DEVELOPMENTS IN UNDERGROUND COAL MINING TECHNOLOGY AND THEIR IMPLICATIONS

By

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ABSTRACT

Developments in mining technology are outlined which point out that longwall face technology has the capacity to produce 20,000 tonne per day on a regular basis. The optimum length of longwall faces is about 250m. Developments of headings and gate roadways require radical changes to meet longwall developments. New conceptual models are outlined to meet the challenge.

INTRODUCTION

Coal was first discovered in Australia in 1791 at Lake Macquarie in NSW, shortly after the arrival of the first fleet in 1788. The first compressed air coal cutting machine (Stanley Head) was introduced at Greta in 1890 and electricity was first introduced in 1893 in the Co-operative Colliery when a motor pump was installed (Elford and McKeown, 1947). This started mechanisation and electrification of Australian mines.

By 1925 about 80% of coal was machine cut. Coal was largely hand-loaded and transported by rail. The first loading machine was installed in 1935 in NSW and the first continuous miner was introduced in 1950 by the New South Wales Coal Board.

By 1960 the mechanisation of the coal industry had been completed when almost 90% of coal was won by coal cutters and loaded by gathering arm loaders. By 1970 continuous miners and shuttle cars contributed to 90% of underground coal production. Productivity had increased from almost 2.8 tonnes per man shift to 14.3 tonnes per man shift in underground coal mining.

The introduction of continuous miners also led to new developments in roof support systems. Roof bolting was experimented upon in Belling Colliery in 1949 and introduced into John Street Colliery to support the weak coal roof of the Victoria Tunnel seam. Point anchors using mechanical wedges were replaced with mechanical shells in the early sixties and point anchors with chemicals in the early seventies. Full column grouting had been introduced in 1980. Only in a few mines where roof conditions were more difficult, particularly in gate roadways developed for longwall mining,

Mechanisation of cutting and loading using continuous miners and shuttle cars led to the development and modifications of mining methods. Room and pillar mining was replaced by bord and pillar (Old Ben System) and later by Mongawilli Split and Lift method in the early sixties. This system gave an enormous boost to productivity with the capacity to deliver 800-1000 tonnes per unit production shift in favourable underground conditions with a face CMS of 70-90 tonnes during pillar extraction.

Success of continuous miners in Australian conditions and the need to increase further their utilisation also led to the development of shortwall systems (Burwood, John Darling, Lambton, Corrimal, Bulli and Nebo Collieries) (Horeman, 1965, Adams and Ray, 1969, Martin and Margraves, 1972). These operations used Joy continuous miners and shuttle cars. The support system in the early stages was timber support which was replaced by 2 and 3 leg hydraulic chock support. The last shortwall face was withdrawn from Australian mines in October 1977 (Corrimal Colliery). The system did not prove very successful inspite of some minor inherent advantages.

Longwall mining was first trialed at Coal Cliff Colliery in 1963 with disastrous results due to incapacity of the support system to handle massive roof rocks. A moderately successful mechanical longwall began operation at the South Bulli and Kemira Collieries in 1965 and a modern successful longwall operation which became a pacesetter was introduced in 1979 at Angus Place. Developments in longwall mining equipment design, particularly the support system, took almost 20 years to achieve acceptable quality and for mining of the Bulli Seam under sandstone conditions. Accordingly, longwall mining got a boost in the early eighties and its contribution to underground production has since seen a dramatic upturn. World records have been created and tumbled in a span of weeks. A

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fully automated longwall face with remote shearer initiation was introduced at South Bulli Colliery in 1987. Presently, 4 are experimenting with this system. Production levels of 8000t/d are common, and peaks of 24,000t/d and 80,000t/week have been achieved. Longwall mining has been accepted as "The Technology of Underground Mining of Coal" and for the first time is challenging open cut mining operations in terms of overall productivity, performance and economics.

LONGWALL - TECHNOLOGY OF THE 21ST CENTURY

Developments in longwall mining technology in the last 15 years have been enormous and their pace is on the increase. The dream of the sixties when the first experimental systems for full automation were tried (ROLF—Remotely operated longwall faces, 1963) in UK is only now being fulfilled. The production capacity of the system has continued to grow over the past 25 years. The dream production level of 1000t/d of the Spear Head faces of the sixties in UK and Europe are not acceptable any more. The peak production levels of the sixties became the mean levels of the seventies and peaks of the seventies are average production levels of the eighties (Tab. 1).

The width of the longwall block (length of the face) has continuously increased to permit better utilisation of the equipment capacity. The concepts of optimisation of the longwall block parameters have also changed and optimum length of the longwall has continuously increased. The best example of this is the German coal mining industry where the average length of the longwall faces has increased from 140m to 240m over the 30 year period from 1955-1985. (Kundel, H. 1985).

Technological developments in the last 2 years in continuous haulage and breaker line supports have allowed doubling of production from Wongawilli systems. Production levels of 3000t/d have been achieved and 4000t/d have been forecasted. This gives another dimension to the bord and pillar system particularly where longwall systems cannot be introduced due to geological constraints. But in no way these systems have threatened or become rivals to longwall technology.

Obviously in future mining operations, longwall technology will be the technology of mining of underground coal where ever geological conditions permit. Mines which cannot introduce this technology effectively or some of its modifications will slowly become uncompetitive.

The effectiveness of longwall technology rests basically with the fact that it permits concentration of output around a much limited area which can be better prepared, more easily monitored, better controlled and hence better managed.

Productivity from a longwall depends upon 3 groups of factors namely:

(a) Ground Control Effectiveness
(b) Environmental Control Effectiveness
(c) Machine Utilisation and Associated Parameters.

All other conditions remaining constant, the 5 factors which directly influence production are:

1. Thickness of the seam
2. Effective width of a shear
3. Rate of shearing
4. Length of the longwall face
5. System of operating a shearer(s) on the longwall

Developments in face technology have increased shearing speed on the longwall faces considerably over the past 25 years. Some of the most powerful shearsers today can cut at rates up to 15m/min in seams of medium strength. Speeds of 14-16m are being considered for shearsers on the design table. This will become much easier with the use of high pressure water assisted cutting and use of diamond picks.

SHEAVER OPERATION ON LONGWALL

Three methods of operating shearsers on longwalls have been analysed:

1. Double ended ranging drum shearer with (a) Unidirectional cutting
(b) Bidirectional cutting

2. Single ended ranging drum shearer taking the full thickness of the seam, with bidirectional cutting, moving into a wide gate roadway eliminating some.

3. Operation of more than one shearer on a longwall face.

Fig. 1 shows the effect of length of longwall and shearing speed on production per unit thickness of coal seam. With shearing speeds of 16m/min and uni-directional shearing with face length of 200m, production of the order of 16,000t/d is not only feasible, but should be achievable on a regular basis. With this system, it is obvious that length of the face is quite important and that increased face length increases production.

With bi-directional shearing, production from a 200m longwall face increased to 25,000t/day but further increases in face length has lesser influence on increase in production. With a single ended ranging drum, where the machine can move straight into a wide main gate (which is possible with better rock mechanics design of excavations) production for a 200m longwall face will increase further to
44,000 t/d from a seam of 1m thickness. The length of the longwall face is now playing a less effective role.

One of the greatest advantages of increasing the length of the longwall face is to proportionally reduce the amount of development required to cope with high production rates. The best system of longwall operation would be that which gives high production but is independent of the length of the longwall face. Use of single ended ranging drum shears with bi-directional cutting comes close to this system. This however imposes the following limitations:

1. Requires uniform thickness of the seam
2. Limits the maximum thickness of the seam possibly 2m and good clean roof
3. Imposes very strict horizon control
4. Requires wide width of mining gate
5. Requires very good loading characteristics of the drum.

These limitations can be overcome by using more than one shearer on a longwall - bidirectional cutting with two miniature shearsers (e.g., ESA system) operating at the end. Production of coal using this system is more or less independent of the length of longwall face.

Table 1. Longwall Mining World Wide

<table>
<thead>
<tr>
<th>YEAR</th>
<th>COUNTRY</th>
<th>PEAK LW PROD. (t/day)</th>
<th>WORLD WIDE AVERAGE (t/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960</td>
<td>U.K.</td>
<td>1,000</td>
<td>500-600</td>
</tr>
<tr>
<td>1965</td>
<td>Czech.</td>
<td>4,500</td>
<td>1,000-1,500</td>
</tr>
<tr>
<td>1970</td>
<td>Poland</td>
<td>7,000</td>
<td>2,000-3,000</td>
</tr>
<tr>
<td>1975</td>
<td>S. Africa</td>
<td>11,000</td>
<td>3,000-4,000</td>
</tr>
<tr>
<td>1980</td>
<td>USA</td>
<td>18,000</td>
<td>5,000-6,500</td>
</tr>
<tr>
<td>1985</td>
<td>Australia (Newstan)</td>
<td>15,600</td>
<td>5,000-8,000</td>
</tr>
<tr>
<td>1985</td>
<td>S. Africa (German Creek)</td>
<td>22,000</td>
<td>6,500-8,000</td>
</tr>
<tr>
<td>1987</td>
<td>Australia (German Creek)</td>
<td>24,400</td>
<td>6,500-8,000</td>
</tr>
</tbody>
</table>

**OPTIMUM FACE LENGTH**

The question of optimum length of a longwall in given mining conditions though important, is very difficult to answer.

A number of optimisation models have been used to define the optimum length of the longwall, but the results obtained, though based on a theoretically sound model and assumptions, are quite useless in practice because of the variability of the cost parameters.

A very large number of parameters influence the cost of production from a longwall operation and hence contribute to the optimum value. These parameters can be grouped in three basic groups:

Group I: Costs related to the face length (not necessarily a linear function); such as face support
equipment, conveyor, part of face installation and removal costs ($C_i$).

Group II: Costs not related to the face length such as development of roadways, ventilation costs, capital costs of shearer, gate end equipment and face conveyor etc. ($C_i$).

Group III: Costs inversely proportional to the face length such as depreciation and maintenance costs of the face cutting machine, gate conveyor, gate road maintenance etc. ($C_i$).

The mining costs ($L_c$) for longwall can then be given by:

$$L_c = C_1 + \frac{C_2}{L} + C_i$$

On differentiation

$$L' (L) = C_1 - \frac{C_2}{L^2} + \text{Constant} = 0$$

or

$$L = \sqrt{\frac{C_2}{C_1}}$$

Since production increases with the increase in length of face, the ratio ($C_2/C_1$) decreases with increase in length and hence the differential decreases further because of the square root value of a decreasing function.

A simplified analysis was conducted with the following assumptions:

- 3 heading development system in an unlimited mining property
- Cost of drivage for 3 heading development
- Variable length of longwall
- Equipment costs include longwall shearer (fixed). Longwall supports linearly proportional to face length; Conveyor costs, a fixed component and a variable component proportional to face length; Gate end equipment costs fixed
- Maintenance and material cost including power, ventilation etc. is dependent upon the face length and taken proportioned to tonnage
- Face labour costs independent of face length for a single shearer
- Gate road development costs inversely proportional to face length

Production costs as a function of face length are given in Figs. 2 and 3. These indicate that except for smaller production levels (<5000t/d), optimum face length is possibly beyond the APC technology of today i.e. >350m. The costs decrease with increase in face length and with increase in production levels, however, the curves tend to flatten at 200-250m face length.

Results obtained from a number of installations in the Warwickshire thick coal at Coventry Colliery (Drake, 1987) show that though the OMS has increased with increase in face length, the variation has been quite wide and so also the costs, but the mean value has tended to flatten out between 200 and 250m length of the face.

The use of more than one shearer makes productivity less dependent upon the length of the longwall and should be considered particularly where hard coal or dykes exist on longwalls which slow down face advances. Otherwise there are no cost advantages of using multiple shearsers.

![Diagram](image)

**Fig. 2** EFFECTS OF FACE LENGTHS ON PRODUCTION COSTS FOR VARIOUS PRODUCTION LEVELS—SINGLE SHEarer

Sudden drops in the production costs with increase in face length over the range of 50-150m and equally sudden drops in costs with increase in production are two important points. Both levelling out with increased production and increased face length. Optimum production capacity therefore seems to lie in the range of 20,000 tonnes/day and capacities beyond that do not materially result in any great reduction in unit production costs. These two factors, therefore, control the system design, and mine capacity design for future mines unless the parameters...
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Retreat longwall systems are required to develop headings at fast rates.

Development rates required for future higher productive systems are dependent upon the length of the longwall face, daily production and the number of roadways required (Figs. 4 and 5). Even at present rates of longwall production of 8000t/d the development technology using shuttle cars and Joy loaders is not in a position to keep up with longwalls. There is hardly a mine around the world that has not fallen short of development and where longwall operations have not stopped or delayed at some time or another.

Higher development rates at present are invariably sought by increasing continuous miner panels. This is surely not a solution as it results in decreased overall mine productivity. Many times it requires four times the labour force in continuous miner panels to support one longwall. The draw back of the existing systems is its cyclic nature of cutting, transportation and roof support. An average cycle consists of the following:

- Cutting time = 10-20%
- Transportation time = 10-20%
- Roof support time = 40-50%
- Others = 10-20%

Options with the existing systems and their effects on improvement in development rates are as follows:

1. Use of more than one continuous miner in a panel - improvement 50-75%
2. Full face cutting - improvement 20-25%
3. Continuous transportation - improvement 50-75%
4. Simultaneous cutting, transportation and roof bolting - improvement 200-400%

It is therefore obvious that to make high production longwall systems the fourth option is not only the best but a necessity.

Developments are rapidly taking place to achieve this end. Use of full face cutting machines with wider cutting headings (Joy 120CM20, Jeffrey 1036), continuous transportation (Joy UCT roof and floor mounted, Klockner Ecorcit Flexible Conveyor), automatic roof bolting rigs (trials by Atlas Copco at Clarence Colliery) and continuous cutting bolting and conveying (Kemco Beaver, Vere Westfalia) are the developments in the right direction. A number of new systems are being developed which have the capacity to cut, convey and bolt simultaneously (Tab. 2). These have the potential to meet requirements of future longwalls.
There is a tendency to move to two heading development which can cut gate road development requirements by more than 60%.

Since a longwall is the technology of extraction of coal, it seems logical to use this technology to develop headings too. This is the basis of the proposed shortwall in wide heading development systems with a pump pack to separate it into two or more headings. The only limitation of this system is the rate at which bolts can be installed on the face. Developing a 15-30 m shortwall face to match the requirements of a longwall face of 250 m width in a 2.5 m thick seam and producing 20,000 t/d on an average requires that 230-350 bolts be set in a day on this face. This is possible to do with automatic roof bolting machines (or a flexible cable bolting machine) moving behind the cutting machine.

Besides the development of new machines, further improvement in development rates are possible by adopting the following approaches:

1. Modify development systems so that the transverse development is minimised and longitudinal development is maximised — i.e., narrower pillars and widely spaced cut-throughs.

2. Develop systems so that more than one roadway is driven simultaneously — e.g., use short wall with pump packing to divide the roadway into two or more headings (Fig. 6).

3. Develop systems so that roadways are driven simultaneously with longwall extraction — hybrid advance retreat systems (Fig. 7).

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

12.
Table 2.

<table>
<thead>
<tr>
<th>MACHINE</th>
<th>MACHINE CAPACITY*</th>
<th>RATE ACHIEVED</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Beaver</td>
<td>30m/day</td>
<td>3m/h - Peak 1.1m/h - Av.</td>
</tr>
<tr>
<td>1.5m Face</td>
<td>50m/day</td>
<td>20m/day (3 shifts)</td>
</tr>
<tr>
<td>HMB-300</td>
<td>60m/day</td>
<td>10m/day (2 shifts)</td>
</tr>
<tr>
<td>1.5m Face</td>
<td></td>
<td>5m/day (single shift)</td>
</tr>
<tr>
<td>Bucyrus E64-EDA-150</td>
<td>80m/day</td>
<td>15m/day (2 shifts)</td>
</tr>
<tr>
<td>1.5m Face</td>
<td></td>
<td>12m/day (2 shifts)</td>
</tr>
<tr>
<td>Westfalia VME</td>
<td>60m/day</td>
<td>15m/day (2 shifts)</td>
</tr>
<tr>
<td>1.5m Face</td>
<td></td>
<td>12m/day (2 shifts)</td>
</tr>
<tr>
<td>Strathclyde</td>
<td></td>
<td>4-6m/day (single shift)</td>
</tr>
<tr>
<td>Minishearers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MTC/Anderson</td>
<td>50-60m/day</td>
<td></td>
</tr>
</tbody>
</table>

*Assuming 1000 minute/day machine availability

Automatic bolting machines with magazines and automatic cable bolting machines are already available and are in use in metal mines. Adopting these technologies is the challenge to the manufacturers of coal mining equipment for the 21st Century mining systems.

Control of roof is the most important consideration in the developments of roadways. Roof support in cyclic systems is the major cause of low development and also a major factor in development costs. In deeper mines, ground support requires higher density of bolts and longer bolts, requiring higher drilling and cutting times. Though direct support costs may seem high, indirect costs due to lost opportunity and slow development are unbelievably high. New methods of ground control must be sought to reduce these costs and increase development rates. One of the solutions is the use of yielding pillars.

Tab. 3 compares the developments required for different situations and the advantages gained using yielding pillars and using packing for simultaneous development of multiple gate roadways.

![Diagram](image)

**Fig. 6 Short Wall Entry Drivage System With Pump Packing**

Away from the Face Technologies

In the last 40 years, great changes have occurred in technologies to support face production, but progress in longwall face technology has found "away from the face technologies" lacking.

These technologies include:

1. Coal clearance, men and material handling systems
2. Ground control Technology
3. Mine environmental systems and mine layout
Coal clearing systems of present mines severely restrict production potentials. Nine hundred millimetre belts running at 2-3m/s cannot handle more than 1000t/hr and are clearly incapable of handling short time production peaks of 50t/min. Future coal clearance systems should be able to handle peaks of 100 tonnes/minute with a continuous rating of 3000t/hr if 20,000t/d are to be achieved.

Developments in belt controls and monitoring, tougher and stronger belts and above all better loading and transfer points are the key to efficient coal clearance systems.

Coal handling systems should take into account online bunkers and rate control feeders. The solution is not always to go to wider belts, but a better utilisation and enhancement of systems capacity with more uniform loading. Some mines have installed 1,800mm belts with a peak capacity of 3500t/hr though the average production is below 400t/hr.

Most of the underground mines in Australia still use drifts for hand and materials handling. The size of the drifts and shafts is usually about 6-8m, with a majority of about 7m. Clearly future mines will need to have larger diameter entries which should permit the mining equipment to be lowered in without dismantling them and also serve for coal clearance.

In South African coal mines 9-10m diameter shafts are a common practice. These mines have adopted the technology from the gold mines of South Africa. Such large diameters permit both men and material transport in one excavation. This concept is bound to have impact on the development of future mines.

Man and material transport in Australian mines and in many overseas mines is changing fast to free steered vehicles. This provides...
flexibility and speed, though a lot more is desired in the area of road maintenance. The result has been that man and material handling speeds rarely exceed 20km/hour, with an average under 15km/hour.

In some of the underground metal mines in the USA, Europe and Scandinavian countries, metalised roads with traffic control, one way traffic and good illumination permit surface cars to be directly driven underground. These systems can surely be adopted in coal mines in Australia. Large diameter tunnels with flood lights can save millions of dollars. The cost of one man minute lost $140,000/shift in a mine employing 500 men underground costs as much as $140,000/year if the lost opportunity costs are taken into consideration.

All electric vehicles have superior power, environmental and maintenance characteristics than diesel powered vehicles. Developments in programmed trolley wire electric vehicles have reached a stage where it is possible to send a vehicle unmanned from one place to another and divert midway if it need be. Such systems are being deployed in some mines (e.g. Kiruna trucks and ore handling system at 1100m level in Kiruna mine). These must find their place in underground coal mines of the future.

GROUND CONTROL TECHNOLOGY

The behaviour of rock which was so well understood personally by miners working with hand picks is now unavailable to a machine driver with 500hp available at his finger tips. Besides, enormous changes in mining rates, increase in depth of mining and high investment costs require that areas which are difficult to mine cannot be sacrificed. Modern equipment has introduced inflexibility into the mine layout. The axis of mine development once fixed at the bottom of a shaft or a drift is almost fixed for the life time. At the same time principles of ground control have evolved slowly and in the last 35 years, the art of ground control has developed into a science, though many times the solution to the problem is invariably based on empirical methods and experience of local conditions.

Roof support has seen changes. Timber support which was the dominant support system in development of roadways in the fifties gave place to roof bolting with chemical anchors and full column grouted roof bolts. Cable bolting has been introduced in a number of mines as specialised support for difficult to support roadways, and for strategic areas such as take off headings and transfer areas.

Longwall face support has seen a great upsurge in the seventies. Individual friction and hydraulic props of the fifties with link bars was replaced with 2 and 3 leg and finally 4 leg hydraulic self advancing roof support with a prop free front system. The capacity of these hydraulic props used in the UK and Europe were small and face support densities were limited to 80-120 tonnes/m (100 tonnes/m at longwall at Coal Cliff Colliery in 1963). These have slowly changed particularly with the introduction of self support (development) and requirements of quite different conditions as these exist in Australia, the USA and South Africa. Support capacities have changed from 20 tonnes/prop to 220 tonnes/prop and support densities from 200 tonnes to 500 tonnes in the eighties (Fig. 8).

Surely, the peak has already been reached. Support densities of 120t/m are some of the highest required for longwall mining under very strong rocks. All future underground mines will have support capacities lying between 600-1000 tonnes even for seams with greater height or weaker rocks.

MINE ENVIRONMENTAL SYSTEMS AND MINE LAYOUT

The system which has undergone minimum change in the mining industry is the ventilation of the mine. Increased gas emission and increased dust levels have been handled by greater ventilation velocities and personal filters and only in limited cases with larger filtering systems. High gas emissions have been controlled by dilution and by gas drainage. These systems are now stretched almost to their limits and some radical thinking is required to solve high gas and high dust problems on high production longwalls and fast advancing development panels.

Mine ventilation control must be resolved with the mine design. The system of placing the intake and return entries of the mine (shafts or drifts) close to each other and bringing the return air in all the workings spread over larger areas back to the place close to the intake entrance must be changed. It is better to place the intake and return shafts apart at the edges of the mine holdings and connect with a large and a smaller diameter tunnel (Fig. 9). This system will eliminate maintenance of roadways, stone dusting and upkeep. This will permit high speed transportation, and being placed in rock will have all the advantages of main structures placed in rock. It must be borne in mind that in an average mine, it costs more than a million dollars/annum to maintain transport roadways alone and more than half the ventilation costs are due to leakage. This system greatly reduces overcasts, leakage, and hence ventilation costs.

Control of gas will continue to be a problem in deeper mines and it will further increase with depth as pre and post drainage of gas forms an integral system of mining of coal. Longhole drilling technology which presently permits increase up to 1200m long holes to be drilled on an experimental basis (Appin, NSW, September, 1988).
must ultimately become a common practice in all mines having high gas emission problems. A possible system of gas emission using staple shafts and long boreholes underground is given in Fig. 10. Drainage of gas from surface boreholes using directional drilling (Dunn, 1984) and hydro-fracturing has been successful employed in the USA in the Warrior basin. This technology could be applied and must be tried in deeper mines in Australia.

**Fig. 8** DEVELOPMENT OF LONGWALL FACE SUPPORT IN AUSTRALIA

**Fig. 9** LAYOUT OF LONGWALL BLOCKS WITH MAIN INTAKES & RETURNS PLACED IN ROCK

**Fig. 10** SCHEMATIC OF INSEAM DRAINAGE HOLES FROM STAPLE SHAFT INSETS

**SYSTEM AVAILABILITY**

The factor which can contribute most to productivity, and which is going to change radically in future mines is the system availability and its utilisation. It is ridiculous to invest $300M in a modern underground working operation with an overall capacity of 30,000t/d, 9 million tonnes/year, and produce only 25% of its capacity, two million tonnes/year.

Unfortunately, over the last 25 years, increased production has been achieved only increased machine horse power and only less
than 10% by increase in utilisation (Kundel, 1982). Mines which have broken and established new world records in production do not have high powered equipment alone, but rather increased utilisation.

Condition monitoring, automation, computer control with all possible data about the status of the system transferred to a common control point must help improve total availability. The concept of “Transparent Mine” is essential if high system availability is to be achieved.

In Australian mines, studies conducted over a two year period have given the following information:

- System availability = 49%
- Delays = 50%: System inefficiency = 13%
- Breakdown = 24%
- Ground control = 54%
- Other delays = 15%

In reality, system availability does not necessarily mean that it is operating at its full capacity. In actual practice even when 10,000 tonnes/day production is obtained from a single longwall face in a 2.5m thick seam, the system has functioned only for 23% of the total time at full capacity.

One of the reasons of low utilisation has also been that engineering effort in the last twenty years has been concentrated more on technical development of individual operations such as mining, conveying and supporting, rather than on integration. This is more true for the systems used in first workings – i.e. development of headings.

It is obvious that short to medium term advance in productivity must come from improvements in system availability. It is the area which presents the greatest potential at very little additional investment. Development in micro-processor technology for control and automation offer the starting point to build upon in our mines. Treating a coal mining panel as an integrated process control system, its improvement can be affected by improving the following:

- Raising awareness of unutilised time – time wasted
- Simplifying organisation and work cycle
- Improving planning and monitoring
- Improving safety work
- Protection of equipment from overloads
- Reducing human error
- Improving cost effectiveness
- Improving on-site decision making

Electronic monitoring and use of computers must form an integral system of fault detection planning and preventive maintenance. Up until now there has been a lack of appropriate sensors which can work efficiently and reliably under harsh mining environments. In the last few years, a series of developments have narrowed the gap considerably. Condition monitoring has developed as an integral discipline of mining equipment.

CONCLUSIONS

Future mines will be developed with an integral capacity of 8-10Mtpa from a single longwall operation with main development arteries placed in rocks. Development of gate roadways will require novel solutions with continuous cutting, loading and bolting. Information technology with the concept of “Transparent Mines” will form the backbone of decision making. New conceptual layouts are essential to meet the challenge of the 21st Century.

REFERENCES


