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THEORETICAL ANALYSIS OF EFFICIENCY OF HORIZONTAL APPARATUS WITH BUCKET-LIKE DISPERSERS IN THE DUST TRAPPING SYSTEM

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Abstract. The efficiency of horizontal apparatus with bucket-like dispersers has been theoretically grounded to remove dust from industrial waste gases. The mathematical dependencies have been developed to calculate main technological characteristics. The values of dust-laden gas obtained during red ferrum oxide pigment production have been calculated. The optimum technological regime for apparatus operation has been determined.

Keywords: dust trapping, ferrum oxide pigment.

1. Introduction

Aerosols with continuous (dispersing) gas and solid dispersed phases are formed in many technological processes. Depending on the sizes of dispersed solid particles gas systems are divided into dust ($0.5–10.0\cdot10^{-5}$ m) and fume ($0.1–5.0\cdot10^{-6}$ m). Generally dust has the dispersing origin and fume – the condensing one. Aerosols of gas-solid system are polydispersed, *i.e.* sizes of solid particles vary within a wide range.

Most of existing in Ukraine dust trapping systems are outmoded and have not prospects for their upgrading. It is the reason that maximum allowed emissions exceed the standards of European Union [1, 2]. In particular, monitoring of two-staged cleaning of waste gases obtained during red ferrum oxide pigment production at JSC "Krymsky Titan" exhibits its low efficiency and impossibility to be upgraded [3]. Therefore the problem of waste gases cleaning demands new technological solutions with the application of modern apparatus.

Horizontal apparatus with bucket-like dispersers (HABD) was found to be the most promising one for the above-mentioned system. This apparatus has a lot of advantages and proves itself in the industry [3, 4].

The aim of the work is theoretical analysis of HABD operation and confirmation of its efficiency for dust removal from waste gases, namely from furnace gases of red ferrum oxide pigment burning from Fe_2O_3 particles.

Investigation tasks:

- to systematically analyze the factors affecting the efficiency of dust trapping in HABD and establish interrelation between them;
- to choose main intensifying factors and create grounds for the process simulation;
- to calculate technological characteristics of dust trapping in HABD on the basis of approximate mathematical formulation taking waste gases emissions as an example during the red ferrum oxide pigment production.

2. Experimental

2.1. Theoretical Part

While using "wet" method of dust removal from gases there are two main mechanisms of particles trapping: by liquid film and drops. According to the first method dust particles are directed to the liquid surface, to a wall wetted by liquid or to the film formed by gas bubbles. According to the second method dust-laden gas is washed by dispersed liquid, the drops of which trap dust particles and take them off the gas flow.

Dust is trapped in HABD according to both mechanisms at the same time. Due to the intensive rotation of bucket-like disperser the centrifugal forces occur providing liquid and gas motion from the centre to periphery (fan-driven effect). Thus dust particles are accumulated on wetted walls of the apparatus. According to the second (inertial) mechanism dust particles are trapped by a high-active droplet curtain in the apparatus volume. There are grounds to reckon that the second mechanism is predominant and determinant one.

The initial drops are formed during destruction of water film formed in slits of bucket-like disperser. Then, depending on hydro- and thermodynamic conditions in HABD the following processes are possible: drops coalescence; their spontaneous crushing; secondary crushing caused by knocks; evaporation and condensation growth. The system is multiplex and possible mechanisms of droplet curtain formation are determined by various factors. Therefore we assumed that formation of initial drops is a determinant factor.

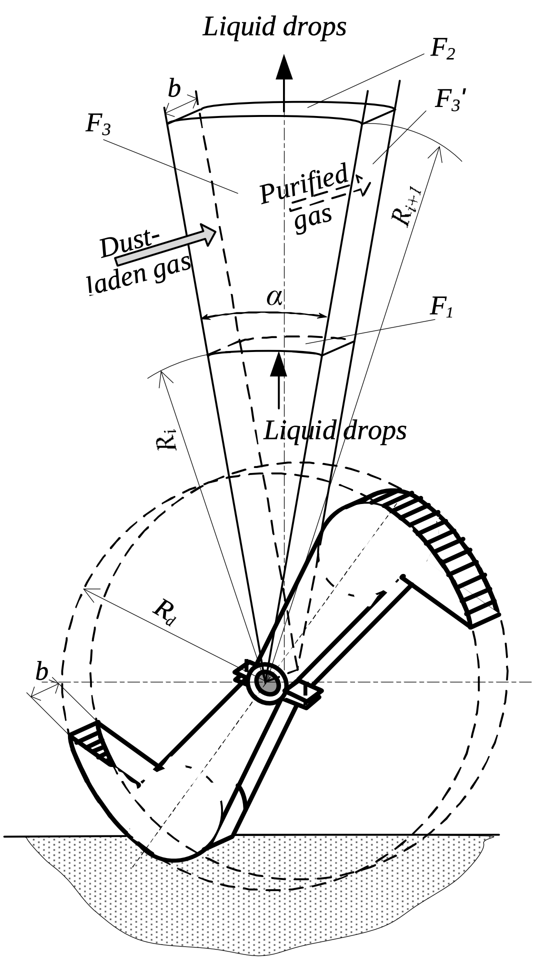

Fig. 1. Scheme of bucket-like disperser

Taking into account multifactor and complicated task, we assumed the following approximations:

– all drops formed under the same conditions have the same size and don't interact between each other;

– heat- and mass transfers are absent between the drop and environment;

– drops secondary crushing is neglected.

Then the gas cleaning degree may be theoretically calculated by means of the equation derived *via* integration of the material balance differential equation of Fe_2O_3 dust in HABD elementary volume. For this purpose elementary volume was chosen limited by F_1, F_2, F_3 and F_3' areas ($F_3 = F_3'$, Fig. 1). Volumetric rate of dust-laden gas (W_g, m^3/s) passed through elementary volume is equal:

$$W_g = n_g \cdot F_3 = n_g \cdot \left(\frac{a}{360} \cdot p \cdot R_{i+1}^2 - \frac{a}{360} \cdot p \cdot R_i^2 \right) = \left| = n_g \cdot \frac{a}{360} \cdot p \cdot \left(R_{i+1}^2 - R_i^2 \right) \right. \quad (1)$$

where n_g – gas rate, m/s.

Liquid instant flow rate through elementary volume is:

$$W_l = n_d \cdot x \cdot F_{av} = n_d \cdot x \cdot \frac{a}{360} \cdot p \cdot b \cdot \left(R_i + R_{i+1} \right) \quad (2)$$

where v_d – drop rate, m/s; ξ – part of elementary volume occupied by drops; b – width of sprinkling sector equal to bucket width, m; F_{av} – average square of sprinkling sector calculated according to Eq. (3).

$$F_{av} = \frac{F_1 + F_2}{2} = \frac{1}{2} \cdot \frac{2 \cdot a}{360} \cdot p \cdot b \cdot \left(R_i + R_{i+1} \right) \quad (3)$$

If we assume that drops are spherical ones and are not in contact between each other, then the following quantity of drops may be in the elementary volume:

$$N_V = \frac{F_3 \cdot b \cdot x}{V_d} = \frac{a \cdot p \cdot \left(R_{i+1}^2 - R_i^2 \right) \cdot b \cdot x \cdot 6}{360 \cdot p \cdot d_d^3} \quad (4)$$

where V_d – drop volume, m^3; d_d – drop average diameter, m.

Substituting the value ξ from Eq. (2) into Eq. (4):

$$N_V = \frac{6 \cdot a \cdot p \cdot \left(R_{i+1}^2 - R_i^2 \right) \cdot b \cdot W_l \cdot 360}{360 \cdot p \cdot d_d^3 \cdot n_d \cdot p \cdot a \cdot b \cdot (R_i + R_{i+1})} = \frac{6 \cdot (R_{i+1} - R_i) \cdot W_l}{p \cdot d_d^3 \cdot n_d} \quad (5)$$

During drop motion in a dust-laden space the dust particles are accumulated mainly due to kinematical coagulation. It is caused by motion of particles with different sizes and different relative rates. If we examine the drop motion through aerosol of fine particles, then the mass of trapped dust particles (kg/s) by one drop in time unit is:

$$\mathrm{m_d} = h_t \cdot \mathrm{F_d} \cdot n_{sed} \cdot \mathrm{z} = h_t \cdot \frac{p \cdot \mathrm{d_d^2}}{4} \cdot n_{sed} \cdot \mathrm{z} \quad (6)$$

where h_t – coefficient of particles trapping; F_d – square of drop midlength section, m^2; n_{sed} – rate of dust particles sedimentation (dust and drop relative velocities), m/s; z – dust content in gas, kg/m^3 [5, 6]. Taking into account that sprinkling in HABD is carried out in a transverse direction, rate of drop sedimentation and drop movement will be equal, $n_{sed} = n_d$.

Mass of dust trapped by all drops of the elementary volume is:

$$m_V = m_d \cdot N_V = h_t \cdot \frac{p \cdot d_d^2}{4} \cdot n_d \cdot z \cdot \frac{6 \cdot (R_{i+1} - R_i) \cdot W_l}{p \cdot d_d^3 \cdot n_d} =$$

$$= \frac{3 \cdot h_t \cdot z \cdot (R_{i+1} - R_i) \cdot W_l}{2 \cdot d_d} \quad (7)$$

The equation of material balance of Fe_2O_3 dust for the elementary volume is:

$$z \cdot W_g - (z - dz) \cdot W_g = \frac{3 \cdot h_t \cdot z \cdot dR \cdot W_l}{2 \cdot d_d} \quad (8)$$

After simplification:

$$\frac{dz}{z} = \frac{3 \cdot h_t \cdot dR \cdot W_l}{2 \cdot d_d \cdot W_g} \quad (9)$$

Integration within the range from z_f to z_i and from R_{dis} та R_{app} allows to obtain Eq. (10):

$$\ln \frac{z_f}{z_i} = -\frac{3}{2} \cdot \frac{W_l \cdot (R_{app} - R_{dis})}{W_g \cdot d_d} \cdot h_t \quad (10)$$

where z_i and z_f – initial and final dust content in gas, respectively, kg/m^3; R_{app} and R_{dis} – radius of apparatus and disperser, respectively, m.

To determine the trapping efficiency Eq. (10) is exponentiated and Eq. (11) is formed:

$$X = 1 - \frac{z_f}{z_i} = 1 - exp\left(-\frac{3}{2} \cdot \frac{W_l \cdot (R_{app} - R_{dis})}{W_g \cdot d_d} \cdot h_t\right) \quad (11)$$

Physical processes occurred in HABD are complicated and difficult to be described mathematically. Thus the obtained equation is somehow approximated one. However, such approach allows to emphasize main factors affecting the apparatus efficiency.

Efficiency of gas cleaning in HABD increases with the increase in specific flow rate of dispersed liquid $\frac{W_l}{W_g}$ and coefficient of trapping h_t and decreases with the increase in drop diameter d_d.

The height of sprinkling sector ($\Delta R = R_{app} - R_{dis}$) is determined by the kinetic energy of dispersed drops. This energy is consumed for drops lifting, their secondary crushing as a result of drops collision with apparatus walls and formation of secondary drip flow. Using the results of our previous investigations [4] we determined the optimum ratio $R_{dis} \approx 0.2R_{app}$ for $R_{dis} \leq 650$ mm.

It is known that jet of sprayed liquid contains drops of various diameters; hence dispersibility is one of the process main factors. Average diameter d_d is incomplete characteristics of dispersibility but it may be used for approximated estimation of the process in HABD volume.

In view of spraying process complicity and absence of universal theory for its description, dispersed characteristics of the process are determined by empirical approach [7-9]. Therefore Lastovtsev's formula [7] was used to calculate diameter of drops formed during perforated shells rotation:

$$d_d = 81 \cdot \frac{s_l^{0.46} \cdot d_l^{0.46} \cdot m_l^{0.08}}{n_l \cdot r_l^{0.54}} \quad (12)$$

where s_l – coefficient of surface tension, N/m; d_l – film thickness of dispersed liquid, m; m_l – dynamic coefficient of liquid viscosity, Pa·s; r_l – liquid density, kg/m^3;n_l – linear rate of liquid at the moment of detachment from disperser ends, m/s.

In the first approximation, without taking into account the medium aerodynamic resistance, the linear rate of liquid is equal to the linear rates of disperser ends and drop rate ($n_l = n_{dis} = n_d$).

For bucket-like disperser the thickness of liquid film is determined as width of the jet formed as a result of liquid passing through a disperser split. Due to contraction the cross-section area of the jet (f_j) is less than the area of disperser split hole (f_s).

The contraction coefficient j is determined as the ratio between jet cross-section and disperser split area:

$$j = \frac{f_j}{f_s} \quad (13)$$

For rectangular split of the bucket-like disperser $f_s = a \cdot b$, where a – split width, m; b – split length, m.

Then the film width is:

$$d_f = \frac{f_s \cdot j}{b} = \frac{a \cdot b \cdot j}{b} = a \cdot j \quad (14)$$

The contraction coefficient is a function of Reynolds number and depends on hydrodynamic regime of liquid flowed out of the hole:

$$\mathrm{Re}_{eq} = \frac{r_l \cdot n_d \cdot d_{eq}}{m_l} \quad (15)$$

where d_{eq} – equivalent diameter of the hole, m.

$$d_{eq} = \frac{4 \cdot S}{P} \quad (16)$$

where S – hole area, m^2; P – hole perimeter, m.

For calculations the dependence $j = f(\mathrm{Re}_{eq})$ [10] was used.

During the drop movement its deformation and destruction may take place under the influence of gas resistance. Aerodynamic effect of gas on drop stability is estimated according to Weber criterion $\left(We = \frac{r_g \cdot n_d^2 \cdot d_d}{2 \cdot s_l}\right)$ [11]. The drops are destructed under the condition that Weber criterion exceeds the critical value. However in later publications [12] it is shown that Weber criterion depends on other criteria, in particular on drop stability criterion G and Re. It is proposed to use We_{cr} according to Eq. (17):

$$We_{cr} = \frac{1}{2}\mathrm{Re}^2 \cdot \left(\frac{m_g}{m_l}\right)^2 \cdot \frac{r_l}{r_g} \cdot \Gamma \tag{17}$$

where $\Gamma = \dfrac{m_l^2}{s_l \cdot r_l \cdot d_d}$; $\mathrm{Re} = \dfrac{r_g \cdot n_d \cdot d_d}{m_g}$; m_g – dynamic coefficient of gas viscosity, Pa·s.

Simple spontaneous division of drop by 2–4 parts occurs under following conditions:

$$4 \le We_{cr} \le 20,\ 0.1 \le We \cdot \mathrm{Re}^{-0,5} \le 0.8$$

The coefficient of particles trapping h_t is determined *via* the mechanism of aerosol particles sedimentation on the drop. For mobile drop the inertial trapping mechanism plays the key role. As a result of drop movement the dust particles are trapped by drop surface under inertia. The efficiency of inertial trapping h_i is a function of Stokes' criterion characterizing the ratio between inertia of dust particles and medium resistance:

$$Stk = \frac{r_p \cdot d_p^2 \cdot n_d \cdot C_k}{18 \cdot m_g \cdot d_d} \tag{18}$$

where r_p – density of dust particle, kg/m^3; d_p – diameter of dust particle, m; C_k – Kanninhem-Milliken correlation including mobility of fine particles (0.1–2·10^{-6} m), the size of which is comparable with the free path length of gas molecules.

$$C_k = 1 + \frac{2 \cdot l}{d_p}\left[1.257 + 0.4 \cdot \exp\left(-\frac{1.1 \cdot d_p}{2 \cdot l}\right)\right] \tag{19}$$

where l – the free path length of gas molecules, m.

Under normal conditions the free path length of air molecules is 6.08·10^{-8} m.

For other temperatures and atmospheric pressure the free path length of air molecules is calculated according to Eq. (20) [5]:

$$l_T = l_{norm.}\frac{(273 + A) \cdot T}{(T + A) \cdot 273} \tag{20}$$

where T – air temperature, K; A – constant depending on gas nature, for the air A = 124.

There is a minimum, so called critical value of Stokes' number Stk_{cr}, under which the inertial forces of the particle are capable to overcome medium resistance and the particle is trapped by the drop. Thus the inertial trapping is possible only under the condition $Stk > Stk_{cr}$. Moreover, the inertial trapping depends on regime of the gas flow motion which is characterized by Reynolds number. Therefore, different formulas are used for different regimes. The coefficient of trapping for turbulent regime is [12]:

$$h_{Stk}^{turb.} = \frac{Stk^2}{(Stk + 0.5)^2};\ Stk_{cr} = 0.0417 \tag{21}$$

Trapping may take place *via* mechanism of straight linking. If we neglect the inertial effects we may consider that dust particles move only along gas flow motion. In such a case the sedimentation of dust particles on the drop surface takes place not only if their motion paths are crossed but at the distance of radius of dust particle touched to the drop. The determinative parameter of the linking coefficient increment is the ratio (22):

$$c = \frac{r_p}{r_d} \tag{22}$$

where r_p and r_d – radii of dust particle and drop, respectively.

The linking coefficient increment due to the straight linking effect is calculated under two limited conditions: $Stk \to \infty$, *i.e.* inertia of the dust particles is so high that they move only in straight lines; $Stk \to 0$, *i.e.* they move linearly along gas flow motion. Thus, for the case of flow spherical drop the value h_c is between 2χ and 3χ, then:

$$h_c \approx \frac{2+3}{2}c = 2.5 \cdot c \tag{23}$$

The effect of straight linking is obvious if dust particles are accumulated on the drops with little diameter. Moreover, it does not depend on gas rate but on gas flow regime [5].

These two mechanisms are determinative for dust particles trapped in HABD; hence other mechanisms are of minor importance and may be neglected. So, the general trapping efficiency may be calculated according to Eq. (24):

$$h_t = 1 - (1 - h_{Stk})(1 - h_c) \tag{24}$$

For polydispersed dust the general coefficient is:

$$h_t' = \frac{h_{t_1} \cdot F_1}{100} + \frac{h_{t_2} \cdot F_2}{100} + ... + \frac{h_{t_n} \cdot F_n}{100}, \tag{25}$$

where F_n – content of definite fraction, %

2.2. Calculations

One can see from above-mentioned equations that efficiency of gas wet cleaning is determined by physical and dynamical characteristics of the system gas–liquid–solid (G-L-S) components. Taking into account that the process takes place under constant pressure, the temperature is the main factor and relative rate of phases movement is equal to the rate of drops movement. Therefore we investigated the effect of mentioned parameters on the system characteristics and efficiency of dust trapping.

The definite temperature and averaged gas composition for ovens at the production of color ferrum oxide pigments [1] are represented in Table 1.

Table 1

Averaged temperature and gas composition of burning stage at the production of red ferrum oxide pigments

Waste gases temperature, K	Waste gases composition			
	N_2, vol %	H_2O, vol %	O_2, vol %	CO_2, vol %
673	63.9	21.4	11.4	3.3

Table 2

Physical properties of the system components depending on temperatures

Temperature, K	Liquid phase			Gas phase		Solid phase
	ρ_l, kg/m^3	$\mu_l \cdot 10^4$, Pa·s	$\sigma_l \cdot 10^2$, N/m	ρ_g, kg/m^3	$\mu_g \cdot 10^6$, Pa·s	ρ_s, kg/m^3
283	999.45	13.314	7.420	1.165	14.754	5250
293	997.68	10.258	7.270	1.133	15.168	5250
303	995.19	8.142	7.114	1.101	15.582	5250
313	991.98	6.638	6.952	1.069	15.996	5250
323	988.06	5.538	6.784	1.037	16.410	5250
333	983.41	4.713	6.610	1.005	16.824	5250
343	978.04	4.079	6.430	0.973	17.239	5250

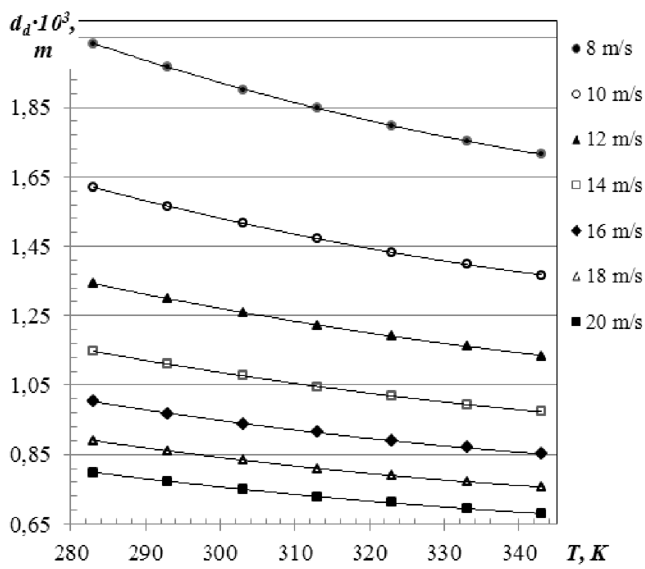

Fig. 2. Dependence of drop average diameter (d_d) on temperature (T)

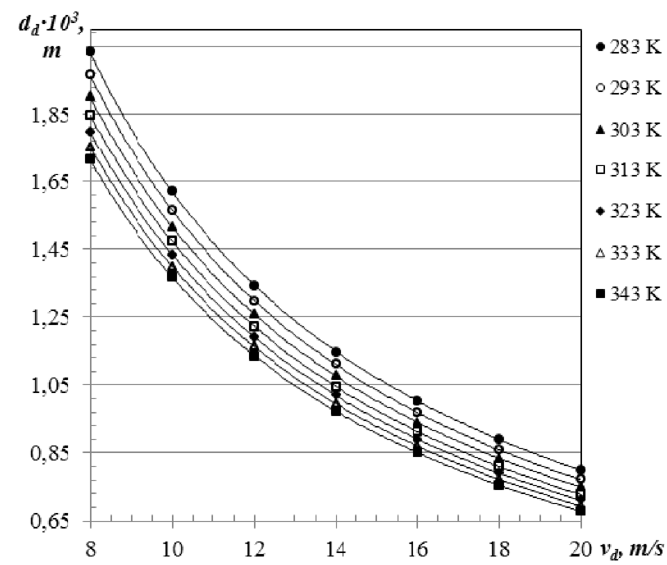

Fig. 3. Dependence of drop average diameter (d_d) on linear rate of disperser ends (n_d)

The maximum temperature in a wet cleaning apparatus is determined by the temperature of wet thermometer. For given gas composition (Table 1), at definite initial temperature and average moisture content $x_{H_2O} = \frac{21.4 \cdot 10 \cdot 18}{22.4} = 172$ g/m^3 the calculated temperature of wet thermometer was found to be 343 K.

Several dispersers may be located on HABD shaft; thus the apparatus operation is similar to the model cascade of the reactor: the process is isothermal inside the sprinkling section and generally in the apparatus – polythermal and counterflow. It is the reason for variability of gas and liquid phase parameters within a wide temperature range of 283–343 K.

The values of physical properties of the system components were chosen from [13]. Gas density for every temperature is calculated as an additive value

$$r_g = \sum_{i=1}^{n} r_i \cdot w_i \tag{26}$$

and dynamic viscosity – according to the formula (27):

$$m_g = \frac{\sum_{i=1}^{n} w_i \cdot m_i \sqrt{M_i \cdot T_{cr}^i}}{\sum_{i=1}^{n} w_i \cdot \sqrt{M_i \cdot T_{cr}^i}} \tag{27}$$

where w_i – volumetric part of the gas mixture component, part of unity; M_i – molecular mass of the gas mixture component, g/mol; T^i_{cr} – critical temperature of the gas mixture component, K [14]. Referenced and calculated values of physical properties of the system components are represented in Table 2 depending on temperature.

The average diameter of drops formed during operation of bucket-like disperser is calculated according to the formula (12) within the wide temperature range of 283–343 K and range of rates 8–20 m/s. The obtained results are represented by plots (Figs. 2 and 3).

In all cases the increase in linear rate of disperser ends decreases the average diameter of drops. The decrease in drop diameter with increasing temperature is caused by sharp decrease in viscosity and surface tension of water, as well as by minor change of density.

Within the investigated range of temperatures and rates the Weber criterion calculated according to Eq. (17) is $0.83 \le We_{cr} \le 2.51$, and criteria product is $0.029 \le We \cdot \mathrm{Re}^{-0.5} \le 0.074$. It means that *We* value does not exceed the critical value and the drop will not be crushed during its motion under the influence of gas aerodynamic resistance; thus its average diameter is constant.

In accordance with literature data [15] the averaged dispersed composition of the dust from burning ovens for the production of red ferrum oxide pigment is as follows (Table 3).

The calculated values of Kanninhem-Milliken correlation (Eqs. (19) and (20)) within investigated temperature range for the dust of above-mentioned composition are represented in Table 4.

The dependence of trapping efficiency on temperature and rate of drop movement is given by plots (Figs. 4 and 5). The temperature practically does not affect the general coefficient of dust trapping. The reason is minor increase in gas viscosity compensated by the increase in Kanninhem-Milliken correlation. Therefore the general Stokes' criterion is actually constant (Eq. (18)). While increasing the rate of drops movement the value of *Stk* increases as a result of not only drops acceleration but decrease of their diameters as well (Fig. 3).

Thus, to intensify the process it is necessary to increase the rate of drops movement and decrease their sizes. However, fine drops cause technological problems with their trapping. Therefore, the recommended size of drops at gas wet cleaning is $0.8–1\cdot10^{-3}$ m [6]. Taking into account the secondary crushing occurring when drops impact the apparatus walls and results of the previous studies [4], the drop rate of 10–12 m/s is technologically advisable.

To determine the effect of specific flow rate $\left(\frac{W_l}{W_g}\right)$ on degree of dust trapping we accepted the following sizes of HABD, m: $R_{dis} = 0.6$; $R_{app} = R_{dis}/0.2 = 3$; $b = 0.03$.

Table 3

Averaged dispersed composition of the dust from burning ovens for the production of red ferrum oxide pigment

$d_p\cdot10^6$	50–40	40–25	25–16	16–10	10–6.3	6.3–4	4–2.5	2.5–0.1
%	7	18	25	20	13	8	5	4

Table 4

Kanninhem-Milliken correlations for the dust from burning ovens for the production of red ferrum oxide pigment

T, K	$d_p\cdot10^6$, m								
	50	40	25	16	10	6.3	4	2.5	0.1
283	1.003	1.004	1.006	1.010	1.015	1.025	1.039	1.062	2.747
293	1.003	1.004	1.006	1.010	1.016	1.025	1.039	1.062	2.767
303	1.003	1.004	1.006	1.010	1.016	1.025	1.039	1.063	2.786
313	1.003	1.004	1.006	1.010	1.016	1.025	1.040	1.064	2.804
323	1.003	1.004	1.006	1.010	1.016	1.025	1.040	1.064	2.823
333	1.003	1.004	1.006	1.010	1.016	1.026	1.040	1.065	2.839
343	1.003	1.004	1.007	1.010	1.016	1.026	1.041	1.065	2.854

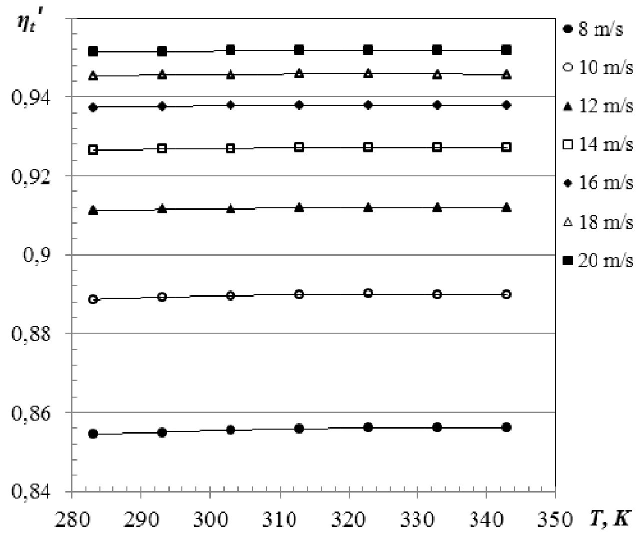

Fig. 4. Dependence of trapping efficiency (h'_t) on temperature (T)

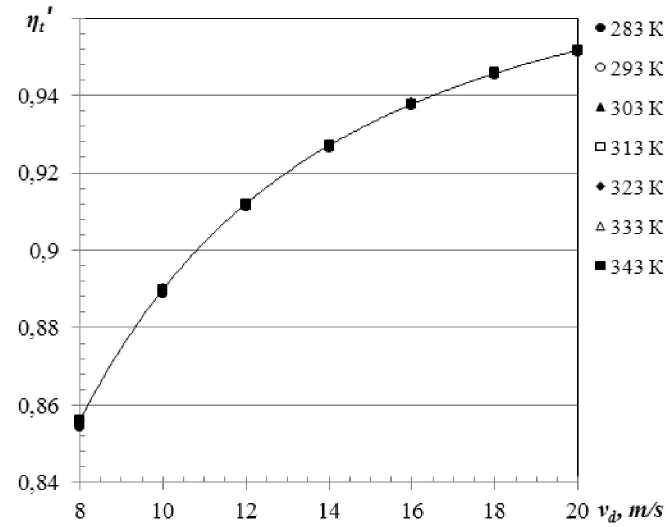

Fig. 5. Dependence of trapping efficiency (h'_t) on rate of drops movement (n_d)

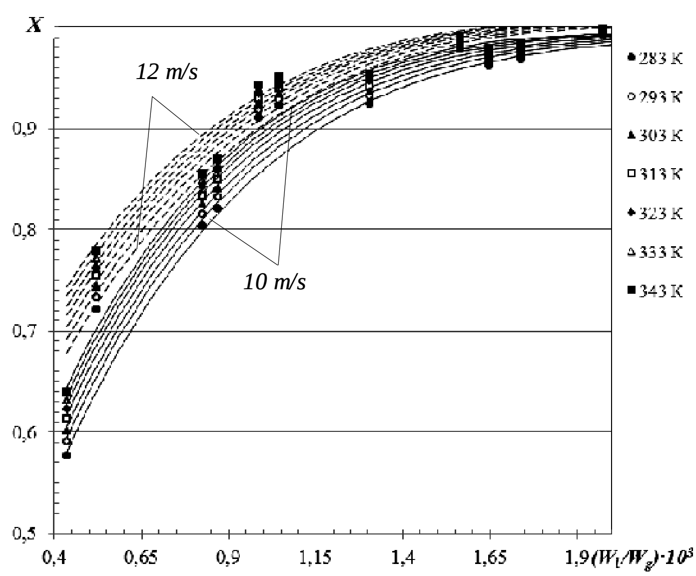

Fig. 6. Dependence of trapping efficiency (X) on specific flow rate $\left(\dfrac{W_l}{W_g}\right)$

Productivity of two-bucket disperser (W_l) is determined according to Eq. (28):

$$W_l = \frac{n \cdot 2 \cdot 286.5 \cdot b \cdot n_{dis} \cdot h^{0.9}}{3600} \tag{28}$$

where n – number of dispersers, pieces; v_{dis} – linear rate of disperser ends, m/s ($v_{dis} = v_d$); h –depth of disperser immersion, m [4].

Gas volumetric rate (W_g, m^3/s) is calculated as follows: optimum rate of gas movement in HABD v_g = 0.8–1.5 m/s; cross-section of the apparatus is a part of the circle, the square of which is calculated according to: $S = 0.4 \cdot p \cdot R_{app}^{\ 2}$, m^2; then $W_g = v_g \cdot S$. The calculations were carried out for the rates of drops movement of 10 and 12 m/s.

The dependence of trapping efficiency (X) on specific flow rate is represented in Fig. 6. The increase in specific rate of water naturally increases the degree of dust trapping. Within the investigated range of temperatures and rates, at $\dfrac{W_l}{W_g} \geq 2 \cdot 10^{-3} \dfrac{m^3}{m^3}$ the degree of trapping approximates to one (100 %). Such intensity of sprinkling may be provided by 4-5 bucket-like dispersers with above-mentioned sizes.

3. Conclusions

On the basis of theoretical analysis of HABD operation we derived the mathematical dependencies which allow to calculate the main technological parameters of dust trapping process.

The high efficiency of described mass-transfer apparatus is exhibited at drop rates of 10–12 m/s and specific flow rate of $\frac{W_l}{W_g} \geq 2 \cdot 10^{-3} \frac{m^3}{m^3}$. This is confirmed by the calculations of dust trapping parameters for waste gases obtained at the production of red ferrumoxide pigment.

While deriving the mathematical dependencies a series of assumptions was adopted, therefore it is advisable to carry out additional experiments allowing to make the theoretical results more precise.

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ТЕОРЕТИЧНИЙ АНАЛІЗ ЕФЕКТИВНОСТІ ГОРИЗОНТАЛЬНОГО МАСООБМІННОГО АПАРАТА З КОВШОПОДІБНИМИ ДИСПЕРГАТОРАМИ У СИСТЕМАХ ПИЛОВЛОВЛЕННЯ

Анотація. *Теоретично обґрунтовано ефективність горизонтального масообмінного апарата з ковшоподібними диспергаторами для очищення промислових викидних газів від пилу. Виведено математичні залежності для розрахунку головних технологічних показників. Розраховано показники очищення запиленого газу виробництва червоного ферумоксидного пігмента. Встановлено технологічно доцільний режим роботи масообмінного апарата.*

Ключові слова: *пиловловлення, масообмінний апарат.*