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Research of Hydrodynamic Parameters of Drum Dryer

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ABSTRACT: This article examines the effect of a two-component drum dryer nozzle on hydrodynamic conditions. In experiments, it was found that the material density of the nozzle part of the nozzle is R=15; 30 and 45°C, the number of heat exchange zones is 5, the number of nozzles in one row is 5 (the nozzles are placed in the order of chess rows by zones), the speed of the heating agent (air) coming out of the colorifier is υ= 1,4÷14,2 m/s, the productivity of the K_{prod} device is Q_{prod} =0,18÷0,46 kg/s. It is experimentally established that for different values of the gas velocity, the coefficient of resistance of the drum and nozzle, as well as its effect on the hydraulic resistance. Empirical equations that adequately describe the process are processed in the appropriate order of experiments.

KEYWORDS: drum dryer, two-component nozzle, hydraulic resistance, coefficient of resistance, product spill angle, gas velocity, open area**.**

I. INTRODUCTION

Studies and practice of drum dryers show that changing the inclination angle of standard nozzles present in the drum along the axis of the drum does not significantly increase the area of material curtains scattered over the surface of the drum [1].

If the nozzle is installed on the axis of the drum, the area of the curtains will be maximum, but it will not be enough. Open "A" zones are formed to the right and left of the drum surface. Among other technical measures aimed at expanding the area of curtains, a chess scheme of nozzles and a comb edge of the nozzle are used. But 30-40% of the surface of the drum section remains open [2,3].

The optimal solution to eliminate the open "A" zone in the dryer is to choose a nozzle suitable for the process and improve its design. Currently, many research works are being carried out in this direction, and two-section packing structures [1] are a promising option.

II. MATERIALS AND METHODS

Based on the above, existing nozzle designs were systematically analyzed based on the MATLAB program and their operating parameters were compared [4].

Based on multistage analysis, an improved calculation scheme of a two-element nozzle was developed. Figure 1 shows the installation of the nozzle on the drum.

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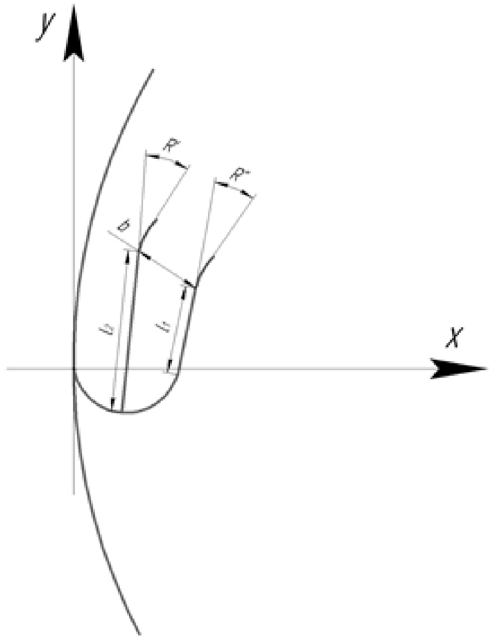

Figure 1.Scheme of installation of the proposed nozzle on the drum.

The advantage of the nozzle over existing structures is that, firstly, the fact that its pouring part of the material forms a certain slope (R' and R" in Figure 1) provides a sharp reduction in the open areas "A" in the dryer. Secondly, the parts are mounted on a semi-circular structure, which prevents the material from getting stuck in the nozzle. To evaluate the hydrodynamic modes of the nozzle design in open areas "A" and its effect on the heat exchange processes, a laboratory version of the drum dryer was developed and experiments were carried out (Figures 4 A and B). The experiments were carried out in two stages.

Figure 2. General view of the drum dryer

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III. RESULTS AND DISCUSSION

At the first stage, a fan for determining the velocity of the gas leaving the heater and the resistance coefficients of the proposed nozzle (efficiency Q_{max} = 150 m^3/h; electromotive force N_{dv} = 0.3 kW; frequency n = 400 rpm) of centrifugal type Pito-Prandtl tube (7.18) (size 50 and 100 mm). Metal tube D = 60 mm, L = 1200 mm, determining the dust gas velocity. The pipe has two Pito-Prandtl tubes with an internal diameter of 7 mm, which determine static and dynamic pressure. The Pito-Prandtl tube was selected according to the diameter of the fan outlet pipe according to St requirements to determine gas velocity, efficiency and pressure. Also, for comparing the results, gases of the ANEMOMETER VA06 - TROTEC grade were obtained (measurement range of 1.1 m/s – 50 m/s with an error coefficient of 0.2%, the error coefficient at a gas velocity of more than 50 m/s is up to 5%), a ruler was used.

To control the dusty gas velocity, a 0°; 30°; 45°; 60°; 90° gate was set in the colourizer vent and the gas velocity at the inlet and outlet of the drum and the flow rate were experimentally determined. Each experiment was repeated 5 times and arithmetic averages were selected. Results of the first stage of experiment 1; Shown in Tables 2 and 3.

Table 3.The inclination of the pouring part of the nozzle (When R = 15°)

№	Degree calorifer gate	Access speed	Output speed	Coefficient of resistance
Product filling coefficient of 0.18 kg/h				
1	90°	14,2	4.23	3.35
2	75°	10.55	3.16	3.33
3	60°	7.15	2.12	3.37
4	45°	5.62	1.72	3.29
5	30°	2.60	0.77	3.35
6	15°	1.40	0.41	3.36
				On average,3.34
Product filling coefficient of0.32 kg/h				
1	90°	14,2	4.04	3.51
2	75°	10.55	3.02	3.49
3	60°	7.15	2.01	3.56
4	45°	5.62	1.59	3.52
5	30°	2.60	0.73	3.54
6	15°	1.40	0.39	3.53
				On average, 3.52
Product filling coefficient 0,46 kg/s				
1	90°	14,2	3.78	3.75
2	75°	10.55	2.83	3.72
3	60°	7.15	1.91	3.74
4	45°	5.62	1.51	3.75
5	30°	2.60	0.69	3.73
6	15°	1.40	0.37	3.76
				On average, 3.74

Table 2. The inclination of the pouring part of the nozzle. (When R = 30°)

№	Degree calorifer gate	Access speed	Output speed	Coefficient of resistance
Product filling coefficient of 0.18 kg/h				
1	90°	14,2	3.03	4.68
2	75°	10.55	2.26	4.66
3	60°	7.15	1.52	4.70
4	45°	5.62	1.21	4.62

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5	30°	2.60	0.55	4.68
6	15°	1.40	0.30	4.67
				On average, 4.66
Product filling coefficient of0.32 kg/h				
1	90°	14,2	2.93	4.84
2	75°	10.55	2.18	4.82
3	60°	7.15	1.46	4.89
4	45°	5.62	1.15	4.85
5	30°	2.60	0.53	4.87
6	15°	1.40	0.28	4.86
				On average, 4.81
Product filling coefficient 0,46 kg/s				
1	90°	14,2	2.79	5.08
2	75°	10.55	2.08	5.05
3	60°	7.15	1.41	5.07
4	45°	5.62	1.10	5.09
5	30°	2.60	0.51	5.06
6	15°	1.40	0.27	5.08
				On average, 5.07

Table 3.The inclination of the pouring part of the nozzle (When R = 45°)

№	Degree calorifer gate	Access speed	Output speed	Coefficient of resistance
Product filling coefficient 0.18 kg/h				
1	90°	14,2	2.39	5.92
2	75°	10.55	1.78	5.90
3	60°	7.15	1.20	5.94
4	45°	5.62	0.95	5.86
5	30°	2.60	0.43	5.92
6	15°	1.40	0.23	5.93
				On average, 5.91
Product filling coefficient 0.32 kg/h				
1	90°	14,2	2.33	6.08
2	75°	10.55	1.74	6.06
3	60°	7.15	1.16	6.13
4	45°	5.62	0.92	6.09
5	30°	2.60	0.42	6.11
6	15°	1.40	0.22	6.10
				On average, 6.09
Product filling coefficient 0,46 kg/s				
1	90°	14,2	2.24	6.32
2	75°	10.55	1.67	6.29
3	60°	7.15	1.13	6.31
4	45°	5.62	0.88	6.32
5	30°	2.60	0.41	6.30
6	15°	1.40	0.22	6.33
				On average, 6.31

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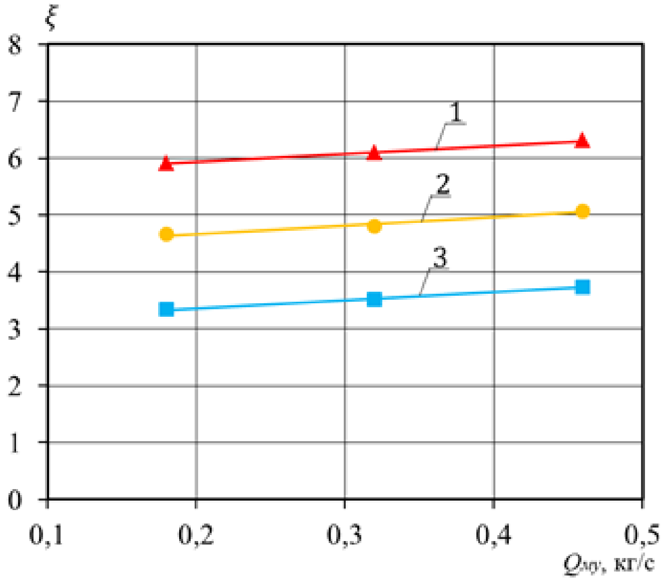
To check the correctness of the experiments, a graph of the dependence of the resistance coefficient on the second workability of the product was built (Figure 3).



1 working capacity 0.18 kg / h; 2 working productivity 0.32 kg / h; 3 working productivity 0.46 kg / h;

Figure 3.Dependence of the coefficient of resistance on performance.

The following empirical equations [5] were obtained using the method of least squares for the graphical relationships shown in Figure 3, and the correlation errors (R) were determined separately for each point of the graphical relationships. It can be seen from the obtained values that the experimental error did not exceed 5%. 1 working capacity 0.18 kg/h;

$$y = 1{,}4286x + 5{,}6462 \left(R^2 = 0{,}9967\right) \quad (1)$$

2 working productivity 0.32 kg/h;

$$y = 1{,}4643x + 4{,}3781 \left(R^2 = 0{,}9766\right) \quad (2)$$

3 working productivity 0.46 kg/h;

$$y = 1{,}4286x + 3{,}0762 \left(R^2 = 0{,}9967\right) \quad (3)$$

At the second stage, the hydraulic resistance of the drum of the device was determined for various values of the gas velocity and per second productivity of the product in the device. The next limits of the variables for the study, the slope of the pouring part of the nozzle R = 15; 30 and 45^o, the number of heat exchange zones is 5, the number of nozzles in one row is 5 (the nozzles are placed in the order of chess rows by zones), The speed of the coolant (air) leaving the heater υ= 1,4÷14,2 m/s, Device efficiency Qprod = 0.18 ÷ 0.46 kg/s, The angle of inclination of the drying drum relative to the plane α=2,24 gr (according to the technical regulations), The rotational speed of the drying drum was set to n = 4 rpm. In the experimental determination of the hydraulic resistance, an electronic measuring device JM-510 was used and compared with the theoretical values determined by equation (4), [1010] Pa;

$$P_{iyu} = n \cdot \alpha \cdot z \cdot \frac{w^2 \cdot \rho \cdot S_b}{2 \cdot S_{fyu}} \quad (4)$$

where υ is the speed of the coolant, m-s; ρ - is the density of the coolant (air), kg / m^3; n - is the number of nodules, pcs.;α - the angle of inclination of the nozzle for pouring the product, degrees; z - is the number of rows of nozzles; S_b - drum cross-sectional area, m^2; S_{fu} - dryer is an unused surface of the heat carrier, which is determined depending on the

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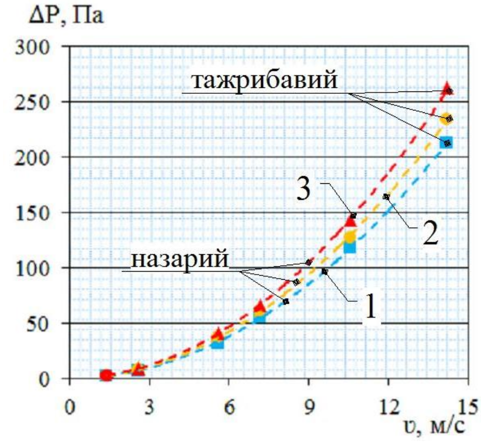
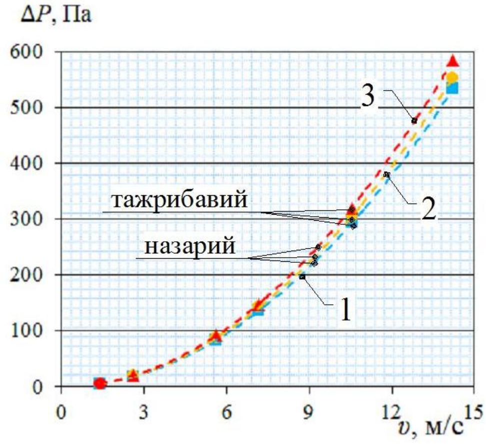
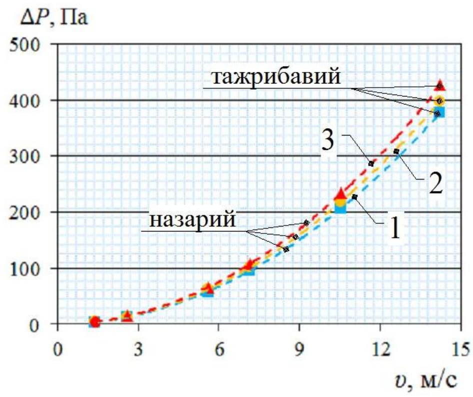
design of the selected nozzle, filling the surface of the dryer and the movement pattern. The results of the experiment are shown in Figure 4A.



A).



C).



B).

1–Q=0,18kg/s;2–Q=0,32kg/s;3–Q=0,46 kg/s;

Figure 4. Dependence of hydraulic resistance on gas velocity.

From the data shown in figure 4, it can be seen that the gas velocity υ= 1,4÷14,2 m/s. the intermediate step is 2.65 m/s, and when increasing Q =0,18 ÷ 0,46 kg/s to 0.14 kg/s, the minimum value of hydraulic resistance in R=15^o when bending the nozzle material was ΔP = 2,11 Pa, while the maximum value of hydraulic resistance was ΔP = 262,6 Pa. At R=30^o, the minimum hydraulic resistance value ΔP = 3.65 PA and the maximum hydraulic resistance value ΔP = 426,5 Pa. At R=45^o, the minimum hydraulic resistance value ΔP = 5.23 Pa, and the maximum hydraulic resistance value ΔP = 583.09 Pa. The graphical dependencies are shown in Figures 4 A, B and C can be expressed by the following empirical formulas defined by the least-squares method [5];

The inclination of the pouring part of the nozzle. (R = 15^o)

$$y = 1{,}037x^2 + 0{,}3127x - 0{,}7683\,; \qquad R^2 = 0{,}9999 \qquad (5)$$

$$y = 1{,}1507x^2 + 0{,}0772x + 0{,}1076\,; \qquad R^2 = 0{,}9999 \qquad (6)$$

$$y = 1{,}3233x^2 - 0{,}3806x + 0{,}7827; \qquad R^2 = 0{,}9987 \qquad (7)$$

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The inclination of the pouring part of the nozzle. (R = 30°)

$$y = 1,8813x^2 - 0,2381x + 0,3982; \qquad R^2 = 0,9971 \quad (8)$$

$$y = 2,1493x^2 - 0,5588x + 0,8606; \qquad R^2 = 0,9846 \quad (9)$$

$$y = 2,1493x^2 - 0,5588x + 0,8606; \qquad R^2 = 0,9923 \quad (10)$$

The inclination of the pouring part of the nozzle. (R = 45°)

$$y = 2,7308x^2 + 0,0846x + 0,1638; \qquad R^2 = 0,9871 \quad (11)$$

$$y = 2,7308x^2 + 0,0846x + 0,1638; \qquad R^2 = 0,9924 \quad (12)$$

$$y = 2,9072x^2 - 0,2993x + 0,682; \qquad R^2 = 0,9904 \quad (13)$$

IV. CONCLUSION

The empirical equations derived from the experimental values were solved separately for each point and compared with the determined theoretical values.

Calculations show that the error between theoretical and experimental values does not exceed 5%.

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