Methods for Dust Removal in Roadway Sections

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ABSTRACT

Systems for dust extraction in roadway workings subjected to suction or forced ventilation are a combination of dust collecting equipment and facilities designed for ventilating the working. Such a combination of suitable equipment provides safe and effective dust removal and ventilation of a roadway working as well as is determinant of proper cooperation of the equipment a system is composed of. The development of effective dust collectors of wet type which provide safe operation under conditions of great exposure to coal dust and methane explosion hazards as well as of vortex ventubes allowing methane accumulations under the roof to be removed makes it possible to apply regularly the designed systems. The efficiency of dust collecting equipment ranges from 99% to 99.8%. Measurements of the efficiency are carried out on a measuring stand in conformity with polish standards and when applying the dust of grain size as established by the standards.

KEYWORDS

Dust Extraction, Dust Explosions, Dust Hazards, Methane Hazards, Health Protection, Pneumoconiosis, Wet Dust Collectors, Vortex Ventubes, Combined Ventilation System, and Exhaust Ventilation.

INTRODUCTION

First driving of roadway workings of 500 to 2000 m in length is mainly applied in Polish coal mines to open up coal deposits. All the time there are from 300 to 350 operating roadway workings. In general the drivage of roadways takes place under severe coal dust and methane hazards. The research and design work carried out at the KOMAG Mining Mechanization Centre in Gliwice as well as the scientific and research cooperation with the Pittsburgh Research Laboratory realized within the Maria Curie–Sklodowska Fund made it possible to solve the problem of the named hazards on an overall scale of the Polish mining industry. The research work resulted in the development of suitable

- A system of ventilation and dust extraction by means of suction ventilation facilities and a dust collector installed either after or before a suction fan,
- A system of ventilation and dust extraction by means of combined ventilation consisting of forced ventilation supplying the air to a heading face and of suction ventilation effected with the aid of a short ventilation pipeline of forced type incorporating a dust collector and a suction fan. In case of methane hazard the combined ventilation needs using of vortex ventubes. The application of vortex ventubes allows to reduce 10 times the concentration of methane accumulated under the roof. In panels where methane does not occur it is permitted to use perforated ventubes at the outlet of a ventilation pipeline forcing the air to a working.

systems and equipment characterized by high efficiency and effectiveness and satisfying the requirements as to safe operation under mining conditions. Systems of a dust extraction in roadway workings subjected to suction or forced ventilation make a configuration of dust collecting equipment and ventilation facilities. The electrical equipment necessary to supply and control components of the installation as well as methane detecting apparatus belongs to the system. Such a combination of suitable equipment provides safe and effective dust removal and ventilation of a roadway working as well as is determinant of proper cooperation of the equipment a system is composed of.

In general there are two basic systems used:

The development of effective dust collectors of wet types which provide safe operation under conditions of great exposure to coal dust and methane explosion hazards as well as of vortex ventubes allowing methane accumulations under the roof to be removed makes it possible to apply regularly the designed systems. The efficiency of dust collecting equipment ranges from 99% to 99.8%.

Measurements of the efficiency are carried out on a when applying the dust of grain size as established by the standards. At present in Poland it is not permitted to drive a roadway if the dust collecting equipment is not installed.

The installations evolved from such technical solutions are provided with devices giving protection to a system of ventilation and dust extraction in case of a rapid increase of the methane hazard. They cover the devices, which allow a dust collector and a fan of suction ventilation to be operated as self-contained units and enable removal of considerable methane accumulations. The solutions based on systems of ventilation and dust extraction in roadway workings contribute to a vast decrease of methane and coal dust hazards and to an effective reduction in pneumoconiosis rate. The presented configuration of equipment provides safe ventilation and dust collection in roadway workings that have proven effective under operational conditions of Polish mines.

Advantages of the equipment incorporated in the systems are a relatively low price of the purchase enabling wide application of the systems in all mines as well as their high proven reliability.

SYSTEMS OF SUCTION VENTILATION ALONG WITH A DUST COLLECTING FACILITY

A system of suction ventilation along with a dust collecting facility relates to a configuration of the equipment for ventilation and dust extraction installed in a roadway working as well as to descriptions of functions the equipment performs in the system. The pieces of equipment presented in Figure 1 are incorporated in the system used for dust removal and suction ventilation of a roadway.

- Dust collector [1] Item 1
- Surge chamber Item 2
- Short ventilation pipeline of forced type Item 3
- Aeration chamber Item 4
- WLE fan Item 5
- Vortex ventube Item 6
- Suction ventilation pipeline Item 7
- Dust collector's fan Item 8

[1] An UO dust collector can be situated in positions A, B, or C as shown in the figure. The dust collector is designed with the same number in any position.

A WLE fan (Item 5) along with a suction ventilation pipeline (Item 7) make the basic equipment of the known installation of suction ventilation operated within a system of ventilation and dust collection. According to Polish mining regulations a suitable project of ventilation pipeline must be provided for each roadway longer than 50 m. A suction ventilation forces the air to flow through a roadway working as shown by means of arrows in Figure 1.

A dust collector (Item 1) which can be installed before a fan (position A) or after a fan (position B) of the WLE type which forces the air to flow in the dust collector serves for measuring stand in conformity with Polish Standards and cleaning the dust-laden air flowing through a suction ventilation pipeline. In positions A or B the dust collector and the WLE fan are directly connected one with another. A characteristic curve of resistances in ventilation network and in a dust collector should pass across the operating portion of fan's characteristic.

It is recommended to install a dust collector after a WLE fan (position C) on introducing a surge chamber (Item 2) the task of which is to ensure safe and independent cooperation of the dust collector with the WLE fan. In this case a dust collector must be furnished with its own fan (Item 8). Stoppage of the dust collector and its fan results in that the air stream leaving the WLE fan flows out through the surge chamber and the dust collector without causing any essential changes in the rate of air flow in the WLE fan. One of the important features of the surge chamber cooperating with the dust collector is reducing the concentration of gases at the outlet of the equipment due to aeration of the mixture of air and gases flowing out of the WLE fan with stream of air flowing around.

At a distance of up to 4 m before the WLE fan inlet an aeration chamber (Item 4) is installed. It is recommended to use that chamber when driving roadways by means of roadheaders in panels recognized as II, III and IV class of methane hazard. The aeration chamber is a facility designed to regulate the outflow of air from a suction ventilation pipeline when renewing the ventilation (e.g., after emergency stoppage of the operation of a ventilation system). The regulation consists in controlled adding the air of stream flowing out of a suction ventilation pipeline to the stream of air flowing around so that in a roadway section after a fan the permissible concentrations of gases and especially of methane are not exceeded. A methane detecting apparatus (M1) a sensor of which is installed in the stream of air flowing around at a distance of 3 m after the fan's outlet (or after the outlet of the dust collector in position C) serves for direct monitoring of methane concentration after the fan. The engineer responsible for ventilation states a type and kind of the methane detecting apparatus. It is recommended to apply a methane detecting apparatus the display monitor of which is situated in a place visible for the personnel servicing the surge chamber. The air outflow is manually controlled by means of a diaphragm and a flap. During normal operation of a suction ventilation pipeline the chamber is tightly closed and does not cause any increase in resistances of flow. Polish mining regulations define the cases of using the aeration chamber to regulate the amount of air flowing out of the suction ventilation pipeline. A procedure of acting when gas hazards occur is also stated by the regulations.

When working under conditions of severe coal dust or methane hazard existing in a heading face it is recommended to apply a vortex ventube (Item 6) provided with a fan drive. The objective of using the vortex ventube is removing methane accumulations under the roof and stabiliz-

ing of the stream of dust-laden air in a heading face. Within its operation range a vortex is capable to reduce the methane concentration under the roof even 10 times. The air vortex flowing out of a ventilation pipe increases the velocity of air in a roadway and thus improves climate conditions in the working. According to recommendations a vortex ventube should be placed on a side opposite to a suction ventilation pipeline. The vortex ventube can be laid on the floor or suspended to a monorail. Its capacity should be at least by 20% lower than the amount of air drawn in the suction ventilation pipeline (at its inlet). It is recommended to maintain the outlet of a vortex ventube at a maximum 15 m from a face of roadway being driven. A short ventilation pipeline of forced type (Item 3) which connects a fan to a surge chamber should be made of an air hose reinforced with spiral casing of 2-5 m in length. A suction ventilation pipe (Item 7) is a commercially available air conduit.

SYSTEM OF COMBINED VENTILATION INCORPORATING A DUST COLLECTOR

A system of combined ventilation incorporating a dust collector relates to a configuration of the equipment for ventilation and dust extraction installed in a roadway working as well as to descriptions of functions the equipment performs in the system. The pieces of equipment presented in Figure 2 are incorporated in the system for dust extraction and combined ventilation of roadway.

- Dust collecting installation Item 1
- Vortex ventube Item 2
- Set of suction ventilation pipes Item 3
- Ventube container Item 4
- Fan Item 5
- Deaeration chamber Item 6
- Forced ventilation pipeline Item 7
- Dust collector's fan Item 8

A dust collecting installation (Item 1) is used to clean the dust laden air drawn in an auxiliary suction ventilation pipeline. A dust collector of wet type characterized by closed circulation of water forced by a pump adapted for forcing water with high level of impurities constitutes a basic unit of the dust collecting installation. A vortex ventube (Item 2) furnished with a ventube container (Item 6) is installed parallel to the auxiliary suction ventilation pipeline along with the dust collector. The vortex ventube is used to distribute the air along a roadway working and to impart proper velocity to the air directing it towards the roof so that methane being accumulated there is removed.

In methane panels flapless vortex ventubes of the WIR-700W type are used. They ensure that the air velocity within the range of 1–1.5 m/s is maintained under the roof over the length of this ventube. The vortex ventube has also an intense effect on the overlapping zone where it increases the air velocity under the roof. A forced ventilation pipeline (Item 7) is a commercially available air conduit. A fan (Item 3) of the WLE type is installed in the stream of air flowing around. It is recommended to apply a deaeration chamber (Item 4) after the fan. This chamber serves for regulation of the air outflow from a roadway working to the stream of air flowing around during renewing the ventilation (e.g. after emergency stoppage of the ventilation system). The regulation consists in controlled adding the air to the roadway working (to the forced ventilation pipeline) so that the mixture of air and gases flowing out of the forced ventilation pipeline does not lead to exceeding permissible concentrations of gases in the stream of air flowing around. The regulation is effected manually by means of a flap. Polish mining regulations define cases of using the deaeration chamber to regulate the amount of air flowing out of a roadway working. A procedure of acting when gas hazards occur is also stated by the regulations. The deaeration chamber can be utilized when starting-up a fan in order to prevent bursting the air hose in consequence of impact inflow of air stream. Opening flaps of the chamber results in that portion of air flowing out through the chamber and as the flaps are being closed the ventilation pipeline is softly filled with air stream forced by the fan. During normal operation of the ventilation pipeline the chamber is tightly closed and does not cause any increase in resistances of flow in the forced ventilation pipeline. A combined ventilation system is a forced ventilation installation cooperating with an auxiliary suction ventilation pipeline situated in a heading face and incorporating a dust collecting installation. It requires use of a vortex ventube or a perforated ventube. The combined ventilation system forces the air flow as shown by arrows in Figure 2. The air is forced to a roadway working by means of a fan of the WLE type (Item 3) installed in the stream of air flowing around and flows through a forced ventilation pipeline (Item 7) to a vortex ventube (Item 2). The vortex ventube distributes the air along the roadway working over the length of minimum 10 m via a longitudinal gap. In non-methane panels or in panels recognized as first class of methane hazard it is possible to replace a vortex ventube by a perforated ventube. The vortex ventube brings about better distribution of air in a working, higher velocities of air, and better stabilizing of dust laden air streams on a heading face than a perforated ventube. The air flows from the vortex ventube to a heading face and (along with dust contained in it) is drawn in an auxiliary suction ventilation pipeline in which a dust collecting installation (Item 1) is built in. Between the outlet of the auxiliary suction ventilation pipeline and the beginning of a gap of the vortex ventube, when looking from a side where air inlet is situated, it is necessary to maintain a section of parallel installation of ventilation pipelines (overlapping zone) so that its length should not exceed 10 m. At the same time it should be taken into account that the amount of air flowing out through a xgap of the vortex tube must be at least by 20% greater than the amount of air drawn in the inlet of the auxiliary suction ventilation pipeline incorporating a dust collector. This

excess of 20% of air provides ventilation of the overlapping zone. With the object of avoiding any possible accumulation of methane in this zone it is recommended to apply flapless vortex ventubes, electrically driven, controlled with air vortex, of the WIR-700 W type. Versions of vortex ventubes other than WIR-700 W and perforated ventubes need using a flap for closing the outlet of the ventilation pipe. Manually operated or automatically controlled flaps are used to change the direction of outflow of air from vortex ventubes or perforated ones. In panels recognized as II, III and IV class of methane hazard it is recommended to apply automatic control of air flow through a vortex ventube because of work safety.

DUST COLLECTING EQUIPMENT

A dust collector of wet type characterized by a closed water cycle forced with a pump adapted for pumping water with high level of impurities constitutes a basic unit of the UO dust collecting installation. The applied UO dust collecting installation is protected against any possible coal dust explosion within the installation and is free from wire meshes and partitions likely to impede air flow. The dust collecting equipment does not become clogged with coal dust and thus there is no need to apply sensors for monitoring and protecting the equipment against an excessive increase in flow resistance.

The effectiveness of dust extraction provided by the UO dust collecting equipment complies with requirements of the Polish Standard PN-93/G-50036. Testing of the equipment is carried out on a special-purpose testing stand in accordance with the methodology of tests as per the standard BN-86/2370-11 and when using the standard pattern dust. The technical characteristic of the UO dust collecting equipment is presented in Table 1.

Table 1.

Parameters	Units	UO-600	UO-800	UO-1000
Capacity	m^3/min	200-400	300-500	400-700
Effectiveness of dust extraction	%	99-99.8	99-99.8	99-99.8
Power of driving unit	kW	18.5	18.5	37
Width	mm	700	900	1100
Height	Mm	800	1100	1300

VORTEX VENTUBES

Vortex ventubes constitute the equipment necessary to be applied in a system designed for dust suppression and ventilation in roadway workings subjected to a combined ventilation as well as required for suction ventilation systems used under conditions of methane hazards. Vortex ventubes of special patented type in which a vortex of air stream is used to change (to control) the direction of air flow are presented hereafter.

The operation of vortex ventubes results in 10-fold reduction of methane concentration under the roof.

Table 2.

Type of vortex ventube	Capacity m^3/min	Gap length m	Gap diameter m	Type Of ventilation
WIR-700W	200-600	10	800	Combined
WIR-600S	200-320	6	600	Suction
WIR-500S	100-180	6	500	Suction

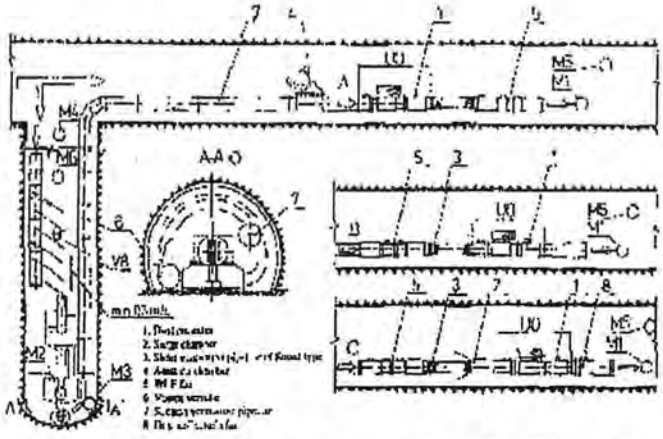

Figure 1. System of Suction ventilation along with a dust collector.

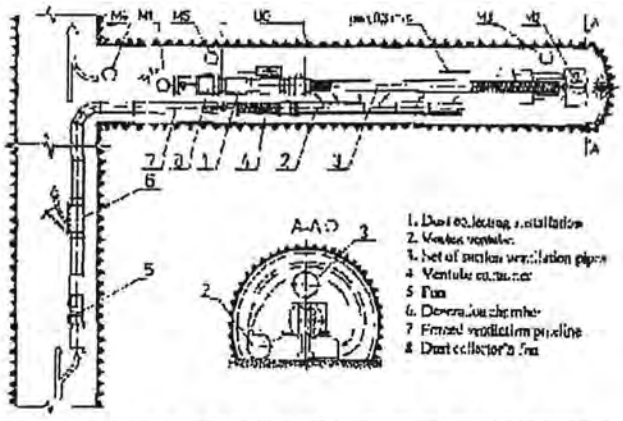

Figure 2. System of combined ventilation incorporating a dust collector.