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Elimination of diatomite dust in the longwall extraction section of the Sig mine in western Algeria

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Abstract

Research relevance. *Dust generated by mining machines due to continuous loading and transport equipment movement especially in mines with no optimal ventilation conditions is a major problem for decision-makers. Dust directly affects mine capacity and exposes workers' lives to a risk of chronic disease due to the inhalation of large quantities of this dust and toxic gases during a seven-hour or eight-hour shift. Dust control methods in longwall mines vary from one mine to another, depending on ore composition.*

Research aim. *In this article we will examine the current flow process of eliminating dust in the longwall working section and propose another process to ensure optimal working conditions in the diatomite mine.*

Methodology. *Analysis of the technical equipment which is currently used in mining and geological operations and evaluation of its application at the facility under study represents a relevant approach to production efficiency improvement. The present research considers the possibility of using the flooded-bed scrubber system which was mainly used in underground coal mines to monitor dust in the longwall section. It has been evaluated how efficient the scrubber absorbs the dust generated as a results of the mineralized layer extraction, the concentration of the coal dust in the working section making up from 0.7 to 8.8 mg/m^3, while the dust produced during the extraction of the mineralized layer in the underground diatomite deposit is 0.38–1.21 mg/m^3 in the working section.*

Research results. The research resulted in the positive attitude towards the possibility of applying the flooded-bed scrubber, which is used in coal mines, at the longwall extraction sections of the Sig mine. It will significantly reduce the concentration of dust in the longwall section.

Conclusion. *In order to set the appropriate working environment inside the mine, an effective method of removing dust must be developed, it is especially important to remove dust during work, which will contribute greatly to boosting productivity and reducing diseases among workers.*

Key words: *longwall; flooded-bed scrubber; shearer; diatomite; dust.*

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Introduction. Previous studies in the health field have confirmed that inhalation of dust in mining exploitation resulting from the extraction of minerals was the main culprit in most cases of disease called “pneumoconiosis”. Many decision makers have tried to solve the problem of dust, especially in the longwall section in front of shearer where the main dust source.

Most mining industries in the world have used regulatory measures of dust especially in underground coal mines for example the AS285 standard for respirable dust particles [1], and AS3640 for inhalable dust particles [2]. In the last years many dust removal techniques have been developed in the United States and UK mainly and other countries in the world, but their adoption was that in underground mines there is thicknesses not exceeding 3 m. Operators in underground mines using the longwall extraction method did not have much success in reducing the levels of dust in the working sections.

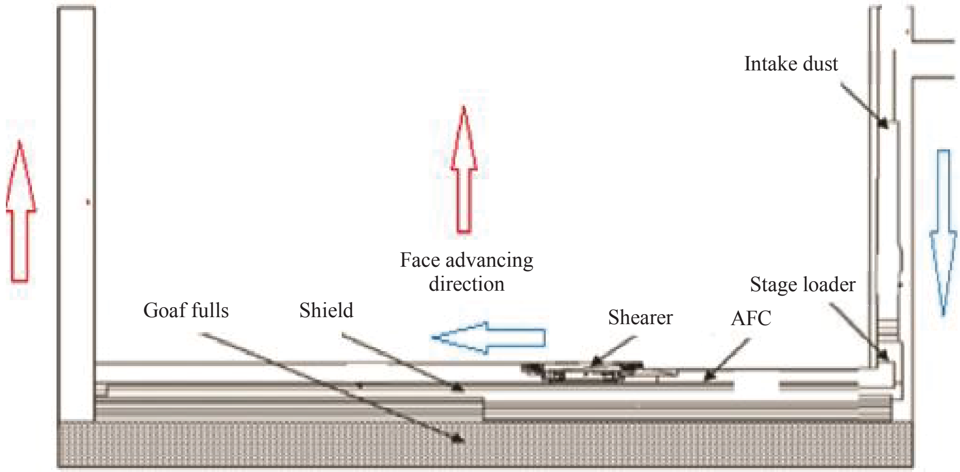

Fig. 1. Main sources of dust on the longwall section
Рис. 1. Основные источники образования пыли на участках длинных забоев

In this article we will propose the flooded-bed scrubber dust collection system that has been used in coal mines and used in the diatomite mine of Sig in western Algeria to help eliminate dust in the working section where the concentration of dust is very high. By isolating the sand-laden dust generated from the diatomite extraction face and produce breathable air, and put practices and a new methodology for dust monitoring.

Table 1. Dust contributions from major longwall dust sources
Таблица 1. Основные источники привноса пыли при разработке длинными забоями

Source	Average percent	Contribution median, mg/m^3	Contribution range, mg/m^3
Intake	9	0.33	0.07–1.1
Stage loader-crusher	15	0.78	0.29–1.3
Shield	23	1.8	0.67–2.3
Shearer	53	3.5	0.70–8.8

Sources of dust generation. The dust generated in front of the shearer during ore mining in face causes a complicated problem to workers especially in the longwall section. And dust generation may also occur during ore transportation with the AFC, where the ore direction is opposite of the air as shown in the fig. 1. Moving any equipment inside the underground mine can also cause significant amounts of dust. The collapse of the roof behind the supports and falling rocks can also become a source of dust.

Longwall underground mining method is one of the most productive methods in the world. In 2015 in the United States 54 coal mines used this method to produce 182 million tonnes of coal, or 59% of total production in the United States [3]. However, this significant production was negatively reflected in dust generation, which required finding effective solutions to deal with these large quantities affecting the workers inside the mine.

According to extensive studies conducted on underground mines that use longwall technology, only the main sources of dust due to:

– insufficient amount of air pumped into the mine;
– insufficient water quantity and pressure;
– water spray systems in the work section is poorly designed;
– there is no dust control system in the AFC loading;
– due to the movement of supports;
– the longwall extraction shearer.

Fig. 2. Photograph of shearer clearer on the shearer
Рис. 2. Фотография системы распыления на комбайне

Surveys of 13 mines using the longwall mining method indicate that the shearer is one of the main contributors to the production of respirable dust at the working section [4, 5]. As shown in table 1, the shearer represents more than 50% of the dust generated [4].

a *b*

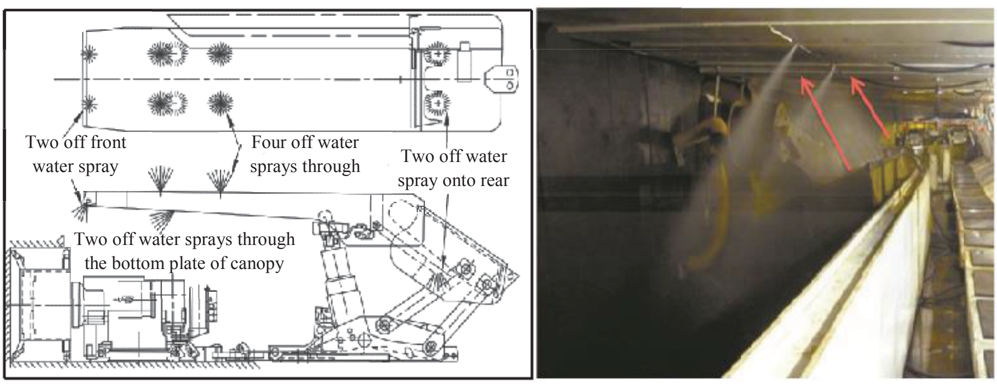

Fig. 3. Typical water spray layout pattern on longwall support in Australia:
a – spray system over canopy; *b* – spray system under canopy
Рис. 3. Типичная схема расположения распыления воды на участках длинных забоев в Австралии:
а – система распыления над навесом; *b* – система распыления под навесом

Longwall dust control systems.

Water spray layout on shearers. Underground mine workers realize that the continuous movement of the supports and the shearer is the main source of sand-laden dust to which they are constantly exposed. The dust cloud inside the mine spreads very terribly, if it is not controlled quickly and conveniently by placing a high-efficiency dust collector, so the working conditions will be very difficult because the speed of the shears is very high during work [6]. These large amounts of dust are mainly treated by applying a spraying system along the shearer body and concentrated on the shearer's drums where the proportion of dust is relatively greater than that of other areas of the shearer as shown in fig. 2. Water is pumped under high pressure into a device called NPSDR to produce a high-speed water spray. This helps to produce a negative pressure field in the suction area of the device. So, it can absorb the dust laden with sand to clean it [7]. It is a very good idea but it must be perfected [8].

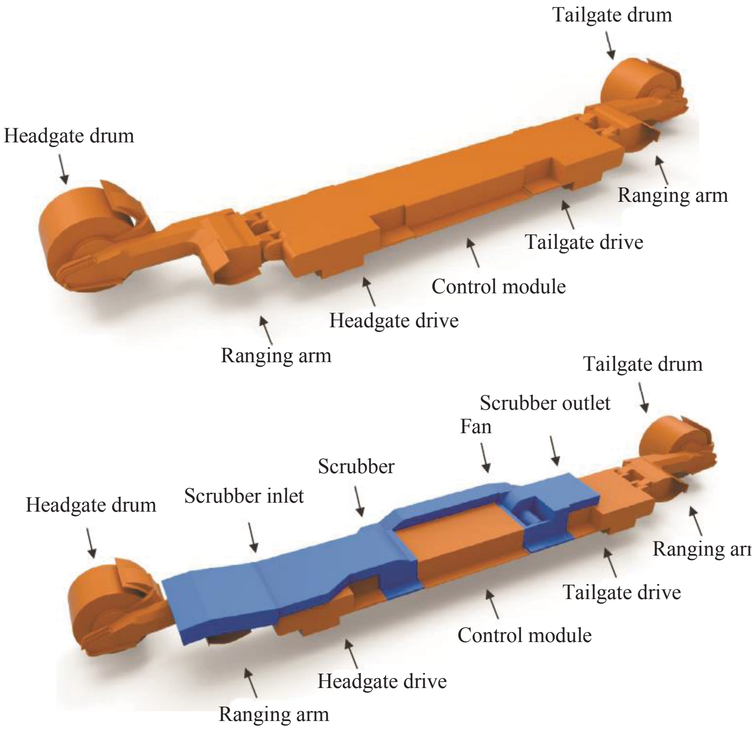

Fig. 4. 3D-drawing of the longwall shearer without and with an integrated flooded-bed scrubber
Рис. 4. Трехмерная модель врубовой машины для длинных забоев без встроенного скруббера с системой водной очистки и с ним

Dust control by the shields. Due to the permanent movement of the longwall shields and as the shields descend and advance towards the face of the mineralized layer, it is normal when the roof falls from the top of the shields towards the ventilation surface. Most of this dust is suspended in the air and disperses quickly in the walkway. As a result, we can say that the movement of the shields is an important source of dust for the operators of the shearer, when these shields move behind the shearer, from the headgate to the tailgate. To control the dust caused by the movements of the shields, many methods have been developed in recent years.

Canopy-mounted spray systems. This system includes a set of sprayers on the shields which sprays the roof for a short time before and after the movement of the shields to ensure that the material is wet in order to reduce the dust concentration at the longwall section, as shown in fig. 3. Studies in the United States and Australia have shown that this system is not effective for the control of dust [9].

Shield sprays under the canopy. This type of sprayer automatically works with the drum movement to form a water curtain to eliminate the dust cloud from the headgate to the tailgate as shown in fig. 3.

Flooded-bed scrubber for removing diatomite dust at a longwall mining section. A flooded-bed scrubber is a very effective dust control device, equipped with a high-speed main fan which is an integral part of the shearer as shown in the fig. 4 [10] to capture and remove the dust generated from the shearer at the longwall section during the ore extraction operation. This system has worked very well with the longwall underground mining method in the United States since its invention in 1983 [11]. The flooded-bed scrubber dust control system consists of six main elements: an inlet, water sump, a series of water sprays, a demister, a flooded-bed screen, and a vane axial exhaust fan as shown in the fig. 5, 6 [5, 12]. The inlet is well positioned in the dust area near the drum of shearer in the longwall section for quick dust recovery using ventilation. Sprayers produce large amounts of water, making flooded-bed screen always saturated with water. The fan draws the dust-laden air from the longwall section to the ductwork through the flooded-bed screen.

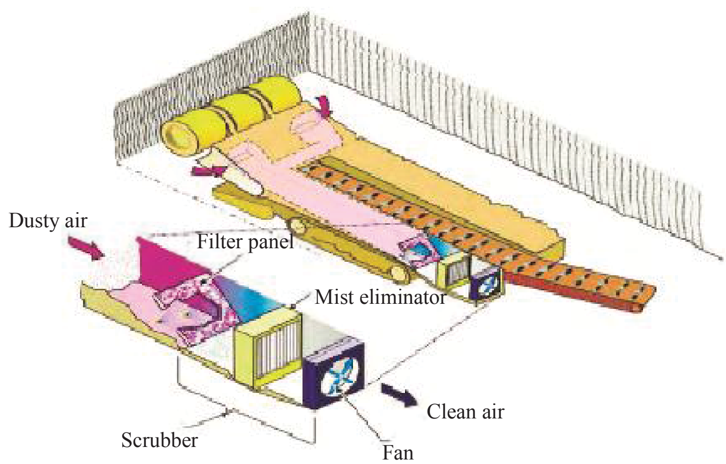

Fig. 5. 3D flooded-bed scrubber system
Рис. 5. 3D-изображение скруббера с системой водной очистки

When air enters the flooded-bed screen, the dust interacts with the water droplets inside the device, creating a mixture of water droplets and dust. This mixture of dust and water in the flooded-bed screen moves in the direction of the wind towards the demister. The latter is composed of several PVC layers, which separate the dust-laden water before the air reaches the fan. After completion of the separation process this mixture will be pumped into the sump under the demister. The clean air, almost dry passes through the fan to the back side of the longwall section and the workers where it runs out.

Full-cone water spray distributes the water inside at approximately 24.6 l/min usually under low pressure (< 345 kPa), these quantities guaranteeing in turn a complete water supply to flooded-bed screen. The fan motor power typically varies from 9.7 kW to 29.8 kW, with an air flow rate of 1.7 m^3/s to 4.7 m^3/s [14]. In order to increase the ventilation area, the flooded-bed screen must be placed at 45° from the working platform. This screen is mainly composed of layers (about 10–30 layers) of woven steel. The increase in the number of layers leads on the one hand an increased filtration, but on the other hand a significant reduction of the pressure in the flooded-bed.

The effectiveness of the flooded-bed scrubber system is based on two main factors: filter dust quality (cleaning efficiency) of screen, which also depends on the amount of dust absorbed in the longwall section (capture efficiency) [15]. The use of surfactants in the spraying operation at the interior of this device can greatly increase the efficiency of the screen cleaning, it helps to increase the wettability by reducing the surface tension of the water droplets [16]. A 2002 study was conducted on the effectiveness of surfactants added to water when spraying at a concentration of 0.013% by weight showed an increase in the percentage of dust reduction to 31% [17]. In conclusion, it can be said that the effectiveness of dust collection depends mainly on: the position of the scrubber inlet, and the air quantities and the capacity of the fans, and the design of the ducts.

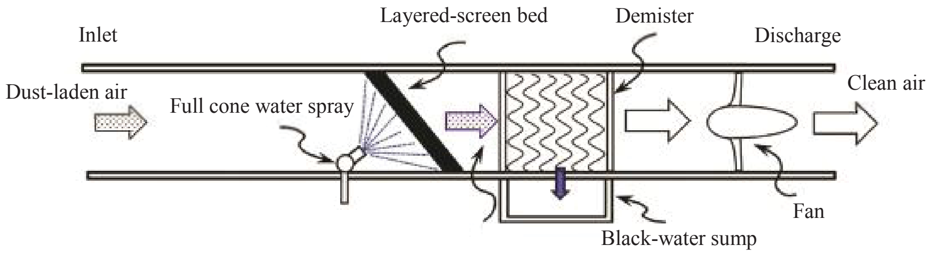

Fig. 6. Fan-powered flooded-bed scrubbers
Рис. 6. Вентиляторные скрубберы с системой водной очистки

Results and discussion. Given the geological nature of the diatomite deposit, dust produced during the exploitation of the deposit is very rich in SiO_2 silica up to 0.65 (0.38–1.21) mg/m^3 in the working section. On the other hand, a study was carried out in 2002 in the United States shows that the average levels of exposure to respirable SiO_2 silica in similar industrial environments is 0.05 (0.02–0.08) mg/m^3 [13]. While the coal dust generated by the shearer during its extraction is 0.7–8.8 mg/m^3 as shown in table 1. From these results it can be said that the system flooded-bed scrubber used in coal mines will be adequate and very effective in the diatomite mine.

Conclusion. The flooded bed scrubber system is one of the most efficient systems in the world and has attracted the interest of many researchers in this field for years. He has been very successful in longwall coal mines with large amounts of dust and gas. And from the results that we have indicated we can say that this system will be adequate with our case in the diatomite mine of sig west of Algeria (underground). This system will greatly reduce the exposure to dust in the working section, and as an integral part of the shearer this will suit the thickness of the mineralized layer of diatomite.

REFERENCES

1. AS2985-2004. Workplace atmospheres – method for sampling and gravimetric determination of respirable dust. Available from: www.saiglobal.com/pdftemp/previews/osh/as/as2000/2900/2985.pdf (Accessed 20.01.2020)

2. AS3640. Workplace atmospheres – method for sampling and gravimetric determination of inhalable dust. Available from: codehub.building.govt.nz/home/resources/as-3640-2009/ (Accessed 20.01.2020)

3. Fiscor S., 2016. *Coal age*. Mining Media Publ. P. 18–22.

4. Colinet J. F., Spencer E. R., Jankowski R. A. 1997. Status of dust control technology on U. S. Longwalls. In: *Proceedings of 6th International Mine Ventilation Congress*. P. 345–351.

5. Rider J. P. and J. F. Colinet, 2010. Chapter 3 – Controlling Respirable Dust on Longwall Mining Operations. In: *Best Practices for Dust Control in Coal Mining*. IC 9517, National Institute for Occupational Safety and Health. P. 17–39.

6. Ren X. F. Research on ventilation dust technology of long-pressure and short axis for fully mechanized excavation face. *Shaanxi Coal*. 2013; 4: 005.

7. Xie Y. S., Fan G. X., Dai J. W., Song X. B. New respirable dust suppression systems for coal mines. *J. China Univ. Min. Technol*. 2007; 17(3): 321–5.

8. Tien J. C. Dust control practices in Chinese coal mines, with remarks on black lung. *Min. Eng*. 2011; 63(10): 24–9.

9. Ren T. X., Plush B., Aziz N. Dust controls and monitoring practices on Australian longwalls. *Proc. Eng*. 2011; 26: 1417–29.

10. Sampurna Arya, et al., 2018. *Development of a flooded-bed scrubber for removing coal dust at a longwall mining section*. Available from: doi.org/10.1016/j.ssci.2018.08.003.

11. Campbell J. A. L., Moynihan D. J., Roper W. D., Willis C., 1983. Dust control system and method of operation. US 4380353 A.

12. Sampurna Arya, et al., 2018. Design and experimental evaluation of a flooded-bed dust scrubber integrated into a longwall shearer. *Powder Technology*. Available from: doi.org/10.1016/j.powtec.2018.07.072.

13. Dirk Dahmann et al., 2008. *Assessment of exposure in epidemiological studies: the example of silica dust*. No. 18. P. 452–461. Available from: www.nature.com/jes

14. Wedding W. C., Novak T., Arya S., Kumar A., 2015. CFD modeling of a flooded-bed scrubber concept for a longwall shearer operating in a U.S. coal seam. In: *Proceedings of 15th US Mine Ventilation Symposium*. P. 385–390.

15. Colinet J. F., Jankowski R. A., 2000. Silica collection concerns when using flooded-bed scrubbers. *Min. Eng*. No. 4. P. 49–54.

16. Listak J. M., 2010. Chapter 4 – Controlling Respirable Dust on Continuous Mining Operations. In: *Best Practices for Dust Control in Coal Mining*. P. 41–64.

17. Hirschi J. C., Chugh Y. P., Saha A., Mohany M., 2002. Evaluating the use of surfactants to enhance dust control efficiency of wet scrubbers for illinois coal seams. In: *Proceedings of 9th U. S. Mine Ventilation Symposium*. P. 601–606.

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Очистка участков разработки длинными забоями от диатомитовой пыли в шахте Сиг в Западном Алжире

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Реферат

Актуальность. *Для работников горнодобывающей промышленности серьезной проблемой является пыль, которая создается горными машинами из-за постоянного движения транспортного оборудования и погрузки, особенно в шахтах, где отсутствуют оптимальные условия вентиляции. Наличие пыли напрямую влияет на производительность шахты и создает для рабочих повышенные риски получения хронических заболеваний, связанных с вдыханием в течение семи-восьмичасового рабочего дня большого количества пыли, а также токсичных газов. Методы подавления пыли в шахтах с системой разработки длинными забоями отличаются друг от друга в зависимости от состава извлекаемой руды.*

Цель работы. *Рассмотреть действующие технологические процессы для устранения пыли в рабочей секции длинных забоев и предложить другой процесс для обеспечения оптимальных рабочих условий в диатомитовой шахте.*

Методология. *Анализ используемых в горно-геологическом производстве технических средств и оценка их применения на исследуемом объекте представляет собой актуальный подход к увеличению эффективности производства. В статье рассмотрена возможность применения скруббера с системой водной очистки, который используется главным образом в подземных угольных шахтах для поглощения пыли на участках длинных забоев. Проведена оценка эффективности поглощения скруббером пыли, образующейся при разработке угольных пластов, где концентрация угольной пыли в рабочей секции составляет от 0,7 до 8,8 мг/м^3, и осуществлено сравнение с возможностью использования скруббера при добыче минерализованного слоя в подземном месторождении диатомита, где плотность пыли составляет 0,38–1,21 мг/м^3.*

Результаты исследования. *В результате исследования была получена положительная оценка возможности использования для участков разработки длинными забоями на диатомитовой шахте Сиг модели скруббера с интегрированной системой мокрой очистки, которая используется в угольных шахтах. Это позволит значительно снизить концентрацию пыли на участках разработки длинными забоями.*

Выводы. *Для того чтобы установить подходящие условия для работы внутри шахты, необходимо разработать эффективный метод удаления пыли, особенно во время работы, который будет в значительной степени способствовать увеличению производительности и снижению заболеваемости среди работников.*

Ключевые слова: *длинный забой; скруббер с системой мокрой очистки; врубовая машина; диатомит; пыль.*

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БИБЛИОГРАФИЧЕСКИЙ СПИСОК

1. AS2985-2004. Workplace atmospheres – method for sampling and gravimetric determination of respirable dust. URL: www.saiglobal.com/pdftemp/previews/osh/as/as2000/2900/2985.pdf (дата обращения 20.01.2020)
2. AS3640 Workplace atmospheres – method for sampling and gravimetric determination of inhalable dust. URL: codehub.building.govt.nz/home/resources/as-3640-2009/ (дата обращения 20.01.2020)
3. Fiscor S., 2016. Coal age. Miniing Media Publ. P. 18–22.
4. Colinet J. F., Spencer E. R., Jankowski R. A. 1997. Status of dust control technology on U. S. Longwalls. In: Proceedings of 6th International Mine Ventilation Congress. P. 345–351.
5. Rider J. P. and J. F. Colinet, 2010. Chapter 3 – Controlling Respirable Dust on Longwall Mining Operations. In: Best Practices for Dust Control in Coal Mining. IC 9517, National Institute for Occupational Safety and Health. P. 17–39.
6. Ren X. F. Research on ventilation dust technology of long-pressure and short axis for fully mechanized excavation face // Shaanxi Coal. 2013. No. 4. P. 005.
7. Xie Y. S., Fan G. X., Dai J. W., Song X. B. New respirable dust suppression systems for coal mines // J. China Univ. Min. Technol. 2007. No. 17(3). P. 321–5.
8. Tien J. C. Dust control practices in Chinese coal mines, with remarks on black lung // Min. Eng. 2011. No. 63(10). P. 24–9.
9. Ren T. X., Plush B., Aziz N. Dust controls and monitoring practices on Australian longwalls // Proc. Eng. 2011. No. 26. P. 1417–29.
10. Sampurna Arya, et al., 2018. Development of a flooded-bed scrubber for removing coal dust at a longwall mining section. URL: doi.org/10.1016/j.ssci.2018.08.003.
11. Campbell J. A. L., Moynihan D. J., Roper W. D., Willis C., 1983. Dust control system and method of operation. US 4380353 A.
12. Sampurna Arya, et al., 2018. Design and experimental evaluation of a flooded-bed dust scrubber integrated into a longwall shearer // Powder Technology, URL: doi.org/10.1016/j.powtec.2018.07.072.
13. Dirk Dahmann et al., 2008. Assessment of exposure in epidemiological studies: the example of silica dust. No. 18. P. 452–461. URL: www.nature.com/jes
14. Wedding W. C., Novak T., Arya S., Kumar A., 2015. CFD modeling of a flooded-bed scrubber concept for a longwall shearer operating in a U.S. coal seam. In: Proceedings of 15th US Mine Ventilation Symposium. P. 385–390.
15. Colinet J. F., Jankowski R. A., 2000. Silica collection concerns when using flooded-bed scrubbers // Min. Eng. No. 4. P. 49–54.
16. Listak J. M., 2010. Chapter 4 – Controlling Respirable Dust on Continuous Mining Operations. In: Best Practices for Dust Control in Coal Mining. P. 41–64.
17. Hirschi J. C., Chugh Y. P., Saha A., Mohany M., 2002. Evaluating the use of surfactants to enhance dust control efficiency of wet scrubbers for illinois coal seams. In: Proceedings of 9th U. S. Mine Ventilation Symposium. P. 601–606.

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