

DRYING IN THE APPARATUS WITH A QUICK ROTATING ROTOR

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Annotation

Drying finely dispersed materials with particles smaller than 50 μm using the convective method of heat supply is impractical, since a significant part of the processed material particles is carried out of the apparatus by the drying agent flow, resulting in environmental pollution. Also, the flow of heat input in such devices is usually limited due to convective heat transfer, but also due to an underdeveloped heat supply surface.

Keywords: heating temperature, supply surface, dispersed materials, drying, process, materials, quality, transferred, convective, decarbonization processes.

Introduction

Promising for drying fine materials is the use of continuously operating devices of the conductive type, which exclude the entrainment of the dried material, for example, contact drum dryers with a rapidly rotating rotor. The contact dryers of the Venulet type used today, although they give a significant effect due to the transition from convective heat exchange to conductive heat exchange, they have a significant drawback due to the slowly rotating mixing device [1-7]. As a result, the inner heat transfer surface of the drum is not fully utilized.

Object and method of research

In the design of the apparatus under study, heat is supplied directly from the heated drum wall to the layer of finely dispersed material, which excludes the entrainment of particles, since

there is no flow of a heat-carrying drying agent [8-11]. Also, rapidly rotating blades create a uniform layer of dispersed material several millimeters across the entire inner surface of the heat supply, and intensive mixing and movement of the material relative to the drum wall provides high heat transfer coefficients between the wall and the material layer [12-19]. The studies were carried out in an apparatus, which is a fixed horizontal, heated drum, inside which a rotating rotor with blades is located (Fig. 1). When the rotor rotates, the blades entrain the material, and the resulting centrifugal force throws the material to the periphery of the apparatus, where a moving layer is formed that contacts the heated inner wall of the drum [20-27]. Heat treatment of the material takes place in this layer, the thickness of which, and hence the residence time of the material in it, is determined by the size of the gap [28-33]. Heat was supplied to the material from the condensation of water vapor through the drum wall, which made it possible to control the heating temperature.

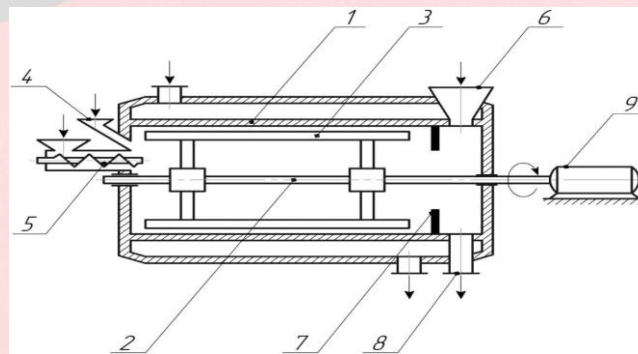


figure. 1. Scheme of the experimental setup. 1-case; 2-rotor; 3-blades; 4-fitting; 5- feeder; 6-fitting secondary steam; 7- unloading threshold; 8 - output of the dried product; 9-electric motor.

Secondary steam with a small amount of non-condensable gases is removed from the apparatus countercurrent to the movement of the dried material through a gap near the shaft and condensed in the heat exchanger. Therefore, losses and environmental pollution were excluded. The angular speed of rotation of the rotor was stabilized by a control electric drive. To determine the drying rate in a contact apparatus with a rapidly rotating rotor, experimental kinetic curves obtained experimentally are used. A sample of wet material for moisture content analysis is obtained at regular intervals from a sampler located in the middle of the apparatus drum [34-37]. The obtained samples are dried in an oven. For each sample, we calculate the moisture content of the material. Then build the dependence of moisture content on time - drying curve. There are two drying periods on the drying curve. In the first period, the moisture content of the material changes in a straight line. This section of the drying curve, where the moisture content of the material decreases along a line approaching the horizontal, is called the period of falling drying rate. The drying rate is determined dividing the drying curve into segments equal in time, followed by dividing the value of the moisture content loss by the

value of the time interval. Then, the dependence of the drying rate on the moisture content of the material is built - the drying rate curve. Using the drying rate curve, the value of the constant drying rate in the first period, the critical and equilibrium moisture content of the material are found. The drying rate constant in the second period is determined, after which the drying time in the first and second periods and the total drying time of the material are calculated.

Usually, the drying of dispersed materials is carried out in belt, tunnel and shaft dryers. In these designs, the drying agent passes through a fixed layer of particles. In laboratory conditions, to determine the rate of drying of dispersed materials, the drying agent is passed through a dryer. Inside it is a fixed layer of material on a grid, which is suspended on a balance. Over time, change the weight of the layer. The inaccuracy in determining the mass of moisture removed from the material lies in the fact that it is very difficult to take into account the aerodynamic effect of the moving flow of the drying agent on the readings of the scales.

With the aim of to simplify the method for determining the drying rate, and to take into account the hydrodynamic features of the operation of a convective dryer, it is proposed to determine the moisture content of the material according to the parameters of the drying agent. Passing through the layer of the material to be dried, the drying agent increases its moisture content. With the material balance equations, the moisture content of the material is determined by the known moisture content of the drying agent before and after the layer. The experimental values of this method significantly depend on the speed and accuracy of instruments for measuring the parameters of the drying agent. Let us consider the process of drying a dispersed material in a contact apparatus with a horizontal fast-rotating rotor. The device is a stationary horizontal heated drum, inside which is a rotating rotor with blades; when the rotor rotates with blades, the material is thrown to the periphery, where a moving mixed layer is formed, which is in contact with the heated wall. Dry material is pre-weighed and then moistened to a certain moisture content. From below, heated air passes through the layer at a given flow rate at a constant temperature at the inlet to the layer. The moisture content of the air before and after the layer is recorded using instruments at certain intervals. According to the known flow rate and moisture content of the air, the amount of moisture removed for the first period of time is determined.

$$W_1 = LC - B(x_k - x_H) \cdot \tau_1$$

Where: W_1 - the amount of moisture removed from the material, kg; $LC - B$ - dry air consumption, kg/s; x_n ; x_k - air moisture content before and after drying, kg/kg; τ_1 - the first period of time, s.

Then the moisture content of the material for the first period of time

$$U_1 = \frac{W_L - w_1}{G_{cm}}$$

Where: U_1 - moisture content of the material in the first period of time, kg/kg s.m; - the amount of moisture in the material before drying, kg; - amount of dry material, kg $W_L G_{cm}$

The moisture content of the material in subsequent periods of time is calculated by the formula:

$$U_1 = \frac{W_L - \sum_{n=1}^i W_i}{G_{c.m}}$$

where is the total amount of removed moisture, kg.

$$\sum_{n=1}^i W_i$$

According to the results of experiments and calculations, a drying curve is constructed, that is, a graphical dependence of the moisture content of the material on the drying time.

To obtain the drying rate of the material at any point of the drying curve, a tangent is drawn, the tangent of the slope of which is equal to the drying rate.

An analysis of studies on heat and mass transfer processes occurring during drying in rotary dryers shows that, based on existing studies of the drying process, it is impossible to take into account all the characteristic features and changes in the kinetics of such a process. A more complete model would be that would take into account the change in material temperature in each of the stages of drying, the balance between wet material, additional heat input from energy dissipation due to the rapid movement of the particulate material and heated structural elements of the drum, as well as the effect of longitudinal mixing of the particulate material. On the basis of general ideas about drying and its laws, we have considered the physical picture of the process by stages occurring in the drying plant, described the developed mathematical models and provided their solution. The development of a mathematical model is based on the known laws of conservation of energy and mass of matter, provisions from the theory of drying and the laws of equilibrium between the material and the drying agent. Consider the characteristic components of the processes occurring during drying. The period of removal of free moisture is characterized by the fact that evaporation proceeds according to the laws of the transformation of free liquid into vapor. During this period, the drying process is determined mainly by the rate of heat supply from the heated wall to the material being dried. One of the most important parameters that determine the drying regime is the wall temperature. In a continuous drying process, the wall temperature along the length of the dryer changes due to heat transfer to the evaporation of the liquid, to heating the material and rotor blades. The calculation of the period of removal of bound moisture differs from the calculation of the period of removal of free moisture in that the surface temperature of the material rises, it is necessary to calculate using the modified relationship between the wall and the material being dried. As a result of thermal contact of the material with the hot walls and rotor blades, a layer of dried material appears, the thickness of which gradually increases. And in the dried state, the dispersed material in terms of heat-conducting properties is not so far from the properties of heat-insulating materials. This is due to the fact that the main resistance to heat transfer is concentrated in the zone of the material in contact with the heat-releasing surface. The processes taking place in this zone essentially depend on the Lykov criterion. With its

small values, the liquid will not have time to be supplied from the inner layers of the material to the contact surface, a layer of dry material will appear separating the contact surface and the evaporation surface. The temperature of this layer on the contact surface is the same as the temperature of the heated wall, and on the opposite side it is equal to the evaporation temperature of the liquid, determined by the pressure in the drying drum.

Conclusion

Empirically, using the parameters of the drying agent, the drying rate curve was obtained. These curves allow you to determine the drying rate at any time during the process. The dependence of the drying rate in the first period on the rate of the drying agent shows that with an increase in the rate of passage of the drying agent through the layer of the particulate material being dried, the drying process is accelerated due to convection.

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