DETERMINATION OF OPTIMAL PARAMETERS OF A WET CLEANING DEVICE

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Abstract
In the article, based on the results of the experimental study, the optimal values of the parameter in the experimental device of the drum wet dust cleaning device are determined. Assuming that the effect of variable factors is fully explained by a second-order polynomial, the experiments were carried out on the basis of the "Fractional Factorial Experiment" plan.

Keywords: Wet method, drum, sieve, gas flow, liquid flow, pressure, dust, speed, apparatus.

Introduction

The composition of dust particles in air and gases emitted into the atmosphere from industrial enterprises is polydisperse, i.e., it contains particles of different sizes. Monodimer dusts, i.e., it contains particles of the same size, are almost never found.

Thus, for the analysis of polydisperse dusts, it is necessary to have information about the total amount of dust particles, the ratio of particles of individual sizes, and the average size (median size) of particles.

Determining the dispersion composition of dust is important in determining the cleaning efficiency of a wet drum dust collector and determining its optimal values [1,2,3,7].

Research object

The experimental model of a wet dust collector installed in the scientific laboratory of the Department of Technological Machines and Equipment was used as the research object (Figure 1) [5,6]. Also, the method of mathematical processing was used to select the optimal values of the apparatus based on multifactorial experiments and their determined parameters [4].

Figure 1.

In the mathematical processing, the following variable parameters were selected as factors affecting the hydraulic resistance, energy consumption and cleaning efficiency of the device;
1. Dust gas velocity (X1). Gas velocity values ωg=5÷25 m/s (in steps of 5 m/s);
2. Liquid consumption (X2). 4 pieces of S32-412 brand nozzles (hole size 1mm) Qs=0.075÷0.3m3/h (in steps of 0.075 m3/h);
3. Mesh square hole size (X3). Square hole size a==0.6÷1 mm (in steps of 0.2 m/s);
4. Mesh drum rotation frequency (X4). Drum rotation frequency n=15÷25 rpm (in steps of 5 rpm);
Based on the results of the theoretical and experimental research, the ranges of change of the variable factors were determined. Table 1 presents the levels and ranges of change of the factors.

Table 1. Factor levels and ranges of change

№	Factors	Unit of measurement	Identification of factors	Change interval	Levels of factors		
					lower (–1)	general (0)	high (+1)
1.	Dusty gas velocity	m/s	X_1	10	5	15	25
2.	Fluid consumption	m^3/ hour	X_2	0,1125	0,075	0,1875	0,3
3.	Mesh hole size	mm	X_3	0,2	0,6	0,8	1
4.	Drum rotation frequency	rot/min	X_4	5	15	20	25

The experiments were carried out according to the "Fractional Factorial Experiment" design, assuming that a second-degree polynomial fully reflects the influence of variable factors on the criteria being determined. [4].
In order to reduce the influence of uncontrolled factors on the criteria to be determined and to facilitate calculations, the sequence of experiments was determined using the 1/17 form of the random number table. Soil (suglinka) dust was selected as the sample dust when conducting the experiments. To determine the optimal parameters of the hydraulic resistance, energy consumption and cleaning efficiency of the apparatus, the experiments were repeated 3 times separately. The arithmetic mean values of the experimental results obtained were selected. To determine the level of cleaning, a multi-component ANKT-410 gas analyzer and the following formula were used to determine the energy consumption.

$$K_{РФА} = \Delta P_c + \Delta P_{сб} \frac{V_{сую}}{V_{газ}} + \frac{N_{РФА}}{V_{газ}} \qquad (1)$$

where ΔPc is the hydraulic resistance of the device without liquid supply, Pa; ΔPcb is the hydraulic resistance of the device with liquid supply, which depends on the density of dust entering with gas, Pa; Vsuyu is the volumetric consumption of liquid, m3; Vgas is the volumetric consumption of dusty gas, m3; NRFA is the power consumed to rotate the drum, transfer liquid and gas, W;
Based on the results of the experiment, it was found that the efficiency of Suglinka dust removal and the energy consumption and the hydraulic resistance of the device depend on variable factors (2-table).

Table 2. The efficiency of dust removal from the Suglinka and the energy consumption and the dependence of the hydraulic resistance of the device on variable factors

Dusty gas velocity	Fluid consumption	Mesh square hole size	Number of drum revolutions	Hydraulic resistance	Energy consumption	Cleaning efficiency
-1	-1	-1	1	57	27	99,76
1	-1	-1	1	940	661	99,3
-1	1	-1	-1	62	24	96,6
1	1	-1	-1	965	500	96,9
-1	-1	1	-1	46	24	98,4
1	-1	1	-1	780	667	96,78
-1	1	1	1	53	21	99,8
1	1	1	1	870	498	99,6
-1	0	0	0	50	24	99,8
1	0	0	0	901	585	99,21
0	-1	0	0	546	326	99,4
0	1	0	0	700	247	99,7
0	0	-1	0	619	287	99,1
0	0	1	0	620	285	99,3
0	0	0	-1	673	284	93,7
0	0	0	1	701	289	99,9
0	0	0	0	621	294	99

Results

The experimental results were processed in an appropriate manner, the following regression equations that adequately represent the evaluation criteria were obtained using the HARTLI-4 program of the "PLANEX" program, and graphs of the dependence of variable factors on the evaluation criteria were constructed (Figures 4.1, 4.2, 4.3).

According to it:

The hydraulic resistance of the device is determined by the following regression equation:, Pa

ΔP=646+612 X1+71 X2+0,7 X3+14 X4+33 X1X1-1,1 X2X2-4,3 X3X3+63,1 X4X4+35 X1X2-62,6 X1X3+7 X1X4-6,3 X2X3-68 X2X4-37 X3X4

The energy consumed for the cleaning process of an apartment is determined by the following regression equation:, kJ/1000 m^3

K_{ch}=284+35 X1+1,1 X2+154 X3+183 X4+65 X1X1+60 X2X2-88 X3X3-120 X4X4+45,5 X1X2-42 X1X3-45 X1X4-227 X2X3-20 X2X4+44 X3X4

The cleaning efficiency of the appartment is determined by the following regression equation, %

η=99,61-0,27 X1+0,14 X2+0,09 X3+3 X4+0,6 X1X1+0,64 X2X2+0,3 X3X3-2,1 X4X4+0,33 X1X2-0,18 X1X3+0,06 X1X4-1,9 X2X3+0,18 X2X4-0,26 X3X4

Using the regression equation obtained for hydraulic resistance, energy consumption, and cleaning efficiency in the process of cleaning soot dust, graphs of the dependence of hydraulic resistance, energy consumption, and cleaning efficiency on the gas velocity in the device, liquid consumption, square hole size of the filter mesh, and the number of revolutions of the screen drum were constructed. The results are presented in Figures 2; 3, and 4.

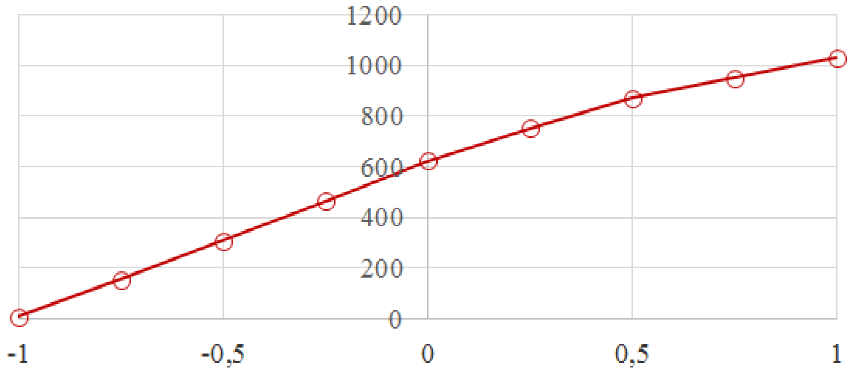

Figure 2. Dependence of hydraulic resistance on variable criteria.

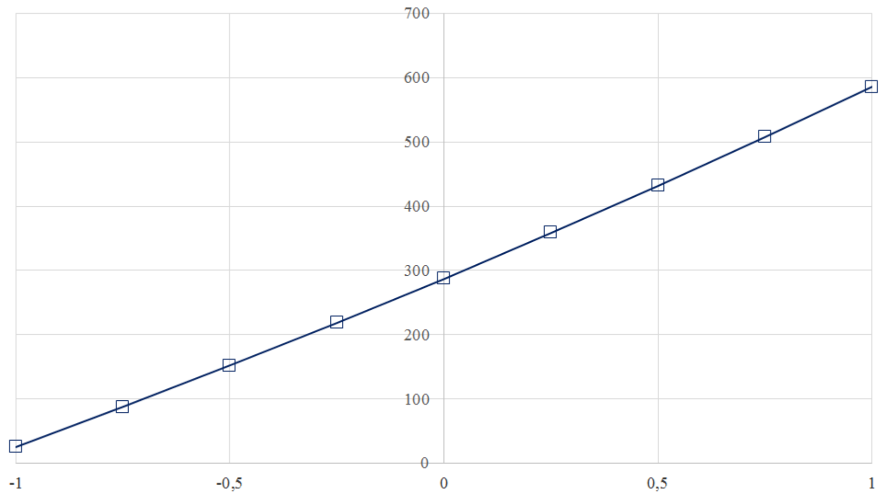

Figure 3. Dependence of energy consumption on variable criteria.

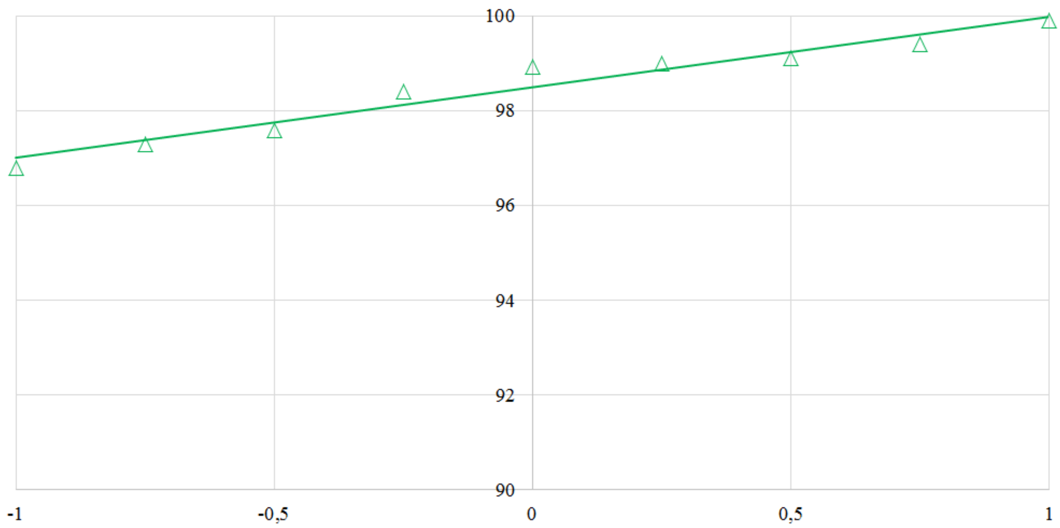

Figure 4. Dependence of cleaning efficiency on variable criteria.

As can be seen from the analysis of the obtained regression equations and graphs (Figures 1; 2 and 3), all factors have a significant impact on the evaluation criteria. In addition, the size of the square holes of the filter mesh and the fluid consumption are in a complex relationship with the factors under study.

In order to determine the optimal values of the factors affecting the processes under study, namely the hydraulic resistance of the device, cleaning efficiency and energy consumption, regression equations (1), (2) and (3) were solved separately for the cotton dust cleaning process. In this case, the cotton dust cleaning efficiency was accepted under the condition of being higher than 99.61%. This task was solved using the Excel program "search for a solution" function, the optimal values of the variable factors in coded form were obtained and the coded values were converted to natural values Table 3).

Table 3. Transition from coded values to natural values

№	Factors	Unit of measurement	Conditional designation	Coded value	Actual value
	Gas speed	m/s	X_1	0,13	12,4
3	Fluid consumption	m^3/h	X_2	-0,04	0,3
3	Mesh square hole size	mm	X_3	-0,64	0,6
4	Number of drum revolutions	ayl/min	X_4	0,19	15

Thus, the optimal parameters of the device for the process of cleaning the dust of the Sulinka were standardized and can be written as follows.

- dusty gas velocity, υ=12.4 m/s;
- liquid consumption, Qcuyu=0.3 m3/h.
- Square hole size of the filter mesh, 0.6 mm;
- Number of revolutions of the mesh drum, 15 rpm

At these values of the factors, the energy consumption of the device was 1.385 kW/h, the cleaning efficiency was 99.798%, and the hydraulic resistance was 700 Pa.

Conclusion

The article describes the optimal values of the device based on the results of the experimental study of the wet dust collector drum device. The experiments were carried out based on the "Fractional Factorial Experiment" plan, assuming that the influence of variable factors is fully reflected by a second-order polynomial. When designing an industrial device, this is done through the determined optimal values.

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