Highwall Mining

Extend Mine-able Reserves
# Agenda

<table>
<thead>
<tr>
<th>Introduction</th>
<th>- What is Highwall Mining?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- History</td>
</tr>
<tr>
<td></td>
<td>- Latest Technology</td>
</tr>
</tbody>
</table>

Where to do Highwall Mining

When to do Highwall Mining

Benefits of Highwall Mining

Requirements for Highwall Mining - Equipment
  - Bucyrus Quick Scan
  - Pick Changes

The Highwall Miner

Installations

South Africa
What is Highwall Mining

- Mining Coal from
  1. a visible, horizontal or inclined coal seam, making
  2. rectangular, parallel, unsupported entries, with
  3. unmanned cutter head and coal transport system, which
  4. is remotely controlled from a
  5. mining unit positioned outside the drive, in front of the highwall.
| Agenda |
|---|---|
| **Introduction** | - What is Highwall Mining? |
|  | - History |
|  | - Latest Technology |
| Where to do Highwall Mining |
| When to do Highwall Mining |
| Benefits of Highwall Mining |
| Requirements for Highwall Mining | - Equipment |
|  | - Bucyrus Quick Scan |
|  | - Pick Changes |
| The Highwall Miner |
| Installations |
| South Africa |
Prior to the development of the new designed Bucyrus Superior Highwall System (B-SHS), the most successful concept historically, had been the coal auger.

This uses open thread, steel drill sections behind a cutting bit which operates like a wood drill.

It is of large diameter, relatively slow in rotation, and the 'shavings' of coal are drawn out through the open drill thread.

**Auger Disadvantages:**
1. Diminishing power with increased depth. (restricted to about 130 m penetration)
2. Augers suffers from increasing coal size degradation with depth,
3. Fixed cutting height that diminish the percentage of coal recovered. (extract 30% to 40% of the coal to that depth).
4. No ability to negotiate dips and rolls in the seam because of the rigid structure of the auger flights.
5. Low production rate
Agenda

Introduction
- What is Highwall Mining?
- History
- Latest Technology

Where to do Highwall Mining
When to do Highwall Mining
Benefits of Highwall Mining
Requirements for Highwall Mining
- Equipment
  - Bucyrus Quick Scan
  - Pick Changes

The Highwall Miner
Installations
South Africa
Modern HWM - Introduction

The equipment is closely related to underground mining machinery, and is operated by remote control as it penetrates the coal seam.
Advantages:

1. Greater depth of penetration with almost constant power (305 m penetration)
2. No coal size degrading with increase mining depth,
3. Variable cutting height using adjustable continuous miner cutting head (0.75m – 3.05m), extracting 60% to 80% of available coal.
4. Negotiate dips and rolls in the seam because of non-rigid structure of the push beams.
5. High production rate (80 000 – 120 000 ton / month)
6. Mine seam dips of +5 degree to -12 degree
Bucyrus HWM History

- First SHM delivered in 1994
- 70 machines delivered
- Bucyrus since February 2010
Agenda

Introduction - What is Highwall Mining?
- History
- Latest Technology

Where to do Highwall Mining

When to do Highwall Mining

Benefits of Highwall Mining

Requirements for Highwall Mining - Equipment
- Bucyrus Quick Scan
- Pick Changes

The Highwall Miner

Installations

South Africa
Where to Highwall Mine

Trench Mining

Contour Mining

Open Cast Mining
Agenda

- Introduction - What is Highwall Mining?
  - History
  - Latest Technology

- Where to do Highwall Mining

- When to do Highwall Mining

- Benefits of Highwall Mining

- Requirements for Highwall Mining - Equipment
  - Bucyrus Quick Scan
  - Pick Changes

- The Highwall Miner

- Installations

- South Africa
When to Highwall Mining

- When economic strip limits are reached.
- When strip limits are reached by surface conditions.
- Extend operational life of mine
- Transition from surface mining to underground mining
- Specific Highwall Mining situations
  - Contour Mining
  - Open Cast Mining
  - Trench Mining
  - Augered seams
<table>
<thead>
<tr>
<th>Agenda</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
</tr>
<tr>
<td>- What is Highwall Mining?</td>
</tr>
<tr>
<td>- History</td>
</tr>
<tr>
<td>- Latest Technology</td>
</tr>
<tr>
<td>Where to do Highwall Mining</td>
</tr>
<tr>
<td>When to do Highwall Mining</td>
</tr>
<tr>
<td>Benefits of Highwall Mining</td>
</tr>
<tr>
<td>Requirements for Highwall Mining</td>
</tr>
<tr>
<td>- Equipment</td>
</tr>
<tr>
<td>- Bucyrus Quick Scan</td>
</tr>
<tr>
<td>- Pick Changes</td>
</tr>
<tr>
<td>The Highwall Miner</td>
</tr>
<tr>
<td>Installations</td>
</tr>
<tr>
<td>South Africa</td>
</tr>
</tbody>
</table>
**Advantage of Highwall Mining**

**Cost:** Highwall mining is clearly cheaper, due to the lower establishment and development costs. *(ALREADY PAID FOR BY OPEN CAST OPERATION)* No in-seam support or transport systems are required, the cost of ventilation measures is negligible and the capital cost is a fraction of that of a longwall.

**Flexibility:** Highwall mining can economically access smaller blocks of coal and is more readily able to avoid geological structures or other impediments to production. The mobility of the highwall mining equipment makes it easy to move around a pit, from pit to pit or from mine to mine.

**Applicability:** Because it operates by remote control, highwall mining equipment can work in thin seams without having to cut stone to make height for people to move around, or it can selectively extract a high-quality segment of a seam. The equipment can operate on steeper dips than miners and shuttle cars, and can mine multiple seams without subsidence.

**Safety:** Operations are inherently safer because they are carried out by remote control, so all personnel remain outside the entries. Personnel are therefore not exposed to underground hazards such as roof falls, gas, dust, irrespirable atmospheres, flooding, vehicle movements in confined spaces, etc. With the use of ventilation or inert gas, highwall mining can continue in gassy seam conditions that would stop or impede underground mining.
Advantage of Highwall Mining

Coal Recovery: Although at certain times a longwall block or a pillar extraction unit will recover more coal than a highwall mining panel, the overall recovery is drastically reduced by the large areas of pillars that must be left to protect the underground roadways and the odd shapes that cannot be accessed. Even a modern longwall mine will typically recover 85% or less of the in situ coal reserve, marginally higher to the recovery from highwall mining.

Productivity: Highwall mining requires fewer personnel, i.e. with the Bucyrus SHS 12 people total (for 3x shifts) can produce 1.5 million tonne pa, compared to around 90 people (3 shifts) to get the same output from an underground mine. A Bucyrus SHS system produces more coal per man than an underground continuous mining unit.

When factoring the lower capital and labor costs of highwall mining, the cost per tonne is much less than underground mining.

Production: Modern highwall mining equipment operate in seam heights of 0.76 meter to 3.05 meter in one pass and seam dips of up to 12 degrees. Coal production per machine ranges from 0.5 million tons per year for low seams to 1.5 million tons per year for high seams, in a continuous operation.
Introduction

- What is Highwall Mining?
- History
- Latest Technology

Where to do Highwall Mining

When to do Highwall Mining

Benefits of Highwall Mining

Requirements for Highwall Mining

- Equipment
  - Bucyrus Quick Scan

The Highwall Miner

Installations

South Africa
Miner in operation

- Stacker Belt
- High Wall Miner
- Generator
- Front End Loader with QDS
Requirement for Highwall Mining

- Competent coal.
- Competent immediate overburden.
  - If overburden is not competent, coal may be left as roof.
- Coal seams dipping from -12 to + 5 degrees.
- Relative flat seams, no faults
- Coal seams thicker than 80cm.
Safety: Web- and Barrier Pillars

- Web pillars ensure support of OB
- Barrier pillars prevent cascading collapse
- Barrier pillar typically every 10 to 20 drives
- Calculation method to be approved by local Mine Safety Authorities
Indicative Recovery Rate

Extraction ratio for different seam heights

- 1m seam
- 2m seam
- 3m seam

Extraction Ratio (%) vs. Overburden Thickness
Introduction - What is Highwall Mining?
- History
- Latest Technology
Where to do Highwall Mining
When to do Highwall Mining
Benefits of Highwall Mining
Requirements for Highwall Mining - Equipment
- Bucyrus Quick Scan
- Pick Changes
The Highwall Miner
Installations
South Africa
## Bucyrus Quick Scan

**FLAC 3D Simulation Input**

- Coal seam height
- Coal seam dip
- Coal mechanical properties
- OB height
- OB mechanical properties
FLAC 3D simulation output

- Pillar design
- Roof / Floor stability
Methods to improve roof/floor stability

- Subsidence
Production Rates

- Depending on circumstance:
  - Penetration depth
  - Seam height
  - Dip angle
  - Shift system
  - Logistics, Site Management, Mine Planning

- Typically from 500,000 to 1,500,000 t/a
Agenda

Introduction - What is Highwall Mining?
- History
- Latest Technology

Where to do Highwall Mining

When to do Highwall Mining

Benefits of Highwall Mining

Requirements for Highwall Mining - Equipment
- Bucyrus Quick Scan
- Pick Changes

The Highwall Miner

Installations

South Africa
Penetration Depth

**PICK CHANGES**

→ We need to punch mine 300m without need to extract all the pushbeams and miner in order to change picks!

**Assumptions:**
- Coal Hardness \( (P_L) \) → 30-40 MPa
- Pick life: \( (P_L) \) → 60 ton/pick
- Coal Density \( (C_D) \) → 1.3 ton / m³

\[ W = \text{cutter width} \quad L = \text{length of heading} \quad H = \text{height of CM cutter head} \]
\[ N^P = \text{number of picks on cutter head} \]

For LSCM:
- \( W = 2.9 \text{m} \)
- \( H = 1.62 \text{m} \)
- \( N^P = 81 \text{ picks} \)

For MSCM:
- \( W = 3.5 \text{m} \)
- \( H = 3.05 \text{m} \)
- \( N^P = 71 \text{ picks} \)

**Formulae:**
\[ \text{TON}_{\text{coal}} = W \times H \times L \times C_D = P_L \times N^P \]
\[ L = \frac{P_L \times N^P}{W \times H \times C_D} \]

For LSCM:
- / 300m heading = 1832 ton \( \rightarrow L_{\text{LSCM}} = 795 \text{ m} \)

For MSCM:
- / 300m heading = 4163 ton \( \rightarrow L_{\text{MSCM}} = 306 \text{ m} \)
Agenda

Introduction
- What is Highwall Mining?
- History
- Latest Technology

Where to do Highwall Mining

When to do Highwall Mining

Benefits of Highwall Mining

Requirements for Highwall Mining
- Equipment
  - Bucyrus Quick Scan
  - Pick Changes

The Highwall Miner

Installations

South Africa
The Machine
Dimensions of Miner

- Length base: 16.6 m
- Width base: 8.3 m
- Weight miner: 225 t
- Length push beam: 6 m
- Weight push beam: 5150 kg
- 50 push beams per miner

- Max. Push Force
  - in: 136 t
  - out: 276 t
Cutter Module

- Low Seam Cutter Module
  75 cm to 1,50 m
  2,90 m width

- High Seam Cutter Module
  1,20 m to 3,05 m
  3,50 m width
Push beams

Pushing / Pulling cutter module

- Coal Convey modules
- Sturdy, simple, 2 moving parts only
- Enclosed - no External Contamination
- Low Ground Pressure
- Protect cables/hoses

Inter-Connecting

- Horizontally rigid: ➔ Straight Drives
- Vertically hinged: ➔ Follow the seam undulations
Hose Reel

- Power chain for cutter module
  - Electrical cables
  - Hydraulic lines
  - Cooling water lines
  - Methane sensor cable
  - Control cables
- Hoses / cabling protected by steel plating
- Auto unwinds/winds in trough on push beams
- > 300 m
Anchoring System

- Stabilizes the Highwall Miner
- Two Machine mounted drills
- Two high strength 2,5 m pins
Power

- By the grid via a transformer
- 1500 kW Generator Set
  - 80 kW auxiliary set
  - Build in a sound attenuated 20 ft container
  - Mounted on tracks
  - Tropical / Arctic version
Control

- Operated from the cabin
- Fully graphical touch screen interface
- All machine diagnostics
- Automated mining mode
- Accurate heading:
  - Precise alignment
  - FOG (fiber optic gyro) guided steering (Optional)
- Automatic seam following:
  - Cutter motor current
  - Gamma Ray Sensor (Optional)
Mobility

- Tracks for positioning in the mine, relative short distances.
- Longer distances on heavy weight special transport low loader.
- Long distances; disassembled
  Operational 3 – 4 days.
Local Certification

- EIC Ex compliance of miner and in accordance with:
  - South Africa: DME (to be obtained)
  - United States: MSHA
  - Russia: GOST R / RTN
  - Australia: NSW / QLD / WA
  - India: DGMS
  - China: MA
Special optional features

- Push beam holding device for operation in seams dipping in access of 8 degrees
- Water pump on cutter module for operation in seams with ingress of big volumes of water.
- Inert gas system for operation in gaseous seams.
- Arctic and Tropical execution of the miner / genet.
- Second air-conditioned cabin for personnel working on push beam launch platform.
- Stacker belt for stockpiling mined coal.
Key Characteristics

- Penetration 300 meters
- Dip of up to -12 degrees
- Production up to 120,000 t / month
- Up to 75% seam recovery
- Operates with a 4 / 5 man crew per shift
- Personnel safety
- Low establish cost
- Lower production cost than underground
- No external contamination or product dilution.
Agenda

Introduction - What is Highwall Mining?
- History
- Latest Technology

Where to do Highwall Mining

When to do Highwall Mining

Benefits of Highwall Mining

Requirements for Highwall Mining - Equipment
- Bucyrus Quick Scan
- Pick Changes

The Highwall Miner

Installations

South Africa
Installed base and Potential

64 units

4 units

1 unit

1 unit
Agenda

Introduction
- What is Highwall Mining?
- History
- Latest Technology

Where to do Highwall Mining

When to do Highwall Mining

Benefits of Highwall Mining

Requirements for Highwall Mining
- Equipment
  - Bucyrus Quick Scan
  - Pick Changes

The Highwall Miner

Installations

South Africa
Potential Customers

- Anglo Coal
- BECSA
- Exxaro
- Sasol Mining
- Xstrata
- Contractors
- Coal of Africa
- Optimum Coal
Concluding

Highwall Mining as a coal mining method:

- increases your mine-able reserves,
- mine coal cost effectively,
- with maximum safety
- with minimum risk,

that otherwise would be unrecovered.
Concluding

THANK YOU..