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METHODS OF INTENSIFICATION OF THE OPTIMAL OPTIONS OF INTERNAL NOZZLES OF DRUM DRYERS IN THE PROCESS OF MASS EXCHANGE

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Abstract
The article provides a method of experimental determination of the optimal shape and amount of material of the nozzle of the drum apparatus intended for drying granular materials. Depending on the physical and geometrical parameters of the material, its quantity and occupied surface are experimentally determined during the rotation of the drying drum.
Keywords: drying drum, nozzle, natural slope angle, drum cross-section, material distribution, material filling factor.

Introduction

Information on the amount of solids carried up by the nozzles and then sprayed is essential for the dryer to operate within the optimum loading range. Researchers recommend choosing a solids volume of 10-15% of the drum's total volume and the shape and number of nozzles to suit the dryer's operating conditions for optimal drum performance. If the drum load is less than the limit of this range, the dryer will operate below its capacity, inefficiently. On the other hand, if the material drum load is more than the limit of the range, excess material will accumulate in the dryer, which will reduce the time of drying materials in the machine. As a result, part of the material may not be dried to the required moisture level and may have a negative effect on the quality of the final product. It is very important to know the amount of material in the nozzle and the amount of material scattered from the nozzles when determining the optimal loading coefficient of the device. If the amount of material in the drum is less than the optimal value, it will reduce its productivity. It should be noted that the equation is proposed only for solids at constant moisture content, which does not fully correspond to the actual drying process. Because the moisture content decreases as the solid moves through the dryer, it is necessary to take into account the change in material moisture content before using the equation in the design of actual dryers. If the natural slope angle φ of the material and the angular position of the nozzle on the inner circle of the dryer Θ are known, it is possible to calculate the cross-sectional area filled with material for nozzles of any shape. In this case, the amount of material in the nozzles is determined by their geometry, angular position and the natural inclination angle of the material. If the natural inclination angle φ of the material and the angle Θ in the inner circle of the dryer for two-segment nozzles are known, the cross-sectional area S occupied by the material in the nozzle can be calculated. For such two-segment

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nozzles, many researchers have calculated the cross-sectional area S occupied by the material. The analysis of these studies showed that the filling of the nozzle with material depends on the shape of the nozzle on the drum, the angular position and the angle of the natural slope of the material.

$$\tan\varphi = \frac{\mu + R_0 \dfrac{\omega^2}{g}\left(\cos\theta - \mu \sin^{-1}\theta\right)}{1 - R_0 \dfrac{\omega^2}{g}\left(\sin^{-1}\theta + \mu\cos\theta\right)}$$

This is the ratio of centrifugal and gravitational forces in Eq displayed through $R_0\ \omega^2/g$. Drum dryers are usually used in the range of 0.0025<(R0 ω2/g)<0.04

Therefore, the purpose of the current work is to check whether the kinetic PH is independently and related to any other material properties that can be measured outside the drum. According to the researchers, empirical models to determine the static natural slope angle [Subbotin, Kalman]. The static slope angle is defined as the free surface angle of the pile of material, which is achieved by spreading the material on the surface in a pile of a specified size. The angle formed as a result of scattering of a layer of particles after being thrown is the static natural slope angle. Dynamic means the natural slope angle formed when the dispersed material is spread on a plane. Undoubtedly, in order to design the nozzle of the drying drum in accordance with the natural slope angle of the dried material, it is necessary to determine which angle of the natural slope will cause the scattering of the material in the internal devices of the dryer. To answer this question, it is necessary to theoretically analyze the conditions for the formation of static and dynamic natural slope angle, as well as experimental modeling of the formation of the slope angle in the nozzles of the dryer.

The researcher found that the static and dynamic tilt angles are a function of Ar number, with different values for spherical and non-spherical particles. For spherical particles, the behavior is defined by a single equation, and both angles increase with decreasing Ar number or particle size.

$$\varphi_{\text{ст}} = 22 + 16\text{Ar}^{-0.21}$$

$$\varphi_{\text{дин}} = 28.3 + \frac{39.7}{1 + \left(\text{Ar}/2.52\right)^{0.57}}$$

Here, the number of Ar is determined by the following equation:

$$\text{Ar} = \frac{\rho_{\text{х}}\left(\rho_{\text{м}} - \rho_{\text{х}}\right)\text{gd}^3}{\mu^2}$$

where rx and rm are the density of air and particles, respectively; m-dynamic viscosity of air; d - average particle diameter; g - acceleration of free fall. For non-spherical particles, the behavior is more complex and each material is defined at a specific value of the Ar number.

As the moisture content of the spreadable material increases, the value of the natural slope angle of the material increases proportionally until the material acquires liquid properties (passes into a pulp state) under the influence of binding capillary forces. Since the increase of the binding capillary forces in the composition of dispersed materials is directly proportional to the increase in moisture, this relationship has the form of a linear function, and taking into account the moisture content of the material, the dependence of the natural slope angle of the

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dispersed material on its moisture content is subject to a linear function. When studying the natural slope angle in drying processes, if the samples are dried to a dry state before measurement, the equation can be presented in the following form:

φст.нам. = φст +W*Б

Here: phst.nam. – static slope angle of wet material, degree; W – moisture of material, phst – static slope angle of dry material, grad; B is a coefficient reflecting the dependence of the moisture content of scattered materials on the natural slope angle, it is determined experimentally and is called the coefficient of change of the natural slope angle. (AX)

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