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ANALYSIS OF MODERN DEVICES FOR WET CLEANING OF INDUSTRIAL DUST GASES

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Abstract
The article analyzes hydraulic, flow inertial and rotor dust cleaning devices that clean industrial dust gases in a wet way. Devices of this type are used to clean flue gases from industrial furnaces and technological waste gases. Scientific research and many patents have been studied on the designs of this type of devices. In the researches, the parameters studied during the process of cleaning dusty gas by the wet method were analyzed and the effect of surface contact elements on the device parameters was evaluated.
Keywords: dust gas, wet method, hydraulics, flow inertia, rotor, efficiency, drag coefficient, local resistance, frictional resistance, coanda effect.

Introduction:
One of the main characteristics of wet dust cleaning devices is the increase of contact surfaces and thus the selection of optimal parameters of hydraulic resistance, cleaning efficiency and energy consumption. Therefore, most of the research work in this area is focused on the creation of a simple design of surface contact elements of the device and a type of high quality work. It is known from the results of research to date that the hydraulic resistance in the surface contact element decreases as it is simplified, but this factor has a negative impact on the cleaning efficiency of the device. In addition, the leakage of liquid droplets increases along with the purified gas from the device [1-4]. This in turn increases the accumulation of dust particles in the pipes of the device.
V.N. Ujov, G.M. Aliyev, A.Y. Valdberg, O.S. Balabekov, L.SH. Baltabayev, I.A. Radionov, K.S. Polotnikov, E.S. Nechayeva, I.M. Kavashnin, R.J. Tojiyev, Alimatov and others conducted research on the design and application of wet dust cleaning devices, the study of their performance and substantiation of parameters, as well as the study of hydraulic resistances in the device [5-11].
Most of the research work on minimizing energy consumption and increasing the cleaning efficiency of wet dust cleaning devices has studied the effect of device operating parameters on hydraulic resistance. Computational equations are recommended depending on the design structure of the hydraulic resistance device. One of the main reasons for this is that the friction and local resistances in each working body of the device affect the flow of dusty gas. Resistances that adversely affect the dusty gas supplied to the device will automatically cause a loss of pressure in the device, which in turn will reduce operating efficiency and increase energy consumption. Several factors need to be considered when calculating hydraulic resistances in dust collectors. For example, gas velocity, flow regime, local and contact element resistance coefficients [12-19].
Therefore, in determining the coefficient of resistance can be found experimentally on the basis of research results of Blazius, Prandtl, Karman, Konakov, Idelchik, Darsi, Nikuradze and

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others [6,7,8]. Due to the complexity of determining the resistance coefficient in scientific research work, correction factors are included in the calculation work. Let's take a look at the research work that has achieved a minimum value of hydraulic losses in the devices discussed above.

For example:

Experimental studies of Khokhlov D.V., I.M. Kavashnin and A.A. Chistyakova in a combined flow-inertial disk dust cleaning device focused on the laws of motion of dusty gas inside the device [20-27]. The dusty gas entering the device is purified in an inertial environment using the Koanda effect. The following correlation was obtained from the results of a study on the Koanda effect:

The current deflection angle of the gas flow f (m / s), the equation for determining the maximum velocity in the flow section, $f \leq f_0$ based on equality.

$$\vartheta_m = \vartheta_0 \cdot (1 - k\frac{\varphi}{\pi}) \quad (1)$$

ϑ_0 - flow velocity in the cross-section of the pipe, m / s; k - 0.83 research coefficient;

This equation makes it possible to determine the maximum and minimum velocities of the dusty gas supplied to the device and the pressure drop in the device. All studies were conducted in finely ground quartz sand with a standard dispersion density of 2650 kg / m^3.

Experimental studies were conducted on the velocity of the dusty gas in the range of 9.6 ÷ 26.7 m / s and in the slit of a nozzle measuring 12 ÷ 18 mm. The total hydraulic loss in the device was determined only by the irrigation effect. According to him, the hydraulic loss was 100 Pa when the nozzle bore was 18 mm and the hydraulic loss was 400 Pa when it was 12 mm.

Conducted in scientific research the cleaning efficiency of several factors in the initial testing process (ē) The effect of:

The diameter of the dust particle ($\overline{d}$), tube width ($\overline{b}$), inter-disc velocity (Re_f), filtering surface (S_f). four-phase research is planned to assess the interaction of factors. Experimental tests were performed four to sixteen times.

The results of the study were processed and the following regression equation was obtained to determine the cleaning efficiency:

$$\begin{aligned}\eta = 79{,}761 + 39704 \cdot \overline{d} + 0{,}018 \cdot \mathrm{Re}_f + 53{,}28 \cdot \overline{b} + 1{,}04 \cdot S_f - \\ - 26{,}05 \cdot \overline{d} \cdot \mathrm{Re}_f - 134500 \cdot \overline{d} \cdot \overline{b} - 3258{,}7 \cdot \overline{d} \cdot S_f - 0{,}049 \cdot \mathrm{Re}_f \cdot \overline{b} - \\ - 0{,}001 \cdot \mathrm{Re}_f \cdot S_f - 2{,}31 \cdot \overline{b} \cdot S_f + 2{,}41 \cdot \overline{d} \cdot \mathrm{Re}_f \cdot S_f + 12454 \cdot \overline{d} \cdot \overline{b} \cdot S_f\end{aligned} \quad (2)$$

In this device, the particle diameter, filtration surface, and dust capture coefficient are listed as the factors that have the greatest impact on dust capture efficiency.

All studies were performed on quartz sand dust in the range of 0 ÷ 90 μm. In experimental studies, the velocity of the dusty gas was found to be in the range of 9.6 ÷ 26.7 m / s. The dependence of the diameter of the trapped dust particle and the degree of cleaning of the filtration surface was studied. According to it, dust particles were found to be in the range of 98.5% at 0 ÷ 5 mkm and 95.5% at 5 ÷ 90 mkm.

The following scientific results were obtained in the experimental studies of A.F.Sorokopud, N.M.Goryachkina and I.E.Beldyaev on determination of hydraulic resistance in a rotor spray

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dust collector. According to him, the total lost hydraulic pressure ΔP_0 (Pa) in the device was determined as follows [1,12,13].

$$\Delta P_0 = \Delta P_{кур} + \Delta P_{суг}. \quad (3)$$

$$\Delta P_{кур} = \zeta_{кур} \frac{\cdot \vartheta^2_{газ} \cdot \rho_{газ}}{2} = 6.415 \cdot \vartheta^2_{газ} \cdot \rho_{газ}. \quad (4)$$

$$\Delta P_{суг} = \zeta_{суг} \cdot \vartheta^2_{газ} \cdot \rho_{газ}. \quad (5)$$

$$\zeta_{суг} = C \cdot (f \cdot \beta)^a \cdot \mathrm{Re}^B_{газ} \cdot K^C_{ук}. \quad (6)$$

In Equation (3), the total hydraulic pressure loss in the device is assumed to be equal to the sum of the pressures lost in the case of the irrigation effect and in the absence of the irrigation effect. One of the main reasons for this is that the working fluid supplied to the device has an internal circulation and can be said to move along the axis line with the dusty gas. Equation (6) is derived in determining the local resistances in the device. Experimental studies were carried out within the following limits of the main quantities: gas velocity 0.7 ÷ 4.1 m / s, frequency of rotation of the pollinator 11.07 ÷ 25.8 s^{-1}, liquid density 880 ÷ 1280 kg / m^3, kinematic viscosity of the liquid 0.001 ÷ 0.106 Pa · s, surface tension coefficient of the liquid 32.1 ÷ 90.4 mN / m, number of rows of spray hole 6 ÷ 17 number of irrigation holes in one row 37 ÷ 70 [28-34];

In the research work of ES Nichaeva experiments to determine the hydraulic resistance of the rotor dusting device, the diameter of the dispersing hole is 1.4 ÷ 2.5 mm, rotation and reading step 2.5, the holes are arranged in six rows in a checkerboard pattern; gas velocity in the device is 0.5 ÷ 3.78 m / s; the rotational frequency of the transport cylinder was 800 ÷ 1000 rpm. [35-41].

The following calculation equation for the coefficient of resistance of a device without liquid is proposed.

$$\zeta_c = -0.121 \cdot \upsilon_г + 6.264 \quad (7)$$

When the velocity range was 0.59 ÷ 3.78 m / s, the coefficient variation was found to vary from 5.8 to 6.2, and the resistance coefficient was assumed to be 6 with sufficient accuracy and average value.

At a gas velocity of 3.5 m / s, the pressure loss increased by 10-15%, which is explained by the fact that the frequency of rotation of the duster is 900–1000 rev / min. The total hydraulic resistance of the non-liquid device was 200 Pa, while the hydraulic resistance of the liquid device was increased to 810 Pa.

R.J. Tojiev and A.S. Isomidinov with rotor-filter in experimental studies in a dust treatment plant, the effect of hydraulic resistance on cleaning efficiency and energy consumption has been studied at different values of active and passive surfaces of the filter material [1]. In studies, the following equation determining the total hydraulic resistance of the device has been proposed.

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$$\Delta P_{ум} = \frac{\lambda_{диф}}{8\sin\frac{\alpha_{кб}}{2}}\left(1-\frac{1}{n^2_{диф}}\right)+\sin\frac{\alpha_{кб}}{2}\left(1-\frac{1}{n_{диф}}\right)^2\frac{\rho_{ap}\cdot\upsilon^2{}_{диф}}{2}+$$
$$+\xi_1\frac{\rho_{ap}\cdot\upsilon^2{}_1}{2}+\xi_2\frac{\rho_{ap}\cdot\upsilon^2{}_2}{2}+\frac{\lambda_{конф}}{8\sin\frac{\alpha_{тб}}{2}}\left(1-\frac{1}{n^2_{конф}}\right)\frac{\rho_{ap}\cdot\upsilon^2{}_{конф}}{2} \quad (8)$$

By the obtained equation (8) it is possible to determine the total hydraulic resistance in the rotor-filter device.

The equations ξ_1 and ξ_2 are the coefficients of resistance of the rotor-filter working surfaces, the determination of which is complex and requires different deviations. Therefore, the equation for determining the coefficient of resistance on the working surfaces A and B of the rotor-filtering device by the ratio of the active surface of the filter material coated on the rotating rotor to the passive surface is introduced.

$$\xi_{ию} = \Delta k\frac{\sum S_{акт}}{\sum S_{пас}} \quad (9)$$

where S_{akt} is the surface of the device without holes in the filter material, m2; S_{pas} - perforated surface of the filter material of the device, m^2; D_k is the correction factor, which is determined experimentally. K.T.Semrau's research work [4] was used to determine the cleaning efficiency of the device and the amount of energy consumed.

The values of the variables for the experiments are fluid flow Q_{suyu} = 0.70 ÷ 0.360 m^3 / h, diameter of the nozzle hole d_{sh} = 1; 2; 3 mm, gas velocity y_g = 7 m / s ÷ 35 m / s, intermediate step 4 m / s, active surface of filter mesh material $\sum S_{act}$ = 0.202; 0.229; 0.268 m^2, the rotational frequency of the rotor was selected at an average value of n = 25 rpm for the experiment. Saltpeter and ammophos powder were selected for the sample. Experimental tests were performed based on the basic physical and chemical characteristics of the dust. According to him, the amount of dust in 1m^3 of air was 333.7 mg / m^3 for nitrate dust, and 245.91 mg / m^3 for ammophos dust [45,46]. In the study, the dust density was defined as ρ_{ap} = 1.82 kg / m^3 for a mixture of nitrate dust and gas and ρ_{ap} = 1.88 kg / m^3 for a mixture of ammophos dust and gas.

In order to determine the optimal parameters of the device, a mathematical planning method was used and the following regression equations were obtained on the basis of the PLANEX program [1,16];

The efficiency of nitrate dust removal in a rotor-filter device is derived from the following regression equation,%

Y = + 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 X324 - 0.418 X3X4; (10)

The efficiency of ammophos dust removal in a rotor-filter device is derived from the following regression equation,%

Y = + 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 X34 (11)

Conclusion:

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However, Andersen BO, Nielsen NF, Walthe JH,Kasatkin A.G., Nechaev Yu.G., Esipov G.P., E.M. Mixalchuk E.M. It should be noted the results of scientific research conducted by S.V. Sorokopud on wet cleaning of dust gases, which showed that the efficiency of cleaning dusty gases with water on the surface of the contact element is much higher (99.9%). This indicates that the surface contact elements have a high performance during the cleaning process

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