COAL MINING METHODS

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COAL MINING METHODS

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Abstract:

Minerals and mineral products are the backbone of most industries. Coal is an organic sediment consisting of a complex mixture of substances. It has a lot of commercial and industrial applications. It is an energy giving non-renewable source of energy. Mining of coal is one of the oldest industrial operation. The mining method selected for exploitation is determined mainly by the characteristics of the coal deposit and the limits imposed by safety, technology, environmental concerns, and economics. Geologic conditions play a key role in selecting the method. Coal is friable and loose in its structure. The methods of mining of coal varies from deposit to deposit. This report highlights the coal mining methods, their significances, issues of concern and the stages of using coal after mining.

1. Introduction:

Coal is a readily combustible rock containing more than 50 percent by weight of carbonaceous material, formed from compaction and induration of variously altered plant remains similar to those in peat. Most coal is fossil peat. Peat is an unconsolidated deposit of plant remains from a water-saturated environment such as a bog or mire; structures of the vegetal matter can be seen, and, when dried, peat burns freely.

Coal is the most abundant fossil fuel on Earth. Coal is found in beds or seams interstratified with shales, clays, sandstones, or (rarely) limestones. The Coal deposits in India are of two distinct geological ages. The earliest coal deposits are of Permian age formed about 270 million years ago. At that time South Africa , South America , Antarctica , Australia , India and Madagascar formed a landmass called Gondwanaland. Coal formed in Gondwanaland are known as Gondwana Coal . Other deposits of Tertiary age (30-60 million years) have been formed comparatively recently. These are known as Tertiary Coal . Coal is extracted from the ground by coal mining. Since 1983, the world's top coal producer has been China.

2. Historical mining of Coal:

Ancient people mined coal by picking and scraping and used it for heating, cooking, and in ceremonial chambers as early as the 12th century AD; in the 14th century they used it industrially in pottery making. Small-scale mining of surface coal deposits dates back thousands of years. The Romans were exploiting all major coalfields by the late 2nd century AD. Coal was mined in America in the early 18th century, and commercial mining started around 1730 in Midlothian, Virginia.

Coal-cutting machines were invented in the 1880s. Before this invention, coal was mined from underground with a pick and shovel. By 1912, surface mining was conducted with steam shovels designed for coal mining. Coal mining has had many developments over the recent years, from the early days of men tunneling, digging and manually extracting the coal on carts, to large open cut and long wall mines.
The various methods of mining a coal seam can be classified under two headings, surface mining and underground mining.

3. Methods of extraction

The most economical method of coal extraction from coal seams depends on the depth and quality of the seams, and the geology and environmental factors. Many coal deposits are extracted from both surface and underground mines. Surface mining and deep underground mining are the two basic methods adopted for mining coal. The choice of mining method depends primarily on depth of burial, density of the overburden and thickness of the coal seam. Seams relatively close to the surface, at depths less than approximately 180 ft (50 m), are usually surface mined. Coal that occurs at depths of 50 to 100 m are usually deep mined, but in some cases surface mining techniques can be used. Coals occurring below 100 m are usually deep mined.

4. Feasibility of coal mining

The technical and economic feasibility of coal mining are evaluated based on the following:

a) regional geological conditions;
b) overburden characteristics;
c) coal seam continuity, thickness, structure, quality, and depth;
d) strength of materials above and below the seam for roof and floor conditions;
e) topography (especially altitude and slope);
f) climate;
g) land ownership as it affects the availability of land for mining and access;
h) surface drainage patterns;
i) ground water conditions;
j) availability of labor and materials;
k) coal purchaser requirements in terms of tonnage, quality, and destination; and
l) capital investment.

5. **Surface mining :**

Surface coal mining generally involves the following sequence of unit operations:
(1) clearing the land of trees and vegetation,
(2) removing and storing the top layers of the unconsolidated soil (topsoil),
(3) drilling the hard strata over the coal seam,
(4) fragmenting or blasting the hard strata with explosives,
(5) removing the blasted material, exposing the coal seam, and cleaning the top of the coal seam,
(6) fragmenting the coal seam, as required, by drilling and blasting,
(7) loading the loose coal onto haulage conveyances,
(8) transporting the coal from the mine to the plant, and
(9) reclaiming lands affected by the mining activity.

6. Methods adopted in Surface Mining:

When the coal seams occur near the surface, it may be economical to extract the coal using open cut (also referred to as open cast, open pit, mountaintop removal or strip) mining methods. Open cast coal mining recovers a greater proportion of the coal deposit than underground methods. Large open cast mines can cover an area of many square kilometers and use very large pieces of equipment.
Surface mining techniques can be broadly classified into the following types:
(1) contour strip mining,
(2) area strip mining,
(3) open-pit mining, and
(4) auger mining.

6.1 **Contour strip mining:**

Contour strip mining is a method of surface **mining** or in which bulldozers, power shovels, or stripping wheels are used to remove large chunks of earth in terraced **strips** in order to extract coal from a seam or series of seams on a hill or mountain.

The contour mining method consists of removing overburden from the seam in a pattern following the contours along a ridge or around the hillside.
The process of contour mining begins with constructing roads to access the coal seam elevation and the top or the mountain. A bench is excavated in the mountain at the coal seam elevation, allowing for room for the mining equipment and facilities.
The limitations of this method of mining are both economical and technical .When the burden undertaken exceeds the coal obtained, the result would be a financial loss. The amount of waste accumulated after this method of mining is comparatively very high to open pit mining.

6.2 **Area strip mining :**

Strip mining exposes coal by removing earth above each coal seam. This earth is referred to as overburden and is removed in long strips. The overburden from the first strip is deposited in an area outside the planned mining area and referred to as out-of-pit dumping. Overburden from subsequent strips are deposited in the void left from mining the coal and overburden from the previous strip. This is referred to as in-pit dumping.

"**Strip mining**" is the practice of **mining** a seam of mineral, by first removing a long**strip** of overlying soil and rock (the overburden). It is most commonly used to **mine coal** and lignite (brown **coal**).

Area strip mining, applied where the terrain is flat, commences with a trench or "box cut" made through the overburden to expose a portion of the coal seam.
This trench is extended to the limits of the property in the strike direction.

After coal removal, a second cut is made parallel to the first one, and the overburden material from this cut is placed in the void of the first cut. The process is repeated in successive parallel cuts until the stripping ratio indicates that continued surface mining is uneconomical.

6.3 **Open-pit mining:**

This type of mining involves the extraction of rock or minerals from the earth by forming an open pit. This process differs from the other method which requires digging into the earth. This method of mining is carried out where useful minerals or rocks are found near the surface. The open-pit method is generally practiced where thick coal seams are overlain by thick or thin overburden; it is also used for mining steeply pitching coal seams.
In open-pit mining of the coal seam, several benches are established in both the overburden strata and the coal seam. In the beginning stages of mining, considerable volumes of overburden materials must be accumulated in large dump areas outside the mine.

6.4 **Auger mining:**

Auger mining is a relatively low cost method of coal mining and is practical in areas where the overburden (material covering the coal seam) is too thick to be removed economically or where the coal seam is too thin for underground mining.

Auger mining is a surface **mining** technique used to recover additional coal from a seam located behind a highwall produced either by stripping or open-pit **mining.**

Auger mining uses large-diameter drills mounted on mobile equipment to bore into a coal seam. Holes are horizontally drilled at regular intervals to depths of as much as 1,000 feet. As the cutting head of the auger bites into the coalface, the cut coal is carried out by the screw portion of the bit. Once the hole is mined to its required depth, the auger machine is moved a few feet and another hole is drilled.

Auger mining can create pits up to 500 feet into the highwall depending on the conditions of the site and the type of auger used. This mining method is generally inexpensive; however, coal recovery rates are low. Auger mining is usually associated with contour strip mining.

Coal recovery rates approach 60 percent with this method. The cutting heads of some augers are as high as 2.5 metres. As each stem works its way into the coal seam, additional auger stems are added, so that hole depths of more than 60 to 100 metres are not uncommon. Problems of subsidence, water pollution, and potential fires are associated with augering.

Highwall mining is an adaptation of auger mining.
Instead of an auger hole, an entry into the coal seam is made by a continuous miner, remotely operated from a cabin at the surface.
The cut coal is transported by conveyors behind the miner to the outside. Using a television camera, the operator can see and control the miner's progress.

The entry can be advanced 300 to 400 metres into the coal seam, after which the miner is retreated to the surface and repositioned to drive an entry adjacent to the previous one.
Advantages over augering include higher productivity, greater safety, and lower cost.

7. Underground Coal mining Methods:

In underground coal mining, the working environment is completely enclosed by the geologic medium, which consists of the coal seam and the overlying and underlying strata.
Modern underground coal-mining methods can be classified into four distinct categories:
room-and-pillar,
longwall,
shortwall, and
thick-seam.

7.1. Room-and-pillar mining:

In this method, a number of parallel entries are driven into the coal seam. These entries are then connected at intervals by wider entries, called rooms, that are cut through the seam at right angles to the entries. The resulting grid formation creates thick pillars of coal that support the overhead strata of earth and rock.

There are two main room-and-pillar systems, the conventional and the continuous.

In the conventional system, the unit operations of undercutting, drilling, blasting, and loading are performed by separate machines and work crews. In a continuous operation, one machine—the continuous miner—rips coal from the face and loads it directly into a hauling unit. In both methods, the exposed roof is supported after loading, usually by rock bolts.

Under favourable conditions, between 30 and 50 percent of the coal in an area can be recovered during development of the pillars. For recovering coal from the pillars themselves, many methods are practiced, depending on the roof and floor conditions. The increased pressure created by pillar removal must be transferred in an orderly manner to the remaining pillars, so that there is no excessive accumulation of stress on them.

Otherwise, the unrecovered pillars may start to fail, endangering the miners and mining equipment. The general procedure is to extract one row of pillars at a time, leaving the mined-out portion, or gob, free to subside. While extraction of all the coal in a pillar is a desirable objective, partial pillar extraction schemes are more common. At depths greater than 400 to 500 metres, room-and-pillar methods become very difficult to practice, owing to excessive roof pressure and the larger pillar sizes that are required.

7. 2 **Longwall mining:**

In the longwall mining method, mine development is carried out in such a manner that large blocks of coal, usually 100 to 300 metres wide and 1,000 to 3,000 metres long, are available for complete extraction.
A block of coal is extracted in slices, the dimensions of which are fixed by the height of coal extracted, the width of the longwall face, and the thickness of the slice (ranging from 0.6 to 1.2 metres).
In manual or semi-mechanized operations, the coal is undercut along the width of the panel to the depth of the intended slice. It is then drilled and blasted, and the broken coal is loaded onto a conveyor at the face.
The sequence of operations continues with support of the roof at the face and shifting of the conveyor forward. The cycle of cutting, drilling, blasting, loading, roof supporting, and conveyor shifting is repeated until the entire block is mined out.
In modern mechanized longwall operations, the coal is cut and loaded onto a face conveyor by continuous longwall miners called shearers or plows.

Two main longwall systems are widely practiced. In the advancing longwall method, development of the block takes place only 30 to 40 metres ahead of the mining of the block, and the two operations proceed together to the boundary.

In longwall mining, as in the room-and-pillar system, the safe transfer of roof pressures to the solid coal ahead of the face and to the caved roof behind the face is necessary.

Caving of the overlying strata generally extends to the surface, causing surface subsidence.
The subsidence over a longwall face is generally more uniform than it is over room-and-pillar workings.

If conditions are such that the roof will not cave or subsidence to the surface is not allowable, it will be necessary to backfill the void with materials such as sand, waste from coal-preparation plants, or fly ash.

Owing to technical and environmental reasons, backfilling is practiced in many mining countries (*e.g.*, Poland, India), but the cost of production is much higher with backfilling than it is without.

7. 3 **Shortwall mining:**

In the shortwall mining method, the layout is similar to the longwall method except that the block of coal is not more than 100 metres wide.

Furthermore, the slices are as much as three metres thick and are taken by a continuous miner. The mined coal is dumped onto a face conveyor or other face haulage equipment.
The roof is supported by specially designed shields, which operate in the same manner as longwall shields.

Although a great future was envisioned for shortwall mining, it has not lived up to expectations.

7. 4 **Thick-seam mining:**

Coal seams as much as five metres thick can be mined in a single "lift" by the longwall method, and seams up to seven metres thick have been extracted by conventional mining systems in one pass. However, when a seam exceeds these thicknesses, its extraction usually involves dividing the seam into a number of slices and mining each slice with longwall, continuous, or conventional mining methods.

The thickness of each slice may vary from three to four metres. Many variations exist in the manner in which the complete seam is extracted. The slices may be taken in ascending or descending order. If the roof conditions or spontaneous-combustion liability of the seam requires that there be no caving, the void created by mining will be backfilled. The backfill material then acts as an artificial floor or roof for the next slice. Caving is the preferred practice. Thick coal seams containing soft coal or friable bands and overlain by a medium-to-strong roof that parts easily from the coal can be fragmented by a high-pressure water jet.

For successful operation, the floor must not deteriorate through contact with water, and the seam gradient must be steep enough to allow the water to flush the broken coal from the mined areas. Under favourable conditions, hydraulic mining of coal is productive, safe, and economical.

8. Auxiliary and unit operations:

Those activities which are essential to maintain safe and productive operating conditions both at the working faces and in all parts of the mine are known as auxiliary operations.

These include ground control, ventilation, haulage, drainage, power supply, lighting, and communications. Those activities which are conducted sequentially in a production cycle—*i.e.,* cutting and hauling the coal and supporting the immediate exposed roof after coal removal—are called unit operations.

9. Access to a coal seams:

Accesses to a coal seam, called portals, are the first to be completed and generally the last to be sealed. A large coal mine will have several portals.
Their locations and the types of facilities installed in them depend on their principal use, whether for worker and material transport, ventilation, drainage and power lines, or emergency services. In many cases, the surface facilities near a portal include bathhouses and a lamp room; coal handling, storage, preparation, and load-out facilities; a fan house; water- and waste-handling systems; maintenance warehouses; office buildings; and parking lots.
There are three types of portal adopted in coal mining as drift, slope, and shaft.

10. Drift Mining

Drift mining is a process of accessing precious geological material, like coal, by cutting into the side of the earth, rather than tunneling directly downwards. Drift mines have flat entries into the coal seam from a hillside. Drift mines are different from slope mines, which have a tending opening from the surface to the coal vein. If likely, while, drifts are driven at just a slight predispose so that removal of material may be helped out by gravity.

11. Slope mining:

Slope mining is a method of accessing valuable geological material, such as coal or ore.
A sloping access shaft travels downwards towards the desired material. Slope mines differ from shaft and drift mines, which access resources by tunneling straight down or horizontally, respectively. In slope mining, the primary access to the mine is on an incline.

Where the coal seam does not outcrop but is not far below the surface, it is accessed by driving sloping tunnels through the intervening ground.

Slopes are driven at as steep an angle as is practicable for transporting coal by belt. Commonly, a pair of slopes is driven (or a slope is divided into two separate airtight compartments) or ventilation and material transport. Where the minimum coal-seam depth exceeds 250 to 300 metres, it is common to drive vertical shafts. (Poor ground conditions are another factor in selecting a shaft over a slope.)

12. Shaft Mining:

Shaft mining is a form of underground mining where shafts are pushed vertically from top to bottom to excavate the ores and minerals. It is also called shaft sinking. It is best suited for concentrated minerals such as iron, coal, etc. which can be found at the depth of the earth's surface. It is found mostly all over the world. Shaft sinking refers to shallow shafts and it is different from a deep shaft.

Shafts, too, may be split into separate compartments for fresh air, return air, worker and supply transport, and coal haulage.

Capital and operating costs for coal haulage are lowest in a drift access.

13. Roof support:

In modern mechanized mines, roof bolting is the most common method employed.
Steel bolts, usually 1.2 to 2 metres long and 15 to 25 millimetres in diameter, are inserted in holes drilled into the roof by an electric rotary drill and are secured by either friction or resin.
The bolts are set in rows across the entry, 1.2 to 1.8 metres apart.
Failure to support the roof of a mine is the greatest cause of accidents in mining.

14. Rockbolts

Rock bolts and cables have been used in supporting the underground excavations for decades and are still the most reliable means of support.
In coal mining, the surrounding strata is weakened and fractured around mine openings in underground mines due to the in situ stress redistribution. The main purpose of rockbolt reinforcement is to improve the internal load bearing strength of the rock mass to support itself.

Rockbolt performance is influenced by the rockbolt type, anchorage system, strata lithology and other geological conditions.
Roof support at the face (the area where coal is actively mined) is intended to hold the immediate roof above the coal face.

Several theories explain how roof bolts hold the roof.

Theories of **Rock Bolting**. In coal mining, the surrounding strata is weakened and fractured around mine openings in underground mines due to the in situ stress redistribution. The main purpose of rockbolt reinforcement is to improve the internal load bearing strength of the rock mass to support itself.

These include the beam theory (roof bolts tie together several weak strata into one),
the suspension theory (weak members of the strata are suspended from a strong anchor horizon), and the keying-effect theory (roof bolts act much like the keystone in an arch).

15. **Haulage:**

Haulage is the business of transporting goods by road or rail. It includes the horizontal transport of ore, coal, supplies, and waste, also called cartage or drayage. The vertical transport of the same with cranes is called hoisting. Coal haulage, the transport of mined coal from working faces to the surface, is a major factor in underground-mine efficiency.
It can be considered in three stages:
a) *Face or section haulage*, which transfers the coal from the active working faces; b) *intermediate or panel haulage*, which transfers the coal onto the primary or main haulage; and c) the *main haulage system*, which removes the coal from the mine.

In room-and-pillar systems, electric-powered, rubber-tired vehicles called shuttle cars haul coal from the face to the intermediate haulage system.
In some semimechanized or manual longwall operations, chain haulage is used.

16. Mine Conveyors:
Belt conveyors have been used for mineral transport below ground in mines. It started more vigorously after the time of the First World War. Their use continued to grow, aligned to the move from pillar and stall to longwall mining systems. They were initially used to replace horses and rope haulages for the more efficient transportation of minerals in mines. The available records show that there were 1356 km of belt conveyors installed in British coal mines in 1948 which rose to 2692 km by 1953. A typical present-day large coal mine has some 30 km of belt conveyors. Individual belt conveyor installations vary widely in their design, capacity and duty.

17. Mine Ventilation:

Underground mine ventilation provides a flow of air to the underground workings of a mine of sufficient volume to dilute and remove dust and noxious gases and to regulate the temperature. The source of gases are equipment that runs on diesel engines, blasting with explosives and sometimes, the ore body itself. Mine ventilation is done to provide oxygen to the miners and to dilute, render harmless, and carry away dangerous accumulations of gases and dust. In some of the gassiest mines, more than six tons of air are circulated through the mine for every ton of coal mined. Air circulation is achieved by creating a pressure difference between the mine workings and the surface through the use of fans. Fresh air is conducted through a set of mine entries (called intakes) to all places where miners may be working. After passing through the workings, this air (now termed return air) is conducted back to the surface through another set of entries (called returns).

18. **Monitoring and control:**

Advancements in sensor technology and in computer hardware and software capabilities are finding increasing application in underground coal mines, especially in the monitoring and control of ventilation, haulage, and machine condition.

Longwall shearers and shields can be remotely operated, and continuous miners have also been equipped with automatic controls.

The atmospheric environment is remotely monitored for air velocity, concentrations of various gases, and airborne dust; fans and pumps are also monitored continuously for their operational status and characteristics.

19. Health, safety, and environment:

Code of practice for occupational safety and occupational health in coal mining - prescribes responsibilitys of the state, coal miners, employers, managers, supervisors and surveyors; covers notification and reporting system for occupational accidents and occupational diseases, protective

equipment, ventilation, precautions to take against explosions, fires and dust, use of explosives, electricity, equipment and machinery, first aid, rescue, training needs, etc.

20. Coal mining in India:

Coal mining in India began in 1774 when John Sumner and Suetonius Grant Heatly of the East India Company commenced commercial exploitation in the Raniganj Coalfield along the Western bank of Damodar river.

The first proposal for regulation of mining in India came in 1890, which was introduced by Lord Cross, who at that time was the Secretary of State of India, later in 1894 for the first time Inspector of Mines was appointed for the purpose of management and supervision.
In the year 1901, first Mine Act enacted in India which was only applicable to the mines situated in British India, which was accompanied with establishment of "Bureau of Mines Inspection" in Kolkata. Since then Mine Act has been re-enacted in 1923, 1928 and 1935.

The mineral resources in India consist of Coal, Iron ore, Manganese, Mica, Bauxite, Titanium ore, Chromite, Diamonds, etc. India is the third largest producer of Coal and Lignite & Barytes and the largest producer of mica in the world. India is also ranked among the top producers of Iron ore, Bauxite, Manganese ore and Aluminium.

In 2003-2004 India has produced 355 million tones of coal all of which has been consumed internally. Coal India Limited is a State owned company which contributes a bulk percentage in the Coal production. As on 31 March 2015, India had estimated coal reserves of 306.6 billion metric tons (338.0 billion short tons), the fifth largest coal reserves in the world.

For this reason, coal mining worldwide is heavily regulated through health and safety laws.
In coal mining—particularly underground coal mining—there are numerous conditions that can threaten the health and safety of the miners. The operation of the mining sector in India is governed by the Mines and Minerals (Development and Regulation Act, 1957, the Mines Act, 1952 and the rules and regulations framed under them.

21. Legal aspects of Coal Mining:

The Coal Mines (Nationalisation) Act, came in 1973. The Administration of the Coal Mines (Conservation and Development) Act, came in 1974 (28 of 1974).
Coal mining, world over, is highly regulated industry due to presence of many inherent, operational and occupational hazards. Coal Mine Safety Legislation in India is one of the most comprehensive and pervasive statutory framework for ensuring occupational health and safety (OHS). Compliance of these safety statutes is mandatory.

22. Conclusion:

Coal mining has had many developments over the recent years. Technological advancements have made coal mining today more productive than it has ever been. To cope up with the technology and to extract coal as efficiently as possible, the mining personnel must be highly skilled and well trained in the use of complex, state-of-the-art instruments and equipment. It is also necessary to know all these coal mining methods.