Continuous haulage: worth another look

Continuous haulage systems have not always presented a satisfactory operational experience for hard rock or coal miners. Some mines use one of the continuous haulage systems. Some have tried and abandoned continuous haulage. Yet, continuous haulage offers considerable benefits which are not always realised. By **Allison Golsby**

There is now a resurgence of interest in continuous haulage systems as coal mines seek to improve gate road development rates.

As most market players are very reluctant to publish information, benchmarking continuous haulage systems can be difficult. This is to the detriment of the industry as a whole.

There are various designs of continuous haulage systems on the market. Most of these systems are used in the US. Before use in Australia, the systems need to be modified to meet the Australian regulatory requirements.

The continuous haulage examples explored in this article will be bridge, flexible belt, chain, temporary belt support, pipe conveyors and pneumatic systems.

Bridge Conveyor

Most bridge conveyor systems consist of mobile bridge sections, track or wheel mounted, and carry chain or rubber belt conveying decks. Bridge sections are typically short (6 metres on conveyor bridges and 16m on chain type bridge systems) and are self-propelled.

Depending upon seam (and hence mining) height, the discharge end of these systems can either run over or beside the main conveyor. This enables the bridge conveyor to discharge on the section conveyor as the bridge conveyor follows the continuous miner through the development sequence. Bridge continuous haulage systems provide a haulage system similar to the flexible conveyor train systems. A chain-type bridge system was operated in one Australian mine during the 1990s with limited success.

Bridge conveyors consist of several linked bridge segments using chain conveyors. At each intersection a crawler unit is required, ▶

Diversified Mining Services is distributor for the Flexiveyor continuous haulage system in Australia and New Zealand

A section of the 4FCT flexible conveyor underground at the Clarence colliery in NSW

where one operator for each unit might be required. An 80m pillar block would require a bridge conveyor with about eight segments and an overall length of 180m.

The Flexiveyor system is a self-deploying conveyor that straddles the section conveyor and loop take up. The Flexiveyor conveyor might have 16 individual cars to a total of 96m, resulting in a belt advance occurring between every 30 and 90 m.

The Voest Alpine bridge conveyor system was equipped with a rubber belt conveyor and propelled on rubber wheels. Spillage was uncontrollable and thus tramming became a problem.

Flexible Belt Conveyor

Various flexible conveyor trains have been produced including both floor-mounted and roof-mounted continuous conveyor systems. Both systems offer some degree of operational flexibility. The discharge end of the flexible conveyor runs above the section conveyor.

This enables the flexible conveyor to discharge onto the section conveyor as the flexible conveyor follows the continuous miner through the development sequence. The face end of the flexible conveyor is attached to the rear of the continuous miner or is self-propelled and kept at that position. Both roof and floor mounted flexible conveyor systems were trialled in Australian mines during the late 1980s with limited success.

The Joy 4FCT01 is available in lengths up to 128m and requires one operator.

Chain Conveyor

Chain conveyors consist of four basic units: a breaker car module, conveyor bridge module, mobile bridge module and rigid haulage system. The system configuration and number of these units depends on individual mine application and production requirements but can be up to 200m of flexible chain conveyor with a feeder breaker behind a continuous miner.

From the chain conveyor the coal is transferred via a belt interface onto the section belt. Chain conveyor systems often have a lower profile and are thus more conducive to lower seam workings.

Temporary Belt Support

Temporary belt support systems comprise a telescopic conveyor utilising a belt bending section and collapsible A-frame belt supports mounted on skids. Temporary belt support systems are available that can facilitate belt extensions during belt operation. These systems allow inserting new belt structure and idlers parallel to production.

Joy's system requires a take up unit and has a length of 12 m, where Consol's temporary belt support system is 80m long and has an optional take up unit. There is the potential for the continuous miner to be connected directly to the section conveyor when driving the belt road.

Pipe Conveyor

Pipe conveyors are self-advancing and retreating via a monorail system and a hydraulic winch system. Maximum effective haulage length is approximately 200m. Due to the closed conveyor concept the spillage is non-existent. The design relies on a stretchable rubber belt driven by multiple friction rollers acting on a vertically vulcanised drive strip.

The mobility of the continuous haulage system will be achieved via a monorail system where the conveyor is suspended from and a track driven hopper car, which will also acts as the loading device for the conveyor system. The hopper car can be equipped with a roof bolter and enough storage space for 100m of monorail and an inboard lump breaker.

Pneumatic Conveyor

A pneumatic conveyor system can be designed and operated as either a positive pressure or negative pressure conveying system, or as ▶

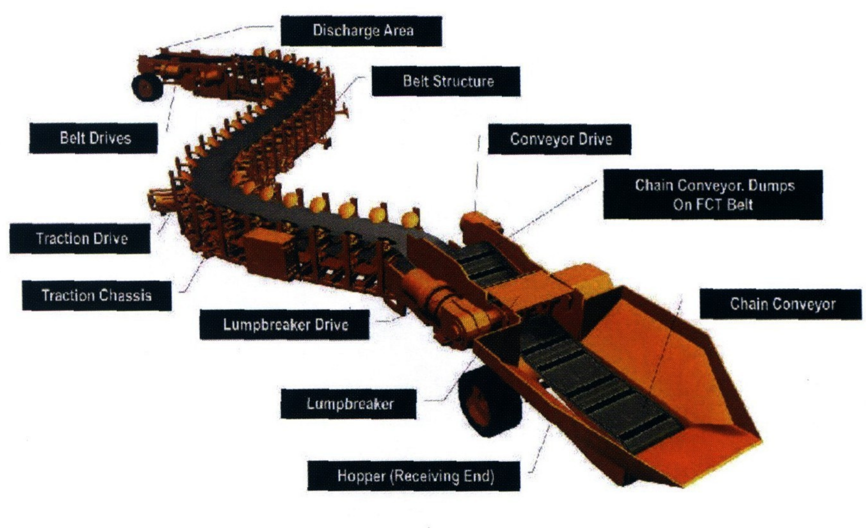


Diagram of flexible conveyor

a combination. However, pneumatic blower conveying systems cannot be adapted for loading and conveying coal from the mine face.

Negative pressure (vacuum) conveying systems are ideal for coal recovery because coal can be loaded and conveyed from several faces to a common storage hopper. Coal is loaded directly into the conveying system at the face by the vacuum action of the system. The operation of the vacuum loading hose is simple and suited for loading coal in all coal mining operations. The vacuum system has proved itself in thin-seam operations, where it has also proved effective in removing slurry and waste from sumps.

The vacuum coal loading and conveying system also eliminates most of the health and safety hazards associated with the operation of conventional mining and haulage equipment by removing powered mobile equipment from the mine. Ventilation is also improved by the coincidental removal of gas and respirable dust from the mine by the operation of the pneumatic vacuum loading and conveying system. A negative pressure system can operate over 300m length, using a 150mm to 180mm diameter pipe, with 4 to 9 psi pressure, as described by Bessemer (1999).

The vacuum coal loading system is composed of air injector pumps to generate the vacuum, a separator/surge hopper to remove the coal from the air stream, plastic PVC pipe for haulage and flexible loading tubes for loading the coal at the face. High wear was experienced by the PVC elbows and Y pieces, where steel pieces were implemented. The vacuum coal loading system has not experienced any blockages, even when the system has been stopped and started with coal in it.

The vacuum coal loading and conveying system is technically simple and inherently safe. Advantages include operating flexibility, low cost, quiet operations, and ease of automation. This system does not damage the coal particle; though a breaker may need to be placed before the vacuum loading system to reduce oversize.

Mine planning

Mine planning needs are to be considered as sites assess and implement continuous haulage. Besides panel design, the sequencing needs to be analysed and developed to optimise the productivity, recovery and utilisation of the new technology and mining operational requirements.

The selection process of the potential continuous haulage systems needs to consider matching mining and outbye equipment production compatibility. To optimise utilisation, the continuous haulage system will need belt moves and installations as and when needed. Since continuous haulage requires a process-driven culture, maintenance and operational skills need to be dispersed over all shifts.

Continuous haulage systems are less flexible than batch haulage systems, with mine planning constraints evident where variable geology might be encountered, especially in bord and pillar mining.

When considering wheel-driven continuous haulage systems, wider tread pneumatic wheels reduce damage to soft floors. Detection sensor covers reduce their downtime due to obstruction from dust and mud. Soft floors are damaged more by batch haulage than by continuous haulage systems. Track mounted continuous haulage systems are particularly effective with soft floors.

Continuous haulage systems often can traverse 90 degree drivage, though angled cut-throughs are preferred (70 degrees) to facilitate material handling. At this stage, continuous haulage systems cannot handle right angle bends. This necessitates the formation of diamond shaped pillars, which may in some circumstances be prone to crushing on pillar ends. This may result in larger intersections than would otherwise be preferred.

Other considerations to improve cycle times include: dry and graded outbye roadways, water inflow management, panel move standards, mapping of tasks and resources using Gantt charts in precise and clear language, and timely feedback for continuous improvement.

Water inflow has to be kept at a minimum, pumps have to be installed close to the water sources to protect the road and mud has to be addressed before its formation. This effort is worth the trouble, making most of the other processes faster and easier. It protects the equipment, and keeps the safety and worker motivation higher.

Conclusions

The choice of the "better option" in any analysis is not always made for monetary reasons. Often decisions are made for safety, operational ease or engineering design optimisation. Money is not the prime driver, but part of a thorough decision-making process, using an investment evaluation process model.

Continuous haulage takes personnel out of shuttle cars, reducing ergonomic issues. Continuous haulage equipment implies safer operation, with less relative movement of mine personnel and mobile equipment in the face area. For example, when transporting the same amount of coal from the face to a section conveyor in one shift, two shuttle cars may travel over 50 times the total distance covered by a continuous haulage system. In addition, shuttle car tram speed is up to six times greater than that of a continuous face haulage system.

Based on the removal of loading times alone, continuous haulage can achieve increases of up to 35% in utilisation time when compared with batch haulage systems. Continuous haulage takes the batch haulage bottleneck out of the coal clearance system.

To complement continuous haulage improvement, bolting constraints need to be addressed to make continuous mining truly continuous. However, a continuous haulage system, properly matched for these ▶

Surface coal handling conveyors

requirements, results in significant design changes to "bolting machine that mines coal" and vice versa. The first principle of design shifts from peak throughput capacity, to consistent steady state production.

Continuous haulage systems are required to complement the current equipment and roadway dimensions used on mine sites. Continuous haulage systems are not yet completely compatible with present development practices. Currently, a common effective mining cable is 200 to 300m in length. Since cables and hoses on the monorail can be extended only so far, this effective length needs to be considered when selecting the pillar length and should be a multiple of the pillar length: if not then the monorail has to be relocated more often than necessary.

To improve continuous haulage, the biggest organisational issues to be addressed on site are communication, education and the scheduling of tasks. The benefits of scheduling analysis should be able to show potential options for decreased costs, improved productivity, safety and finally increased return on investment.

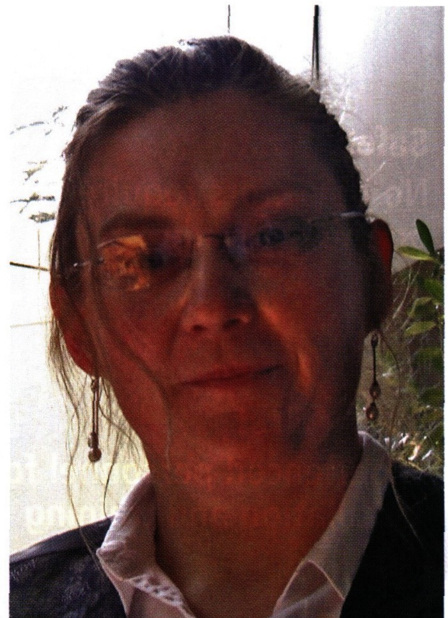
Some mines have found it necessary to modify or reengineer the continuous haulage system as delivered by the OEM, to enable it to adapt to mine conditions. These trial and error modifications have proved quite productive.

Some of the other issues encountered with continuous haulage have been spillage and deterioration of minerals. Every transfer station is a potential source for spillage. While conveying up to 10,000t per shift, even as little as 0.1% of spilled material (10t) necessitates an expensive cleaning exercise. In confined spaces, manual labour is often the only option. Rubber belts are prone to retaining sticky materials and the application of multiple cleaning stations is, in many cases, not technically feasible. Hence, chain conveyor systems are most in use and these are prone to wear and tear.

Deterioration of minerals creates fine particles, causing major loss of revenue, especially to the coal industry. The more transfer waterfalls, the more fines. Chain conveyors cause an additional milling action, especially in the bottom layers of the conveyed heap.

Although the initial capital costs for continuous face haulage in some instances may be higher than batch haulage, increases in shift production and productivity with continuous haulage should offset these costs. The goal is to increase shift production of coal and reduce operating and accident-related costs enough to justify the initial purchase and long-term use of this technology.

In some mining conditions, continuous haulage may not be just an alternative to batch haulage, but the only means by which some coal seams can be extracted. It should be noted that haulage costs usually make up 15% to 20% of the total operational cost of a section. Running steel on steel and transporting sandstone-laden ores causes high wear and a short time between overhauls (one million tonnes on average) is the costly result.



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At present, roadway development cannot keep up with longwall production, which often needs to slow down or wait for roadway development to catch up. It is necessary to adopt continuous haulage systems to improve the pace of roadway development.

If longwall is to reach the operational goal of being fully automated, then continuous haulage in conjunction with appropriate support services such as monorails need to be introduced and developed. AL

Allison Golsby has more than 25 years experience in the mining industry in planning and logistics, project management, mining engineering, geomechanics and mine ventilation in underground and open cut mining methods, in both coal and hard rock applications. She was the first woman accredited winder driver in Australia and has a Masters in Mining Engineering, a Masters in Geomechanics and a Graduate Diploma in Ventilation, all from UNSW.