Experimental studies in determining the hydraulic resistors of a Rotor fuse device

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ABSTRACT
The article presents the results of experiments conducted on a rotary filter apparatus, in which the modes of gas and liquid mixtures were studied. As a result of experimental tests, the friction coefficients between the contact elements of the basalt thrust and the hydraulic thrust were determined. As a result of these studies, it was found that a certain amount of ionizing radiation energy is required for optimal separation of gases and gas mixtures in liquids and gaseous media.

Keywords: *Where is velocity, apparatus, grid, coefficient of friction, basalt field, gas velocity, liquid velocity, pressure, velocity.*

Introduction:
In the wet method, aqueous solutions of water or chemical reagents are used in the process of cleaning mixtures of powdery gases and gases. These devices can be called different types of scrubbers, gas washers,filters, hydrocyclones and other devices.
The principle of operation is that when gases and gas mixtures are compressed in the liquid phase, the liquid phase comes into contact with the liquid gas formed during compression of the liquid phase in the liquid phase.

Object of study:
Due to the above requirements, a new construction of a rotor apparatus was created by us, which cleans gases in a wet way [1]. Below is an overview of the accounting scheme of this hardware and the experimental device. (Figures 1 and 2).
As a result of theoretical studies, the equation for calculating the total hydraulic resistance of the proposed device was derived [2].

$$\Delta P_{ум} = \lambda_1 \cdot \frac{l_1}{d_{д}} \cdot \rho_{см} \cdot \frac{\omega_{см}^{2}}{2} + \left(\Delta П \frac{\Sigma S_c \cdot \delta}{\Sigma S_c \cdot a} + \frac{S_f}{\Delta K \cdot S_r} + \xi_{суюклик} \right) \times$$
$$\times \frac{\rho_{см} \cdot \omega_{см}^2}{2} + \lambda_2 \frac{l_2}{d_k} \cdot \frac{\rho \cdot \omega^2}{2} + \lambda_3 \cdot \frac{l_3}{d_t} \cdot \frac{\rho \cdot \omega_ч^2}{2} \qquad (1)$$

Using this equation, we can write the total resistance coefficient of the device as

$$\xi_{ум} = \xi_{кир} + \xi_{к.м.} + \xi_{чик} \qquad (2)$$

In this case, $\xi_{кир}$ is the coefficient of resistance created by the friction force when entering the purified gas into the device, $\xi_{к.м}$ is the resistance coefficient of the contact device with a rotor, $\xi_{чик}$ is the coefficient of resistance created by the friction force when releasing the purified gas from the device.

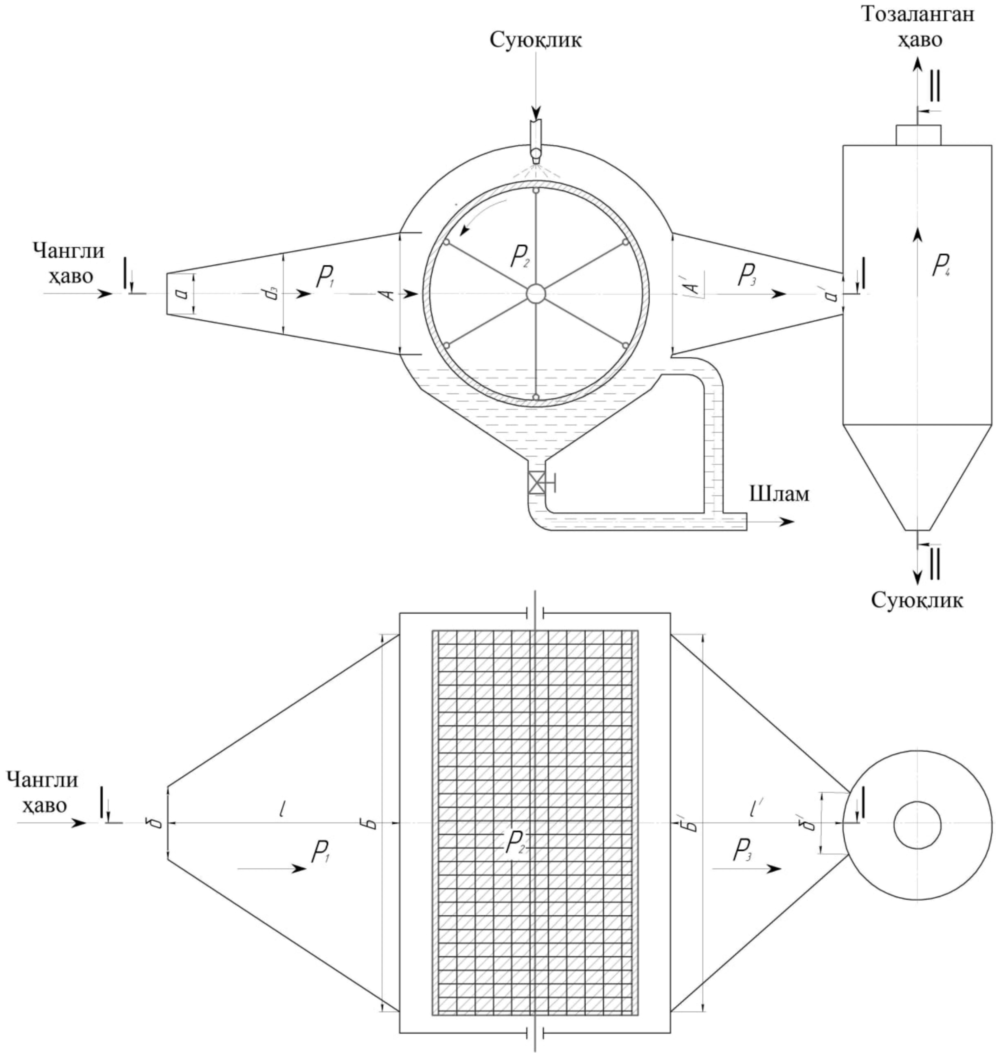

Figure 1. Device calculation scheme.

The total resistance coefficient of the rotor contact device of the device is equal to the sum of the resistance coefficient $\xi_{К.ум}$, the resistance coefficient ξ_c of the support grids on which the fibrous material is laid, the resistance coefficient ξ_m of the fibrous material, and the resistance coefficient $\xi_{суюқлик}$ resulting from the liquid sprayed onto the contact device. That is,

$$\xi_{К.ум} = \left(\xi_c + \xi_m + \xi_{суюклик}\right) \quad (3)$$

The results obtained:

As a result of theoretical studies, the relative contact surfaces of basalt fibers of 3 different weights placed on the rotor filter were determined. According to them, when 1m = 100 gr, S_f = 17 m^2; when 2m = 150 gr, S_f = 25.5 m^2; when 3m = 200 gr, S_f = 34 m^2 [3].

Experimental studies were conducted on a prototype of the proposed new device (Figure 2), and the resistance coefficients of the device's local and basalt fiber contact elements were determined for the non-watered and watered states [4,5].

During the experimental studies, the gas velocity was supplied to the apparatus at a constant value of υ_g=7÷35 *m/s* with a step of υ_g=7 *m/s*. At each constant value of the gas velocity, liquid was sequentially sprayed onto the basalt fiber rotor filter using 3 nozzles up to *Q*=0.068÷0.228 m^3/h with a step of 0.044 m^3/h. The gas velocities exiting the device were determined using an electronic anemometer, and the resistance coefficients of the contact element of the apparatus for the case where liquid was supplied to the apparatus from the difference in gas velocities when no liquid was sprayed were determined. The results obtained from the experimental studies are presented in Tables 1, 2, and 3.

According to the results of experimental studies, the equation for calculating the total resistance coefficient of the device was simplified.

2- Picture. Overview of the experimental device.

$$\Sigma\xi = 0,7 + \Delta K \frac{S_f}{S_r} \quad (4)$$

In this case, equation 1, which calculates the total hydraulic resistance of the device, becomes the following simple form.

$$\Delta P_{ум} = 0,7 + \left(\Delta K \frac{S_f}{S_r} \cdot \frac{\rho_{см} \cdot \omega_{см}^2}{2} \right); Па \quad (5)$$

Based on the results of the experimental research, the hydraulic resistance of the device was determined. Based on the obtained experimental results, graphs of the change in hydraulic resistance depending on the change in gas velocity were constructed for basalt fibers of 3 different weights (Figures 3, 4, 5). The results of the conducted research and calculations are presented in Tables 1, 2, and 3.

Table 1
Experimental results obtained in determining the resistance coefficients and hydraulic resistances of a basalt fiber filter when liquid is sprayed into the apparatus.
Basalt fiber mass m=100 grams

№	When no fluid is given				When fluid is given			
	Input speed V_k, m/sec	Output speed $V_ч$, m/sec	Resistance coefficient $\xi_{ум}$	Pressure ΔP, Pa	Fluid consumption Q, M³/hour	On the way out Speed $V_ч$, m/sec	Resistance coefficient ξ	Pressure ΔP, Pa
1					0,068	3,2	2,18	69
2					0,108	3,1	2,25	71
3		3,3	2,1	66	0,148	3	2,33	73
4	7				0,188	2,9	2,41	76
5					0,228	2,8	2,5	79
1					0,068	6,6	2,12	267
2					0,108	6,5	2,15	271
3			2,1		0,148	6,4	2,18	275
4	14	6,7		265	0,188	6,3	2,22	280
5					0,228	6,2	2,25	283
1					0,068	9,9	2,12	603
2		10		597	0,108	9,8	2,14	608
3	21		2,1		0,148	9,7	2,16	614
4					0,188	9,6	2,18	619
5					0,228	9,5	2,21	628
1					0,068	13	2,13	1076
2					0,108	13	2,14	1081
3	28	13	2,1	1061	0,148	12,9	2,15	1086
4					0,188	12,9	2,16	1091
5					0,228	12,9	2,17	1096
1					0,068	16,5	2,12	1674
2			2,1	1659	0,108	16,4	2,13	1682
3	35	17			0,148	16,3	2,14	1690
4					0,188	16,2	2,15	1698
5					0,228	16,1	2,16	1706

Table 2
Experimental results obtained in determining the resistance coefficients of a basalt fiber filter when liquid is sprayed onto the device.
Basalt fiber mass m=150 grams

№	When no fluid is given				When fluid is given			
	Input speed V_k, m/sec	Output speed $V_ч$, m/sec	Input speed V_k, m/sec	Output speed $V_ч$, m/sec	Input speed V_k, m/sec	Output speed $V_ч$, m/sec	Input speed V_k, m/sec	Output speed $V_ч$, m/sec
1		2,3			0,068	2,25	3,11	98
2					0,108	2,2	3,18	101
3			3	95	0,148	2,15	3,25	103

4	7				0,188	2,1	3,33	105
5					0,228	2	3,5	110
1	14	4,5	3	379	0,068	4,49	3,08	389
2					0,108	4,43	3,16	399
3					0,148	4,33	3,23	408
4					0,188	4,24	3,3	416
5					0,228	4,1	3,4	430
1	21	7	3	853	0,068	6,8	3,06	870
2					0,108	6,69	3,14	892
3					0,148	6,54	3,21	913
4					0,188	6,4	3,28	933
5					0,228	6,25	3,36	955
1	28	9,5	3	1517	0,068	9,2	3,04	1537
2					0,108	8,9	3,12	1598
3					0,148	8,7	3,19	1613
4					0,188	8,6	3,25	1643
5					0,228	8,4	3,32	1678
1	35	12	3	2370	0,068	11,5	3,02	2385
2					0,108	11,2	3,1	2449
3					0,148	11	3,16	2496
4					0,188	10,8	3,22	2543
5					0,228	10,6	3,28	2591

Table 3

Experimental results obtained in determining the resistance coefficients of a basalt fiber filter when liquid is sprayed onto the device.

Basalt fiber mass m=200 grams

№	When no fluid is given				When fluid is given			
	Input speed Vk, m/sec	Output speed Vч, m/sec	Input speed Vk, m/sec	Output speed Vч, m/sec	Input speed Vk, m/sec	Output speed Vч, m/sec	Input speed Vk, m/sec	Output speed Vч, m/sec
1	7	1,75	4	126	0,068	1,67	4,2	132
2					0,108	1,6	4,38	138
3					0,148	1,58	4,43	140
4					0,188	1,56	4,48	141
5					0,228	1,53	4,55	143
1	14	3,4	4	505	0,068	3,34	4,18	527
2					0,108	3,21	4,35	549
3					0,148	3,19	4,39	554
4					0,188	3,15	4,44	560
5					0,228	3,1	4,5	568
1	21	5,2	4	1137	0,068	5,04	4,16	1182
2					0,108	4,86	4,32	1227
3					0,148	4,81	4,36	1239
4					0,188	4,75	4,4	1250
5					0,228	4,7	4,42	1256
1					0,068	6,76	4,14	2093
2					0,108	6,54	4,28	2164

3	28	7	4	2022	0,148	6,46	4,33	2188
4					0,188	6,39	4,38	2214
5					0,228	6,36	4,4	2224
1	35	9	4	3160	0,068	8,5	4,12	3254
2					0,108	8,21	4,26	3365
3					0,148	8,1	4,32	3413
4					0,188	8	4,36	3444
5					0,228	7,9	4,38	3460

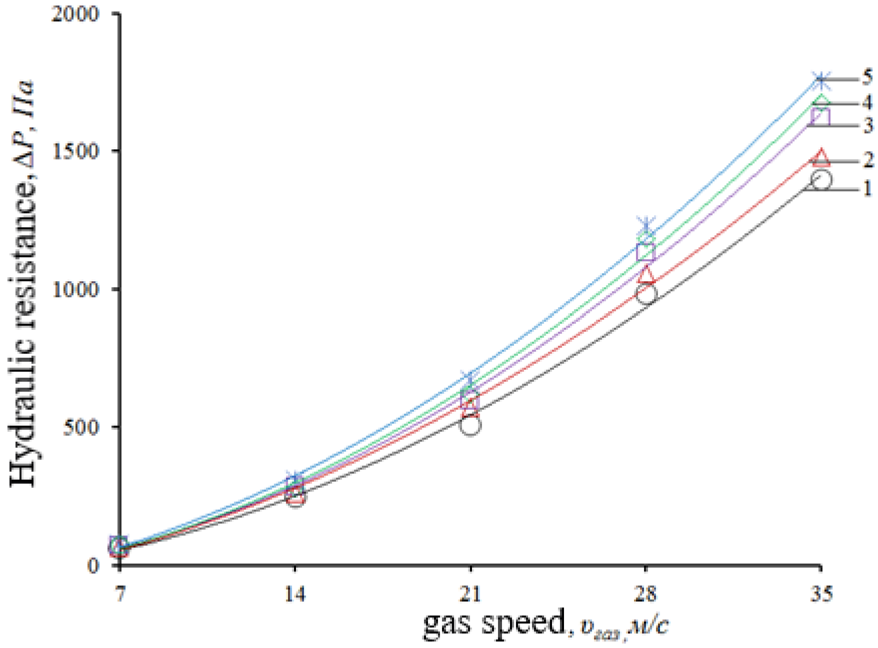

Figure 3. Graph of the change in hydraulic resistance (ΔP) depending on the gas velocity (υ_{gas}).
m=100 grams constant**.**
1- When the fluid flow rate is Q=0,068 m³/hour; 2- When the fluid flow rate is Q=0,108 m³/hour; 3- When the fluid flow rate is Q=0,148 m³/hour; 4- When the fluid flow rate is Q=0,188 m³/hour; 5- When the fluid flow rate is Q=0,228 m³/hour.

$$y = 1{,}1385x^2 + 13{,}284x - 84 \qquad R^2 = 0{,}9979 \qquad (6)$$
$$y = 0{,}9169x^2 + 13{,}133x - 82{,}8 \qquad R^2 = 0{,}9967 \qquad (7)$$
$$y = 1{,}1531x^2 + 10{,}271x - 70{,}2 \qquad R^2 = 0{,}9964 \qquad (8)$$
$$y = 1{,}1297x^2 + 8{,}9082x - 56{,}6 \qquad R^2 = 0{,}9973 \qquad (9)$$
$$y = 0{,}9606x^2 + 8{,}2673x - 52{,}2 \qquad R^2 = 0{,}9963 \qquad (10)$$

gas speed, $\upsilon_{газ}$,m/s	When Q=0,068 m³/hour	When Q=0,108 m³/hour	When Q=0,148 m³/hour	When Q=0,188 m³/hour	When Q=0,228 m³/hour
7	61	68	70	73	77
14	247	261	283	281	309
21	510	573	595	621	672
28	984	1056	1130	1184	1230
35	1394	1478	1619	1676	1755

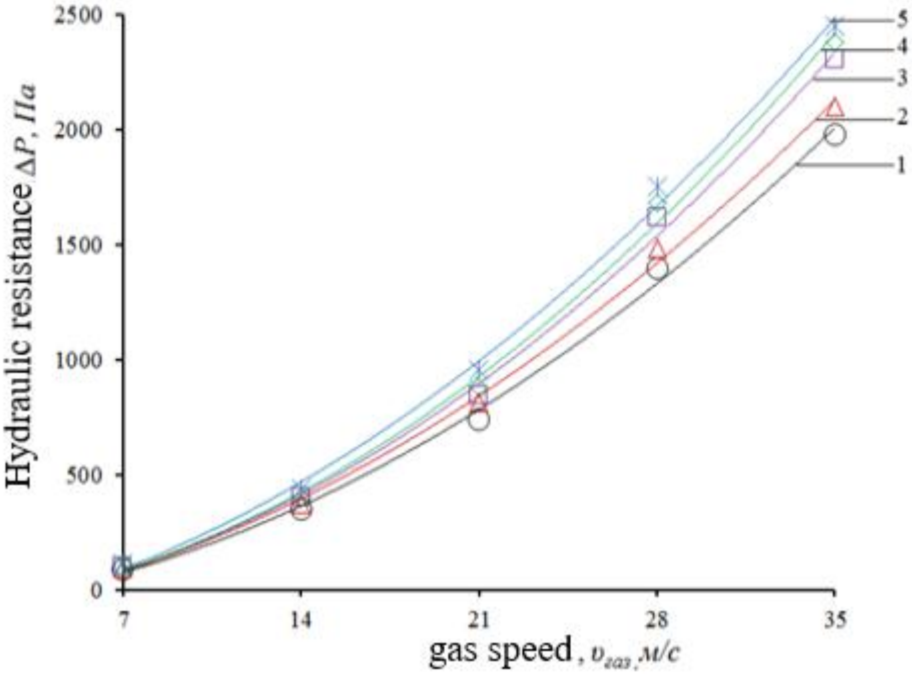

Figure 4. Graph of the change in hydraulic resistance (ΔP) depending on the gas velocity (υ_{gas}).

m=150 grams constant.

1- When the fluid flow rate is Q=0,068 m^3/hour; 2- When the fluid flow rate is Q=0,108 m^3/hour; 3- When the fluid flow rate is Q=0,148 m^3/hour; 4- When the fluid flow rate is Q=0,188 m^3/hour; 5- When the fluid flow rate is Q=0,228 m^3/hour.

$y = 1,4913x^2 + 22,924x - 144,8$ $R^2 = 0,9971$ (11)

$y = 1,3294x^2 + 17,249x - 105,8$ $R^2 = 0,9976$ (12)

$y = 1,6443x^2 + 14,282x - 97,2$ $R^2 = 0,9963$ (13)

$y = 1,5904x^2 + 13,418x - 86,2$ $R^2 = 0,9968$ (14)

$y = 1,3149x^2 + 13,776x – 86$ $R^2 = 0,997$ (15)

gas speed, $\upsilon_{газ}$,m/s	When Q=0,068 m^3/hour	When Q=0,108 m^3/hour	When Q=0,148 m^3/hour	When Q=0,188 m^3/hour	When Q=0,228 m^3/hour
7	88	97	100	104	110
14	352	372	402	400	439
21	742	814	845	879	955
28	1398	1482	1617	1682	1748
35	1980	2100	2300	2380	2450

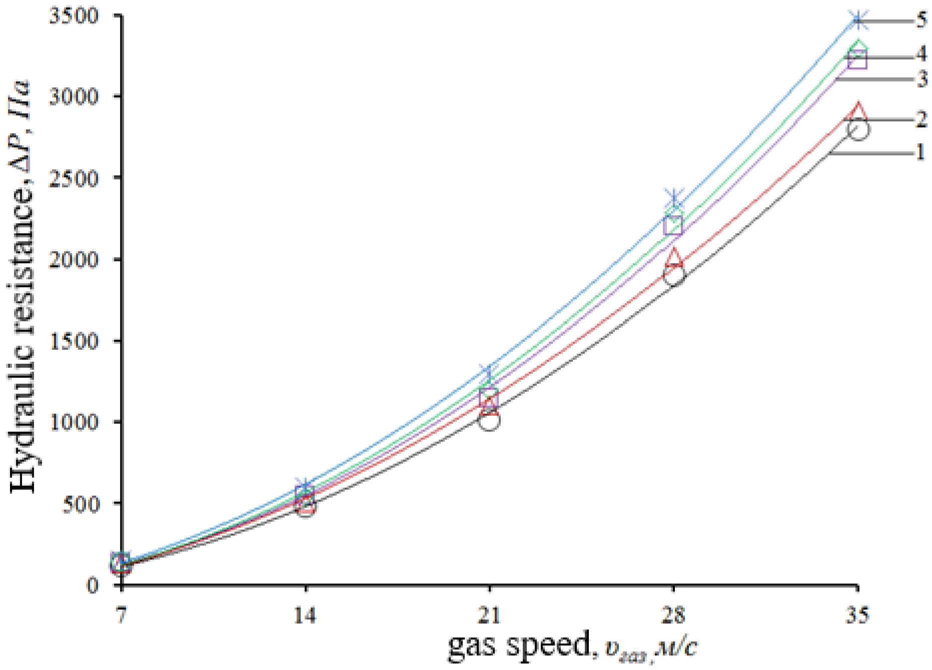

Figure 5. Graph of the change in hydraulic resistance (ΔP) depending on the gas velocity (υ_{gas}).
m=200 grams constant.
1- When the fluid flow rate is Q=0,068 m³/hour; 2- When the fluid flow rate is Q=0,108 m³/hour; 3- When the fluid flow rate is Q=0,148 m³/hour; 4- When the fluid flow rate is Q=0,188 m³/hour; 5- When the fluid flow rate is Q=0,228 m³/hour.

$$y = 2,4402x^2 + 17,939x - 111,8 \quad R^2 = 0,9988 \quad (16)$$
$$y = 1,9752x^2 + 18,112x - 109,4 \quad R^2 = 0,9985 \quad (17)$$
$$y = 2,4184x^2 + 13,557x - 94 \quad R^2 = 0,9973 \quad (18)$$
$$y = 2,4461x^2 + 9,1224x - 57,8 \quad R^2 = 0,9981 \quad (19)$$
$$y = 2,0977x^2 + 8,798x - 53,2 \quad R^2 = 0,9985 \quad (20)$$

gas speed, $\upsilon_{газ}$,m/s	When Q=0,068 m³/hour	When Q=0,108 m³/hour	When Q=0,148 m³/hour	When Q=0,188 m³/hour	When Q=0,228 m³/hour
7	120	132	137	142	150
14	479	507	548	545	598
21	1010	1108	1150	1196	1300
28	1902	2016	2200	2288	2378
35	2800	2915	3226	3300	3475

As a result of processing the empirical formulas obtained as a result of the research, the following empirical equation was recommended to simplify the determination of the hydraulic resistance of the rotor-filter apparatus that cleans dust gases in a wet way, Pa;

$$\Delta P= -0,2041\ \upsilon_{газ}^2 + 129,14\ \upsilon_{газ} - 797 \quad (21)$$

The results of the study differ from the theoretical calculation results by 3.75% and do not exceed them. The quantities in equation (3.7) are meaningful when υ=7÷35 m/s, and Q_{unm}=0.068÷0.228 m³/hour.

Within the specified limits, the difference of the research results according to equation (21) does not exceed 5% on average compared to the calculated results, which means that the parameters creating the hydraulic resistance are correctly selected. Equation (21) can also be used in engineering calculations and in choosing the rational operating mode and parameters of the apparatus.

Conclusion:

The article describes the results of experimental research conducted in the pilot device of the basalt fiber-laid rotor filter apparatus for cleaning dust and gas mixtures in a wet method, in different gas and liquid flow regimes. As a result of experimental studies, the hydraulic resistance of the device was determined depending on the resistance coefficients of local and 3 different weight basalt fiber contact elements. As a result, depending on these pressures, an opportunity was created to determine the optimal values of the efficiency of cleaning dusty gas and gas mixtures and the energy consumption of the device.

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