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IMPROVED TECHNIQUES FOR HEADING DRIVAGE

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ABSTRACT: An obvious need exists for more efficient and safer techniques for driving development headings for longwalls and also, in many cases, for bord and pillar operations. A very expeditious solution to this problem is proposed, with the potential to drive such headings two or more times faster than can presently be achieved for any specific set of mining conditions.

INTRODUCTION

The importance of maintaining development ahead of extraction has been emphasised by Mitchell (2010) who pointed out that most mines have little or no lead-time on development. Speed of development has been mentioned by a number of writers, Kathage (2010) has discussed the use of extendable conveyors and Golsby (2010) the introduction of continuous haulage at Clarence Colliery. Place-change mining has been discussed by Howarth and Bevan (1991) and Kathage (2010) and this system has been described as having the effect of reducing delays caused by the need to stop production to erect supports. It is considered that improved rates of development can be achieved by simplifying current procedures.

PROPOSED PROJECT

The following description applies to a typical pair of headings. The belt, which will later carry the longwall production, is in the return airway. The intake road is used for transport of men and materials.

Basic heading machine

Captive at the face would be a "heading machine", which may be a "conventional" continuous miner, but preferably would be a unit of much simpler and more rugged design. Such a header would incorporate a standard continuous miner ripper head, mounted in a different, more stable way, being incorporated in a beam immediately behind the rotating picks. The beam would be mounted at each end on a heavy duty, but relatively narrow frame, several metres long on each side of the heading. The rear ends of these side members would be joined in a wide, low cross member, incorporating the hydraulic tank, pump, motor and electrical and radio control equipment for the header.

The side frames would be equipped with suitable hydraulic cylinders to raise and lower the ripper head. At ground level at the front of the side frames, they would be connected to a short shovel ramp, incorporating at the centre, the tail end of a chain conveyor, flat on the floor extending a few metres beyond the rear of the header. As is common in many continuous miners these days, the cut coal is swept towards the centre chain conveyor by large, opposing helixes, inherent in the construction of the ripper head.

It will be noted that the header would be constructed of only six large components, able to be transported easily to its commencement site and connected together with only one or two large pins at each carefully designed and constructed junction. Electric cable, hydraulic and water hoses would be incorporated in each component, with well designed junction boxes inherent at each connecting joint.

It will be seen, therefore, that there would be a large empty space immediately behind the ripper head. In this space would be located what may be regarded as a "roof support installation factory", equipped with all required equipment for convenient, expeditious and simultaneous installation of mesh, roof bolts, rib bolts, cable bolts and mega bolts, without any compromise of hydraulic capacity, whilst providing total safety and convenient amenity for the operators. A bolting machine would be provided for every bolt. All supplies for a pillar length of drivage would be always readily at hand for the operators. The "roof support installation factory" would be connected to the surrounding frame of the header only by two short lengths of chain or wire rope, with which the "factory" could pull itself forward at the conclusion of each module. In some mines, propulsion of the header could be by using a system similar to a tunnel boring machine, with hydraulically actuated pads impinging on the walls, but the use of the principle of the "sliding floor"

seems generally far more appropriate, as it is completely unaffected by soft or spalling ribs, or indeed even soft, wet ground conditions, being dependent only on its mass, evenly spread from rib to rib and for 20 or 30 m along the headings.

Sliding floor principle

This technology was very successfully employed in many large scale hard rock tunnel projects around the world in the late 1950s and early 1960s, until it was superseded by tunnel boring machines. In such projects, the sliding floor carried a very stable by-pass close to the face, on which could stand two muck trains, side by side, each comprising a 25 t locomotive and five 10 m³ muck cars. For about 50 m inbye of the by-pass, the single track was surrounded by a heavy steel floor. After blasting, broken rock covered most of this 50 m, providing ideal conditions for very fast clean up by a high capacity mucker, typically a Conway mucker, which could continue to clean up to two metres beyond the front of the floor, when the floor would be moved forward, with the mucker continuing to operate.

The floor, typically about 150 m long, was divided into three components of roughly equal mass. Hydraulic cylinders, of about one metre stroke, connected the first and second and second and third components. To move forward, the front rams were extended about a metre, the second and third sections providing more than adequate reaction to enable the front section to move forward about a metre. Then, by retracting these rams and simultaneously extending the second set of rams, the centre section moved forward, with the first and third sections providing reaction. Then the third section was pulled forward. The rails of the heavy permanent track extended into the body of the third section, beneath the rails on the floor. Short, tapered rails overlapped the permanent track, enabling rolling stock to travel effortlessly on to or off the floor. As the floor progressed, it was only necessary to slip sleepers under the rails and dog them.

In applying the principle of the sliding floor to the drivage of a pair of headings in a coal seam, it is proposed to use a small sliding floor, about 20 or 30 m long in each heading, constructed of shallow steel tubs, about 2 m wide by 4.6 m long, filled with concrete and pin jointed together.

Intake road equipment and operation

Two options are available:

- Using a continuous miner as the heading machine, the disadvantage, however, being that roof support installation would be much slower and less expeditious. In this option, the same machine is also used to drive the cut-through.
- Using a heading machine, as described earlier, and a completely separate machine, called "the cut-through cutter", solely to drive the cut through.

Where a heading machine is used, it would be connected to the inbye end of the sliding floor by two hydraulic rams, enabling it to sump forward, rip down and retract, cutting the cusp. In this case, the sliding floor would be about 0.3 m thick. A standard shuttle car would ride on it, doing nothing until required to drive the cut-through. Figure 1 shows the intake road equipment with the vent tube on the right-hand side. The cutter for the cut through, the associated shuttle car and the short elevating conveyor are carried on the sliding floor until they are in position to drive the cut through.



Figure 1 - Intake road heading equipment with the vent tube on the right-hand side

Where a continuous miner is employed as the header, when the advancing heading reaches the cut-through location, the continuous miner would turn the corner and drive the cut-through in the conventional way, with the shuttle car dumping on to the chain conveyor of the sliding floor.

Where Option 2 is employed, the specialized "cut-through cutter" would also ride on the sliding floor until required, when it would drive the cut-through, with the shuttle car operating behind it. For both options, it may be noted that the average length of the shuttle car haul is only about 15 m. The layout while driving the cut through is shown in Figure 2. The elevating conveyor that was shown in Figure 1 has been attached to the cutter and loads into the shuttle car.

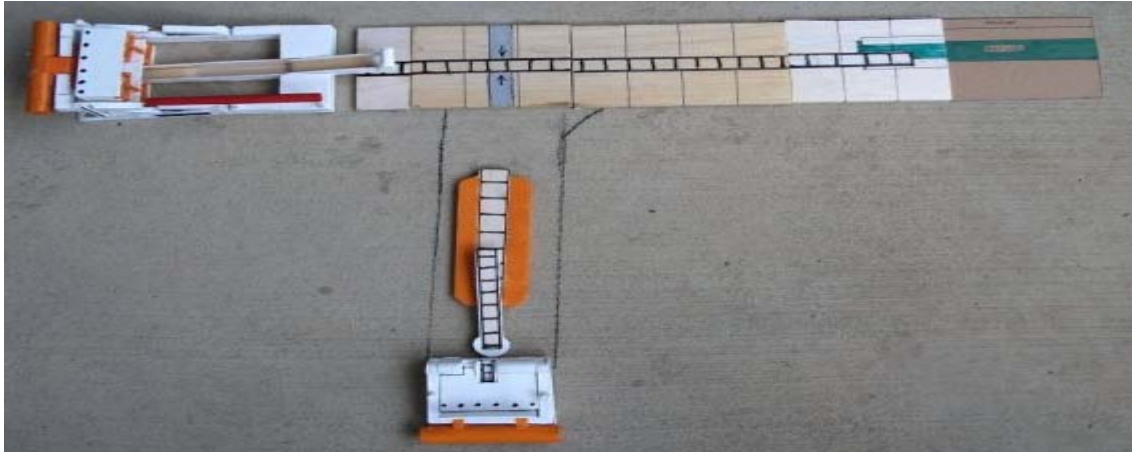


Figure 2 - Heading machine for a cut-through drivage

At the outbye end of this sliding floor would be attached the tail end of a belt conveyor, of much lighter construction than the belt road conveyor. (The belt road conveyor would be required to haul longwall production of 40 or 50 tpm, whereas the maximum from a continuous miner ripper head is about 20 tpm). As well as the relatively light tail end, this sliding floor would also haul forward a pillar length of conveyor and structure, including the drive head. The structure would be appropriately modified to enable it to slide forward easily.

Included with this belt and structure would be a tripper, similar to the tripper on a skyline stockpiling installation, but in this case, in operation the tripper would be stationary, locked between the floor and the roof while the conveyor is pulled slowly and steadily through it. Incorporated into the construction of the tripper would be the tail end assembly and about two metres of a chain conveyor 700 mm wide. The drive head and about 1.5 m of chain conveyor would be permanently mounted on the belt road sliding floor, delivering directly into the conveyor boot end.

The central section of the chain conveyor (about 40 m long) would be designed to be always handled in one piece, including the top and bottom chains. It would be designed to be dragged out of a cut-through, around a corner protected by a few suitable rollers, outbye along the intake road, then inbye to the newly driven cut-through, around its corner and into it to near its face, to await the arrival of the belt road header and sliding floor.

To achieve this, the conveyor pans would be only about 700 mm long, vertically pin-jointed on only the outbye side, with their floors overlapping so as not to impede the operation of the chain.

Belt road equipment and operation

As indicated earlier, the "header" could be either a conventional continuous miner or a heading machine as previously described.

The sliding floor would be of similar length but of greater thickness, possibly about 700 mm.

This is to ensure that an extremely strong, stable anchorage would be provided for the belt. A chain conveyor 700 mm wide would extend along the centerline of the floor, in a "canyon", which may be covered, discharging into the conveyor tail end.

The conveyor tail end would be equipped with hydraulic powered adjustments to trim it marginally for line and level. Immediately behind this and also attached to the sliding floor would be a purpose built frame to enable the permanent conveyor structure to be safely and conveniently assembled while the belt is operating.

The heading machine in the belt road, shown in Figure 3, has space for capsules of chain wire mesh carried close to the ripper head. The vent tubes in this heading are located on the left hand side.

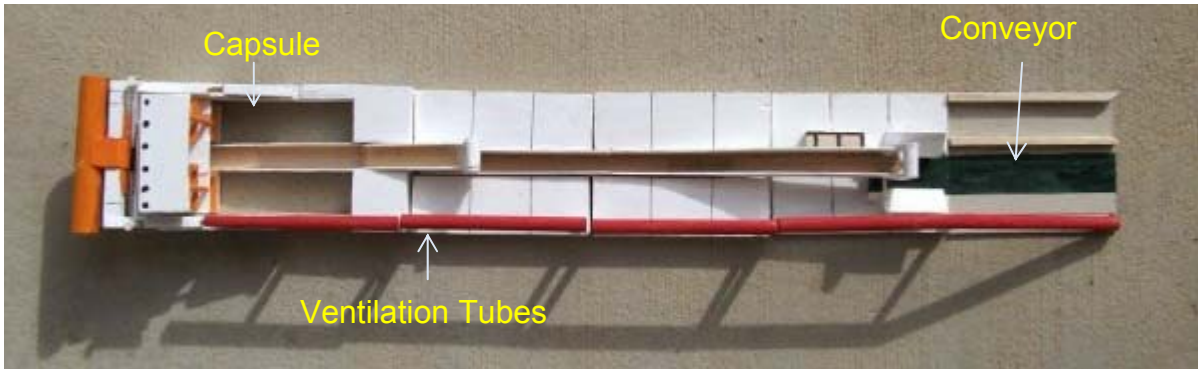


Figure 3 - Belt road heading machine and ancillaries

It would be intended that drivage would occur in only one heading at a time. This would enable all materials for the next pillar length of drivage to be conveniently stocked on the sliding floor or on a trailer immediately behind it. An overhead mono-rail, mounted on the sliding floor would facilitate this materials handling work.

Operating sequence

The intake road would be driven as far as the cut-through.
The cut-through would be driven beyond the centreline of the belt road.

The intake road would be further advanced, bringing the future position of the tripper and chain conveyor tail end in line with its future position in the cut-through.

The drive head section of the chain conveyor would be disconnected.

Production would now commence in the belt road, provided that 200 m had been inserted in the loop take up.

The tail end section of the chain conveyor would be disconnected.

The central section of the chain conveyor would be withdrawn and relocated to the new cut-through.

Routine maintenance, stonedusting and re-stocking of supplies would now be done in the intake road.

The tripper would be moved forward to its new position. This would be done by clamping it to the top belt, then reversing the belt at low speed.

The exhaust fan and 100 m of telescoped ventube is moved forward to its new position.

When production in the belt road stops, production would now re-commence in the intake road.

Ventilation

In both headings ventilation would be by means of a pillar length of telescopic tubing, extending on to the sliding floor and close to the faces.

In both cases, tubing of slightly larger than normal diameter, mounted on a sleigh type sub frame about 0.3 m high, would extend from the rear of the sliding floor back to close to the fan, but not attached to it. A second ventube, of normal diameter, attached to the fan would extend inside the larger tube to the rear of

the sliding floor. As the header and the sliding floor progressed forward, the smaller tube would be left behind on the floor, maintaining ventilation right to the face. Appropriately designed small rollers inside the larger tube would facilitate the telescopic action.

At the conclusion of a pillar length of advance by the header and sliding floor, the smaller tube and the fan would be pulled forward, by a wire rope inside the larger tube, with a winch mounted on the sliding floor below the upward bend in the ventube.

Ventilation of the cut-through would be by conventionally installed ventube from a T-piece on the intake road's tube.

Transport of supplies

Advancing a pair of headings more rapidly would require a corresponding increase in the quantity of supplies required to be delivered from the surface to the working area near the face. Additionally, the last 100 m to the face would be more restricted than for a typical shuttle car operation.

It is proposed to use "gondola" type trailers, with the load carrying gondola about 5 m long by about 1.6 m wide, slung quite low between a pair of wheels at each end, mounted on heavy duty kingpins. When travelling, the forward pair of wheels would be steered by the drawbar, the steering of the rear pair being locked.

Such trailers could be hauled by a pivot steer tractor of about 10 -12 t, preferably also only about 1.6 m wide. Hence, it would be convenient for the tractor to deliver one or more trailers of supplies to the vicinity of the second last open cut-through, leave them on one side of the heading and drive out on the other side, picking up any empty trailers on the way.

For the area close to the face, it is proposed to use two small electric cable powered general purpose pivot steer or skid steer tractors. Such tractors would conveniently move the supplies trailers up close to the sliding floor, where their loads would be moved on overhead monorails, integrally mounted on the sliding floors, to their ultimate destinations.

These small tractors would also be very beneficial in handling the pulling equipment for relocating the central part of the cut-through conveyor from one cut-through to the next.

Relocation of the cut-through conveyor

This job of relocating the cut through conveyor would be done when production work in the intake road had been completed and production in the belt road had commenced.

A sledge, fitted with a small hydraulic system powering a "hand over hand" puller would be connected to the outbye end of the centre section of the chain conveyor. The inbye end of a 150 m length of wire rope, say 50 mm in diameter, would be connected to the puller. The outbye end of the rope would be clamped to a sledge-mounted hydraulic powered anchorage between roof and floor.

A group of 3 or 4 appropriate rollers, anchored between roof and floor at the corner of the cut-through would be installed, enabling the conveyor to be pulled from the cut-through, around the corner and 40 m outbye along the intake road.

The corner roller assembly would then be moved forward and installed in a similar position at the corner of the new cut-through. The anchorage sledge would also be moved forward, to the face of the new cut-through and the end of the rope attached to it. The puller would then be hooked to the inbye end of the conveyor and operated until it was close to the anchorage at the face, to await the arrival of the belt road heading machine and sliding floor.

CONCLUSIONS

The potential benefits of the system are:

- Generally, the time to install one complete roof support module could be expected to be only slightly more than the time to install one bolt.

- Operation of the ripper head would be independent of roof support work.
- Supplies for face work would be always readily at hand.
- In the drivage of both headings, no labour at all would be required for ventilation. (However, in drivage of the cut-through, the standard method would be required.)
- In the drivage of both headings, coal haulage would be continuous from the picks to the belt.
- The overall capital cost would be low.
- The cost per tonne would be much lower for any specific set of conditions.

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