TECHNOSPHERE SAFETY
ТЕХНОСФЕРНАЯ БЕЗОПАСНОСТЬ

UDC 504.05/06
https://doi.org/10.23947/2541-9129-2024-8-3-19-28

Original Empirical Research

Improving the Environmental Safety of Construction Industry Enterprises through the Use of Modern Dust Suppression Technologies

EDN: JDCNLX

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Abstract
Introduction. In the modern world, special attention is paid to the quality of atmospheric air. One of the major contributors to air pollution is the release of harmful substances, including solid particles from industrial activities. These particles can accumulate in high concentrations, making it difficult for even the most efficient (up to 95.0%) cleaning devices to keep up. That is why the development and improvement of highly efficient air purification devices from dust are very relevant. In this regard, as a scientific problem, the authors highlighted the need to improve engineering means of air purification from dust by separating the dispersed phase (dust particles) and the dispersion medium (air), which ultimately will lead to an increase in cleaning efficiency. The aim of this study is to improve the environmental safety of industrial sites of construction industry enterprises and adjacent residential areas by using highly effective means of air purification.
To achieve this goal, we have developed a physics and power-engineering concept and created a block diagram of a physical model for reducing air pollution from construction dust. We have also developed a highly efficient and economical device for hydrodynamic purification of ventilation air from poorly wetted clumping dust. The experiments were conducted to identify the real range of values of the efficiency of air purification from dust.
Materials and Methods. The research is based on methods of physical modeling, mathematical description, and statistical analysis of experimental data.
Results. As a result of the research, it was found that:
– the basis for the development of a highly efficient and economical air purification device from various types of construction dust could be based on the physics and power-engineering scientific concept proposed by the authors, describing the processes of pollution and reduction of air pollution;
– step-by-step consideration of the process of air pollution could be the basis for scientific justification and description of the process of air pollution reduction in the construction industry;
– based on the analysis of the process of the reduction of air pollution by various types of construction dust, it was possible to develop a block diagram of a physical model of this process;
– the study of the behavior and properties of dust aerosol and external force influences directed at it made it possible to outline the main directions, technologies and engineering means to increase the efficiency of the cleaning process and develop a highly efficient and economical device that implemented this process;
– to study the range of changes in the values of the efficiency of air purification from dust, a number of experimental studies were conducted in laboratory conditions.
Discussion and Conclusion. The studies conducted allowed us to determine that an increase in air purification efficiency from dust with a SiO_2 content of 20–70% was achieved in the device through a series of design modifications that enhanced wetting, bonding, and removal of particulate matter from the air. Simultaneously, high levels of integrated efficiency (96.5–98.7%) ensured the compliance with regulatory environmental standards for atmospheric surface air quality.

Keywords: environmental safety, dust suppression, air purification device, efficiency improvement

Acknowledgements. The authors would like to thank Head of the Industrial Safety Department, Dr. Sci. (Engeneering), Professor S.L. Pushenko for his assistance in organizing laboratory experiments.

For citation. Bespalov VI, Gurova OS. Improving the Environmental Safety of Construction Industry Enterprises through the Use of Modern Dust Suppression Technologies. *Safety of Technogenic and Natural Systems.* 2024;8(3):19–28. https://doi.org/10.23947/2541-9129-2024-8-3-19-28

Оригинальное эмпирическое исследование

Повышение экологической безопасности предприятий стройиндустрии на основе современной технологии пылеподавления

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Аннотация
Введение. В современном мире особое внимание уделяется качеству атмосферного воздуха. Одним из основных факторов негативного воздействия на атмосферу является выброс загрязняющих веществ, среди которых наиболее массово наблюдаются твердые (пылевые) частицы от промышленных источников. При высоких концентрациях пыли устройства очистки, даже обладая высокой эффективностью (до 95,0 %), не справляются с нагрузкой. Именно поэтому разработка и совершенствование высокоэффективных устройств очистки воздуха от пыли являются весьма актуальными. В связи с этим в качестве научной проблемы авторами выделена необходимость совершенствования инженерных средств очистки воздуха от пыли за счет разделения дисперсной фазы (пылевых частиц) и дисперсионной среды (воздуха), что в конечном счете приведет к повышению эффективности очистки. Целью данного исследования явилось повышение экологической безопасности территорий промышленных площадок предприятий стройиндустрии и прилегающих селитебных зон на основе применения упомянутых высокоэффективных средств очистки воздуха от пыли.
Для достижения поставленной цели авторами решены следующие задачи: применена физико-энергетическая концепция и разработана блок-схема физической модели процесса снижения загрязнения воздушной среды различными видами строительной пыли, разработано высокоэффективное и экономичное устройство гидродинамической очистки вентиляционного воздуха от плохо смачиваемой слипающейся пыли, проведены экспериментальные исследования для выявления реального диапазона значений эффективности очистки воздуха от пыли.
Материалы и методы. В основу исследований авторами положены методы физического моделирования, математического описания и статистической обработки экспериментальных данных.
Результаты исследования. В результате исследований установлено, что:
– в основу разработки высокоэффективного и экономичного устройства очистки воздуха от различных видов строительной пыли может быть положена предложенная авторами физико-энергетическая научная концепция, описывающая процессы загрязнения и снижения загрязнения воздушной среды;
– поэтапное рассмотрение процесса загрязнения воздушной среды может быть основой научного обоснования и описания процесса снижения загрязнения воздушной среды предприятий строительной индустрии;
– на основании выполненного анализа процесса снижения загрязнения воздушной среды различными видами строительной пыли возможна разработка блок-схемы физической модели этого процесса;
– изучение особенностей поведения и свойств пылевого аэрозоля и направленных на него внешних силовых воздействий дает возможность наметить основные направления, технологии и инженерные средства повышения эффективности процесса очистки и разработать высокоэффективное и экономичное устройство, реализующее этот процесс;
– для исследования диапазона изменения значений эффективности очистки воздуха от пыли проведен ряд экспериментальных исследований в лабораторных условиях.
Обсуждение и заключение. Выполненные исследования позволили установить, что повышение эффективности очистки воздуха от пыли с содержанием от 20 до 70 % SiO_2 обеспечивается в устройстве за счет ряда конструктивных изменений, приводящих к интенсификации смачивания, связывания и удаления из воздуха пылевых частиц. При этом высокие значения (96,5–98,7 %) интегральной эффективности обеспечивают нормативные экологические требования к качеству воздуха приземного слоя атмосферы.

Ключевые слова: экологическая безопасность, пылеподавление, устройство очистки воздуха, повышение эффективности

Благодарности. Авторы благодарят доктора технических наук, профессора, заведующего кафедрой «Производственная безопасность» С.Л. Пушенко за содействие в организации лабораторных экспериментов.

Для цитирования. Беспалов В.И., Гурова О.С. Повышение экологической безопасности предприятий стройиндустрии на основе современной технологии пылеподавления. *Безопасность природных и техногенных систем.* 2024;8(3):19–28. https://doi.org/10.23947/2541-9129-2024-8-3-19-28

Introduction. Currently, dry construction mixes are in high demand among various construction-related consumers. In particular, the production of highly dispersed binding materials such as gypsum, cement, tile adhesive, and facade adhesive occupies a special place [1, 2]. During the preparatory stage of production, raw materials such as clinker are sieved and crushed (ground) in accordance with standards. General manufacturing process of any dry building material includes filling with crushed raw materials, mixing different ingredients, and packaging the mixture. However, the specific technologies may vary depending on the recipe for the mixture, the initial product, the number and type of ingredients used, and the corresponding equipment.

From the perspective of ensuring the required environmental standards for dust particle content in the air at industrial sites of companies producing building materials and binders, the areas where the most intense dust formation occurs are during the crushing of raw materials [3]. It is during this process that the main types of construction dust are formed, including cement, gypsum, and sand, with SiO_2 content ranging from 20% to 70%, and with particle sizes primarily of PM2.5 and PM10. With subsequent release, this dust leads to an excess of MPC in the air of the working areas of construction industry enterprises and maximum single MPC (average daily MPC) in the air of the surface layer of the atmosphere of both at the industrial sites and in adjacent residential areas. The negative effects of this dust include its potential to enter the human body via the respiratory system, gastrointestinal tract, skin, and mucous membranes, causing various health problems. At the same time, it is the smallest particles, with sizes of PM2.5 and PM10 that pose the greatest danger [1, 4].

As a result, for the main types of industrial dust listed above, there is an excess of the corresponding MPC values by 5–25 times. This ranges from 10 to 300 milligrams per cubic meter (mg/m³) without the use of engineering dust suppression measures. This state of the air environment has a negative impact on employees of enterprises and the population in adjacent territories [5–7]. It should be noted that while the use of modern dust suppression devices, such as dust collection devices (exhaust hoods, umbrellas, etc.) effectively meet sanitary and hygiene requirements by removing dust from industrial premises, it also creates high concentrations of dust that even advanced air purification systems with high efficiency (up to 95.0%) cannot completely eliminate. Thus they do not ensure the compliance with environmental regulations. This is a scientific problem related to improving engineering methods for removing dust from air emitted into the atmosphere, with the aim of increasing the efficiency of dust removal (over 96.0%). Therefore, the goal of this research is to develop highly effective and modern technologies and tools for dust suppression in order to improve the environmental safety of construction industry sites and adjacent residential areas.

Materials and Methods. The study used an analytical method for studying accumulated experience in the scientific and technical field, as well as methods for constructing a physical model combined with a mathematical description of the resulting characteristics of this process. In addition, methods of statistical processing of the results of laboratory studies obtained by the authors and comparing them with the results of similar studies by other scientists were used.

At the same time, a device was selected as the object of research for purifying the air from dust emitted by construction industries, which is one of the main stages in the dust suppression process. The effectiveness of this process depended on the basic physical and chemical properties of the dispersed phase and the dispersion medium of the dust aerosol, as well as on external factors that could destroy it. The subject of the study was to improve the efficiency of air purification devices in order to ensure environmental safety in industrial sites and adjacent residential areas of construction enterprises.

The most suitable approach for the development of a device for purifying air from dust with a concentration of 20–70% SiO_2 was based on the use of the physical and energy concept [5]. This approach allowed for establishing physical connections between all components of the pollution reduction process, including dust aerosol, cleaning device, and external forces. It also allowed for outlining technologies to improve the efficiency of the cleaning process and developing the design of an effective air purification device for specific conditions and types of dust generated by construction industry enterprises.

Results. The development of a highly efficient and economical air purification device from construction dust was based on the physics and power engineering scientific approach proposed by the authors. This approach allowed us to describe the processes of pollution and air pollution reduction [5–7]. This concept was based on the consideration of the dispersed "pollutant" system, which changed the parameters of its state in the process of air pollution and passed from one quality (dust material) to another (dust aerosol) [5, 8]. Thus, when processing raw materials (construction materials) on technological equipment, the formation of dust particles and the formation of dust material was observed. Then the formed dust material was released into the air of production room and a dust aerosol was formed. And finally, the dust aerosol, spreading in the space of the production room, was released into the air of the surface layer of the atmosphere of the territories of industrial sites of construction industry enterprises and adjacent residential areas with subsequent dispersion.

At the same time, it should be noted that the stages of dust formation and internal release allowed dust particles to be returned to the initial technological material, which was advantageous from an environmental and economic perspective, but not always feasible in terms of the requirements of technological regulations. Other stages were associated with the aerosol state of dust, where dust particles were suspended in air and could not be easily separated from the aerosol for subsequent return to the technological raw material, or cause significant difficulties.

A step-by-step analysis of the air pollution process formed the basis for a scientific justification and description of how to reduce pollution from the considered types of dust in the air surrounding construction industry facilities. At the same time, there was a clear correlation between the stages of pollution reduction and the stages of atmospheric pollution [8, 9]:

– the first stage: binding of dust particles formed during the processing of raw materials on technological equipment;

– the second stage: detention of unbound dust particles in the area where processed raw materials weare located, including those formed within the internal volume of the production facility;

– the third stage: capture of dust aerosols released into the internal space of the production area in order to prevent the spread of dust particles within a designated limited area. Removal of these particles from the zone and transportation to a cleaning area;

– the fourth stage: purification of air (dispersion medium) from dust particles (dispersed phase) of dust aerosol captured and released into the surface layer of the atmosphere through maximum separation;

– the fifth stage: dispersion of the remaining amount of dust particles after purification, immediately before their release into the surface layer of the atmosphere. This was done by intensively separating dust particles during their release and accelerating gravitational seeding in a pre-selected, strictly limited area on the industrial site. This additional measure helped to reduce the concentration of dust particles in the atmosphere to levels below the MPC maximum single (MPC mean daily).

The main goal of each stage in the pollution reduction process was to decrease the stability and, ultimately, the destruction of the dust aerosol as a dispersed system by using pre-determined parameters of external influences applied to it of various physical natures.

The analysis conducted by the authors has allowed them to examine the process of air pollution reduction, which was implemented in two main cycles [8, 9]:

Cycle I was the reduction of pollution of technological raw materials (technological equipment), which included the development of new or improvement of the existing basic production equipment and the organization of technological processes that excluded the stages of formation and release of pollutants;

Cycle II was the reduction of air pollution, which included the use of additional engineering devices, structures, and devices in the current or projected technological process that localized the spread of dust aerosol and ensure its destruction as a dispersed system.

It should be noted that activities related to the first cycle were often not possible due to violations of requirements for raw materials and technical processes. Therefore, the authors have laid the foundation for further research and development of a second cycle of measures to reduce air pollution.

Thus, the main goal of the second stage of the air pollution reduction process was to eliminate dust aerosol particles by separating them from the air. This was achieved through the consistent implementation of several stages, including dust capture, air purification, and dispersion of the remaining dust in the atmosphere. Let us consider the physical foundations of each of the stages of Cycle II.

As a result of the research, the authors found that the physical essence of the dust capture process consisted in purposeful exposure to the released dust aerosol with pre-prepared parameters, or additional (Д–II.1) dispersed system, or a force field leading to the formation of two dispersed systems [8, 10]:

– residual (O–II.1) dispersed system, which contained a minimum amount of dust particles as a dispersed phase (focused on compliance with the MPC maximum single), and which spatially remained and spread in the internal volume of the production room (air of the working area);

– intermediate (П–II.1), which contained the maximum amount of dust particles trapped and removed from the emission zone, and which had increased stability in the dust aerosol state.

Further research by the authors also made it possible to reveal the physical essence of the air purification process from dust. This process involved the purposeful exposure to solid particles of dust aerosol (intermediate (П–II.1) dispersed system) in the active cleaning zone after capture with pre-prepared parameters or additional (Д-II.2) dispersed system, or a force field leading to the formation of two dispersed systems [8, 10]:

– residual (O–II.2), which contained the maximum amount of dust particles as a dispersed phase and has increased stability after passing into the state of a dust material, accumulated in special dust collectors (accumulators);

– intermediate (П–II.2), which contained a minimum amount of dust particles as a dispersed phase (aiming for compliance with the MPC maximum single or MPC mean daily). It was then released into the surface layer of the atmosphere.

Further research by the authors has also allowed them to reveal the physical nature of forced dispersion of remaining dust particles in the atmospheric surface layer, which occurred when the purification process failed to achieve a concentration of dust at environmentally significant points in the surface atmosphere that corresponded to the MPC maximum single (MPC mean daily). Thus, the physical essence of the process of scattering dust particles consisted in the purposeful effect on solid particles of a dust aerosol (intermediate (П–II.2) dispersed system) in the active dispersion zone after cleaning with pre-prepared parameters, or an additional (Д–II.3) dispersed system, or a force field leading to the formation of two dispersed systems [8, 10]:

– residual (O–II.3), which contained the main amount of emitted dust particles as a dispersed phase, and which in the airspace outside ecologically significant zones was subject to intensive deposition on the underlying surfaces, having increased stability during the transition to the state of dusty material;

– residual (O–II.4), which contained a minimum amount (aiming for compliance with the MPC maximum single or MPC mean daily) dust particles as a dispersed phase, and which remained floating in the surface layer of the atmosphere.

Based on the analysis of the reduction of air pollution caused by various types of construction dust, the authors have developed a block diagram of a physical model of this process, taking into account the two cycles discussed above for the conditions of implementation of technological processes at enterprises of the construction industry (Fig. 1) [8, 11, 12].

A visual representation of the flowchart for the physical model of air pollution reduction allowed us to draw several conclusions. Firstly, despite the numerous advantages, the initial cycle of the pollution reduction process under real-world conditions and the organization of technological processes at construction industry enterprises were overwhelmingly not implemented due to violations of technical regulations.

Secondly, within the framework of Cycle II, the capture stage determined the effectiveness of ensuring sanitary and hygiene standards in the air in work areas of industrial premises. In modern conditions, technological processes at construction industry enterprises were provided with very efficient and economical engineering solutions, such as exhaust hoods, panels, and other structures.

Thirdly, within the framework of Cycle II, the stage of forced dispersion of the remaining dust particles in the surface layer of the atmosphere was auxiliary to the air purification process and was used in very rare cases.

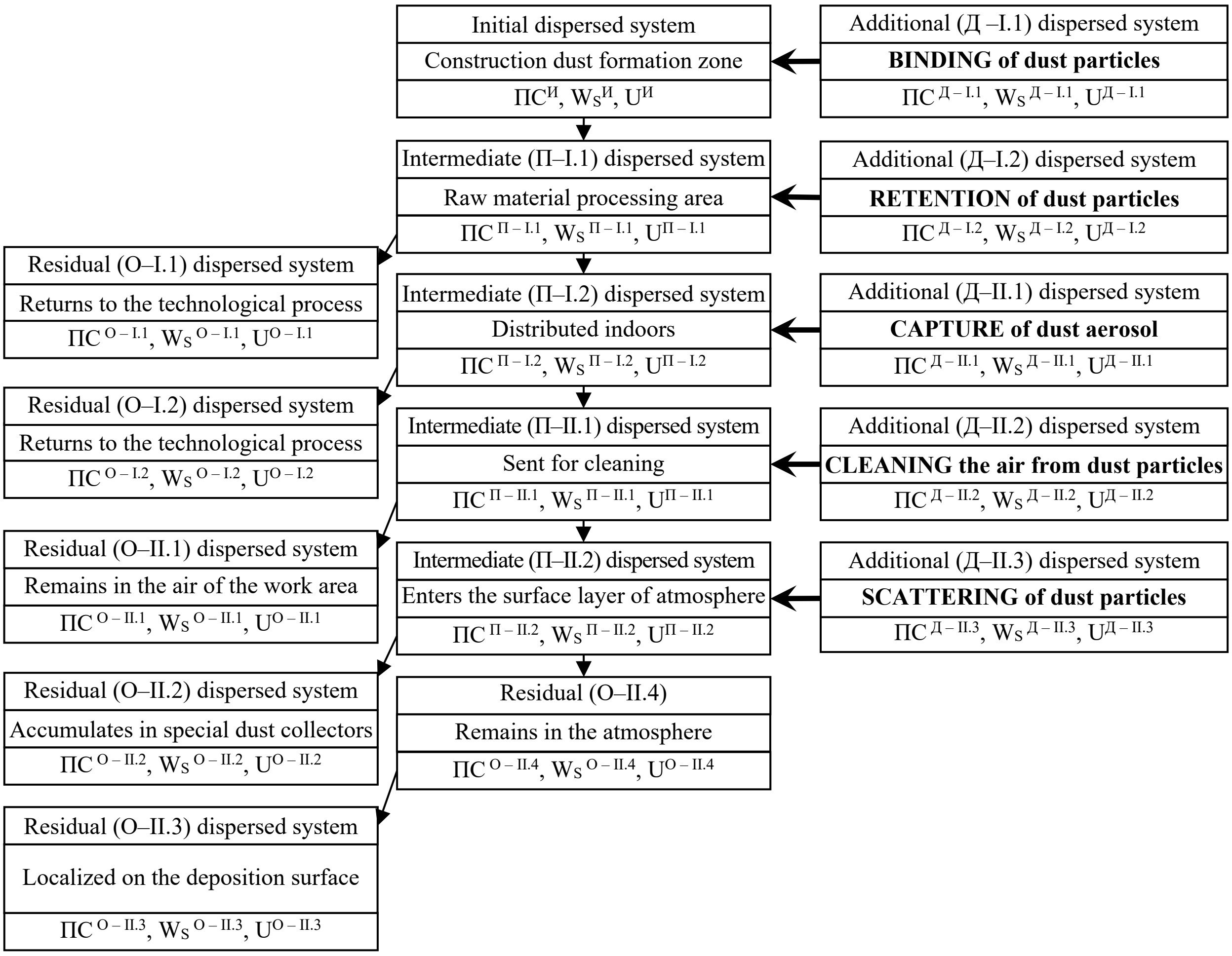

Fig. 1. Physical model of the process of air pollution reduction

Thus, the authors based their practical developments on the stage of air purification from various types of construction dust, for which the possibilities of increasing efficiency were far from exhausted. Improving the efficiency of cleaning agents was possible on the basis of the theoretical research results presented above and, in particular, the flowchart of the physical model for air pollution reduction [13–15].

The study of the behavior and properties of dust aerosol and external dispersed systems or force influences directed at it during the cleaning process allowed the authors to outline the main directions, appropriate technologies and engineering means to increase the efficiency of the cleaning process. One of the brightest representatives of such means was a highly efficient and economical device developed by the authors, designed for hydrodynamic purification of ventilation air (Fig. 2).

The main structural element of the developed device is its cylindrical body (1), which ends in conical section (2). Partially inside and partially outside body (1) there is cylindrical chamber (3) with bottom (4) in the shape of a cone. In this case, chamber (3) is divided by solid hollow bump cone (5) into two parts: the lower and the upper. Slotted air intakes (6) are located on the inner side surfaces of these parts. Inlet tangential inclined branch pipe (7) and outlet tangential branch pipe (8) are connected to the side surfaces of the upper and lower parts of chamber (3). Branch pipe (7) in plan enters body (1) in its upper part "counterclockwise", and branch pipe (8) — in its lower part "clockwise". In this case, branch pipes (7) and (8) face the same side.

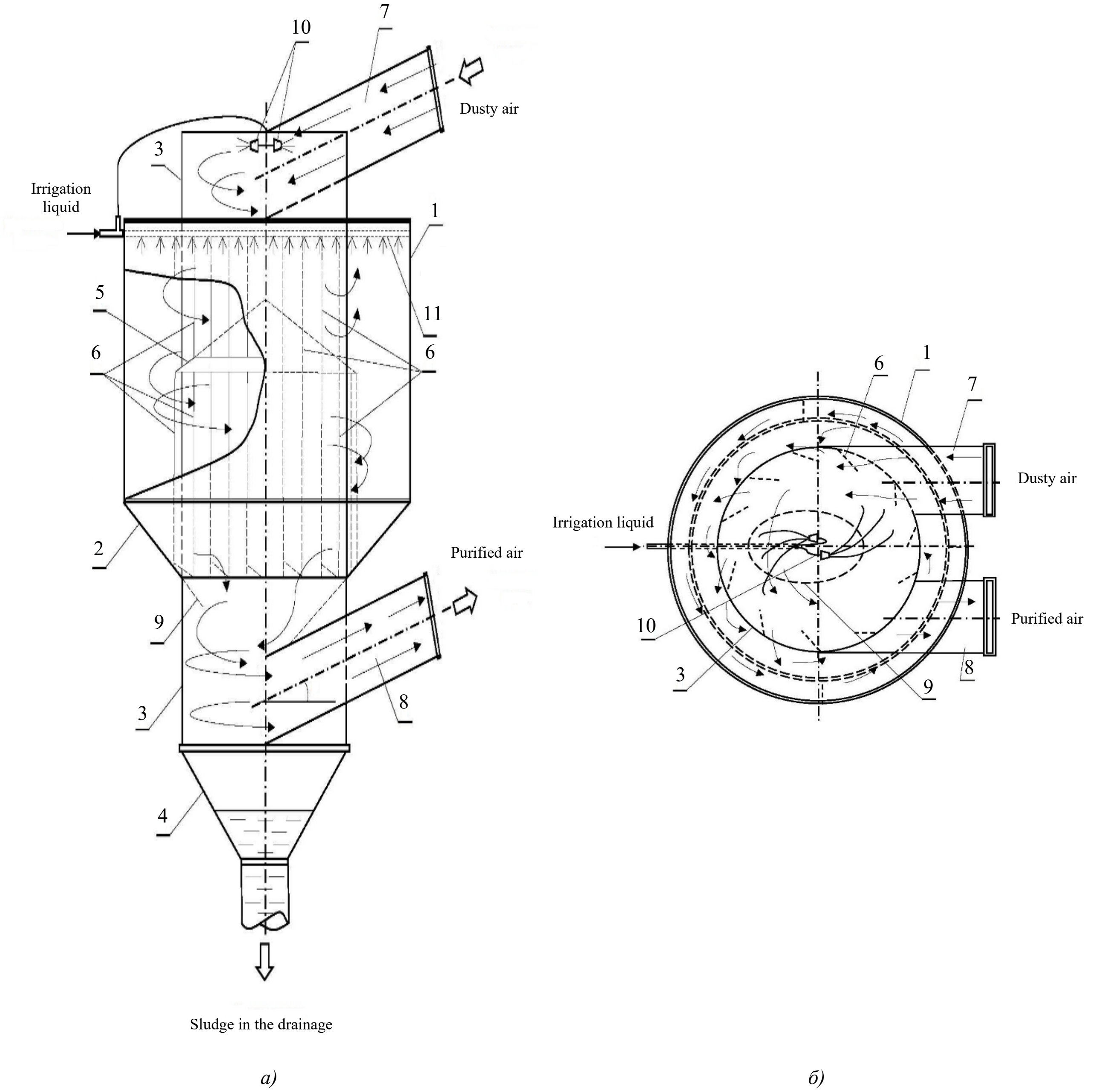

Fig. 2. Device for hydrodynamic purification of ventilation air from poorly wetted clumping dust formed at enterprises of the construction industry: *a* — front view; *b* — top view

Slotted air intakes (6) mentioned above are made in the form of rectangular slotted holes. Moreover, in the upper part of chamber (3), the edges of slotted air intakes (6) are bent inside chamber (3), and in the lower part — outwards so that the air flow is captured in both the upper and lower parts.

The lower part of chamber (3) is equipped with cone (9), which is combined with conical section (2), and the base is located along the lower edge of air intakes (6). Hydrodynamic cleaning system in the device includes three stages:

– two nozzles (10), which are tangentially directed along the incoming flow of dusty air;

– annular perforated pipeline (11) installed under the upper wall of body (1) in an annular cavity between the walls of body (1) and chamber (3) with exit holes directed vertically downward;

– a hydrofilter formed by a continuous liquid film flowing from the edges of cone (9).

The principle of operation of the device is as follows. The dusty air flow from the technological equipment enters inlet tangential pipe (7), and then go into the inner cavity of the upper part of chamber (3) and is irrigated with droplets of liquid, which moisten, bind and remove a certain amount of dust particles from the stream (the first stage of purification) and which are formed using nozzles (10). As a result of irrigation, the sludge moves through chamber (3) from top to bottom onto bump cone (5). And the dust and gas-liquid mixture, thanks to air intakes (6) with inward-curved edges and installed solid hollow cone-bump (5), is removed from the upper part of chamber (3) into the annular cavity between it and body (1), falling into a dense annular drip-liquid curtain, which also captures a certain amount of dust particles (the second stage of purification) formed by annular perforated pipe (11).

At the same time, flowing down from the surface of bump cone (5), the sludge forms a dense annular film curtain (the third stage of purification), which moistens and binds a significant part of dust particles. After passing through this curtain, the residual dusty flow is captured by the outward-bent edges of air intake (6) in the lower part of chamber (3) and returns to its inner cavity.

Ultimately, the total sludge flow from the annular cavity between chamber (3) and body (1) flows down conical section (2) of body (1), and then along cone (9), forming another annular film curtain with different film thicknesses (fourth stage of purification), which increases towards the outlet The sludge is discharged from the device through conical bottom (4). Thus, after passing four stages of purification sequentially, the air stream, as free from dust particles as possible, is released into the atmosphere through outlet pipe (8). All the above-described design features of the developed device determine its integral efficiency in cleaning the air from dust.

To investigate the range of variations in the efficiency values, the authors performed a series of experiments in laboratory settings. During these experiments, the overall efficiency of air purification from dust containing from 20 to 70% SiO_2 (sand dust) was measured. The average median diameter of dust particles was 50 μm, and the bulk density of dust material was 1,860 kg/m³. The dust had a weak adhesion with a breaking strength of 200 Pa and an angle of natural inclination of 57°, while the marginal wetting angle was 10°. The researchers changed the design and parameters of bump cone (5) as well as the design and position of slit air intake (6) to study their effects on the efficiency. The results of the research are presented in Tables 1 and 2.

Table 1

Experimental values of integral efficiency $E_{эф}$, %, of air purification from dust containing from 20 to 70% SiO2, depending on the design of bump cone (5) and the location of slit air intakes (6) with other optimal design solutions

Location of the slit air intakes (6) in the upper part of the chamber (3)	Design of the bump cone (5)								
	The edges of the bump cone coincide with the walls of the chamber (3)			The edges of the bump cone protrude beyond the chamber (3)			The edges of the bump cone form a gap with the inner walls of the chamber (3)		
	conic	spherical	ellipsoid	conic	spherical	ellipsoid	conic	spherical	ellipsoid
Along the entire height of the body (1)	86.9	85.7	83.9	98.7	98.5	91.8	85.2	84.8	83.1
On the upper and lower parts of the chamber (3) partially along the height of the body (1)	84.1	83.8	83.5	95.3	94.9	88.6	83.2	82.9	82.6

Table 2

Experimental values of integral efficiency Eэф, %, of air purification from dust containing from 20 to 70% SiO2, depending on the design of slit air intakes

Design of the slit air intakes (6) in the plan		At the top of the camera (3)	
		with the edges bent outward in the direction of flow	with the edges bent inward towards the flow
At the bottom of the camera (3)	With the edges bent outwards	95.8	98.7
	With the edges spread outwards	93.4	97.2

Discussion and Conclusion. The analysis of the experimental results in the laboratory leads to the following conclusions: Based on Table 1, we can see that the maximum value of integral $E_{эф}$, with SiO_2 content between 20 and 70%, is 98.7%. This occurs when slit air intakes (6) are positioned in the upper part of chamber (3), along the entire height of body (1).

According to Table 2, it can be seen that the same maximum value of integral $E_{эф}$ containing from 20 to 70% SiO_2. amounting to 98.7%, is ensured by the fact that in the design of slit air intakes (6) in the plan in the upper part of chamber (3) the edges are bent inward towards the flow, and in the lower part of chamber (3) the edges of slit air intakes (6) are bent outward.

In conclusion, it should be noted that an increase (up to 96.5–98.7%) of $E_{эф}$ containing from 20 to 70% SiO_2 is provided in the proposed device due to a number of design changes leading to an intensification of wetting, binding and removal of dust particles from the air.

For example, the installation of nozzles (10) and annular perforated pipe (11) increases the likelihood of meeting and trapping dust particles by droplets of dispersed liquid. At the same time, the aerodynamic characteristics of the dust and gas-liquid flow during irrigation are maintained constant.

In addition, cylindrical chamber (3) coaxially passed through body (1) of the device helps to maintain a uniform distribution of the swirling air flow when it exits chamber (1) through slit air intakes (6).

The design of bump cone (5) makes it possible to evenly distribute the air coming from the volume of chamber (3), which, in turn, contributes to the formation of a dense curtain in the form of an annular film, which acts as an additional cleaning filter (the third stage of purification) installed in the path of a dust and gas-liquid stream swirled in the annular cavity.

The sequential movement of the dust-air flow into the cavity of the device through all air purification zones from dust is provided by air intakes (6). At the same time, the shape and location of the edges of the slots allow to stabilize the aerodynamics in the cavity of the device.

Moreover, an additional contribution to improving efficiency is made by cone (9), the shape and location of which create an additional annular film curtain with different film thicknesses (the fourth stage of purification). It is created in the path of the air flow due to the runoff of sludge from the edges of the smaller base of cone (9) and increases in thickness towards outlet pipe (8). Also, the design of cone (9) ensures the removal of sludge from the device in the area of removal of purified air with a significant reduction in drop entrainment into outlet pipe (8). At the same time, the slope of outlet pipe (8) helps to reduce drop entrainment.

It should be noted that in order to ensure stable, reliable and all-season operation of the device, it is necessary to use aqueous solutions as an irrigation liquid that do not freeze even at negative ambient temperatures. If water is used, the device must be kept in closed, heated rooms.

In conclusion, it should be noted that the developed air purification device from dust with all the design features described above provides the required integral efficiency, due to high values (96.5–98.7%), which, in turn, complies with regulatory environmental requirements for the air quality of the surface layer of the atmosphere.

Thus, as a result of the research, the final goal was achieved — the possibility of improving the environmental safety of industrial sites of construction industry enterprises and adjacent residential areas was determined by developing and applying highly effective (at least 96.0%) modern technologies and dust suppression tools, which included the device proposed by the authors for cleaning air from dust containing from 20 to 70% SiO_2.

References

1. Pokotilo VE, Strezhnev DO, Tolmacheva LV. Study of Chemical Pollution of the Environment. In: *Achievements of modern science and education. Collection of articles and abstracts of the IV International Interdisciplinary Conference. Stavropol. 2018*. Taganrog: El'Direkt; 2018. P. 59–61. (In Russ.)

2. Andreeva EV, Klado TN. *Atmosphere and Life.* Leningrad: Hydrometeorological Publishing House; 1963. 268 p. (In Russ.)

3. Kulagina TA, Andrunyak IV. *Technological Processes and Polluting Emissions*. Krasnoyarsk: Siberian Federal University; 2019. 206 p. (In Russ.)

4. Malashkina AV. Factors for Assessing the Impact of Industrial Cities on Public Health. In: *Proceedings of the 1st National Scientific and Practical Conference with international participation "Innovations in environmental management and environmental protection".* Saratov: KUBiK Publishing House; 2019. PC. 196–199. (In Russ.)

5. Lysova E., Paramonova O., Samarskaya N., Gyrova O., Tsarevskaya I. Application of Physical and Energetic Approach to Estimation and Selection of Atmospheric Protection Systems for Energetic Devices. *MATEC Web of Conferences.* 2018;170:04013. https://doi.org/10.1051/matecconf/201817004013

6. Momei Qin, Murphy BN, Isaacs KK, McDonald BC, Quanyang Lu, McKeen SA, et al. Criteria Pollutant Impacts of Volatile Chemical Products Informed by Near-Field Modelling. *Nature Sustainability.* 2021;4(2):129–137. https://doi.org/10.1038/s41893-020-00614-1

7. Khalikov IS. Identification of Natural Objects Contamination by Polycyclic Aromatic Hydrocarbons with the Use of Molecular Relations. *Ekologicheskaya khimiya.* 2018;27(2):76–85. (In Russ.)

8. Bespalov V, Gurova O, Samarskaya N, Paramonova O. Classification of Air Pollution Criteria for the Improvement of Methodical Approaches to Ensure the Environmental Safety of Major Cities. *E3S Web of Conferences.* 2019;135:01033. https://doi.org/10.1051/e3sconf/201913501033 (accessed: 04.05.2024).

9. Palliyarayil A, Saini H, Vinayakumar K, Selvarajan P, Vinu A, Kumar NS, et al. Advances in porous material research towards the management of air pollution. *Emergent Materials.* 2021;4:607–643. https://doi.org/10.1007/s42247-020-00151-9

10. Sadunishvili TA, Khatisashvili GA, Gurova OS, Samarskaya NS. *Global Environmental Issues and Biotechnological Approach.* Monograph. Rostov-on-Don: Don State Technical University; 2021. 146 p. (In Russ.)

11. Samarskaya N, Paramonova O, Lysova E. Study of the Air Pollution Reduction Process in the Production of Film-Forming Substances for Quick-Drying Enamels. *IOP Conference Series: Earth and Environmental Science.* 2021;666:042072 http://doi.org/10.1088/1755-1315/666/4/042072

12. Bespalov V, Gurova O. Development of an Integrated Approach to the Selection of Remediation Measures and Environmental Technologies for their Implementation. *E3S Web of Conferences*. 2021;258:08027. https://doi.org/10.1051/e3sconf/202125808027

13. Samarskaya N, Gyrova O. Analysis of the Results of Theoretical Calculations Based on the Methodology for Making a Decision on the Choice of Optimal Technologies for Dedusting with Foam. *AIP Conference Proceedings.* 2022;2503(1):040004. https://doi.org/10.1063/5.0099703

14. Bespalov VI, Gurova OS. Scientific Substantiation of New Concept for Environmental Technologies Choice. *AIP Conference Proceedings.* 2022;2503(1):040005. https://doi.org/10.1063/5.0099700

15. Bespalov VI, Lysova EP, Paramonova ON, Samarskaya NS. Justification of the Scientific Approach Choice for Formation of the Most Effective Ways and Means of Reducing Air Pollution in the Operation of Power Plants. *Engineering journal of Don.* 2018;(3). URL: http://www.ivdon.ru/uploads/article/pdf/IVD_42_Bespalov_Lysova.pdf_c86775c35f.pdf (accessed: 04.05.2024). (In Russ.)

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Claimed Contributorship:

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Conflict of Interest Statement: **the authors do not have any conflict of interest.**

All authors have read and approved the final manuscript.

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Заявленный вклад авторов:

В.И. Беспалов: формирование основной концепции, цели и задачи исследования, научное руководство.

О.С. Гурова: анализ результатов исследований, корректировка выводов, графическое оформление, доработка текста.

Конфликт интересов: **авторы заявляют об отсутствии конфликта интересов.**

Все авторы прочитали и одобрили окончательный вариант рукописи.

Received / Поступила в редакцию 13.06.2024
Revised / Поступила после рецензирования 07.07.2024
Accepted / Принята к публикации 15.07.2024