Highwall Mining in Australia

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Introduction

Highwall mining is the process of mining the coal that extends back under the highwall exposed by surface mining operations. It's benefits have been recognized since the 1940's resulting in a number of attempts to develop a workable system. These attempts all failed in the primary challenge which was to produce a simple but effective conveyance system. Thus prior to 1989, the only machinery to perform this type of mining was limited to augers or auger-type machines that penetrated a short distance back under the highwall and only produced a small volume of coal while sterilizing the remaining reserves.

The Addcar Highwall Mining System was developed by Addington Resources over a period of almost 2 years beginning in August of 1989 because of the need for a machine that could go deeper and produce larger volumes without wasting reserves. During this two year period, four different types of machines were built and tested in the field before a workable highwall mining system was developed. During the later part of the development phase, two prototype Addcar Systems™ (the fourth type of machine) were built and placed into service. Since that time, eleven (11) additional machines have been built by Addington for a total of thirteen (13) systems in operation. Joy Technologies has also placed two systems into operation this spring, one in the Western United States and one in Queensland, Australia.

The Addcar System™ regularly produces an average of 75,000 tonnes per month and reaches peaks of 135,000 tonnes per month. These figures are achieved in what would be considered thin seams by Australian standards with thicknesses ranging from below 1.0 meter to 2.5 meters. Undoubtedly, a Highwall Miner will be utilized in the future in most opencut mines which contain significant reserves beyond final highwalls. Also the cost effectiveness of the system will have an impact on coal reserves that were

previously considered uneconomic and offers a possible viable alternative mining method for such reserves.

The Addcar System™ was such a departure from past efforts to highwall mine that it was awarded a United States patent in May of 1992. A patent is now pending in Australia for the system as well. Mining Technologies reached a Licensing Agreement with Joy Technologies on June of 1992 to allow them to manufacture and market the Addcar System™ on a world wide basis. The Addcar System™ was introduced to the mining community at the Las Vegas Coal Expo in mid October, 1992 and was described by a number of coal executives as the most significant development in the coal industry in over 20 years. The following pages will attempt to explain the machine and it's future impact on the coal industry.

The Addcar System™ consists of several components that are used together for the purpose of highwall mining. These components are:

A.) One (1) **Launch Vehicle** that remains stationary during the mining cycle and is used to add the cars and receive the coal from the cars. When a hole has been completed and the system has been retracted, the continuous miner is backed out onto the **Launch Vehicle** and the entire system is moved over and aligned with the next hole.

B.) One (1) **Continuous Miner** that actually breaks up the coal and loads it on the cars. The head of the **Continuous Miner** is raised and lowered as it rotates allowing the **Continuous Miner** to mine a variety of seam thicknesses.

C.) Twenty-four (24) conveyor **Cars** that are added, one at a time, behind the continuous miner as the system is advanced under the hill. These **Cars** receive the coal from the continuous miner and transport it to the outside where it is received by the launch vehicle. Each **Car** is 12 meters long providing a total of 300 meters of penetration for each hole that is mined.

D.) One truck loading **Stacker Conveyor** that receives the coal that is discharged from the launch vehicle and loads it into awaiting trucks. There is a reversible cross conveyor at the end of the **Stacker Conveyor** that is switched from one truck to another allowing for non-stop loading of the trucks to prevent delays normally associated with coal loading.

E.) Electrical power is delivered to the system by the power grid that serves the other surface equipment. The machine can also be operated with a portable electric generator set if no stationary power is available.

There are variations to each of these components depending upon seam height and other site specific requirements for a particular application.

Australian Highwall Mining

There is a natural fit for the Highwall Miner in Australia, as coal mining operations are predominantly opencut surface mines working in multi-seam deposits. Coal seams generally dip from 2 degrees to 6 degrees which results in steadily increasing strip ratios throughout the life of the mine. In the coming 20 years, the majority of existing Australian opencut mines will reach economic limits. By using the Highwall Miner in conjunction with surface mining operations, the operating life of these mines can be extended and in most cases with improved profitability. This defers the need to move to higher operating cost underground mining operations and prevents the sterilization of reserves above longwall panels.

For mines with flatter dipping seams, the opportunity exists to employ trench mining techniques to open up extensive highwall mining reserves using surface mining equipment. The process of trench mining allows the recovery of the coal in the trench by the surface equipment and the recovery of 300 meters of coal on both sides of the trench by the Highwall Miner. The trenches would be dug on 620 meter centers and will extend to perhaps 920 meter centers in the future as greater depth of penetration is achieved with the Highwall Miner. A variation of this technique is called slot mining whereby the final pit on an upper seam is generated at a sufficient width to allow a slot to be opened in the floor of this pit to access the underlying seam. This method would have particular application in steeper dipping multi-seam mines and offers the opportunity of undertaking two highwall mining passes on the one seam in the same location.

In addition, thin seams (down to 0.85 meters) which in the past may not have been economic must be revisited to determine the viability of mining these seams with the benefits of Highwall Mining incorporated. Thick seams (5 meters and above) are also minable with the Highwall Miner and research is currently underway to incorporate the process of backfilling of highwall drivages to improve the percentage seam recovery by providing the necessary roof support. Overall, the extensive length of existing opencut strip mining operations in Queensland will ensure long term availability of highwalls suitable for the Highwall Miner.

Safety Considerations

Prior to the introduction of the Highwall Miner into Australia, a risk assessment was held which identified a number of details about the machine that needed to be addressed. These changes were incorporated in the System being operated at Oaky Creek prior to it's construction. All future Highwall Miners will also comply with the findings of that risk assessment.

Highwall Mining has been described as underground mining from the outside. This is in fact a fair analogy as the equipment and methods used are very similar. Both styles of mining use a continuous miner to break up the coal and load it onto a conveyor belt. There are however numerous differences, especially from a safety perspective, in Highwall Mining verses underground mining. Highwall Mining, for instance, avoids several sources for injuries that are common in a underground mine such as:

1.) Roof falls and any accident relating to the roof, rib, or roof bolter.

2.) Crushing accidents caused by mobile equipment being operated in a confined space with poor visibility.

3.) Maintenance related injuries because of the ease of working on the equipment outside, the availability of cranes for lifting, the ability to cut and weld on the equipment, and the overall reduced strain on the work force.

4.) Tripping and falling injuries due to improved visibility, dryer and more solid footing and the ability to perform housekeeping functions with ease.

The subject of ventilation is of great importance in Highwall Mining as it is in underground mining. It should be realized that the possibility for a methane ignition or a dust explosion exists in any coal related activity. Highwall Mining has several significant advantages over underground mining as it relates to the control and prevention of these types of accidents. These advantages are as follows:

- There are no men working underground on a Highwall Miner. Thus the potential is eliminated for suffocation or carbon monoxide poisoning. All of the men are in fresh air all of the time.
- It is possible to inert the a™osphere inside a highwall entry to totally prevent an explosion from occurring because of the absence or depletion of oxygen.
- The Highwall Miner only deals with a single entry at any given time instead of a complex and growing network of interconnected passageways that have to be maintained for the life of the mine.

The differences between Highwall Mining and other forms of mining extends past the topic of ventilation. Other safety advantages of highwall mining are as follows:

- It transfers workers from a higher risk area (underground) to a lower risk area (Opencut) which, in a broad sense, reduces the likelihood of an accident as Opencut mines are inherently safer than Underground mines. The historical difference between accident rates in Opencut coal mines and Underground coal mines in Queensland is very dramatic. When measured by either frequency rate or incidence rate, the Opencut mines are an average of 3.5 times safer than the Underground mines for the period from mid 1986 to mid 1992. When measured from a production standpoint, the Opencut mines are an average of 8.75 times safer than the Underground mines for the same period.
- The employees are protected from objects falling from the highwall by at least one FOPS canopy and most often by two FOPS canopies.
- The assigned work stations are either in a protected environment or outside a hazard zone.
- Highwall Mining does not require the use of explosives as Opencut Mining does.
- The work lends itself to job functions that can be easily learned and safety can be easily monitored. All employees are within sight of the supervisor at all times.
- Communications are enhanced because each crew member maintains direct line of sight with the other crew members at all times. An intercom system is also located at each work station for ease of communications.
- The time required to transport an injured underground worker outside is eliminated providing immediate access to the finest of emergency equipment and supplies.

Current Research Projects

There are several research projects that are either underway or in the process of being implemented that are directed specifically toward enhancing the safety of Highwall Mining. These include:

- Inert Gas Testing will be conducted this fall to determine the best machinery available for producing an inert a™osphere and the quantities, techniques, and machinery required to deliver this inert gas to the correct location.

- Machine Guidance System development continues at Mining Technologies with considerable success being achieved in tests performed recently in the United States. A workable model is expected to be in operation in early 1994.
- Ground Control Research is being conducted on Addington properties among others to ensure highwall stability both during and after mining. The Addington research involves the mining of multiple seams starting with the lowest seam and working up the strata. This allows for very economical surface mining by replacing the hauling of material with cast blasting and dozer push.
- Highwall Stowage Research has began as a joint project of the University of Kentucky and Mining Technologies to evaluate the use of dry flue desulfurization by-products (FGD or stack scrubber waste material) to back fill the holes left by the highwall mining process and allow 100% extraction of the coal seam by the highwall miner. Stowage will also be an important topic in Australia because of the excellent quality of the coal and the thickness of the seams. The slenderness ratio of the highwall web pillars becomes the controlling factor in thicker seams and reduces the overall recovery rate. Stowage offsets this effect and also prevents the subsidence of upper seams in a multiple seam application.

Machinery Development

There are several areas of machinery development on the Highwall Miner that are of particular interest to Australia. These include:

1.) High Production System

Most of the seams that are mined in the United States with the highwall miner are very thin by Australian Standards averaging about 1.2 Meters thick. The current continuous miners being used on the Addcar System™ have the most powerful cutter heads available. Nevertheless, they are the production bottle neck - the factor that limits the production capacity of the machine. There are two design features of the Addcar System™ that have been critical to it's success and the extreme productivity of the system. These are A.) the ability to exert an external sumping force on the continuous miner such that the continuous miner no longer has to rely on it's own tractive effort to generate the sumping force; and B.) the ability to remove the coal from the rear of the continuous miner on a continuous basis and at a rate that will always exceed the production rate of the continuous

miner. Thus the necessary pieces of the puzzle are in place to increase the horse power and be able to move the coal after it is produced. The current continuous miners have evolved over a period of twenty years with the evolution subject to the limitations of an underground environment such that the current horsepower is more than adequate given the other bottle necks of haulage and available sumping force found underground. In longwall mining, there has been a trend over the past several years toward higher horse power shearing machines and higher voltages to support the higher horsepowers. Mining Technologies will be accepting delivery of a high horse power continuous miner in early 1994. This machine will have two major design improvements over the current continuous miners:

1.) It will have twin 250 kW cutter motors for a total of 500 kW just on the cutterhead. This is a horse power increase of 60% over the current 157 kW cutter motors.

2.) The machine voltage will increase to 3.3 kV from the current 0.95 kV which will provide a stiffer power source for the continuous miner and allow it to penetrate deeper than the current 300 meters.

To accommodate the additional coal that will be produced from this continuous miner, the width of the conveyor belts on the cars has been increased from 1.2 meters to 1.5 meters which gives a 60% increase in conveying capacity. The capacity of the Launch Vehicle and the Truck Loading Conveyor have also been increased. The current system is capable of producing about 137,000 tonnes per month in a 1.5 meters thick coal seam. The High Production System will exceed that tonnage but will require at least 1.5 meters of mining height to operate comfortably.

2.) Steeply Pitching Seam Version

Steeply dipping coal seams (greater than 6 degrees of dip) are common around the world but prevalent in Australia. There has been no practical method to mine these types of seams in the past for a number of reasons. From a surface mining standpoint, the strip ratio steadily increases over the life of the mine so only a limited percentage of the total reserve is actually recovered. It is very difficult to underground mine this type of seam cost effectively because of the lack of mobility of the equipment, severe water problems, and the difficulty of turning cross cuts either up hill or across the dip. Highwall mining, on the other hand, is actually assisted by steeply pitching seams. Instead of pushing the system, the launch vehicle actually holds back the system. The hydraulics are enlarged and modified to

help retract the system after the hole has been completed. In applications above 20 degrees of inclination, the cars will be equipped with drag chains instead of a conveyor belt to prevent the coal from sliding back down the incline. Otherwise, the system does not greatly depart from the normal design. This opens up huge areas of reserves that has made coal companies scratch their heads for years. It is also very feasible to drop down and Highwall mine the next lower seam from a final pit which multiplies the accessible coal reserves further. Steep dipping seams will be tamed with the Highwall Miner in Australia. The first steep dipping seam system should be in operation in Australia in early 1994.

3.) **Automation and Miscellaneous**

The Addcar System™ is very simple to partially automate to the point where the operator only adjusts how high and how low the machine cuts. This will allow the machine to be operated at it's peak capacity by people with a variety of skill levels. Increased reliability will also result from automation because the pushing force will be controlled by the amperage level from the cutter head which will optimize the machine performance but prevent the machine from being over stressed. The addition of a car can will also be automated to increase safety and production simultaneously. Other areas of development for the Highwall Miner include a very thin seam version of the machine that will be capable of operating in 0.6 meter thick seams, and a continuous miner that is more compatible with poor roof conditions.

Summary

The Addcar Highwall Miner is a rugged, simple machine that is very effective in producing coal from a variety of applications. It put it bluntly - IT WORKS! It has been well received by the coal industry because it answers a number of their problems. It allows them to mine reserves they are currently mining in a more cost effective manner that contributes directly to the bottom line. It allows them to mine reserves that have been written out of their mine plan converting them into valuable assets. The productivity of the highwall miner is close to twice that of a comparable underground mine and has a significantly lower consumables cost per ton because the normal activities of either underground mining (such as roof bolting, rock dusting, stoppings, and miles of conveyor belts) or surface mining (such as mining to the economic strip ratio) are either minimized or totally eliminated. It

requires fewer people to mine the same amount of coal. It also is very portable allowing the operator to move the machine around on a job in an average of 8 to 10 hours or to another minesite in 2 to 3 days. This mobility provides the flexibility needed to meet short term coal orders or minimize costs among several locations with one machine.

The Addcar System™ is still in it's early stages of development and will evolve quickly opening up new markets as it goes. From it's first design to the current design, the productivity has more than doubled and this trend promises to continue with the introduction of higher horsepower cutter heads and automation. The safety record of the Highwall Miner has been excellent and will continue to improve with the ongoing research that will allow us to better understand and prevent accidents from occurring.