LONGWALL PUNCH MINING FROM OPEN CUT HIGHWALLS

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ABSTRACT

'High access longwall mining' or 'longwall punch mining' is a proposed extraction method whereby longwall gate roads are driven into a seam directly from an opencut highwall. The longwall panel thus formed is retreated back to within 40 m of the highwall providing an extremely simple, reliable and therefore highly productive longwall mining system.

The concept is of particular benefit for the recovery of isolated pockets of coal (adjacent to a highwall) not easily accessible from a conventional underground mine. As panel gate roads are driven directly from the open cut, minimal delays are incurred between the end of open cut start and underground production, allowing the method to bridge the gap between open cut mining and a total underground commitment.

The study was specific to the Bowen Basin, and given the likely conditions, no significant operational or geotechnical hindrances to the concept could be identified. It was therefore concluded that longwall punch mining would not expose the operator to any additional risks above that normally associated with the introduction of longwall mining. Thus, longwall punch mining is an attractive option, both operationally and financially, for open cut mines reaching their maximum economic depth.

INTRODUCTION AND BACKGROUND

As the strip ratios of current open cut coal operations in the Bowen Basin increase with depth, alternative economical mining methods must be sought. An attractive underground longwall method of winning coal by rapid access from final highwalls in open cut strip mines was first proposed by Mr. B.W. Robertson, Chief Mining Engineer, Carman Creek Mine, in 1982. The method referred to as "Longwall Punch Mining" promises to give a high rate of return on investment from an independent operation, while allowing time to develop more conventional underground operations in deeper reserves.

In 1984 Capricorn Coal Management Pty Ltd (CAPCOAL) applied for funding from the National Energy Research Development and Demonstration Council (NERDDC) to fully explore the potential of the method, as possible applications in several Bowen Basin Mines existed. The grant was awarded to CAPCOAL and subsequently sub-contracted to the Australian Coal Industry Research Laboratories Ltd (ACIRL) with work commencing in January 1985 and completed in June 1987.

The proposed mining method involves the rapid development of longwall blocks by driving the maingate and tailgate roadways directly from the open cut highwall into the exposed coal seam. These blocks are extracted by the retreat longwall method leaving a barrier pillar adjacent to the highwall which could possibly be recovered by open cut methods at a later time. Figure 1 shows an artist's impression of the proposed concept.

Advantages of this mining method are
1. minimal delay between production from open cut and underground sources,
2. low operating costs,
3. low manpower (high productivity),
4. rapid development of longwall panels,
5. reduction in travelling time to the face,
6. simple ventilation system,
7. simple coal clearance system,
8. simple services provision,
9. use of well proven readily available equipment, and
10. increased flexibility.

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Incorporation of longwall punch mine extraction in an overall mine plan offers an intermediate step towards conventional underground mining when the limits of the open cut are reached.

The method provides an opportunity to recover reserves which would be difficult to mine otherwise, in particular pockets of coal adjacent to highwalls limited by faults or other structures, which would not be easily accessible from a conventional underground mine. The system is portable between open pits and this high degree of flexibility may allow substantial reserves to become mineable at low cost. These advantages were highlighted in a case study for German Creek Mine, where two pockets of coal isolated by faults and a dyke were shown to be recoverable over a five year period by a series of longwall punch mine panels – refer to Figure 2. Without consideration of this extraction method, these reserves would be difficult to access from the proposed underground Southern Colliery, and so would have possibly been deleted from estimates of mineable reserves.

LITERATURE REVIEW

A literature review found only one previous attempt at recovering reserves adjacent to an opencut highwall exposure using powered roof supports (Anon, 1977). The system trialled, referred to as a "surface shortwall" involved a continuous miner taking successive web at right angles to the highwall. The continuous miner started each web from the open strip, with the powered roof supports advanced above the highwall – see Figure 3.

The concept was not developed further due mainly to geotechnical problems, i.e. lack of abutment support on the highwall side of the caved overburden, caused unpredictable lateral forces on the roof supports, resulting in

FIGURE 1: Artists Impression of Concept

FIGURE 2: Proposed Panel Layouts

"failure" of the supports. This problem was accentuated when discontinuities such as minor faults and adversely dipping joints were present in the overburden. Poor roof control due to the wide web inherent with all shortwall methods also hampered the trial.

GEOTECHNICAL APPRAISAL

The following geotechnical considerations were identified as unique to longwall punch mining and therefore warranted special attention.

1. Caving and support loading under shallow depths of cover
2. Effects of retreat longwall mining towards a highwall
3. Long term highwall and spoil stability.

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The first potential risk considered was the possibility of abnormally high support loading under shallow depths of cover, resulting from the lack of an abutment arch. Several collieries, i.e. Laurel Run (USA), Newstan, Ulan, and Angus Place have extracted coal by longwall methods at less than 100 m depth. The shallowest recorded operating depth was Laurel Run under 18 m of cover, whereas in Australia, Newstan Colliery has extracted coal from under 35 m depth of cover. These collieries reported no abnormal support loading or face deterioration due to the shallow depth. Water ingress from overlying water courses was the main operational problem in these collieries.

To further address the problem, both mathematical and physical models were constructed assuming typical Bowen Basin strata properties. The results from the modelling work combined with operational experience conclude that operators are exposing themselves to no additional risk with longwall punch mining provided appropriate roof supports are selected. It is recommended that physical modelling for the given conditions be undertaken to identify any potentially abnormal loading due to the given geology.

Mining towards a highwall was also studied as part of both the physical and mathematical modelling investigations. The mathematical model showed that leaving a 50 m barrier pillar from the highwall caused some strata yielding and significant areas of tensile stresses adjacent to the free highwall face (refer Figure 4). Highwall stability in these zones of tensile stress will be dependent on individual block stability defined by structural planes. The physical model face was retrofitted to within 40 m of the highwall, with the highwall face remaining intact without visible deterioration (refer Figure 5). Importantly, both the mathematical and physical models showed a normal angle of break behind the face continuing through to the surface with no fractures extending ahead of the longwall face, i.e. an intact block of strata approximately 40 m wide remained between the highwall and caving zone. In conclusion, given favourable structural geological conditions, a retreating longwall face could be brought to within 40 m of a highwall toe without causing major stability problems within the open cut.

The topic of longwall coal face stability is the only geotechnical consideration in which punch longwalls are disadvantaged when compared with normal longwall panels at a similar depth. The reason is that ideally the punch longwalls would be retreated up dip, with seam dips ranging between 5° and 10°, in combination with thick seams and hence high faces, it is recommended some form of face sprag be incorporated with the roof supports. For similar reasons, a lump breaker on the tailgate end of the shearer would be advantageous.

To ensure long term stability of both the highwall and spoil slopes a safety factor of at least 1.5 is recommended for design calculations. Remedial methods such as berms, buttresses or floor key cuts can be incorporated to improve spoil pile safety margins. In addition to designing the highwall angle for the required safety margin, berms are recommended to intercept any falling debris to avoid impacting the portal structures at the highwall toe.

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OPERATIONAL ASPECTS

Two operational aspects required particular attention for longwall punch mining, i.e. coal clearance systems and water ingress prevention.

Three principal methods of coal clearance are available:

1. Trucks as the sole means of coal clearance from the portal or open pit floor.
2. Continuous conveying to ground level with truck haulage to the ROM stockpile.
3. Continuous conveying to ground level with an overland conveyor to the ROM area.

Continuous conveying to ground level out of the pit can be achieved via: a conveyor on the existing haul ramp, a conveyor on a specially constructed spoil or highwall ramp, or by a steep angle conveyor over the highwall. Due to its flexibility and low operating costs a steep angle conveyor discharging at the highwall crest is the recommended system for coal clearance, see Figure 1.

Initially water control within the open pit was viewed as a major operational problem. With the portals at the base of the highwall, rainfall runoff from the spoil slope, highwall and pit floor will drain towards the highwall and into the portals, flooding the underground workings. Several methods for water control are possible, the preferred method being the use of raised portals above the seam floor and ramping down into the coal beyond the highwall. Compacted earth ramps up to the portals should have culverts adjacent to the highwall to allow water drainage to an in-pit water storage area (refer Figure 1). Clearly, precautions to prevent water draining from other catchment areas into the pit should be taken.

Other operational aspects of longwall mining such as panel layout, ventilation, and portal design etc. were considered, but in summary they present no abnormal constraints to the proposed concept.
ECONOMIC ANALYSIS

A fictitious but realistic scenario (see Figure 6) was examined to indicate likely capital input and rate of return. As Figure 6 illustrates, seven panels with a face length of 200 m, and panel length of 2000 m, (restricted for operational reasons), were laid out, giving a total longwall tonnage of 11.76 Mt for the 3 m thick seam.

Clearly capital costs will be site specific but for this study a likely scenario was examined to provide estimates for various items i.e., drainage systems and water supply lines etc. Similarly, equipment costs can vary significantly depending on options required and again the estimated values were for general configurations. The total capital cost thus estimated in current Australian dollars was $58,910,000.00.

The rate of return was estimated on a pre-tax, pre-finance basis with an assumed inflation rate of 8% p.a., applicable to both material and labour costs. As the rate of return is sensitive to the coal price assumed for each year, the results are presented graphically as a function of the coal price escalation rate, see Figure 7. Many other assumptions are inherent in the calculation and a more complete explanation and analysis is presented in the End of Grant NEX00C Report (O'Regan et al., 1987).

CONCLUSION

The general conclusion from the feasibility study is that the proposed longwall punch mining concept is both technically and economically feasible with current technology, and exposes the operation to no additional risk above that normally associated with the introduction of longwall mining.
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