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INSTALLATION FOR DRYING MATERIALS IN A FLUIDIZED BED

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Abstract

The article highlights the fluidized bed dryer, which achieves intensive mixing of the material, accelerated heat and mass transfer, due to which the drying agent can be used at elevated temperatures without significant loss in the quality of the final product. Combining the simplicity of the device with high efficiency and ease of automation.

Keywords: layer, dryer, agent, devices, air, evaporation, pressure, process, particle, heating.

Introduction

Many industries are faced with the need to reduce the moisture content of various materials. At any scale of use of drying technologies, it is fundamental to implement several technical and economic parameters, such as the minimum drying uniformity, the minimum time to reach a given moisture content, and some other dehydration characteristics. These parameters can be provided by a competent approach to the choice of the most appropriate basic physical processes for a given specific situation, the corresponding drying technologies, and finally, by creating equipment on which these processes and technologies can be implemented.

However, the heat and mass transfer between the outer surface of the particles and their inner regions in this technological scheme is no different from that typical for convection drying, which leads to a multiple increase in energy consumption and a decrease in the drying rate at low product moisture and, accordingly, to an increase in the energy intensity of the process. The creation and introduction into industrial production of devices of this design, which make it possible to increase the efficiency of the drying process and reduce the specific cost of thermal energy per unit of output, is relevant. The solution of this problem is impossible without further improvement and study of the equilibrium and kinetic laws of mass and heat transfer between the dried material and the drying agent, as well as the hydrodynamic features of the motion of the solid and gas phases in the apparatus. Therefore, the development of such models is relevant and of great practical importance.

To date, there are a large number of different drying (dehydration) technologies: natural drying, aeration [1], convection, drying in a pseudo fluidized bed [2], infrared drying, microwave [1,3], freeze drying [3], etc. . We will conduct a comparative analysis of these technologies, based on the use.

Relatively small systems of parameters (criteria): productivity, energy consumption, drying speed, drying quality, preservation in the process of drying useful substances. In the chemical industry, drying along with evaporation and roasting, as a rule, determines the technical and economic indicators of the entire production as a whole, which is associated with significant costs of thermal energy for these processes. Convective drying processes are widely used in the production of mineral salts and fertilizers, polymeric materials and other industries.

For drying dispersed materials, fluidized bed dryers are successfully used, the undeniable advantage of which, compared with other dryers, is the developed contact surface between the particles and the drying agent and the intensive evaporation of moisture from the material.

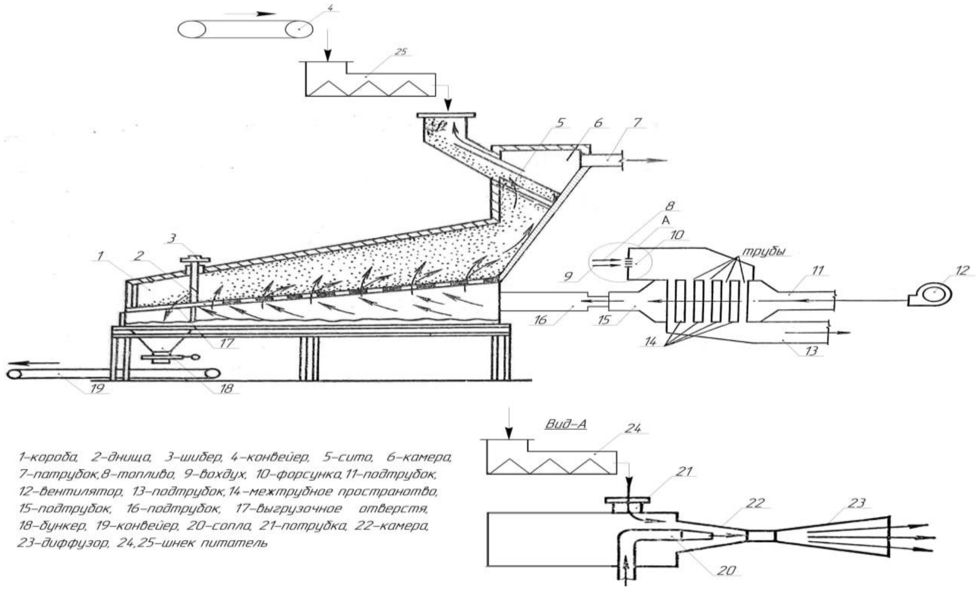

Fig 1. Scheme of the installation for drying materials in a fluidized bed.

Consider the design of the simplest installation for drying bulk materials (fertilizers) in a fluidized bed (Fig. 1). The installation consists of a drying chamber (box and bottom) 1, equipped with gratings, 2 made in the form of inclined steps along which the material moves. The material for drying is continuously supplied by a screw feeder 3 using a conveyor 4. The drying agent is prepared in a heat generator 15 with a temperature of about 473 K and fed to the grate 16. Passing through the holes of the grate, the drying agent enters the layer at a speed equal to the speed of hovering particles of average diameter, and creates a fluidized bed for the final drying of the material that has already passed drying on the grate.

High-pressure fan 12 through a heat generator, depending on the source of heat they receive, are classified into those using coal dust.

Thermal generator for the preparation of the coolant-heated air. Coal dust 8 and air 9 through the nozzle 22 are fed into the furnace 14, where the combustion process takes place. Solid fuel is burned in the furnace.

In Fig.2. the principal schemes of the operation of burners for burning dust of coal fuel are given. Figure 2 shows a burner diagram with the air mixture supplied through the central pipe, and secondary air through the peripheral channel; in Fig. 2b, on the contrary, the secondary air is supplied to the burner through the central pipe, and the air mixture is supplied through the peripheral channel. Both the air mixture and the secondary air are often supplied in swirling jets. In this case, the combustion products are recirculated to the flame base (shown by arrows) and contribute to the stable combustion of the air mixture.

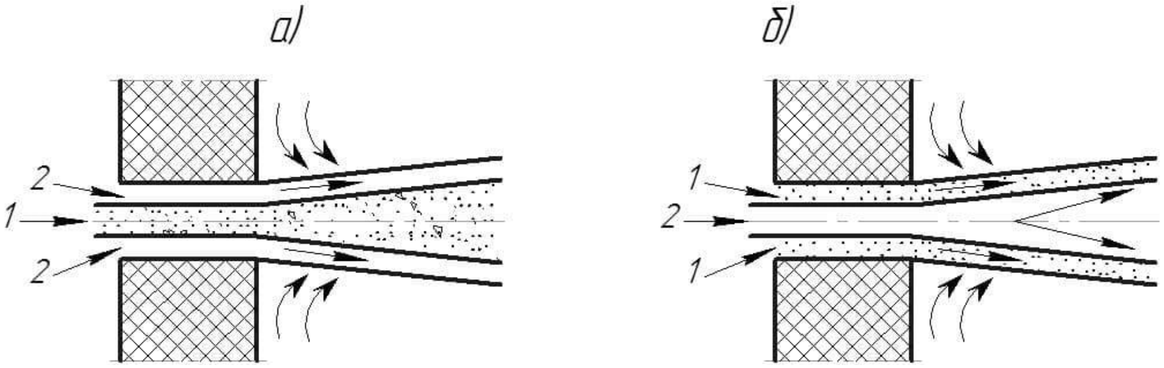

Fig.2. Scheme of operation of burners for burning dust of coal fuel.
1-supply of an aero mixture of solid fuel; 2-secondary air supply.

Pulverized fuel is obtained by crushing solid lumpy fuel, followed by fine grinding and drying. Fineness of grinding determined the presence of combustible volatile substances in the original fuel; the smaller they are, the more difficult it is for the fuel to burn, so its grinding should be finer.

Pulverized fuel burns as a result of chemical reactions of oxidation of its combustible part with atmospheric oxygen. Burning is preceded by thermal decomposition. Thermal decomposition products are better oxidized by atmospheric oxygen. The calculation of the amount of oxygen required for fuel combustion is based on the stoichiometric ratios of the oxidation reactions of combustible elements of the working fuel mass: O^p; S^p; H^p. For example, carbon oxidation can be written: $C+O_2=CO_2$, or 12 kg C + 32 kg + O_2=44 kg CO_2. For complete combustion of 1 kg of carbon, C is necessary $\frac{\mu_{02}}{\mu_c}$kg O_2, where, $\frac{\mu_{02}}{\mu_c}$ – the relative molecular masses of oxygen and carbon.

1 kg of working fuel contains carbon $C^p/100$. Then, for the complete combustion of carbon in 1 kg of working fuel, oxygen $(\frac{\mu_{02}}{\mu_c})(C^p/100)$kg is required. Similarly, it can be obtained from the stoichiometric ratios $S+O_2= SO_2$ and $2H_2+ O_2=2H_2O$ that the combustion of sulfur $S^p/100$ and hydrogen $H^p/100$ contained in 1 kg of working fuel, respectively, requires $(\frac{\mu_{02}}{\mu_c})(C^p/100)(\mu_{02}/\mu_c)(S^p/100)(\mu_{02}/2\mu_{H_2})(H^p/100)$kg of oxygen.

The composition of the working fuel contains $O^p/100$ kg of oxygen, the mass of which must be subtracted from the oxygen required for combustion. Therefore, the amount of oxygen G02 required to burn 1 kg of working fuel can be written

$$G_{02} = \left[\left(\frac{\mu_{02}}{\mu c}\right)\left(\frac{C^p}{100}\right) + \left(\frac{\mu_{02}}{\mu s}\right)\left(\frac{S^p}{100}\right) + \left(\frac{\mu_{02}}{2\mu_{H2}}\right)\left(\frac{H^p}{100}\right)\right] - \frac{O^p}{100}$$

Atmospheric air contains only 21% oxygen, then the volume of air V_T, theoretically necessary for burning 1 kg of working fuel, will be

$V_T = \left(\frac{G_{02}}{S_{20}}\right)\left(\frac{100}{21}\right)$ or

$$V_T = [\left(\frac{100}{21}\right)\left(\frac{1}{100}\right)\left(\frac{\mu_{o2}}{S_{o2}}\right)][\left(\frac{C^p}{\mu_c}\right) + \left(\frac{S^p}{\mu_S}\right) + \left(\frac{H^p}{2\mu_{H2}}\right) - \left(\frac{O^p}{\mu_{O2}}\right)]$$

Similarly, according to stoichiometric dependencies, the yield of combustion products is determined when burning 1 kg of fuel. However, for practical purposes, the above calculations are not made, but use empirical formulas.

In real conditions, when burning fuel, the oxidation of the combustible mass requires a slightly larger amount of air, because part of the oxygen does not have time to enter into a chemical reaction due to the imperfection of the process of mixing fuel with air. The required increase in air is determined by the ratio of the actual air consumed for combustion of 1 kg of fuel Vд to the theoretical Vт. This ratio is called the excess air coefficient L

$$L = V_д / V_Т$$

The value of L depends on the type of fuel and on the design of the combustion device. The greatest completeness of mixing is achieved when working with solid fuel, so it can be drained with a minimum excess of air (L=1,1-1,15).

The combustion of solid fuels requires a significant increase in L, which ranges from 1.5 to 3.5. Therefore, in each specific case, for the combustion of solid fuels, the value of L is chosen according to heat engineering reference books. Cold air is blown by a fan 12 in the pipe 11, takes heat from the pipes and enters through pipe 15 for use in thermal installations, for example, in a dryer. The calculation of such a generator is reduced to determining the required heating surface. On the one hand, the combustion products of the fuel heat the pipes, on the other hand, the moving air takes away this heat from the surface of each pipe. The initial calculation is the amount of air V_n and the degree of its heating ΔT. Then you can determine the amount of heat that needs to be transferred to the air,

$$Q_Т = V_Н C_v (T_k - T_Н),$$

Where V_n is the volume of heated air; C_v is the heat capacity of air; $T_н$ and $T_к$ – initial and final air temperature [2].

Therefore, the generator must provide a given amount of heat, which must be transferred to the air $Q_Т$

$$Q_T = KA(\overline{T}_{HC} - \overline{T}_B)$$

K is the heat transfer coefficient through the heating surface of the generator; A - the required heating surface (the total surface of the pipes washed by air); $\overline{T}_{нс}$ -$\overline{T}_B$ average inlet and outlet temperatures for combustion products and air, respectively. For example $(T_к+T_н)/2$.

The heat transfer coefficient K is determined by the formula

$$К = 1/(\frac{1}{L_1} + \frac{\delta}{\lambda} + 1/L_2)$$

Where, L_2 is the heat transfer coefficient from the combustion products to the surface of the pipes, L_2- also from the heating surface to the air; δ - pipe wall thickness; λ - thermal conductivity of the pipe wall.

Thus, knowing Q_t, as well as determining K and ΔT, they find the heating surface A, and then the number of pipes.

The process of dehydration in these dryers is that the heated air moves in a vertical direction (from bottom to top) at such a speed that the air pressure forces on the product particles balance the gravitational forces acting on these particles. As a result, each particle, as it were, “floats” independently of the others, and all elements of its surface are the same. Effectively interact with the flow of heated air, that is, the entire area of its surface is the area of evaporation, which somewhat reduces the energy intensity of the process.

A fluidized (pseudo-fluidized) bed dryer achieves intensive mixing of the material, accelerated heat and mass transfer so that the drying agent can be used at elevated temperatures without significant loss of quality of the final product. Combining the simplicity of the device with high specific productivity and ease of automation.

The parametric series of these dryers with an effective cross-sectional area (blown through by a stream of heated air) from several tens of square decimeters to several square meters is used for drying a wide variety of materials.

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