UDC 622.411.51:622.232.72 DOI: https://doi.org/10.15407/geotm2025.174.021

# INFLUENCE OF DYNAMIC CHARACTERISTICS OF VENTILATION FLOW ON THE INTENSITY OF DUST TRANSITION TO THE SUSPENDED STATE

**[1]Bedniuk O., [1]Cheberiachko Yu., [1]Stolbchenko O., [2]Shevchenko V., [2]Luts I., [3]Bolibrukh B.**

*[1]Dnipro University of Technology*
*[2]M.S. Poliakov Institute of Geotechnical Mechanics of the National Academy of Sciences of Ukraine*
*[3]Lviv Polytechnic National University*

**Abstract.** Estimation of the amount of dust transitioning to the suspended state from the reflected rock mass during the operation of the roadheader. In this paper, analytical methods are used to determine the amount of dust transitioning from the reflected rock mass to the suspended state during the operation of the roadheader, taking into account the peculiarities of the operation of tunnelling machines with a boom-shaped working body and the dynamic characteristics of the ventilation flow. It has been established that as a result of the interaction of the ventilation flow with the rock mass broken by the roadheader's actuator, the dynamic characteristics of the ventilation flow have a significant impact on dust formation. Based on the analysis of the process of dust generation during the destruction of a rock mass by a roadheader and subsequent transportation of the rock mass, a formula is recommended for determining the amount of dust which becomes suspended and enters the mine atmosphere. The dependence of the mass of dust formed per unit time on the capacity of the roadheader and is a constant value (within this capacity), and the mass of dust 'blown out' from the destroyed part of the massif increases with an increase in the air flow velocity. A mathematical model of the transition of dust to the suspended state and its entry into the mine atmosphere has been developed and theoretically substantiated, which differs from the known ones in that it takes into account the process of dust rise due to the influence of dynamic characteristics of the ventilation flow. Based on the analysis of the influence of the dynamic characteristics of the ventilation flow on the intensity of dust inflow into the face space during the operation of the roadheader, an expression for determining the mass of dust formed as a result of the air flow was obtained. The derived expression provides a predictive tool for estimating the intensity of dust inflow into the mine atmosphere under specific operational and ventilation parameters. This capability is indispensable for the proactive design and optimization of integrated dust control strategies, including the strategic placement of dust suppression systems, local exhaust ventilation, and the determination of optimal airflow rates that balance the need for gas dilution with the risk of excessive dust suspension. By moving from empirical observation to a quantifiable model, this work lays a scientific foundation for enhancing air quality and ensuring miner safety in mechanized underground coal mining.

**Keywords:** amount of dust, dynamic characteristics of the ventilation flow, broken rock mass, suspended dust.

## 1. Introduction

During the operation of a roadheader, a significant amount of dust entering the mine atmosphere is generated by the aerogel which is trapped in the broken rock mass.

The dust contained in the overburden consists of dust present in the seam prior to mining, dust generated by the destruction of coal by the cutter of the mining machine and dust deposited by sedimentation processes. The dust present in the seam, commonly referred to as 'shear dust', is formed as a result of tectonic forces and the redistribution of stress in the massif in the area affected by the mine workings. The largest amount of shear dust is located in areas subjected to increased stress, which results in the formation of new cracks and the removal of the surrounding seam elements relative to each other. The intensity of the suspension of this type of aerogel depends on the dynamic characteristics of the ventilation current, its interaction with the aerogel during the transportation of the broken rock mass along the length of the workings, productivity and the nature of the production process.

Received: 05.03.2025 Accepted: 15.09.2025 Available online: 19.09.2025

In view of the above, the objective of this study is to develop a method for determining the amount of dust entering the mine atmosphere from the broken rock mass during the operation of the roadheader.

The amount of dust that becomes suspended depends on both the properties of the broken rock mass (fineness, moisture content, etc.) and the influence of the external environment. The greater the dynamic pressure of the air flow is, the more dust particles are suspended. Under certain conditions, the intensity of the removal of fine particles can be so significant that an increase in air flow will lead to an increase in dust concentration in the workings rather than in a decrease.

Whirling-up of dust occurs with ventilation modes changing, when the aerogel is removed from the surfaces under the dynamic influence of the flow following the air velocity decrease to a certain critical value. Moreover, relatively large dust particles formed earlier can be destroyed under the influence of mechanical factors (friction between pieces of rock mass, etc.) and then enter the air, forming an aerosol.

The change in the cross-section of the workings during the technological process has a significant impact on the dust entrainment by the air flow, creating an increased velocity in a narrow cross-section and contributing to its disruption from the surface of the broken rock mass. In transport workings, when the rock mass moves towards the ventilation flow, the relative velocity of the air stream increases, which also leads to dust being dislodged from the surface of the transported mineral.

It is possible to avoid contamination of the air flow by blown dust by creating such ventilation modes in which the aerodynamic forces acting on previously settled dust particles would be lower than the intermolecular forces holding them.

However, this issue has not been studied sufficiently. The information published on the air-flow velocity at which whirling-up of dust in mine workings begins is very controversial; the given relationship between the amount of dust removal from a dust-laden surface and the air flow velocity lacks sufficient experimental confirmation.

Many works have been devoted to theoretical and experimental studies on processes of dust entrainment from surfaces, including those by such prominent scientists as O.O. Skochynskyi, L.I. Baron, V.M. Voroninin, L.D. Voronina, A.D. Bahrynovskyi, B.F. Kirin, A.I. Ksenofontova, A.S. Burchakov, V.V. Kudriashov, K.P. Mednikov, P.I. Mustel, P.M. Petrukhin, S.B. Romanchenko, A.A. Trubitsyn, N.A. Fuks, V.Ye. Kolesnyk and many others.

The issues of ensuring safe working conditions for miners and determining ventilation parameters in mines are discussed in [1, 2].

The analysis of the studies [3, 4] shows that when calculating and organising anti-dust ventilation mode, it is necessary to know not only the critical velocity at which dust is dislodged, but also the amount of its whirling-up from the dusty surface, depending on the air-flow velocity. This issue was studied by V.N. Voronin, L.D. Voronina, and A.D. Bahrynovskyi. Their theoretical conclusions are based on the hypothesis that the amount of dust blown off a unit area of the dust-laden surface is linearly dependent on the difference in the air flow velocity and the critical velocity at which dust particles begin to break off. However, experimental work performed by other researchers [5, 6, 7] did not confirm this.

The data on the intensity of the transition of dust to the suspended state, and, consequently, the amount of dust formation associated with this process, allow not only calculating the optimal ventilation modes, but also determining the rational locations for the installation of ventilation and dust collection equipment.

## 2. Methods

As noted in [8], in a ventilated workplace, the process of aerosol formation during the continuous release of dust is significantly influenced by the dynamic parameters of the flow.

The increase in dust concentration due to an increase in air flow is associated with the process of entrainment of previously settled dust.

The processes of dust aerosol particle deposition and entrainment are considered in close correlation [9, 10]. These include dust settled due to the high drag of the conglomerate, reduced humidity or neutralisation of binding charges, dust microstructures, which have settled and are collapsing, and particles which revert to the suspended state. Under certain conditions, due to the significant intensity of the removal of fine particles, an increase in air flow can lead to an increase in the concentration of dust in the air rather than to a decrease [9].

The velocity at which dust particles begin to rise is about 0.3 m/s [11, 12]. The authors of the studies [11, 12, 13] state that the critical air velocity $u_{cr}$, at which dust starts to rise, depends on the cross-sectional area $S_w$ of the workings and is determined by the expression

$$u_{кр} \geq \frac{10.1}{S_w}. \tag{1}$$

Expression (1) defines the permissible lower limit of the flow velocity in the mode of stable dusting, i.e. it shows that stable dusting is possible if the air velocity is not lower than shown in (1). At the lower limit of the flow velocity, the deeper-lying particles become compacted and form large conglomerates. [14].

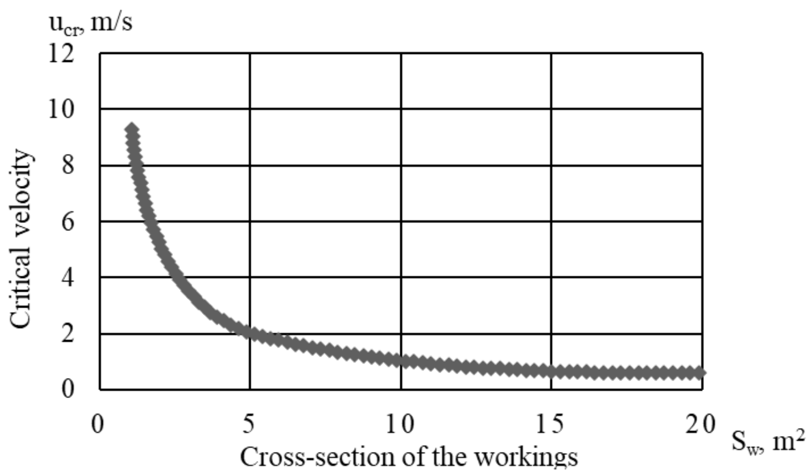

Figure 1 – Relationship between the critical velocity $u_{cr}$ and the cross-section of the workings $S_w$

Therefore, equation (1) gives only the permissible lower limit, not the value of the critical velocity.

The graphical interpretation of expression (1), shown in Fig. 1, indicates that the relationship between the critical velocity $u_{cr}$ and the cross-section of the working $S_w$ is exponential

To study the dynamics of dust entrainment, it is of interest to use the empirical dependence for taking into account the dust which rises into the air from the broken rock mass $M$, which was proposed in [15] and can be used in calculations

$$\frac{m}{M} = 1 - \left(1 - \frac{m_{\min}}{M}\right)\exp\left(-a\frac{u_{av}}{u_s}\right), \tag{2}$$

where $m$ is the mass of dust that is carried into the atmosphere from the broken rock mass by the air flow, kg; $M$ is the mass of dust contained in the broken rock mass, kg; $m_{min}$ is the minimum mass of dust rising into the atmosphere at the air flow rate $u_a$=0 (during the interaction of different fractions associated with the movement of rock mass); $u_s$ is the dust suspension velocity, m/s; $u_{av}$ is the average air flow rate, m/s; $a$ is the empirical coefficient.

Expression (2) can be represented as a schematic dependence of the transition of a part of the dust to the suspended state on the air velocity (Fig. 2) [12].

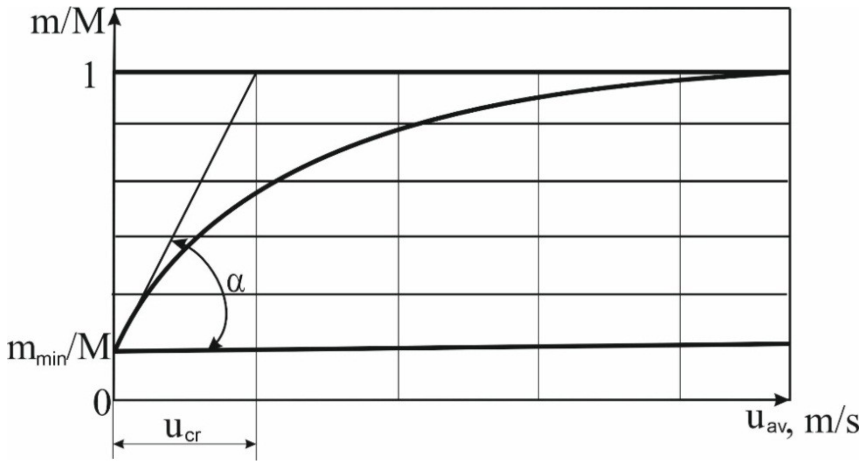


Figure 2 – Schematic dependence of the proportion of dust that passes into the suspended state $m/M$ on air velocity $u_{av}$

The coefficient $a$ can be determined from the expression [11]

$$a = \frac{u_s tg\alpha}{1 - \frac{m_{\min}}{M}}$$

or after simple transformations

$$a=\frac{Mu_s tg\alpha}{M-m_{\min}}, \tag{3}$$

where $\alpha$ is the angle of inclination of the tangent to the function $m/M=f\left(u_{av}\right)$, drawn from the point (0; $m_{min}/M$).

Taking into account (3), expression (2) will take the following form

$$\frac{m}{M}=1-\left(\frac{M-m_{\min}}{M}\right)\exp\left(-u_{av}tg\alpha\frac{M}{M-m_{\min}}\right) \tag{4}$$

or

$$\frac{m}{M}=1-\left(1-\frac{m_{\min}}{M}\right)\exp\left(-\frac{u_{av}tg\alpha}{1-\frac{m_{\min}}{M}}\right). \tag{5}$$

The left-hand side of equation (4) represents the fraction of dust which is suspended due to the dynamic characteristics of the air flow (air velocity and its degree of turbulence), which can be expressed as the percentage of the total dust content in the rock mass. At the maximum amount of dust which can be suspended from the rock mass ($m_{max}$=$M$), the ratio $m_{max}/M$=1.

At $u_{av}$ = 0 expression (4) looks like $m$=$m_{min}$, i.e., the amount of dust released is related only to the process of rock mass movement.

According to Fig. 2, the critical velocity $u_{cr}$ of the entrainment of the main dust mass is the projection of the tangent to the function $m/M=f$ ($U_{av}$) drawn from the point (0; $m_{min}/M$) to the point of intersection with the axis $m/M$=1 and can be determined from the right triangle in Fig. 2 as the ratio of the opposite leg to the adjacent one, i.e.

$$tg\alpha=\frac{1-\frac{m_{\min}}{M}}{u_{cr}} \tag{6}$$

from which

$$u_{cr}=\frac{1-\frac{m_{\min}}{M}}{tg\alpha}. \tag{7}$$

Substituting (6) into (5), we obtain

$$\frac{m}{M}=1-\left(1-\frac{m_{\min}}{M}\right)\exp\left(-\frac{u_{av}}{u_{cr}}\right). \tag{8}$$

From the obtained expression (8), taking into account (1), we determine the mass of dust that is lifted into the atmosphere from the broken rock mass by the air flow

$$m = M\left[1-\left(1-\frac{m_{\min}}{M}\right)\exp\left(-0{,}1\cdot S_{в}u_{av}\right)\right]. \tag{9}$$

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The total amount of broken rock mass ($A$, t) depends on the productivity of the roadheader ($P_s$, $t$ per min) and is determined by the amount of broken rock mass ($A$, t) per unit of time

$$A = P_s t. \tag{10}$$

As a result of special studies [16,17], it was found that in the size range from -0.01 to +100 mm, the distribution of grains by their size in the total mass of coal destroyed by cutting follows the statistical law of Weibull distribution

$$W = 1-\exp(-\lambda\cdot d^{\mu}), \tag{11}$$

where $W$ is the total yield (in fractions of the weight of the whole sample) of the destroyed coal which passed through a sieve with holes of $d$ mm; $\lambda$ is the parameter of the grinding degree, which depends on the adopted methods and cutting modes; $\mu$ is a constant parameter for the given coal (seam) which characterises its ability to crush and does not depend on cutting methods and modes; $d$ is the size of the particles of the destroyed coal which have passed through the sieve with the pass-through openings for these particles, mm.

On the basis of (10) and taking into account (11), we determine the mass of the dust contained in the broken rock mass

$$M = WP_s t. \tag{12}$$

Substituting (11) into (10) and expressing $a_{ds}$ in fractions, we obtain

$$M = P_s t\left[1-\exp\left(-\lambda\cdot d^{\mu}\right)\right] \text{ kg.} \tag{13}$$

Substituting (13) into (9), we obtain an expression for determining the mass of dust released into the atmosphere from the broken rock mass by the air flow during the time $t$

$$m = P_s t\left[\exp\left(\lambda\cdot d^{\mu}\right)-1\right]\left[\exp\left(-\lambda\cdot d^{\mu}\right)\right]\times$$
$$\times\left\{1-\left[\exp\left(-0{,}1\cdot S_{w}u_{av}\right)\right]\right\}-m_{\min}\left[\exp\left(-0{,}1\cdot S_{w}u_{av}\right)\right] \text{ kg.} \tag{14}$$

Taking $m_{min}$=0 in (14), we obtain an expression for calculating the mass of dust which rises into the mine atmosphere only due to the dynamic properties of the flow

$$m_D = P_s t\left[\exp\left(\lambda \cdot d^{\mu}\right)-1\right]\left[\exp\left(-\lambda \cdot d^{\mu}\right)\right]\left\{1-\left[\exp\left(-0,1 \cdot S_w u_{av}\right)\right]\right\}. \quad (15)$$

Since the size of the particles capable of passing into the suspended state is equal to <70 µm, we assume d=0.07 mm.

According to the studies conducted [18], the values of indicators of the ability of coal to grind are in the range from 0.4 to 1.3, with the most common indicators $\mu$=0.6...0.85.

The parameter of the grinding degree $\lambda$ depends on the adopted methods and modes of cutting and is determined according to the graph [18], depending on the value of the parameter $\mu$; $\lambda$=0.1.

The productivity of the EBZ-160 roadheading machine, which is currently the most widely used in coal mines, makes 300 tonnes per hour or 5 tonnes per minute.

Substituting the obtained values of the parameters into (15), we obtain an expression for determining the mass of dust formed as a result of the action of the air flow, which, according to research [12], is 63% of the total mass of dust rising into the mine atmosphere

$$m_D = 1,63\left\{1-\left[\exp\left(-1,32 \cdot u_{av}\right)\right]\right\} \text{ kg/s.} \quad (16)$$

Since expression (16) determines 63% of the total mass of dust rising into the mine atmosphere of the dead-end workings $m_D$, the total mass of this dust is therefore equal to

$$m_T = 2,23\left\{1-\left[\exp\left(-1,32 \cdot u_{av}\right)\right]\right\} \text{ kg/s.} \quad (17)$$

Fig. 3 shows a graph of the relationship between the mass of dust entrained by the air flow from the broken rock mass and the ventilation flow rate.

The graph shows that as the air flow velocity increases, the mass of dust ‘blown’ from the destroyed part of the massif increases, but the activity of this process decreases, as indicated by the nature of the curve.

**3. Theoretical and experimental parts**

The decreasing intensity of the process of ‘blowing’ dust from the destroyed part of the massif is explained by the fact that the mass of dust generated per unit time mainly depends on the productivity of the roadheader and is a constant value (within this capacity), while the mass of dust ‘blown’ from the destroyed part of the massif increases with an increase in the air flow rate. In this regard, theoretically, the maximum air velocity can be achieved at which the dust will be almost completely blown away [15]. However, in practice, this does not occur, because with the increasing influence of the dynamic characteristics of the air flow, new dust particles are formed which are prone to being blown away. Therefore, the curve in Fig. 3 is an exponent which asymptotically approaching 1, i.e. to the position at which the mass of dust raised into the atmosphere from the broken rock mass by the air flow *m* is equal to the mass of dust contained in the broken rock mass *M* (*m*=*M*).

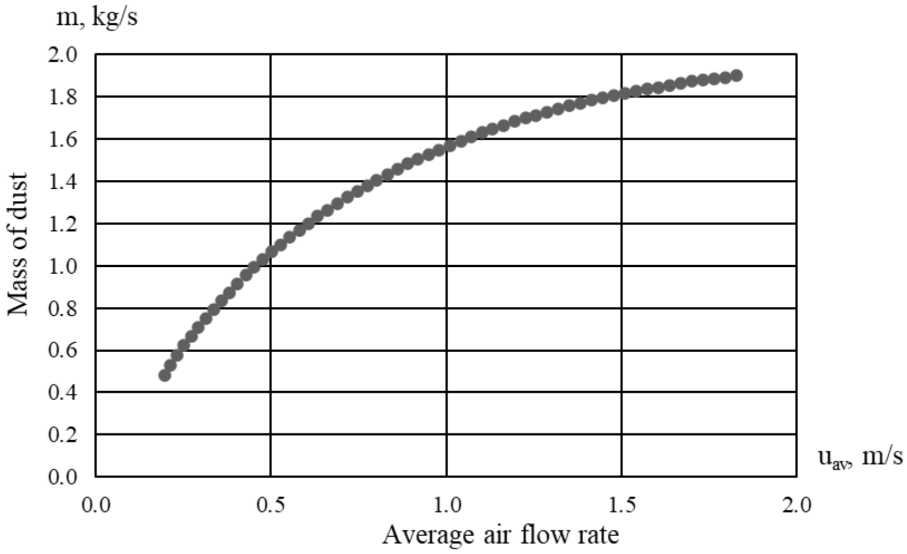


Figure 3 – Relationship between the mass of dust *m*, which rises into the mining atmosphere, and the value of the air flow velocity $u_{av}$ in the development workings carried out by the EBZ-160 roadheader

According to (14), in a steady-state mode (given a sufficient amount of generated dust), dust rises along the entire length of the mine workings and depends on the squared velocity of the air flow.

Dust suspension occurs most intensively in the face space (during the cutting and loading of rock mass). In this part of the mine workings, the rising dust can be represented as spreading from a single source (rock mass destruction and rock mass loading onto the conveyor) and can be described by the relationship between dust concentration and the intensity of its formation

$$C_0 = \frac{m}{S_w u_{av}}. \quad (18)$$

Substituting (14) into (18), we obtain an expression for determining the dust concentration in the face space of the development workings

$$C_0 = \frac{P_к t\left[\exp\left(\lambda \cdot d^{\mu}\right)-1\right]\left[\exp\left(-\lambda \cdot d^{\mu}\right)\right]}{S_w u_{av}} \times$$
$$\times\left\{1-\left[\exp\left(-0,1 \cdot S_w u_{av}\right)\right]\right\} - \frac{m_{\min}\left[\exp\left(-0,1 \cdot S_w u_{av}\right)\right]}{S_w u_{av}}. \qquad (19)$$

The dust generated in the face space spreads further along the working face and can be described by the concentration-length dependence, taking into account its initial formation $C_0$ and deposition, i.e., as [19, 20]:

$$C = \frac{C_0}{1+\dfrac{\sigma_h^2\gamma\left(g+K_T\pi\right)L}{4,5\cdot\pi\mu R u_{av}}} + \frac{jL}{S_w u_{av}\left(1+\dfrac{\sigma_h^2\gamma\left(g+K_T\pi\right)L}{4,5\cdot\pi\mu R u_{av}}\right)}, \qquad (20)$$

where $\dfrac{\sigma_h^2\gamma\left(g+K_T\pi\right)L}{4,5\cdot\pi\mu R u_{av}}$ is a parameter which characterises the dust settling along the length of the workings [8]; $\sigma_h$ is standard deviation of the size of protrusions and depressions relative to the plane of the cut, when rock mass particles are destroyed by interaction; $\sigma_h$=3·10$^3$...10·10$^{-3}$; $\gamma$ is density of dust particles, kg/m$^3$; $L$, $R$ are length and hydraulic radius of the mine workings, m; $g$ is acceleration of free fall, m/s$^2$; $\mu$ is dynamic air viscosity, at a temperature of 20°C $\mu$=18.1·10$^{-6}$ Pa·s; $K_T$ is the turbulent diffusion coefficient.

For mine workings, $K_T$ is determined from the expression [16]

$$K_T = 0,044\, v\, \mathrm{Re}^{0,75},$$

where $v$ is kinematic air viscosity, m$^2$/s; $v$=14.41·10$^{-6}$ m$^2$/s [17]; Re is the Reynolds number; it is determined from the expression [17]:

$$\mathrm{Re} = \frac{u_{av}}{d_z},$$

where $d_z$ is a hydraulic diameter of the workings, m:

$$d_h = \frac{4S}{P},$$

where $S$ is cross-section of the workings, m$^2$; $P$ is the perimeter of the workings, m.

By specifying the parameter which characterises dust deposition along the length of the product through $\varphi$, we obtain

$$C=\frac{C_0}{1+\phi\dfrac{L}{u_{av}}}+\frac{jL}{S_w\left(u_{av}+\phi L\right)}, \tag{21}$$

where $j$ is a quantity taken into account in the equations to describe the phase shifts between air velocity and dust concentration.

Substituting (19) into (20), taking into account (21), we obtain

$$C=\frac{P_s t\left[\exp\left(\lambda\cdot d^{\mu}\right)-1\right]\left[\exp\left(-\lambda\cdot d^{\mu}\right)\right]}{S_w\left(u_{av}+\phi L\right)}\left\{1-\left[\exp\left(-0{,}1\cdot S_w u_{av}\right)\right]\right\}-$$
$$-\frac{m_{\min}\left[\exp\left(-0{,}1\cdot S_w u_{av}\right)\right]}{S_w\left(u_{av}+\phi L\right)}+\frac{m_{\min}L}{S_w\left(u_{av}+\phi L\right)}. \tag{22}$$

In a particular case, when the EBZ-160 roadheader operates in dead-end workings, taking into account expressions (17), (21), we obtain

$$C_T=\frac{0{,}6\cdot10^6\left\{1-\left[\exp\left(-1{,}32\cdot u_{av}\right)\right]\right\}}{S_w\left(u_{av}+\phi L\right)}\left(3{,}72+L\right)\ \text{mg/m}^3. \tag{23}$$

At $u_{av}$=0, the $C_T$ parameter also equals 0, i.e., it turns out that no dust is released from the destroyed rock mass during the operation of the roadheader and in the absence of ventilation.

However, even in the absence of ventilation, the air environment in any process does not remain absolutely stationary due to local disturbances caused by the specifics of the process (movement of the roadheader and its executive body, movement of miners, heat flows arising from high temperatures during rock cutting, etc.), so $u_{av} \neq 0$ and takes on some minimum values.

## 4. Results and discussion

The results of the calculations performed based on expression (23) under the conditions of mining with the EBZ-160 roadheader without the use of dust suppression equipment are shown in Fig. 4.

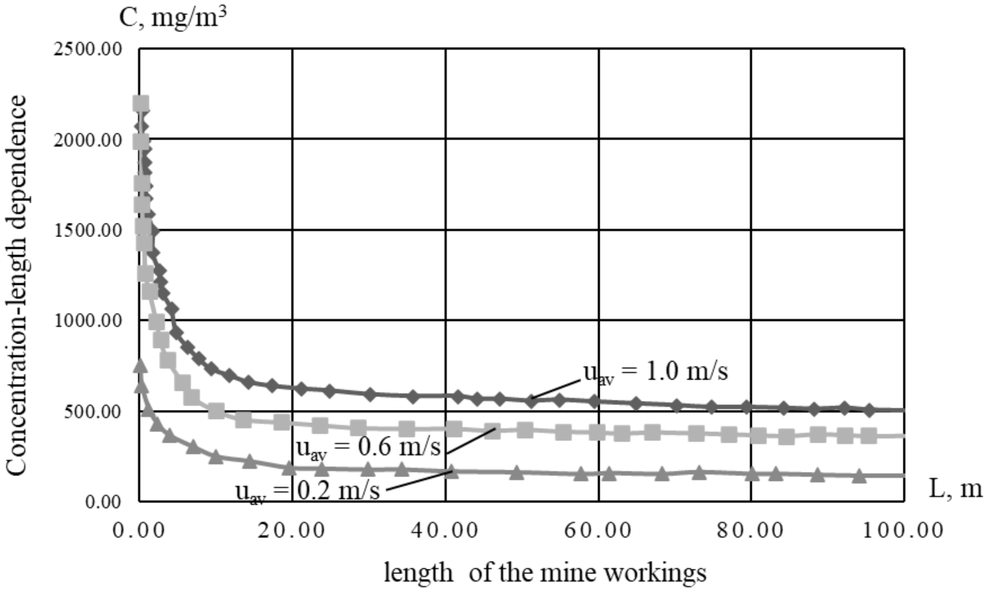


Figure 4 – Graph of dust content variation in the air along the length of the development workings depending on the air velocity

The graph in Fig. 4 shows that the highest dust content is found in the bottomhole space at the working place of the roadheader operator, where the concentration of coal dust can exceed the critical concentration by 250...800 times.

Outside the face space, the dust content in the air decreases significantly. This is due to the deposition of coarse dust. Further along the length of the working face, the process of dust deposition dies down due to gravitational forces and the amount of dust in the air is almost constant, which is due to the content of the ventilation stream mainly of fine dust, which is almost completely removed from the development workings.

## 5. Conclusions

The intensive increase in the dust concentration in the air of the face space of a dead-end working face during the operation of the roadheader should be considered as a result of the rise of a significant amount of fine dust from the broken rock mass due to the influence of the dynamic characteristics of the ventilation flow, which allows taking this influence into account when predicting the amount of dust entering the mine atmosphere during the operation of the roadheader.

It has been established that an important role in the transition of fine dust particles to the suspended state is played by the air flow velocity, with an increase in which the mass of dust ‘blown’ from the destroyed part of the massif increases, but the intensity of this process decreases. This is explained by the dependence of the mass of dust formed per unit time on the capacity of the roadheader and is a constant value (within this capacity), and the mass of dust ‘blown out’ from the destroyed part of the massif increases with an increase in the air flow velocity.

A mathematical model of dust inflow into the mine atmosphere has been developed and theoretically substantiated, which differs from the known ones in that it takes into account the process of dust suspension due to the influence of dynamic characteristics of the ventilation flow.

Based on the analysis of the influence of the dynamic characteristics of the ventilation flow on the intensity of dust inflow into the face space during the operation of the roadheader, an expression for determining the mass of dust formed as a result of the air flow was obtained.

## Conflict of interest

Authors state no conflict of interest.


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## About the authors

***Bedniuk Oleksandr,*** Postgraduate Student at the Department of Labour Protection and Civil Security, Dnipro University of Technology, Dnipro, Ukraine, Bedniuk.O.V@nmu.one ***(Corresponding author),*** ORCID ***0009-0006-3346-9317***

***Cheberiachko Yurii,*** Doctor of Technical Science (D.Sc.), Professor, Professor of Labour Protection and Civil Security Department, Dnipro University of Technology, Dnipro, Ukraine, cheberiachko.yu.i@nmu.one ORCID ***0000-0003-3281-7157***

***Stolbchenko Olena,*** Candidate of Technical Sciences (Ph.D.), Associate Professor, Associate Professor of the Department of Labor safety and civil security, Dnipro University of Technology, Dnipro, Ukraine, stolbchenko.o.v@nmu.one, ORCID ***0000-0003-2003-4382***

***Shevchenko Volodymyr,*** Doctor of Technical Sciences (D.Sc.), Professor, Scientific Secretary of the Institute, Head of Department of Vibratory Transporting Systems and Complexes, M.S. Poliakov Institute of Geotechnical Mechanics of the NAS of Ukraine (IGTM of the NAS of Ukraine), Dnipro, Ukraine, V.Shevchenko@nas.gov.ua, ORCID ***0000-0002-7290-811X***

***Luts Ihor***, Candidate of Technical Sciences (Ph.D), Associate Professor, Researcher in the Department of Vibratory Transporting Systems and Complexes, M. S. Poliakov Institute of Geotechnical Mechanics of the National Academy of Sciences of Ukraine (IGTM of the NAS of Ukraine), Dnipro, Ukraine, i.luts.aot@gmail.com, ORCID ***0000-0003-0333-5730***

***Bolibrukh Borys***, Doctor of Technical Science (D.Sc.), Professor, Professor of the Department of Civil Security, Lviv Polytechnic National University, Lviv, Ukraine, prof.bolibrukh@gmail.com, ORCID ***0000-0002-9879-7454***


## ВПЛИВ ДИНАМІЧНИХ ХАРАКТЕРИСТИК ВЕНТИЛЯЦІЙНОГО ПОТОКУ НА ІНТЕНСИВНІСТЬ ПЕРЕХОДУ ПИЛУ У ЗВАЖЕНИЙ СТАН

*Беднюк О., Чеберячко Ю., Столбченко О., Шевченко В., Лутс І., Болібрух Б.*

**Анотація**. Оцінка кількості пилу, що переходить у зважений стан з відбитої гірничої маси під час роботи комбайну. У роботі використано аналітичні методи - для визначення кількості пилу, що переходить у зважений стан з відбитої гірничої маси під час роботи комбайну з урахуванням особливостей роботи прохідницьких комбайнів зі стрілоподібним робочим органом та динамічних характеристик вентиляційного потоку. Встановлено, що в результаті процесу взаємодії вентиляційного потоку з гірничою масою, відбитою виконавчим органом прохідницького комбайну, значний вплив на пилоутворення мають динамічні характеристики вентиляційного потоку. На підставі аналізу процесу здіймання пилу при руйнуванні гірського масиву комбайном з подальшим транспортуванні гірничої маси, рекомендована формула для визначення кількості пилу, що переходить у зважений стан і надходить у рудникову атмосферу. Залежність маси пилу, що утворюється за одиницю часу, від продуктивності прохідницької машини є постійною величиною (в межах цієї продуктивності), а маса пилу, що «видується» із зруйнованої частини масиву, збільшується зі збільшенням швидкості повітряного потоку. Розроблена та теоретично обґрунтована математична модель переходу пилу у зважений стан та його надходження у рудникову атмосферу, яка відрізняється від відомих тим, що враховує процес здіймання пилу за рахунок впливу динамічних характеристик вентиляційного потоку. На основі аналізу впливу динамічних характеристик вентиляційного потоку на інтенсивність надходження пилу в забійний простір під час роботи прохідницького комбайна отримано вираз для визначення маси пилу, що утворюється в результаті дії повітряного потоку. Отримане рівняння надає інструмент для прогнозування інтенсивності надходження пилу в шахтну атмосферу за конкретних операційних та вентиляційних параметрів. Ця можливість є незамінною для проактивного проектування та оптимізації комплексних стратегій боротьби з пилом, включаючи стратегічне розміщення систем пилопридушення, локальну витяжну вентиляцію та визначення оптимальних швидкостей повітряного потоку, які балансують потребу в розведенні газів із ризиком надмірного пилопідйому. Переходячи від емпіричного спостереження до кількісної моделі, ця робота закладає наукову основу для поліпшення якості повітря та забезпечення безпеки гірників на механізованих підземних вугільних шахтах.

**Ключові слова:** кількість пилу, динамічні характеристики вентиляційного потоку, відбита гірнича маса, зважений пил.