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INVESTIGATION OF THE EFFECT OF INERTIAL SCRUBBER HYDRAULIC RESISTANCE ON CLEANING EFFICIENCY

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Abstract:
The article investigates the effect of inertial scrubber hydraulic resistance on cleaning efficiency of an inertial scrubber that cleans industrial secondary gases in the wet method. In experimental studies, gas velocity, liquid flow and nozzle bore diameter were selected as variable factors. During the examinations, it was found that the intermediate increase in the cleaning efficiency of the minimum and maximum values of liquid consumption was 6.7%, the gas flow rate in the process of hydrogen-fluoride gas cleaning was 17.32 m/s and the cleaning efficiency of the device in a 30% solution of calcium white soda in water was 97.42%.

Keywords
Inertial scrubber, hydraulic resistance, cleaning efficiency, fluid flow, liquid layer, nozzle, mass transfer.

Introduction

Configurations of devices for the removal of dust and gases by the wet method are more diverse, the most common among these devices are scrubbers. The main advantage of scrubbers over other devices of the wet method is that wastewater gets stuck in the device pipes, and the sludge formed during cleaning is less likely to stick to the walls of the device. In addition, its efficiency in the purification of gases with aggressive temperatures as well as high flow rates is considered to be high [1,2,3].

This method also has its own drawbacks, for example, the energy consumption for cleaning is higher than that of the dry method, and the liquid membrane has to process absorbed dust and gases. In addition, the efficiency of scrubbers used in industry does not always meet the requirements of existing environmental standards for the level of PDK of harmful

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substances released into the atmosphere. This is mainly due to external influences placed on the device and the high level of addition of dust and secondary gases to the gas stream. Therefore, it will be necessary to use new effective methods or external energy action to increase the probability of dust and secondary gases colliding with liquid droplets [4,5]. For example, the liquid, which is used to clean gases with a higher temperature, evaporates. But this pond is not used for the purification of gases. If ways and methods of using this vapor are created, the energy spent on cleaning can be reduced by 50%. In addition, most devices currently in use clash with liquid at a particular contact element. This in turn requires a finite setting of the gas velocity and the particle amount in the stream. Because of this, mass transfer processes slow down or the full transfer of mass becomes more difficult. In this direction, it is considered more efficient to discover and apply the method of inertial transfer of gases directly into the internal atmosphere of the liquid. At present, a lot of research work is underway in this area [3, 6,7,8,9, etc].

Tadkikot OB'a:
On the basis of the foregoing, a systematic analysis of the constructions of currently used and presented in research works, their advantages and disadvantages was carried out and on the basis of the results obtained, a constructive scheme of an inertial inertial scrubber for dust and gas removal was developed [10] (Fig. 1), the method of hydraulic resistance of the device and the experimental determination of the hydraulic resistances of the device depending on the gas velocity was carried out. [7].

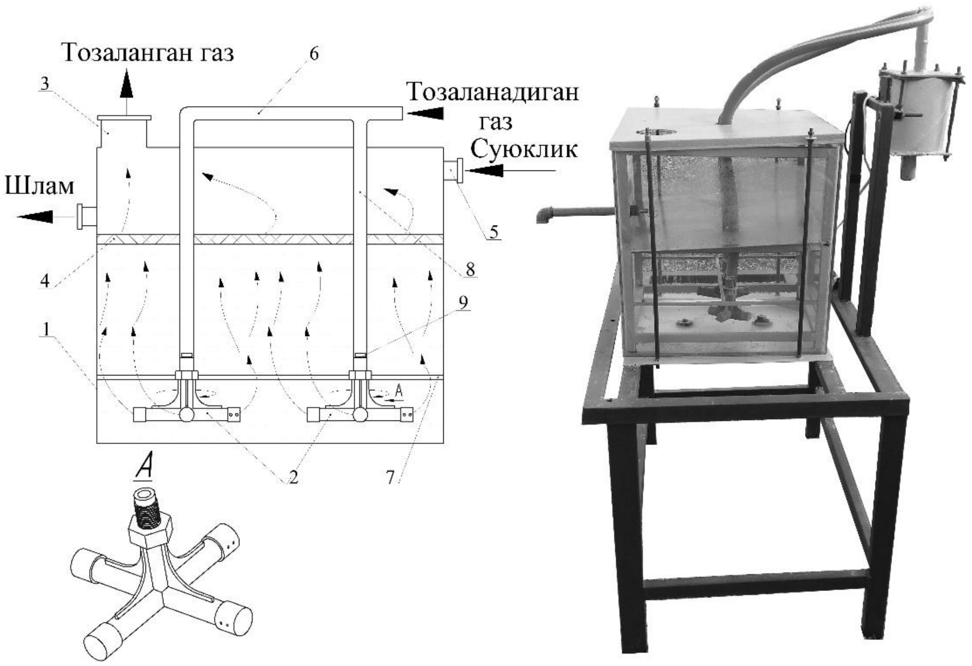

Figure 1. Overview of inertial scrubber

1st Scrubber Corps; 2- Secondary gas distributing syom; 3 - Purified gas outlet boiler; 4-Nozzle with a grille; 5-Fluid transmission pipe; 6-Purified gas pipeline; 7-Trigger; 8-Routing Pipe; 9- Conical plug for gas diversion; 10-Liquid Slurry.

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Research findings:

In this paper, the effect of hydraulic resistance on cleaning efficiency is investigated. The following parameters of variable factors in determining the hydraulic resistance of the device, gas velocity *υg = 7÷25.6* m/s was increased by an average of 4.5 m/s, gas consumption was increased to *Qg = 150÷330* m3/h, the intermediate step was increased to an average of 70 m3/h, nozzle bore diameter *dt* = 2; 3 and 4 mm, liquid consumption *Qwater = 0.141; 0.168* and 0.178 m3/h, inert gas density *ρg=1.29* kg/m3 (for air) was chosen. When conducting the experiments, taking into account the external environmental influences, the temperature for the water and gas system was set to 200°C±2.

The results obtained from the experiment were processed using EXM and the dependence of hydraulic resistance on different values of variable factors was investigated in the case of fluid supply to the device. Based on the results of the resulting experiment, a comparison graph has been constructed regarding the dependence of hydraulic resistance on the gas velocity. (Figs. 2; 3 and 4).

From the data given in Figures 2; 3 and 4, it can be seen that the variable factors increased the gas velocity *υg=7÷25.6* m/s by an average of 4.5 m/s, while gas ÷ consumption increased by an average of 70 m3/h from *ΔPsb=221* Pa to *ΔPsb=2959* Pa for dt=4 *mm*. It was observed that the intermediate step increased from *ΔPsb=252* Pa to *ΔPsb=3381* Pa for dt=3 *mm*, while *the mean was ΔPsb=400* Pa. The mean step was *ΔPsb=450* Pa and increased from *ΔPsb=316* Pa to *ΔPsb=4227* Pa for dt=2 *mm*. The intermediate step averaged *ΔPsb=600* Pa.

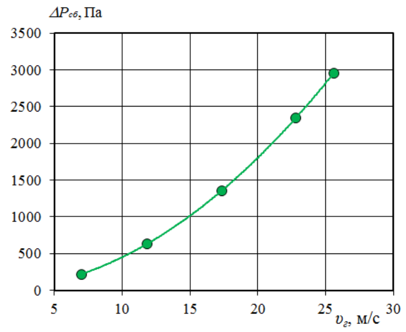

Figure 2. *When ξum* = 4.6 and *ρg* = 1.29 kg/m3–const.

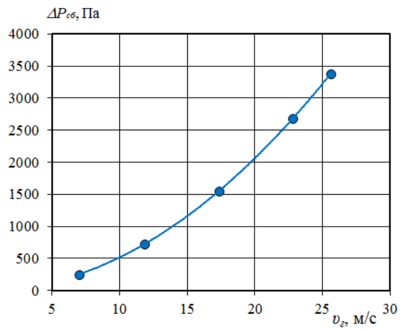

Figure 3. *When ξum* = 6 and *ρg* = 1.29 kg/m3–const.

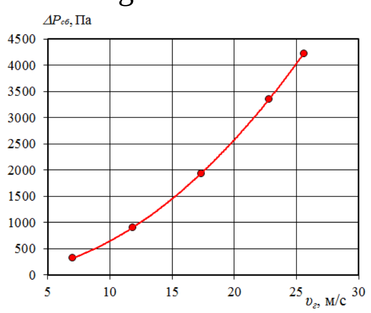

Figure 4. *When ξum* = 7.4 and *ρg* = 1.29 kg/m3–const.

2; Figures 3 and 4. The hydraulic resistance of the device is determined by the dependence of *ΔPcb* on the *gas velocity* υg

2; The following empirical formulas were obtained using the least squared method to the graphical relationships shown in Figures 3 and 4 [13,14,15,16].

$\xi_{um} = 4.6$ and $\rho_g = 1.29$ kg/m3–const

$$y = 4.515x^2 - 0.0004x - 0.0391 \qquad R^2 = 0.9879 \qquad (1)$$

When $\xi_{um} = 6$ and $\rho_g = 1.29$ kg/m3–const

$$y = 5.1598x^2 + 0.0023x - 0.0056 \qquad R^2 = 0.9989 \qquad (2)$$

When $\xi_{um} = 7.4$ and $\rho_g = 1.29$ kg/m3–const

$$y = 7.2597x^2 + 0.0056x - 0.0079 \qquad R^2 = 0.9914 \qquad (3)$$

In experimental studies to determine the cleaning efficiency of the device, the amount of hydrogen-fluoride gas selected for namuna was selected for 1 m3 and the amount of air secondary gas 2459.1 mg/m3 was selected [11,12]. The device was installed on a secondary hydrogen-fluoride gas network coming out of mixing reactors in technological line of supperphosphate shop of JSC "Ferganazot" (Figure 5).

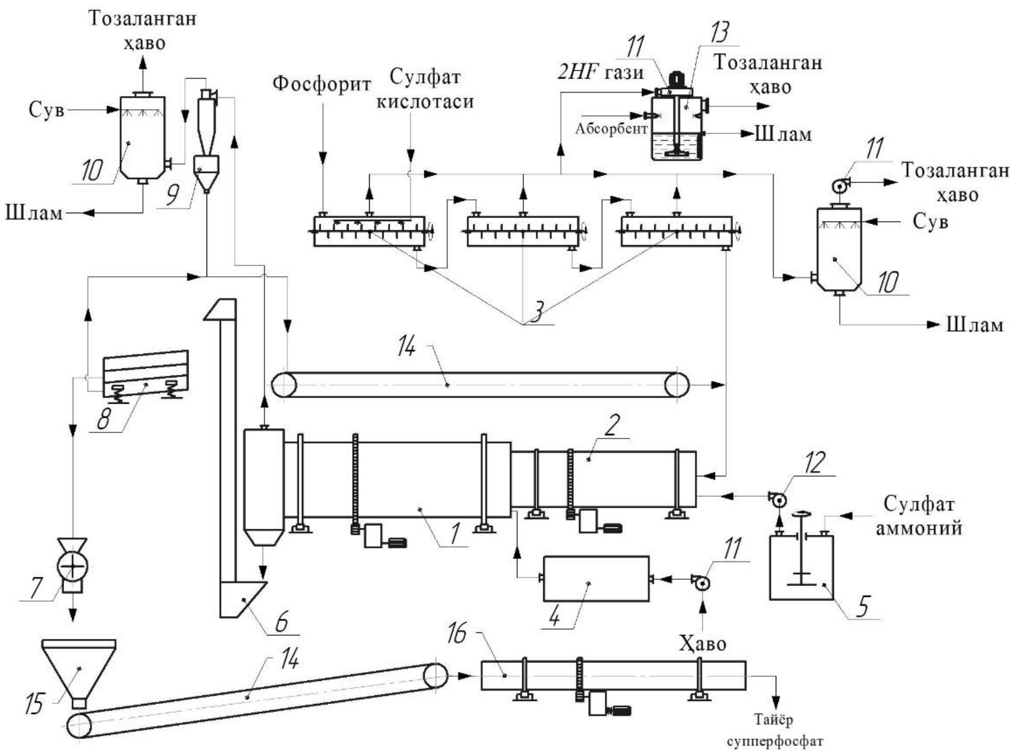

Figure 5. Technological line of production of supperphosphate mineral fertilizer

1-drum dryer; 2-drum granulator; a horizontal reactor with a 3-gauge switch; 4-Coloriferous; 5-mixer vertical reactor; Elevator 6; 7-hammer grinder; 8-galvir; 9-cyclone NIOGAS; 10th hollow scrubber; 11th Ventilator; centrifugal type pump No. 12; 13th scrubber; 14-belt conveyor; Bunker No. 15; 16-drum cooler.

Phase 1:

Experiments on the selected absorbents were conducted depending on the velocity of the gas entering the device. The duration of each experiment was 30 minutes. Laboratory analyses to determine the neutrality of the gas absorbed into the absorbent liquid medium are presented in Table 1.

Table 1 Results on the neutrality of a gas absorbed to an absorbent liquid medium

When there is a 10% solution			
Y, m/s	Technical white soda with calcium	Calcium-carbonate soda	Technical shampoo
7	6,5	6,14	5,8
11,83	6,1	5,9	5,61
17,32	5,85	5,67	5,12
22,8	5,34	5,1	4,83
25,6	5,1	4,79	4,42
When in a 20% solution			
7	7,9	7,1	6,8
11,83	7,4	6,4	6,1
17,32	7,15	6,2	5,8
22,8	6,8	6,1	5,4
25,6	6,3	6,0	5,0
When there is a solution of 30%			
7	9,9	8,7	8,1
11,83	9,48	8,45	7,6
17,32	8,73	8,1	7,19
22,8	8,4	7,78	6,84
25,6	8,12	7,4	6,5

At the time when the neutrality of the acid in the wastewater generated by technological requirements is above 7 Ph, the wastewater will be considered alkaline and will become available for industrial reuse. In the scrubber that is currently used in production, the condition is 3.5÷5.0 Ph. Table 1 shows that the purification of hydrogen-fluoride gas into the absorbent liquid added as a solution of 10, 20.30% to the water composition and the increase in the neutrality of the resulting wastewater would depend on the rate of gas supplied to the device.

Phase 2:

The following results were obtained by experiments on the determination of effective absorption of hydrogen-fluoride gas into the absorbent liquid and determination of the efficiency of device cleaning. Experimental research was derived from the experimental method of K.T. Simrau [1,4].

In the absorbent, which is added as a 10% solution of water to the composition.

1.In technical white soda with calcium - absorption of toxic gas into liquid in the range of gas velocity 7÷25.6 m/s up to 87.4÷92.6%.

2.Calcium carbonate soda with a gas velocity of 7÷25.6 m/s absorption of toxic gas to liquid up to 81.8÷86.5%.

2.Technical shampoo-gas absorption to liquid in the range of 7÷25.6 m/s up to 78.9÷84.7 %.

In the absorbent, which is added water as a 20% solution to the composition.

1. In technical white soda with calcium - gas velocity in the range of 7÷25.6 m/s absorption of toxic gas to liquid up to 93.4÷98.9%.

2.Calcium carbonate soda with gas velocity of 7÷25.6 m/s absorption of toxic gas into liquid up to 84.7÷92.7%.

2.Technical shampoo - gas velocity 7÷25.6 m/s absorption of toxic gas into liquid up to 81÷88.5 %.

In the absorbent, which is added as a 30% solution of water to the composition.

1.In technical white soda with calcium - gas velocity in the range of 7÷25.6 m/s absorption of toxic gas into liquid up to 96.1÷99.4%.

2.Calcium carbonate soda - gas velocity in the range of 7÷25.6 m/s absorption of toxic gas into liquid up to 94÷97.3%.

2.Technical shampoo-gas absorption to liquid in the range of 7÷25.6 m/s absorption of toxic gas to liquid up to 90.4÷95.6 %.

Based on the results of the experiment, a graph of the dependence of the cleaning efficiency of the device on the velocity of gas supplied to the apparatus is constructed. Results of the experiment 6; Figures 7 and 8 show it.

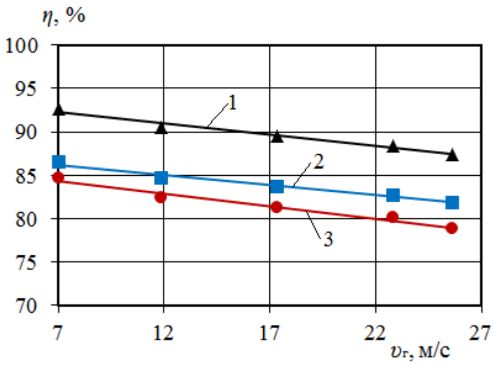

Figure 6. The Treatment Efficiency *Depends* **on the Gas Velocity** *of η* **υg**

1-In a 10% solution of technical white soda with calcium in water; 1-A 10% solution of calcium carbonate soda in water; 1st dilution in a 10% solution of technical shampoo in water;

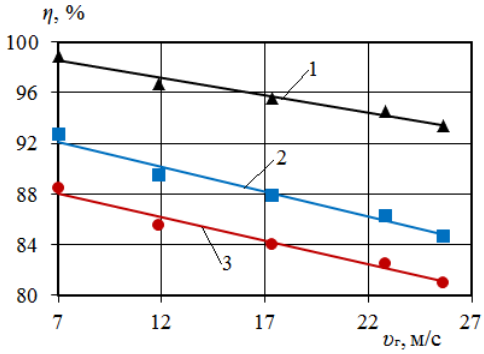

Figure 7. The dependence of the cleaning efficiency *η* **υg** *on* **the gas velocity of the** 1-In a 20% solution of technical white soda with calcium in water; 1-A 20% solution of calcium carbonate soda in water; 1st diluted in a 20% solution of technical shampoo in water;

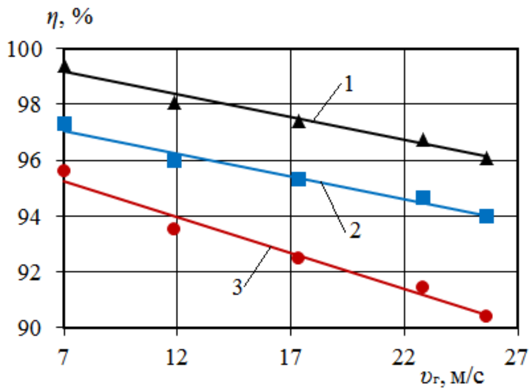

Figure 8. The dependence of the cleaning efficiency *η* **υg** *on* **the gas velocity of the** 1-In a 30% solution of technical white soda with calcium in water; 1-In a 30% solution of calcium carbonate soda distilled in water; 1st diluted in a 30% solution of technical shampoo in water;

The following empirical formulas were obtained using the least squared method to the graphical dependencies shown in Figures 6; 7 and 8 [13,14,15,16]:

In the absorbent, which is added as a 10% solution of water to the composition.

$$y = 94.122e^{-0,003x} \qquad R^2 = 0,9741 \qquad (4)$$
$$y = 87.873e^{-0,003x} \qquad R^2 = 0.974 \qquad (5)$$
$$y = 86,417e^{-0,004x} \qquad R^2 = 0,9744 \qquad (6)$$

In the absorbent, which is added water as a 20% solution to the composition.

$$y = 100.51e^{-0,003x} \qquad R^2 = 0,9741 \qquad (7)$$
$$y = 95.11e^{-0,004x} \qquad R^2 = 0,9749 \qquad (8)$$
$$y = 90,756e^{-0,004x} \qquad R^2 = 0,9749 \qquad (9)$$

In the absorbent, which is added as a 30% solution of water to the composition.

$$y = 100.35e^{-0,002x} \qquad R^2 = 0,9734 \qquad (10)$$
$$y = 98.246e^{-0,002x} \qquad R^2 = 0,9734 \qquad (11)$$
$$y = 97.119e^{-0,003x} \qquad R^2 = 0,974 \qquad (12)$$

When the device is applied to remove hydrogen-fluorine gas and airborne phosphoride dust from mixing reactors in supperphosphate production process, the results of the test experiment showed that the cleaning efficiency was 5.7% higher than that of the existing wet method cleaning scrubber, and the neutrality of the waste water (Ph) generated during the treatment process increased from 5.4 to 9.9.

Conclusion:

Experiments conducted reveal that:

• changes in the coefficient of resistance depending on different values of the injector of the device leads to an increase in hydraulic resistance and an improvement in cleaning efficiency;

The intermediate increase in cleaning efficiency at the minimum and maximum values of liquid consumption was found to be 6.7%.

• during the treatment of hydrogen-fluoride gas, the flow rate of 17.32 m/s, the technical solution of white soda with calcium in water with 30% and the cleaning efficiency 97.42% were found to be the optimal parameters for the device.

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