



Productive longwall systems from Joy Global

Introduction

Worldwide, more and more longwall mining operations are realising the advantages of complete longwall system automation.

Case studies conducted by Joy Global within various longwall mining operations reveal a direct correlation between integrated longwall automation systems and the resulting - quite significant - increases in worker safety, equipment utilisation and overall productivity. Improvements in safety, utilisation and productivity are the drivers behind developments in automation, with the ultimate goal of automation being to both increase productivity and reduce the exposure of mining personnel to potential harm.

While integrated system automation allows longwall mining operations to maintain consistent equipment utilisation, the main reason behind why longwall mining customers decide to purchase an integrated longwall system is safety. From a bottom-line standpoint, when longwall system components work in harmony with real-time communication, increased safety is a top result. With remote control operation and monitoring, the risks of hazardous

gases, respirable dust and working in close proximity to mobile mining equipment are reduced.

The most effective way to increase both safety and productivity in longwall mining is complete longwall system automation, which is achieved through the application of an integrated longwall system solution.

Single-source systems integration

A complete, integrated longwall system solution requires a single-source supplier that is the single point of contact for the longwall operation, as well as the prime contractor responsible for customising the system to meet the required operational criteria and production goals. The system is complete due to the seamless integration of the shearer, armoured face conveyor (AFC), powered roof supports (PRS), power system, hydraulic pumps and monorail system. Offering the highest level of equipment integration, the system components are sized to work in harmony, with all of the mechanical and electrical interfaces being compatible. Additionally, a remote operation centre can be used to provide a single means of operation for the entire face.



An integrated longwall has safety features incorporated throughout the system. For example, an integrated proximity detection system is designed to track mine personnel present at the face and halt PRS advance when a miner gets too close to the longwall system. Safety features are built into the integrated longwall system, whereas bolt-on, aftermarket, safety device is unable to communicate effectively among all longwall system components. The integrated system approach allows longwall operations to maximise equipment utilisation and maintain those levels consistently, so that the mine operates more efficiently and safely.

Certified OEM trainers provide hands-on operational training that teaches mine personnel to operate and maintain the integrated longwall system and helps facilitate mine personnel's acceptance and optimisation of the automated longwall system. Online parts catalogues cover all elements of the integrated longwall system, with design and documentation procedures being consistent for all integrated longwall system components. Joy Global longwall service representatives are cross-trained and can provide support for the complete integrated, longwall system.

JoySmart Solutions team members match communication protocols throughout the integrated longwall system and transmit data to the surface of the mine using Wi-Fi or cable,

allowing real-time visibility into longwall system operation and performance. With integrated communications systems, the mine's management personnel can easily and accurately analyse production processes to attain optimal utilisation of any cycle or component within the system.

In India, Joy Global is providing a new Joy longwall system for the Kapuria coal mine operated by AMR India Limited. The US-based company provides longwall systems throughout the world and regularly

Powering Kapuria

One of the most recent examples of a Joy Global system going into place is at the Kapuria coal mine operated by AMR India Limited. Kapuria is a greenfield site situated in the Western Jharia area. The coal block is owned by Bharat Coking Coal Limited (BCCL, a subsidiary of CIL). AMR is the mine developer and operator for this project. Joy Global will supply longwall equipment, road headers, roof bolters, belt conveyors and LCM for the entire system.

Joy is providing five roadheaders, three of which will have on-board integral roof bolters. With two bolting rigs per roadheader it allows for the quick, effective and accurate installation of roof bolt support immediately after the cutting cycle has been completed and the roof has been exposed.

With a close bolt-to-face distance of 0.5m and a wide rotation angle of 100 degrees it enables both roof and side bolts to be inserted in a range of bolting patterns and roadway shapes and dimensions. The control operation of the bolters is carried out from position at the rear of the apron keeping the operator away from the face of the heading and in a position of safety. The bolters are capable of drilling strata of up to 80MPa and with a torque of 200Nm it allows for quick and efficient roadway drivage.

Behind the roadheader is a walking tail end unit. The cut material from the roadheader is delivered onto the walking tail end by means of a 'bridge' or second conveyor. This simple but effective unit is a mechanised means of self-advancing the development conveyor allowing the operation to be carried out independently and concurrent with other development operations thereby increasing the development performance. The design and operation of the tail end is simple and effective with no chains involved, helping reduce the risk of injury. The walking tail end has the additional benefit in that it also carries the development electrics, ancillary equipment and the exhaust fan so these are also advanced as part of the operation, reducing the time for move ups, reducing manpower requirements and improving productivity.

The shearer to cut the coal on the longwall will be 3.3kV, 1106kW machine equipped with the latest version of the Joy control system, Faceboss. The control system monitors the various sensors, managing motor controls, machine diagnostics, radio remotes, inverter controls and data transmission. The latest system improvements incorporate faster processing speed, better communication and improved diagnostics. The user interface is a full colour, multi-lingual display navigated by the use of a mouse, page turner or the handheld radio transmitters. The machine has a modular, multi motor design.

Using finite element analysis and design failure mode and effect analysis, Joy's design team has produced a roof support to meet exacting cycle and operating requirements. The powered roof supports will be cycled tested to 45,000 cycles as against the normal 26,000 cycles with EN1804. The roof supports are controlled by Joy's state-of-the-art electronic control system, RS20s. The system is more powerful and communicates faster than earlier models, offering comprehensive control and monitoring capabilities with excellent reliability. Designed with operator friendliness in mind, it features large buttons and an audible beep alert on each button press to provide operator feedback. The front panel uses a shield legend to clearly illustrate all support functions. A backlit display allows the operator to examine not just the support, but the whole system for status and faults, helping ensure consistent operation, reliability and maximum utilisation of equipment.

With 40mm-thick deck-plates, the AFC has been designed

to operate on the steep grades within the mine. The low delivery end of the AFC and interface with the stage loader has a pivoting frame designed to cater to the variable gradient changes throughout the mine while still delivering 1,200 tonnes per hour. An overlap belt tail end will provide efficient transfer of coal onto the gate conveyor. This allows the beam stage loader to be pushed out without the belt tail end moving and altering the load from the coal face. The belt return end can be retreated at a suitable time within the mining cycle to minimise disruption to face operations.

A dual purpose pan line bolter will be used to ensure efficient preparation of the face. This is an AFC mounted, hydraulically propelled roofbolting machine specially designed for face salvage and adverse geological conditions. The bolter has the flexibility of a swinging and elevating boom for the operator, in addition to mast swing to allow bolts to be installed in the coal face. All tramping and bolting operations are carried out from an operator's platform with canopy protection, offering enhanced safety. To provide increased flexibility the pan line bolter has pockets within its construction, enabling it to be carried by shield haulers and used around the mine as a portable bolting machine.

The LCM plan for this equipment system is unique from any project in India. As the OEM, Joy Global takes all responsibility for the Life Cycle Management of the entire system, employing CEP, overhauls and rebuilds as required, to guarantee availability of the system for nine Annual Production Periods (APP's), with an expected annual tonnage of 2 million tonnes per annum. The LCM contract guarantees minimized unplanned downtime, lower instances of machines waiting for components after failure, predicted structural repair requirements and changes, minimized secondary damage, and optimized training and maintenance execution, with the end goal of providing higher availability of the system for continuous production.

Longwall automation

System integration is a critical next step for longwall operations. However, combining automation with remote longwall operation is not the ultimate goal. Instead, Joy Global aims to achieve autonomous longwall operation with remote supervision.

In particular, very high or very low seams pose challenges to safe, efficient operations. These challenges are addressed with the utilisation of integrated automation. In addition, older conventional longwall mining methods remain costly and inefficient, in large part due to the amount of rock and dirt being extracted with the coal. When compared to the typical performance of conventional medium – seam longwall equipment, an integrated low-seam longwall system can reduce waste by up to 40%, while achieving significant operational cost savings.

Shearer automation systems that allow the programming

of fully-automated cutting sequences, including gate-end turnarounds, highlight the advantages of advanced automation solutions. Mine operations using these shearer automation systems can benefit from the following:

- ♦ Controlling the shearing machine with a single operator positioned upwind with less dust and noise exposure.
- ♦ Achieving consistent extraction heights and cutting methods across shifts.
- ♦ Managing shearer speed, while easily accessing valuable system performance data at the mine surface.

These productivity features are the result of specific software enhancements, new sensor technologies and the sharing of data between the shearer, PRS and the face conveyor subsystems. Integrated PRS inclinometers, which indicate the position of roof supports with respect to each other (for the purpose of minimising the chances of a collision between the PRS and the shearer), are an additional safety feature.

One of the latest safety features in longwall automation is radio motion monitoring. This is an accelerometer-based detection system intended to reduce risk in longwall shearer and PRS operation. Radio motion monitoring is designed to minimise the potential of mine personnel being injured by moving roof supports in the event that a miner falls or becomes immobilised. While continuously being monitored by the shearer control system, radio motion monitoring functions as a two-way radio that incorporates the accelerometer-based detection system in an operator-handheld transceiver (HHX), which flags the absence of movement, a sudden impact or a free fall. Should any such events occur, the shearer control system is designed to react by disabling all motors on the shearer. At the same time, the PRS also reacts to the HHX trip status with parameter-selectable actions that include dumping face pressure, stopping all roof support movement or allowing the PRS to finish its current cycle. The radio motion monitoring system offers an advantage over conventional tilt switches because the operator is not required to maintain a particular angular position of the radio, giving the operator a greater ability to more closely monitor cutting positions, while not increasing the safety risks associated with interacting with the shearer.

Additional safety optimisation can be obtained through the use of a Remote Operation Centre (ROC), which allows push-button control in full automation mode or manual override, from a safer and cleaner environment away from the face. The ROC interface consists of a Facebook control platform, which monitors and displays equipment performance, while several advanced camera displays allow the longwall operator to monitor the surrounding

environment. Relevant system data is transmitted to the mine surface where advanced analytics are performed through JoySmart to predict potential equipment failures, define specific maintenance needs or recommend process improvement opportunities. Cameras are mounted on the shearer and roof supports to give a traditional systems view during operation.

Joy also now offers a full 3D longwall visualisation control platform that combines all of the component information with video images to create a 3D system profile of the longwall components: shearer, AFC, and PRS system.

Advancements in longwall automation are stimulated by a safety-first focus and the mine operator's need for maximum uptime. However, because new technologies often encounter resistance, the success of a single-source, systems approach to longwall system automation relies upon a close partnership between the provider and the entire mining operation team.

Case studies conducted by Joy Global illustrate the link between complete, integrated longwall automation systems and significant increases in safety, equipment utilisation, and productivity.

Mine 1

Data collected at a mine in Australia over a two-year period indicates a strong linear correlation (r-value of 0.70) between tonnes per cutting hour and overall automation

The operation averaged 54% of automation features in use. Note that roughly half of the variance is tied to automation, with geology and other factors controlling the remainder. Automation use included:

- ♦ 60% run-of-face average
- ♦ 32% face-end average
- ♦ 31% main gate average
- ♦ 34% tail gate average

Mine 2

Automation use at a mine in the US, with an average panel size of 300 m by 3800 m, resulted in a 20% increase in short tons per operating hour (STPOH). Automation played a significant role in this production increase. Earlier longwall panels accessed minimal levels of automation with production capacities of up to 2300 STPOH.

Following the introduction of PRS and shearer automation features, as well as the addition of technologies to allow operation from the headgate (utilising cameras), production capacities averaged up to 2700 STPOH, a 20% increase.