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Wet Method Dust Gas Cleaning Device

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ABSTRACT

The article studies the design and principles of operation of wet dust collectors widely used in industry, analyzes their advantages and disadvantages, and also develops a new design of cone-mesh wet dust collectors. As a result of the theoretical studies carried out, equations were derived that calculate the total pressure lost during the transfer of dusty air into the device and the dispersion of liquid from the nozzle. Depending on the total pressure supplied to the device by dusty gases and liquids, it is possible to determine the efficiency of cleaning dusty air.

KEYWORDS

Dusty Gas, Wet Method, Liquid, Mesh Drum, Electric Motor, Pulley, Belt, Support, Water Tank.

INTRODUCTION

Wet purification of dust gases generated in the production process is widely used around the world in various industries of chemical, building materials, metallurgy, mining and other industries. A distinctive feature of their use is that the device cleans the dusty gas by making contact of the gas and airborne dust particles with the liquid, which are directed to the cleaning chambers.

With the advantages of wet cleaning of dust gases, simplicity and relative cheapness of construction, high cleaning efficiency compared to inert type dry mechanical dust cleaning devices, small size compared to fabric and electric filters, can be used for cleaning high temperature, high humidity gases and explosive gases stands out. It can also be said that the composition of vapor and gaseous components has a high chance of trapping solid particles. The use of these devices is currently increasing due to their ability to trap dusts smaller than 1 μm and can also be used in the process of cleaning dusty gases from dry filters [1].

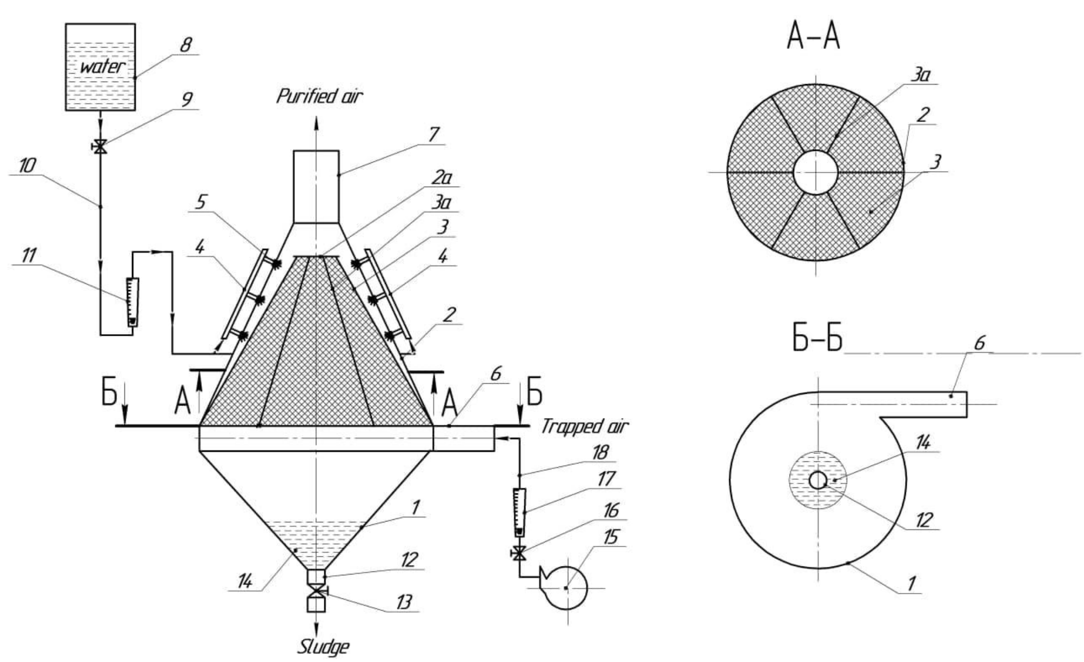
In addition to cleaning dusty gases from these devices, it is also used when it is necessary to cool and humidify the gases.

At present, the industry uses wet-powered vacuum cleaners with devices of various constructions. Including: felod scrubber, wet gas dust cleaning device, centrifugal inertial dust cleaner, rotor bubble gas cleaner, rotary disk apparatus CHPOSVUCHZ, rotor spray gas cleaner, porous rotary rotary conveyor, rotor distributor dust cleaner 2,3,4] .

If we analyze these devices in terms of design structure and efficiency, the cleaning rate of various industrial dusts is 97-99%. However, the complexity of the structural structure can indicate the high hydrodynamic and aerodynamic resistances in the energy consumed by them and the apparatus as a common shortcoming [5].

OBJECT OF RESEARCH

In order to overcome the above-mentioned shortcomings and increase the contact surface between the dust gases and the liquid supplied to the apparatus, a new design of the grid apparatus for wet dust purification is recommended. The structure and principle of operation of the device are described below (Figure 1)



1 ¬ bottom conical sludge bath, 2 ¬ upper conical cleaning chamber, 3 ¬ conical grid, 3 ¬ µ grid support, 4 ¬ sprinkler nozzle, 5 ¬ water distribution pipe, 6 ¬ dust gas inlet pipe, 7 ¬ purified gas outlet pipe, 8 ¬ water tank, 9 ¬ water jet, 10 ¬ water pipe, 11 ¬ water rotameter, 12 ¬ sludge drain pipe, 13 ¬ sludge jug, 14 ¬ sludge, 15 ¬ dust fan, 16 ¬ dust air jet, 17 ¬ dust Rotameter, 18 ¬ dust gas transmission pipe.

Figure 1. Schematic diagram of a wet-powered grid

The structure of the device is as follows. The device consists of a bottom conical sludge bath 1 and an upper cut conical cleaning chamber 2, on the inside of which is mounted a conical mesh 3. This grid is attached to the base 3a. Nozzles 4 serve to spray water into the treatment chamber 2, and these nozzles are supplied through a water distribution pipe 5. Pipe 6 serves to enter the dust gas cleaning chamber and pipe 7 serves to remove the purified gas from the apparatus. Water is transferred to the treatment chamber from the vessel 8 through the tap 9 through the pipe 10 and the water rotameter 11. The sludge generated in the apparatus is poured through the discharge pipe 12 using the sludge jug 13. Dusty gases are fed to the cleaning chamber by means of a fan 15 through a nozzle 16 and a rotameter 17, and a dusty gas supply pipe 18.

The device works as follows. The cleaning chamber of the apparatus is supplied with special dust pipes 18 and 6 by means of a dust gas fan 15 through a nozzle 16 and a rotameter 17. During the movement of the dusty gas pipe 6 rotates in a test position on the walls of the apparatus and the speed decreases. Large-sized dust particles sink to the bottom conical sludge bath 1 under the action of centrifugal force. The fine-grained dusty gas rises to the upper conical cleaning chamber 2. Simultaneously, water is transferred from the water tank 8 through the pipe 11 to the cleaning chamber 2, and through the distribution pipe 5 to the nozzles 4. Water from the nozzles 4 is sprinkled along the surface of the cut conical grid 3 mounted on the cleaning chamber. This creates contact of the dusty gas with the water droplets sprinkled on the grid and the gas is cleaned of dust. The water consumption sprayed on the grid is controlled by a tap 9 and a rotameter 10. Dust is absorbed into the water droplets and sinks to the bottom sludge bath under the influence of gravity. The purified gas rises to the top of the conical chamber and is released into the atmosphere through pipe 7. The sludge collected in the bottom conical sludge bath of the apparatus is drained through the discharge pipe 12 by means of a sludge nozzle 13 and the water is separated by distillation.

The consumption of water coming out of the hole of the nozzle 4s, which sprinkles water on the truncated conical grid 3, depends on the resistance coefficient of the hole and is determined experimentally. The number of nozzles 4 s is selected by the degree of spraying water on the conical grids and the cleaning efficiency. The diameter and height of the conical cleaning chamber 2 and the base of the truncated conical mesh are determined depending on the consumption of dusty air supplied for cleaning and the cleaning efficiency of the selected mesh. The ratios of dusty air and water flow to the device are determined experimentally by means of cleaning efficiency indicators depending on the resistance coefficients of the cleaning conical grid. The height of the vessel 8 installed to supply water to the device is determined by the value of the static pressure of the water, which is sufficient to spray the water in fine particles and form a level of contact with dusty air in the cleaning chamber of the device, depending on the coefficients of resistance.

RESEARCH METHODS

Theoretical research was conducted to calculate the apparatus. The calculation scheme of the device is shown in Figure 2, and the total lost pressure in the device for sections I – I and II-II can be written as, Pa;

$$\Delta P_{ум} = P_1 + P_2 + P_3$$

where P1 is the pressure lost due to internal friction in the transmission of dusty air through the pipe to the device, determined according to the Darcy-Weisbach formula, Pa [6,7,8];

$$P_1 = \left(\lambda_1 \frac{2l_1}{D + d_1} \right) \cdot \rho_{см} \cdot \frac{\omega_{см}^{\;2}}{2}$$

where l1 ¬ is the coefficient of friction with the wall of the pipe conveying the dusty gas to the device, l1 ¬ is the length of the pipe moving the dusty gas, m; D ¬ diameter of the base of the conical grid, m; d1 ¬ pipe diameter, m; tezligism ¬ velocity of the mixture of dust and air moving in the pipe, m / s; rsm ¬ is the density of the dusty air mixture, which is determined by the following equation [2,3,9,10], kg / m3;

$$\rho_{см} = \rho_г + (\rho_ч \cdot \gamma)$$

where rg ¬ air density, kg / m3; rp ¬ dust density, kg / m3; Percentage of dust in the air,%.

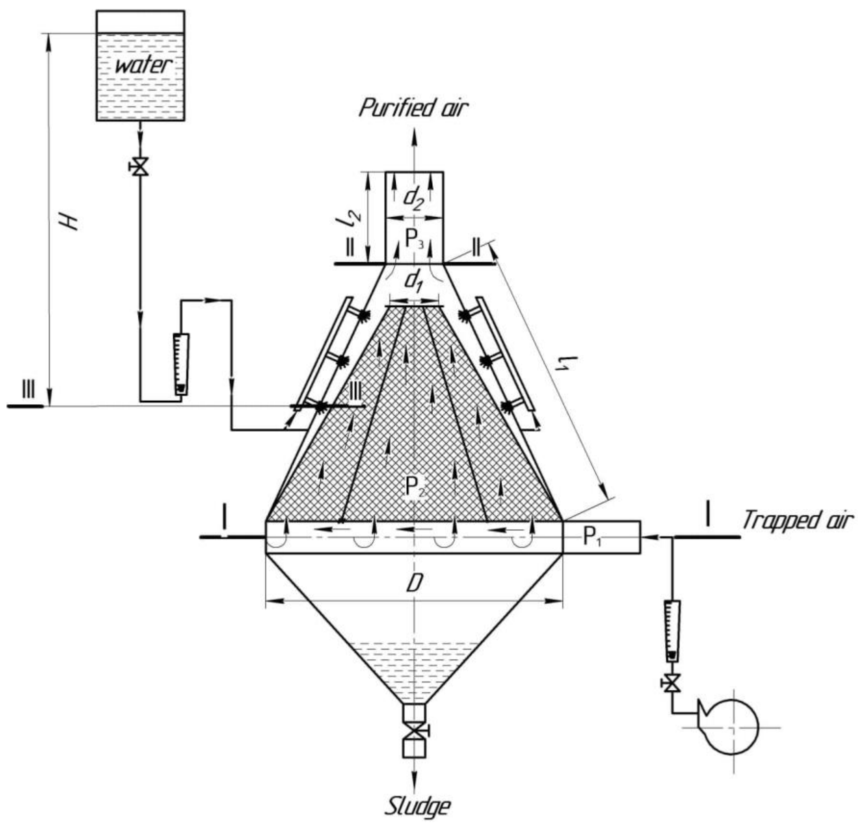


Figure 2. The calculation scheme of the device

The coefficient of friction l1 depends on the flow regimes of the dusty gas in the pipe and is determined as follows when Re ≤ 2320 for the laminar mode;

$$\lambda = \frac{64}{\text{Re}}$$

When the flow mode is 2320 <Re <4000, it is defined as follows

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$$\lambda = 0{,}0025\mathrm{Re}^{0{,}333}$$

For smooth pipes, 4000 <Re <10000 is defined as follows

$$\lambda = \frac{0{,}3164}{R^{0{,}25}}$$

P2 is the pressure lost as the dusty air passes through the drum mesh holes, defined as Pa;

$$P_2 = \xi_c \frac{\rho_{см} \cdot \omega^2{}_{см}}{2}$$

where $\omega_{см}$ - is the velocity of the dusty air mixture on the surface of the drum grid, м/с; ξ_c - is the coefficient of resistance of the drum grid, which is determined as follows. From Figures 1 and 2, the total resistance coefficient of the truncated conical grid on sections A-A is determined as follows, m2, depending on the total surface area of the grid through which the dusty air passes and the diameter of the grid wire and the square hole size of the grid;

$$\xi_c = \Delta k \left[\pi (R + r) \cdot l_c \cdot \frac{d}{a} \right]$$

where Δk ¬ is the correction factor, determined experimentally, R ¬ is the radius of the base of the conical grid, m; r ¬ radius of the cut part of the conical grid, m; lc ¬ average value of the circumference of the base of the grid and the circumference of the cut part, m; d ¬ net wire diameter, m; a ¬ square hole size of the grid, m.

The optimal values of the dimensions of the mesh holes to be installed are determined by experiments.

The pressure P3 lost due to internal friction in the pipe discharging the purified air from the device is also determined by the Darcy-Weisbach formula, Pa;

$$P_3 = \left(\lambda_2 \cdot \frac{l_2}{d_2} \right) \cdot \rho \cdot \frac{\omega^2}{2}$$

where l2 is the coefficient of friction in the pipe that releases the purified air into the atmosphere (calculation method is given above), l2 ¬ is the length of the pipe through which the purified air moves, m; d2 ¬ pipe diameter, m; r ¬ density of purified air, kg / m3; tezligi ¬ velocity of purified air moving in the pipe, m / s.

Now if we put equations (2), (7), (8), (9) into the 1st equation, the equation for calculating the total lost pressure in the device looks like this, Pa;

$$P_{об} = \left(\lambda_1 \cdot \frac{l_1}{d_2} \right) \cdot \rho_{см} \cdot \frac{\omega_{см}{}^2}{2} + \Delta k \left[\pi (R + r) \cdot l_c \cdot \frac{d}{a} \right] \cdot \frac{\rho_{см} \cdot \omega^2_{см}}{2} + \left(\lambda_2 \cdot \frac{l_2}{d_2} \right) \cdot \rho \cdot \frac{\omega^2}{2}$$

Consider the effect of pressures through section III-III in the hole of the nozzle that is spraying water into the device (Fig. 2).

Accordingly, the pressures in section III-III are equal to, Pa;

$$\Delta P_c = P_c + P_\partial$$

where Ps is the geometric pressure inside the pipe through which the liquid flows, which is determined by the following equation [4,5], Pa;

$$p_c = \rho g H$$

where r is the density of the liquid, kg / m3; g - free fall acceleration, m / s2; H is the height of the liquid level, m.

Pd is the lost pressure at the outflow of fluid from the hole, which is defined as [6,12,13], Pa;

$$P_\partial = \xi_ш \frac{\cdot \upsilon_c^2 \cdot \rho_c}{2}$$

where ys is the velocity of the liquid flowing out of the hole, m / s; xsh is the coefficient of resistance of the liquid flowing out of the nozzle hole, which is determined experimentally by the thickness d of the nozzle hole and the diameter of the hole dsh and the surface tension of the liquid.

If the Bernoulli equation is applied [2,6,12,13], the total pressure in one nozzle hole of the device is equal to, Pa;

$$\Delta P_c = \rho_c g H + \xi_{ш} \frac{\upsilon_c^2 \cdot \rho_c}{2}$$

Using Equation (14), it is possible to determine the optimal values of the fluid velocity in the nozzle hole depending on the change in total pressure.

The fluid flow rate through a single nozzle hole of the apparatus is determined as follows [2,13,14], m3 / h;

$$Q_c = 3600\pi R^2 \upsilon_c = 3600\pi R^2 \sqrt{\frac{2gH}{\xi_{ш}}}$$

The number of nozzles is selected according to the length of the contact surface of the filter mesh material to achieve complete wetting of the contact surface of the filter cross-section mesh and high purification efficiency of dust gases using the liquid supplied to the apparatus in working condition. In this case, equation (15) can be written in the following form, m3 / h;

$$Q_c = 3600\pi R^2 \upsilon_c = 3600 n\pi R^2 \sqrt{\frac{2gH}{\xi_{ш}}}$$

where n is the number of nozzles spraying the liquid, pcs.

Using Equation (16), we are able to determine the total flow rate of the working fluid supplied to the conical lattice apparatus [2,13,14].

CONCLUSION

The design and principles of operation of wet dust cleaning devices were studied, their advantages and disadvantages were analyzed, and a new design of wet dust cleaning grid apparatus was developed. As a result of theoretical research, formulas have been developed to determine the total pressure lost in the transmission of dusty air to the device and the total pressure at which the liquid flows out of the nozzle. As a result, it was possible to determine the efficiency of dusty air purification depending on the total pressure in the supply of dusty gas and liquid to the device.

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