MSE-402

Constituents of Coal

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Constituents Important for Coal Use:

The coal contains moisture, incombustible inorganic matter and volatile constituents in addition to carbon. These constituents affect the use of coal. The proximate analysis of coal deals with the determination of following constituents by weight per cent:

- Moisture
- Volatile matter
- Ash, and
- Fixed carbon

*** The knowledge of these constituents is useful in the selection of coal for a given purpose.

Moisture:

The moisture is present in every type of coal in variable amount (0.5 wt. % to 20 wt. %). In peat, the moisture content could be 90%. The moisture present in the solid fuel is removed during use at the expense of its heating value. It is an undesired constituent in solid fuels.

The moisture could be present in free (surface), adsorbed (inherent) or combined (chemical compound) state.

- **Free or surface moisture**

As the name suggests, this kind of moisture is loosely present on the surface or in the pores of coal. This moisture is derived from rain during storage, transportation and washing of coal. When water saturated coal is left in air for some time, the excess free water evaporates and the moisture content in the coal attains equilibrium with the atmospheric humidity. The

percent weight loss of free water by air drying at room temperature is termed as free or surface moisture.

- **Inherent moisture**

The water molecules adsorbed on the external surface and internal open pore surface is termed as inherent moisture. Its value would depend on porosity and atmospheric humidity. As the lower rank coals possess high porosity, therefore, the inherent moisture content would also be more in lower rank coals compared to higher rank coals.

The coal sample when heated to 110 ± 5 °C temperatures for some time, then the adsorbed (inherent) moisture

molecules are detached and get removed. However, if the coal sample is left again in open atmosphere for longer time, then it may regain its inherent moisture content. This regaining tendency for inherent moisture will be more for high rank coals, while this re adsorption will be less in lower rank coals, since their cell walls may breakdown during drying stage due to weak structure. This reduces the number of pores available for re adsorption of moisture, causing lower inherent moisture in coal sample which has been heated and cooled.

This inherent moisture content in coal cannot be avoided. However, a lower value would be appreciated.

- **Combined moisture**

Coal contains mineral matter which, sometimes, contains water molecules that are chemically attached. Such chemically bonded water molecules do not evolve when the coal is heated at 100°C. This kind of moisture can be removed only when the coal is heated at higher temperature. Such combined moisture forms the part of volatile matter, and it is not determined separately. However, the presence of combined water in coal is not appreciated as it consumes some heat for its own

dissociation, rendering lower net calorific value of coal for use.

- **Volatile matter:**

It is the part of coal which is evolved as volatile (gaseous) product when the coal is heated in the absence of air. As the quantity of volatile product is dependent on temperature, time, surface area, etc., therefore, a specified procedure is adopted to make the result reproducible and comparable.

The quantity of volatile matter in coal may range from 2 wt. % to 40 wt.%, while it is below 2 wt.% in coke and wood char. The volatile matter content plays an important role during its selection for a given application. Its higher content could be useful in gas making coals, but may not be appreciated in coking coal. The knowledge of volatile matter content helps in designing combustion system to provide appropriate primary and secondary air.

- **Mineral matter and ash:**

Coal contains various minerals which are incombustibles part of coal, called ash. It is common to state that coal contains ash, but technically coal contains mineral matter and yields ash on combustion. Chemically,

mineral matter is different from ash. The coal may have following minerals in varying quantities in addition to oxides of sodium and potassium:

- Shale or silt (Hydrated silicates of aluminum)
- Pyrite (FeS_2)
- Gypsum ($CaSO_4.2H_2O$)
- Lime stone ($CaCO_3$)
- Siderite ($FeCO_3$)
- Magnesite ($MgCO_3$)
- Apatite ($Ca_5(PO_4)_3$ (F, Cl, OH)

Some of these minerals originate from the vegetal mass from which the coal was formed. These minerals are required by the tree for its growth. Such mineral matter is known as intrinsic mineral matter and is present in very fine form in the matrix of coal which cannot be liberated or separated by coal cleaning methods. The bulk of the mineral matter present in coal is incorporated during peat formation stage and termed as extrinsic mineral matter. These could be present in coarser form which could be removed by coal cleaning methods.

When the coal is heated or burned, the minerals undergo changes depending upon temperature to yield ash. The ash content in a given coal is determined by

observing the weight of uncombusted matter left after exposing the coal sample to oxidising condition at 800 °C. In Indian coals, which contain low ‘sulphur’ and ‘carbonate’ minerals, the mineral matter (M % wt.) is given by:

$$\mathbf{M = 1.1\ A}$$

where, A is the ash (wt.%) determined by proximate analysis of coal sample assuming the sulphur and carbonate are very low.

- **Fixed carbon:**

Fixed carbon content in the coal is considered to be useful for a given application, e.g. combustion, reduction, etc. There is no direct method for its determination.

It is estimated as:

$$\mathbf{Fixed\ carbon = 100 - [M + VM + A]}$$

where, M, VM and A are moisture, volatile matter and ash content in coal determined experimentally.

This fixed carbon value is not the total carbon in coal. A higher fixed carbon content in coal increases its commercial value.

COAL CLASSIFICATION:

The coal occurring in nature differs in their properties due to various factors affecting its formation. The proximate analysis (volatile matter and fixed carbon) and heating value or the ultimate analysis (carbon, hydrogen and oxygen) of coal are used for its classification. There are different systems of coal classification followed in various parts of the world, developed in the past.

These are as follows:

- **Regnault–Gruner system**
- **Parr's system**
- **Seyler's system**
- **British National Coal Board system**