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 (SO₂), carbon dioxide (CO₂) 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, 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 up to 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 washability 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) Washability 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.](image-url)
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.

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.

Figure 2. Baum Jig
References


