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Recent developments in longwall mining entry development, and room and pillar systems

1. Synopsis

Continued strong growth in the global demand for energy, driven by both developed and developing markets, has lead to the coal sector playing a major role in meeting current demand and in raising production to meet annual planned increases. The most important of these markets for coal is the Asian Pacific area with consumption at over 3.3 billion tonnes last year, or over half the world's consumption. China is the most important coal-consuming country by far with its energy sector growing at between 7 to 9% per year.

With this booming growth, underground coal owners and operators are looking at ever more productive and powerful equipment. This paper looks at recent technological advances in equipment for longwall, longwall development and room and pillar systems. Particular emphasis is made on the high capacity Chinese, Australian and the US markets where high productivity is coupled with maximising the extraction of coal reserves in both very thick seams and in thin high quality seams where premium prices can be commanded. As a result of this demand for increased production, manufacturers have made significant advances in thin seam and ultra high seam extraction equipment.

The paper covers the highest and most powerful longwall shearer, Joy's 7LS7 with a capacity of over 4,500 tonnes per hour for operating in up to 6.5 m high seams. Four of these machines have been delivered or are on delivery for the Chinese market.

Also the world's most powerful roof supports, with an incredible 30% increase in performance life over the previous largest supports are highlighted. These supports have

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a massive yield load of 1750 tonnes using 480 mm diameter legs and are due to be installed in a North Australian mine in 2008.

Manufacturers have increased the available power and chain strength of longwall armoured face conveyors (AFC's) enabling operators to maximise longwall panel widths and increasing reliability. New panels are now installed and operating at and above 400 m wide.

In the area of thin seams, designers have reduced the operating height of longwall equipment while still allowing high-powered shearers and conveyors to operate efficiently. The overall height of the equipment is critical in such situations and the paper discusses ways of reducing the height of the conveyor while providing enough conveyor chain strength and power to maintain high levels of coal production.

New miner bolter models have been introduced into the Russian market place with reduced bolt to face distances and significant increases in productivity. These advances in roadway development equipment are discussed along with the introduction of continuous haulage flexible belt conveyors (FCT's) and "wet head" continuous miners for room and pillar operations. The new wet head continuous miners offer water sprays to the pick point and have significantly reduced dust and pick consumption.

Finally the paper also details recent advances in monitoring, control and information technology systems for mine operators.

2. Underground Longwall Mining

The worlds most productive longwalls are still located in the USA, Australia and the Shenhua coalfield of China.

Shenhua was developed from a greenfield site in 1992 and now has more than seven major underground mines producing over 200 million tonnes per year and all equipped with the latest high productive longwall equipment. These mines now set the standard for longwall performance around the world with outputs of between 5 and 10 million tonnes per longwall face per year.

In the USA there are now 49 operating longwalls producing over 175 million tonnes per year with the best achieving over 7 million tonnes per year. It is interesting to note that the average production is over 3.8 million tonnes per longwall face per year, making the USA the most consistent longwall operator worldwide.

Australia has 29 operating faces with a total longwall production of 47.5 million tonnes with a best output of over 7 million tonnes from a single longwall face. New faces are now under design and planning for increased extraction heights of over 7 metres using longwall sub level caving systems.

2.1. World's Highest Longwall Shearer

The world's highest and most powerful longwall shearer, Joy's 7LS7, has an installed power of over 2300 kW, with each ranging arm rated at 860 kW, and is over 110 tonnes in

weight. It is designed to cut up to 6.5 metres (Fig. 1). This will be the highest extraction height of any standard longwall face worldwide. Two machines are now operating in Shenhua and two others are under delivery to the Ning Mei group in China. Cutting rates of over 4,500 tonnes per hour are achievable.

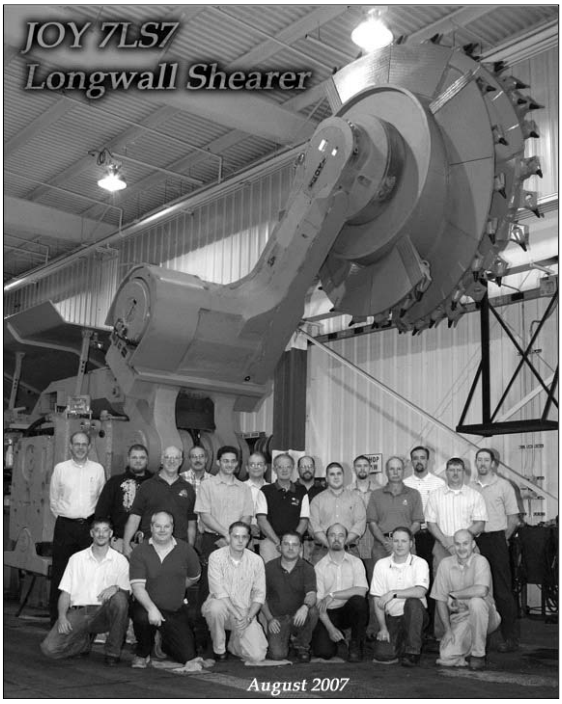

Fig. 1. World's highest shearer 7LS7 at 6.5 metres – China

Rys. 1. Najwyższy kombajn w świecie; 7LS7 – 6,5 m, Chiny

2.2. World's Largest and longest life Roof Support

The worlds highest rated shield roof support has now successfully completed a full design and test programme up to 90,000 cycles. The supports (Fig. 2) represent a 33% increase in life on the worlds previous largest support and a 66% greater life than most commonly used supports. Each of the 143 supports weighs in at 64 tonnes, which is double the previous largest heavy-duty support weight of 32 tonnes. Rated at 2 × 1750 tonne (yield) with a range of 2.4 to 5 metres height, each support is spaced at 2.05 metre centres. The previous largest leg diameter was 400 mm, the new support has 480mm diameter legs and a 200 mm bore advancing ram.

These supports are currently under manufacture and are to be supplied to a North Australian mine early in 2008 to control a massive sandstone roof and have a life commensurate with the mine reserves. The investment for such a radical specification upgrade was made on the life cycle demands and the success achieved with the previous roof supports supplied by Joy Mining.

Fig. 2. World's Biggest and Highest Rated Roof Support – 62 tonnes, 90,000 cycles

Rys. 2. Największe i najwyższe stemple stropu – 62 tony, 90 000 cykli

The AFC for the same project also has one of the world's most powerful transmissions systems with a 1.1 m wide pan, 4500 tph rating and 3 × 1000 kW drives together with 50 mm Broadband chain (see section 2.4 and 2.6 below).

2.3. World's first Full Cycle Automation of Roof Supports – The RS20s Roof Support Control System

Joy's RS20s automated control system (Fig. 3) was installed in an Eastern USA mine in 2006 and completed three longwall panels with over 5000 operating cycles. The operating system was then transferred to another mine in the same group where a different operating system had previously been in operation. The underground operators had to get used to the new controls and operating system but within ten days of training were already running on full automation with over 9 completely automated strips per shift achieved. That is the complete remote operation of all the roof supports without any direct intervention by the operator for the entire length of the face and including the gate end turnarounds! That is an industry first.

The RS20s system is also under installation in the Nothern Australian mine with the worlds largest and longest life roof supports (as discussed in section 2.2 above).

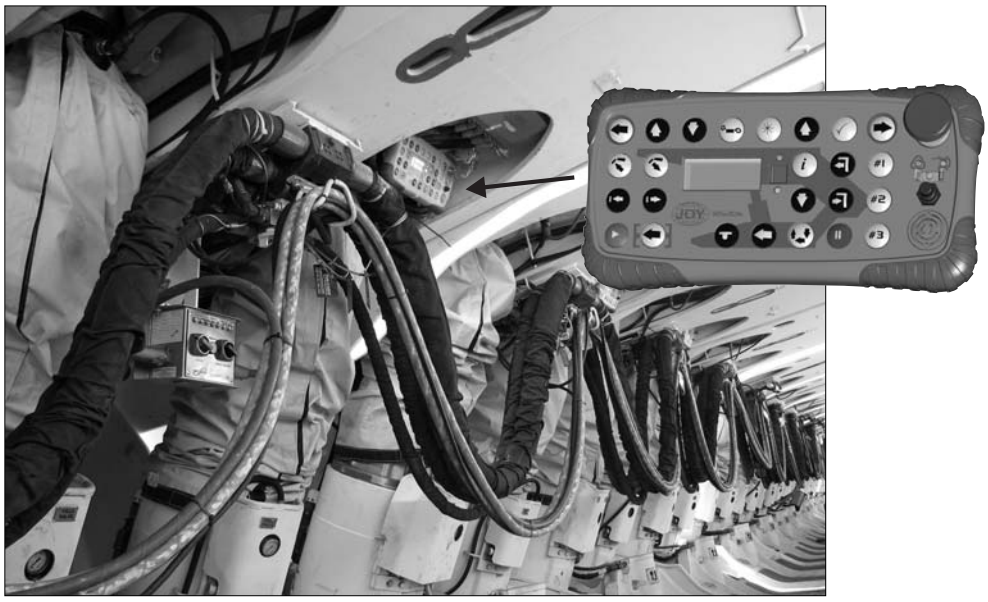

Fig. 3. Full automation of Longwall roof supports with the RS20s Control system

Rys. 3. Pełna automatyzacja podpór stropów przodka ścianowego z systemem sterowania RS20s

2.4. Widest Longwall Panels

Longwall panels generally average 250 to 300 metres in width. Recently however several mines have invested in technology to increase the operating width up to and above 400 metres. A mine in Eastern Australia installed a new 400 metre wide "Fat face" in August 2006. This included an AFC (Armoured Face Conveyor) with 3 × 1000 kW drives driven through Voith TTT (Turbo Transmission Technology) couplings and using a new design 50mm Broadband chain (this fits into a standard 42 mm chain panline, Fig. 5) with reduced height profile. Output rating is 3500 tph and the face includes the Joy RS20s automatic control system. This face completed 3.2 million tonnes last year.

2.5. Biggest Armoured Face Conveyors

Another East Australian mine in the Hunter Valley region recently ordered a new 405m wide "Fat Face" longwall system (Fig. 4). This new "state-of-the-art" longwall will extract low ash thermal and semi-soft coal and produce over 8 million tonne per year for supply into the Asia market.

The new Longwall utilises approximately 200, 2.0 m wide 1,270 tonne (yield) powered roof supports fitted with the RS20s control system. The armoured face conveyor (AFC) sets a new world benchmark for installed power with a 400 kW crusher, 600 kW 1550 mm wide breaker stage loader (BSL) and 2 × 1600 kW, 1100 mm AFC. (The AFC is also upgradeable

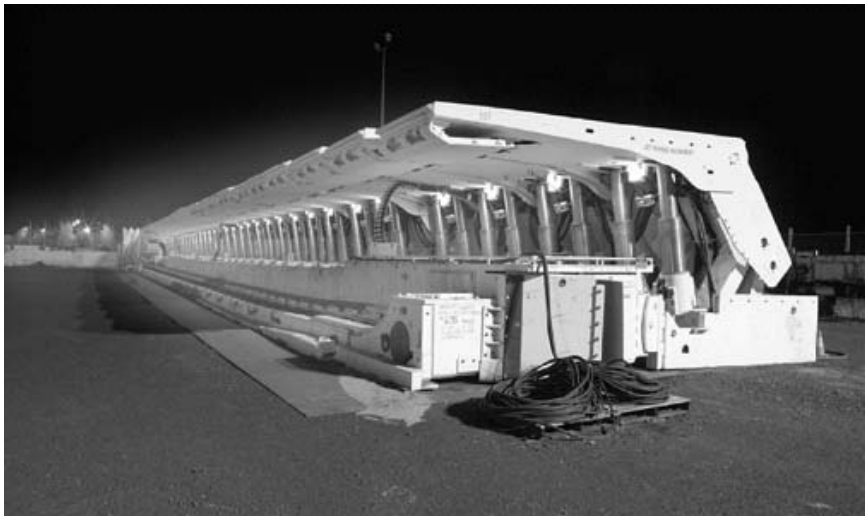

Fig. 4. 405 metre wide face Eastern Australia

Rys. 4. Przodek o szerokości 405 m, Wschodnia Australia

Fig. 5. BROADBAND Armoured Conveyor chain increased strength and reduced height

Rys. 5. BROADBAND, łańcuch przenośnika w osłonie zwiększa wytrzymałość i zmniejsza wysokość

to 3 × 1600 kW). The shearer is a Joy 7LS6 state-of-the-art with 1000 kW rated ranging arms, 860 kW cutter motors and150kW mega drive haulage.

2.6. New Low seam extraction of coking coal and high quality steam coals

In certain areas of the world coal producers are looking to mine thin seams, which can command significant price differentials compared to other coals. Here it is important to

reduce seam dirt and contamination as much as practical. This has lead to a number of innovative and evolutionary upgrades in equipment.

The main technological innovation has been the introduction of the Broadband chain over the past two years. This is a revolutionary chain with a vertical "wide flat link" which reduces the overall chain height and is linked together with a large horizontal round link (Fig. 5). This allows a 50 mm strength of chain to fit into a 42 mm chain panline profile (and a 42 mm Broadband chain to fit into a 34 mm chain panline profile) saving over 25 mm of height. Coupled with design enhancements to reduce the thickness of the roof support beam and savings in the design of the shearer haulage system, these innovations have lead to longwall face heights of under 1.5 metre heights (refer to Fig. 5).

2.7. Longwall Automation

Full automation of roof supports on the longwall face (including gate end turn arounds) has now been realised with the RS20s operating system discussed in section 2.3 has been well proven. More recently automated shearer control using onboard cameras is under development with the potential to allow remote operation in either thick seams of 5 to 6.5 metres or in thin seams reduced heights below 1.5 metres. This is technology to improve operator safety and will make a big impact in the future .

The Joy Faceboss automated management information and control system is now available on all mobile equipment including shearers and continuous miners. This allows automatic transmission of all equipment parameters and operating statistics to the surface control centre. Detailed information is therefore now available for shift by shift and hour by hour analysis including graphs of operating time, stoppages and assessment of the equipment operating parameters (i.e. time when the cutter motors are actually taking load). This is an invaluable management tool and can be used for continual assessment, increased utilisation and better maintenance and training. This type of manufacturer/ machine/ customer interface is proving invaluable in increasing awareness and in the reduction of all non-production time.

Joy is also working actively on new Navigational Systems, which will offer another level of automated control for mobile equipment.

Life cycle management agreements including technical support, training, repair and spare parts are part of the full customer commitment offered to support all new equipment. In many areas of the world these automation, management reporting, management information systems are contributing significantly to world-class safety and productivity.

3. New Approach to Rapid Longwall Development

Another area that merits significant investment is longwall development. A longwall producing over 4 million tonnes per year, in a 3.5 metre seam height and with a panel width of 250 metres, will retreat at around 3,500 metres in a year. That requires an initial panel

development of over 14 km (assuming 2 gate roads at each side of the face) and over 7 km for each subsequent panel.

These rates of development require heading machines capable of achieving an average of 585 meters per month. As this is the average, (not including set up time, breakdowns, corners, facelines and tramming out time) the actual straight-line drivage rate after installation needs to be in the region of 1000 metres a month. This is leading to a development crisis in some mines worldwide and specifically in emerging markets like Russia where many mines are struggling to get new faces developed on time to take over from the existing production faces.

3.1. Advances in Miner Bolter Design

Several Russian mines have recently installed the latest continuous miner-bolter equipment in order to improve development rates. Raspadskaya, SUEK, Severstal and Yzhkuzbassugol have all invested in new development equipment. The new Joy 12CM30 miner bolter cuts at the full roadway width (normally 5.2 metres) and typically has four "state of the art" hydraulic roof bolting and two rib bolting machines placed immediately behind the cutting head. The design of the new 12CM30 (Fig. 6) miner bolter has a "bolting shield" immediately behind the cutter head and coal is loaded by the scroll action of the cutter head. This eliminates all loading devices and eliminates reliability and maintenance issues associated with these areas on other machines. Most importantly it allows the roofbolting rigs to be placed as close to the working place as possible (typically around 2.0 metres from the

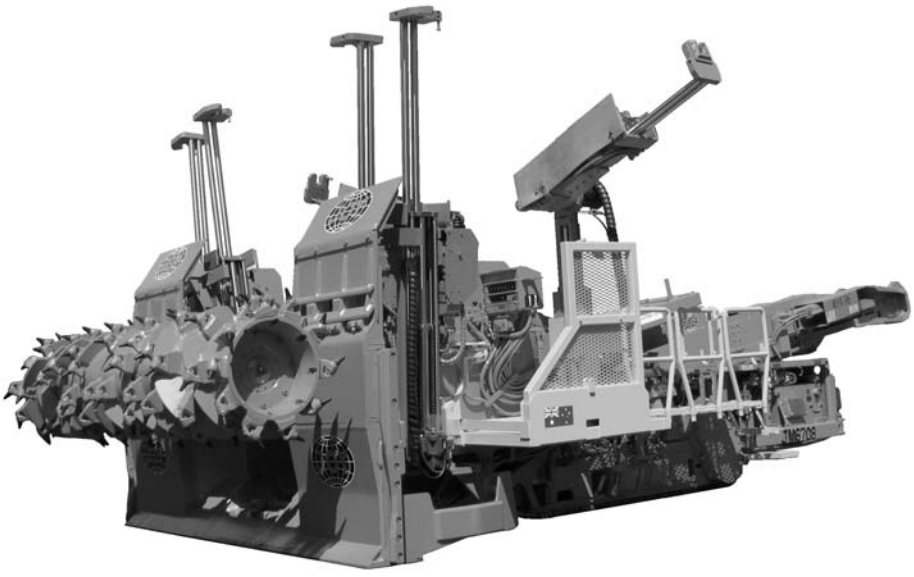

Fig. 6. New 12CM30 miner bolter with bolting shield and roofbolts 2 metres from head end

Rys. 6. Nowy przesiewacz 12CM30 z osłoną i obudową kotwiową, 2 m od końca wyrobiska

face end) which is essential in markets where legislation stipulates that bolting distances must be kept to a minimum or where weak roof conditions dictate bolting must be as close to the face as possible (like in Russia and the UK).

The equipment is based on the typical Australian system of twin entry roadway drivage and has been very successful at several locations. One mine in Queensland has achieved over 500 metres in a week and over 2000 metres in a month with an average advance per shift in good conditions around 40 metres.

These miner bolters have been developed and improved significantly with increased reliability and development rates. Changes include the introduction of a standard centralised modular hydraulic module that eliminates 57 hoses and 152 fittings and gives easy access for maintenance to all valves, solenoids, and pressure switches. A similar integrated water module eliminates 11 hoses and 22 fittings further improving reliability.

The latest Faceboss operating system also provides full control of electrical and hydraulic functions with fault diagnosis, trend analysis, graphs of cutting cycles, motor amp, voltage and temperature readings and full details of all monitored functions. It is now possible to have live outbye communications from the miner bolter to the surface with displays of shift reporting details on a surface computer.

These new miner bolters are operating both in single entry systems with walking tail end belt conveyors providing continuous haulage and in double entry systems where a shuttle car and feeder breaker are used allowing the miner bolter to tram through cross cuts and develop two parallel gate roads simultaneously.

4. Room & Pillar Mining

It is interesting to note that highly mechanised room and pillar mining still accounts for approximately 92% of South African underground production, 45% of the USA underground production and 15% of Australia's underground production. Over 30% of the coal from Western underground mines is from room and pillar methods.

There have been large increases in the power of the equipment and in the method of operating with double continuous miner "super-sections" and varying methods of coal haulage introduced. Performance varies widely from mine to mine and from section to section but is typically between 500,000 tonnes to one million tonnes per year from a single continuous miner. This compares favourably with many of the lower specification longwall operations using local equipment in China, Russia and Poland. The low capital cost to set up and extreme flexibility of room and pillar systems allows quick installation and quick panel changes as well as changes in the direction of mining. It is ideal in the mechanised extraction of remnant pillars that are too small for longwall mining.

Although this system does not have the same potential for bulk production as longwall, it is a very cost effective method of mining, less complex than longwall (both to manage and operate) and is far more flexible with a much lower initial capital cost.

4.1. Wethead Systems – significantly reduced dust make

One new innovation is making a big impact on reducing dust in the Republic of South Africa. This is an industry-leading dust suppression system of pick face flushing (providing water immediately behind the pick point instead of general spray bars over the cutter head). This directs high-pressure water at 16 bar to each and every cutter head pick (typically 63 picks and about 130 litres water per minute) through an internal seal arrangement in the cutter head (Fig. 7). Average dust levels have been recorded and assessed against conventional miners with standard spray bar systems and the airborne dust has been reduced by approximately 50% from a level 5.0 to 6.5 mg/m^3 down to between 1.8 to 4 mg/m^3 depending on the circumstances. Most operations achieve 2 to 3 mg/m^3. This is a significant improvement and is a major advantage in meeting new legislative and safety requirements. Legislation has become much stricter recently and this new technology is proving to be the most cost effective manner to reduce dust levels to within the strict legal limits in highly productive room and pillar operations. Interestingly bit usage levels also decreased dramatically (by up to 70% in some locations) when using the wet head technology giving an added bonus of strong operating cost reductions.

Fig. 7. New 'Wet Head' technology for continuous miners – Water sprays to each cutter pick

Rys. 7. Nowa technologia „mokrej głowicy" do wydobywania ciągłego – woda jest natryskiwana na każdy nóż wrębowy

4.2. World Record for advance metres – Flexible Conveyor Train (FCT)

The flexible conveyor train (FCT) has recently been upgraded with new track systems, new AC variable frequency haulage system and new tram chain oiling system as well as new

electronic control and management control systems. The FCT trams directly behind a continuous miner in a room and pillar system providing coal transport around the pillars and onto the main panel belt (Fig. 8). One mine in Eastern USA runs two flexible conveyor trains with

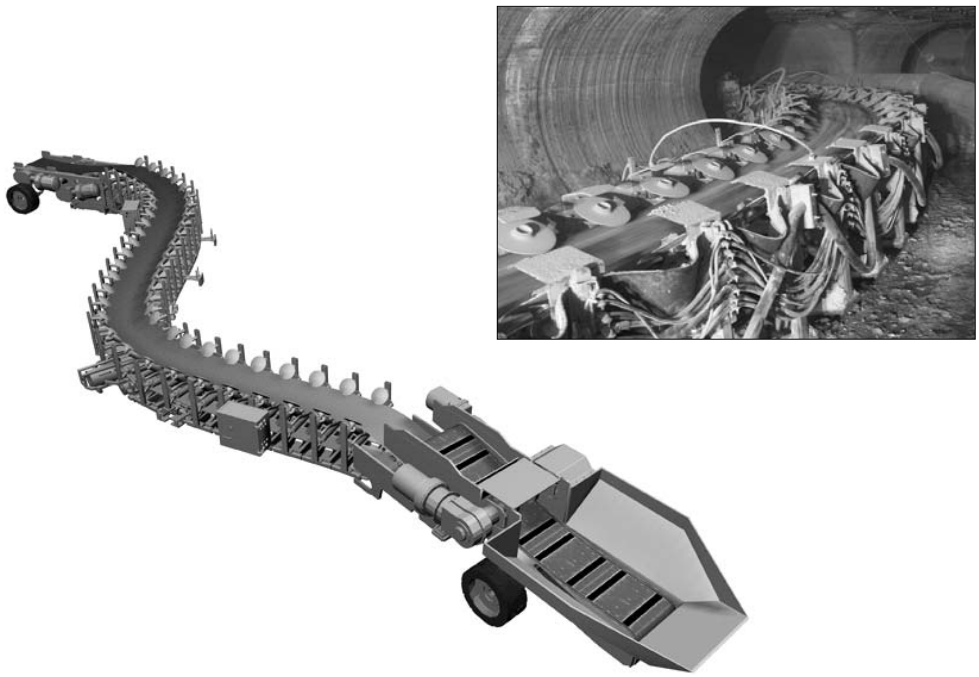

Fig. 8. World record breaking continuous haulage for continuous miners – The Joy Flexible Conveyor Train (FCT)

Rys. 8. Największa w świecie odstawa ciągła w wydobyciu ciągłym – Zespół Przenośników Elastycznych Joy (FCT)

two 14CM27 continuous miners. Each FCT system is 99 metres long and has a 1050 mm wide belt. On Dec 8th 2007 the world record for single shift production was broken with an advance of 259 metres in one 9 hour shift equating to 3,986 raw tonnes. These units have the latest Faceboss operating and management control systems and Joy provide a full maintenance management package including parts support and life cycle management. Further FCT's have been sold to a Potash mine in the UK and to other coal operations in the USA.

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WYNIKI NIEDAWNYCH BADAŃ PRZODKÓW ŚCIANOWYCH. ZABUDOWA WEJŚCIA I SYSTEMY KOMÓR I KOLUMN

Słowa kluczowe

Górnictwo przodka ścianowego, kontrola stropu, górnictwo podziemne

Streszczenie

Niedawny wzrost cen węgla i duże zapotrzebowanie na węgiel doprowadziły do opracowania bardziej produktywnych przodków ścianowych, większej szybkości postępowej prac i większej wydajności urządzeń służących do opracowania komór i filarów.

Zagłębie Węglowe Shendong jest dobrym przykładem tego, co można osiągnąć. 10 lat temu było to miejsce ekologiczne. Dziś produkuje się tu ponad 200 milionów ton rocznie, a ilość ta rośnie o 10 milionów ton rocznie, przy łącznym wydobyciu z przodków ścianowych pomiędzy 5 i 10 milionów ton rocznie.

Największe kiedykolwiek wykonane podpory stropów (30% więcej cykli niż poprzednie największe) i największe AFC i najszersze przodki mają być wkrótce zainstalowane lub są już użytkowane w Chinach i Australii. Nowy wysokowydajny przenośnik łańcuchowy wydłuża długość przodka, co zwiększa limity produkcji i zmniejsza wysokość użytkowania ścian przodka.

Ponieważ produkcja z przodka i produktywność wzrosły, podwyższyły się też wymogi opracowania systemu szybkiego chodnika przewozowego. Wprowadzenie przesiewaczy pełnej szerokości ze zintegrowanym kotwieniem stropu w pobliżu urabianego przodka spełnia wymogi stawiane takim pracom.

W wydobyciu komorowym i filarowym, nowe cięższe urządzenia do ciągłego wydobycia wyposażone w systemy spłukiwania „mokrej głowicy" doprowadziły do znacznego zmniejszenia zapylenia i zwiększenia trwałości oskardów, a nowy zmodernizowany elastyczny przenośnik łańcuchowy pozwolił na zwiększenie produkcji i poprawienie produktywności.

Nowa technologia sterowania i systemy automatyzacji takie jak RS20s i Faceboss zapewniają lepszą kontrolę, lepszą diagnostykę i pełną automatyzację prowadzącą do znacznego zwiększenia produkcji rocznej. Takie lepsze zarządzanie informacją doprowadziło do dalszego zwiększenia czasu pracy i technologia ta okazała się być połączeniem wszystkich nowych osiągnięć w dziedzinie nowoczesnych urządzeń górniczych.

Wraz ze wzrostem zapotrzebowania na węgiel, wiodący producenci i operatorzy kopalni węgla nadal rozwijają nowe systemy i nowa urządzenia dla zaspokojenia potrzeb wzrostu produkcji i produktywności. Można oczekiwać, że taki wzrost innowacyjności i kontroli zarządzaniem w przyszłości doprowadzi do powstania większych, bardziej produktywnych i bardziej niezawodnych urządzeń, co pozwoli uzyskać zwiększenie produkcji.

RECENT DEVELOPMENTS IN LONGWALL MINING ENTRY DEVELOPMENT, AND ROOM AND PILLAR SYSTEMS

Key words

Longwall mining, roof control, underground mining

Abstract

Recent coal price increases and high demand for coal have lead to more productive longwalls, higher advance rates in developments and greater capacity equipment for room and pillar mining.

The Shendong Coalfield is a good example of what can be achieved. This was a Greenfield site 10 years ago. Today it is producing over 200 million tonnes per annum and growing at a rate in excess of 10 million tonnes per annum with longwalls all achieving between 5 and 10 million tonnes per longwall per year.

The largest roof supports ever made (30% more cycles than the previous biggest) and the biggest AFC's and widest faces are shortly to be installed or have had operating experience in China and Australia. New broadband

conveyor chain is extending the face lengths, increasing the production limits and reducing the operating height of longwall faces.

As the longwall production and productivity has increased the requirement for high-speed roadway development systems has risen. The introduction of full width miner bolters with integrated roofbolting equipment close to the extracted face is meeting these development targets.

In room and pillar mining new heavier duty continuous miners equipped with ‘wet head’ pick face flushing systems have lead to greatly reduced dust makes and increased pick life and the new uprated flexible chain conveyor has brought more production and productivity records.

New control technology and automation systems like the RS20s and Faceboss systems are providing better control, increased diagnostics and full automation leading to large increases in the annual rate of production. This improved management information has lead to further increases in operating time and this technology has provided a link across all these new advances in modern mining equipment.

As the demand for coal has increased, so the leading manufacturers and coal mine operators have continued to develop new systems and new equipment to meet to the increased production and productivity demands. This increase in innovation and management control can be expected to continue in the future with larger, more productive, more reliable equipment giving ever more increases in production.