RESEARCH ON DUST CONTROL  
FOR HIGH PRODUCTION LONGWALL MINING IN AUSTRALIA

By

A. Hewitt* and R.D. Luma**

ABSTRACT

The paper outlines the development in the control of dust in Australia over the last 20 years. Factors influencing dust make at the faces are discussed. The effect of high production systems is analyzed. Changes in dust standards and results of dust sampling on longwalls and continuous miner panels are given. Research conducted on air curtains and water infusion on dust control on longwall faces is presented along with recommendations for future research. It is found that both dust curtains and water infusion can cut dust make by 50% each when applied separately.

1. INTRODUCTION

Traditionally, New South Wales production has been Bord and Pillar working with continuous miners using mainly the Wongawilli or split and lift on pillar extraction. Ventilation has always been wide intake narrow return which places the face workers in relatively fresh air providing good mining practices are observed. Good ventilation and selectively placed water sprays has been the main stay of good dust control which has been effectively controlled.

Pressure from international competition and as a result of high productivity with low costs from open-cut mining in Australia, underground mines had to reduce costs with increased productivity to compete. To achieve this longwall mining has been introduced at a number of mines in New South Wales.

In 1987 there were 19 longwalls faces operating in Australia, out of which 18 were in New South Wales. Figure 1 shows the contribution by longwall mining to total underground coal production in New South Wales. It is obvious that the contribution of longwall coal is increasing at a very rapid rate. It is now well recognised that if underground mining is to compete with open cut mining and if Australia has to maintain its share in world coal export, longwall mining is the only available system. The share of underground in overall coal production in New South Wales has declined and only in the last 3 years, 1985 onwards, coal mined by underground methods has seen an upturn mainly due to the contribution of longwall operations.

Although longwall mining offers a safe method of mining and high productivity the full potential has not been realised due to high dust concentration. The pattern and movement of men on a longwall face make it more difficult to keep the workers in dust concentration below the maximum allowable limit of 3 mg/m³. Due to high dust concentration the majority of longwalls do not use Bi-di which limits shearing in one direction only and hence limits production. If Bi-directional shearing was possible, it will increase production by 25-40% depending upon the shearing speed, face length and method of cutting. Workers today are more aware of the dangers when working in heavy concentration of dust which has resulted in demands from Unions for workers protection with improved working conditions (Fig. 1).

Dust make on longwall operations is bound to increase with better utilisation and higher production levels. Anticipated production of longwalls over the next 10 years will possibly double compared to present day standards resulting in higher dust concentration levels. Though full automation and remote control with manless faces is the aim of future mining, dust control will remain an essential part of efficient longwall operation for equipment maintenance, better visibility and better reliability of sensors for automation and control.

2. STANDARDS

Airborne dust monitoring was introduced into the New South Wales mining industry in 1943 based on particle counting using the Owen's

---

* Hewitt, A., Manager, South & West Regions Joint Coal Board, New South Wales, Australia.
**Luma, R.D., Manager, Mining Technology, Kembla Coal & Coke Pty Ltd., Wollongong, New South Wales, Australia.
Dust Counter. The standard required that the average number of particles in the 0-10 micrometres range found in each cubic centimetre of air should not exceed 700 ppc (particle per cubic centimetre) and that out of a minimum of twelve samples taken in the hour, no more than 10% should exceed 1500 ppc.

Because virtually all coal mining activities at that time were carried out in the coal seam, this standard failed to recognize any differences in the harmful effects of coal and quartz dust. The introduction of continuous miners and roof bolting for strata control in the mid 1950s provided the potential for higher concentrations of respirable quartz dust. At about the same time, medical evidence showed that dust most readily retained in the lungs was in the 0.5 microns range size.

In 1957 the standard was revised so that the permitted dust concentration decreased linearly with increasing free silica content (Table 1). Further revision of the respirable dust standard took place in 1967 which reduced the number of particles permitted to take into account the smaller size range of 1.5 microns.

**TABLE 1**

<table>
<thead>
<tr>
<th>Free silica content of parent rock, %</th>
<th>1957 Average dust concentration (in particles less than 5 micron) not to exceed</th>
<th>1957 Average dust concentration (in particles in the range 1 to 5 micron) not to exceed</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>700</td>
<td>175</td>
</tr>
<tr>
<td>10-20</td>
<td>600</td>
<td>150</td>
</tr>
<tr>
<td>20-30</td>
<td>500</td>
<td>125</td>
</tr>
<tr>
<td>30-40</td>
<td>400</td>
<td>100</td>
</tr>
<tr>
<td>40-50</td>
<td>300</td>
<td>75</td>
</tr>
<tr>
<td>50</td>
<td>200</td>
<td>50</td>
</tr>
</tbody>
</table>

These results clearly indicate that dust counts on longwalls using the particle count method gave values almost 70% higher compared to non-longwall operations.

Table 2 and 3 also shows that the South Coast, which mines the Bulli Seam with longwall operations during 84-85, 3.6% of samples exceeded 3 mg/m³ limits. In comparison 25% of samples exceeded 3 mg/m³ in longwall operations. The longwall operation in the Bulli Seam had 31% of samples which exceeded 3 mg/m³ limits. All other longwall operations had only 22% samples exceeding this limit.

Longwall operation in the Northern Coal Fields had only 4% of samples exceeding the statutory limits. This indicates that the Bulli Coal is almost 6 times more dusty than the coals in the Northern District and about 1.5 times more dusty than the coal in the Western Districts.

Longwall production per day in 1987 stood at 6600 tonnes. If these values are projected to anticipated production of 10 000 tonnes/day over the next couple of years, then anticipated dust levels will be that even longwall in the Southern Coal Fields where normally only 10% of samples exceed statutory limits, this will increase to 22% and on the South Coast samples exceeding 3mg/m³ will increase from 4% to 64%. Operations which to-day can be classified as non-dusty will become dusty with increase in productivity levels. It is therefore essential that continued effort is directed to dust control along with any change in technology leading to higher production levels.

4. CONTROL OF DUST ON LONGWALL FACES

Dust on longwalls is not only produced during cutting and loading of the coal at the face, but a large percentage of dust is also contributed by other essential operations forming a part of the longwall face technology.

### Table 2

| District | Total No. of Samples | Average Particle Count | Ratio of Longwall/Other
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Overall</td>
<td>For all mining</td>
<td>except longwall</td>
</tr>
<tr>
<td>North</td>
<td>24 879</td>
<td>42.68</td>
<td>43.02</td>
</tr>
<tr>
<td>North-West</td>
<td>21 147</td>
<td>50.39</td>
<td>50.39</td>
</tr>
<tr>
<td>West</td>
<td>5 404</td>
<td>91.70</td>
<td>90.50</td>
</tr>
<tr>
<td>South</td>
<td>49 788</td>
<td>117.54</td>
<td>105.37</td>
</tr>
<tr>
<td>Mean</td>
<td>1.71</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
TABLE 3
RESULTS OF GRAVIMETRIC SAMPLING
BETWEEN MARCH 1984 & MARCH 1985 - N.S.W.

For all mining except longwalls

<table>
<thead>
<tr>
<th>DISTRICT</th>
<th>TOTAL NO OF SAMPLES</th>
<th>SAMPLES BETWEEN 0-2 mg/m³</th>
<th>SAMPLES BETWEEN 2-3 mg/m³</th>
<th>SAMPLES BETWEEN 3-4 mg/m³</th>
<th>SAMPLES OVER 4 mg/m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>North</td>
<td>2036</td>
<td>1824</td>
<td>160</td>
<td>27</td>
<td>15</td>
</tr>
<tr>
<td>North-West</td>
<td>562</td>
<td>575</td>
<td>104</td>
<td>53</td>
<td>30</td>
</tr>
<tr>
<td>West</td>
<td>431</td>
<td>388</td>
<td>32</td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>South</td>
<td>1850</td>
<td>1574</td>
<td>169</td>
<td>59</td>
<td>29</td>
</tr>
</tbody>
</table>

For all longwalls

<table>
<thead>
<tr>
<th>DISTRICT</th>
<th>NO OF SAMPLES</th>
<th>SAMPLES BETWEEN 0-2 mg/m³</th>
<th>SAMPLES BETWEEN 2-3 mg/m³</th>
<th>SAMPLES BETWEEN 3-4 mg/m³</th>
<th>SAMPLES OVER 4 mg/m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>North</td>
<td>129</td>
<td>95</td>
<td>21</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td>North-West</td>
<td>40</td>
<td>32</td>
<td>6</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>West</td>
<td>55</td>
<td>42</td>
<td>13</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>South</td>
<td>288</td>
<td>201</td>
<td>93</td>
<td>57</td>
<td>37</td>
</tr>
</tbody>
</table>

Various sources of dust on longwall faces are as follows:
1. Shearer cutting and loading.
2. Dust produced by the crusher at the stage loader.
3. Chock advance.
4. Spalling of coal at the face.
5. Conveyance of coal, and transfer points.

The most effective control measures adopted on longwall faces include changes in cutting technology, use of sprays/mists, water infusion, ventilation changes including air splitting, i.e. air curtains, homopropal ventilation and lastly removal of men from the high dust concentration areas using remote operation of chocks.

Developments in cutting technology have reached a stage which indicates that the status of research in this area is on the top of the S-curve. Future mining machines will be more powerful, with slower pick speeds, deeper cutting depths and less cutting picks. However, as indicated earlier, higher rates production from these machines will tend to produce more dust.

Spray systems used on mining machines together with splitting of the air and movement of the dust laden air direct into the return is a very successful technique for control of dust on mining faces. The use of surfactants (wetting agents) has produced conflicting data. Not enough work has been done on the nature and activity of the surfactant, its mechanism during dust knockdown, and the properties of coal dust. These areas require further detailed study.

Considerable dust control success has been achieved in the use of water infusion on the faces in France and Germany with limited success in other countries. This technique is quite adaptable in mines in which holes have already been drilled into the seam for methane drainage. These holes in some instances can be used for injection of water into the seam.

Methane drainage can lead to a higher dust make due to moisture being removed from the coal with the methane.

The use of homopropal ventilation in non-gassy mines has been used for better dust control, but in gassy mines this system may lead to gas problems.

A State of Art Report was prepared under a NERDO (National Energy Research Development and Demonstration Project) grant by Lana and Membr (1986) which discusses the technology of dust control at length. This report made the following recommendations:

Research is required into the factors which make a coal seam dusty. The structure of the seam and the types of lithotypes present appear to influence the amount of airborne dust generated in mines. This aspect needs further study.

High pressure, water-assisted cutting drums offer a completely new area for longwall extraction and dust control. The use of this technology is being investigated for use in the mining of the Bulli Seam.

Water infusion has been successfully applied in many countries overseas. Use of water infusion to increase in-situ moisture of the Bulli Seam has greatly reduced dust levels on a longwall face.

Ventilation control on the longwall with air splitting using water plus compressed air ventilis should be standardized. This system is quite helpful to reducing dust levels at the operator position.

The AusMM Illawarra Branch, 21st Century Higher Production Coal Mining Systems – Their Implications, Wollongong, NSW, April 1988

275.
Complete automation of the face operation with removal of operators from the face will ultimately reduce dust exposure levels. The developments in automation need to be followed very carefully. However, dust control is still required to allow limited personnel access, to minimise dust explosions and premature failure of equipment.

Accordingly, a research supported by NERDT, Kynalia Coal and Coke and Joint Coal Board has been initiated at West Cliff Colliery in particular and South Coast in general to investigate methods of dust control on longwalls, particularly in relation to the Bulli Seam. The work programme of this research is as follows:

1. Water injection to wet inherent dust (coal) in situ and thereby eliminate its dispersion.
2. Development of a system for automatic shear operated air curtains for air splitting on longwall faces.
3. Trial of dust extraction drums on longwall at West Cliff Colliery.
4. Comparative studies of dust levels using standard picks and diamond picks on longwall shear drums.
5. Further investigate the use of high pressure water assisted cutting to dust control.

Some of the results of this research are presented below:

5. WATER INFUSION

Coal within a seam may be below the critical moisture level so that when it is mined, there is insufficient free moisture to agglomerate all the dust size particles produced before they become airborne in the ventilating air stream. The lack of moisture can be a result of natural conditions or can be a result of mining operations such as methane drainage. To increase the moisture content of a seam it may be possible (depending on the physical condition of the seam) to pump water into it. If sufficient water is able to be injected and distributed throughout the seam to raise the average total moisture level, dust made during mining may be reduced substantially.

Not only can the airborne dust levels be reduced directly by increasing the moisture content, but the velocity of the ventilating air can be increased to further decrease the airborne dust concentrations. Water infusion of longwall panels is currently practised in the U.K., France, West Germany, The People's Republic of China, the U.S.S.R., and the U.S.A. Water infusion is not currently used in Australia on a regular production basis. Water infusion in some of these countries is used to control methane emissions as well as dust.

Water infusion was tried for dust suppression as early as 1947 in bord and pillar workings.

At two mines on the South Coast of New South Wales practicing retreat longwall mining in the 2.8m thick Bulli Seam, infusion was tried using 45.6 mm diameter holes with lengths varying between 75 and 100 m in the longwall block outbye of the face line. In both cases roof collapse occurred when mining through the infused area. This was blamed entirely on the water infusion. In one case, dye used in the water was observed 9 m into the roof above the coal seam. There is, however, insufficient data to support that the falls were really due to water infusion. However, these incidents did put back the use of this technology by almost 15 years.

Success for water infusion is dependant on fracture permeability, cleating of the coal bed and its ability to absorb water. Infusion cannot be used effectively in all seams. At West Cliff Colliery, methane drainage of future retreat longwall blocks is practiced from adjacent development heading. Due to difficulty in complying with airborne dust regulations, water infusion was tried in 1984 using disused methane drainage holes.

Problems associated with collapse of holes due to lateral stress abutment made infusion very difficult.

In June 1987, studies were further initiated using water infusion. Three holes placed at 1.6m apart were infused with water on longwall 9 at West Cliff Colliery. The average length of the holes was 140 m with a bore diameter of 60mm. A total of 28 000 tonnes of coal was infused and mined. Monitoring was conducted using a Dimsel placed at the 50th chock placed between the front legs and two DuPont Personal Samplers placed at the 5th and 95th chocks. A DuPont Personal Sampler was also used for the Swearer Operator. Results of measurements are given in Table 4.

More detailed studies are presently being conducted. Results to date indicate that Bulli coal after gas extraction is amenable to water infusion at 500 m depth. The uptake of water is measured in 9 holes over an average period of 11 days gave a value of 113 000 litres/hole increasing the moisture content of coal by 0.58% by weight or 0.95% by volume. Samples of coal from the Bulli Seam without infusion of water have given values varying between 0.9 - 1.1%. It is felt that increased moisture of 0.7% has resulted in reducing dust levels by 30-50%.

Longwall 10 at West Cliff Colliery with a total length of 500 m has been fully infused with 40 holes. This longwall will start production in mid-March. An extensive dust measurement programme is planned on this longwall.
6. Compressed Air Curtain

Trials were conducted using air curtains on a retreat longwall at West Cliff Colliery in the Bulli Seam. When the ventilation enters the longwall face a ventilation split occurs when part travels in the chock walkway and part down the face or pan line. If it was not for the shearer travelling on the pan line and dust laden air as it travels through the face would not migrate between the chock walkway and pan line.

Smoke tubes released on the main gate side of the shearer showed that when the dust laden air on the pan line came into contact with the shearer’s body, it took the easiest path into the chock walkway where the shearer operator was located.

Although the shearer operator spends a majority of his shift in the chock walkway one or two lengths of the main gate side of the shearer, he occasionally had to inspect the position of the tailgate drum. To prevent the dust laden air entering the chock walkway and force it over the shearer body, two compressed air curtains were tried in the initial test. The air curtains were fixed to chocks number 11 and 12 for the test and readings were taken with the Simul in the chock walkway opposite the centre of the shearer during the shear run only as the respirable dust is more concentrated on that run.

Over six shear runs from the tailgate to No 14 chock, readings varied from a low of 2.94 mg/m³ to a high of 6.42 mg/m³. When passing numbers 14, 13 and 12 chocks the lowest reading was 1.50 mg/m³ and the highest 1.74 mg/m³. These encouraging results led to an order being placed for twelve steel air curtains to extend the test area on the longwall face.

In the first trials, four air curtains were fitted to the front leg of numbers 12, 14, 16 and 18 chocks, making a total length covered by the air curtain of eight chocks. The reason for restricting to four the number of air curtains was that compressed air available at the face would only effectively operate four units at any one time. The air curtains were angled at approximately 15° off the face line towards the coal face. Average readings were recorded on the NMD respirable dust sampling instrument each eight chock section and results are given in Figure 2.

7. Further Research

The next stage of the project will include the installation of four air curtains every third chock to compare the dust concentration with results of research to date presented in this paper. Following this work all twelve air curtains will be located on the face, although only four curtains will operate at any one time. Initially four curtains will be operating them at number 6 18 turned on, number 1 will be turned off manually and so on. Three air curtains will be operating on the main gate side of the shearer and one adjacent to the shearer body at all times. If results are favourable the air curtains will be fitted throughout the length of the face and it is intended to fit equipment to the shearer to have shearer initiation to turn the air curtains on and off as required automatically.

8. Conclusions

Dust control is becoming more important with the introduction of high productive longwall systems.
Longwall mining in the Bulli Seam produces dust samples which have rarely met the statutory New South Wales requirements of 3 mg/m³. The Bulli Seam is almost six times more dusty than the coal seams in the Northern Districts.

Use of water infusion, even on a limited scale, has reduced dust levels by 30-50% along the longwall. It has not affected roof conditions. It is possible to infuse the Bulli Seam with water at low pressures (5 bar).

Use of air curtains suitably placed have successfully reduced dust levels by an average of 50%.

Both these techniques could be applied successfully. It is, however, realized that a single dust control technique is not going to control and minimise dust levels on future longwall faces which are capable of producing up to 50 tonnes/minute. A multi-pronged approach is required. Bearing in mind Collieries on the South Coast are introducing dust extractor drums (West Cliff and Appin) water assisted cutting (electroic drum - South Bulli), research into the use of diamond picks to control both dust main and reduce frictional ignition is being conducted under a separate programme supported by NEERDFP. On longwall 11, at West Cliff Colliery, a dust extractor drum with poly crystalline diamond (PCD) picks will be tested.

Homostropic ventilation has been applied in USA (Kelly and Jankowski 1985) and at Appin Colliery. This method along with water infusion, dust extractor drum and PCD picks is presently being investigated at West Cliff Colliery under the research programme supported by NEERDP.

ACKNOWLEDGMENTS

Research work reported in this programme has been supported by NEERDP, Kembos Coal and Coke and Joint Coal Board. Authors are thankful to their organisations for permission to present result of investigations.

REFERENCES


Hewitt, A. 1987 Joint Coal Board Statistics

Joint Coal Board, Standing Committee on Dust Research and Control, Water Infusion. Sydney, N.S.W., 1965.

