Module 2: Solid Fossil Fuel (Coal)

Lecture 8: Coal Mining

Keywords: Extraction of coal, types of mining, equipments of mining, stripping

2.2. Coal Mining

Introduction:

The technology required for recovering coal from the earth crust and transporting it into coal processing unit, is the vital step of the coal mining. This technology is based on the following operations:

1. Extraction of coal: the method used to break out the coal deposit into smaller lumps
2. Material handling: transportation of coal from the production locality.
3. Ventilation: the development of proper air circulation system within the mine
4. Ground control: to control and prevent the ~~sagging~~ of the underground or surface opening developed during extraction of coal.

There are two broad categories for mining of coal

(a) Surface mining

(b) Underground mining

Surface mining

Surface mining is generally used when the coal seams are found within 200 ft below the earth surface. Very big utilities and machineries are used for removing soil and rocks to expose the top layer of coal. After extraction of coal, the rocks and soils are returned to fill up the holes of the mine and the whole surface on the ground is properly revived to its original state and can be used for cultivation, industrialization etc. This process is comparatively less expensive compared to underground mining.

The prime considerations for this technique are geographic location, thickness and removal of inter-seam waste and overburden and quality of the coal to be produced. Much of the overburden contains layers of shale, limestone or sandstone and must be blasted before it can be removed. After the overburden is removed coal is usually drilled and blasted, then loaded into coal haulers with a shovel. Removal of overburden is called stripping and hence it is called strip-mining. The types of surface mining are

a) area mining or modified open-pit mining
b) contour mining
c) mountain top removal
d) auger mining

Area mining is applied in relatively flat coal seams, where they are expanded in large area at different depths. In this type of mining, overburden is removed by scrapers and placed outside the mining area and loaded into trucks. Mining begins with drilling and blasting waste rocks to expose the coal seams. Coal is removed and transported. The size and depth of the pit are increased as mining progresses. This mining is adapted for the case when several seams lie in parallel.

Contour mining and mountain top removal are used in hilly areas. Contour mining creates a shelf or bench on the side of the hill. The mountain top mining process involves the removal of upto 1000 vertical feet of overburden to expose underlying coal seams. The overburden is often scraped into the adjacent valley which is called a valley fill. Overburden is the soil and rocks to be removed to expose the coal seams.

Augur mining is another type of surface method where overburden removal is uneconomic, where terrain is too steep for overburden removal and where the underground method is impractical or unsafe. It involves boring of large diameter holes into more or less horizontal coal beds. In this method, exposed surface of the coal is drilled and removed by means of an auger. Single, dual or triple auger heads can remove upto 90 inches of coal for a distance of about 200 ft.

Underground mining

When a coal seam does not appear near to the surface, it must be extracted by underground process. Different underground methods may be classified as 1) room and pillar, 2) longwall. **Room and pillar** is a mining technique in which the coal is extracted across a horizontal plane making horizontal arrays of rooms and pillars to support the roof created due to extraction. In this type of mining, the methods may be either continuous or conventional. The main differences between the two methods are in the nature of equipments and the face of operation. In continuous mining, the cycle begins with the continuous sumping cut into the coal face by a continuous cutter or miner. A shuttle car is positioned behind the miner to receive and transport the cut coal to the belt feeder. When the shuttle car is filled up, it moves away and the next shuttle car is fed by the new cut and the cycle is continued.

In conventional mining, the breaking out of the coal from the face is done by cutting, drilling and blasting operation. At the beginning, the cutting machine cuts a 3-4 meter slice horizontally across the room width and then moves out to the next place to be cut. Then the drilling machine moves in and drills holes into the cut face. This is followed by the blasting operation. Now the

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area is examined for safety for entering the loading machine and shuttle car. The cars come in for loading the coal cut.

The system of rooms and crosscuts driven in the production panels divides the panels into a series of coal pillars. These coal pillars are extracted by the methods that allow the mining operation to retreat toward the panel entries. Since methane gas may accumulate into the caves, a ventilation arrangement is done by circulating air through the caves.

Longwall mining is a typical form of underground coal mining where a long wall of coal is mined in a single piece of around 3–4 km long and 250–400 m wide. Longwall mining has a greater production activity than room and pillar arrangement and is safer, as mining is done beneath a complete overhead steel canopy that moves forward as the face of coal deposit is mined.

Three pieces of equipment are fundamental for modern longwall mining: armored face conveyors, powered supports and the coal cutting machine. The cycle of face operations is based on the movement of this equipment. The armored face conveyors are erected along the coal face and are connected to a power support with the help of hydraulic jacks. The cutter loaded usually slides along the top of the conveyor and breaks out a 20-30 in coal strip. The broken coal chunks are carried by the conveyor.

Other methods

Shortwall mining is an alternative method which uses the equipments of both room and pillar and longwall mining. The shortwall layout is similar to the longwall panels except that the panel width is 150-200 ft wide. A continuous miner loading shuttle cars substitute for the cutter-loader face conveyor system. Shortwall mining is applied to relatively shallow coal seam.

Hydraulic mining uses large amount of water at high pressure to break and convey the coal from the working area. It is usually applied for a relatively thick coal seam. Jets of water are directed tangentially to the coal face for breaking coal lumps.

Modification of the equipments and methods for underground mining system to overcome the difficulties of mining is a great challenge for the future. Remotely controlled longwall and continuous miners may be adopted for higher productivity and improve safety.

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Module 2: Solid Fossil Fuel (Coal)

Lecture 9: Coal preparation and washing

Keywords: run-of-mine coal, coal preparation, washing, Float and sink test

2.3 Coal preparation and washing

The raw coal extracted out from the coal mine is processed through different techniques to achieve the desired qualities. These result in higher economic value of run of-mine (ROM) coal. The environmental impacts of burning of coal should also to be kept in mind. The mineral matters of the coal should be reduced during its processing such that, the emissions of sulphur dioxide (SO_2), carbon dioxide (CO_2) and particulate matters are minimized during burning. The technology of coal washing or coal preparation is applied to produce specific desirable coal products from the run-of-mine coal without the change of the physical identity.

In the early days, the coal in the form of lumps were supplied for domestic use and the intermediate sizes were kept for the industrial use, whereas, the fines were rejected. The sizing facilities were gradually developed. The sophisticated handling and screening facilities were introduced into the market as per customer requirements. Recently, the demand of smaller sized coal has increased. The larger sized coals are kept for their shipment. The washing technique was first introduced in Europe in 1918 and later "Chance" washer was used. The washer utilized sand and water as medium. In course of time, many other types of washing technology have been introduced and then they were modified or rejected according to the need.

Coal preparation

Coal preparation includes blending and homogenization, size reduction, grinding, screening and handling. The most important step is coal beneficiation or cleaning. The cost of coal preparation depends on the methods used and also on the degree of beneficiation required,

which is greatly determined by the market demand of the product. Almost all coal used for electric power generation and industrial boilers is either pulverized or crushed and sized before burning. The presence of non-combustible material or ash in run-off-mine coal increases in net heat content but it reduces the dust, ash content, transportation and shipping costs. Ash content also increases wear in coal grinding equipment and boilers.

Therefore, coal can be subjected to different levels of cleaning, depending upon its type, its utilisation with consideration of the cost of cleaning. Very dirty coals containing large amount of extraneous mineral material, could only match the market specification after substantial cleaning. The final selling price of these coal is determined by the cost of the cleaning steps. The equipments used for washing of coal include centrifuges, froth flotation devices, disc filters, thickeners, cyclones, and thermal dryers

Coal preparation process

Typical steps in coal preparation include:

- crushing
- screening into different size fractions
- physical, chemical or mechanical processes to remove undesired impurities
- dewatering
- thermal drying
- blending
- agglomeration or briquetting

Coal preparation process starts with crushing and screening of freshly mined coal, which removes some of the non-coal material. Mechanical cleaning or "washing" is actually the process of separation of non-coal materials or undesired adherent materials of coal by using a

liquid medium. The liquid medium may be an aqueous solution or organic liquid. Sometimes a heavy, finely ground mineral, such as magnetite is added in the liquid medium to ensure the removal of unwanted rock and mineral matter from coal particles. Wet or "hydraulic" cleaning technique is a process which includes agitation of the coal-liquid feed by aeration, materials sorting according to relative density in hydrocyclones, and froth flotation to recover fine coal particles. To meet environmental regulations, The modern wash plants are able remove around 40 percent of the inorganic sulfur in coal. A rarely used technique is dry technique in which coal and non-coal materials are segregated by vigorous shaking and pneumatic air-flow separation for crushed feed coal. Dry technique is used before actual washing.

Prepared coal is usually dewatered to some extent as excess moisture lowers the deliverable heat content in the coal and increases the weight of coal. Dewatering equipments includes less costly vibrating screens, filters, or centrifuges to the more costly heated rotary kilns or dryer units.

Washing or cleaning of coal

Washing of coal represents the most important step of coal preparation. The raw run-of-mine coal must require some selective qualitative and quantitative analysis for finding out the most suitable operating conditions for cleaning of coal to obtain the desired quality. Among these analyses washability test is most important.

Washability test

The washability test method can be used to investigate the cleaning characteristics of coarse- and fine-coal fractions. However, especially with the fine-coal fractions, this test method may not be applicable for low-rank coals.

Washability characteristics of coal is applied

(1) To find the relative ease for separation of coal from the refuse based on the difference in specific gravity.

(2) To find the effectiveness of coal washing in particular process.

(3) To characterize the type and amount of impurities

(4) To select the optimum plant operation

(5) To gather the information for designing a separation plant.

The washability test is done by float and sink method. The float and sink test is an important analytical technique for the cleaning of coal in most effective way.

Float and Sink Test

In the float and sink method, the freshly mined coal lumps are first crushed into different size fractions such as, 50-25, 25-13, 13-06, 06-03, 03-0.5 mm through screen analysis. The different fractions of the coal are separated by washing with different specific gravity organic solutions like carbon tetrachloride, perchloroethylene, benzene or aqueous solution of zinc chloride or other inorganic salt. Each of the individual size fractions are subjected to sequential float and sink tests with different density liquid. The liquid solutions of varying density with a very small difference in specific gravity such as 0.01 are prepared within the range of 1.25 and 1.9. Sometimes the density range may be broadened upto 2.25 depending on the type of coal. The different size coal samples are immersed into organic solution of known specific gravity, then the float and sink fractions of coal obtained in the washabilty test are separated out. The ash content of each fraction is determined. The float-sink test can be performed on samples ranging in size from bulk samples to bench-scale of coal samples.

By using liquid of different specific gravity the coal samples are divided into number of fractions with increasing order of specific gravity and hence, of ash value. From the results of the test, three curves are plotted.

i) Total float-ash curve

ii) Total sink-ash curve

iii) Washablity characteristic curve or instantaneous ash curve.

By the analysis of plots i) and ii), as shown in Figure 1, the ash content of the clean product (float) and waste material (sink) are obtained by washing with a particular specific gravity of liquid.

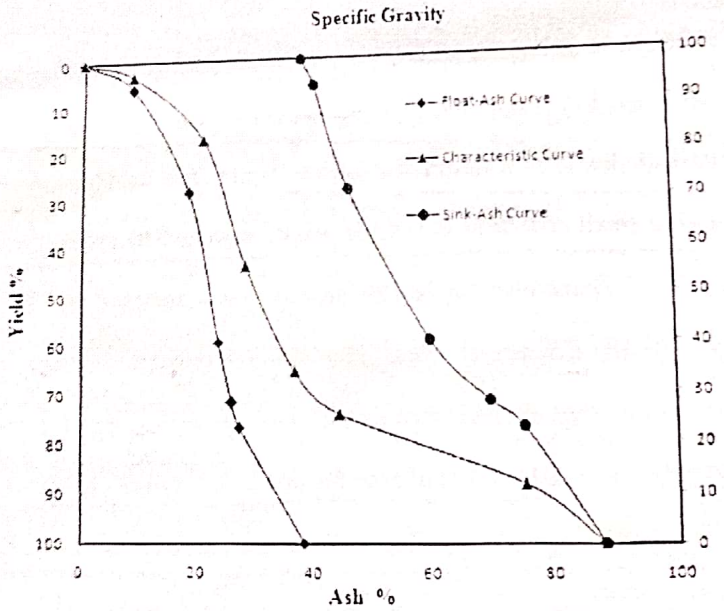

Figure 1. Characteristic curve of Float and Sink test.

Among the widely used washers, jig washer is one of the important one. In a jig washer, coal is supported on a perforated tray and a continuous periodic flow of water is applied in both upward and downward direction. While washing by this way, clean coal is accumulated in the upper layer of the bed while unwanted heavy non-coal part settles at the bottom. The water may be pulsated by various means.

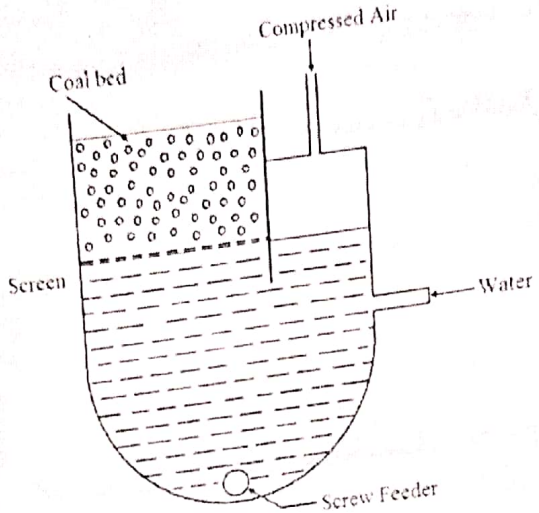

Figure 2. Baum Jig

A typical jig washer is shown in Figure 2, which is called baum jig. It consists of a U-shaped chamber, divided vertically by a partition in two parts. One section is washing chamber and another one is air chamber. Feed coal is fed in the washing compartment and compressed air is passed in air compartment for generation of pulse in water. Cleaned coal carried out by the water flow over a weir and the refuse sinks at the bottom. Refuse is removed time to time from the washer.