates (jet impactors, impact separators) on cylindrical and spherical collectors located in aerosol streams (fiber filters, gas scrubbers) is determined by inertial mechanisms as a function of the Stokes number: $\eta = f(\sqrt{Stk})$ [5,6]. The amount $\sqrt{St_{кр}}$ under precipitation of particles on plates for the circular jets, proportioned to their total extraction from two-phase stream, reach, by data of researches [5], 0.58; for right-angled jets – 0.82. The particles precipitation is hardly in evidence if $\sqrt{St_{кр}}$ is less than 0.2 for circular jets, and $\sqrt{St_{кр}}$ is less than 0.3 for right-angled jets. The studies to determine the capture efficiency of aerosol at air velocity in holes (chinks) is 10÷180 m/s found that changing of distance between the hole in the first plate and the surface of the second plate, within the limits of 1 to 3 equivalent diameters of holes, has no effect on the findings.

Minimal diameters of particles $d_{min}$, which will be deleted from the flow, determined by using calculated criteria $Stk_{lim}$:

$$d_{\min} = \sqrt{\frac{18\mu_g Stk_{\lim} l}{v_g \rho_p}}. \qquad (2)$$

For all cases of inertial deposition of particles considered, the capture efficiency is proportional to the diameter of the particles $d_p$. In other words, it is necessary to create conditions conducive to an increase in the particle diameter, for example, an increase in the turbulence of the air flow, which promotes the coagulation of particles.

The rate of turbulent coagulation is a quantity that contributes to the number of encounters of particles per unit volume per unit of time, (1/m$^3$·s) – occurring due to the so-called “acceleration mechanism” is determined by the formula [7]:

$$N = \pi \frac{\rho_p}{\rho_g} n_0 \frac{\varepsilon_T^{3/4}}{v_g^{5/4}} \beta d_{pm}^4, \qquad (3)$$

where: $n_0$ – is the initial concentration of particles, 1/m$^3$; $\varepsilon_T \approx v_g^3 / l_t$ - is quantity characterizing the turbulent flow, m$^2$/s$^3$; $l_t$ – is a linear parameter (for pipe l is equal to its diameter), m; $\nu_g$– is gas

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kinematic viscosity, m$^2$/s; $\beta$ – is the coefficient characterizing the particle size distribution; $d_{pm}$ – is the middle particle size, m.

**The device operation principle**

Based on the above-mentioned dependencies, an apparatus for cleaning air from fine aerosols is proposed (Figure 1).

Contaminated air entering the device through the inlet is irrigated with water. Then a three-phase flow consisting of air, dust particles and water passes through a separator of fine particles consisting of two parallel plates with slotted holes, the axes of which are displaced (Figure 2). When a three-phase flow passes through the first separator plate slots, turbulent coagulation (mutual) of dust particles and water splashed by a nozzle (nozzles) occurs due to turbulence of the flow in streams with a small turbulence scale, which leads to coarsening of the particles. The air flow, breaking from the sharp edges of the slit holes of the first plate, with great speed rushes to the interstitial areas of the second plate.

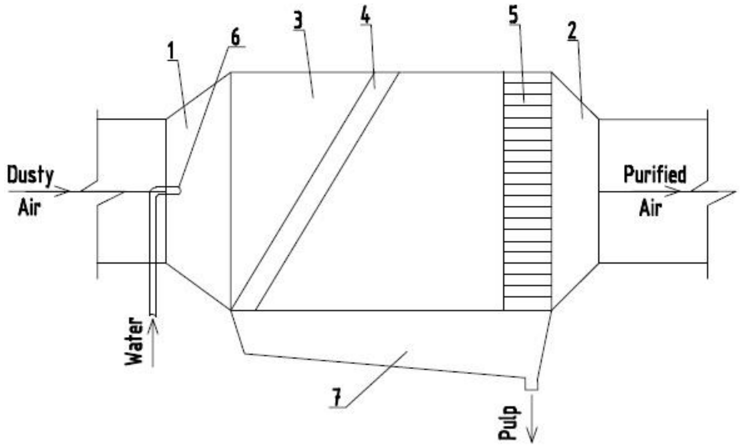


**Figure 1.** Device for air cleaning from fine solid particles: *1* - inlet branch pipe, *2* - outlet branch pipe, *3* - device body, *4* - separator, *5* - louver drip catcher, *6* - injector, *7* - tray for pulp.

When running a jet on the second plate, the boundary layer which has a high viscosity to the components of the jet is formed. Viscosity is formed due to sedimentation and mixing of particles of water and dust (including enlarged) on the surface of the second plate.

The first plate contributes to the separate plane-parallel streams formation with a small scale of turbulence, which promotes the mutual coagulation of dust particles and water sprayed by nozzles, and also ensures the coagulation of aerosols with the speed of coagulated aerosols on the second plate.

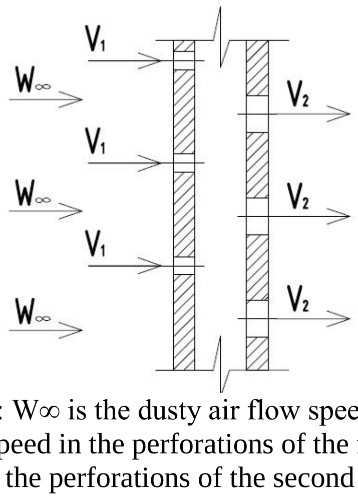


**Figure 2.** The dusty air flow pattern: W∞ is the dusty air flow speed in the device body in front of the first plate, V1 is the dusty air flow speed in the perforations of the first plate, V2 is the purified air flow speed in the perforations of the second plate

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## Results and discussions

The proposed device allows to remove the fine dust particles of with a dispersed composition of more than 0.1 micron from a stream of dusty air.

Improving the reliability of the device and the efficiency of air purification is achieved by perforation of the separator plates in the form of longitudinal vertical slits and irrigation of polluted air with water through nozzles with a dispersed composition of water particles from 2.0 μm to 10 μm. The living section of the slots of the first plate provides a plane-parallel jet motion of the flow and rushing it onto the second plate at an angle of 90 °.

Experimental studies have shown that the increased coagulation mode and the particles stable deposition is observed with the slit width of the first plate b1 = 4 mm, the distance between the centers of the slit holes is (6 ÷ 8)) b1, the width of the slits of the second plate (2.0 ÷ 2.5) · b1, the distance between the plates is equal to (1.5 ÷ 2.0) · b1 and the offset of the axes of the slit holes of the first and second plates relative to each other.

Due to the coagulated particles moistened with water flow, under the gravity action into the sludge pan, the separator plates are self-cleaning, which do not become clogged and do not require frequent device stopping for their cleaning.

Perforation of the separator plates, made in the form of longitudinal vertical slots, and their installation at an angle of 30-60 ° reduces the aerodynamic resistance, and, consequently, reduces the energy consumption of the device during its operation.

## Summary

The proposed device can be used in chemical, textile, food, light and other industries to clean the ventilation and process emissions from the dust particles with a dispersion of 0.1 microns formed in technological processes. The device operation is based on the enlargement and subsequent capture of solid fine particles, using a simple and reliable design, with low aerodynamic drag and reduced energy costs. The captured substances can be recycled or returned to production.

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