EFFECT OF DRUM DRYER NOZZLE DESIGN ON HYDRODYNAMIC REGIMES

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Abstract
The article examines the process of drying by pickling and the analysis of the devices used in it, the existing problems in the process and their optimal solutions, as well as the hydrodynamic regimes of the drum dryer. The equation that determines the total hydraulic resistance of the device and the resistance coefficient of the contact element is recommended.

Keywords: convective, drum dryer, nozzle, contact element, hydraulic resistance, hydrodynamic regime, contact surface.

INTRODUCTION

Thermal drying of materials is one of the most energy-intensive processes in the technological line. Using this process is important to determine the quality of the finished product. The cost of thermal drying is 10% of the total cost of processing

In such conditions, it is urgent to create highly efficient, energy-saving drying regimes and regulate and optimize heat exchange processes in drying devices [1-7].

Drying processit is known that it depends on material moisture, size, the method of their movement in the drum, the hydrodynamics of the movement of the material with the drying agent, and the parameters of the internal and external environment. The combination of these factors determines the conditions of the drying process. Therefore, in the industrydifferent methods and devices are used according to the physical, chemical and mechanical properties of the material to be dried.

The most common type of the above-mentioned method and devices is the convective drying method, and drum dryers used in this process are distinguished by their simplicity of construction, high performance and universality. Therefore, the tendency to use these drying units in various sectors of the national economy is expanding. But this type of dryer has its own disadvantages. For example, some complex processes can be mentioned, such as ensuring the drying intensity, rational use of the heat agent used for drying, optimizing the hydrodynamic parameters and minimizing the energy consumption. Therefore, the issues of determining and justifying the optimal parameters for this type of devices are relevant [8-21]

Many scientific and research works have been carried out to determine the optimal parameters of the mentioned factors. However, a full solution of optimal and reasonable parameters of dryer hydraulic resistance, heat exchanger contact element (nozzles) and heat exchange processes has not been developed.

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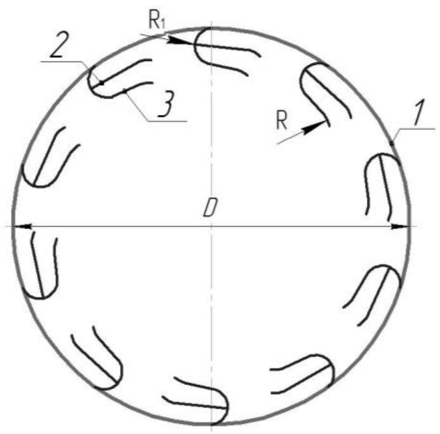
Research object

It is known that there are two types of heat exchange in a drum dryer - contact and convective methods. However, a large amount of heat transferred to the dried material is carried out by convective heat exchange. The amount of heat transferred to the material being dried in a drum dryer by convective method is up to 20 times higher than the amount of heat transferred by contact method. The intensity of convective heat transfer in a drum dryer, in turn, directly depends on the opening of the surface of the particles and the median size of the particle. The more the material spreads over the surface of the drum, the larger the area of convective heat exchange.



1-drum body; the first part of the 2 - nasadka; the second part of the 3 - nozzle.

Figure 1. The scheme of the proposed nozzle and its installation on the drum.

Summarizing the above, we see that the drying efficiency of mineral fertilizers in a drum dryer depends on the surface of the material film falling from the nozzles of the drum dryer. In turn, ensuring that the material is spread across the section of the drum - the internal devices of the drumcontact element, hydraulic resistance, hydrodynamics,depends on the constructive structure of nozzles [3;4, etc.]. Based on the above, in order to intensify the mineral fertilizer drying process and increase the heat exchange surfaces, a two-part design of the nozzle forming heat exchange surfaces and an experimental device of the dryer were developed and hydrodynamic modes were studied [22-31]. Figure 1.

Research method

Scientific and research works were carried out in order to choose the optimal parameters of the hydraulic resistance of the dryer and the heat exchange surface, and to improve the contact elements with the heat agent [32-41].

It is known that in drum dryers, the heat transfer agent experiences hydraulic resistance as it moves inside the dryer and in the channels. They are friction P_{ishq}, local P_{max}, P_{iyu} inside the dryer and P_k in the heater. Then the total hydraulic resistance of the device can be written as follows, Pa;

□$P=P_{ishk}+P_{max}+P_{k}+P_{kyu}$ (1)

where it is the pressure lost due to the frictional force of the flow of the heat agent moving in the cooking device, which is determined by the following equation, Pa [6];

$$P_{ишк} = \lambda \cdot \frac{l}{d} \cdot \frac{w^2 \cdot \rho}{2} \qquad (2)$$

where l is the length of the dryer, m; λ is the coefficient of frictional resistance, which depends on the mode of flow and is determined by the Blazius equation[6;7];

$$\lambda = \frac{1}{\sqrt[4]{Re}} \qquad (3)$$

in this equation, the Reynolds number is equal to;

$$Re = \frac{w \cdot d \cdot \rho}{\mu} \qquad (4)$$

Then, if we put equation (4) into equation (3), it will look like this;

$$\lambda = \sqrt[4]{\frac{\mu}{w \cdot d \cdot \rho}} \qquad (5)$$

where w is the velocity of the drying agent, m/s. Usually it can be taken around 10-20 m/s; d is the diameter of the heater pipe, which is determined from the second consumption equation, m;

$$d = \sqrt{\frac{V_c}{0{,}785 \cdot w}} \qquad (6)$$

where Vc is the volume consumption of the drying agent per second, m^3/s; □ - air density.
Then, if we perform mathematical operations in equation (2), it will look like this.

$$P_{ishk} = \sqrt[4]{\frac{\mu}{w \cdot \rho \sqrt{\frac{V_c}{0{,}785 \cdot w}}}} \cdot \frac{l}{d} \cdot \frac{w^2 \cdot \rho}{2} \qquad (7)$$

P_{max} - is the local lost pressure in the dryer, which is determined according to the following equation, Pa;

$$P_{max} = \zeta_{max} \cdot \frac{w^2 \cdot \rho}{2} \qquad (8)$$

P_k - is the lost pressure in the calorifier, Pa. When determining it, the heater brand selected for the dryer is taken into account, and the hydraulic resistance values are taken from the heater calculation table.

P_{kyu} - is the lost pressure of the drying agent on the working surfaces of the device, which is determined by the following equation, Pa;

$$P_{ию} = \zeta_{ию} \cdot \frac{w^2 \cdot \rho}{2} \qquad (9)$$

in this $\zeta_{ию}$ - is the resistance coefficient of the working surface and depends on several factors. Its determination is complex and requires various deviations. In order to simplify the determination of the resistance coefficient of the working surface in the dryer under study, we introduce the equation for determining the ratio of the surface of the drum to the unused surface of the heat agent;

$$\zeta_{ию} = n \cdot \alpha \cdot \frac{S_b}{S_{fyu}} \cdot z \qquad (10)$$

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where Sb is the cross-sectional surface of the drum, m2; Sfue-dryer is the surface of the heat agent that is not used, it is determined depending on the design of the selected nozzle, the filling surface of the dryer and the movement scheme.

(9) is the drag coefficient in Eq $\zeta_{ию}$ if we put equation (10) instead, then equation (9) becomes the following form, Pa;

$$P_{iyu} = n \cdot \alpha \cdot z \cdot \frac{w^2 \cdot \rho \cdot S_б}{2 \cdot S_{фю}} \qquad (11)$$

Using the obtained theoretical results, equation (1) can be written as follows, Pa;

$$\Delta P = \sqrt[4]{\frac{\mu}{w \cdot \rho \sqrt{\frac{V_c}{0{,}785 \cdot w}}}} \cdot \frac{l}{d} \cdot \frac{w^2 \cdot \rho}{2} + \zeta_{max} \cdot \frac{w^2 \cdot \rho}{2} + P_k + n \cdot \alpha \cdot z \cdot \frac{w^2 \cdot \rho \cdot S_b}{2 \cdot S_{fyu}} \qquad (12)$$

According to the given equation (12), we will be able to determine the total hydraulic resistance of a drum dryer equipped with a two-part nozzle.

Summary

Based on the considered drying process and drum dryers used in it, heat exchanger nozzles and their operating parameters, an improved design of a two-part nozzle and an experimental device of a drum dryer were developed.

In order to intensify the heat exchange during the drying process, the hydrodynamic modes of the device were studied and an equation defining the total hydraulic resistance and the coefficient of resistance of the contact surfaces of the nozzle was created.

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