STUDY OF THE KINETICS OF DRYING IRON (II) SULFATE HEPTAHYDRATE BY FILTRATION METHOD

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ABSTRACT

The object of research: kinetics of filtration drying process of iron (II) sulfate heptahydrate. Solved problem: to obtain the calculated dependence of the kinetics of filtration drying, which predicts the nature of the change in the moisture content of the material in time during the period of complete saturation of the thermal agent with moisture in the range of heights of the material layer 30.10^{-3}–120.10^{-3} m and the speeds of the thermal agent 0.46–1.61 m/s.
Main scientific results: the kinetics of filtration drying of iron (II) sulfate heptahydrate was investigated at different heights of the material layer and pressure drops over dry material, which means at different speeds of movement of the thermal agent. A certain critical moisture content, which is W_{cr}=0.065 kg H_2O/kg dry mat and the time it reaches at different heights of the material layer and the speeds of movement of the thermal agent. Based on the solution of the system of differential equations of material balance in the layer and the kinetics of drying, the kinetic coefficients for iron (II) sulfate heptahydrate a=15.75 1/m, $\alpha=3.03.10^{-3}$ 1/s were determined, which made it possible to obtain the calculated dependence of the kinetics drying, which predicts the nature of the change in the moisture content of the material over time during the period of complete saturation of the thermal agent with moisture in the range of heights of the material layer $H=30.10^{-3}$–120.10^{-3} m and the velocities of the thermal agent υ=0.46–1.61 m/s.
The area of practical application of the results: enterprises for the production of titanium (IV) oxide with the production of iron (II) sulfate heptahydrate as a by-product and enterprises specializing in the manufacture of pigments based on iron (II) sulfate heptahydrate.
Innovative technological product: iron (II) sulfate tetrahydrate ($FeSO_4 \cdot 4H_2O$, rosenite), obtained as a result of drying by the filtration method.
Scope of application of the innovative technological product: in the production technology of iron oxide pigments.

1. Introduction

World production of titanium (IV) oxide TiO_2 is about 6 million tons per year [1] and this product is widely used for the production of paints and varnishes, the manufacture of plastics and materials based on them, rubber, rubber and linoleum, paper, cardboard, wallpaper, is used in the cosmetic industry, in the food and radioelectronic industries [2–13]. There are two main industrial methods for the production of TiO_2: sulfate and chloride. The Sumykhimprom enterprise, which is the main producer of TiO_2 in Ukraine, uses the sulfate method of TiO_2 production, the raw material for the production of which is ilmenite. Production of TiO_2 by the sulfate method consists of a large number of sequential operations, which can be grouped into three groups: sulfate acid schedule of ilmenite; hydrolysis of titanyl sulfate; frying the metatitanic acid paste to obtain TiO_2 [9, 12].

As a result of the use of the sulfate method for the production of pigment TiO_2, a significant amount of waste is formed, among which the main ones are hydrolytic sulfuric acid and the «black solution» formed at the stage of the sulfate acid schedule of ilmenite and floating leaching, consist-

ing mainly of $TiOSO_4$, $FeSO_4$, SiO_2, rutile, $CaSO_4$ etc. [14–17]. For the purpose of a more complete use of raw materials, the «black solution» is purified by settling using coagulants and subsequent filtration. The solution purified from sludge is fed into a vacuum crystallization unit, in which crystallization of iron (II) sulfate heptacrystal hydrate ($FeSO_4 \cdot 7H_2O$) occurs due to a decrease in salt solubility during its evaporation and cooling. The crystallization process is carried out according to strict adherence to the temperature regime, which makes it possible to obtain clean and large crystals of $FeSO_4 \cdot 7H_2O$, which, after thickening, are separated in centrifuges or plan-filters. Thus, when using sulfur technology for the production of TiO_2, $FeSO_4 \cdot 7H_2O$ is obtained as a by-product in the amount of 3…6 tons per ton of the main product obtained. Only a small part of iron (II) sulfate heptacrystal hydrate is used by industry for the production of insecticidib and herbicides for the needs of agriculture, active applications to cement [13], iron-containing mineral fertilizers [17], coagulants for water purification [15, 18], sulfuric acid [10], iron ore pellets [8], etc. A significant part of iron (II) sulfate heptacrystal hydrate remains as production waste [19], it is considered an environmental and economic problem in the titanium dioxide industry in European countries. Considering the high tonnage of obtaining and incomplete use of $FeSO_4 \cdot 7H_2O$, the expansion of the industrial scope of its application, in particular for the production of iron oxide pigments, is a topical issue [8]. For the production of ironoxide pigments, the industry faces a practical problem of drying crystalline hydrates $FeSO_4 \cdot 7H_2O$, associated with the need to remove a small amount of free water (10~20 %) and crystallization water, which leads to significant energy consumption [20].

1. 1. The object of research

The object of research is iron (II) sulfate heptahydrate ($FeSO_4 \cdot 7H_2O$), ferrous sulfate), which is a hygroscopic crystalline powder of greenish-blue color with a density of 1.899 g/cm^3. The granulometric composition of ferrous sulfate obtained from the production cycle of TiO_2 by sulfate technology is presented in **Table 1** [12] and the results of calculating the main characteristics of the stationary layer of ferrous sulfate are summarized in **Table 2.**

Table 1

Granulometric composition of ferrous sulfate

Sieve mesh sizes, mm	Partial residues, %	Total residues, %
2.5	0.9	0.9
1.25	4.2	5.1
0.63	69.1	74.2
0.315	21.6	95.8
0.16	4.2	100

Table 2

Characteristics of the ferrous sulfate layer

P_t, kg/m^3	P_b, kg/m^3	$d_e \cdot 10^3$ m	$d_p \cdot 10^3$, m	a, m^2/m^3	ε, m^3 m^3
1890	902.75	0.4	0.77	3750	0.48

1. 2. Problem statement

The process of dehydration of crystalline hydrates, in particular $FeSO_4 \cdot 7H_2O$, has its own characteristics associated with the nature of the substance and, thus, with the strength of the bonds between the substance and crystallization water, which, in turn, causes the elimination of water molecules from a certain temperature regime of their dehydration [21]. The process of dehydration of iron (II) sulfate heptahydrate ($FeSO_4 \cdot 7H_2O$) is a three-stage process [22]. The elimination of water molecules occurs in the molar sequence 3-3-1, so the transformation sequence is as follows: $FeSO_4 \cdot 7H_2O \rightarrow FeSO_4 \cdot 4H_2O \rightarrow FeSO_4 \cdot H_2O \rightarrow FeSO_4$, according to the results presented in [14–17]. Thus, as a result of the dehydration of iron (II) sulfate heptahydrate, iron (II) sulfate tetrahydrate ($FeSO_4 \cdot H_2O$, rosenite), iron (II) sulfate monohydrate ($FeSO_4 \cdot H_2O$, smolnokite) and anhydrous iron (II) sulfate [9, 12].

Drying of crystalline hydrates in industrial conditions is carried out by the convective method in drum dryers [23, 24], fluidized bed dryers [23]. A combined convective-radiation drying method [24] and a convective-microwave drying method in terms of radiation intensity of 350–400 W in a

pulsed mode [20] are also used, which reduce the duration of the process, but lead to excessive energy consumption [25]. The expansion of the scope of application of iron (II) sulfate heptahydrate is closely related to the establishment of new technological solutions to reduce energy consumption at the drying stage in production lines.

1. 3. Proposed solution to the problem

The use of the filtration method of drying for iron (II) sulfate heptahydrate allows to intensify the process of its dehydration due to the achievement of high values of heat and mass transfer coefficients as a result of intense contact between the mobile thermal agent and the product, is located on a perforated lattice and reduce energy costs for the implementation of the latter in comparison with the specified industrial methods [26–28]. In addition, cooling the crystals at the final stage of drying by filtering cold air through the layer of material reduces the risk of product caking [17, 29].

To ensure high-intensity drying of iron (II) sulfate heptahydrate, it is necessary to study the influence of the process parameters (rate of filtration of the thermal agent), the geometric dimensions of the layer on the nature of the change in moisture content over time [30]. Generalization of the results of the kinetics of drying and determination of kinetic coefficients will allow calculating the main dimensions of the drying unit, substantiating the optimal technological parameters of the process, depending on the required productivity [31, 32]. Despite the fact that there is practically no information in the literature on the kinetic regularities of drying of iron (II) sulfate heptahydrate during the implementation of the process by the filtration method, the goal of the work is formulated.

The aim of this work is to study the effect of the height of the stationary layer of iron (II) sulfate heptahydrate and the rate of movement of the thermal agent on the kinetics of filtration drying and generalize the results in the form of calculated dependencies that will allow calculating the change in the moisture content of the material over time depending on the variable parameters of the process.

2. Materials and methods

To study the kinetics of moisture removal from crystals of iron (II) sulfate heptahydrate, an experimental setup was used, the diagram of which is shown in **Fig. 1.**

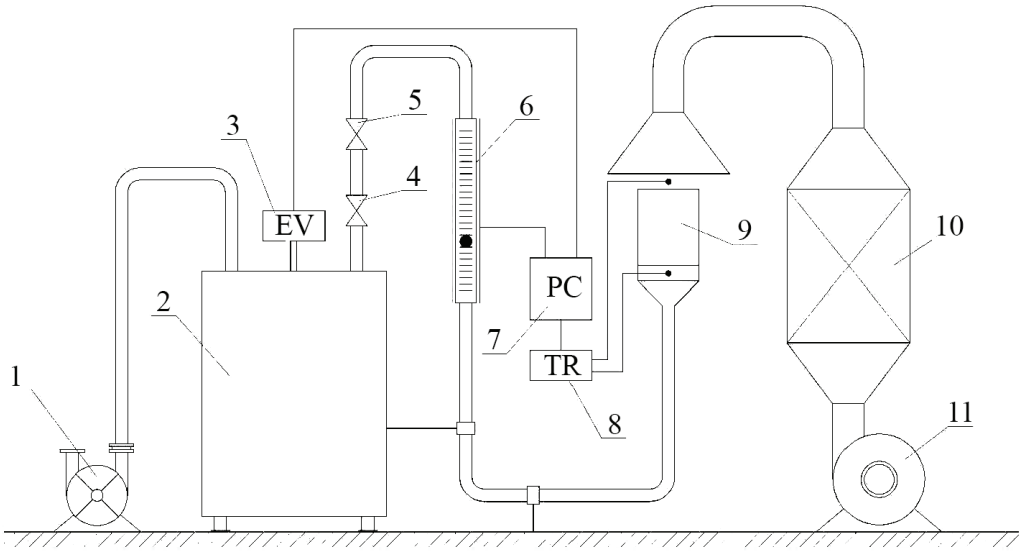

Fig. 1. Diagram of the experimental setup: 1 – liquid ring vacuum pump; 2 – receiver; 3 – electronic vacuum gauge DV250A; 4, 5 – shut-off and control valves; 6 – electronic rotameter RPF-I; 7 – personal computer; 8 – electronic thermostat SESTOS D1S; 9 – container; 10 – air heater; 11 – fan

2. 1. Experiments

For research, the formation of a sample of iron (II) sulfate heptahydrate (ferrous sulfate) with a layer of the appropriate height was carried out in container 9. A weighed portion of ferrous

sulfate was loaded into a container so that the height of the material layer corresponded to the calculated one. This ensured the same porosity of ferrous sulfate in each experiment.

To implement isothermal dehydration of iron (II) sulfate heptahydrate, a fan and a heater were turned on to heat the heating agent to a temperature of 62 °C (the temperature was controlled using an electronic SESTOS D1S thermostat). The selected temperature of the thermal agent was determined by the physicochemical properties of the material (the ability to split off water molecules in a certain temperature range). Dehydration of iron (II) sulfate heptahydrate at 62 °C leads to the loss of three water molecules and the formation of $FeSO4 \cdot 4H_2O$.

After the temperature of the heat agent was set at 62 °C, the vacuum pump was turned on. The container 9, with the formed layer of ferrous sulfate, was installed on the receiver 2, the tap 5 was opened and the studies were carried out. The required flow rate of the thermal agent was set using a control valve, which was measured using a rotameter. The studies were carried out at different rates of filtration of the thermal agent 0.46; 0.61; 0.86; 1.11; 1.61 m/s). This range of speeds corresponds to the following pressure drops for dry material (1210, 1920, 2760, 3960, 7620 Pa). The range of variation of the rate of filtration of the thermal agent through the layer of material was chosen taking into account the performance of the fans and based on the fact that in industrial installations the total area of the drying zone can be 4–6 m^2.

The study was also carried out at different heights of the material layer H (30; 60; 90; 120 mm). The range of variation in the height of the stationary layer of the material was selected according to the recommendations presented in [28], where the minimum layer height should be no less than $20_{d.part}$ and for reasons of ensuring the maximum possible uniform heating of the layer.

During the research, the change in the mass of the material at regular intervals was determined by the gravimetric method using an AXIS-AD3000 electronic balance. The experiments were continued until a constant mass of the ferrous sulfate sample was reached.

3. Results of the study of the kinetics of moisture removal from crystals of iron (II) sulfate heptahydrate using filtration drying and discussion of the results

We have investigated the change in the moisture content of iron (II) sulfate heptahydrate over time at different heights of the wet material and different pressure drops over the dry material and, as a consequence, different speeds of movement of the thermal agent. The studies were carried out on the experimental setup shown in **Fig. 1**, according to the presented methodology.

The results of studies of the effect of the height of the layer of iron (II) sulfate heptahydrate in the range from 30 to 120 mm in drying (at the same temperature and filtration rate of the thermal agent) are presented in the form of graphical dependencies in **Fig. 2**, from which it can be seen that an increase in the layer height leads to an increase in the drying time, is explained by an increase in the path of movement of the mass transfer front in the perforated partition.

The results of studies of the influence of the rate of filtration of a thermal agent through a layer of iron (II) sulfate heptahydrate on the process of filtration drying are presented in the form of graphical dependencies in **Fig. 3.** An increase in the filtration rate of the thermal agent (at the same height of the layer and the temperature of the thermal agent) leads to a reduction in the drying time, since the amount of heat introduced into the porous layer of material increases, and also leads to an increase in the heat and mass transfer coefficients, in addition to this increase in the filtration rate of the thermal the agent helps to reduce the thickness of the hydraulic, thermal and diffusion layers, leads to an intensification of the heat and mass transfer process and allows more moisture to evaporate due to the intensification of the process.

The presented kinetic curves (**Fig. 2, 3**) are characterized by the presence of periods of complete and partial saturation of the thermal agent with moisture. The period of complete saturation of the thermal agent with moisture vapor exists until the mass transfer front of the perforated partition is reached, and on the kinetic curves this period corresponds to a straight line, the slope of which determines the speed of movement of the mass transfer zone. The tangent of the slope of the straight sections of the kinetic curves decreases with an increase in the height of the iron (II) sulfate heptahydrate layer (**Fig. 2**), which indicates not a decrease in the speed of movement of the mass transfer front, but is explained by an increase in the path of its movement in the perforated partition. With an increase in the filtration rate of the thermal agent (**Fig. 3**), the tangent of the slope of the straight lines increases, which is explained by an increase in the drying potential. The

period of partial saturation begins when the mass transfer front reaches the perforated partition, as a result of which the amount of wet material decreases, the thermal agent is partially saturated with moisture vapor and its temperature at the exit from the layer increases. This period corresponds to the curved section on the kinetic curves of filtration drying (**Fig. 2, 3**).

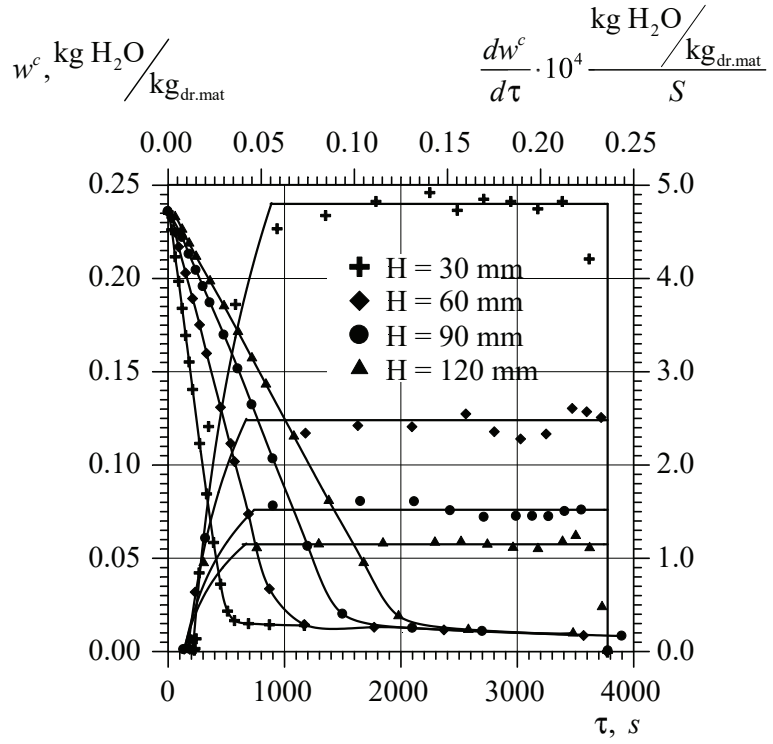

Fig. 2. Kinetic curves of drying of iron (II) sulfate heptahydrate at different heights of the material layer and curves of the drying rate

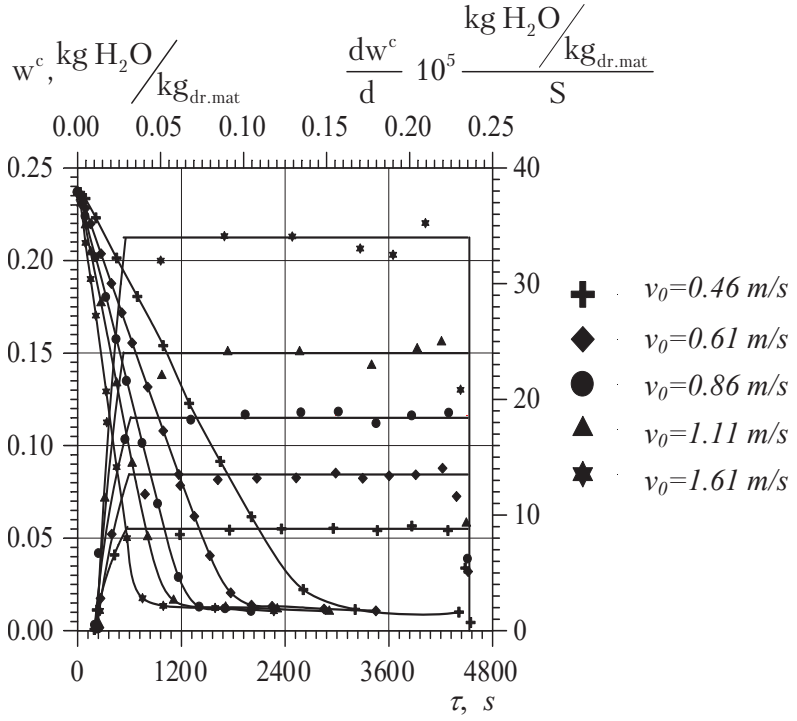

Fig. 3. Kinetic curves of drying of iron (II) sulfate heptahydrate at different rates of filtration of the heating agent and curves of drying rates

In order to obtain a calculated dependence, which makes it possible to determine the change in the moisture content of iron (II) sulfate heptahydrate over time during the period of complete saturation of the thermal agent with moisture, the generalization of the results of the study of the kinetics of drying was carried out. To determine the values of the critical moisture content W_{cr} and the time to reach it τ_{cr} at various pressure drops (velocities of the thermal agent), as well as the heights of the iron (II) sulfate heptahydrate layer, a method was used that consists in constructing kinetic curves in coordinates $\lg(W-W_p)=f(\tau)$ (**Fig. 4, 5**), where W, W_p – running and equilibrium value of moisture content of the material, kg/kg; τ – drying time, s.

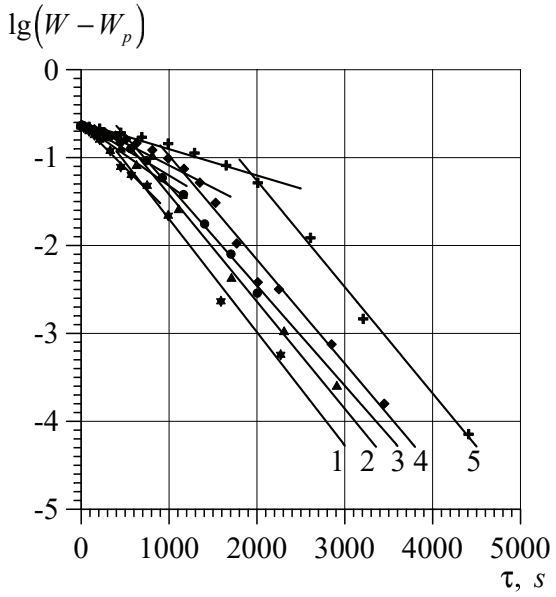

Fig. 4. Determination of the critical moisture content and the time to reach it during the implementation of filtration drying (H=60·10^{-3} m, T=333 K): 1 – ΔP=1210; 2 – ΔP=1920 Pa; 3 – ΔP=2760 Pa; 4 – 3960 Pa; 5 – 7620 Pa

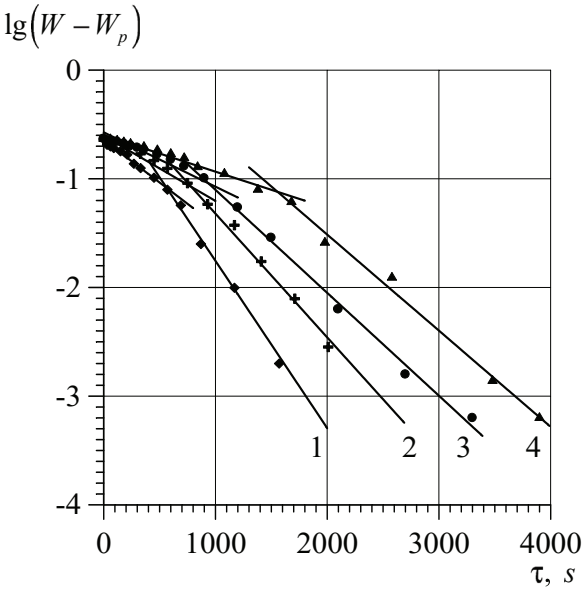

Fig. 5. Determination of the critical moisture content and the time to reach it during the implementation of filtration drying (ΔP=1210 Pa, T=333 K): 1 – H=30·10^{-3} m; 2 – H=60·10^{-3} m; 3 – H=90·10^{-3} m; 4 – N=120·10^{-3} m

As can be seen from the graphical dependencies shown in **Fig. 4**, **5,** the periods of complete and partial saturation of the thermal agent with moisture can be generalized by straight lines, the

ordinate of the intersection point of which will correspond to the critical moisture content lgW_{cr}, and the abscissa is the time of its achievement. In this case, the value of the critical moisture content can be calculated from the dependence:

$$W_{cr} = 10^{x} + W_{p}, \tag{1}$$

where x – ordinate of the point of intersection of two straight lines corresponding to the periods of complete and partial saturation of the thermal agent with moisture.

The ordinates of the points of intersection of two straight lines, corresponding to the periods of complete and partial saturation of the thermal agent with moisture, on the graphical dependencies (**Fig. 4, 5**) are the same and equal x=–1.2. Thus, the value of the critical moisture content does not depend on the speed of movement of the heating agent and the height of the layer of iron (II) sulfate heptahydrate and its value calculated from dependence (1) is equal to

$$W_{cr} = 0.063 + 0.002 = 0.065 \ {}^{\text{kgH}_2\text{O/kg}_{\text{dr.mat}}}.$$

An increase in the pressure drop from ΔP=1210 Pa to ΔP=7620 Pa and, as a consequence, an increase in the speed of movement of the thermal agent leads to an increase in the drying rate of iron (II) sulfate heptahydrate and, accordingly, the value of τ_{cr} decreases (**Fig. 4**). The value of τ_{cr} increases with an increase in the height of the material layer from 30.10^{-3} m to 120.10^{-3} m (**Fig. 5**). An increase in the drying time with an increase in the height of the material layer is explained by an increase in the amount of moisture that is mechanically contained between the crystals of iron (II) sulfate heptahydrate.

To generalize the drying kinetics of iron (II) sulfate heptahydrate during the period of complete saturation of the thermal agent with moisture, let's use the system of differential equations of material balance in the layer and the kinetics of drying [27]:

$$\begin{cases} \dfrac{\partial W}{\partial \tau} = a \cdot (1 - \varphi), \\ \dfrac{\partial W}{\partial \tau} = n \cdot (1 - \varphi), \end{cases} \tag{2}$$

where φ – relative humidity of the heating agent,%; W – running moisture content of the material, kg H_2O/kg dr. mat.

The value of the kinetic coefficient a, /m, which does not depend on the process parameters and depends on the structure of the material, calculated according to the dependence:

$$a = \frac{P \cdot m \cdot n}{0.622 \cdot P_s} \text{ and } a = 0.063 + 0.002 = 0.065, \tag{3}$$

where P – barometric pressure, Pa; P_s – saturated steam pressure, Pa.

The value of m and n included in dependence (3) is determined as:

$$m = \frac{\rho \cdot F}{100 \cdot M} \text{ and } n = S \cdot \beta \cdot P_s,$$

where ρ – density of the drying agent, kg/m^3; F – cross-sectional area of the container, m^2; M – mass flow rate of the thermal agent, kg/s; S – the inner surface of parts of the material, m^2; β – coefficient of mass transfer,

Taking into account the values of m and n, dependence (3) can be represented as:

$$a = \frac{F \cdot P \cdot \rho \cdot S \cdot \beta}{0.622 \cdot M}. \tag{4}$$

The solution to the system of differential equations (2) is an equation that describes the kinetics of drying in the period of complete saturation of the thermal agent with moisture until moisture is reached W=W_{cr}.

$$\frac{W}{W_o} = 1 - \alpha \cdot \tau \cdot e^{-a \cdot H}, \quad (5)$$

where α – drying coefficient, 1/s, which is calculated from the dependence:

$$a = \frac{S \cdot \beta \cdot P_s \cdot (1 - \varphi_0)}{W_0}, \quad (6)$$

where W_o – initial moisture content of the material, kg H_2O/kg dr. mat.; φ_0 – initial relative humidity of the heating agent, %.

Substituting into equation (5) the value of the coefficient a from dependence (4) and the value of α from dependence (6), let's obtain the equation:

$$\frac{W}{W_0} = 1 - \frac{S \cdot \beta \cdot P_s \cdot (1 - \varphi_0)}{W_0} \cdot \tau \cdot e^{-\frac{F \cdot P \cdot \rho \cdot S \cdot \beta \cdot H}{62.2 \cdot M}}. \quad (7)$$

Let's write equation (7) in the form:

$$\frac{1 - \frac{W}{W_0}}{\tau} = \alpha \cdot e^{-a \cdot H}. \quad (8)$$

Let's note:

$$y = \alpha \cdot e^{-a \cdot H}. \quad (9)$$

So

$$\frac{1 - \frac{W}{W_0}}{\tau} = y. \quad (10)$$

Equation (9) logarithmically:

$$\ln(y) = \ln(\alpha) - a \cdot H \cdot \ln(e)$$

or

$$\ln(y) = \ln(\alpha) - a \cdot H. \quad (11)$$

In order to describe the kinetics of the drying process of iron (II) sulfate heptahydrate using equation (5), it is necessary to determine the kinetic coefficients α and *a*. Kinetic coefficients α and *a* are determined from experimental data, by plotting a graphical relationship (according to equation (11)), or $\ln\left((1 - W/W_0)/\tau\right) = f(H)$ according to equation (10). The experimental data can be summarized by a straight line (**Fig. 6**).

From the given graphical dependence, the value of ln(*a*) is determined by the segment that the straight line cuts off on the ordinate axis, whence the value of the coefficient $\alpha = 3.03 \cdot 10^{-3}$ 1/s. The value of the kinetic coefficient, as follows from equation (6), depends on the mass transfer coefficient b and, as a consequence, on the drying parameters. By the tangent of the angle of inclination of the straight line to the abscissa axis, the determined value of the kinetic coefficient is $a = 15.75 \frac{1}{\text{m}}$. The steady-state value of the kinetic coefficient a determines the constancy of the ratio between the mass velocity *M* and the mass transfer coefficient b, which proportionally increase with an increase in the speed of movement of the thermal agent.

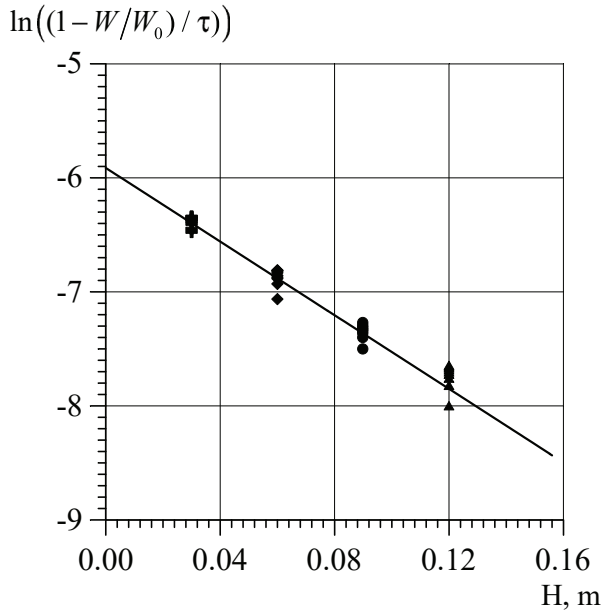

Fig. 6. Determination of the coefficients α and *a*

Let's solve equation (8) with respect to α:

$$a = \frac{1 - \frac{W}{W_0}}{\tau \cdot e^{-a \cdot H}}. \tag{12}$$

The coefficient α depends on the running moisture content of the material. The change in the moisture content of the material during the period of complete saturation is limited by the external conditions of the drying process, namely the speed of movement and the temperature of the thermal agent. The speed of movement of the thermal agent is known to be directly proportional to the hydraulic resistance of the dry material. This means that the coefficient α will be directly proportional to both the temperature of the heating agent and the hydraulic resistance of the dry material.

Considering that α is a function of the hydraulic resistance of a dry material (the temperature of the thermal agent in this case is a constant value), the dependence of the kinetic coefficient α on the process parameters can be represented, based on the method of dimensional analysis [27], by the equation:

$$\alpha = A \cdot \Delta P_c^n, \tag{13}$$

where ΔP_c – the pressure drop over dry material, Pa.

The value of the coefficient A and the exponent n are constant for a given material and are determined based on the results of experiments carried out with different drying parameters of iron (II) sulfate heptahydrate.

To find the values of A and n, a system of two equations was compiled, the solution of which will allow finding unknown coefficients:

$$\begin{cases} \alpha_1 = A \cdot P_1^n, \\ \alpha_2 = A \cdot P_2^n. \end{cases} \tag{14}$$

Each equation corresponds to the following drying parameters:

– a layer with a height of H=60 10^{-3} m, the temperature of the thermal agent is T=333 K;

– pressure drop over dry material within 1210–7620 Pa.

The coefficient α is determined based on experimental data, respectively, for each drying parameter according to equation (12). The calculated values of α according to p by equation (12) are within the error of the coefficient $\alpha=3.03.10^{-3}$ 1/s determined by the graphical method (**Fig. 6**).

Having solved the system of equations (14), let's obtain the value of the coefficient $A=6.5.10^{-4}$ and the exponent $n=0.2$, which shows the degree of influence of the resistance of the dry material and, as a consequence, the speed of movement of the thermal agent.

So, the kinetic equation (7), which allows predicting the filtration drying of iron (II) sulfate heptahydrate during the period of complete saturation with moisture, can be represented as:

$$\frac{W}{W_o}=1-6.5\cdot10^{-4}\cdot\Delta P_c^{0.2}\cdot\tau\cdot e^{-15.75\cdot H}. \quad (15)$$

Dependence (15) makes it possible to calculate the change in the moisture content of iron (II) sulfate heptahydrate over time during the period of complete saturation of the thermal agent with moisture in the range of changes in heights from 30.10^{-3} to 120.10^{-3} m and the velocities of the thermal agent from 0.46 to 1.61 m/s.

The results of studies of the kinetics of the drying process of iron (II) sulfate heptahydrate and the equations obtained as a result of their generalization, allowing to calculate the drying duration.

5. Conclusions

The kinetics of filtration drying of iron (II) sulfate heptahydrate was investigated, namely, the effect on the duration of the process of the height of the material layer (**Fig. 2**) and the speed of movement of the thermal agent (pressure drop over dry material (**Fig. 3**).

A certain critical moisture content and the time to reach it during the implementation of filtration drying of iron (II) sulfate heptahydrate (**Fig. 4, 5**).

Based on the solution of the system of differential equations of material balance in the layer and the kinetics of drying (2), the kinetic coefficients for iron (II) sulfate heptahydrate $a=15.75\ \frac{1}{\text{m}}$, $\alpha=3.03.10^{-3}$ 1/s were determined, and solving the system of equations (14), it was obtained the value of the coefficient $A=6.5.10^{-4}$ and the exponent $n=0.2$, allowing to predict the process in a wide range of parameters.

The proposed calculated dependence of the drying kinetics is proposed $\frac{W}{W_o}=1-6.5\cdot10^{-4}\cdot\Delta P_c^{0.2}\cdot\tau\cdot e^{-15.75\cdot H}$, which predicts the nature of changes in the moisture content of the material over time during the period of complete saturation of the thermal agent with moisture. These results make it possible to select and calculate the hardware design of the ferrous sulfate drying process. Experimental studies of the kinetics of the filtration drying process of iron (II) sulfate heptahydrate in a different temperature range and comparison of the results are planned for the future.

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