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Derivatographic study of chemically deposited chalk

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ABSTRACT:The aim of the study is to increase the energy and technological efficiency of drying heat and mass transfer apparatuses with the intensification of the drying process with simultaneous grinding of the target product, as well as the development and comprehensive study of the effective design of a vortex drying apparatus, a mathematical model and the creation on this basis of calculation methods for industrial drying apparatus.

KEY WORDS: derivatographicstudy, deposited chalk, aero fountain drying unit, swirling gas suspension flows, heat generator.

I.INTRODUCTION

An analysis of the scientific and technical literature of recent years concerning research on the development of methods for increasing the energy efficiency of heat power plants based on the intensification of hydrodynamic and heat and mass transfer processes, indicates the achievement of significant theoretical and practical results in this area.

However, the issues of engineering support to increase the efficiency of heat and mass transfer in dryers with swirling flows of gas suspensions with grinding are still not up to the mark. In literary sources, the hydrodynamics of the process in devices with swirling flows of gas suspensions are not sufficiently appreciated. In connection with the above, there is a need for further research on the development of scientific and engineering foundations of calculation methods, apparatus with swirling flows of gas suspension drying with grinding.

Consider some of the mechanisms of thermal drying, which is a complex process that leads not only to dehydration, but, as mentioned above, a significant change in the properties and characteristics of the dried material. By drying, we also understand the totality of the thermal and mass transfer processes occurring inside the wet material and outside its surface ensuring its dehydration.

Knowing the properties of the drying material as a drying object allows you to choose a rational method and mode of drying, to design a rational drying unit for dehydration.

The identification of general physical laws in the processes of heat and mass transfer inside wet materials, as well as consideration of their structural and mechanical characteristics, allowed A.V. Lykov to propose a classification of dried materials. According to this classification, all wet materials are divided into three groups: capillary-porous, colloidal and capillary simple colloidal.

II. SIGNIFICANCE OF THE SYSTEM

The scientific significance of the research results consists in the development of methods for calculating the parameters of hydrodynamic, thermal processes and operating modes of heat using plants using the example of a drying device. The calculated dependences make it possible to determine the parameters of the motion of solid particles in a chamber with a swirling layer with simultaneous drying and grinding of wet chalk.

The practical significance of the research results lies in the fact that the calculation methods based on the results of theoretical and experimental studies of the swirl layer with grinding allow us to justify the scheme of effective chalk drying and calculate the operating and design parameters of the industrial plant.

The reliability of the research results is confirmed by the use of modern research methods based on adequate mathematical models with the involvement of the relevant sections of the theory of thermodynamics, hydrodynamics and heat transfer and known proven methods for processing experimental data. The reliability of the results of the study is confirmed on the basis of a comparative analysis of the calculated and experimental data obtained in the created experimental plants and computer models of heat power and heat using plants..

III. LITERATURE SURVEY

Scientific research aimed at solving urgent problems of developing methods for improving the energy efficiency of heat power plants based on the intensification of hydrodynamic and heat and mass transfer drying processes is carried out in leading scientific centers and higher educational institutions of the world. In the works of Russian scientists A.V. Lykova, P.D. Lebedeva, Romankov P.G., Rashkovskaya N.B. , Gelperin N, I., Matur KB, Zabrodsky S.S., Elperin I.T., Dolidovich A.F. Sazhin B.S. , Specialized Laboratory of VTI et al. Lukenbach F.A. from USA, Epstein N. and Mathur K.B. Japanese scientists Nikajima Y, Yokogawa A, and also Uzbek scientists academician Nabiev .MN., prof. Rizaev N.U., M.Z. Zvik, R.A. Zakhidov, N.R. Yusupbekov, D.N. Mukhiddinov and others also carried out research in the field of heat and mass transfer and the development of an energy-saving drying apparatus.

IV. METHODOLOGY

During hydrothermal treatment, wet bodies change their technological properties. The reasons for these changes are largely due to the nature of the relationship contained in the liquid with the solid skeleton of the material.

The transfer of moisture and heat in dispersed bodies also largely depends on the forms and types of bonds of moisture with the solid phase. There are various methods for determining the forms of moisture contact with the material. The most common methods for determining the hydrothermal characteristics of materials are the methods of thermograms and energy patterns.

The thermogram method is a powerful tool in studying the properties of wet materials. The energy inhomogeneity of bound water is estimated by this method according to the temperature difference of dehydration (dehydration) of a thin (1-2 mm) wet sample -ΔT, recorded by a drying thermogram under the thermodynamic conditions of successive evaporation of moisture of various forms of coupling (quasi-equilibrium state of the material under mild drying). The drying thermogram, automatically recorded on the chart strip of the potentiometer, has a number of singular points that characterize certain forms and the state of absorbed moisture. The presence of a standard thermogram of a capillary-porous body, which shows all the forms and states of absorbed moisture, allows you to decipher the thermogram of the studied material. In some cases, if there is a loss of individual points (or areas bounded by these points), it is difficult to decipher the thermograms. In these cases, additional use of other methods is necessary.

Methods for studying the hydrothermal properties of materials, sorption isotherms, drying thermograms, etc. are used, as a rule, in the study of moisture in weak forms of bonding (physicomechanical, physicochemical, etc.). Destructive during drying at 105-110°S. Chemically bound moisture is not disturbed. To determine the moisture form of strong chemical bonds, use the thermographic method in the differential thermal analysis (DTA) mode [1]. The derivatograph is a multifunctional system for thermal analysis, which allows one to obtain TG, DTG, DTA and T - sample curves (TG-thermogravimetry, DTG-differential thermogravimetry, DTA-differential thermal analysis, T-temperature) on one tape. The device includes: an analytical balance, a furnace, a device for regulating the furnace temperature according to a given program, crucibles for a sample and a reference, a voltage regulator and a galvanometric recorder operating on the principle of “light beam - photo paper”. An air-damped analytical balance has an accuracy of ± 0.2 mg with a maximum deviation, the working range of mass measurement is from 10 mg to 10 g.

Evaluation of the obtained curves is carried out on the basis of calibration scales applied to photosensitive paper before the test. In the process of experiment, it is necessary to take into account the conditions of the thermoanalytical experiment.

The course of transformations recorded by the recorder with a recorder is determined by three factors: the thermal conductivity of the tested substances, their heat capacity and the equilibrium of chemical reactions. The influence of other factors is either insignificant, or is reduced to the three above.

Thermal analysis was recorded on a F. Paulik, J. Paulik, L. Erdey system derivatograph[1]at a speed of 10 deg / min and 140-180 mg weighed at sensitivity of T-900, DTA, DTG-1/10, TG-200 galvanometers. Recording was performed under atmospheric conditions. The holder was a corundum crucible with a diameter of 10 mm without a lid. Al2O3 was used as a reference.

The studies were conducted by the method of differential thermal analysis (DTA), based on a comparison of the thermal properties of the sample of the test substance and thermally inert substance. The experiments were performed on a complex thermoanalytic installation "DERIVATOGRAPH" system F. Paulik, J. Paulik, L. Erdey company "MOM" Hungary. The measurements were carried out in air with a heating rate of 5.8 degrees per minute (grad / min). The crucible is platinum. Weighed samples of the studied samples of 100 milligrams (mg). Calcined alumina (Al_2O_3)

was used as a thermally inert substance. The test sample - chemically deposited chalk immediately before the measurement was crushed to particles with sizes of 0.2-0.5 microns.

V. EXPERIMENTAL RESULTS

Figure 1 shows the originals of thermograms of chemical precipitated chalk (CPC). Thermograms include four dynamic curves: the course of temperature changes (T); thermogravimetry (TG), recording the change in mass of the sample; derivative thermogravimetry (TGP) or differential thermogravimetry (DTG), indicating the rate of change of mass of the sample; differential thermal analysis (DTA) curve, it shows the degree of heat transfer of the test substance occurring during heating, and records endothermic and exothermic reactions.

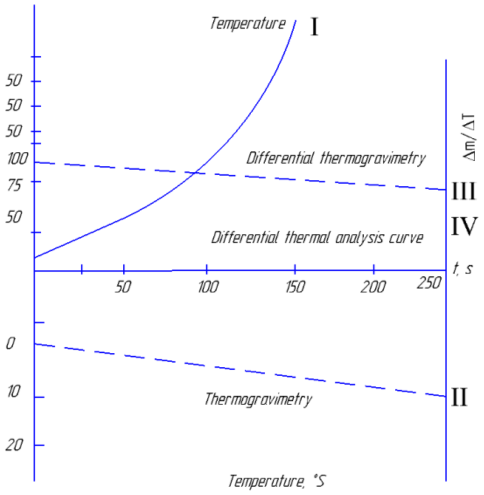

Figure 1. Chemical derivatography of precipitated chalk.

Curve 1 shows the results of processing the experimental thermogravimetric curves in the form of the dependence of the mass loss of the sample — ground chemically deposited chalk(CDC) on the heating temperature, that is, in the form of a diagram $\Delta m = f(T)$.

Curve 2 shows the data on the processing of DTG curves of the same sample. Additionally, auxiliary vertical dashed lines drawn indicate that the loss of the sample in the studied temperature range proceeds in three stages: 1st stage - from room temperature to 170 °S; 2nd stage - from 170 to 230 °S; 3rd stage - from 230 to 250 °S. At the first stage, moisture evaporates from the surface and near-surface layers of the sample. The mass loss in this case is 8% of the initial value. At the second stage, there is a certain relative slowdown in losses, which is 4.5%. This is probably due to the removal of water molecules from layers farther from the surface of the particles. At the third stage, there is a sharp increase in the rate of loss. The temperature range of 230-250 °S represents the beginning of the process of thermo-oxidative degradation that occurs as a result of heating.

Analysis of the thermograms of chalk in the form of finely divided powder shows that the sample does not undergo any special physicochemical transformations during heating. The only, it may be noted, poorly manifested removal of previously adsorbed moisture from the air. The process of evaporation of water molecules is smooth with a constant rate of loss. This conclusion is based on the DTG curve, which has the form of a straight line, allegedly drawn using a ruler. Quantitatively, the amount of adsorbed moisture in the studied temperature range is 1%. Such characteristics allow the use of this brand of chalk as a thermally inert substance in differential thermal analysis in the studied temperature range.

Curve 4 shows the results of processing the experimental thermogravimetric curves in the form of the dependence of the mass loss of the sample - chalk in the form of a dispersed powder on the heating temperature, that is, in the form of a diagram $\Delta m = f(T)$.

Table 1. Equilibrium humidity of chemically precipitated chalk.

φ	40	50	60	70	80	90
Wr	4,3	5,2	5,3	6,0	6,0	6,9

For a theoretical justification of the method of intensification of the drying process, a mechanism for the connection of chalk moisture was revealed, which determines the heat and mass transfer in the drying process [2].

The obtained derivatogram of the heating of chalk allows us to justify the permissible temperature of heating the material. Based on the obtained experimental data on the isotherms of sorption-desorption of chalk and the classification of the material according to its physical properties, differential and integral functions of pore radius distribution are calculated. Based on the sorption data, the following were calculated: nomogram for determining the binding energy of moisture of CDC, specific micropore volume, specific surface area and net heat of desorption of a monolayer. According to the value of the maximum hygroscopic moisture content of the chalk, the maximum sorption volume "over water" was estimated.

Based on a comprehensive analysis of the properties of the chemical precipitated chalk as an object of heat-technological processing by the value of the maximum hygroscopic moisture content according to the classification table of Professor D. Mukhiddinov [2] a flowing bed dryer has been selected. From the technology for producing chemical precipitated chalk, it can be seen that the last stage of the technology is a vacuum unit, from which the CDC with a humidity of 55 ÷ 65% comes out. in the form of lumps. During the drying process of the lumps, its surface is quickly dried and prevents the migration of moisture from inside the lumps. To intensify the drying process, it was proposed to grind the lumps with inert particles to form new evaporation centers, which would allow the process to be carried out in the first drying period. Thus, grinding of lumps of chalk proceeds simultaneously with the drying process and the dried particles leave the apparatus.

The study of the properties of CDC ended with a comprehensive analysis of the properties, consideration of their relationship from the angle of rational organization of the drying process, and the identification of the main (dominant) properties.

In order to compare the energy efficiency of the drying plant, an analysis of the heat engineering principles of the design of the drying process is carried out. Which was carried out in terms of specific volumetric productivity, taking into account the intensity of the drying process in the drying apparatus? Specific heat consumption for heating and evaporation of moisture, porosity of the layer, uneven processing of the material, the proportion of free cross-section, specific features of the used heat engineering principles and the design of the drying unit.

As an integral characteristic reflecting sorption – structural properties, the maximum hygroscopic moisture content of the material is accepted.

The choice of a rational type of dryer with the necessary drying time to the final moisture content was determined from the kinetic curve of the drying of the test material. However, the parameters of the kinetic curves depend on the mode of the drying process; therefore, the choice of a drying apparatus was carried out on the basis of the generalized drying time, the value of which weakly depends on the mode and is a characteristic of the material properties.

Using equations

$$\frac{dU}{d(N\tau)}$$

and sorption-desorption isotherms for the studied material, a drying kinetics curve is constructed, which is described by the equation

$$\mathring{U}=-K(A-U)(U-B)$$

or in general terms

$$\frac{dU}{d(N\tau)}=-K_{*}(A-U)(U-B)$$

Parameter B equilibrium moisture content of the material can be found by the desorption isotherm. The parameter K is determined by recalculating the kinetic curve of the drying of the model material in the region of capillary-bound moisture. For KII and K * obtained formulas:

$$K_{II}=\frac{f_{II}\bar{d}_{I}A_{I}}{f_{I}\bar{d}_{II}A_{II}}$$

$$K= K_{*}\ N$$

The parameter K * in the case of generalized drying curves for different modes in the form U = U (N τ) weakly depends on the mode and can be considered as a characteristic of the material. The parameter AII F is determined by minimizing the function F (AII)

$$F(A_{II})=\sum_{i=1}^{i=n}(Un-Ui-\frac{1}{b_3}\left\{\frac{\text{Спр}N}{b_1}\left[1-\exp\left(-\frac{b_1 ln\frac{(Un-B)(\text{A}-Ui)}{(\text{A}-U\text{н})(Ui-B)}}{CnpNk*(\text{A}-\text{B})}\right)\right]-\frac{ln\frac{(Un-B)(\text{A}-Ui)}{(\text{A}-U\text{н})(Ui-B)}}{k*(\text{A}-\text{B})}\right\})$$

The value N τ was chosen as the dominant factor, where τ is the time the material reaches Uk final moisture. This choice is due to the fact that the value of N τ weakly depends on the mode and is a characteristic of the material, and also takes into account its initial and final moisture content. Thus, depending on Un and Uk, a flowing type dryer was chosen. As an integral characteristic reflecting sorption – structural properties, the maximum hygroscopic moisture content of the material is accepted.

A rational type of drying apparatus was selected with the necessary drying time to the final moisture content, which can be determined from the kinetic curve of the drying of the test material. However, the parameters of the kinetic curves depend on the mode of the drying process; therefore, it is more convenient to choose a drying apparatus based on the generalized drying time, the value of which weakly depends on the mode and is a characteristic of the material properties.

In accordance with the well-known classification table [3], we choose the drying method in the apparatus of the gushing layer, taking into account the heat engineering principles of the design of the drying process. The choice is limited to a specific type of apparatus in the class of apparatuses of the gushing layer, which after structural changes can be turned into an industrial drying apparatus.

VI.CONCLUSION AND FUTURE WORK

The derivatographic, sorption and structural properties of chemically precipitated chalk are investigated. As an integral characteristic reflecting sorption – structural properties, the maximum hygroscopic moisture content of the material is accepted.

The investigated chemically deposited chalk was completed by a comprehensive analysis of properties, consideration of their relationship at an angle of dominant properties. The method of drying in the gushing layer was chosen, which after structural changes can be turned into an industrial drying apparatus.

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