ASPECTS OF MODELING THE PROCESS OF DRYING BULK MATERIALS IN A VIBROFLUIDIZED BED

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Annotation. *The article provides a rationale for choosing a drying method for bulk thermolabile products of organic synthesis and calculated dependences for determining the technological parameters of the process*.

Key words: *vibroaerofluidized bed, bulk organic synthesis intermediates, initial, final, equilibrium moisture content of the product, material and drying agent temperature.*

Introduction. The production of synthetic dyes and pigments is one of the main industries in the fine organic synthesis industry. In recent years, the requirements for the quality of manufactured products have increased significantly.

Of great importance for obtaining high-quality semi-products of organic dyes is the drying stage, during which changes in the physicochemical properties and chemical structure of the base substance are possible. Therefore, in some cases, drying is carried out at relatively low temperatures, in vacuum, in an inert gas flow, etc. All three existing options make it possible to obtain a dry product, however, they have a number of significant drawbacks.

In the production of synthetic dyes and intermediates, the final forms are often powdery free-flowing materials (for example, arylides: anilide and orthochloroanilide of acetoacetic acid; intermediates of the pyrazolone series: paratolyl-3 methyl-5 pyrazolone, etc.).

In the chemical industry, the most widely used drying processes are vacuum rake and roller belt dryers. However, the use of this equipment often does not give the required results, since overheating of the material is allowed, which can lead to decomposition of the target substance and a decrease in the concentration in the dried intermediate.

Material and Methods. The most promising for dispersed intermediates of organic dyes with a particle size in the range of 0.2÷0.7 mm is the drying method in a vibrofluidized bed; its application would allow to eliminate the disadvantages listed above and provide a high speed of the process, the required concentration of the target component in the material being dried, and the preservation of the dispersed composition due to the absence of particle crushing.

The mathematical model of the process of drying bulk intermediates of organic dyes in a directionally moving vibroaerofluidized bed should include:

– equations of material and heat balances of the process;

– dependencies describing the hydrodynamics of a directionally moving vibroaerofluidized layer;

– dependencies describing the kinetics of the actual process of drying intermediate products of organic dyes.

In the production of synthetic dyes and intermediates, often the final forms are powdery free-flowing materials. Important in the production of organic synthesis are arylides and intermediates of the pyrazolone series.

The average equivalent particle size, depending on the type of material, ranges from 0.295 to 0.83 mm.

Semi-products of organic dyes decompose at high temperatures and lose their properties. There is a so-called limiting drying temperature at which the process of changing the properties of the material begins.

The initial moisture content of semi-products supplied for drying, depending on the type of material, varies from 8 to 30%, which is mainly determined by the technological processes of separating the solid phase from the suspension.

The materials to be dried are also characterized by the value of the equilibrium moisture content. The value of the equilibrium moisture content of a particular material u^* will be a function of the temperature of the material, the moisture content of the coolant and the operating parameters of the process. The mathematical model of the process of drying bulk intermediates of organic dyes in a vibroaerofluidized bed should take into account:

- the presence of longitudinal mixing of the material along the length of the tray;
- balance character of the drying process in the first period;
- change in the speed of movement of the material and the coefficient of longitudinal mixing, depending on the moisture content of the material.

The mathematical model should provide a mutual relationship between the design, input and output parameters of the process.

The input parameters are

- M - is the mass flow rate of an absolutely dry product, kg/s;
- A - is the oscillation amplitude, m;
- f - oscillation frequency, Hz;

• α and β - are the angles of inclination of the duct and the direction of vibrations, deg;

• Vg - velocity of the blown coolant, m/s;

• uo and uk -initial and required average final moisture content of the material, kg/kg;

• To - initial temperature of the coolant, oC;

• Xo - is the initial moisture content of the coolant, kg/kg;

The physicochemical properties of the product to be dried must also be taken into account, such as

• ρd – dry material density, kg/m3;

• cm - is the heat capacity of the material, j/(kg·0C);

• d – material particle diameter, m.

Design options include

• dryer tray length – L, m;

• dryer tray width – b, m.

The output parameters of the mathematical model of the process of drying bulk products in a vibroaerofluidized bed are

• distribution of temperature, moisture content of the material along the length of the apparatus;

• the value of the average temperature of the waste coolant;

• mass consumption of coolant for drying;

• hydraulic resistance of the drying unit.

Results. Material and heat balance equations for the entire drying unit as a whole

(1)

(2)

where Ig - is the enthalpy of humid air; XK - is the average final moisture content of the waste coolant.

To construct a mathematical description of the drying process of materials, one can restrict oneself to the equations of material and heat balances for a one-dimensional diffusion model, written relative to the average moisture content and temperature of the material for each section.

When using the equations of the diffusion model, it is necessary to take into account the fact that the speed of the directional movement of the material Vm and the coefficient of diffusion mixing D are dependent on its moisture content and change along the length of the dryer according to a certain law.

To calculate the technological parameters of drying, or to design the optimal variant of the vibroaerofluidized bed dryer, it is necessary to use a mathematical model of statics, which makes it possible to trace the relationship of the main parameters that affect the process in the steady state [1, 2].

The steady state is characterized lack of accumulation of matter and energy.

Equation of the material balance of the process of drying bulk materials in a vibroaerofluidized layer with diffusion mixing

(3)

Heat balance equation

(4)

Boundary conditions for equations (3-4) are written as

1) for material balance

(5)

2) for heat balance

(6)

Conclusion. Thus, the material and heat balances of the process of drying semi-products of organic dyes in a directionally moving vibro-boiling mode in a stationary mode will be described by equations with boundary conditions.

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