

Use of Air-And-Water Spraying Systems

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ABSTRACT: *Airborne dust in mine which is produced during reshuffling of the ore exposes workers to the risk of pneumoconiosis as it provides the opportunity for coal dust to explosion and spread. This article describes air-and-water spraying systems which are used in long wall shearers, road headers, conveyor transfer points and roadways. The clear and lightweight design of roadway spraying systems means that wherever dust exists in the air the solutions can be used. The spraying systems form an integral part of longwall shearers and their purpose is to reduce levels of airborne dust and to prevent explosion of methane. Using air and water spraying systems will minimize concentration of dust by up to 80 per cent and lead to a substantial reduction in air dust concentration. Some test results regarding the effectiveness of air-and-water spraying systems, verification tests of the author's spraying solutions are provided there's even talk about nozzles.*

KEYWORDS: *safety, hazard, air dustiness, dust, air dust reduction, air-and-water spray*

INTRODUCTION

Airborne dust in mine exposes employees to the possibility of pneumoconiosis because it creates the possibility of explosion of coal dust and its spread. According to the regulations, when dust concentration reaches 30 g / m³, it is mandatory to take the steps to protect the deposited coal dust against ignition. According to the study, exposure of employees' respiratory system to dusty air in mines results in 400-500 new cases of pneumoconiosis per year, while cumulative period of disease is 5-10 years pending exposure strength of the respiratory system to dust breathing fraction[1].

The number of pneumoconiosis cases is expected to rise over the next few years. Current methods used to manage airborne dust in mines, including the methods utilizing the spraying and ventilation systems, do not produce the desired result, i.e. reduction of dust levels below the maximum allowable concentration. One of the methods used in the cutting drums produced by Krummenauer was the spraying process using rotating spraying curtain (RAC)[2], which resulted in a reduction of the airborne dust concentration below the maximum permissible amount. Then the concentration of airborne dust was at the point at which the workers were able to operate without devices to protect the respiratory system. Sprinkling water consumption was around 400 l / min, however, so it surpassed the water consumption of a typical shearer spraying system.

The primary techniques used to control airborne dust are powder management and spraying. Dry and wet dust controllers with the exhaust fan attached to or in the vicinity of the road header are primarily used in the faces of the roadway. Spraying systems are used as part of shearers or road headers facilities, or as an isolated unit attached to the road support, in long wall panels and roadway faces. It is often used to spray on crushers, transfer points of conveyors and in roadways in the form of spraying curtains.

Air-and-water spraying systems are used most frequently because of the issues created by the disproportionate volume of water in a roadway arising from the use of water spraying systems. We have excellent properties with regard to extinguishing methane combustion and accumulated methane dilution, as well as requiring less water volume. Owing to the atomization of water to the smaller particles, higher efficiency of dust control is achieved than with conventional water spraying systems. Such solutions do not require the use of a pump that increases the pressure as the water pressure required is usually lower than can be found in firefighting pipelines[3].

Research, development and implementation work has been carried out at the KOMAG Institute of Mining Technology for many years regarding the use of air-and-water spraying to reduce airborne dust concentration. The product of this work is the design and implementation of spraying systems that use air and water spraying systems which are used in longwall shearers, road headers, conveyor transfer points which spraying curtains designed to manage airborne dust on roads. Air-and-water spray nozzles are designed and tested at the same time. The research is performed in a simulated world, at stands with object models and on actual objects[4].

CHARACTERISTICS OF AIR-AND-WATER SPRAYING SYSTEMS

As a result of cooperation between the Mining Technology KOMAG Institute, JSW S.A. KOPEX Machinery SA (manufacturer of longwall shearers) and KOPEX Machinery SA (manufacturer of longwall shearers), an air and water spraying system for longwall shearers, have been developed and introduced as the first industrial-scale system used in longwall shearers to reduce the danger of methane ignition during longwall shear mining. Highly atomized gas clouds around the cutting drum provide protection outside of the mining area against unintended methane ignition. Methane ignition was not recorded when air- and water-spraying installation longwall shearers were used.

It has been shown after the first tests that air-and-water spraying is highly effective in regulating air from the dust mine. Original nozzles designed for the system were called STK. Their design and parameters for air-water supply fully satisfied the requirements of the collieries. Air-and-water nozzles use less water in this solution than conventional water nozzles and at the same time have a much better atomized current.

The air-and-water spraying systems are used in all forms of KOPEX Machinery provided longwall shearers. As they have become a standard colliery installation, a substantial improvement in dust reduction efficiency has been recorded, and no instances of methane ignition have occurred in longwalls.

Positive results from air-and-water spraying curtains used in longwall shearers led to the design for road headers of a similar solution. The air-and-water spraying curtain was designed and commissioned for all types of road headers generated by them as a result of the activities. The new machine is using less water to remove the particles.

Aside from the mining fronts and mine faces, conveyor transfer points are also places that contain considerable dust amounts. The transfer points located on the intake side of a longwall significantly increase the dust concentration, exceeding the maximum permissible concentration (MAC) during run-of-mine conveyor transport in a fresh air stream. The transfer points produce dust far from the mining fronts during run-of-mine conveyor transport in a flux of used fuel.

MAC means the concentration of coal dust above which, without personal equipment, people can not work to protect their respiratory system. MAC is equivalent to 4 mg / m³ for total coal dust, and equals 2 mg / m³ for respirable fraction, according to Polish regulations.

The airborne dust problem was completely solved by the Bryza-1200 transfer point spraying system, developed by KOMAG (manufactured by Elektron S.C.) and Virga spraying system (manufactured by Hellfeier). These are basic devices consisting of a frame with nozzles for air and water, and a feeding mechanism. The collieries became interested in them because of their very high efficiency in suppressing airborne dust and water consumption ranging between 0.5 and 2.0 dm³ / min. The further move in solving the dust problem was the construction of a roadway dust barrier.

Components of the Bryza-1200 transfer point sprinkler were used to construct the dust barrier on the CZP BRYZA roadway. The system has water consumption ranging from 1.5 to 3.0 dm³ / min and airborne dust control performance is greater than 50 per cent. This reduced concentration of dust below MAC. The solution has been used for removing dust from the outline of headings covering a distance of approx. in several

collieries. 100 m and to increase moisture on the floor. It ensures that time is increased by around 50 percent between operations of dusting the head-in with rock dust. The Bryza system has all the benefits of a newly built version of a spraying unit for processing plants. Collieries were interested in implementing the solution due to its low water consumption, easy control and high dust control performance.

Two-medium spraying nozzles

STK type air-and-water spraying nozzles have been designed for air-and-water spraying devices developed by KO- MAG. The nozzles have a monolithic design with two inlet openings for separate supply of water and compressed air to the mixing chamber. Water in the form of aerosol is atomized and expelled from the chamber. Depending on the use of the nozzle the outlet opening has a diameter of 1-3 mm. STK nozzles have a flow rate of 0.1–1 dm³ / min for water and a flow rate of 50–100 dm³ / min for air below 0.5 MPa, depending on their function. STK nozzles produce drops of median diameter between 20 and 50 µm, where 90% of nozzle drops do not exceed 90 µm and 10% of drops do not exceed 10 µm[5].

The diameter of the spraying nozzles as well as the shape of the mixing chamber were adjusted in the next design iterations, and the exterior design features of the nozzles were also updated.

The air-and-water spraying nozzles have to create a stream of drops of very similar size and size distribution irrespective of their configuration and the diameter of the nozzle orifices. Depending on the expected level of airborne dust, the type and quantity of the nozzles should be selected in such a way that sufficient drops are produced to eliminate dust accompanying the transfer of run-of-mine[6].

Spraying installations of longwall shearers

The efficiency of spraying systems in reducing concentration of air-borne dust in mines was evaluated under operating conditions during experiments.

A longwall test was performed using a KSW-880EU screwdriver to compare the efficiency of airborne dust reduction between an air-and-water spray system with STK nozzles and a water spray system with G-243 nozzles mounted in a cutting tank.

Dust concentration measurements were conducted using CIP-10 gravimetric dust meters. They require the weight of the total dust to be measured as well as the weight of the respirable fraction thereof. Dust meters suck the air at a rate of 10 dm³ / min and force its movement through filters that remove dust from the surface. The dust meters were still hung near the cutting drum on the longwall shearer. The calculation was only taken when the solid coal was removed.

Dust concentration measurements showed that the concentration of total suspended particulate matter produced by the longwall shearer's cutting drums with the use of water spraying exceeded 170 mg / m³, while the concentration of respirable fraction of dust was about 12 mg / m³, respectively. The calculated total suspended particulate matter was found to be reduced to 100 mg / m³ when the air-and-water spraying method was used, while the concentration of the respirable fraction was not greater than 1 mg / m³. The above results revealed that the performance of the reduction of airborne dust is higher when using the air and water spraying system (42% for total suspended particulate matter and 93% for respirable dust) than when using the water spraying system. During longwall shearer cutting, respirable dust concentrations are lower than MAC when using the air-and-water spraying method.

VIRGA spraying system

Using the expertise and experience of KOMAG specialists in air-and-water spraying to control airborne dust, the VIRGA spraying system (using air and water) could be designed to control dust in belt conveyors and conveyors. The machine was used in the BRZESZCZE colliery in the fresh air flows along the haulage way.

The solution's versatility allows for the use of it at all forms of conveyor transfer points and other sources of dust[7].

The VIRGA spraying device mounted along transport routes was planned to meet the Brzeszcze colliery requirements. Three possible designs of spraying systems were prepared after analysis of the mine's needs. Both of them required 2 dm³ / min of water under 0.3 MPa pressure and 250π350 dm³ / min of compressed air under 0.3 MPa pressure.

Following the installation of the VIRGA spraying device in the conveyor of the run-of-mine transport network from longwall 128 in seam 401, at level 740 m in Brzeszcze colliery, tests have been carried out on the efficiency of dust control in the mine environment. The air-and-water VIRGA spraying system was mounted as close as possible to the longwall inlet at the straight transfer point of the belt conveyor, at the angular transfer point of the belt conveyor (located as far as possible from the longwall inlet), and at the straight beam stage loader transfer point (Grot type)[8].

Measurements taken at all transition points allowed the measurement of the efficiency of minimizing air dust concentration with the VIRGA system's air- and water spraying systems.

With the use of the VIRGA air and water spraying system, the average concentration of total suspended particulate matter and breathable dust fraction were found to be significantly lower than the measured average dust concentration in the air without spraying. At the transfer point on a flight-bar conveyor the maximum average concentration of total suspended particulate matter and breathable fraction of dust was measured. The total suspended particulate matter without the spraying system was approximately 136 mg / m³ while the actual average concentration of total suspended particulate matter was approximately 31 mg / m³ with the use of the VIRGA system. Concentration of the respirable dust fraction without spraying was 26.7 mg / m³, the lowest average concentration of respirable dust fraction was 4.3 mg / m³ with the use of the VIRGA air-and-water spraying method.

The lowest dust concentration was determined at a transfer point which was angled. The average suspended particulate matter with a spray system was 12.1 mg / m³, while it was 3.2 mg / m³ with the use of the VIRGA system, i.e. below MAC. The average concentration of respirable dust fraction without spraying was 5.9 mg / m³ and 1.2 mg / m³ with the use of the VIRGA air-and-water spray system.

Bryza-1200 transfer point sprinkler

The Bryza-1200 sprinkler transfer point is composed of three basic components:

- Frame with spray nozzles bank
- Ribbing
- Control Panel

The sprinkler is supplied to the mine network under pressure with water and compressed air.

A typical sprinkler frame is fitted with three spraying banks, each with 3 nozzles. At a flow rate of approx. each of the nozzles is filled with water. 0.1 dm³ / min and flow rate of air approx. 50 p.m./min. The sprinkler fitted with five air-and-water spray nozzles has a water flow rate of approximately 0.5 dm³ / min. The first Bryza-1200 transfer point sprinkler unit was mounted at a conveyor belt transfer point in the LW Bogdanka S.A. mine, where it was tested. The use of the Bryza-1200 sprinkler with a water flow rate of approximately 0.5 dm³ / min concentration of dust has been decreased by 67%, up to 82% for different directions of the spraying stream to a transfer point. Such a high decrease in airborne dust concentration was achieved not only by spraying well atomized water through compressed air, but also by installing a grid where wet dust and dry

dust could settle. The positive results of the performance tests in reducing the concentration of airborne dust, simple handling and reliability of the sprinkler mounted in the LW Bogdanka mine resulted in the installation of another 20 Bryza-1200 sprinklers[9].

Bryza roadway dust barrier

The dust barrier on the Bryza roadway (Fig. 10) is a modification to the Bryza sprinkler. The concept aims to reduce amounts of airborne dust in air flowing in roadways. The following components form a roadway dust barrier:

- Panels with spray nozzles banks
- Louvers fixed
- Slipping ribs
- Control panel

The barrier is fitted with three spray containers, each with three spray nozzle banks, where three nozzles can be put in. A typical version of a Bryza barrier is fitted with approximately 15 air-and-water spraying nozzles with a total water flow rate of about 1.5 dm³ / min. As in the case of a Bryza 1200 transfer point sprinkler, a preparation unit controls the volume of the compressed air and water.

The drops of sprayed water collide with particles of dust which raise their mass. Then the particles settle on the chains-hanging louvers and arranged along the entire surface of a heading in a labyrinth filter to catch most of the wet dust, and allow safe passage of mine personnel. The barrier is fitted with sliding louvers to allow for the passage of a suspended monorail or transported long objects. The first device of the dust barrier at the Bryza roadway was in-stalled in the Budryk colliery main gate. Dust reduction measurements, taken at the Barbara Experimental Mine, while using the BRYZA barrier, shown in Fig. 12, demonstrates dust control output between 40 percent and 50 percent of total airborne particles. During experiments, water condensed along the whole job on the side walls washing away the dust that had accumulated on it in a portion of around 100 meters. In addition, months in the floor increased enough to expand time intervals between dusting operations of the heading with rock dust by approximately 50 per cent. Good findings regarding the removal of airborne dust during the introduction of the Bryza roadway dust barrier in the Budryk colliery resulted in the construction of another dust barrier in the tailgate.

The tests ordered by the mine showed that the concentration of airborne dust behind the barrier was reduced by about 50 per cent.

CONCLUSION

KOMAG-designed air-and-water spraying systems significantly minimize concentration of dust in mine soil. The spraying systems are intended for areas in a mine which generate significant dust where clean air is required. A small volume of water (between 0,1 and 0,4 dm³ / min) and a small volume of air (between 50 and 150 dm³ / min) are needed for the two-medium spraying nozzles.

The air-and-water spraying facility built at KO- MAG to eradicate the danger of methane ignition also turned out to be a useful tool in reducing dust. Concentration of total dust during longwall shearer service. The concentration of the respiratory fraction was reduced by 42 percent, and by 93 percent. Currently all types of KOPEX Machinery manufactured longwall shearers can be fitted with such an device.

The spraying devices VIRGA and Bryza-1200, equipped for belt transfer points, are also very effective in dust management, exceeding the dust reduction by more than 70 per cent. The dust defense barrier of the BRYZA roadway decreases dust accumulation in the entire cross-section of the roadway by around 50 per cent. The

effects of the management of coal dust meet the mines' full standards. Additional benefits were also found in the case of the BRYZA dust barrier, such as an improvement in floor moisture and the removal of dust from roadway outlines at a length of about 100 m.

Flexibility of the approaches addressed for dust management allows use them in other places where there may be a similar issue with airborne dust.

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