METHOD OF EXTRACTION

Opencast
1. Conventional Shovel Dumper
2. Dragline
3. In-pit Crushing & Conveying
4. Surface Miner

Underground
1. Bord & Pillar
   a. SDL
   b. LHD
   c. Continuous Miner
2. Longwall
   a. Retreating
   b. Advancing
3. Longwall Top Coal caving
4. Underground Coal Gassification
5. Punch Longwall
6. **Highwall Mining**
HIGHWALL MINING
“Highwall”
Terms involved in highwall mining

- **Web cut**
- **Web pillar**
- **Barrier pillar**

**Front View**
- Web cut
- Web pillar
- Barrier pillar

**Section**
- Highwall face
- Surface

**Panel width**
- Next panel

**Top View**
- Web cut
- Web pillar
- Barrier pillar

**Front View**
- Web pillar – is the pillar left adjacent to highwall miner cut to support highwall
Types of highwall mining

Contour Mining
(follows contour of the coal seam)

Trench Mining

India’s first Trench mining started operations in Sharda Opencast Mine, Sohagpur, SECL on 09-02-2011
Development status

- Modified version of Auger mining (dates back to 1940)
- In 1989-91 ADDCAR highwall mining system was developed and introduced to mining community in expo in oct. 1992. later modified and now
- Popularly used in U.S and Australia
- Recently introduced in Europe and Canada, First highwall mining operations will start in 2013 in Canada
- Many design techniques are developed in U.S & Australia
- In India, in developing stage and CIMFR is committed to develop guidelines for highwall mining suited to Indian condition and in collaboration with Australia an S&T project is going on.
A Highwall mining equipment has the following Subassembly-

1. Launch Vehicle
   a. Operators cabin (control unit)
   b. Electrical power unit
   c. Ventilation and water hoses
2. Continuous Miner/cutter head
3. Conveyor cars
4. Stacker conveyor
5. Wheel Loader
Main Components

(ADDCAR Highwall Mining System)
Two machine manufacturers are dominating the market

1. Bucyrus (earlier SHM) USA now Caterpillar

2. ADDCARS USA

Trench mining by contractor Cuprum Bagodia, Kolkata using Bucyrus machine while Highwall mining in SCCL by Advanced Mining Technology (AMT) using ADDCAR system

The machine maximum cut width is limited to 3.5 m.
Steps in highwall mining

• The launch vehicle is set up perpendicular to the coal seam at the desired location.
• Crawler-mounted continuous miner cuts the coal and feed it onto the unique ADDCAR conveyor cars.
• It makes long parallel rectangular shaped drives into the coal seam.
• The conveyor cars feed the coal car-to-car.
• The last conveyor car dumps it to a stacking conveyor at back of the vehicle.
View of Asia’s First Highwall Mining operations at Ramagundam OCP-II RG-III, SCCL
Sectional view of web cut by SHM
Applicability Conditions

- Flat to moderately dipping seams (up to 12°)
- Thin seam (as thin as 0.8 m)
- Competent roof and floor of the coal seam
- Coal seam preferably free from geological disturbances
- Coal blocked in final highwall mainly due to uneconomic stripping ratio
- Coal blocked in barriers and/or below surface features like., village, road, power transmission lines, forests, hills, etc
MERITS

- Higher production rate (2500 to 4000 TPD) with less manpower
- Remote controlled operations and thus greater safety
- Uniform sized coal obtained, no further crushing is required.
- No men are entering the mine workings and thus it eliminates all the hazards associated with underground mining.
- No blasting operation and no dangers associated with it
- Thin seam which were uneconomic can be extracted.
- It leads to added recovery of coal from highwall without disturbing existing opencast mining operations.
- Generation of waste in terms of huge overburden is reduced significantly.
DEMERITS

- It requires skilled manpower to operate the machine.
- Cost of the machine
- Applicable for competent roof and floor of the seam.
- Machine entrapment chances exist if catastrophic failure occurs.
Web cuts (cuts made by CHM in highwall) are neither supported nor ventilated

Thus if a series of web pillar fails, the whole Highwall collapses and it will extend further
And It needs to be avoided with proper design
Most important aspect ..... as stability of whole highwall mining depends on it.

Due to poor design many catastrophic failure have occurred earlier in U.S and Australia, so it needs to be designed carefully.......for Indian .....mines...

Highwall collapse in multiple seam mining
Major causes of failure

- **Web Pillar failure**
- Panel collapse caused by convergence of web cut,
- roof falls in HWM cut (Heightened pillars) & by collapse of web pillar
- Soft floor
- Stress concentration in the vicinity of highwall.
- Pillar strength reduction with time and water fill
- Elevated stress in benched highwall
- Panel width less than critical panel width
- Low FoS due to geological variability. Even with excellent CHM guidance, deviation in entry width cannot be ruled out. This can also reduce FoS.
Almost all the pillar design approaches developed so far are for square/rectangular pillars having width/height (w/h) ratio > 3.

but in highwall mining Pillars are long (100 to 500m) and narrow having w/h ratio 1 to 3.

U.S and Australia have already developed many design techniques including pillar design.
CIMFR pillar strength formula
(developed for B&P and modified for HWM)
(By Dr. P. R. Sheorey)

\[ S = 0.27 \sigma_c h^{-0.36} + \left( \frac{H}{250} + 1 \right) \left( \frac{W_e}{h} - 1 \right) \]

where,
- \( S \) = strength of web pillar (MPa)
- \( \sigma_c \) = strength of 25mm cube coal sample (MPa)
- \( h \) = working height (m)
- \( H \) = Depth of cover (m)
- \( W_e \) = Equivalent pillar width (m)
  - \( W_e = 2W \) for long pillar (as per study of WAGNER, 1994)
- \( W \) = width of web pillar (m) in highwall mining
  (it is equal to width of pillar for B&P mining)

Successfully used in Ramagundam OCP-II highwall mining site
Case study I  GEOMINING DETAILS AT RG-III OCP-II, SCCL

Existence of Multiseam viz., Seam I, II, III, IIIA & IV
Seam Dip – 1 in 4.2 (12.5°),
Slope of highwall – 47°
Highwall length – 750 to 1 km
UCS of coal seam – 36 to 41 Mpa

<table>
<thead>
<tr>
<th>Seam</th>
<th>Depth of cover, m</th>
<th>Thickness, m</th>
<th>Parting, m</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>95-154</td>
<td>5.2-6.7</td>
<td>Topmost seam</td>
</tr>
<tr>
<td>II</td>
<td>112-182</td>
<td>3.1-4.0</td>
<td>21-29 with Seam I</td>
</tr>
<tr>
<td>IIIA</td>
<td>155-229</td>
<td>0.9-1.8</td>
<td>31-47 with Seam II</td>
</tr>
<tr>
<td>III</td>
<td>184-255</td>
<td>11-12.2</td>
<td>24-28 with Seam IIIA</td>
</tr>
<tr>
<td>IV</td>
<td>199-270</td>
<td>3.7-4.1</td>
<td>4-5.6 with Seam III</td>
</tr>
</tbody>
</table>
Panels targeted for Highwall Mining

Seam I

Web pillar width – 3.9 m, planned depth – 138 m
Maximum depth of penetration achieved – 140 m
Others Factors affecting Highwall Mining Performance

- Presence of stone band
- Stability of unsupported span,
- Width of panel,
- Pillar width to height ratio
- Knowledge of in situ stress in benched highwall and
  - Continuous monitoring of highwall during mining

Can be visualised to some extent by Numerical Modeling
Highwall Monitoring

Can we monitor the face of such highwall by survey points ???
How to fix targets ??
Highwall Monitoring contd.....

SLOPE STABILITY RADAR

Rampura Agucha, HZL is the first mine in India to adopt SSR for continuous monitoring of slope.
Scanning

- Scans 270 deg horizontally and 100 deg vertically
- Distance range of SSR is 1200 to 2,800m

- SSR-X antenna size = 1.8m
- SSR antenna size = 0.9m
- Higher the size of Antenna higher the resolution
- Compares phase measurement in each region from previous scan to determine movement of the slope
- Scan rate: 1 – 30 mins
ADVANTAGES

- Real-time monitoring
- It covers wider area during scan
- No need to mount reflectors on slope
- Sub-millimeters deformation can be measured
- Not affected by rain, fog, dust, smoke and haze
- Can be easily moved from pit to pit
FUTURE HIGHWALL MINING OPERATIONS

A] SCCL

1. Medapalli OCP (already started with low height cutter module)

2. Koyagudem OCP

TISCO

1. West Bokaro

CIL

1. Kathara OCP

2. East Bokaro (Amlo, Tisri, Dhori & Kalyani opencast mines by trench mining)
Punch Longwall
Steps of drivage

1. Two parallel headings are driven from highwall into the coal seam.

2. After reaching designed distance, the headings are connected to form a panel.

3. Longwall face equipment is installed across the panel and the face retreats back to the highwall.

4. Short distance away from the highwall face, section of coal is left as a barrier pillar to protect the highwall.

5. In this way series of longwall blocks are excavated
APPLICABILITY CONDITIONS

1. Seam is exposed at the highwall of an open pit and pit limit reached due to uneconomic S.R

2. Seam has extensive natural outcrop
MERITS

1. The method does not require conveyor drifts, shafts, complex ventilation or main headings, so development cost is reduced.

2. Mining, geological, and other information is achieved at an early stage.

3. The whole infrastructure of first punch set can be easily used in second set.

4. Future gate roads in adjacent area can be made in advance as two punch longwall operation is independent of each other due to the use of barrier pillars.

5. Manpower requirement is less.

6. Existing facilities (coal prep plant, surface transport loading facilities, stockpiles, etc.) of open pit can be used.
DEMERITS

1. Good reserve should be available to justify the investment on longwall equipments

2. Subsidence may occur

3. Multiseam working may pose trouble in caving operation – stowing may be needed
CASE STUDY IN AUSTRALIA

BroadMeadow Coal Mine, Australia

- Continuous miners were used to drive gateroads from highwall.
- In place JOY bolter miners and JOY shuttle cars are used to drive roadways.
- Retreat punch longwall panels were typically
  - 320 m wide by 2100 m long
  - 4.1 – 4.8 m seam section

Beltana Coal Mine, New South Wales, Australia

Here Punch Longwall mining is the means of secondary extraction of coal
LONGWALL TOP COAL CAVING
- LTCC is extension of original Soutirage method,
- modified in terms of equipment and face operational changes associated with use of rear AFC widely used in China for thick seams.
MAJOR REQUIREMENT FOR ITS APPLICABILITY:

- The top coal should cave behind the support canopies,
- the top coal should cave in small pieces to ensure good flow through draw points at the rear canopy

The Chinese industry has developed a caving index based on observable or measurable properties.

Overlying strata should also cave in time to avoid weighting troubles, air blast and associated ventilation problems.
MODIFICATIONS BY CHINESE EXPERTS

1. Relocation of the top coal draw points to the rear of the longwall supports.

2. A pivoted supplementary goaf or tail canopy behind the support to protect the retractable second AFC.
EARLIER SYSTEM

MODIFIED SYSTEM

Loading from support top face

Loading from rear canopy used in China & Australia
MERITS

1. It is more economical, easier to be applied in thick seams and requires less labor. As much of the development cost is reduced compared to multi-single lift longwall operations.

2. The overall length of the roof supports would be greater than normal supports to cover the rear AFC and allow space for access
DEMERITS

1. Coal loss occurring during the production of the top coal (20 to 30 %)

2. The coal left behind the face poses danger of spontaneous combustion.

3. Poor face alignment may not only cause face roof control problems but also affect the top coal caving process.

4. Floor heave behind the rear AFC is likely.

5. Face ventilation requirements will be more especially along the rear AFC to make the zone comfortable as well as to dilute the gases.
References:


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5. www.coalindia.in


8. www.groundprobe.com
THANK YOU