Innovative concepts in underground materials handling

by M. Fuchs*

Synopsis

There is still a drive worldwide to improve on existing methods of mining. The demand is for mining volumes to be increased while the productions costs must be reduced.

Against the background of these requirements, SANDVIK has been researching and developing innovative concepts for meeting these particular demands. The purpose of this presentation is to share information on two of these methodologies.

The one system illustrates the deployment of conveyors capable of operating around corners while still operating as a continuous haulage system. The other system demonstrates the principle of extremely fast straight line development coupled with the flexibility of sustained rapid redeployment of the system.

Both of the systems will be described and discussed in turn.

Continuous haulage sytem

General description

The continuous haulage system serves the requirement to mine underground mineral deposits in a way that increases the efficiency of a continuous mining machine by maximizing the machine utilization, which means eliminating the waiting for an intermittent material clearing system in the likes of a shuttle car.

The continuous haulage system will serve as a permanent connection between the continuous mining machine and the permanently installed underground material handling system of the mine. (Figure 1.)

The continuous haulage system follows the continuous mining machine throughout the entire cutting process. During this mining process the continuous miner cuts the material out of the mining face and transports it via on-board loading devices and conveyors to the back of the machine where it is discharged into a hopper car. This hopper car, as an integral part of the continuous haulage system, loads the Sicon conveyor system which transfers the material at its discharge end onto the permanently installed underground material handling system, which in the case of a coal mine will typically be the section conveyor.

During the retreating operation of the continuous miner, the continuous haulage systems also backs up out of the mined area, always maintaining the connection of the material flow between the miner and the section belt conveyor system.

Detailed description

Intermittent material clearing systems are very time consuming and therefore money consuming.

Shuttle cars receive the mined material from the back of a continuous miner and 'truck' it to the section belt conveyor for conveying the material out of the mine. After discharging the load onto the belt conveyor, the shuttle car returns to the back of the miner to receive the next load. During those extended waiting periods for the shuttle car to return, the continuous miner, in our case an ABM14, is not being utilized. Low utilization figures are being followed by low mining advance distances, which again are directly affecting the production figures and therefore the income of the mine itself.

High emphasis is being given to reduce this waiting time by, for example, utilizing two shuttle cars so one can be loaded while the other one is in transit. This has increased the utilization of the continuous miner to some degree.

The ultimate target is to eliminate all the waiting time and this can be achieved when connecting the continuous miner permanently with the section belt conveyor and also giving the miner enough freedom to travel forwards and backwards during its cutting/mining process.

A real continuous mining process can then be performed. (Figure 2.)

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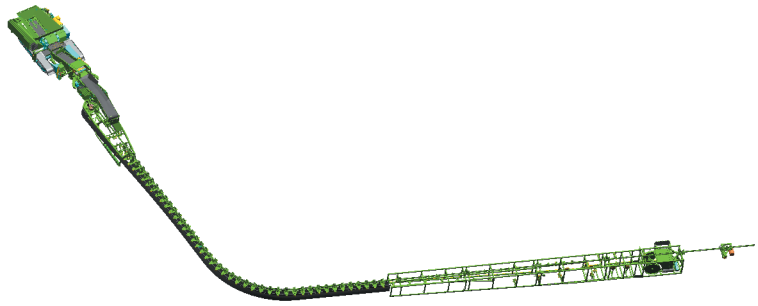


Figure 1—Continous haulage system

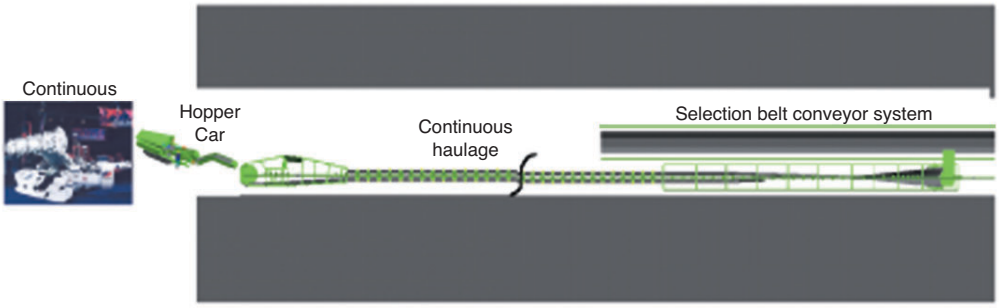


Figure 2—Continuous mining process

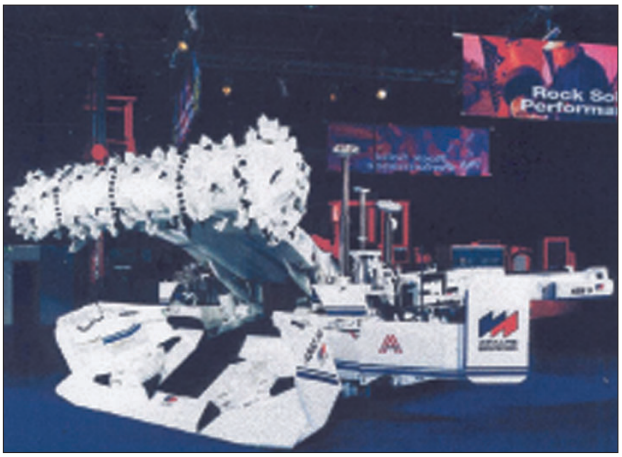


Figure 3—Continuous bolter miner

This can be done, even for a restricted distance, with a so-called continuous haulage system. In our case the distance that the continuous miner is able to move forwards and backwards is 200 m between the rear end of the miner and the main section belt conveyor.

A maximum but continuous material flow of 500m^3/operating hour is thus guaranteed.

Continuous mining operation

The cutting/mining process is performed by a continuous bolter miner (Figure 3), which cuts the material deposit and transfers the cut material via on-board conveyor systems to the back of the machine. There it is discharged into the continuous haulage system. The bolter miner also installs the necessary roof and rib anchors to keep the cut section permanently secure for the mining process and future access.

The material handling process between the continuous bolter miner and the permanently installed main underground conveyor system is done via the continuous haulage system.

A hopper car is anchored to and acts as the mechanism for advancing and retreating the haulage system. It is hydraulically driven via tracks and powered by its on-board hydraulic system. (Figure 4.)

The hopper car follows the continuous bolter miner and receives the cut material from it and transports it for further handling through to the back of the hopper car via chain conveyors. Due to the fact that the mining process delivers material sizes in all different dimensions, an on-board rock breaker will reduce the material size to around 70 mm for improved handling and managing downstream.

The hopper car, when advancing forward, pulls an approximately 200 m fixed length SICON conveyor belt system behind, which consists of a loading station, the actual SICON conveyor and a discharge station at the rear end of the conveyor.

Figure 4—Hopper car

The Sicon conveying system is suspended from wheel mounted brackets, which run on a roof mounted tubular monorail system. This system is installed by the hopper car. The drill rig, all the monorail tubes and all materials necessary to install the monorail system are located and stored on the hopper car.

The SICON conveyor system is a teardrop shaped conveyor, which fully encloses the material and gives the conveyor, based on its design, the ability to run around very tight corners of around 6 m radius. (Figure 6.) The ability and flexibility of this continuous haulage system going around such tight corners gives the system the leading edge in the underground market place.

The hopper car discharges the mined material into the SICON conveyor via a loading station. Inside the loading Station the enclosed SICON conveyor belt is opened up and filled via a loading funnel and closed again for the full conveying length. The hopper car has the ability to load into the loading station through all manoeuvers, even during going through the 6 m turns. (Figure 7.)

The drive station (40kW) of the SICON Conveyor is an integral part of the loading station.

At the head end of the SICON conveyor the discharge Station transfers the mined material onto the main underground material handling system, which in the case of a coal mine will typically be the section conveyor.

The SICON belt is opened up again within the discharge station. There it is also turned over to empty the belt. After that the belt is formed back into the tear-drop shape and returned back to the loading station in a parallel strand to the loaded conveyor belt side. (Figure 8.)

The tensioning of the SICON conveyor system is achieved by a frequency controlled winch, which is located at the head of the continuous haulage system. During the forward motion the conveyor system is pulled by the hopper car against the force of the winch and on the reverse motion the winch pulls the conveyor system back against the resistance of the hopper car. During all the movements of the mining process, the continuous haulage system stays operational and is able to transfer material from the mining face to the section conveyor.

Figure 5—Monorial system

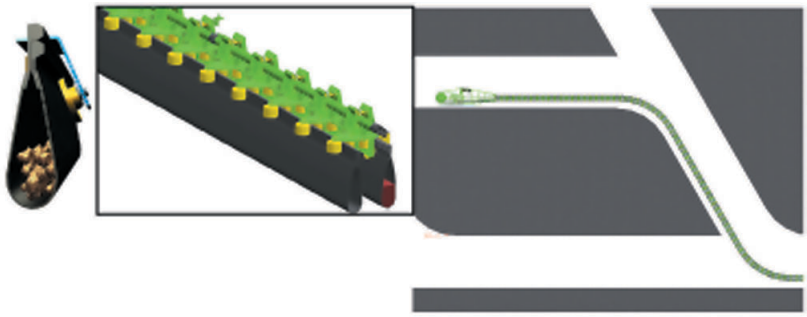


Figure 6—SICON conveyor system

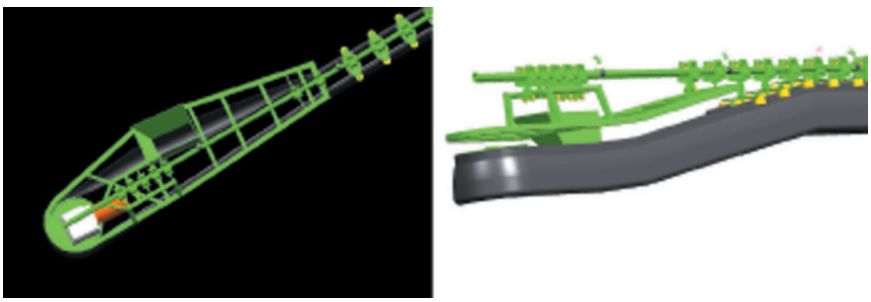


Figure 7—Loading station

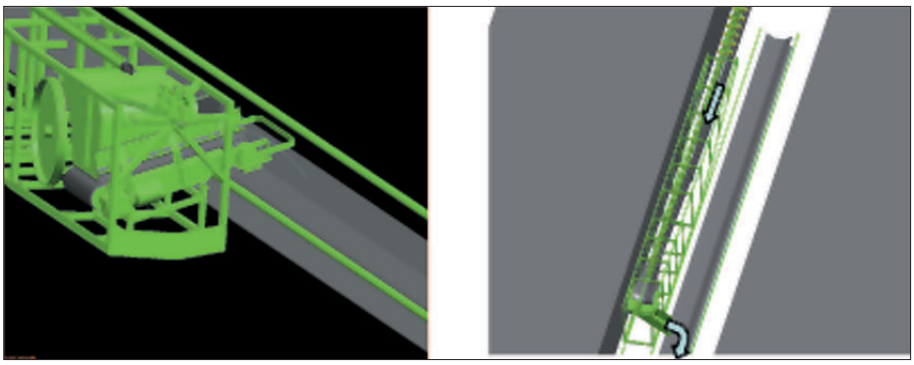


Figure 8—SICON belt

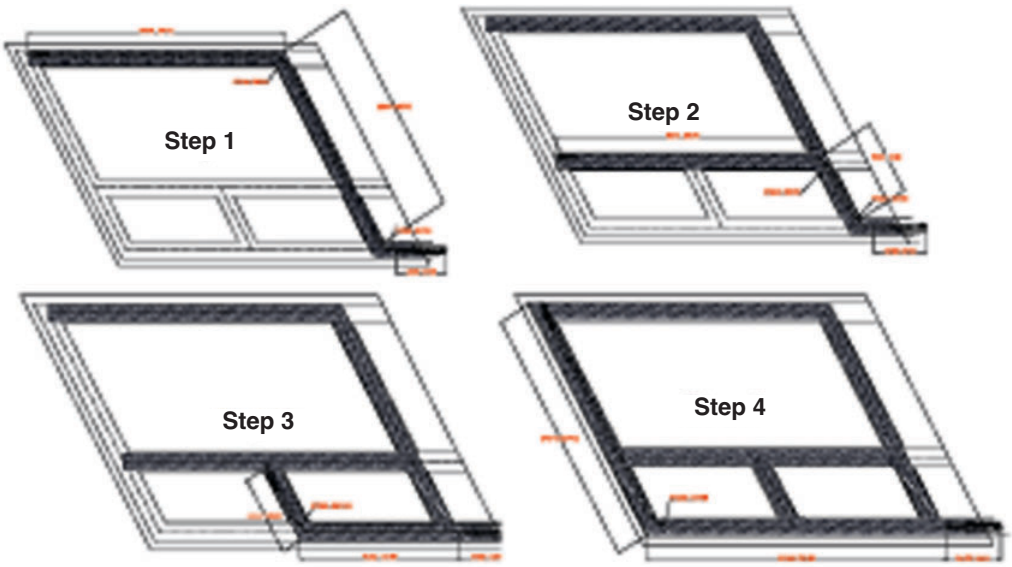


Figure 9—Start-up length One 200 m Mining/Cutting Sequence

Relocation of the continuous haulage system

At the end of one mining/cutting sequence of about 200 m distance from the main section conveyor, the whole system is relocated with the hopper car to its new start-up area. For this the winch will be retracted and detached from its anchoring. The full relocation process is performed via the monorail system.

The start-up length of the continuous haulage system (including the continuous miner) is approximately 220 meters. This will give the continuous haulage system a reach of about 200 m from the main section conveyor for a fully flexible cutting/mining process. (Figure 9.)

The minimum operating height is limited to 2200 mm and the width to 3 000 mm.

Punch mining system

General description

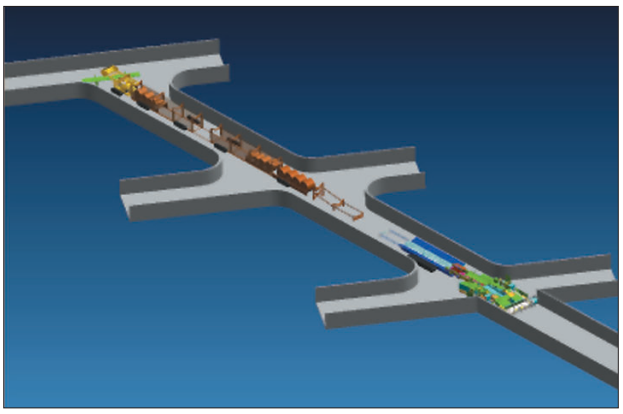
The punch mining system serves the requirement to mine underground mineral deposits in a way that cuts short straight distances (punches) into the deposits, taking only a short period of time, and to have the complete mining system retrieved out of those finished punches, before permanent strata control measurements (roof/rib bolts) become necessary. (Figures 10 and 11.)

Those short straight distances, or so-called punches are currently limited to a length of 200 metres and can be cut/mined within a period of 2 two 8-hour shifts, whereas the retrieving of the whole system, including a new set-up for a new punch in an adjacent section, will take 1 one 8-hour shift.

The punch mining system combines a continuous mining machine, for example the Alpine bolter miner ABM10 and a continuous straight line conveyor system, to cut a coal or ore deposit and to transport the mined material from the cutting face to the permanently installed main underground material handling system, which clears the material out of the underground section.

Detailed description

Strata control and ventilation measures of underground mining sections are very time and money consuming.



Figrue 10—Punch mining system

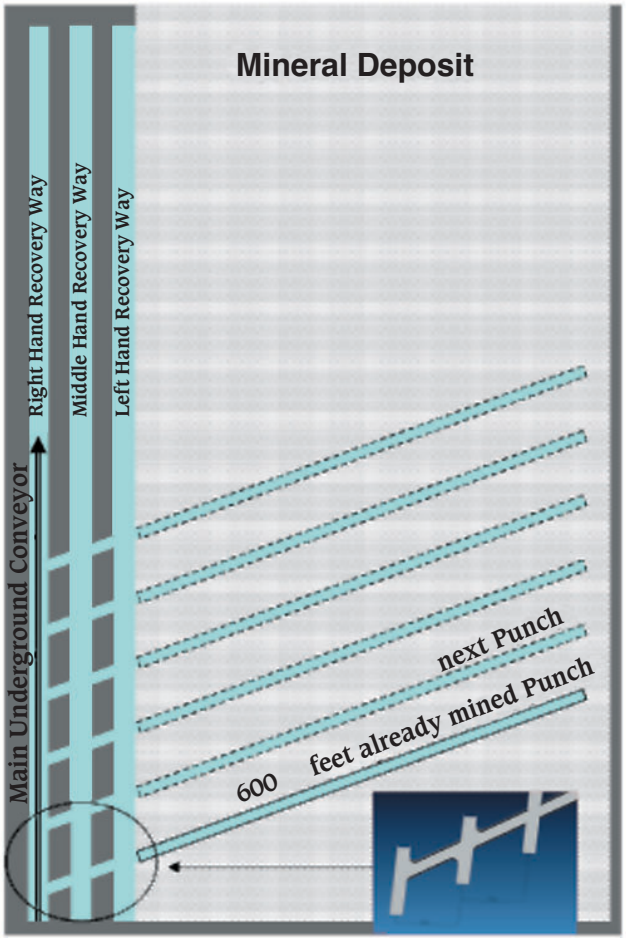


Figure 11—Punch mining

Whereas the ventilation of the newly cut sections is of utmost importance during the mining process (extraction of gases of any kind), the strata control in the likes of permanent roof and rib anchors can be skipped, if the mining process is finished and all equipment and personnel have left the newly cut section (one mining sequence) within a, by law, set period of time (i.e within 24 hours). Only short-term or temporary strata control systems will be installed, which secure the operation for the time it takes to mine and retrieve the whole system.

This rapidly mined and temporary secured newly cut section must not be entered by anybody after all equipment and personnel had been removed.

In case this section has to be entered in the future, permanent strata control measures have to be installed prior to entering and the ventilation requirements have to be fulfilled.

Punch mining operation

The cutting/mining process is performed by a continuous bolter miner, which cuts the material deposit and transfers the cut material via on-board conveyor systems to the back of the machine. There it is handed over to the straight line continuous haulage system. The bolter miner is also installs the necessary roof and rib anchors just to keep the cut section temporarily secure for the time it takes to mine and retrieve.

The material handling process between the continuous bolter miner and the permanently installed main underground conveyor system is done via a straight line continuous haulage system.

A hopper car acts as the advancing system for the haulage system. It is hydraulically driven via tracks and powered by the continuous miner's hydraulic system via two hydraulic hose connections (pressure and tank line). (Figure 13.)

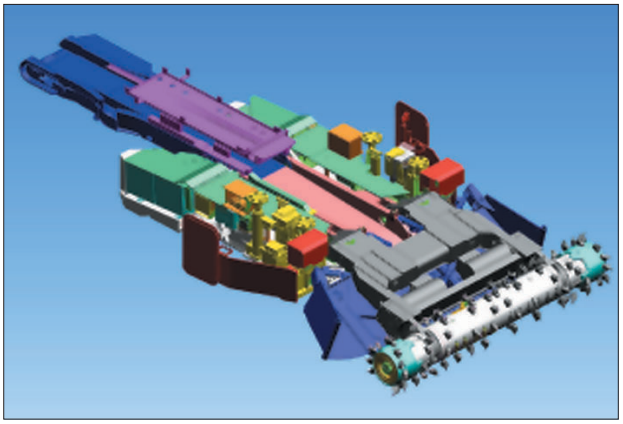


Figure 12—Continuous bolter miner

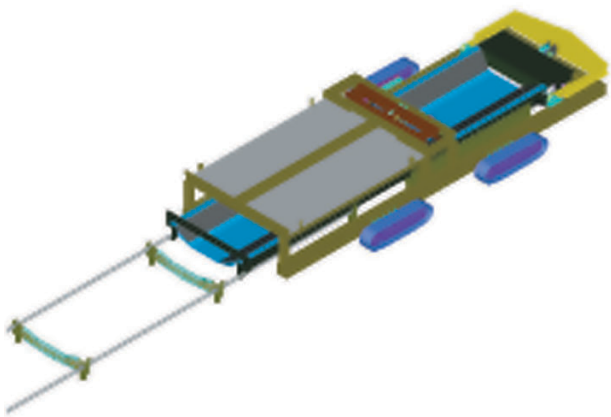


Figure 13—Hopper car

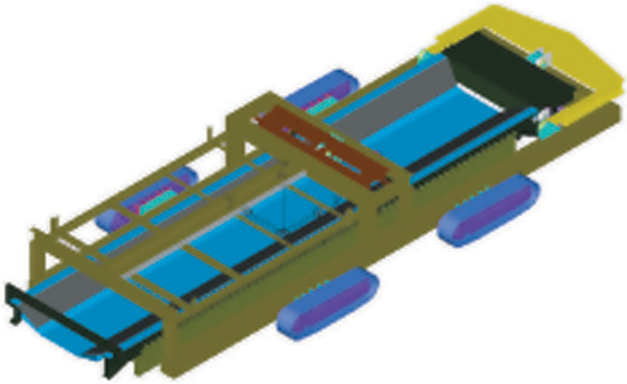


Figure 14—Hopper car

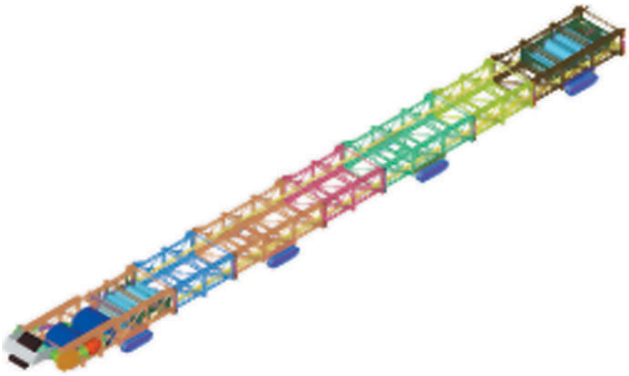


Figure 15—Loop-take-up system

The hopper car follows the continuous bolter miner and receive the cut material from it. The necessary additional conveyor belt structures, including the carry and return rollers for the full length of one punch, are stored inside the hopper car and are released in distances of approximately 2.6 metres when the hopper car advances. (Figure 14.)

The hopper car, when advancing forward, pulls the additional conveyor belt out of a loop-take-up system, sitting at the other end of the haulage system. The loop-take-up system can store approximately 160 metres of conveyor belt, which gives an advancing distance of about 80 metres. The additional conveyor belt length necessary to reach the 200 metre mark is stored in the form of 2 belt rolls at the front of the loop-take-up system and will be pulled into the loop-take-up via on-board hydraulic motors, a belt clamping device and the conveyor belt tensioning winch. For relocation purposes, the Loop-Take-Up system is track mounted and divided into sections, which are individually hinged to manoeuvre around corners. (Figure 15.)

The drive/transfer station (45 kW) combined with the transfer chute connects the haulage system to the main underground conveyor system. It sits at the end of the straight line continuous haulage system. This system component is also track driven. (Figure 16.)

The start-up length of the punch mining system (including the continuous miner) is approximately 55 metres. (Figure 17.)

One example of a start-up section set-up is to have a three roadway arrangement along the whole length of the, mineral deposit to be extracted.

- Left-hand roadway containing the main underground conveyor and for ventilation
- Middle roadway for intermediate storage (material, transformers, etc.) and for ventilation purposes
- Right-hand roadway for relocation (continuous miner and haulage system) and for ventilation purposes.

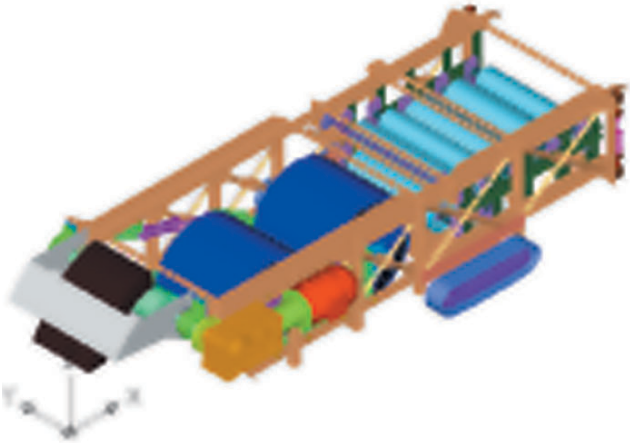


Figure 16—Driver/transfer station

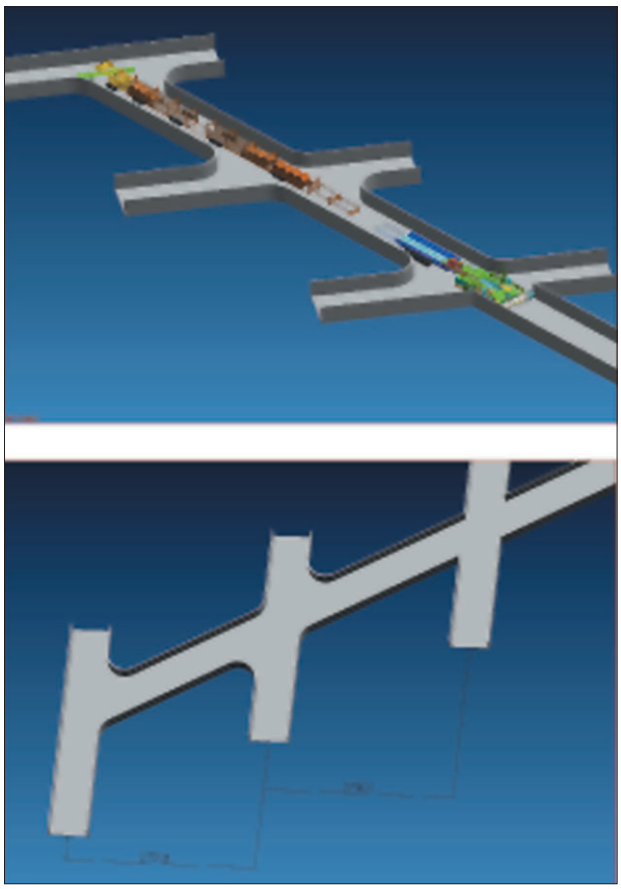


Figure 17—Start-up length of the punch mining system

Figure 18—Punch mining system

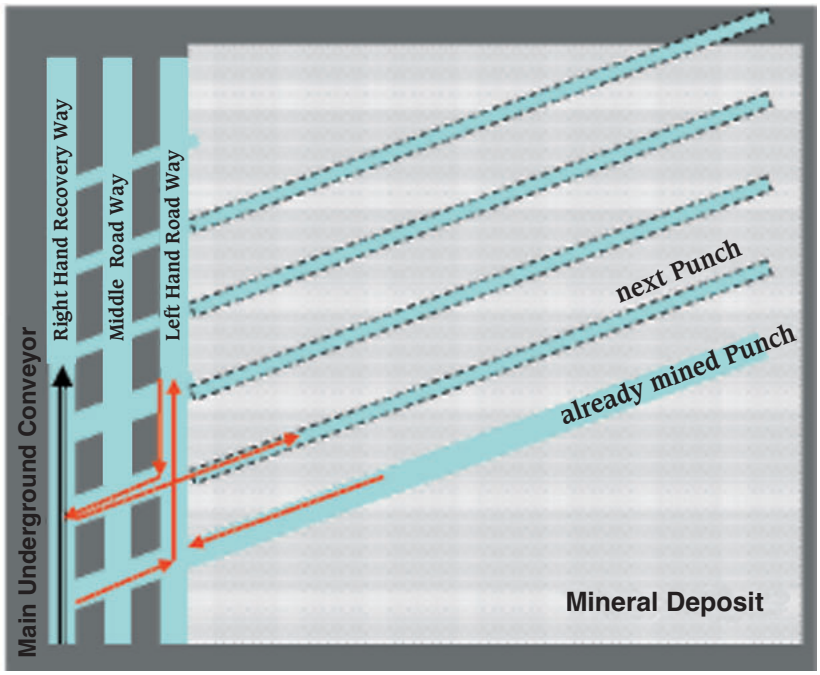


Figure 19—Retrieving/relocation sequence

Retrieving/relocation operation

After finalizing the 200 metre punch, the mining system has to be retrieved out of the section, relocated and set up for a new 200 metre cutting/mining sequence.

For this the continuous bolter miner and the hopper car will return to their starting position, collecting all conveyor structure (back into the storage area of the hopper car) on their way back and also reeling the conveyor belt surplus back onto the rolls via on-board hydraulic driven reelers.

Back in their start-up position and therefore out of the latest cut punch, the whole punch mining system will be split by separating the continuous bolter miner from the hopper car (hopper car will be connected to the hydraulic system of the conveyor system). The two split parts will manoeuvre individually up the right-hand roadway by releasing all hinge points of the conveyor system to give the flexibility to get around the corners. (Figure 18.)

The system will move up the right-hand roadway till the drive/transfer station is at the same height as the next 'start-up' roadway, and will then reverse backwards towards the main underground conveyor till the transfer chute and the main underground conveyor line up. In this position the continuous bolter miner as well as the hopper car will be fully in line with the new 'start-up' roadway.

The continuous bolter miner and the hopper car will now move forwards till standing at the new cutting face and the new cutting/mining sequence, punch, can start in the above described way.

Conclusion

Both systems are scheduled for extensive field trials the latter part of this year with production applications early in 2007.