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Effect of Rotor-Filter Device Operation Parameters on Cleaning Efficiency

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ANNOTATION

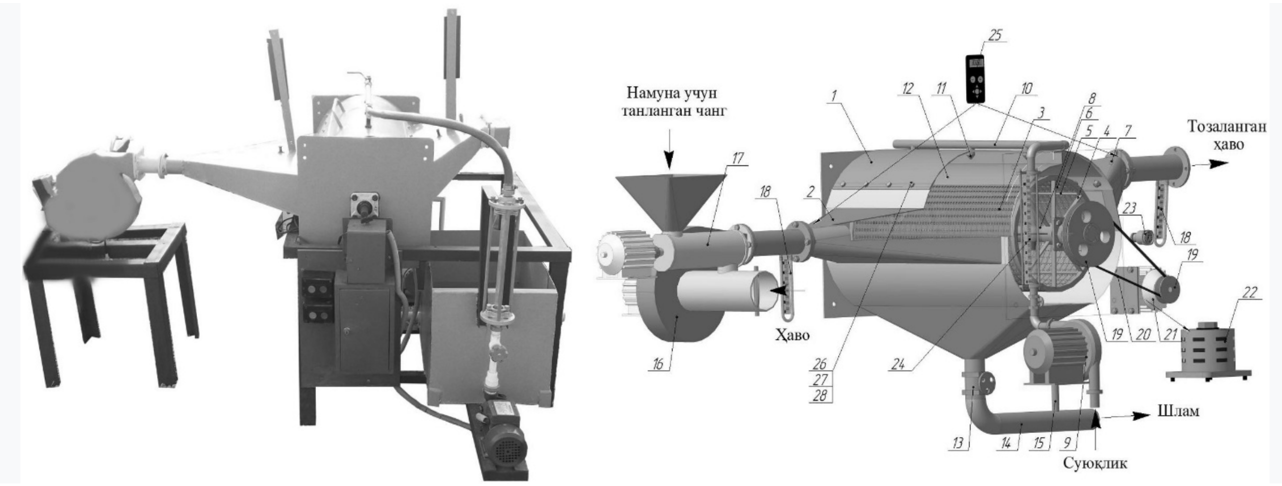
The article presents the results of research on the impact of variable parameters on the cleaning efficiency of a rotor-filter device for wet cleaning of industrial dust gases. The parameters were the diameter of the nozzle hole, the working fluid flow, the gas velocity, the flow rate, the flow mode, and the values of the resistance coefficient in the working bodies of the device. In evaluating the cleaning efficiency of the device, dust samples were selected and studies were conducted. Graphs comparing theoretical and experimental results were constructed and empirical formulas were proposed.

Key words: rotor-filter, filter material, water consumption, flow regime, hydraulic resistance, resistance coefficient, superphosphate dust, calcium technical soda dust.

Introduction:

Wet cleaning of industrial dust gases in devices provides the maximum effect of dust gas and working liquid on the contact surface, intensive transfer of dust particles from gas to liquid medium and increases the efficiency of cleaning the device. This process depends on the hydraulic resistance of the device, the liquid flow and the dusty gas flow regime. Determining these parameters allows you to calculate the exact value of the cleaning efficiency of the device. Much of the research work in this area today scrutinizes these questions. However, it remains important to compare several methods for calculating the cleaning efficiency, assess the dependence on the device parameters and justify the exact values of the efficiency. Therefore, it is important to create a new generation of energy efficient dust collection plants, to substantiate the exact value of the cleaning efficiency, to apply it in production processes and to conduct research in this area. On the basis of the above, a structural diagram and an experimental device of a rotary-filter apparatus for wet cleaning of dust gases [1,2] (pic. 1) were developed, research work was carried out to determine the hydraulic resistance, resistance coefficient and cleaning efficiency of the device [2; 3; 4 and others].

As examples, the studies used a saline solution and powder of the mineral fertilizer ammophos. The results obtained are based on the choice of the optimal parameters of the device using the method of mathematical planning [5,6]. However, no studies have been conducted to evaluate the use of the device for cleaning dust gases generated in other industries, the effect of dust gas flow regimes and liquid flow rates on processing efficiency [7,8].



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1-device case; 2–diffuser; 3-filter mesh material; 5–sterjen; 6-steel mesh; 7–confuser; 8- shaft; 9–pump; 10–pipe of fluid; 11–choke; 12–zont; 13–valve; 14-pipe of sludge; 15-level control pipe; 16–ventilator; 17-screw supplier; 18-Prandl pipe 19-pulley; 20–tape; 21-electric motor; 22-LATA (Laboratory auto transformer adjustable); 23–tachometer; 24–rotometer; 25-electronic monometer **JM-510**; 26–bolt, nut and gang;

Picture-1. General view of the device

Research results:

In this article, experiments are carried out on the use of a rotary filtering device in other industries and the substantiation of its technical and economic indicators. The research results were based on the results obtained by the mathematical planning method.

The values of the factors in the experiments: d_{sh} = 2,2 mm, the diameter of the nozzle of the working fluid, the active surface of the filter mesh material $\sum S_{akt}$ = 0,241 m^2, the diameter of the opening of the filter mesh material d_f = 2,5 mm, the rotor speed is the average value for the experiment n = 25 circle/min was chosen [1,2,4,9].

For the study, fertilizer dust formed during the production of superphosphate mineral fertilizers at “Farg’onaazot” AJ and soda ash generated during drying of technical white soda at “QuvasoyKvars” AJ were selected. When determining the density of a dusty gas, ρ_{ap} = 2,14 kg/m^3 for a mixture of superphosphate dust and gas and ρ_{ap} = 1,72 kg/m^3 for a mixture of technical white powder of soda and gas with calcium. The temperature for the water-gas system was 18^{o}C ± 2, taking into account the influence of the external environment during the experiments. The experiments were carried out in three stages [10,11,12].

At the first stage, for the case of the diameter of the opening of the material of the filtering mesh of the rotor-filtering device d_{fil} = 2,5 mm, the gas velocity, flow rate, flow regime and the coefficient of hydraulic resistance in the working elements of the device were experimentally determined. In the course of the experiments, we used a VG - 4 (efficiency Q_{max} = 400 m^3/h; electromotive force N_{dv} = 0.7 kW; frequency n = 1200 circle/min) of the centrifugal type, anemometer **BA06-TROTEC** (measuring range 1,1-50 m/s error factor 0,2%, error factor 5 % at a gas velocity of more than 50 m/s) used proprietary electronic measuring devices and existing standard methods [6; 7; 8, 13, 14 etc.]. Table 1 shows the experimental results.

Table-1 Values of gas velocity, efficiency and flow regime at a hole diameter of the filter mesh material d_f = 2,5 mm

Shiber degrees α	Speed of gas					Q, м^3/hour	R_e	ξ
	Y_{inter}, м/с	$\upsilon_{диф}$, м/с	υ_A, м/с	$\upsilon_Б$, м/с	υ Exit, м/с			
90^o	34,4	24,66	23,1	13,75	10,54	396,77	154967	3,26
60^o	28	19,8	18,21	9,33	8,7	167,8	127152	3,21
45^o	23,8	17,15	15,8	6,83	7,12	145,3	109271	3,3
30^o	18,79	10,84	8,91	6,79	5,6	85,6	91390	3,35
0^o	7,67	5,42	5,2	3,75	2,45	34,4	32450	3,13

To determine the coefficient of error of the obtained experimental results, a graph of changes in labor productivity was built depending on the degree of the gate. picture-2.

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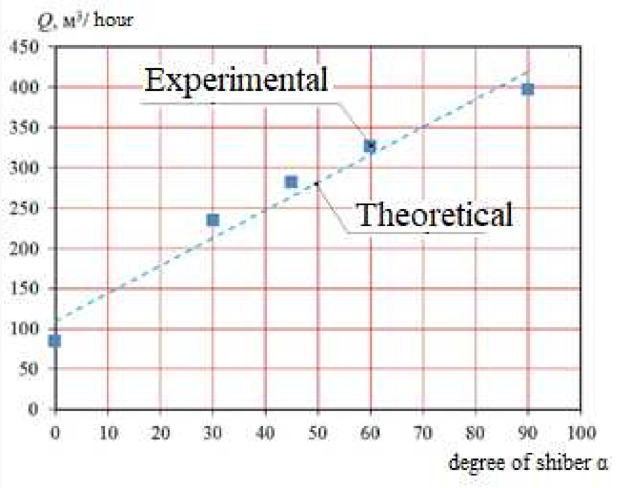

Picture-2.Graph of changes in labor productivity depending on the degree of shiber

From the graphical dependence shown in picture-2, it can be seen that the coefficient of error between theoretical and experimental values, determined by the change in labor productivity depending on the degree of shale, did not exceed 4%. The following empirical formula was obtained for experimental results using the least squares method [2, 14];

$y = 3,4283x + 110,03$ $R^2 = 0,9646$ (1)

At the second stage, the flow rate of the working fluid was determined by the volumetric method for the case when the diameter of the orifice of the working fluid nozzle d_{sh} = 2,2 mm. For this, the time of filling the glass with liquid was determined from the readings of the rotometer 0 ÷ 90. Nozzle S32-412 for experiments, centrifugal pump (PEDROLLA-Q_{max} = 40 l/min; N_{dv} = 0.37 kW; h_{max} = 38 m; V = 220V; $n_{general}$ = 3000 circle/ min according to INST-2757030-91), rotometer (RS-5; scale readings in the range 0 ÷ 100; according to INST -13045-81) and a glass (full volume 3,2 l). Table 2 shows the experimental results.

Table-2 The results of experiments to determine fluid consumption. d_{sh} = 2,2 mm.

R_{sh} view. ном.	0	10	20	30	40	50	60	70	80	90
$T_{average}$ min	2	1,65	1,1	0,97	0,85	0,45	0,39	0,35	0,32	-
Q_{liquid} l/hour	88,75	108,6	163,02	184,4	210,2	236,8	277,7	308,21	340,8	-
Q_{liquid} м³/hour	0,088	0,108	0,163	0,184	0,210	0,236	0,277	0,308	0,340	-

To determine the coefficient of error of the obtained experimental results, a graph of changes in labor productivity was built depending on the readings of the rotometer. picture-3

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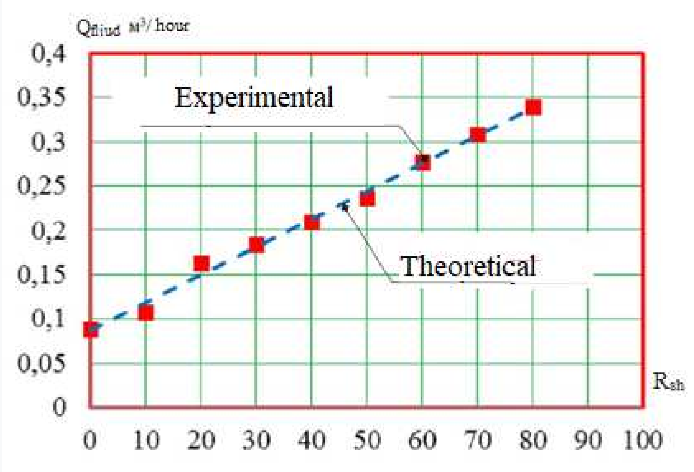


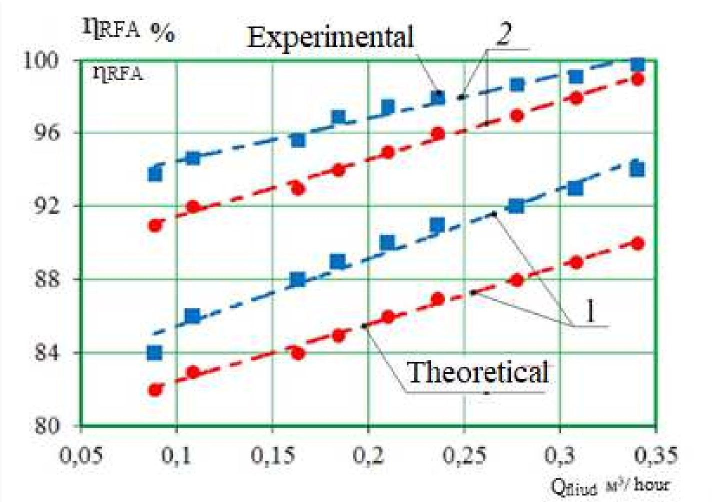
Picture-3. Graph of changes in labor productivity depending on the readings of the rotameter.

From the graphical dependence shown in 3-picture, it can be seen that the error coefficient between theoretical and experimental values determined by the change in labor productivity depending on the readings of the rotometer did not exceed 2.5%. The following empirical formula was obtained for the experimental results by the least squares method [15];

$y = 0,0031x + 0,0868 \qquad R^2 = 0,9938 \qquad (2)$

At the third stage, the cleaning efficiency of superphosphate mineral fertilizers and calcium soda dust in the device was studied using the values determined above. In the course of experiments (the amount of dust in 1 m^3 of gas was determined as 365,7 mg/m^3 for superphosphate dust and 460,91 mg / m^3 for industrial soda dust), the effect of liquid flow rate and gas velocity on the processing efficiency was theoretically and experimentally studied.

The theoretical calculations used the research of K.T. Semrau [1,2] and laboratory experiments PA-40M. The results are shown in picture-4.



1- at a gas velocity of 35 m / s; 2- at a gas velocity of 7 m / s;

● - technical soda dust; ■ - superphosphate fertilizer powder

Picture-4. Cleaning efficiency η_{RFA} dependence on Q_{liquid} flow rate

The graphical dependencies presented in picture 3 show that the cleaning efficiency of the device is η_{RFA} = 93,78 ÷ 99,81% for superphosphate fertilizer powder and η_{RFA} for calcium technical soda powder, when the gas velocity is constant and is 7 m/s, and the flow of the working fluid is η_{RFA} = 0,088 ÷ 0,340 m^3/h 91,67 ÷ 99,23%, with no change in the gas velocity of 35 m/s and the change in the flow rate of the working fluid 0,088 ÷ 0,340 m^3/ h, the efficiency of cleaning the device from dust from superphosphate fertilizers η_{RFA} = 84.51 ÷ 94.99%, texnical calcium η_{RFA} = 82,72 ÷

90,45% for technical soda powder. It is seen that an increase in the gas velocity negatively affects the cleaning efficiency of the device. As can be seen from the graphs, the purification efficiency of calcium technical soda powder is lower than that of superphosphate fertilizer powder, which can be explained by differences in average average powder sizes. When creating an industrial version of the device, it is recommended to take into account the average size of dust emitted by industrial plants. The following empirical formula was obtained for the experimental results by the least squares method [1,2,15,16,17]

for the condition when the gas velocity is 35 m/s;

$y = 79{,}5e^{0{,}3674x}$ $R^2 = 0{,}9936$ (3)

$y = 81{,}949e^{0{,}4204x}$ $R^2 = 0{,}9728$ (4)

for the condition when the gas velocity is 7 m/s;

$y = 88{,}48e^{0{,}3326x}$ $R^2 = 0{,}9936$ (5)

$y = 92{,}219e^{0{,}2431x}$ $R^2 = 0{,}9688$ (6)

Conclusion:

According to the results of the experiments, it can be concluded that an increase in the resistance coefficient of the working organs due to the consumption of the working fluid in the device has a significant effect on the cleaning efficiency. But this decreases the performance of the device and increases power consumption. In addition, the difference in the average average size of the selected dust and the number of dust particles in 1 m3 of gas affects the cleaning efficiency. Experiments have shown that with a dust-laden gas flow rate into the device in the range of 15–20 m /s, the purification efficiency exceeds the PS requirements, and the energy consumption fully meets the specified requirements.

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