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SYSTEM MANAGEMENT APPROACH TO IMPROVEMENTS IN LONGWALL DEVELOPMENT

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ABSTRACT: The requirement for continuous improvement in the coal industry to achieve the combination of lower costs, greater capital efficiency and higher production. Longwall panels are now being mined at a faster rate requiring a commensurate increase in development rates. Development operations that cannot deliver continuity of longwall mining result in substantial flow on costs for the entire mine – from higher unit costs, lower production and loss of reliable supplier status in the coal market. A development unit which can remain well ahead of the longwall as a result of an efficient system – machines; human resources; supply logistics and efficient planning and scheduling is a vital factor in delivering a productive longwall mine. While capital solutions are often used to increase production, they may not lead to improved profitability. Often, a more efficient approach is to generate improvements through better management of existing equipment. Through an analysis of the development delays at an Australian longwall mine, a number of potential areas for improvement have been identified. Increasing operating time is one aspect of increasing roadway development rates and the second is increasing the cutting rate. The time and motion study which was carried out at the same mine identified the bolting and *"shuttle car away"* components of the cycle as holding the most potential for improvement.

INTRODUCTION

Coal mining is vital to Australia, both in terms of its contribution to Gross Domestic Product (GDP) as well as providing a significant proportion of the country's energy needs. Underground mining accounts for approximately 25 percent of the total tonnage produced in Australia and longwall mining accounts for 80 per cent of the underground output (ABARE, 2008).

Longwall mining requires a substantial amount of roadway development prior to the actual installation of the longwall equipment and mining of the longwall block. With the recent increase in the coal price and the overall push for higher production, the focus from most mines has been on increasing the productivity of the longwall machines as this equipment is the principal driver of the production output of the mine.

Longwall Roadway Development

Roadway development utilises three key pieces of equipment which are: the continuous miner; the shuttle car; and the conveyor system. The continuous miners used in Australia are generally in place systems which utilise a combined bolter miner set up to avoid excessive flitting between headings. The typical development panel layout is set out in Figure 1.

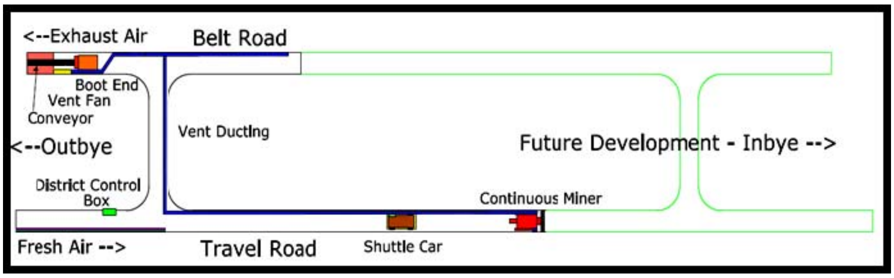

Figure 1 - Development Panel Layout

The mining cycle includes cutting, bolting, meshing, extending ventilation tubing, panel extensions and shuttle car loading and travel times. A typical advance rate of a continuous miner is 2 m/hr or 10 km

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over a calendar year. Cut-through roadways are driven between the belt road and travel road every 100 m, to leave regular pillars.

The cut-throughs help complete the ventilation circuit for development and allow travel between headings in the longwall. Each time the development section finishes a new cut-through section of the gate road, a panel extension takes place. A typical cycle from one panel extension to the next means that the miner has completed 230 m of development (100 + 100 + 30) which typically takes 9 days (18 x 12 hour shifts). Figure 2 shows an active development face including: bolting rigs, cutting drum and personnel.

Figure 2 - Active Development Face

The development section of the mine must remain ahead of the longwall so that the longwall equipment can be installed into the new block without waiting for the development to finish. A problem that the industry is currently facing is that longwall production rates have increased faster than development rates and many mines are struggling to maintain a development float. Wilkinson (2008) states that *"Longwalls are recognised money spinners, but the "pulse" of a longwall mine is determined by development rates. Generally, throughout Australian longwall mines development float is marginal or non-existent, and various efforts and techniques are employed to reduce the possible negative and restrictive effects it could have on longwall production levels."*

Development Delay Time Analysis

In order to increase the roadway development rate, the continuous miner must operate for longer or at a quicker rate. A development delay time analysis was carried out at an Australian mine to determine the important factors affecting the utilisation the development process. It can be seen in Figure 3 that operational delays make up 29 per cent of the calendar time with panel extensions accounting for 17 per cent of these delays. Planned maintenance accounts for 14 per cent of total calendar time which is the second biggest single delay component after operational delays.

The operational delays include over 68 categories. Of these categories, the top two comprise over a quarter of the operational delay time and the top 11 form over 63 percent of the operational delay time (Figure 4).

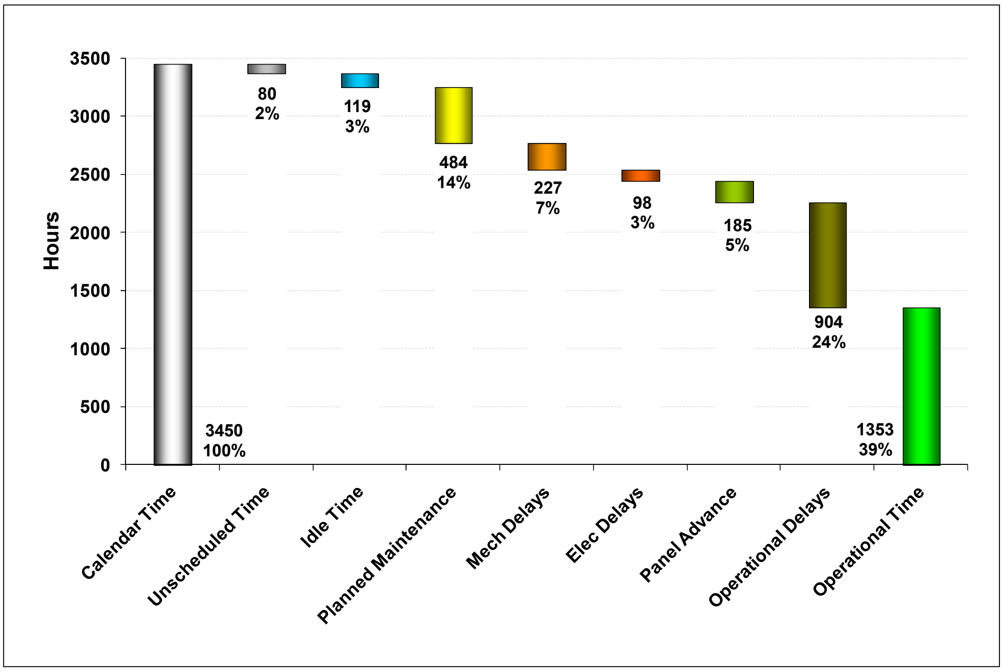

Figure 3 - Break Down of Calendar Time

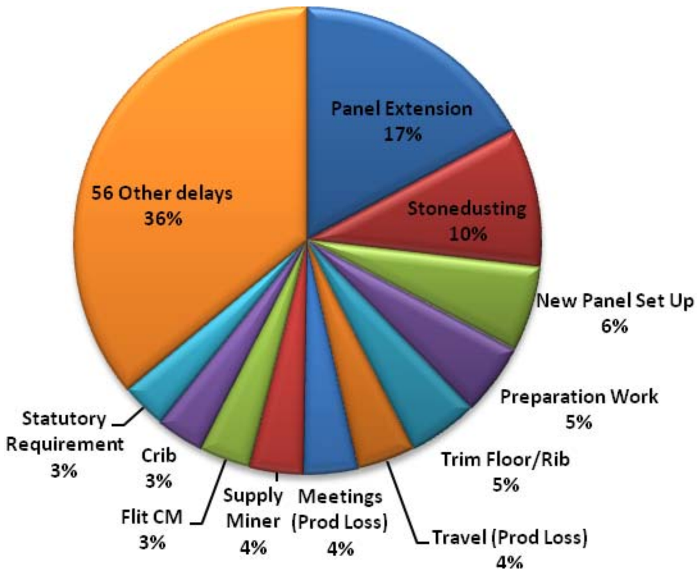

Figure 4 - Top 11 Operational Delays

The operational delay component was recognised as having the most potential for improvement. This is because most of these delays can either be avoided by improved process management or reduced by planning for activities. An example of such management initiative is to increase manning levels on panel advance shifts in order to complete the panel advance more quickly. Further to this, delays such as travel, crib and meetings rarely occur in the longwall sections of the mine due to *"hot seat change over"'* policies, tighter monitoring and accountability. These standards should also be applied to the development sections.

The significance of increasing the operating time increases with higher cutting rates. It is therefore important to study both the operating rate and the operating time for the development section. The time and motion study conducted at the same longwall mine was aimed at identifying process inefficiencies within the cutting cycle to increase the operating rate (metres per operating hour).

Time and Motion Study

The cycle times recorded in the study ranged from 10 minutes and 25 seconds to 24 minutes and 45 seconds, equating to between 2.4 – 5.76 metres per operating hour. It was found that 55 per cent of the cycles lie within the 10 – 16 minute bracket however there tends to be a small number of cycle times well above the median time which greatly reduce the overall metres cut per shift.

The timing study provided a sample of the current production activities which provide an example of the current roadway development practice. To illustrate the raw timing data, Figure 5 shows the high, low and average times for each event in the cutting cycle. The important concept to be noted from Figure 5 is that the events with a large time variance are the events that potentially require review. Consistency is the key to reducing the overall cycle time and in turn optimising development. It can be seen that the shuttle car away and bolting events had the most variance with the maximum times recorded being 3 to 5 times the minimum. For an efficient development cycle, each event must fit in with the other events so that whenever possible tasks are being completed in parallel.

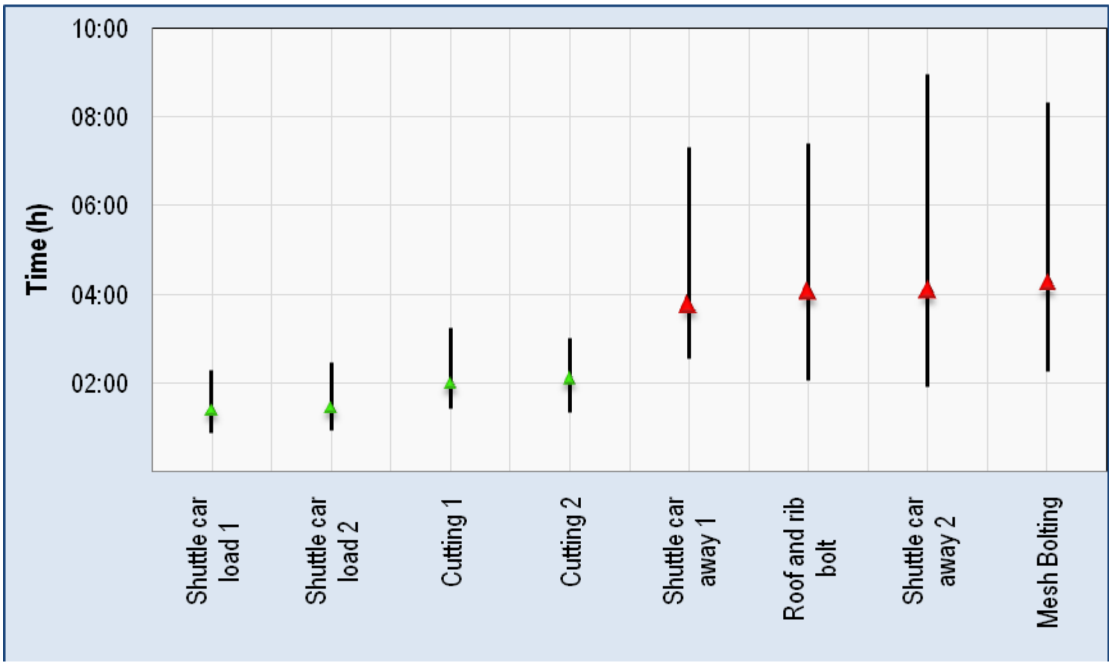

Figure 5 - Delay Cycle Components

The major technological improvements are currently aimed at improving the bolting and shuttle car away times (SCAT) with the use of one step bolts and flexible conveyors. Reducing these two components of the cycle by a certain per cent has the greatest impact on reducing the overall cycle time.

The potential for reducing SCAT depends mainly on the wheeling speed. The wheeling speed is determined by a combination of the following parameters:

1. Roadway floor condition (consistent horizon control);
2. Spillage of coal on floor (correctly loaded shuttle cars);
3. Angle of cut-through roadway (mine planning);
4. Condition of shuttle car (maintenance history);
5. Operator experience and training;
6. Panel procedures – roadway clear of pedestrians (SOP's); and
7. Conditions at boot end (clear spillage regularly).

If the SCAT is reduced, the critical path of the total cycle time will be constrained by bolting for a greater proportion of the pillar. It will therefore become more important to reduce the bolting times.

A greater level of automation with the use of one step bolting has significant potential for increasing the consistency and reducing the length of bolting times. Gibson (2005) identified technology improvements in coal clearance and self-drilling bolts as having the most potential for improved roadway development. Other parameters which impact on the bolting times are:

- Condition of equipment;
- Quality of bolts, drill bits and resins;
- Mining height and roadway width; and
- Ergonomics of equipment.

For improvements to be made within the cutting cycle, a system for monitoring change and providing feed back to operators is essential. An electronic monitoring system and production improvement study, in most development operations would help in create a reliable development float for the operation resulting in improved productivity for the mine.

Scheduling and Mine Planning

The key issue for roadway development is to avoid standing the longwall panel. Apart from improving development rates, as previously discussed, system scheduling can help deliver continuity in longwall production.

As a result of the shortage of qualified planning engineers and an overall shortage of skills throughout the industry, longwall and development supervisors are rarely engaged with the logic behind the final mine schedule. This then forces supervisors into a messenger type role in regards to shiftly and weekly production targets. In order to shift short term planning information to the supervisor level, the longwall/development animation spreadsheet has been designed. By enabling supervisors to run basic scheduling simulations, development and longwall sections will most likely be better managed as the front line management will have a better understanding of the interaction between development and longwall production. In the long run, a greater level of accountability will be expected from supervisors in terms of the development float.

With scheduling software packages that are designed for highly trained technical personnel becoming more complex, a potential market for software which enables front line supervisors to complete simple scheduling tasks which will contribute to improved system performance has been identified.

The spreadsheet software which was designed fits this purpose and has the potential to become a simple and useful scheduling software package in the future. The spreadsheet can be used to:

- Quickly determine development float/longwall stand time given the appropriate input parameters;
- Display the number of metres or tonnes currently mined on a shift by shift basis;
- Assess the impact of changing mining rates or operating time;
- Determine the effects of changing the mining parameters such as longwall block length, cut-through length and width and longwall face width;
- Estimate the financial outputs given the input parameters; and
- Clearly show/teach the impacts of various mining parameters on the mine schedule to crews, students and non-mining personnel.

The animation output page (Figure 6) is where the input parameters are used to simulate the longwall and development mining operations. The longwall panel at the top of the figure shows the current development section and the panel at the bottom represents the active longwall. As each section progresses shift by shift, the program indicates the mined area by changing colour (red for development and blue for longwall mining) and the tables at the bottom of the page display information relating to the performance of each section. The cell at the bottom of the sheet displays the development float/longwall stand information depending on which section is ahead of the other.

Once the animation has finished, the panels are shown as fully extracted and the tables at the bottom of the sheet provide the final output details. The cell at the bottom of the page also displays the difference in the time taken to mine the two production sections which indicates either a longwall stand or development float (Figure 6).

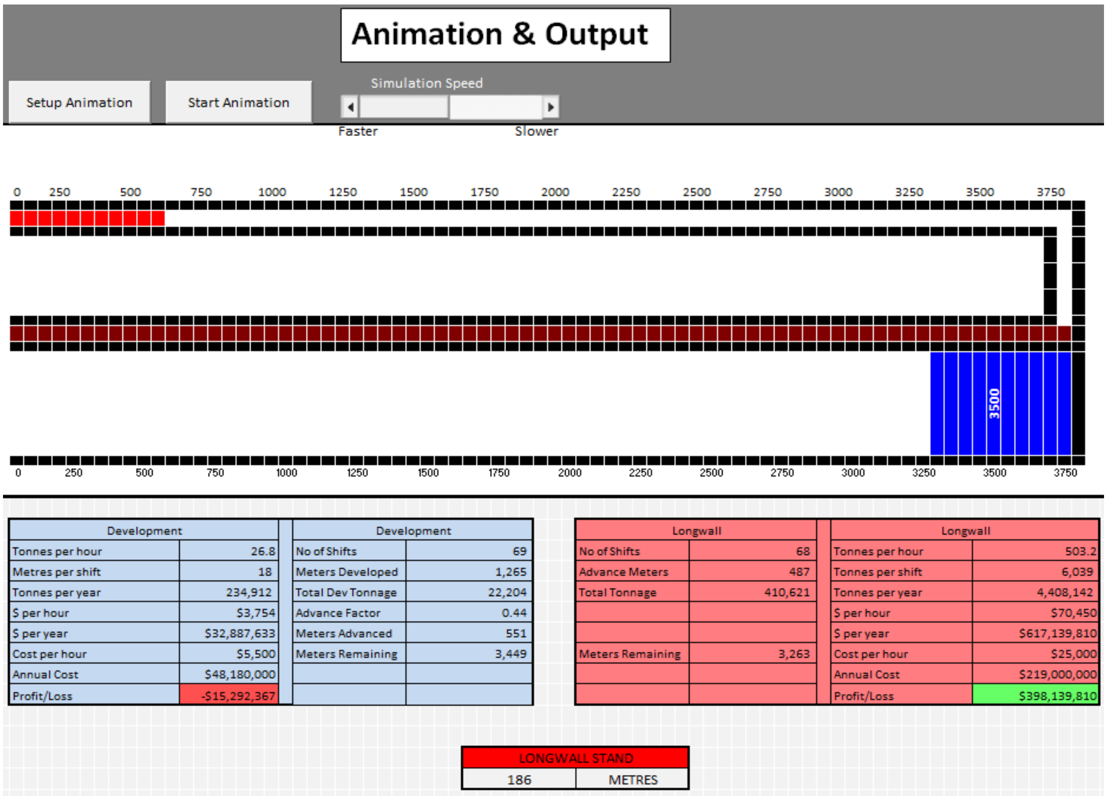

Figure 6 - Longwall mine scheduling tool

The animation itself was programmed using Visual Basic in Microsoft Excel (VBA), which provided a platform to create a concept level simulation program. Future versions of this animation spreadsheet will require more detailed programming software to avoid the restrictions of working within cells in Excel.

CONCLUSIONS

It is widely accepted that the roadway development potential for current equipment has yet to be fully realised due to the number of restraints in the system. The current improvement strategy focused on the two variables which determine production rate, these are operating time (hours) and operating rate (metres per operating hours).

After completing the time and motion study, it was found that the bolting and SCAT time components of the cycle had the greatest impact on the cutting time and were the largest inhibiters to the overall operating rate due to the large variance in these component times. It was found that operators had a larger input to the bolting times and SCAT than the other cycle components which provides some explanation of the large variance in recorded times.

In response to an industry which is struggling to maintain development float, a simple scheduling tool was designed to help supervisory level employees conceptualise the interaction between longwall and development production rates.

An increase in roadway development rates can be achieved not through the introduction of more equipment but through a good framework of management and operating systems which assist in maintaining production and process continuity. Through the use of electronic monitoring, future development sections will have increased accountability for the work carried out by personnel and equipment as well as provide a platform for improvement initiatives.

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