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Mathematical Modeling of the Optimal Parameters of Rotory Filter Apparatus for Wet Cleaning Of Dusty Gases.

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ABSTRACT: In the article, a theoretical and experimental study of energy efficiency and cleaning efficiency of a rotary filter apparatus with wet cleaning of dust gases, as well as optimal device parameters using the method of mathematical planning.

In mathematical planning, it was believed that a second-order polynomial is completely covered by the influence of factors on the evaluation criteria and was performed on the basis of experiments (B4). The experimental results were processed accordingly, and using the HARTLI-4 program, regression equations were obtained that adequately expressed the evaluation criteria.

Based on the results of the experiment, the machine default settings for the dust processing selected for the sample are set by default.

KEYWORDS: rotor-filtering device, filtering material, active surface, wet method, hydraulic resistance, saltpeter and ammophos dust, local resistance coefficient, working surface, stutterer.

I. INTRODUCTION

The cleaning efficiency of wet gas cleaners and the energy consumed by the process are determined by the design of the apparatus. One of the main tasks of current research in this area is to increase the efficiency of the installation per unit volume and reduce energy consumption.

Based on these tasks, the data presented in many research papers and literature [7, etc.] were analyzed. And on this basis, a scheme of a simple low-power device with a rotary filter (Figure 1a) and a pilot device (Figure 1b) were developed . [8]. Experimental studies were conducted on the created experimental device. The following are some methods used to generate regression equations based on experimental data used to calculate the processing efficiency and power consumption of the device.

The gas velocity, fluid flow rate, local resistance coefficients in the device and hydraulic resistance of the device were determined experimentally [3]. Based on the results of the experiment, the energy efficiency and cleaning of the device were studied, and the optimal parameters of the device were determined using the method of mathematical planning. During these experiments, the gas supply rate to the apparatus is from 7 to 35 m / h, 4 m / h, the fluid flow rate is from 0.068 m^3 / h to 0.171 m^3 / h, 0.034 m^3 / h, the active surface of the filter mesh is 0.202 m^2, 0.229m^2. and changed to 0.268 m^2. In this case, the diameter of the filter opening was1;2;3mm, and the rotor speed averaged 25rot/min for experiences, the gas density was 1.82 kg / m3 for a mixture of nitrate and air, and 1.88 kg / m3 for mixture of an ammophosic dust and air. During the experiments, the temperature of water and gas was chosen equal to 200 ± 2 ° C, taking into account the environmental impact.

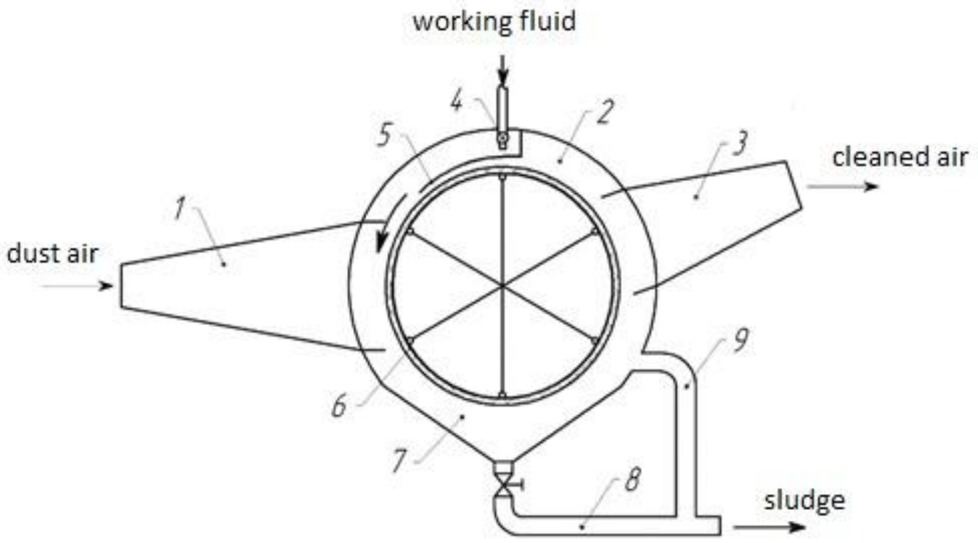


Figure 1a.Device design.
1-diffuser; 2-cylinder camera; 3-configurator ; 4-stutter; 5-dividing bonnet; 6-rotor filter; 7-bath; 8-pipe; 9-adjusting pipe.

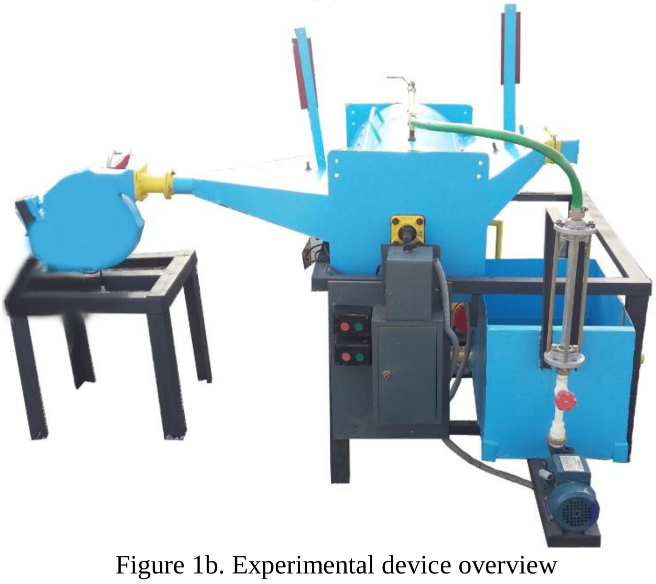


Figure 1b. Experimental device overview

II. RELATED WORK

The gas velocity, fluid flow rate, local resistance coefficients in the device and hydraulic resistance of the device were determined experimentally [3]. Based on the results of the experiment, the energy efficiency and cleaning of the device were studied, and the optimal parameters of the device were determined using the method of mathematical planning. During these experiments, the gas supply rate to the apparatus is from 7 to 35 m / h, 4 m / h, the fluid flow rate is from 0.068 m^3 / h to 0.171 m^3 / h, 0.034 m^3 / h, the active surface of the filter mesh is 0.202 m^2, 0.229m^2. and changed to 0.268 m^2. In this case, the diameter of the filter opening was1;2;3mm, and the rotor speed averaged 25rot/min for experiences, the gas density was 1.82 kg / m3 for a mixture of nitrate and air, and 1.88 kg / m3 for mixture of an ammophosic dust and air. During the experiments, the temperature of water and gas was chosen equal to 200 ± 2 ° C, taking into account the environmental impact.

The energy consumption in the rotor-filtering unit includes the energy consumed at the inlet and outlet of the apparatus, a forklift truck, cleaning from liquid dust, rotation of the rotor and friction in the pump and vent. Since calculating the exact amount of energy consumed is a complex process, K.T. We use the research work of Semrau [2]. Then the total energy consumption of the rotary filter device can be determined by the following equation.

$$K_{РФА} = \Delta P_c + \Delta P_{сб}\frac{V_{сую}}{V_{газ}} + \frac{N_{РФА}}{V_{газ}}, \text{ kJ / 1000 m}^3 \qquad (1)$$

Where: ΔP_c - hydraulic resistance of the apparatus without liquid, $\Delta P_{сб}$ - the hydraulic resistance of the apparatus into which the liquid is transferred depends on the density of dust entering the air, Pa; $V_{сую}$ - volumetric flow rate of liquid, m^3; $V_{газ}$ - volume of dusty air, m^3 $N_{РФА}$ - power consumption during rotation of the rotor, pumping liquid and gas,Wat;

This calculation method gives an error of ± 10% when applied to devices for dust processing by wet methods with different designs and operating principles [2].

The relationship between efficiency and energy consumption of the rotor-filter unit can be determined by the following equation.

$$\eta_{РФА} = 1 - e^{BK^{X}_{РФА}}, \% \qquad (2)$$

Here: *B* and *x* are constant numbers, which are determined by the experimental dispersion composition of dust [5]. (2) The choice of nitrate and ammophosic mineral fertilizers was used to determine the constant values of *B* and *x* in the equation, and a two-stage laboratory analysis was performed to determine the average size of dust particles [4].

To determine the exact cost of cleaning, you can determine the amount of material transferred from the equation.

$$N_{м} = \ln\left(\frac{1}{1-\eta_{РФА}}\right) \qquad (3)$$

Where: $N_{м}$ - the amount of substances carried.

When the numerical value in the equation is 0.5 ÷ 10, the resulting value is using the table presented by K.T. Semrau, the cleaning efficiency of the device is determined.

Mathematical planning of multivariate experiments was performed to assess the effect of variables on the device on the cleaning efficiency and energy consumption [1].

Theoretical studies and multidimensional experiments showed that the filter surfaces were the most active factors (X1), stuttering diameter (X2), dust air velocity (X3) and liquid flow rate (X4), equipment cleaning efficiency and energy consumption. , Based on the results of the above theoretical studies and multidimensional experiments, the intervals of variation of these factors were determined. Table 1 lists the levels of factors and intervals of change.

Table 1
Factor levels and intervals

№	Factors	unit of measure-ment	Deretmi-nation of factors	Interval of change	Levels of factors		
					lower (–1)	main (0)	apper (+1)
1.	Active surface of filtration material	м^2	X1	0.033	0.202	0.235	0.268
2.	The diameter of the stutter hole	мм	X2	1	1	2	3
3.	Dust air velocity supplied to the machine	м/s	X3	13,365	7.670	21.035	34.400

4.	Fluid consumption	м^3/h	X4	0,055	0.068	0,123	0.178

In multivariate experiments, evaluation criteria were considered as energy (Y1) and cleaning efficiency of the device (Y2).

The influence of factors on the evaluation criteria was based on experiments (B4), suggesting that the second polynomial will be fully illuminated [6].

III.TEXT INPAINTING

To minimize the influence of uncontrolled factors on the evaluation criteria, the sequence of experiments was determined using a random number table, and separate experiments were conducted to determine the optimal parameters for treatment with nitrate and ammophos dust. The experimental results were processed in the appropriate order, and using the HARTLI-4 program the following regression equations were obtained that adequately represent the evaluation criteria:

The energy consumed by saltpeter dust treatment in a device with a rotary filter is determined by the following regression equation, kJ / 1000 m3

$$Y1 = + 33.8952 + 3.5563\ X1 + 0.000X2 + 15.4300X3 + 18.2967\ X4 + 6.4683\ X1X1 + 4.5287\ X1X2 - 4.5238\ X1X3 - 4.4679\ X1X4 + 6.2984\ X2X2 - 2.27521\ X2X3 - 1.9629\ X2X4 - 8.8350\ X3X3 + 4.5196\ X3X4 - 11.9949\ X4X4$$

The energy consumed for the deposition of ammophos dust on a device with a rotary filter is determined by the following regression equation, kJ / 1000 m3

$$Y1 = + 32.9121 + 3.5555\ X1 + 3.6200\ X2 + 15.4113\ X3 + 18.2720\ X4 + 7.5567\ X1X1 + 4.5202\ X1X2 - 4.5218\ X1X3 - 4.4578\ X1X4 + 3.8799\ X2X2 - 22.7450\ X2X3 - 1.9373\ X2X4 - 7.7281\ X3X3 + 3.9170\ X3X4 - 10.8821\ X4X4$$

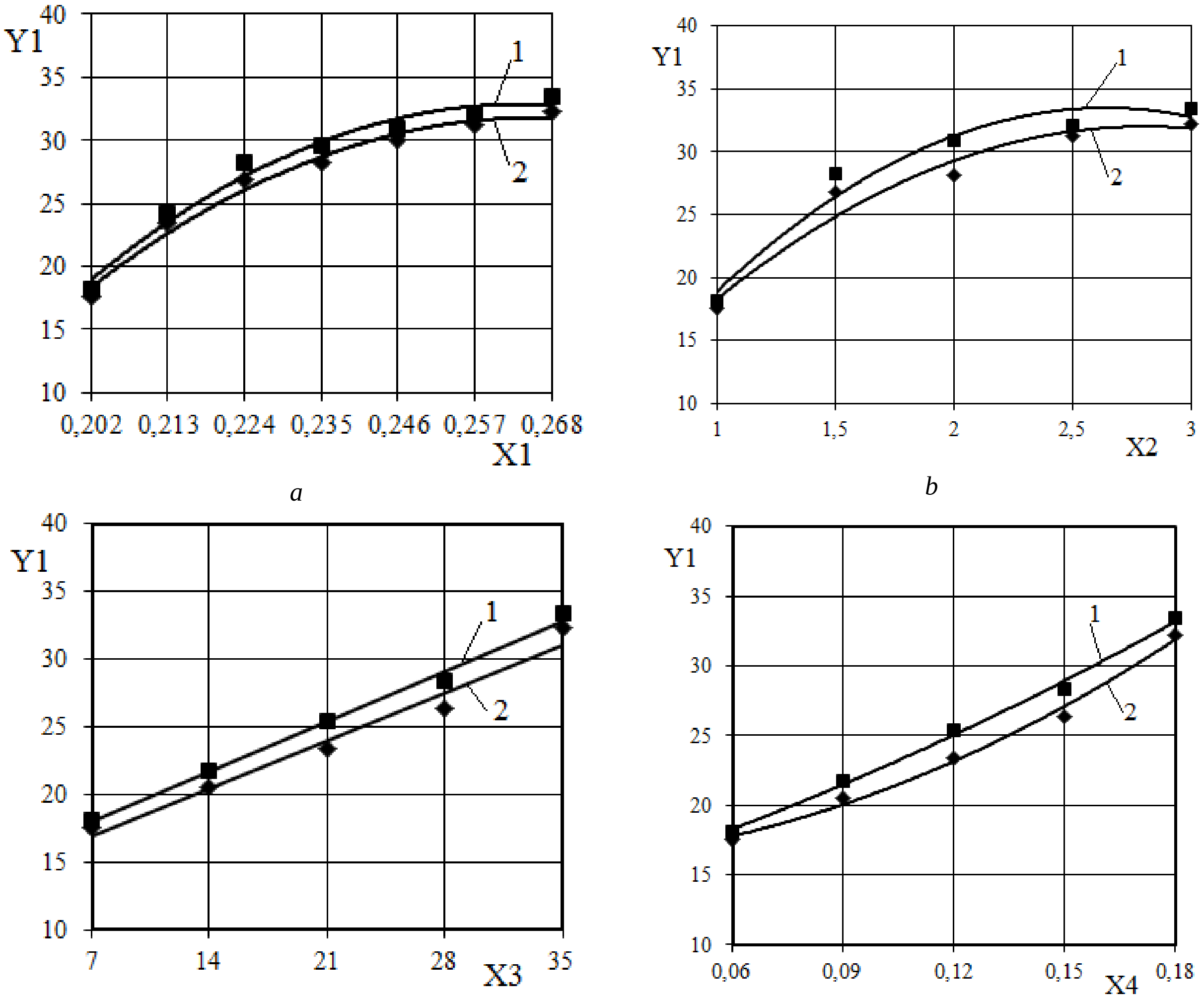
The efficiency of nitrate dust cleaning in a rotary filter device is determined by the following regression equation,%

$$Y2 = + 99.039 - 0.112\ X1 + 0.145\ X2 + 0.233\ X3 + 3.175\ X4 + 0.744\ X1X1 + 0.362\ X1X2 - 0.356\ X1X3 + 0.000\ X1X4 + 0.630\ X2X2 - 2.040\ X2X3 - 0.092\ X2X4 + 0.418\ X3X3 - 0.197\ X3X4 - 2.244\ X4X4$$

The cleaning efficiency of ammophosic dust on a rotary filter is determined by the following regression equation,%

$$Y2 = + 99.350 - 0.151\ X1 + 0.156\ X2 + 0.221\ X3 + 2.094\ X4 + 0.000\ X1X1 + 0.196\ X1X2 - 0.184\ X1X3 + 0.180\ X1X4 - 0.102\ X2X2 - 2.098\ X2X3 - 0.172\ X2X4 + 0.220\ X3X3 - 0.207\ X3X4 - 1.679\ X4X4$$

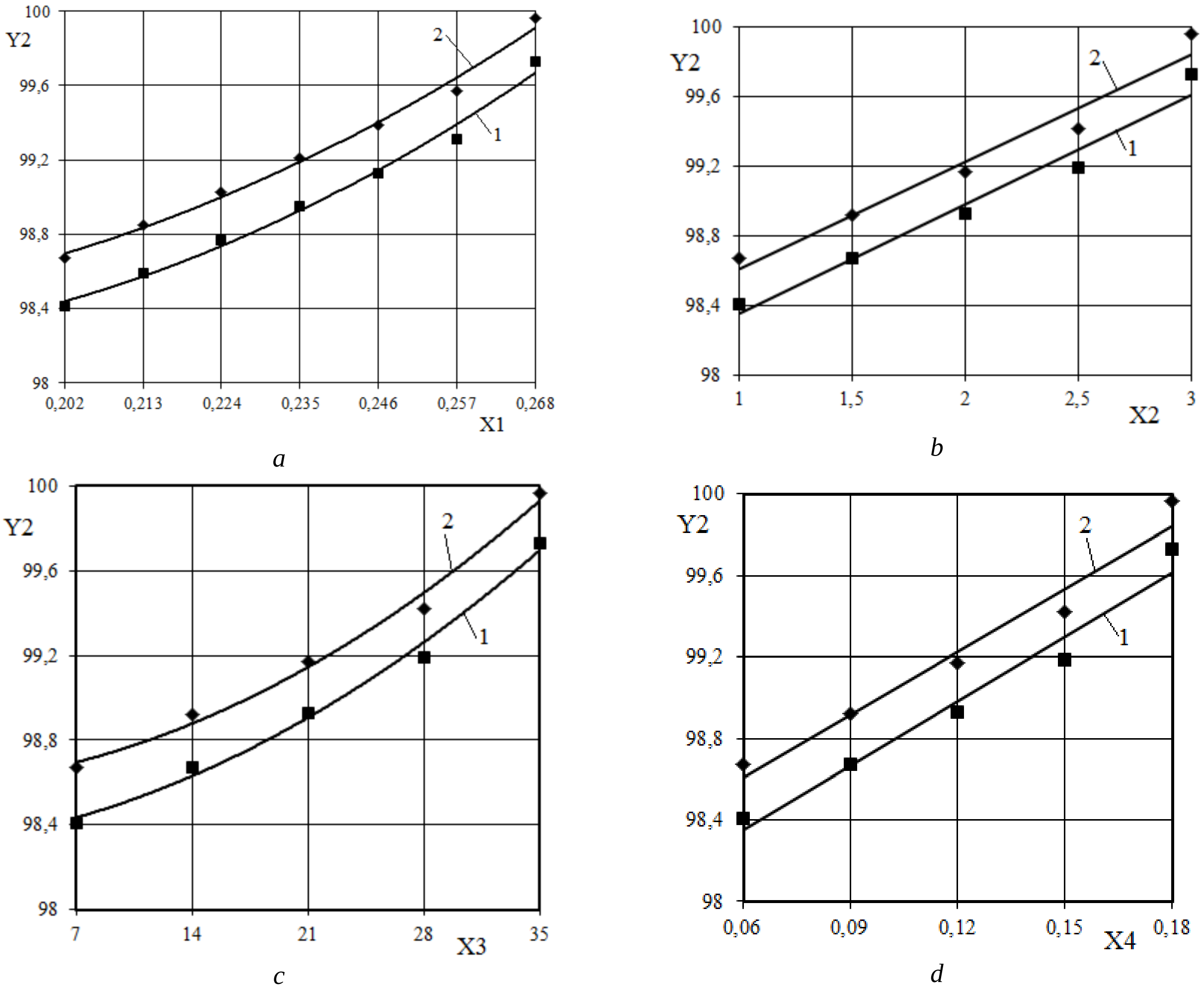
A graph of the dependence of the cleaning efficiency and energy consumption on changing factors in the device was constructed using the regression equation for processing dust of saltpeter and ammophos and energy consumption. The results are presented in figures 2 and 3.



a *b*

c *d*

Figure 2 Energy Dependence on Changing Factors
1 - Saltpeter powder; 2 - Ammophos dust
a – the dependence of energy on the active surface; b - the dependence of energy on the diameter of the stutterer; c-the dependence of energy on gas velocity;
d - the dependence of energy consumption on the liquid



a b c d

Figure 3 Dependence of cleaning efficiency on changing factors
1 - Saltpeter powder; 2 - Ammophos dust
a - depending on the effectiveness of surface cleaning; b - dependence of cleaning efficiency on the diameter of the stutterer; c-the dependence of the cleaning efficiency on the gas velocity; d - depending on the efficiency of cleaning, fluid flow

An analysis of the obtained equations and regression plots shows that all factors have a significant impact on the evaluation criteria. In addition, the fluid flow, the speed of dusty air, the diameter of the filter opening and the active surface of the filter mesh are complex depending on the factors studied.

IV. EXPERIMENTAL RESULTS

The regression equations (1) - (2) were solved separately for the processes of purification from nitrates and ammophos to determine the factors influencing the process, namely the hydraulic resistance of the device, the cleaning efficiency and optimal energy consumption. The requirement for GOST-62-198-142 and GOST-67-198-142 is to comply with the requirements of GOST-62-198-142 and the efficiency of purification from ammophos dust 98.67%. Search for a solution (search for regression) was obtained by obtaining acceptable values of variables in coded form and moving from coded values to natural values table 2.

Table 2.
Switching from encoded values to natural values

№	Factors	Units of measurement	Conditional marking	Encoded value		Real value	
				Saltpeter dust	Ammophos dust	Saltpeter dust	Ammophos dust
1	Active surface of filtration material	м^{2}	X1	-0,62	-0,56	0,245	0,230
2	The diameter of the stutter hole	мм	X2	-0,52	-0,29	1,47	1,70
3	Dust air velocity	м/с	X3	0,12	0,14	22,67	22,97
4	Liquid consumption	м^{3}/соат	X4	-0,03	0,26	0,12	0,13

Thus, the optimal parameters of the device for the dust sampling process for the sample were reset and can be written as follows.

For the cleaning process of saltpeter;
- The active surface of the filtrate of the lining material, S_{act} = 0.245 m^{2}
- diameter of the stutter hole, d_s = 1.5 mm
- speed of dusty air, v = 22.67 m / s
- fluid flow rate, Q_c = 0.121 m^{3} / hour

The energy consumption of these factors was 4.6 kWh, the cleaning efficiency was 99.728%, and the hydraulic resistance was 1016.3 Pa.

For cleaning dust from ammophos;
- active surface of the filter mesh, S_{act} = 0.230 m^{2}
- diameter of the stutter hole, d_s = 2 mm
- speed of dusty air, v = 23 m / s
- fluid flow rate, Q_c = 0.137 m3 / hour

The energy consumption of these factors is 6.2 kWh, the cleaning efficiency is 99.9641%, and its hydraulic resistance is 1098.46 Pa.

V. CONCLUSION

Experimental results show that the efficiency of cleaning is 3.6 ÷ 4.6% higher than the existing wet-cleaning devices, with 1,73 times 2.5-fold water consumption for 1m3 and energy consumption 0.9 times 1.4-fold. found that they are fully satisfied with the technical requirements.

REFERENCES

1. Arkhipov V.A., Berezikov A.P. Fundamentals of the theory of engineering physics experiment. Tomsk: Publishing House of Tomsk Polytechnic University, 2008.206 p.
2. WaldbergA.Yu., Nikolaykina N.E. “Processes and devices are protected by the environment.” Moscow .: “Bustard”, 2008.- 239 pp.
3. Isomidinov A.S., Madaliev A.N. “Hydrodynamics and aerodynamics of the rotor-filter apparatus for cleaning dusty gases.”International scientific-practical conference "International scientific review of the problems and prospects of modern science and education" Boston. USA. November 22-23, 2018. 32 sec
4. Isomidinov A.S. “Choosing dust samples and analysis of dispersion content”, V International Scientific and Practical Conference “Global science and innovations 2019: central asia” V-Tom Astana - 2019 264-268b.
5.Kouzov P.A. Fundamentals of analysis of the dispersed composition of industrial dusts and crushed materials. L .: Chemistry, 1971.280 s.
6.Kobzar A.I., Applied Mathematical Statistics. For engineers and scientists. –Moscow: Fizmatlit, 2006. – 816 p.
7. Nechaeva E. S. Research of the main characteristics of a rotary spray dust collector. Diss Ph.D. Kemerovo - 2014, - 149 s.
8. Isomidinov A.S., Karimov I.T., Tojiev R.J. “Rotary Wet Dust Collector”, FerPI, Scientific and Technical Journal, Issue No. 1, 2018, pp. 195-198: