DUST CONTROL BY WATER SPRAYS AND VENTILATION

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ABSTRACT

Recent field and laboratory results related to the use of water sprays and ventilation in the control of dust at the mine face are presented. Optimization of water sprays for impaction and collection of airborne dust is discussed and guidelines presented. Exhausting versus blowing primary ventilation, dust collectors, several secondary exhaust ventilation systems, and a "throw" technique are discussed.

INTRODUCTION

Prolonged inhalation of dust has long been recognized as a health hazard leading to pulmonary diseases generally termed as pneumoconiosis. In the 16th century, Agricola, the father of mining, discussed dust inhalation during mining and called it a "widow maker". Inhalation of respirable coal mine dust leads to coal worker's pneumoconiosis, or "black lung". Seemingly innocuous dusts such as trona and kaolin are also believed to involve a health hazard and are measured as "total" dust.

The health hazard associated with the inhalation of dust is not trivial. For example, black lung is the most severe health and safety problem facing the coal industry today, for the number of permanent disabilities and deaths of coal miners due to black lung is 3.5 times the disabilities and deaths due to all mine incidents. The cost in the U. S. to government and industry for black lung compensation is approximately 1.5 billion dollars per year.

The necessity for society to devise improved methods for mining minerals at a rapid and economical rate while maintaining a healthful mining environment is apparent. In 1969 the U. S. Bureau of Mines initiated an intensive R&D program to develop improved and new technology for reducing the amount of dust in mine atmospheres during mining operation. This paper will review the Bureau's program to control respirable dust during coal mining operations using water sprays and face ventilation. However, the same concepts should be equally applicable to controlling float dust and to noncoal mining operations. Other dust control techniques such as steam, wetting agents, and foam are available (1) but are expensive, inconvenient, and usually less effective and will not be discussed here.

WATER SPRAYS

Water sprays are widely used for dust control in mining operations and reportedly reduce respirable dust by about 30% (2). The type and placement of the spray nozzles are selected arbitrarily because engineering guidelines are not available--a common approach appears to merely add more nozzles in the hope of reducing more dust. The Bureau's effort was oriented toward devising techniques to use the water more effectively by either greater dust suppression with the existing water flow or the same dust suppression with a smaller water flow. Conventional water sprays have been emphasized.

Water sprays can immobilize dust on the broken coal, and thereby prevent it from becoming airborne, and can collect airborne dust. Spray parameters to be considered include the water flow for a given line pressure, size and velocity of the drops in the spray, nozzle type (hollow or solid cone, spray angle), geometry of nozzle placement (nozzle orientation and distance), and, occasionally, the air jet entrained by the spray.

Impaction

Moistening of a surface by an impinging water spray depends upon the mean drop diameter, the mass concentration of the drops, and the manner in which the individual drops spread over the surface after impact. Bureau laboratory studies with pure water drops similar to those occurring in conventional medium-pressure sprays indicated that such drops flatten upon impacting a solid coal surface or even a thickly dust-laden surface (3). The flattened drop sweeps an area about 10 times the area covered by the static quiescent drop and scavenges and immobilizes the top layer of dust covered by it. A water drop containing wetting agent penetrates into the dust layer and is several times more effective than the pure drop in immobilizing the dust. Although the impacting drop dislodges some of the particles in the dust layer (and preferentially dislodges the smaller particles), the extent of dislodgment is not too significant for most mining operations.

Impact coverage is optimum for drops approximately 500 micrometers in diameter and increases with increasing drop velocity. Reference 3 describes a procedure to predict the required water flowrate for a given mining operation. A spray nozzle then can be selected from the manufacturer's catalog (e.g., Spraying Systems*) to give optimum mean drop size for the line pressure, geometry, and stipulated degree of coverage.

A nozzle giving drops 40% bigger or smaller than the optimum size would give a 25% reduction in coverage for the same water flowrate or would require 25% more water for the same coverage. Alternatively, doubling the line pressure would lead to a 33% increase in coverage, primarily because of the drop

*Reference to trade names is made to facilitate understanding and does not imply endorsement by the Bureau of Mines.

size-velocity effect and secondarily because of the increased water flow.

Collection of Airborne Dust

In airborne collection, the spray drop collides with the dust particle, and the particle-drop agglomerate then settles to the floor or is otherwise collected.

Bureau laboratory research has indicated that optimum capture of airborne respirable coal dust particles in a confining constant-area duct occurs with 200-micrometer water drops for a wide variation in drop velocity (4). Thus, for a mining operation that involves airborne capture, the dust control engineer should as a first approximation select the nozzle that gives ~200 µm drops and is compatible with line pressure and geometry.

This selection is only an approximation because the effect of the air entrainment by the water spray has not yet been included. Most mining operations use unconfined water sprays, and the air jet entrained by the spray may significantly disturb the local airflow pattern at the mining operation.

System Design

In practice, a multibranch water delivery system is often fed by a single water source, and the delivered pressure and flowrate at different nozzles are unknown, or at least not optimized for dust suppression. Reference 6 presents an approach for calculating the pressure/flowrate in a multibranch system. The performance of such a system for dust suppression then can be estimated using the above techniques.

Spray Applications

Briefly summarizing at this point, spray nozzles that give high velocity, ~200-micrometer drops are considered to be best for the airborne capture of respirable-size dust particles, while nozzles that give high velocity 500-micrometer drops are best for impaction. In practice, however, the geometry of the system and especially any local airflow and the air entrainment by the spray may also be important.

Therefore, while a reasonably optimum spray system can be custom designed for a specific system, a complete handbook is still in the future and research at the field site will probably be required for some systems. In the interim, Table 1 gives information

TABLE 1. - Optimum spray nozzles for dust control

Distance,[1] feet	Mean drop size, Micrometers	Optimum nozzle[2]	Water flow rate, gal/min	Line pressure, lb/in^2	Spray angle
AIRBORNE COLLECTION					
2.5	220	BD	0.95	100	78°
3.5	340	BD5	1.0	40	70°
4.5	240	G3004	.90	200	32°
6	340	G2	.77	150	40°
8	420	G3	1.1	150	50°
10	530	G3007	1.1	100	30°
11	580	G3009	1.4	100	30°
IMPACTION					
2	300	G3004	0.78	160	32°
2.5	470	G2	.56	90	46°
3	480	G3.5	1.2	140	40°
4	880	G3.5	.74	50	48°
4	990	G3	.50	30	65°

1 Length of the practical system under consideration.
2 Available from Spraying Systems Co., Bellwood, Ill. These nozzles are included because information on drop size is available.

for several spray nozzles that are optimal for airborne capture or impaction. For example, for a belt conveyor system, impaction of the spray drops probably is the major dust-suppression mechanism. If minimal water is desired, the Spraying Systems G3 nozzles should be operated at 30 lb/in^2 and located about 4 ft from the belt (a G2 nozzle also would give minimal water). A more sophisticated approach would be to preselect the degree of coverage which is desired and then select the optimum nozzle and operating conditions. For example, suppose the desired degree of coverage is 2, i.e., all horizontal exposed surfaces are to be covered twice by the impacting drops. Let the available line pressure be 80 lb/in^2, the nozzle be 3 ft from the belt, the target area be 21x21 in. and the belt travel at a speed of 400 ft/min. Reference 3 describes a procedure that predicts the required water flowrate to be 0.5 gal/min. One then selects the spray nozzle that gives the mean drop size of 500 µm with the water flowrate of 0.5 gal/min for the stipulated pressure and geometry.

As another example, water sprays were being used in a longwall-plow mining operation to wet the face. The mine spray system (2 BD 3 nozzles per chock, 150 lb/in^2 pressure at the nozzle, and a booster pump) was causing problems due to water drippage from the chocks, puddles on the floor, and the formation of a heavy mist in the ventilation airstream that wasted about 30% of the mine water. A Bureau-designed spray system indicated that Spraying System G3009 nozzles operated at 70 lb/in^2 and angled at 45° in the direction of the ventilation airstream gives good face coverage and only 2% mist Fig. 1. The improvement

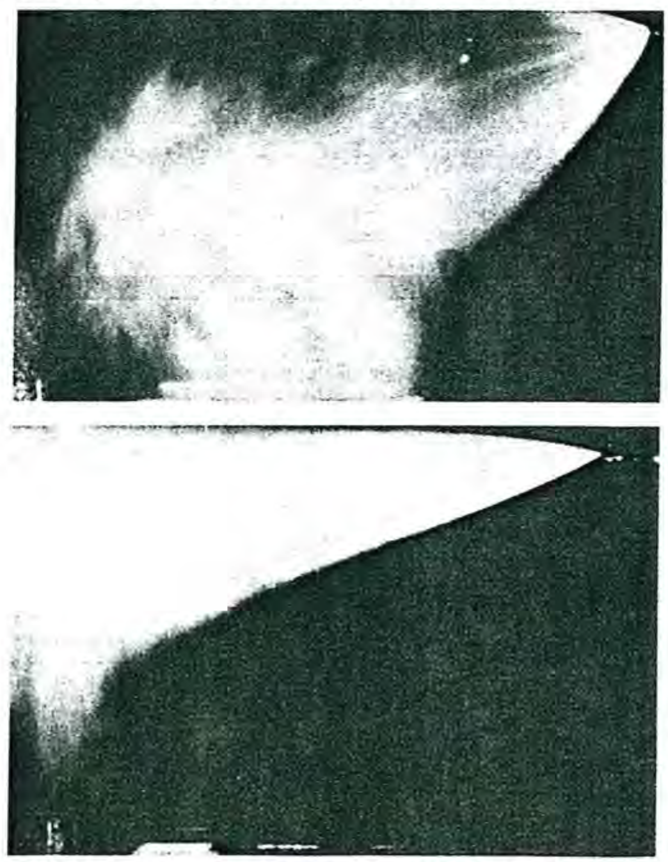

FIGURE 1. Water sprays for longwall plow face: top BD 3 nozzle, 150 lb/in^2; bottom, G3009 nozzle, 70 lb/in^2.

was due to a better throw of the drops and fewer ultrafine drops in the Bureau-designed spray. Field tests indicated that the new Bureau-designed spray system eliminated the drips and mist and reduced the puddles, along with eliminating the inconvenience and expense of the booster pump.

However, some mining operations, such as a ripper-type continuous mining machine, are more difficult to address because of the variety of cutting operations (sump or shear, box or slab) and the chaotic airflow patterns at the boom. Bureau field tests have typically indicated that about 70% of the respirable dust that escapes the area is generated during the sump cut, about 20% during the shear cut, and 10% during the loading operation.

Field tests investigating nozzle location are somewhat mixed to date but generally indicate that: (1) nozzles mounted under the boom and directed downward onto the broken coal are up to 100% more effective for dust suprression than the conventional top-mounted sprays (but not always), (2) side sprays are worthless for dust suppression; (3) throat sprays may wet the broken coal and thereby reduce the formation of secondary dust but do not contribute to the suppression of face dust; (4) a highline pressure is not necessarily a good alternative to pursue because of mist formation and especially because the increased air entrainment can disrupt the local airflow pattern.

The local airflow pattern at the cutting boom is indeed complex. For example, consider a simple entry using exhaust primary ventilation into a duct located in the upper left side of the entry. Without water sprays, the ventilation air essentially passes directly into the exhaust duct and very little air movement occurs about 5 feet beyond the duct entrance. However, water sprays mounted under the boom leads to air being entrained under the boom which then escapes out close to the face. Fig. 2 sketches the local airflow

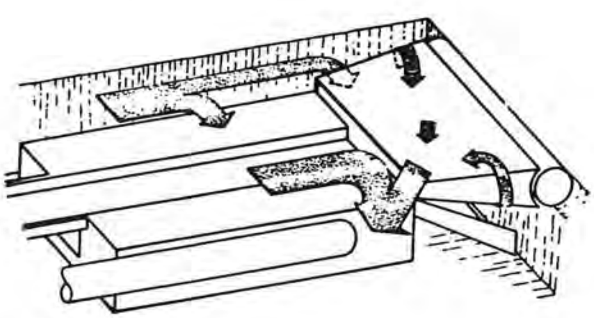

FIGURE 2. Airflow pattern with low-pressure water sprays under boom.

pattern which such a spray system operates at low line pressure (~50 psi). The low-pressure spray system captures about 20-30% of the new respirable dust being formed at the face, with the remainder being passed into the return. With a high line pressure (~200 psi), however, additional air is sucked under the boom and causes a local airstream to flow back over the right side of the machine and back to the machine operator located at the right rear of the machine (Fig. 3). As a result, the high-pressure spray system captures ~50% of the new face dust but also causes a significant disadvantageous increase in the dust concentration at the operation location.

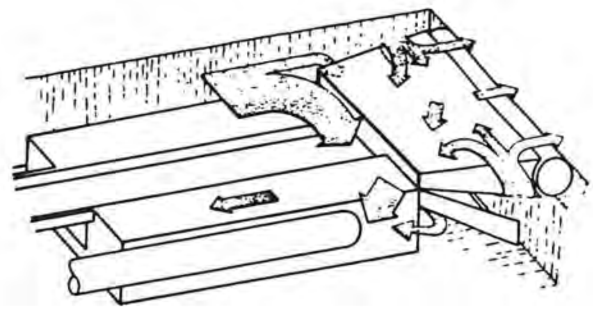

FIGURE 3. Airflow pattern with high-pressure water sprays under boom. Note reversal of flow over right top of machine.

Field studies in coal mines with continuous mining machines whose cutting heads were modified to wet heads, where the water sprays impinge onto or near the bit points, have indicated a 25-50% reduction in respirable dust compared to conventional water spray. Reduction in float dust were higher. Retrofit wet-head kits are available for Wilcox and Jeffrey auger machines at a cost of $5000-$10 000.

In summary, water sprays (1) are a moderately effective dust control technique (up to ~50% dust reduction compared to dry operation), (2) are simple to operate, (3) can probably be improved in performance if modes attention is given to system design, (up to ~50% improvement), but (4) can perhaps be disadvantageous if poorly designed or operated at high pressure.

Lastly, although water sprays when reasonably designed are a valuable dust control technique; their underground use is usually limited because the spray nozzles frequently clog in the rugged mine environment. Clogging is due to particulate in the water line, and conventional filters require significant maintenance (which is often not performed). A Bureau contractor designed a simple nonclogging, low-maintenance system to replace the conventional filter. The system consists of an in-line Y-strainer to remove the plus 1/8-inch rubble, a hydrocyclone to remove virtually all of the remaining particulate material, and a final polishing filter (mainly to remove particulate carry-over during startup and shutdown of the water system (8). The system is maintained about once a week (or more frequently when necessary) by opening the valves on the Y-strainer and hydrocyclone for a few seconds and occasionally replacing the polishing filter.

VENTILATION

Face ventilation can be divided into conventional primary exhausting and blowing ventilation and a less conventional secondary exhausting and blowing ventilation.

Primary Exhausting Ventilation

With exhaust primary ventilation, brattice or ducting is used to draw the ventilation airstream away from the face. As noted earlier, the major amount of the incoming ventilation air passes directly into the return within about 5 feet beyond the end of the brattice or ducting, and the actual airflow near the face is small. Therefore, little use is made of the primary ventilation air for dust removal if the exhausting brattice or duct is too far from the face. Fig. 4 shows a laboratory scale model of a continuous

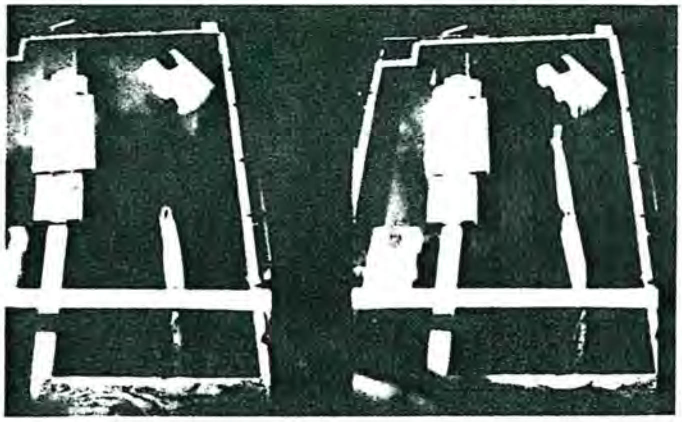

FIGURE 4. Reduction in dust by moving exhausting brattice 20 feet from face (left) to 10 feet from face (right).

mining machine. The left photograph shows a simulated 20-ft brattice, while the right photograph shows a 10-ft brattice. Smoke is used to represent the newly formed face dust. The reduction in dust dispersion by moving the brattice from 20 to 10 feet from the face is evident. In practice, an 80% reduction in dust is achieved at the machine operator. For comparison, doubling the primary ventilation achieved only a 50% reduction in dust with the 20-ft brattice (9). Thus, dust reduction is much more effective by moving the exhausting brattice or duct closer to the face than by increasing the quantity of primary exhausting ventilation.

In actual practice, maintenance of the brattice or duct close to the face is burdensome. The use of an extensible brattice or duct system would increase productivity while maintaining a low-dust environment. Extensible telescoping ducting is commercially available. Several types of extensible brattice systems have been developed in the past but have not been widely accepted by the mining community because of inconvenience or interference with the mining operation. A prototype extensible brattice was recently developed by the Bureau and is being tested. The apparatus is attached to two roof bolts, and the brattice is slid forward as a cantilever. The unit is mechanically simple to operate but is probably limited to medium-height seams (up to about 7 feet in height) and to modest primary ventilation airflows (less than about 7000 cfm).

An alternative system is to use a machine-mounted air curtain (10) to "extend" the brattice/duct. The system consists of a section of slotted pipe running on the top of the mining machine with a machine-mounted fan blowing about 800 cfm of air through the slot upward toward the roof. However, limited field tests have indicated only a modest reduction in dust at the machine operator.

Primary Blowing Ventilation

Blowing primary ventilation, where the intake airstream is directed toward the face, provides better airflow across the face area than does exhausting primary ventilation because the high-velocity air jet that exits from a blowing brattice or duct is more penetrating than the low-velocity airstream that is drawn into an exhausting brattice or duct. A greater distance between the end of the brattice or duct and the face therefore can be tolerated, and interference with the mining operation is thus reduced, while the face area is still being reasonably well ventilated. However, the blowing ventilation air automatically tends to pass the new face dust back over nearby personnel. Field studies by the Bureau and others (11) have shown that the dust exposures of the machine operator, shuttle car operator, and roof bolter were reduced by about 75% by using exhausting instead of blowing primary ventilation.

Secondary Blowing Ventilation

Secondary blowing ventilation, where a machine-mounted auxiliary fan or judiciously oriented water sprays (12) are used to direct ventilation air toward the face, is becoming increasingly popular for dispersing the methane at the face during coal mining operations. However, such a system can also disperse the newly formed face dust. For example, while a secondary blowing system can decrease the methane near the face by 50%, the dust at the machine operator can be increased by 50%. A secondary blowing system thus must be carefully designed and maintained.

Secondary Exhausting Ventilation

General Remarks. Secondary exhaust ventilation, where the face dust is vacuumed from the vicinity of the face and then either ducted to the return or passed through a machine-mounted dust collector and the effluent air discharged at the mining machine, is a very effective dust control technique.

Fig. 5 shows a Bureau scale model of a Joy 12 CM

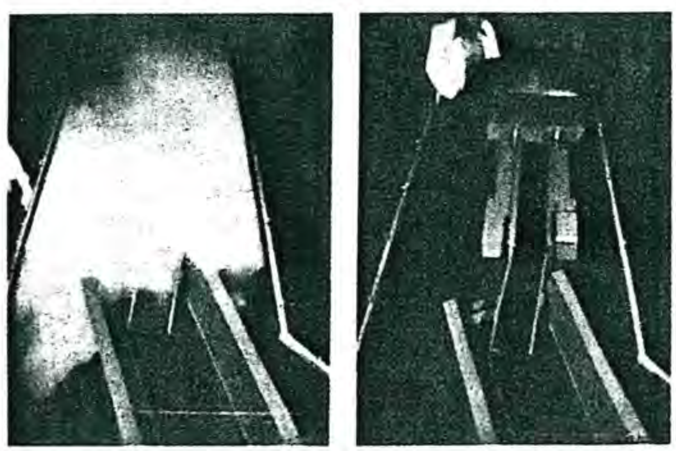

FIGURE 5. Reduction in dust by secondary exhaust ventilation.

modified to include a secondary exhaust ventilation system. Exhaust primary ventilation is being used with a brattice positioned 30 feet (simulated) from the face. The secondary exhaust air is ducted to the return (simulated). The left photograph shows the dispersion of the face dust back over the machine operator when no secondary exhaust ventilation is used. The reduction in dust with secondary exhaust ventilation is shown on the right.

The total dust reduction efficiency of a secondary exhaust ventilation system with a dust collector wherein the effluent is discharged at the mining machine involves (1) the dust capture efficiency of the air intakes, multiplied by (2) the dust collection efficiency of the machine-mounted dust collector and also (3) the interaction between the secondary and primary airflow systems. Bureau laboratory and field results with a ripper machine indicate that an intake efficiency of 90+% can readily be achieved with intakes conveniently located within about 6 feet from the face. Dust collectors will be discussed later. However, the interaction of the primary and secondary airflow systems is complex, e.g., in one case a 40% reduction in dust at the operator was achieved with a 10% increase in the dust collection efficiency of the dust collector.

The secondary airflow must be matched to the primary airflow to be effective. In general, an 80% reduction in dust at the operator can be expected if the secondary airflow is 1/2 the primary airflow, while a 90% reduction can be achieved if the secondary airflow is 7/8 the primary airflow. Thus, a 2000-cfm secondary system matched to a 4000-cfm primary system should be a very effective dust control technique, but its effectiveness will decrease if it is matched to a 6000-cfm primary ventilation system. A 3500-cfm secondary system would be even more effective if coupled to the 4000-cfm primary system, although recirculation problems may develop if the primary ventilation drops to only 3000-cfm. In general, however, recirculation is not as severe a problem as one might think; for example, with a 2000-secondary/4000-primary system wherein the secondary air is discharged at the mining machine, 35% of the effluent from the 2000-cfm secondary system is recirculated back to the air intake of the secondary system, but the secondary system still causes the 80% reduction in dust at the operator and other nearby locations.

It should be noted that a secondary exhaust system <u>also</u> is a powerful technique for reducing the methane concentrations in the face area, again despite significant recirculation. For example, with a square face, the methane concentration at the face when a secondary system is used should be 1/2 of that achieved with a conventional 10-ft exhaust brattice. This benefit is achieved even if a machine-mounted dust collector is not used.

It should additionally be noted that a secondary exhaust system with a machine-mounted dust collector reduces the total amount of airborne dust in the ventilation airstream and thus (1) reduces the respirable dust exposure of downstream personnel and (2) greatly reduces the downstream float dust, i.e., in a coal mine, the rock dusting requirement for the return is reduced.

It should however, be noted that secondary ventilation can be somewhat expensive, is more complicated than other dust control techniques such as water sprays, and requires the <u>careful</u> design of the air ducting and the selection of a fan that is suitably small but that can overcome the pressure drop due to the ducting and the dust collector and provide the desired air volume.

Dust Collectors

A high dust collection efficiency of the dust collector and a small physical size usually are critically important for a secondary ventilation system. For example, if the collection efficiency were increased from 90 to 95%, a 50% reduction in dust penetration through a collector would be achieved.

To date, the Bureau has emphasized dust collectors that utilize water. Wet collectors avoid problems due to safety and material handling in mining operations but may be disadvantageous for soluble ores.

In 1969-72, the Bureau and also a contractor (13), tested the performance of several commercial wet-dust collectors. Results generally indicated that none of the units had a collection efficiency above 90% for respirable dust.

The Bureau recently developed, or participated in the development of, a new family of high-efficiency wet dust collectors (14-15). These collectors were also designed for minimal size and pressure drop and are described below. In general, the dust collection efficiency increases with increased water flowrate and pressure drop and increased particle size. Published data for dust collection efficiencies usually are for total dust and not for the respirable fraction, and the frequent high values reported for collection efficiency must be viewed with caution if respirable dust is being considered. The physical size of the unit of course depends upon the cfm of the unit and the fan. The sizes cited below are for a 2000-cfm unit based upon using a Joy 5112 fan, except otherwise noted.

Table 2 summarizes the state-of-the-art of wet respirable dust collectors and includes data on low-water-consumption ("damp") and dry collectors. All of these collectors should be essentially 100% effective for the collection of float dust. The wet collectors are briefly discussed below.

TABLE 2. - <u>Dust Collectors</u>

	gpm (per 1000 cfm)	size	Respirable Dust Collection Efficiency (%)
<u>Wet</u>			
Wetted fan	1-3	Small	~80%
Cyclone	"	"	~90%
Venturi	"	"	~95%
Flooded bed	"	"	~95+%
<u>Damp</u>	0.1-0.2	Medium	90-96%
<u>Dry</u>			
Cyclone	0	Medium	~50%
Baghouse	0	Big	99%

a. <u>Wetted fan</u>. The wetted fan dust collector consists of a heavy-duty fan (centrifugal or axial) with a water spray at the fan inlet. With the Joy 5122 fan, the collector unit is about 11 inches in diameter and 30 inches long.

b. Wetted brush. The performance of the wetted fan collector can be significantly improved by adding a low-density bed of stainless steel or plastic brushes upstream of the fan and placing the water spray upstream of the brushes. The brushes can be those commonly used to wash the inside of bottles. A typical collector can be about 13 inches high, 13 inches wide, and 35 inches long.

c. Small Diameter Cyclone. Dust collectors incorporating a panel of small cylindrical cyclone tubes with a water spray upstream of the panel are commercially available (Donaldson, Merix). A collector is about 15 inches high, 16 inches wide, and 37 inches long.

d. Flooded bed. Dust collectors based upon a loosely woven wire bed with a water spray upstream of the bed also are commercially available (Donaldson, Vortex). Fig. 6 shows a 2000-cfm Bureau-designed collector utilizing a wire bed which is about 13 inches high, 13 inches wide, and 35 inches long.

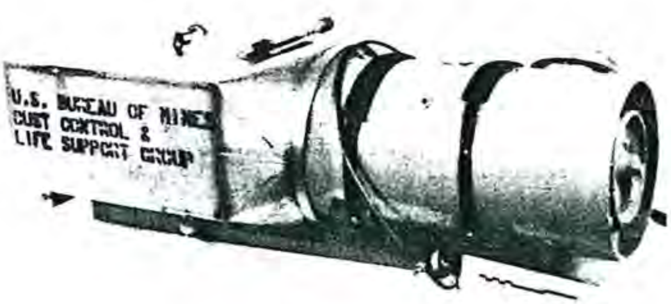

FIGURE 6. A 2000 ft^3 flooded-bed wet dust collector.

e. Venturi. The Bureau designed a simple, short, 6000-cfm venturi-type collector which is 36 inches high, 36 inches wide, and 6 feet long. The unit used a modified Buffalo-Forge fan (30 MW) and included a Euroform droplet eliminator. Water consumption and the pressure drop are larger than for the above collectors. The Venturi probably is best suited for a high-cfm unit.

Except for the venturi example, the above collectors do not include droplet eliminators to reduce the water content of the effluent air. Addition of an eliminator may be required for a machine-mounted collector at the face to avoid discomfort to nearby personnel but adds significantly to the size and cost of a collector. Several commercial eliminators (Merix, Euroform, Donaldson) costing about $1000 for a 2000-cfm unit appear to be very effective but are somewhat large, typically 17 inches high, 16 inches wide, and 12 inches long for a 2000-cfm unit. A short length of transition ducting between the collector and elimimnator therefore is required.

"Throw" Technique

An intriguing variation of a secondary exhaust ventilation system is to use the high penetration power of a blowing air jet and discharge the effluent from the machine-mounted fan in the general direction of a primary exhaust brattice or duct which is somewhat distant from the face, i.e., to merely "throw" the effluent toward the return.

Laboratory model tests have indicated that the "throw" technique is remarkably effective for dust control for a variety of face configurations with an exhausting brattice which is, for example, 30 feet from the face. Field tests are of course required. If successful, the throw technique would have the benefits of a secondary exhaust ventilation system (dust reduction, increased face visibility, and, if applicable, methane and rock dust reduction) and would also increase productivity. A modification of current MSHA regulations would be required to operationally use the technique in coal mines.

Field Applications

Ripper

A Jeffrey Heliminer was modified to incorporate a secondary ventilation system which discharges the effluent at the mining machine. The system uses a 7000-cfm secondary exhaust system matched to a 6000- to 8000-cfm primary blowing system. Air ducting was located on the top of the cutting boom. A 25 HP exhaust fan, Donaldson flooded-bed dust collector, and Donaldson droplet eliminator were installed into the left rear fender of the mining machine.

Field tests indicated a 90+% reduction in respirable dust at the machine operator. When space permits, a simple retrofit of a secondary system onto a ripper machine costs approximately $25 000. The example cited here involved significant machine modification and was more expensive.

Borer

The secondary ventilation concept has also been applied to a Goodman 405 boring machine. Space problems prevented retrofitting a fan and dust collector directly on the borer. The system therefore involved: (1) air ducting mounted on the borer, (2) dust collector, exhaust fan and slurry pump installed on a transfer car towed by the borer, (3) tubing connecting the air duct to the collector, and (4) a conveyor on the transfer car to pass the coal or ore from the boring machine back to the shuttle car. The secondary system was designed by the Bureau for 6000-cfm and includes the wet venturi collector noted earlier. The slurry from the dust collector was dumped onto the conveyor. Primary blowing ventilation was 6000-cfm. The physical layout of the borer is such that the air duct and tubing involves a somewhat tortuous flow path. Significant losses occurred but they were not excessive.

Field research tests wherein the effluent was ducted to the return have indicated a 75% reduction of respirable dust at the machine operator. The reduction is less than expected and is in part due to secondary dust formed by the coal falling from the conveyor into the shuttle car. Cost is difficult to estimate.

Shearer

Shearers have acute problems because the primary ventilation airstream automatically carries the dust over downstream personnel.

The major dust source is the cutting action of the shearer drums. Dust associated with the face conveyor, chock movement, and gob falls appears to be of secondary importance in U.S. mining operations, contrary to the experiences in Europe.

An Eickhoff EDW 340 L double-drum shearer was modified to incorporate air intakes near each cutting drum and small intakes along the bottom of the shearer near the conveyor. Space was available inside the shearer to install air ducting. A 10 HP Joy I 19A exhaust fan and a Donaldson cyclone-type dust collector were mounted on the tailgate end of the shearer.

Field tests in a coal mine indicated a 60+% reduction in respirable dust along the face (16). This reduction closely matches the value predicted from laboratory studies, which indicated an 80% air intake capture efficiency (17) multiplied by an 80% dust collection efficiency of the collection efficiency of the collector. Cost was approximately $30 000.

Laboratory modeling tests indicate that the intake capture efficiency for a shearer-mounted secondary system can be increased by 95+% by increasing the secondary cfm to 8000-cfm. With a flooded-bed dust collector operated at conditions to give 95% dust collection efficiency, the total efficiency of such a secondary system would be 90%. However, shearer operations do not appear to permit sufficient physical space to retrofit the necessary hardware for such a secondary system. The Bureau has initiated a contract to redesign a shearer to install the necessary hardware directly inside the shearer, thereby avoiding the space problem.

A secondary ventilation system was also retrofitted on a Sagem 300 double-drum shearer. An air intake was located near the upstream drum. An air duct placed on top of the shearer arm led to two Joy 5112 fans in parallel which were operated as wetted-fan dust collectors. The effluent from the collector was directed downward between the machine and the coal face. Cost was approximately $8000.

Field tests indicated only a 50% reduction in respirable dust at the tailgate operator. This was less than expected and probably was partly due to reentrainment of dust by the high-velocity airstream (2000 ft/min) exiting from the collector.

DISCUSSION

Mining operations are inherently dusty, and natural convective ventilation usually is quite inadequate to remove the dust from face personnel in an entry. A modest amount of forced primary ventilation usually will provide significant benefits in terms of improved visibility, increased safety and productivity, and personal comfort.

If a forced primary ventilation system is being planned or used, an exhausting system is much more effective than a blowing system for reducing the dust exposure of face personnel. However, the exhausting duct or brattice must be kept within about 10 feet from the face in order to be effective.

If a secondary blowing system is being planned or used, it should be carefully designed in order to avoid boil-back of the face dust. For example, if a water spray "fan" is being considered, a low-pressure spray should be beneficial in pushing the dust toward the return, but operating the spray nozzle at higher than recommended pressures could very possibly be detrimental due to boil-back.

If the mine operator still has a dust problem, the best next step is for him to do a modest dust survey in order to determine how severe the problem is. Dust sampling for 5 shifts and preferably 10 shifts should give a good indication of the severity of the dust problem.

When the problem is minor (for example, if a dust reduction of up to 20 to 50% is desired) and water can be used, the operator probably should first consider improving his water spray system following guidelines given in Reference 1. An improved water spray system is simple and inexpensive, and negligible maintenance is required if a nonclogging system is used.

If improved control of respirable and/or float dust is desired, a secondary exhaust ventilation system will probably be required. At present, a secondary system must be custom designed to the user's needs and availability of space. The designer of a secondary system must select:

(1) The secondary cfm that matches the anticipated primary cfm and the desired degree of dust reduction.

(2) The type of dust collector (Table 2), if desired.

(3) The water eliminator, if desired.

(4) An exhaust fan that delivers the desired secondary cfm (pressure losses in the system must especially be considered and can be critially important).

It should be noted that a secondary system to control methane at the face does not require a dust collector and water eliminator.

While a secondary exhaust ventilation system is moderately complex, is somewhat expensive, and will require some maintenance, it is the most powerful dust control technique available today and has distinct advantages for increased safety, health, productivity and personal comfort.

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