RELIABLE PERFORMANCE AND REASONABLE DESIGN OF DRUM DRYER MACHINE

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Abstract. *The article analyzes the effect of rotation speed on the parameters of movement of materials in a drying drum: the degree of material distribution over the transverse surface of the apparatus, the average time of its stay in the apparatus and the degree of loading. As a model material in the experiments, we used a mineral fertilizer produced in the superphosphate shop of the AS-72 at Farg'onaazot JSC.*

Keywords: *dryer drum, distribution degree, average residence time, load degree, fall length, mineral fertilizer.*

НАДЕЖНАЯ РАБОТА И РАЗУМНАЯ КОНСТРУКЦИЯ БАРАБАННОЙ СУШИЛКИ

Аннотация: *В статье анализируется влияние скорости вращения на параметры движения материалов в сушильном барабане: степень распределения материала по поперечной поверхности аппарата, среднее время его пребывания в аппарате и степень загрузки. В качестве модельного материала в опытах использовали минеральное удобрение, произведенное в суперфосфатном цехе АС-72 ОАО «Фарганазот».*

Ключевые слова: *сушильный барабан, степень распределения, среднее время пребывания, степень нагрузки, длина падения, минеральное удобрение.*

INTRODUCTION

According to the scientific research drum devices are used for heat treatment and drying of dispersed materials. The theory and experimental data on the processing of dispersed material in the Internet and in the literature are different, and there is no generally accepted analysis by researchers. The model of material thermal treatment and drying in the investigated drum dryers is different from the processes mentioned in the literature. In this case, the dispersed material is located inside the cylindrical drum of the apparatus and in the gap between the rotating rotor. Visual observations showed that when the filling coefficient of the interstitial space is less than one, the granular material is in a drum state. The movement of the particles is as follows: the particles collide with the rotating blades and move towards the inner wall of the drum at different angles. Mixing of material particles occurs as a result of the interaction between individual particles and groups of particles, the wall and blade of the apparatus.

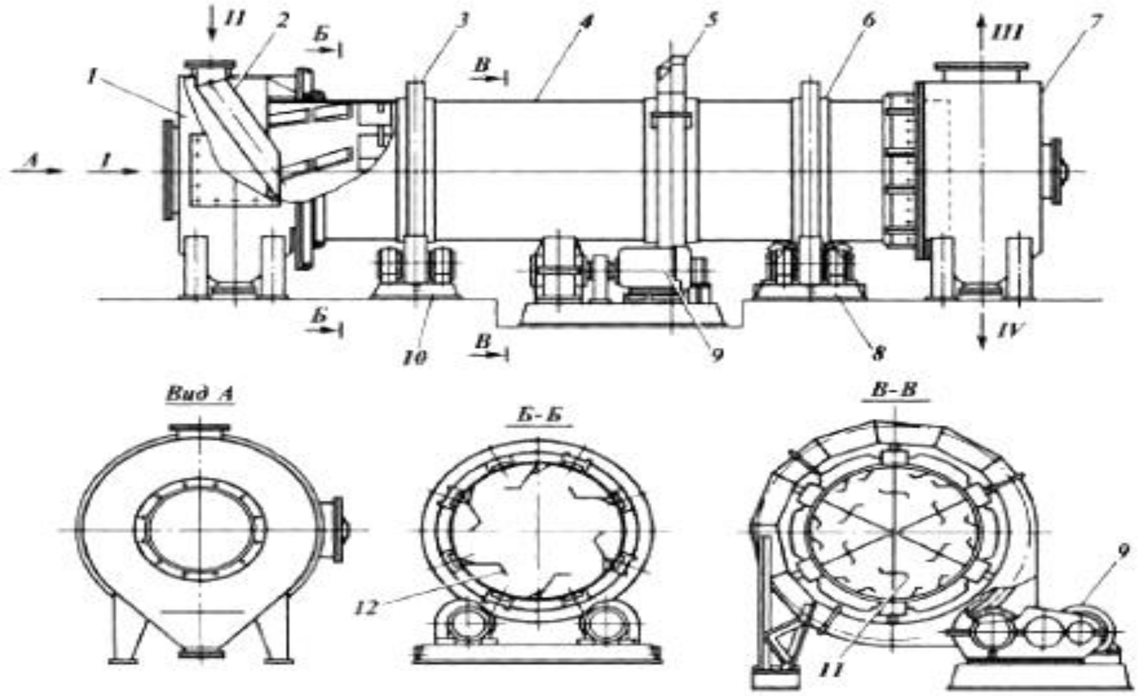
MATERIALS AND METHODS

On the basis of theoretical and experimental research, mathematical equations of the processes formed in the dryer and the thermal treatment and drying process were proposed. At present, various devices are used for drying products in production enterprises [1-3]. The advantage of widely used drying drums over other devices is their structural simplicity, ease of management and relatively low cost. The drying drum consists of a cylindrical body inclined to the horizon, and the processed product is loaded from one end and discharged from the other end. The amount of heat needed to dry the material is given by means of opposite or parallel directed heat agent. In order to improve the contact of the material with the heating air, special nozzles (nozzles) are installed inside the cylindrical drum [4-8].

RESULTS

Acording to the facts in the chemical industry, building materials production, metallurgy and other fields of production, there is a growing demand for high-intensity, small-volume, high-performance thermal processing equipment and devices for dispersed materials. In the current global financial and economic crisis, manufacturers are demanding from designers heat treatment devices that are highly mobile, high-intensity, and easy to adapt to other products when needed, rather than large, high-capacity devices. There are various methods of thermal treatment of dispersed materials, and these processes include heat exchange in layers of dispersed materials, cooling, burning, burning, drying, catalytic reaction processes using dispersed catalysts [9-13].

For finely dispersed materials, the speed of air inside the drum should not exceed 0.5-1.0 m/s, and for large pieces of materials, it should not exceed 3.5-4.5 m/s. Used gases are cleaned of fine dust in a cyclone before being released into the atmosphere. The dried material is removed from the drum through a device that discharges it. Depending on the size and properties of the dried material grains, different nozzles are used in the equipment. Lifting-blade nozzles are used for drying hard lumpy and cohesive materials, and sector nozzles are used for drying large lumpy materials with poor dispersion and high density. Spreading nozzles are widely used for drying small-sized, rapidly dispersing materials. It is advisable to dry crushed, dust-forming materials in drums with closed-cell tunnel nozzles. In some cases, complex nozzles are used. Loss of specific moisture in the drying drum with is equal, and it is determined from the following equation [14-16].



Drum dryer

1-loading hopper; 2-distributing tray; 3-bandages; 4-dryer shell; 5-toothed tray; 6-bandage; 7- bunker; 8- base; 9- reducer; 10-pin roller; 11- base rollers.

Streams I - heat carrier; II – wet material; III- secondary air; IV – finished product [17-19].

The degree of filling of the transverse surface was determined by taking a photo from the side of the drum. An example of a photo for determining the degree of scattering of material rain from a drum is shown in Figure 1, and the obtained values are presented in Table 1

Figure – 1. Sample photo of determining the degree of material raining of the drum.

The temperature, pressure, and relative humidity of the ambient air were preliminarily determined. Before the start of the experiment, the required heating power was determined by the consumption of the drying agent and its temperature, and the corresponding sections of the heater were connected on the control panel.

1 Table

Drum diameter D , m	The number of drum revolutions is circ/min	L-shaped flat nozzle	Three tipe of nozzle	The nozzle of like U
0,4	2,5	55	58	71
0,4	3,0	56	59	73
0,4	3,5	58	61	73
0,4	4,0	58	63	75
2,0	2,5	57	63	74
2,0	3,0	60	64	77

The results of these studies are analyzed. In this case, from the point of view of the uniformity of the distribution of material rain, U-shaped nozzles show a clear advantage, because in this case, the coverage of the drum surface of the material distribution was more valuable than other types of nozzles. The study of the proposed nozzle led to the following conclusion: ensuring uniform distribution of the drying material along the cross section of the drum can be achieved using new types of internal distribution devices, as the existing designs cannot fully solve this problem [1-5]. When using existing structures, only the consumption of the transferred material increases, but there is still a "dead" zone between them, in which there is no heat and mass exchange between gas and particles. During the experiments, the indicators of the average residence time of the mineral fertilizer in the laboratory device at different values of the number of revolutions of the drum and the angle of inclination were determined. In the laboratory dryer, the average time of the product was measured using indicators (colored particles). During the experiments, the number of rotations of the drum was set in the range n= 2.5-4.0 rev/min, with a step of 0.5 rev/min, and the slope of the drum was set as α=10, α=20 and α=30 relative to the horizon. Figure 2 shows a comparison between the experimentally obtained average splitting time and the average splitting time calculated by Equation (9). Analysis of the results from Figure 2 shows that the time the product is in the device is inversely proportional to the change in the drum rotation speed. When the angle of inclination of the drum is constant a=10 and the number of revolutions of the drum is n= 2.5 revolutions/min, the time the product is in the apparatus is t=5.7 minutes, the number of revolutions of the drum is n= 4.0 revolutions When it is increased to /min, the product's time in the device is reduced by t=3.7 minutes. In the same way, when the angle of inclination of the drum is constant a=30, and the number of revolutions of the drum is n= 2.5 revolutions/min, the time of being in the apparatus is t=4.1 minutes, the number of revolutions of the drum is n= 4.0 revolutions When it is increased to /min, the product's time in the device is reduced by t=2.7 minutes [6-10]. These results are consistent with the solutions of Equations (7) and (9). The obtained results also confirm the theoretical data on the angle of inclination of the drum, that is, the increase of the angle of inclination of the drum from a=10 to a=30 degrees at a constant value of the number of revolutions of the drum at 2.5 rpm, the product resulted in a decrease in the time spent on the device from t=5.7 minutes to t=4.1 minutes. From this, we see that the time the product is in the device is inversely proportional to the change in the angle of inclination of the drum [11-15].

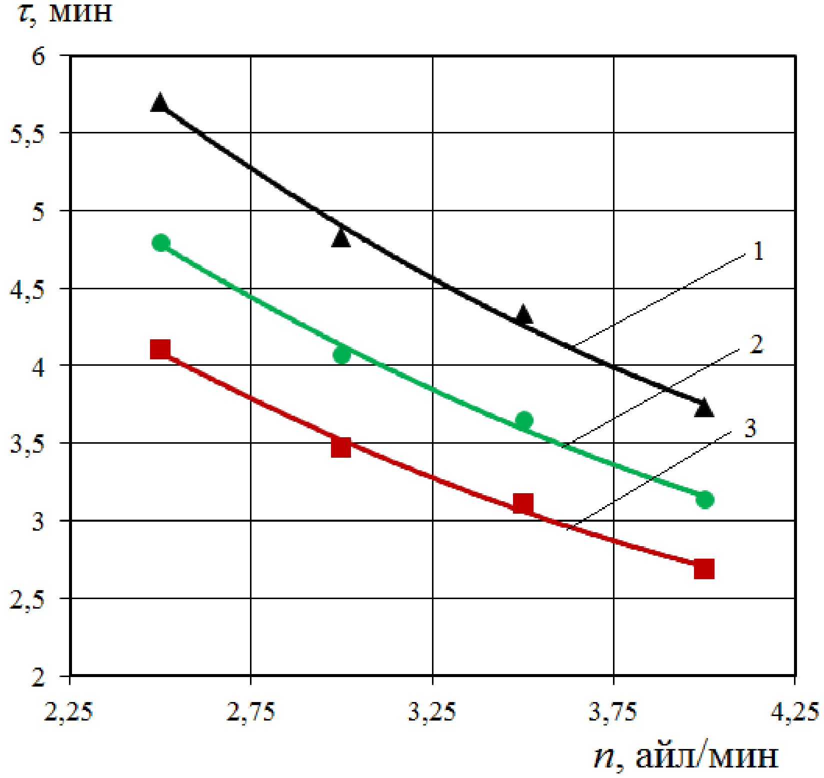


Figure-2. The dependence of the average time of the material in the device on the number of revolutions of the drum.

When the slope angle of the drum is $\alpha=1^0$; 2- when $\alpha = 2^0$; 3- when $\alpha = 3^0$; Using the method of least squares, the following empirical equations were obtained for the experimental results.

$y = 0,27x^2 - 3,037x + 11,582$ $R^2 = 0,9947$ (1)

$y = 0,22x2 - 2,51x + 9,68$ $R^2 = 0,9946$ (2)

$$y = 0{,}21x^2 - 2{,}283x + 8{,}4785 \qquad R^2 = 0{,}9949 \qquad (3)$$

Summarizing the above, we can see that the intensification of material drying in a drum dryer depends on the surface of the material curtain falling from the nozzles of the drum dryer. In turn, ensuring the increase of the scattering surface of the material along the section of the drum depends on the constructive structure of the nozzles of the dryer. In this case, it is necessary to take into account the productivity of filling with material, the angle of inclination of the drum, its rotation speed and the selection of the speed of the drying agent [16-19]. The equations given above can be used to determine the time of the material being dried in the device and to calculate the overall drying process based on this.

DISCUSSION

Using the method of least squares, the following regression equations were obtained and solved separately for each point of graphic links using the experimental data. Empirical equations for the dependence of the residence time of the material in the drum on the productivity of the drum at a drum inclination angle of 1^0.

1. The number of revolutions of the drum n = 3.0 rpm;

$$y = -26x + 4{,}36 \qquad R^2 = 0{,}9657 \qquad (4)$$

2. The number of revolutions of the drum n = 4.0 rpm;

$$y = -20x + 4{,}85 \qquad R^2 = 0{,}9524 \qquad (5)$$

3. The number of revolutions of the drum n = 5.0 rpm;

$$y = -23x + 5{,}18 \qquad R^2 = 0{,}988 \qquad (6)$$

4. The number of revolutions of the drum n = 6.0 rpm;

$$y = -30x + 6{,}35 \qquad R^2 = 0{,}9783 \qquad (7)$$

The empirical equations of the dependence of the residence time of the material in the drum on the productivity of the drum at a drum inclination angle of 2^0.

1. The number of revolutions of the drum n = 3.0 rpm;

$$y = -19x + 3{,}49 \qquad R^2 = 0{,}9627 \qquad (8)$$

2. The number of revolutions of the drum n = 4.0 rpm;

$$y = -15x + 3{,}9 \qquad R^2 = 0{,}8824 \qquad (9)$$

3. The number of revolutions of the drum n = 5.0 rpm;

$$y = -16x + 4{,}41 \qquad R^2 = 0{,}9846 \qquad (10)$$

4. The number of revolutions of the drum n = 6.0 rpm;

$$y = -23x + 5{,}18 \qquad R^2 = 0{,}9888 \qquad (11)$$

Empirical equations for the dependence of the residence time of the material in the drum on the productivity of the drum at a drum inclination angle of 3^0.

1. The number of revolutions of the drum n = 3.0 rpm;

$$y = -11x + 2{,}91 \qquad R^2 = 0{,}8963 \qquad (12)$$

2. The number of revolutions of the drum n = 4.0 rpm;

$$y = -16x + 3{,}41 \qquad R^2 = 0{,}9846 \qquad (13)$$

3. The number of revolutions of the drum n = 5.0 rpm;

$$y = -17x + 3{,}87 \qquad R^2 = 0{,}9797 \qquad (14)$$

4. The number of revolutions of the drum n = 6.0 rpm; (15)

$$y = -14x + 4{,}29 \qquad R^2 = 0{,}98$$

CONCLUSION

From figure it can be seen that an increase in the productivity of the drum leads to an increase in the coefficient of distribution of material over the cross section of the drum by an average of 8-10%. In addition, an increase in the number of rotations of the drum leads to an increase in the material curtain coefficient over the cross section of the drum by an average of 7-8%. From figure it can be seen that an increase in the productivity of the drum leads to a decrease in the residence time of the material in the drum by an average of 14-17%. In addition, an increase in the number of rotations of the drum leads to a decrease in the residence time of the material in the drum by an average of 27-38%. Our experimental data are in good agreement with the equation E.B. Aruda by the average residence time of the material in the drum.

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