

Dust measurement and control in thick seam mining

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ABSTRACT: The increasing scale of thick seam longwall mining operations presents particular dust control challenges above those faced by those at more traditional extraction heights of 1.8 to 3.0m. These include major face slabbing of coal, the leaving of substantial coal in the roof, high average production rates and peak tonnages and high air velocities required to dilute seam gases and because face length are increased. A questionnaire survey of six Australian thick seam miners operators to identify individual mine issues related to dust control is discussed. Thick seam longwall dust issues based on the analysis of dust survey results from both published US data and from Joint Coal Board data are presented. Recommendations have been given for research and innovation in area of airflow and dilution, research into various spray installations, applications of Computational Fluid Dynamics, some engineering approaches and questions of management of dust issues within the mine operating structure. Australia's approach to mining in thick seams is unique. Improvements to the mine atmosphere and dust conditions will be driven through effort undertaken within the country with application where appropriate of overseas developments.

1 INTRODUCTION

The increasing scale of underground longwall mining operations challenges the maintenance of safe and healthy face environments in Australian collieries. This is particularly a challenge in controlling respirable dust in thick seam mining using longwall extraction.

Thick seam longwall production producing high tonnages is relatively new to Australia and the number of mines involved is increasing. Thick seams are those currently of about 3.5 to 5.0m (and possibly of greater thickness in the future) being extracted in one pass. Thick seam extraction presents additional problems in dust measurement and control above those faced by medium extraction heights of 1.8 to 3.5m. These include the leaving of substantial coal in the roof, major face slabbing of coal, high average production rates and peak tonnages, high air velocities required to dilute seam gases and increased face length. Australia is mining at greater seam thicknesses than most similar western countries and particularly the US. The approaches developed by other countries and previous research and innovation are not necessarily directly transferable or adequate for Australian challenges.

The intention of the study was to develop a blueprint for future dust remediation in thick seam mining. In the first instance the problems being faced by

Australian producers were identified. The project was restricted to the technical issues of measurement and control of respirable dust within the underground mine environment. Extensive literature reviews were undertaken and advice sought from recognized dust experts both within Australia and overseas. An examination of some approaches to assessment of dust compliance and analysis of trends exhibited was undertaken. Analysis and evaluation of options for improvement concluded the study.

This paper describes details of a questionnaire survey of six Australian thick seam miners operators to identify individual mine issues related to dust measurements and controls. It also examines some thick seam longwall dust issues based on the analysis of dust survey results from both published US and Australian Joint Coal Board (JCB) data.

2 QUESTIONNAIRE SURVEY OF THICK SEAM LONGWALL OPERATORS

A questionnaire survey on respirable dust in thick seam coal mines was undertaken in order to achieve a better understanding of respirable dust issues faced by Australian thick seam longwall operators. Six of the seven Australian thick seam operating mines were surveyed through interviews with mine per-

sonnel and associated underground visits (Gillies, 2001).

2.1 Survey results summary and analysis

Three mines from each of the states of NSW and Queensland were visited. Most of the mines were established in their present form in the 1990s. Five mines have an annual production rate of more than 3 mtpa with two of these exceeding 5 mtpa. Seam thickness averaged 8.3 m with a range varying from 4.0 to 24.0 m. Average Mains and Panel development height is 3.4 m with a range varying from 3.1 to 4.0 m. Panel height averaged 4.3 m with a ranging from 3.8 to 5.0 m.

2.1.1 Gas and ventilation information

All mines except one surveyed have both tube bundle and telemetry system for underground ventilation monitoring. All have installed various types of gas sensors and two have both air velocity and pressure sensors installed. Three mines have very low seam gas present (<2 m³/tonne), two are low (3-5 m³/tonne), one moderate (5-10 m³/tonne) and none are high (>10 m³/tonne). Of the two mines with gas drainage systems in place, one used water infusion whenever and wherever possible and the other is considering this. All mines have the potential for spontaneous combustion. Two mines used panel bleeders or ventilated behind the goaf. All mines surveyed used Ventsim ventilation network simulation software and one also used VNETPC.

2.1.2 Ranking of respirable dust issue

A question was asked on the priority of dust as a challenge. In general, equipment availability is considered as the most important issue by Australian thick seam coal mine operators in restricting longwall production expansion. This is followed by geological and geotechnical considerations and methane gas problems. Table 1 shows a summary of comments on the most important issue in restricting longwall production expansion from mines surveyed.

Table 1. Comments on important issues in restricting longwall production expansion.

Mine	Comments (ranking 1: most important & 4 least important)				
	Dust	Geo technical	CH ₄ Gas	Equipment	Others
A	4	3	2	1	
B	4	2	3	2	1
C	3	2	4	1	
D	4	1	3	1	
E	2	1	3	4	
F	3		4	1	2

For mines without serious methane gas issues respirable dust ranked as the third important issue affecting longwall production after equipment and geotechnical issues. Respirable dust is generally not an issue that will immediately stop longwall production. In some cases where silica levels were out of compliance the longwall production was slowed. However it was considered that the dust issues could usually be rectified by modifying mining procedures or by the use of personal protective equipment (PPE) to reduce dust exposure. Five out of the six mines surveyed considered respirable dust as a serious problem now or in the near future. Their reasons are mainly related to the health risk and visibility problem associated. However, most of the mines believed that use of PPE, shearer sprays, shearer and chock automation can rectify the problems associated with respirable dust.

All mines used unidirectional (uni-di) longwall shearer cutting methods mainly due to production loading, clean up, ventilation and dust issues associated with bi-directional (bidi). One had recently changed from bidi due to dust. When asked what is the major dust challenge difference between thin seam and thick seam longwall mining most of the mines indicated that high production associated with thick seam longwall means more dust generation and increased face air quantity requirements.

Table 2. Major sources of dust estimated on the longwall face.

Mine	Shearer %	Chock advance %	Stage loader %	Belt heading %	Others %
A	50	50			
B	50	25	10	5	10
C	25	35	20	20	
D	Largest	Worst	Control		
E	45	45	5-10	<5	
F	30	20	20	5	20

Most of the mines considered shearer and chock advance are the major sources of dust on the longwall face (as shown in Table 2). This is followed by dust from the stage loader and the belt heading. Half of the mines surveyed considered spalling of high faces creates a major dust source. One mine indicated that a study into the relationship between slabbing and face abutment loading would be worthwhile. It is believed that slabbing would be reduced if chocks were advanced closer to the face.

All mines surveyed used shearer mounted sprays on the face. Sprays are also installed at the stage loader. Most of mines have sprays on the chocks but are not in use. Most mines used a modified unidi cutting method cutting mainly from Tailgate (TG) to Maingate (MG) while snaking at the TG. Only three mines have used shearer clearer sprays. Of these, two indicated that the shearer clearer configu-

ration used is not fully covering the face. All three mines indicated that designs or operational changes to the shearer clearer system were warranted to achieve a better coverage. Four mines provided data on mine pressure at sprays. Pressures reported by these mines have a wide range from 0.7 to 8.0 MPa.

Three mines have investigated the use of chemical surfactants. Two of them indicated that chemical surfactants are not considered to be cost effective.

2.1.3 Face ventilation arrangement

Longwall face air quantity is generally targeted between 35 and 70 m³/s and averaged around 50 m³/s. Most of the mines indicated that the targeted amount of air was normally achieved. A divided view on whether more air on the face would assist dust reduction was observed. Three mines believed that more air at face would not assist dust reduction but increase dust pick up and disturb spray operation.

When asked whether more air quantity from the whole mine ventilation network could be delivered to the face most of the mines indicated that this is achievable with their current mine ventilation system by increasing the fan operating speed or number of fans in use.

Most of mines were of the view that there is a maximum face air velocity (around 4 m/s) beyond which they thought airborne dust levels would be exacerbated. Four mines indicated that they have some knowledge of the pattern or distribution of air along the face length. Two mines indicated no air escapes through the goaf behind the chocks, three said some air escaped and the other indicated about 15 to 20 m³/s escaped through the goaf. All mines surveyed indicated that filtered air (Airstream) helmets and various face dust masks and filters are available for use by all personnel in the longwall panel.

2.1.4 Dust control plans

Most of mines have formulated a Dust Control Plan for their longwall. Most of the mines (5 out of 6) indicated that a Dust Control Plan is not part of their Mine Ventilation Plan.

Three mines indicated that they are in the process of minimizing the number of operators on the face. Four mines pointed out that the shearer could be remotely controlled by an operator from a distance ranging from 5 to 40 m. Four mines indicated that chock operators were rotated during the shift to minimize individual exposure but with some operational issues. Half of the mines undertake snaking at the TG to limit the dust exposure to operators.

All mines undertook surveys of face dust levels on personnel but only half of the mines conducted surveys for area levels. All NSW mines have the JCB undertake their surveys. All Queensland mines have the Safety In Mines Testing and Research Station (SIMTARS) undertake their surveys. One

Queensland mine also has had the JCB conduct surveys. Two thirds of the mines have the survey undertaken every three to six months as required by statutory regulations. The other two have surveys at shorter intervals

3 THICK SEAM LONGWALL DUST ISSUES

3.1 US longwall dust situation

Thick seam longwall mining has become the most productive method of underground coal mining in Australia and record levels of production have been achieved in recent years. These ever improving production levels have the potential to generate significantly quantities of respirable dust. In the mid 1990s, Pittsburgh Research Center (PRC) initiated a surveillance effort to quantify the levels of dust being generated by various sources found on US longwalls, identify the types of dust control technologies in use and try to quantify the degrees of application for these control technologies (Colinet et al, 1996).

Table 3. Contributions during mining from major longwall dust sources.

Mine	Cutting Height (m)	Contributions from Major Dust Sources			
		Intake Airflow	Stage Loader	Shields Advance	Shearer Cutting
C	3.4	6.2%	14.9%	19.4%	59.5%
E	3.1				
D	2.7	7.6%	24.9%	30.1%	37.4%
G	2.7	13.2%	14.9%	35.6%	36.3%
K	2.7	10.9%	7.5%	21.8%	59.8%
J	2.4	5.5%	4.6%	7.0%	82.9%
F	2.1	8.2%	15.2%	16.9%	59.7%
L	2.1	16.6%	9.1%	30.0%	44.3%
A	2.0	17.4%	20.8%	27.1%	34.7%
B	1.8	6.5%	17.6%	31.1%	44.8%
H	1.8	12.3%	32%	25.7%	30.0%
I	1.7	2.2%	11.1%	21.2%	65.5%
M	1.7	0.4%	4.9%	10.1%	84.6%

PRC conducted dust surveys at 13 longwall operating throughout the US. It collected information on existing operating practices on these longwall, identified the types of dust controls in use, documented the levels at which these controls are being applied and measured the respirable dust levels generated by the major sources on the longwall section to evaluate the relative effectiveness of the control technologies. In order to identify the importance of seam thickness on the generation of respirable dust on longwalls, the information collected by PRC has been reanalyzed based on the seam thickness. Table 3 lists the dust contributions during mining from major longwall dust sources such as intake, stage loader/crusher, chock shield advance and shearer for each mine as

set down by Colinet et al (1996). Mines are listed in decreasing seam extraction height.

The mines were listed according to their cutting heights and were classified into two categories: thin seam ($\leq 2.2\text{m}$) and medium thickness seam (2.1 to 3.4m). Seven mines were classified as thin seam and six mines as medium seam. By analyzing the information from Table 3, it is evidenced that thin and medium seams have different contributions from major dust sources within the longwall section. Table 4 shows average dust contribution of major dust sources on longwall faces.

Table 4. Average contribution of major dust sources based on cutting height.

Mine	Cutting Height (m)	Contributions from Major Dust Sources			
		Intake Airflow	Stage Loader	Shields Advance	Shearer Cutting
Medium Seam	2.9 (2.4-3.4)	9.8% (6%-13%)	13.7% (5%-25%)	24.4% (7%-36%)	52.1% (36%-83%)
Thin Seam	1.9 (1.7-2.1)	8.3% (0%-17%)	15.6% (5%-21%)	22.0% (10%-31%)	54.2% (30%-85%)

With an average cutting height of 2.9 m and a cutting rate averaged at 27.5 tons per minute, the medium seam mines have more dust sourced from intake air and shield advance movement when compared with the thin seam mines with have a cutting height averaged at 1.9 m and an average cutting rate of 16.3 tons per minute.

On average, intake air accounted for 9.8% of the dust make for the medium seam mines and 8.3% for the thin seam mines. One explanation for this could be that medium seam mines might have higher volumes of air supplied to the face with higher airflow velocities in the intake airways. However, this was not the case as average airflow quantities supplied to both categories were compared. Medium seam mines actually had less air quantity on average at 18.4 m³/s at average air velocity of 1.8 m/s supplied to the faces compared with 21.5 m³/s at 3.3 m/s supplied to faces for the thin seam mines. The other reason could be that normally the medium seam mines are generating more dust mine-wide and the chance of intake air being contaminated with dust is therefore higher.

Shield advance movement also accounted for more (24.4% compared with 22%) of the total dust make for medium seam mines than the thin seam mines. This supports earlier research that indicated that greater levels of respirable dust are generated during shield advance if coal is left in the roof. This is commonly found in thicker seam mines. Both stage loader and shearer cutting accounted for slightly less percentages in the total dust make at the longwall face with medium seam mines than with thin seam mines. However, the shearer is still the most significant source of respirable dust generation on the faces regardless of the seam height.

Gravimetric dust samplings including stationary and mobile measurements were collected and summarized during PRC's investigation. An indirect calculation was made to try to work out the average dust concentration contributed by each source at longwall section for all mines considered. This was done by reexamining some of the stationary and mobile gravimetric dust sampling results presented by Colinet et al (1996). The average dust make in mg/m³ at each source within the longwall section can be calculated from knowing the percentage related to the total dust make and the intake air dust concentration measured as shown in Table 5. For example, dust from the stage loader is calculated as

$$\begin{aligned} & \text{Dust generated at stage loader} \\ &= (\text{Average intake air dust level} \div \text{Average intake air \% of total dust make}) \times (\text{Average stage loader \% of total dust make}) \\ &= (0.53 \text{ mg/m}^3 \div 9.8\%) \times 13.7\% = 0.74 \text{ mg/m}^3 \end{aligned}$$

It is apparent that the medium seam mines have generated much more respirable dust than thin seam mines. Total respirable dust generated within the longwall section averaged at 5.41 mg/m³ for the medium seam mines and 3.25 mg/m³ for thin seam mines. Figure 1 summaries average gravimetric dust concentration from longwall sections for both medium and thin seam mines. Thicker seam mines with greater cutting heights will have higher production rates and more respirable dust will be generated during mining from intake air, stage loader/crusher, shield advance and shearer as illustrated.

Table 5. Average dust levels of major dust sources on longwall faces.

Mine	Intake* Airflow (mg/m ³)	Stage Loader (mg/m ³)	Shields Advance (mg/m ³)	Shearer Cutting (mg/m ³)	Total (mg/m ³)
Medium Seam	0.53 (9.8%)	0.74 (13.7%)	1.32 (24.4%)	2.82 (52.1%)	5.41 (100%)
Thin Seam	0.27 (8.3%)	0.51 (15.61%)	0.71 (22.0%)	1.76 (54.2%)	3.25 (100%)

* average of the intake air dust sampling results obtained by Colinet et al (1996).

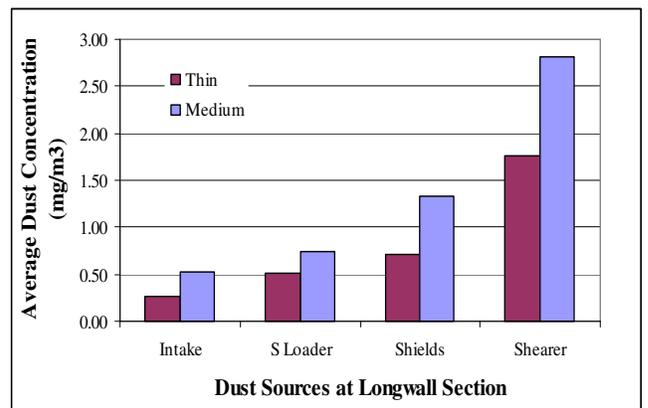


Figure 1. Average dust concentrations of major dust sources on longwall faces.

3.2 Australian longwall dust situation

As mentioned previously, overseas experiences cannot be translated directly to Australian situations. This is particularly true when comparing the operation conditions of US and Australian longwalls. For example, in Australia, thick seam longwall mines surveyed during this study have an average cutting height of 4.3m with a range varying from 3.8 to 5.0m. The thickest seam mine in US examined previously is 3.4m. Therefore, it is necessary to examine the Australian longwall mines to evaluate the effect of thicker seam cutting height on the dust make on longwall faces.

In order to gauge the effect of thick seam mining on the respirable dust makes for Australian longwall, a selection of JCB respirable dust database results were examined and analyzed. The JCB dust database contains all respirable dust sampling results dated back to 1985 conducted by JCB according to the statutory requirements in NSW (Cram, 1998). There are only three longwall mines in NSW that can be regarded as thick seam mines. Therefore, six longwall mines were selected from JCB dust database with the three thick seam longwall operations with panel cutting height of more than 3.5m classified as thick seam mines and the other three with panel cutting height of less than 3.5m as medium seam mines. The medium seam mines were selected based on the similarity of the operational conditions to those of the thick seam mines.

The JCB samplings were conducted for various mine personnel working at longwall faces such as cableman, electrician, MG man/operator, chockman, deputy, fitter, shearer operator and support operator etc. Of these personnel, chockman, deputies and shearer operators are the most important personnel from a dust point of view as they are working most of the shift on longwall faces and have been subjected to dust exposure during the working shift. They are also sampled more frequently than any other personnel at the face.

From an analysis of the sample of JCB respirable dust readings of both thick seam and medium seam mines there appears to be evidence that chockmen in high production thick seam panels are exposed to higher dust exposures than shearer operators as shown in Figure 2.

From Figure 2 it can be seen that over the period under study dust levels in medium seam mines have been, in general, decreasing. This can be explained from general industry awareness and use of improved technology across the industry. However dust levels on thick seam mines have remained relatively consistent, progressively increasing higher production rates contributing more dust were counterbalanced by general industry awareness and use of improved technology.

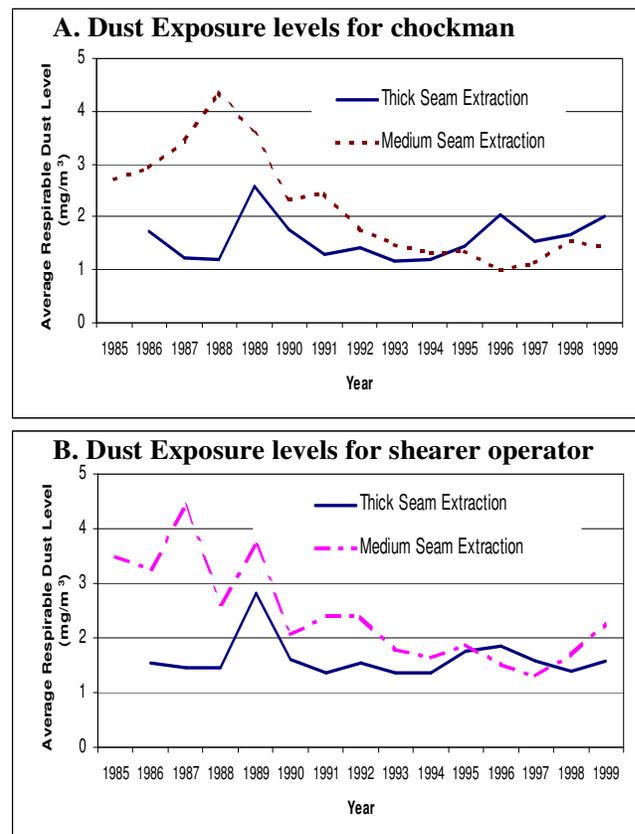


Figure 2. Comparison of yearly dust exposure levels for chockman and shearer operator.

In comparing dust levels on medium seam faces with those in thick it is clearly shown from 1995 that in the thick seam mines, chockman have been exposed to higher dust levels than their counterparts in the medium seam mines. However shearer operators have been exposed to similar dust levels in the medium seam mines to the thick seam mine personnel. In some years thick seam exceeded medium seam operators and in other years the opposite trend was exhibited.

In the most recent years since 1995 the trend is for thick seam chockmen to be exposed to greater dust (average 1.74 mg/m³ compared with 1.63 mg/m³) than their shearer colleagues. This same trend is not seen with medium seam chockmen and shearer operators. This is in agreement with the previous US finding that the chockman has higher dust exposure levels for the increased thickness mines. From these analyses it is recommended that more controls be required and employed for chockman to reduce their dust exposure levels. There is an Australian industry perception that the dust exposure levels for chockmen and shearer operators has been following increasing trends for the last few years, particularly in mines with dramatically increased levels of production. In order to gain a better understanding of the relation between production and dust exposure levels in longwall sections, average yearly shift productions in the 1990s verses both chockman

and shearer operator dust exposure levels for the thick seam mines are shown in Figure 3.

Figure 3 clearly shows that in the 1990s the thick seam mines examined have doubled their average shift production. Shearer operator dust exposure levels have varied over the years but are on an upward trend. Chockman dust exposure levels were definitely on an upward trend with the increased production particularly in the years.

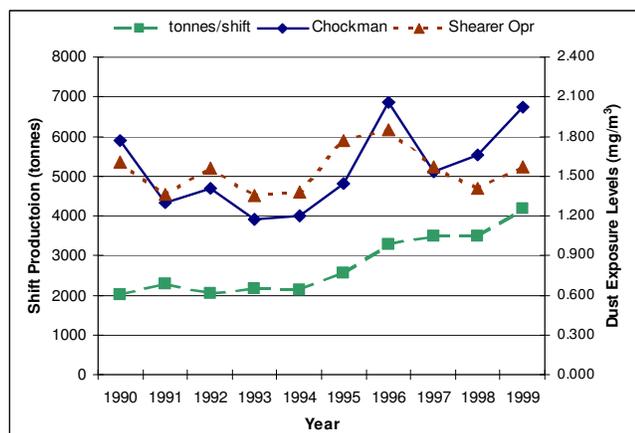


Figure 3. Average shift production versus dust exposure levels for thick seam mines.

Figure 4 examines these dust levels on a basis weighted to production. It illustrates average yearly shift productions versus both chockmen and shearer operator dust exposure levels per 1,000 tonnes of coal mined. It can be seen that both chockman and shearer operator dust exposure levels per 1,000 tonnes of coal mined were on downward trends in the last decade. This may be due to the increased awareness of potential dust problems associated with higher production rates. Mines have introduced dust control strategies either implementing new dust controls or improving existing controls to reduce the dust exposures of their miners.

However, based on the findings of the analysis of the JCB dust database results, there is no doubt that thick seam longwall mines are producing more tonnage. This production results in more respirable dust and better control technologies have at best been level pegging in keeping pace. Chock advance in thick seam longwalls is generating a relatively greater level of respirable dust than in medium seam longwall panels. This supports the findings from analysis of US longwall operations.

There may be a number of reasons for these high chockman dust readings. Friable coal is more likely to be left against roof. High silica dust can result from working against stone roof. Large chocks can collect a lot of dust which waterfalls into the air stream during lowering and advancement. Canopy sprays with different systems have been tried, approaches include:

- Spraying when chock lowering for advance

- Periodic pulsing sprays make the top of chocks wet at all times, and
- Frequent washing of supports with hose by hand

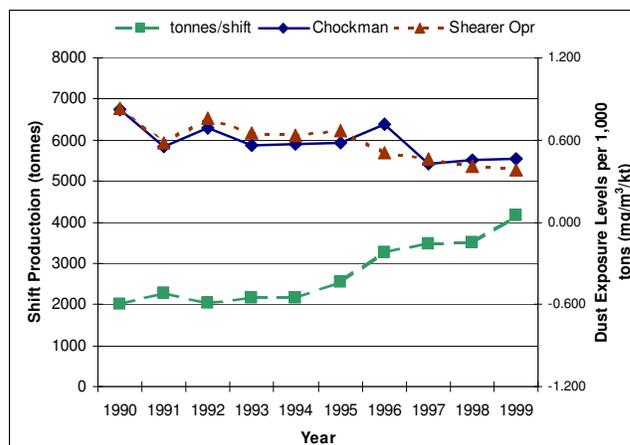


Figure 4. Average shift production versus dust exposure levels per 1,000 tonnes coal mined.

Operators often turn off the sprays as dust is less an issue than annoyance from getting wet from falling water. A greater understanding of the following issues is needed.

- Automatic systems for single or batch chock advancement. These have major scope for improving position of chockmen out of the dust.
- Shearer initiated chock advancement; there appears to be a lack of relevant literature on advantages from dust point of view to chockmen?
- Placement of chockmen during “snaking”.
- Rotation of chockmen during the shift.

Australian thick seam longwall mining is making an effort and giving priority to reduction of the respirable dust levels sourced from chock advance operations.

4 RECOMMENDATIONS AS TO FUTURE RESEARCH

A plan for research and development for dust remediation in thick seam mining is needed to identify cost effective approaches to reduce or overcome the problem.

A recommendation is to investigate both possibility and benefit from increasing face air quantity. High tonnage means more dust and mines have not proportionately increased air with tonnage. Air velocities of 4 to 6 m/s do not necessarily pick up or re-entrain much already settled dust in the wet and geometrically complex longwall face environment. Air velocities in excess of 5 m/s are found on some US Alabama Jim Walters mines longwall faces. Higher air quantities lead to increased velocities in belt headings and in air passing over coal carried along the AFC. This highlights the question of

homotropical/antitropical airflow design. How important is this consideration versus enhanced dilution from greater face quantities?

The mine survey demonstrates that there is an imperfect understanding of face air patterns in three dimensions. Understanding these and directing air should allow personnel to be kept in a clean split out of dusty air streams. Research using Computational Fluid Dynamics (CFD) to understand air/dust interplay on faces should be undertaken. CFD is an ideal application to understand interplay on faces between air, geometry, sprays, shearer clearer and dust scrubber and other factors; such as

- Airflow paths around shearer and through scrubbers
- Cutting with/against the ventilation
- Dust concentration in the walkway
- Water sprays on the shearer body
- Modeling of shearer clearer systems at different seam thicknesses.

It is important to redesign the shearer clearer for thick seam geometries. The shearer clearer was developed for thin and medium seams as much to keep air channeled along the face and away from men as to suppress airborne dust. The machine mounted shearer clearer is considered to have been a major reason for reduction in US longwall dust make in the 1980s and 1990s. Critical to the Shearer Clearer design and operation is awareness of type of sprays, location and outlet direction and water pressure and flow rate. There is a need for greater understanding of the application of sprays for dust capture, suppression and air control. Any optimization studies of this nature will have to consider parameters such as

- face geometry,
- shearer size and influence on face air flow,
- spray number and type,
- spray water consumption,
- spray water pressure,
- robustness of spray arm assemblies.

From the survey of industry and dust issues it would appear that there is poor understanding of how a shearer clearer can improve face dust conditions. Their use and interaction with ventilation flow is complex.

It has been highlighted that chock generated dust has been increasing in relative importance as an issue in Australian thick seam longwall mines. According to the survey conducted on Australian longwall dust issues, dust make from chock advance movements was ranked as the second major dust source following the shearer on the Australian thick seam longwall mines. Colinet et al (1996) has found that chock advance can contribute on average about 23 percent (at times up to 36 percent) of the respirable dust make on modern US longwall faces. He has also found that as the cutting heights of longwall faces increased, the dust make contributed from chock advances increased. From an analysis of Aus-

tralian JCB respirable dust readings from a number of both thick seam and medium seam mines there appears to be evidence that chockmen in high production thick seam panels are exposed to higher dust exposures than shearer operators.

Research is needed to gather basic data in an area where there is little quantifiable information. There is a need to provide useful information on mine airflows and polluting levels around chocks to better understand the effects of existing or new dust control techniques on combating dust generated from chock movements. From a dust point of view

- Are there advantages of shearer initiated chock advancement to chockman?
- Can chockman be better placed during “snaking”?
- Is there a better way of rotating chockmen during the shift?

Review of overseas technology developments must take into account the nature of individual national industries. Modern longwall methods are only in use in a small number of countries. Western European coal operators are backing out of underground extraction. South Africans have found longwall technology unsuitable for most of their seams. The US has about 65 modern longwall faces but almost all are extracting at thin or medium seam heights. A few mines are working at substantial seam thickness but not in excess of 3.8 m

5 CONCLUSIONS

The results of a detailed questionnaire survey on respirable dust in thick seam coal mines that was undertaken in 2000 in order to achieve a better understanding of respirable dust issues faced by the Australian thick seam longwall operators have been analyzed and discussed. High production associated with thick seam longwall, which means more dust generation and increased face air quantity requirements, is the major dust challenge difference between thin seam and thick seam longwall mining.

Shearer and chock advance are regarded as the major sources of dust on the longwall face. Longwall face air quantity is generally targeted between 35 and 70 m³/s and averaged around 50 m³/s. Most of the mines indicated that the targeted amount of air was normally achieved. A divided view on whether more air on the face would assist dust reduction was observed. Three mines believed that more air at the face would not assist dust reduction but increase dust pick up and disturb spray operation. Most of mines agreed that there is a maximum face air velocity beyond which they thought airborne dust levels would be exacerbated.

In order to identify the importance of seam thickness on generation of respirable dust on longwall section, US information collected by PRC in the mid

1990s was reanalyzed based on the seam thickness during this study. Data from thirteen mines was analyzed according to their cutting heights and was classified into two categories: six in thin seam (≤ 2.1 m) and seven in medium thickness seam (> 2.1 m). From the analysis, it is evidenced that thin and medium seams have different contributions from major dust sources within the longwall section.

With an average cutting height of 2.9 m and a cutting rate averaged at 27.5 tons per minute, the medium seam mines have more dust sourced from intake air and chock advance movement when compared with the thin seam mines which have a cutting height averaged at 1.9 m and an average cutting rate of 16.3 tons per minute. This supports earlier research, which indicated that greater levels of respirable dust are generated during chock advance if coal is left at roof, which is commonly found at the thicker seam mines. However, the shearer is still the most significant source of respirable dust generation on the faces regardless of the seam height.

An indirect calculation was made to try to work out the average dust concentration contributed by each source at longwall section for all mines considered. This was done by reexamining some of the stationary and mobile gravimetric dust sampling results presented by Colinet et al (1996). The average dust make in mg/m^3 at each source within the longwall section can be calculated from knowing the percentage related to the total dust make and the intake air dust concentration measured. It was found that the medium seam mines have generated much more respirable dust than the thin seam mines. Total dust generated within the longwall section averaged at $5.41 \text{ mg}/\text{m}^3$ for the medium seam mines and $3.25 \text{ mg}/\text{m}^3$ for the thin seam mines.

Overseas experiences cannot be translated directly to Australian situations. To determine the effect of thick seam mining on the respirable dust makes for Australian longwall, a selection of JCB respirable dust database results were examined and analyzed. Six longwall mines were selected with three thick seam operations with panel cutting height of more than 3.8m classified as thick seam mines and the other three as medium seam mines which were chosen based on the similarity of the operational conditions to those of the thick seam mines.

Based on the findings of the analysis of the JCB dust database results, there is no doubt that Australian thick seam longwall mines were producing more tonnage in recent years. This production results in more respirable dust and improved control technologies have at best been level pegging in keeping pace. Chock advance movement in thick seam longwall is generating a relatively greater level of respirable dust than in medium or thinner seam longwall panels. This supports the findings from analysis of US longwall operations. Australian thick seam longwall

mining should give some priority to reducing the respirable dust levels sourced from chock advance

Australia has about seven modern high production longwalls cutting at 3.8 to 5.0m seam thickness. More thick seam extraction mines are planned. With high, and often record breaking, production rates dust is potentially a major issue. As such the situation faced is unique and different to conditions faced in the rest of the world. The approaches and previous innovation from research and experiences in other countries (particularly the US, Western Europe and South Africa) are not necessarily directly transferable for solving Australian issues.

Recommendations for future research have been given on higher face air quantities and velocities; research with CFD to understand interplay on face between air, geometry, sprays, scrubbers and other factors; redesign of shearer clearers for > 3.5 m thickness seams; and greater understanding of chock dust.

The approaches are directed at thick seam mining although there is no doubt overlapping application to extraction in normal thickness seams. Australia's approach to mining in thick seams is unique. Improvements to the mine atmosphere and dust conditions will be driven through effort undertaken within the country with application where appropriate of overseas developments.

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