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Research Article

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Harmful Dust in Underground Coal Mine and its Assessment

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ABSTRACT
The paper deals with radical dusty conditions at workplaces in underground coal mine and with physical factors that affect employees´ performance. The extreme effect of the dust can significantly contribute to permanent health damage or even the death of employees. Authors present and discuss the results of their measurements of airborne dust and respiratory dust at the wall cutting in a coal mine and propose effective measures to reduce the burden on the life and health of employees and the environment. The measurements were carried out in the 11th mining field, in the main exhaust mine work 08 240 of the B airy pit at a stationing of 220 m. For the representativeness of measurements, the dust tables were placed in the profile of the mine taking into account the braking of the airflow.

Dust sampling is the responsibility of the employees of the Ventilation and Drainage Department. The samples obtained for internal purposes are evaluated within the company. Responsibility for the analysis of samples is bore by Nováky Mine Coal Testing Laboratory. Sampling is carried out by direct data collection in the mining company Hornonitrianske bane Prievidza a.s. in the underground workplaces of the Nováky brown coal mine. The measurement of the minimum ignition energy of the airbone coal dust was carried out at Faculty of Security Engineering, University of Žilina.

The issue of occupational health and safety of employees is legislatively addressed by several regulations and decrees. When measuring and investigating the effects of dust on the human body, international regulations are used in practice.

Keywords: Coal Dust, Underground Coal Mine, Minimum Ignition Temperature, Respiratory Dust Measurement, Explosive Dust

Introduction

Coal dust is a significant issue in coal mines, posing serious health risks to mine workers. The inhalation of coal dust can result in a range of health problems, including respiratory diseases. An equally serious problem associated with the occurrence of flammable coal dust in coal mines is the possibility of its explosion if the conditions of the explosion pentagon are met. In addition, coal dust can also contribute to environmental pollution.

Despite efforts to control coal dust exposure in mines, it remains a persistent problem due to the nature of coal mining operations. Coal dust is generated during the mining, transportation, and processing of coal, and can become airborne in the mine atmosphere. To assess the level of harmful dust in underground coal mines, various monitoring techniques are employed. These include personal dust monitors worn by miners, fixed-point dust monitors installed in key areas of the mine, and periodic air sampling for dust concentration analysis. Several experimental methods are also used to determine the explosiveness of coal dust. One of them is the determination of the minimum ignition temperature of combustible coal dust in a swirling state.

Dust has various definitions. Turekova defines dust as fine particulate matter dispersed in the air , while Weiss considers it inorganic or organic particles in a gaseous environment, excluding smoke [2,3]. Combustible dust consists of particles up to 500 µm, which can form an explosive atmosphere when stirred into the air and settle into a layer capable of explosion [4,5]. The Slovak Mining Authority Decree No. 21/1989 Coll. defines dust as solid particles found in mining air [5].

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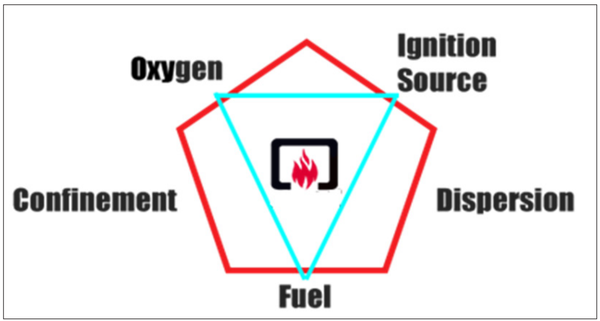

Figure 1: Fire triangle and combustible dust explosion pentagon [1]

Mining operations feature dust particles of different sizes, categorized into four groups respiratory dust (0.5 μm to 10 μm), which penetrates the lungs; airborne dust (5 μm to 30 μm), which remains in the air and is carried by ventilation systems; dust layers (30 μm to 100 μm), which settle quickly; and stirred dust, formed by the disturbance of dust layers [6].

Prolonged exposure to mine dust causes irreversible damage to the body, worsened by factors like temperature, humidity, fumes, and noise. Long-term exposure can lead to diseases such as pulmonary fibrosis, mucosal inflammation, skin and eye inflammation, and ear infections [7].

Materials and Methods

Dust sampling is the responsibility of the employees of the Ventilation and Drainage Department, hereinafter referred to as the UVO. The samples obtained for internal purposes are evaluated within the company. Responsibility for the analysis of samples is bore by Nováky Mine Coal Testing Laboratory, hereinafter referred to as SLUBN. Sampling is carried out by direct data collection in the mining company Hornonitrianske bane Prievidza a.s. in the underground workplaces of the Nováky brown coal mine using accredited CIP 10 type instruments and stationary dust tables.

Measurements of Airborne Dust

were carried out as part of an internal request in the coal mine. The standardized procedure of measuring using dust tables rests in placing the measuring station in the entire transverse axis of the mine at such a height that the bottom edge of the tables is located at half the height of the total height of the mine work. The size of the table is 150x200 mm stacked in a series to cover the entire transverse axis of the mine. The tables were made of hard plastic. In the mine, the airflow ranged from 1,400 m^3/min to 1,500 m^3/min at the time of the measurements [6,8].

Figure 2: Measurement of airborne dust with dust tables

Respiratory Dust Measurements at the Wall Cutting were undertaken based on an internal request from the Production Management Unit and a request from the Occupational Health Service. The measurements were carried out on mechanized cutting of 111 021-95 of staff team X1 and the mechanized boring in the corridor 111 123-05 of staff team X2. Two CIP 10 devices were used for the measurements, attached to the 2 employees in the breathing zone. CIP 10 devices ATEX have CIP-R inlet and 10L per min sampling flow rate. Dust exposure to employees of individual work operations or the total dust concentration of the workplace was measured with the given devices. These are devices that, based on a magnetic field, attract dust particles directly to the measuring zone of the device. The device captures these particles. The measurement output is the amount of captured dust particles per monitored time – in our case, this was a 9.5-hour work shift in my operation. Measurements were made over a long period of time and in continuous operation to capture all work operations at the given workplace. Therefore, we could express measurements for an average workplace occupation by individual employees. Subsequently, we took the captured amounts of dust from individual measurements from the devices, which were only quantitatively weighed and stored. After the measurement, there were calculated average amounts of dust captured on the dust meter, the airflow volume passing through the workplace, and the length of the work shift.

Figure 3: Pair of dust meter CIP 10

Minimum ignition temperature of the coal dust measurement is used to perform experiments using a furnace into which dust is sprayed at a constant temperature. A heating ceramic tube - the furnace - is mounted vertically on an iron frame and air is admitted to the dust container through a valve. The air pressure in the compressed air container is shown by an attached manometer. A dust sample is placed in the dust container, which is dispersed into a ceramic furnace with a constant temperature by releasing compressed air. The furnace temperature is regulated by an attached temperature controller. The possible ignition of flammable dust is observed on the mirror at the bottom of the device.

Results and Discussion

Measurement of Airborne Dust in the Mining Field

Using the described procedures, dust concentration values were calculated and appropriate types of disconnecting mechanisms were assessed for dust production when the mining section was loaded with a certain number and type of active workplaces. the measured values are shown in Table 1.

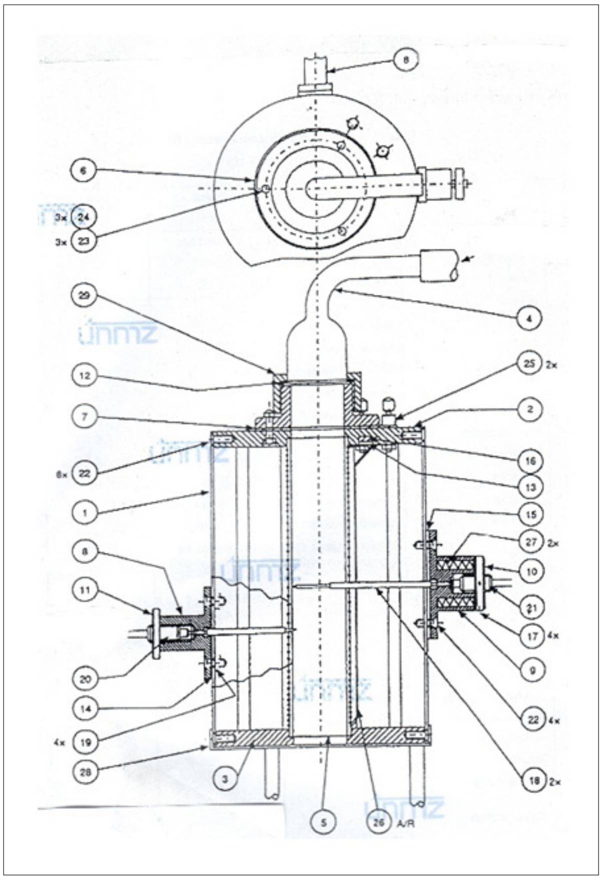

Figure 4: Scheme of the testing device for determining the minimum ignition temperature of dust in a stirred-up state [9]

Table 1: Coal sedimentary dust layer

Sampling	Total concentration (mg.m^{-3})
I.	28/21/
II.	25/26
III.	39/16
IV.	38/24
Average (mg·m^{-3})	**24,575**
Standard deviation (mg·m^{-3})	**8,64**

Measurement Of Respiratory Dust at The Wall Cutting

During specific measurements, we assessed a 9.5-hour work shift at specific workplaces. The results achieved in personal sampling at the mechanized boring 111 021 - 95 were as follows:

Table 2: In person collection of respiratory dust at the wall cutting

Total dust weight [mg.m^{-3}]	Respirable dust fraction [mg.m-3]
28,3	4,4
1,32	0,4

Average values were calculated from the measurements of dust concentration and its respiratory component. The result was 1.27 mg.m^{-3} of dust concentration at the workplace and 0.32 mg.m^{-3} of its respiratory component. When calculating these averages, factors considered included the work shift, airflow temperature before entering the workplace, at the workplace, and when leaving the workplace, as well as humidity and airflow speed. The temperature was particularly important because some workplaces were ventilated with a separate ventilation stream, while others had continuous ventilation.

Measurement of Minimum Ignition Temperature of Airborne Dust

As part of determining the minimum ignition temperature of coal dust, its dependence on the particle size of the dust was examined. The results clearly indicate that with increasing fineness of the dust, the value of the minimum ignition temperature decreases, which increases the risk of explosion. The dependence of the minimum ignition temperature on the weight of the coal dust sample was also investigated. Both dependencies can be seen in Figure 5.

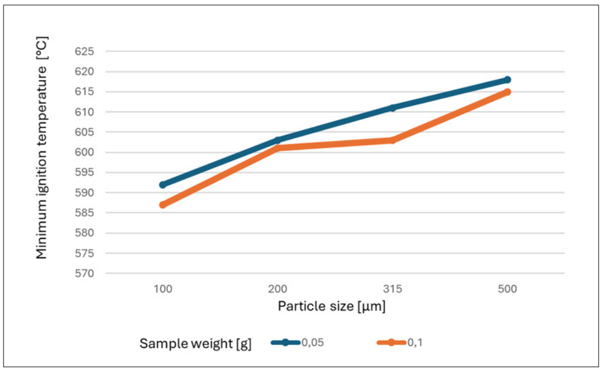

Figure 5: Minimum ignition temperature of coal dust depending on the sample weight and particle size

Conclusion

The article deals with the properties of harmful dust in underground coal mines and its impact on the health of workers. Inhalation of coal dust poses a serious health risk, including respiratory diseases. In addition to health risks, the occurrence of combustible coal dust is also associated with a serious explosion hazard if the conditions of the explosion pentagon are met [10-12]. Dust is generated in the mine during the extraction, transportation and processing of coal.

Various monitoring techniques are used to assess the level of harmful dust in underground coal mines. These include personal dust monitoring, stationary monitors and regular air sampling. The work, both theoretically and through practical measurements, points to the persistent problem of dust in underground coal mines, which poses a significant risk to the health and safety of workers. The presented measurements demonstrate the methods used to quantify dust exposure and assess the risk of explosion. The results of the measurements confirm the presence of dust in the workplaces and the research of the minimum ignition temperature emphasizes that the fineness of the dust directly affects its flammability and the risk of explosion. Based on the findings, it is necessary for the competent authorities to deal with the design of effective measures to reduce the burden on the health of employees and the environment.

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