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Keeping haulage continuous

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Summary

Continuous haulage systems have not always presented a satisfactory operational experience for hard rock or coal miners. Yet, it offers considerable benefits that are not always realised. Allison Golsby reports

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

As most market players are reluctant to publish information, benchmarking continuous haulage systems can be difficult. There are various designs of continuous haulage systems on the market. The 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 (6m on conveyor bridges and 16m on chain-type bridge systems) and are self-propelled.

Depending on 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 former follows the continuous miner through the development sequence. Bridge continuous haulage systems are similar to flexible conveyor train systems. A chain-type bridge system was operated in one Australian mine in the 1990s with limited success.

Bridge conveyors consist of several linked bridge segments using chain conveyors. At each intersection a crawler unit is required, 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, which 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 every 30-90m.

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 floor- and roof-mounted continuous systems, which offer a degree of operational flexibility.

The discharge end of the flexible conveyor runs above the section conveyor, which enables the former to discharge on to the latter 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 it 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 the 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 on to 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, using a belt-bending section and collapsible A-frame belt supports, mounted on skids. Temporary belt-support systems are available that can be extended during operation. New belt structure and idlers can be inserted parallel to production.

Joy's system requires a take-up unit and has a length of 12m, 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 and a hydraulic winch system. The maximum effective haulage length is about 200m. Due to the closed conveyor concept, 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 is achieved via a monorail system, whereby the conveyor is suspended from a track-driven hopper car, which also acts as the loading device. The hopper car can be equipped with a roof bolter and enough storage space for 100m of monorail and an on-board lump breaker.

Pneumatic conveyor

A pneumatic conveyor system can be designed and operated as either a positive or negative pressure conveying system, or as a combination. However, pneumatic blower conveying systems cannot be adapted for loading and conveying coal from the mine face.

Negative pressure (vacuum) systems are ideal for recovering coal because it can be loaded and conveyed from several faces to a common storage hopper. Coal is loaded directly on to the conveying system at the face by vacuum action. The operation of the vacuum-loading hose is simple and suitable for 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 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 150-180mm diameter pipe, with 0.3-0.6Bar pressure.

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. During studies, high wear was experienced by the PVC elbows and Y pieces, where steel pieces were used.

The vacuum coal-loading system did not become blocked, even when the system was stopped and restarted with coal in it.

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

Mine planning

Mine planning needs to be considered as sites assess and implement continuous haulage systems. Besides panel design, the sequencing needs to be analysed and developed to optimise the productivity, recovery and utilisation of the new technology and 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 require 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 may be encountered, especially in board-and-pillar mining.

When considering wheel-driven continuous-haulage systems, wider-tread pneumatic wheels reduce damage to soft floors and detection-sensor covers reduce downtime due to obstructions caused by dust and mud. Soft floors are damaged more by batch haulage than continuous haulage systems, which are particularly effective if track-mounted.

Continuous haulage systems can often traverse 90º drivage, although angled cut-throughs are preferred (70º) to facilitate material handling. At this stage, continuous haulage systems cannot handle right-angle bends. This necessitates the formation of diamond-shaped pillars, which can be prone to crushing on pillar ends and 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 must be kept to a minimum, pumps have to be installed near 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 safety and worker motivation high.

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, and implies safer operation with relatively less movement of workers and mobile equipment at the face.

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 increase usage time by up to 35% when compared with batch haulage systems. Continuous haulage takes the batch haulage bottle-neck out of the coal-clearance system.

To complement haulage improvements, bolting constraints need to be addressed to make continuous mining truly so. However, a continuous haulage system, properly matched for these requirements, results in significant design changes to ‘bolting machines that mine 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, and they are not yet fully compatible with present development practices.

Currently, a common effective mining cable is 200-300m 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 re-engineer the continuous haulage system as delivered by the OEM, to enable it to adapt to mine conditions. These trial and error modifications have proven 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 of spillage. When 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 often not technically feasible. So, chain-conveyor systems are most commonly used, 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 may be higher than batch haulage in some instances, this should be offset by increases in shift production and productivity. The goal is to raise shift production of coal while reducing 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 15-20% 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 (1Mt on average) is the costly result.

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

If a 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.

Allison Golsby has more than 25 years’ experience in the mining industry. She specialises in planning and logistics, project management, mining engineering, geomechanics and mine ventilation in both underground and open-cut mining methods.
