Modeling of cleaning of dust emission' in fluidized bed building aspiration' collector

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Abstract. This article describes one of the modern way to reduce dust emissions of pollutions exhausting into the atmosphere at expanded clay aggregates and other similar building materials manufactures applying filtering fluidized granular particulate material bed' separator with low degree of dust leakage out from one. There is presented quasi-diffusion model featuring of process of cleaning of industrial emissions of dust in devices of tray type with the fluidized and weighted bed. There considered case of variable coefficient of longitudinal hashing intermixing within trough tray type separator in this article. It was made attempt to get meanings value of leakage' degree dust out from separator. It was obtain in an implicit form. It was obtained and announced some results of the carried-out analysis are intended to get high efficiency of dust removal set up installations to clean emissions of aspiration scheme of the air environmental protection in production of bulk dispersed materials building construction industry.

1 Introduction

The efficient use of heat and energy resources, including secondary one's, is very relevant today and contributes to the innovative development of the country's economy. Modernization and further improvement of industrial, building construction complex are important tasks of national innovative development of Russia. The cost of all kinds of resources (natural and secondary) is being rising in present time. Cost-effective development and achievement of efficient use of recyclable and secondary thermal potential are the main problems in the industry and the building construction complex [1]. Some of the ways of these problems' solutions are development heat-saving technologies and equipment including heat exchangers effectively using the secondary heat resources' potential at the building construction enterprises also [1].

Building construction industry adds negative contribution in environment pollution by dust emissions of aspiration schemes. The most of building manufactures are situated close to urban areas or within one with high density of human inhabitance. High level of dust pollution of urban atmosphere makes necessary to reduce negative influence of dust

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emissions. One of the real solutions of this problem could be the use of high effective decreasing dust systems promising methods and devices that could be equipped by separators with filter and fluidized bed dispersed materials [2-5]. The significant part of these gases emissions of aspiration schemes is rather hot. It is very attractive to use these devices for combine treatment of aspiration gases. There could purify gases emissions form dust and use thermal potential one's simultaneously in these devices. It's could achieve combine processes by aerodynamic fluidic conditions in the fluidized bed devices. In these cases values *w* of fluidization' number should be less than 1.5 [5-8]. It's be provided by usage of special construction of gas spread grids inside the fluidized bed devices too [7-9]. Special spread grids design allow to get rather acceptable low leakage of fine dust particles during the separation process and significant intensive heat transfer inside the filter and fluidized bed devices simultaneously [4, 5, 9, 10]. Such special design constructive solutions is provided aerodynamic work's to get relatively small average gas medium average velocity's volumes and reliable acceptable work circulation of filtering and fluidizing bed's granular particulate materials near walls of spread grid [8, 9].

Analysis of published data also shows that the research is being conducted by the description of various processes in fluidized beds are paid attention by numerous authors.

One of the intermediate stages of the production process of the bricks is drying particulate granular materials in a fluidized bed apparatus [11]. It was noted that the expediency of further research and development and devices decreasing waste and emissions of pollutions are actual for processes manufacturing bricks.

The article [12] gives an overview of research and literature, developing the mechanistic model representations drying moist granules in fluidized beds. There was mention that for the descriptions of the drying of moist granules in fluidized beds apparatuses may be applied different including latest numerical calculating flows hydrodynamics methods (CFD) for modeling a process in the article [12]. Description drying granules in the fluidized bed depends substantially from the geometric configuration and design of the dryer, the gas distribution grid, gas velocity, particle characteristics and etc.

It were published numerous articles with results of research of heat and mass transfer in fluidized beds apparatus in the scientific literature. Analysis of one's get reveal out the most popular methods that are being contained in the description of the different processes in a filtering and fluidized beds of solid particulate materials. The most part of experimental results and computing simulation methods of description of dust separation in filtering and fluidized layers based on numerical CFD modeling methods, for example, [13-15]. There is presented results of the study the of collection efficiency of dust particles in medium filtering and fluidized bed cleaners and the application one's in the [13]. It was proposed and studied a new control method for preparing a low-ash coal to obtain stability, that allowed to reduce fluidized bed' density fluctuation and uniformity effectively [13].

There were presented the results of research moving light fluidized bed of granular particulate material to clean up hot gas exhausting by systems in advanced power stations in [14]. There was presented the way to the development of the particulate collection in moving bed devices in this article.

There was shown the results of research of wet dry separation technology in device with air dense medium fluidized bed in article [15]. It was described systems for the dry separation of fine coal consisting of a magnetically fluidized bed and enhances the separation efficiency by preventing remixing of the feedstock.

In the description of patent [16] were presented the apparatus and method for separating particles differing in density materials and for separation of a material containing dust or other impurities. It was described combining the scrubber and fluidized bed apparatus using for separating unwanted organic particles (coal, other impurities) during processing in [16].

One of the most promising ways is applying fluidized beds with solid particulate granular materials for intensification' purposes of heat transfer within heat exchangers, for instance, in [17-21].

There was presented the study results of heat exchange for freeze concentration in a liquid–solid in fluidized bed in heat exchangers in the article [17, 18]. Freeze concentration is studied inside a fluidized bed heat exchanger [17]. The studied kind of heat exchanger can be used to freeze concentrate NaCl liquids more cost-effectively, cheaper than scraped surface heat exchanger at stable conditions within the range of tested parameters. The evaluation of parameters of the investigated heat exchanger showed the feasibility and profitability of its use in stable working conditions in comparison with the conventional surface heat exchanger device in the range of tested parameters [18]. It is also observed that the fluidized bed particles are capable of removing deposits from the walls and prevent contamination of the heat exchangers. Also it noted that sufficiently facilitates scaling these devices [18].

There was presented the results of piezoelectric measurements of impacts on the wall in both stationary and circulating fluidized beds of various particle sizes [19]. This paper presents two types of impacts were measured, namely by collisions of fluidized particles in liquid–solid fluidized bed heat exchangers are able to remove from the walls one's. It was determined working conditions to prevent fouling or scaling and to get stable within the range of tested parameters in [19].

There was shown the experimental study of a continuous gas-solid fluidized bed with an immersed tube where cold water is heated by fluidized solid particles presenting inlet temperature from 450 to 700°C in the article [20]. It was studied the influence of different equivalent dimension's size solid particle of some materials and flow rate and distance between baffles immersed in a shallow fluidized bed in this work. The results showed that heat transfer coefficient increases with the solid particle mass flow rate and with the presence of baffles, suggesting that these are the most important factors to be considered in the design of such heat exchanger.

There was announced the result of research of circulating solid particles' effects on the characteristics of fluid flow and heat transfer in the fluidized bed vertical shell and tube type heat exchanger with counter flow in the article [21]. It was showed that the flow velocity range for collision of particles to the tube wall was higher with heavier density solid particles, and the increases in heat transfer was in the order of sand, copper, steel, aluminium, and glass in [21].

Production of artificial powder and granular building materials for multipurpose gravel concrete is one of the huge and fast increasing volumes of the construction industry. There produce and maintain numerous kinds of these powder and granular building materials, for example, gypsum-containing, calcium sodium, cement and sand building mixes, expanded clay gravel and so on are fast increasing volumes of the construction industry not only in Russia, but in the world too [22, 23]. World demand for cement will grow up about 4.5% of volume per year or 5.2 million tons per year. There is a significant increase in production cement component in 8% in a present time, and it run up to 9% per year about per year till to 2020 in many developing countries in Asia, the Pacific region, including, for example, in India and Russia [22, 23]. The increasingly growing production volumes of bulk building materials further increase the level, respectively at least, atmospheric dust pollution in cities.

A fulfilled review of some of the rather insignificant part of technical literature sources was pointed of the actuality and urgency of further both basic and applied research in the field of technical processes and heat exchange devices in fluidized beds. The essential differences and limitations in the ranges of working conditions for so different and tested parameters of process' devices don't allow use mention above results of researches universally.

Theoretical methods have a more great advantages and degrees of universality and flexibility. Experimental studies conducted earlier showed that there is an essential need for the development of theoretical concepts and describing the modeling of dust separating process, for instance [4, 5, 8]. One of promising research ways of dust capturing process is methods of computational flow hydrodynamics (CFD), for instant [24, 25].

Modeling heat and mass transfer in fluidized and filtering-weighted beds of granular and dispersed material is also relevant in the present time still in demand and focus of theoretical and experimental researches, for example, [2- 5, 8, 11-15, 17-21, 26-28].

It is very attractive to develop and elaborate new apparatuses to allow fulfilling dust separation and heat exchange in fluidized beds simultaneously both. At fist the use of such devices can reduce exhausting dust from the emission control systems of aspiration schemes and the mass amount of industrial waste also. It is becomes more attractive and feasible to carry out when collected dusts may return with a layer of grains, granules of the materials in the production cycle. At second implantation of such devices provide the solution effective use of low thermal potential heat resources' at the building construction enterprises. So that heat-saving technologies and equipment including heat exchangers correlates and responds innovative demand [1] and increase ecological safety building construction industry by decreasing exhaust dust emission into the atmosphere [2, 5 ,8].

2 Materials and Methods

This article describes one of the modern way to reduce dust emissions of pollutions exhausting into the atmosphere at expanded clay aggregates and other similar building materials manufactures applying filtering fluidized granular particulate material bed' separator with low degree of dust leakage out from one.

Feature production the of powder and granular mixture bulk building materials are containing with gypsum-containing, calcium sodium, cement, concrete, expanded clay gravel sand and etc that treat drying and heat-thermal technological processes. There are supplied dust cutting systems of capturing–collecting devices in the local exhaust ventilation' schemes that eject and remove hot gases with significant volume of solid powder secretions from those of technological sources. They are kilns, ovens and dryers and etc. Some of the most effective resources of collective protection of personal staff are aspiration schemes in labor safety protection system at building industry

It should be design special dust collectors with high separation efficiency to provide small quantities exhausting leakage of dust particles' emission throughout one's into the atmosphere. The applying of new modifications of these devices in the dust purification systems of aspiration schemes that eject powder and gas flows out of the various equipment are located at the cement and aggregate concrete plants, manufacturing gypsum-containing mixtures, concrete and sand building mixes factories, and other branches of industry could reduce negative human impacts in the atmosphere and the environment in general both.

The usage of multi-functional combination of devices that combine several of simultaneous processes: dust removal, heat and mass transfer processes in a fluidized bed of dispersed materials are the one of the way to intensify heat and mass transfer processes. This the fluidized bed processes method is applied for drying of substandard solid, granular, etc. materials and bulk dispersed wastes in the construction industry when the humidity is high to allow to cut dust emissions in an atmosphere simultaneously. Thus special engineering solutions of this device' construction [9, 10, 29] allow to achieve hydrodynamic regime ensures reliable operation by effectively utilizing the thermal capacity of the drying agent

could be increase environmental safety at the same time. The appearance of this new device' construction proposes their research, modeling development.
It should be noted that the numerical simulation of processes in a fluidized bed is associated with a number of difficulties. The one of them is the precision control of numerous parameters and the use of adoptive modeling programs. In fact these circumstances and problems lead to the development of computing programs and elaboration of new complex software systems. Also accuracy of calculating results that receive by these computing methods isn't acceptable today and formulized procedures are difficult too. One of the basic methods of research is a combination of the theoretical and computing modeling based, as a rule, on experimental determination of the characteristics of the devices.
The dust collectors can be trough tray type, or the cylindrical shape with a circular - round cross-section of body. Thus first trough tray cross-section square form kind of possess' devices have a several of advantages in comparison with the circular - round shape in cross-section one. One of them is that a degree of intermixing materials in the trough tray beds in the longitudinal direction significantly lower than in circular shape one [3, 4, 8]. The kind of trough tray type was accepted for study and desings.
There is presented quasi-diffusion model featuring of process of cleaning of industrial emissions of dust in proposed devices of tray type with the fluidized and weighted bed. In were used standard mathematical procedures' methods to analyze and summarize. It was formulized system of differential equations of the second order' partial derivatives that describing the process within studied device. It was and received the solution one for the case when quasi-diffusion longitudinal intermixing coefficient D was accepted variable. There is used the experimental data [3, 4, 8] in proposed and announced model too.

3 Results

Description continuous particulate collecting process in the apparatus with the trough tray type fluidized and filtering - weighted bed through one-parameter models under constant quasi-diffusion longitudinal intermixing coefficient D is given in [2, 26, 27]. We now consider the particular dust decreasing emissions in the devices with fluidized and filtering - weighted beds, provided changes in this ratio.
We divide the length of the apparatus into three sections $|x| \in [0;\delta]$, $|x| \in [\delta;\ L-\delta]$ and $|x| \in [L-\delta; L]$, where the ratio varies $D=var$

$$D = \frac{Dx}{\delta}, |x| \in [0;\delta] \qquad D = const, |x| \in [\delta;\ L-\delta] \qquad D = \frac{D(L-x)}{\delta}, \; |x| \in [L-\delta; L].$$

The linear velocity v of the material will vary over the length of the apparatus as a result of admission to the unit volume of additional material equal to the volume collected dust V_c = const per 1 longitudinal m of collector. The reasons of changing bed' volume along trough tray type are uniform assuming V_c capturing is the part of volume of particles dust to be clean V_p = const and removal (V_{out} = const) of material' dust within the bed that is distributed evenly along the length of the dust collector. It is possible for the simplification to accept, for example, on the specific volume of particles dust to be clean per 1 longitudinal 1 m of unit V_p = const. This volumes of dust are connected between themselves: $V_{out} = \zeta V_p$, $V_c = (1-\zeta)V_p$, where: ζ – value of leakage' degree dust out from separator. It characterizes amount particles of the material that assuming capturing in the filtering-weighted bed of separator.
The scheme of trough tray type device for heat and mass transfer, capturing gust processes in fluidized and filtering - weighted beds of dispersed materials is shown in fig.1.

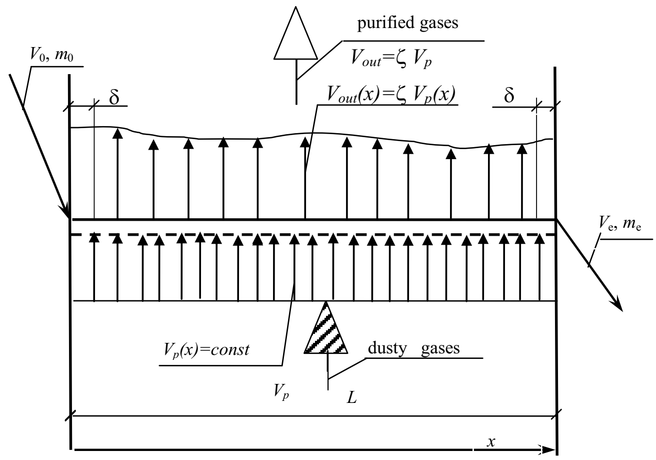

Fig. 1. The plot of motion granulated particulate material, purified and dusty gas flows (drying agent) in a longitudinal section trough tray type device in a fluidized bed' dust separator

We obtain a system of equations describing the process of changing amount mass bed' material along trough tray type using quasi-diffusion model in a general case ($m_0 \neq 0$).

$$\begin{cases} \frac{D}{\delta} x \frac{d^2 m_1}{dx_2} + \left(\frac{D}{\delta} - (\alpha + \beta x)\right) \frac{dm_1}{dx} - k m_1 = -\beta(1 - m_0), D = \frac{Dx}{\delta}, |x| \in [0; \delta] \\ D \frac{d^2 m_2}{dx^2} - (\alpha + \beta x) \frac{dm_2}{dx} - k\, m_2 = -\beta(1 - m_0), D = const, |x| \in [\delta; L - \delta] \\ \frac{D}{\delta}(L - x) \frac{d^2 m_3}{dx^2} - \left(\frac{D}{\delta} + \alpha + \beta x\right) \frac{dm_3}{dx} - k\, m_3 = -\beta(1 - m_0), D = \frac{D(L - x)}{\delta}. \\ |x| \in [L - \delta; L] \end{cases} \quad (1)$$

where: m_1, m_2, m_3 - mass (volume) growth rate of the pellets of the material layer filtering and weighted at respective sections (segments) in the filtering-weighted bed of separator; ε_0 - the initial porosity of the fluidized bed material (porosity of the peripheral dense layer) $\varepsilon_0 = 0{,}40$ value of initial porosity of filtering-weighted and fluidized bed [30]; ε_b - experimentally or theoretically determined average value of porosity filtering-weighted and fluidized bed, $\varepsilon_b = 0{,}42 - 0{,}45$ [30]; V_0 - the initial volume of the granular material fed to the filtering-weighted and fluidized bed apparatus; B, H - width and height of the filtering-weighted and fluidized bed in apparatus, m; k - linearly decreasing along the length of the device quasi kinetic separation' velocity of fluidized bed.

$$\alpha = \frac{(1 - \varepsilon_0)V_0}{(1 - \varepsilon_b)BH}; \qquad \beta = \frac{(1 - \varepsilon_0)V_p}{(1 - \varepsilon_b)BH}$$

Volumes of constant quasi-diffusion longitudinal intermixing coefficient D and volumes quasi kinetic separation' velocity k of fluidized bed that was approximate by linearly decreasing dependence along the length of the device was studied and determined for such kinds of apparatus in experiments [2, 3, 8]. The first and third equations of the system (1) are a type of Kummer's equation, and the second is kind equations of parabolic cylinder

(Weber's equation). Literary recommendations [31] lead to the following general form solutions of equations that write to standard versions.

$$\begin{cases} m_1 = C_1 \mathrm{M}(E, B, x\gamma) + C_2 U(E, B, \gamma x) - \dfrac{1 - m_0}{1 + (\mathrm{k}/\Lambda \mathrm{D}(1-\zeta)V_p)}; \\ m_2 = \exp\left(\dfrac{t}{2}\right)^2 \{C_3 U(A, t) + C_4 V(A, t)\} - \dfrac{1 - m_0}{1 + (k/\Lambda_1(1-\zeta)V_p)}; \\ m_3 = C_5 M\big(E, B, \gamma(L - x)\big) + C_6 U\big(E, B, \gamma(L - x)\big) - \dfrac{1 - m_0}{1 + (k/\Lambda_1(1-\zeta)V_p)}; \end{cases} \quad (2)$$

where $\gamma = \frac{D}{\delta\Lambda_1(1-\zeta)V_p}$; $\Lambda_1 = \Lambda D$; $\Lambda = \frac{1-\mathcal{E}_0}{(1-\mathcal{E}_b)BHt}$; $E = (\frac{k}{\left((1-\zeta)V_p\Lambda_1\right)}$;

$$B = \frac{1}{(1-\zeta)V_p}\left(\frac{D}{\delta\Lambda_1} - V_0\right); t = \Lambda(V_0 + (1-\zeta)V_p x)\sqrt{\Lambda(1-\zeta)V_p}$$

$$A = \left[\frac{(1-\zeta)V_p + (k/\Lambda D)}{(1-\zeta)V_p} - \frac{1}{2}\right].$$

where: V_p – value of specific dust assuming capturing per 1 m longitudinal length of tray separator, it was accepted is constant for the simplification V_p = const.

Boundary conditions to solution of the Cauchy task (problem) were formulized by Dankverts and most often used ones to describe the chemical-technological processes in devices (reactors) [8, 26, 27]

$$vm_o = vm|_{x=0} - D\frac{\partial m}{\partial x}\Big|_{x=0}; \quad \frac{dm}{dx}\Big|_{x=L} = 0 \quad (3)$$

In the case use three sections: $|x| \in [0; \delta]$, $|x| \in [\delta;\ L - \delta]$ and $|x| \in [L - \delta; L]$, where δ is area close to wall of apparatus that reflect damper wall effect. Changing volume of quasi-diffusion longitudinal intermixing coefficient *D* as reflect of damper wall effect varies *D=var* in mention above three sections. The flow of the mass concentration of the material in the bed *m* (*x*) in these sections along of length' apparatus *L* is changing too. The docking relations of the mass concentration' flow at the points (3) of have the form

$$\begin{gathered} v_1 m_0 = v_1 m_1|_{x=0} - D\frac{dm_1}{dx}\Big|_{x=0}, \quad m_1|_{x=\delta} = m_2|_{x=\delta}, \\ v_1 m_1|_{x=\delta} - D\frac{dm_1}{dx}\Big|_{x=\delta} = v_1 m_2|_{x=\delta} - D\frac{dm_2}{dx}\Big|_{x=\delta}, \\ m_2|_{x=(L-\delta)} = m_3|_{x=(L-\delta)} \\ v_2 m_2|_{x=(L-\delta)} - D\frac{dm_2}{dx}\Big|_{x=(L-\delta)} = v_2 m_3|_{x=(L-\delta)} - D\frac{dm_3}{dx}\Big|_{x=(L-\delta)}, \\ \frac{dm_3}{dx}\Big|_{x=L}. \end{gathered} \quad (4)$$

$$\begin{cases} M(E,B,O)C_1 + U(E,B,O)C_2 = (1-m_0)\left(\dfrac{1}{1+\left(\dfrac{k}{\Lambda D(1-\zeta)V_p}\right)} - 1\right) \\ M\,(E,B,\gamma,\delta)C_1 + U(E,B,\gamma,\delta)C_2 - exp\left(\dfrac{z_1}{2}\right)^2 U(A,z_1)C_3 - \\ -exp\left(\dfrac{z_1}{2}\right)^2 V(A,z_1)C_4 = 0 \\ M'(E,B,\gamma,\delta)\,C_1 + U'(E,B,\gamma,\delta)\,C_2 - exp\left(\dfrac{z_1}{2}\right)^2 \\ \left(A_1+\dfrac{1}{2}\right)V(A+1,z_1)C_3 - exp\left(\dfrac{z_1}{2}\right)^2 U(A+1,z_1)C_4 = 0 \\ exp\left(\dfrac{z_2}{2}\right)^2 (A+z_2)C_3 + exp\left(\dfrac{z_2}{2}\right)^2 V(A,z_2)C_4 - \\ U(E,B,(L-\delta)\gamma)C_6 = 0 \\ exp\left(\dfrac{z_1}{2}\right)^2\left(A+\dfrac{1}{2}\right)V(A+1,z_2)C_3 + exp\left(\dfrac{z_1}{2}\right)^2 U(A+1,z_2)C_4 + M(E,B,(L-\gamma)\gamma)C_5 - \\ -U'(E,B,(L-\gamma)\gamma)C_6 = 0 \end{cases} \quad (5)$$

where $z_1 = \left(V_0 + (1-\zeta)V_\text{p}\delta\right)\Lambda\sqrt{(1-\zeta)V_p\Lambda}$; $z_2 = \left(V_0 + \zeta(1-\zeta)V_p x\right)\sqrt{\Lambda(1-\zeta)V_p}$;
$M\,(E,B,\gamma,\delta), M(E,B,(L-\gamma)\gamma),\ M'(E,B,\gamma,\delta)$ – are Kummer's functions;
$U(E,B,O),\ U'(E,B,\gamma,\delta), U(A,z_1), V(A,z_1)$ – are Whittaker's functions; ζ – leakage' dust degree (factor) in separator.

System (5) allows determine integration' constants C_1 - C_6. The analytical form of the constants C_1 –C_6 form the solution of system (5) turns out bulky. It is not carried out for this reason. For practical calculations, numerical values of the constants are calculated by computer using standard software for solving linear equations. It is calculated the required value for leakage' dust degree ζ in separator using (5) for the accepted geometric parameters of the apparatus (*B, H, L*) and hydromechanical characteristic of the apparatus (quasi-diffusion longitudinal intermixing coefficient *D*) for the reliable aerodynamic regimes (gas velocity *w*). The calculation procedure is iterative and comprehensive. Leakage' dust degree ζ could to determine for the volume' velocity variation of moving dispersed materials in the separator *v* for massive of constant meanings mention above parameters.

4 Discussion

Research of proposed dust separator with a filtering fluidized bed of dispersed material using counter flow dynamics' methods is very difficult to fulfill. It requires special calculating program and a lot of precision operation including control and monitoring. To facilitate and simplify study ways was used theoretical approach.

One of definite advantage of trough tray cross-section square form of dust collectors is pronounced characteristic of intermixing materials in the fluidized beds in the longitudinal direction. It is considered that coefficient of dispersed materials' intermixing is constant. This parameter is variable in the longitudinal direction and physically is changed especially within close area's walls of dust collectors. Such contradictions and physical defect postulate of constancy coefficient of dispersed materials' intermixing could be eliminated by attempt to describe the process of dust separation applying variable meaning of it. It is rather important to consider influence of coefficient of dispersed materials' intermixing on leakage' degree throw out dust particles from dust separator and increasing of dust capturing coefficient in 5-7% at least.

The presented model allows defining influence and contribution coefficient of intermixing and calculating of featuring process of dust emissions cleaning of in proposed tray type devices with more accuracy. It was and received the solution for the case when quasi-diffusion longitudinal intermixing coefficient D was accepted variable in function' form.

Proposed separator with a filtering - fluidized dispersed clay bed was installed in cutting dust control systems. It allowed to decrease dust emissions of aspiration schemes vastly both.

5 Conclusions

Innovative development of the country's economy presupposes application high effective heat and mass transfer devices in building industry in our country widely. There was presented theoretical description for dust separation in the filtering-weighted bed of granular dispersed material trough tray type of separator by system equation' solution (5) based on quasi-diffusion model in this article. The solution (5) allows to get changing mass concentration capturing assuming dust particles at the end and along of length of the granular material's bed in the trough tray type separator in changing meaning of quasi-diffusion longitudinal intermixing coefficient D as reflect of damper wall effect varies $D=var$. It was yielded increasing of dust capturing coefficient in 5-7%. It was made attempt to get meanings value of leakage' degree dust out from separator ζ.

Present the results of theoretical research were used for design industrial pilot factory separator that were experienced and implemented at the one of concrete factories in Volgograd region. It is a real effective way to increase the environmental protection and labor safety using these proposed dust separators at the building manufacturing.

D – longitudinal coefficient quasi diffusion remixing particulate material in the tray' bed, m^2/s;
ζ - value of degree dust leakage out from dust separator;
V_p – specific volume of particles dust that is contained in the emissions aspiration' gases need to be clean per 1 longitudinal 1 m of the tray length of dust separator, $m^3/(m\ s)$;
V_0 - the initial volume of the granular material fed to the filtering-weighted and fluidized bed apparatus, m^3/s;
V_e - the final volume of the granular material discharged from the outlet of apparatus, m^3/s;
k - linearly decreasing along the length of the device quasi kinetic separation' velocity of fluidized bed, kg/s;
m_0 - the initial relative mass concentration capturing assuming of the granular material particles fed in the filtering-weighted bed of the of separator;
m_1, m_2, m_3 - relative mass concentration (mass volume) growth rate of the pellets of the material at respective sections (segments) in the filtering-weighted bed of separator, kg/kg;
m_e - the final relative mass concentration capturing assuming of the granular material particles fed in the filtering-weighted bed of the of separator;
v_1, v_2, v_3 – volume' velocity of the dispersed materials at respective sections (segments) in the filtering-weighted bed of separator, m/s;
ε_0 – value of initial porosity of filtering-weighted and fluidized bed;
ε_b – experimentally or theoretically determined average value of porosity filtering-weighted and fluidized bed;
B, H - width and height of the filtering-weighted and fluidized bed in apparatus, m.

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