MSE-402

Lecture 3: Solid fuels

Dr. Alka Gupta

Definition: Solid fuel refers to various forms of solid material that can be burnt to release energy, providing heat and light through the process of combustion. Solid fuels can be contrasted with liquid fuels and gaseous fuels. Common examples of solid fuels include wood, charcoal, peat, coal, wood pellets, corn, wheat and other grains.

Solid fuels are mainly classified into two categories:

- **Natural fuel:** Fuels that are naturally occurred such as -wood, coal, etc. and
- **Manufactured fuels:** manufactured by human being/human made such as charcoal, coke, briquettes, etc.

Different types of solid fuels are:

a. Wood

b. Biomass

c. Peat

d. Coal

e. Coke

f. Municipal waste

g. Fossil fuels

Properties of Solid Fuel:

Specific Heat:

Specific heat is the amount of kCals needed to raise the temperature of 1 kg of fuel by 1°C. The unit of specific heat is kcal/kg degree C. The specific heat determines how much steam or electrical energy it takes to heat oil to a desired temperature.

Calorific Value:

The calorific value is the measurement of heat or energy produced and is measured either as gross calorific value (GCV) or net calorific value (NCV). The difference is determined by the latent heat of condensation of the water vapour produced during the combustion process. Gross calorific value (GCV) assumes all vapour produced during the combustion process is fully condensed. Net calorific value (NCV) assumes the water leaves with the combustion products without fully being condensed. Fuels should be compared based on the net calorific value.

Ash Content:

The ash value is associated to the inorganic material or salts in the fuel oil. The ash levels in distillate fuels are negligible. Residual fuels have higher ash levels. These salts may be compounds of vanadium, sodium, magnesium, calcium, silicon, aluminum, iron, nickel, etc.

Carbon Residue:

Carbon residue specifies the tendency of oil to deposit a carbonaceous solid residue on a hot surface, such as a burner or injection nozzle, when its vaporizable constituents evaporate.

Coal:

Coal is a naturally occurring carbonaceous rock. The coal is made from vegetal matter over a long period on the geological time scale. The coal suitable for making of coke is designated as coking coal. There are many varieties of coal occurring in nature. The coals yielding coke for metallurgical applications are termed as metallurgical coal.

Origin and formation of coal:

- Coal occurs in nature as sedimentary rock where the carbonaceous matter is present with many other minerals.
- The structural examination of the coal shows confirmed evidence of its formation from vegetal matter.
- The fossil imprint of leaf, bark and other tree components on the coal provide evidence of its vegetal origin.
- The micro-structural examination of the thin section of coal reveals the presence of spores, pollens, resins and other essential components of vegetal matter which help in confirming and identifying the type of tree from which such coal is originated in the nature.
- It is believed that the large forest vegetation growing long ago got buried in the ground and was fossilized to become coal.

There are two theories for origin of coal: ‘In-situ’ theory and ‘Drift’ theory.

➢ **The ‘in-situ’ theory**: This describes it as natural growth of trees in swamps, their death and accumulation as peat over long period of time followed by its coalification to coal due to some geological action in nature, sustained for long duration of time.

The ‘drift’ theory: It differs in first part of the process of coal formation to deposit peat at other location than its growth, while the second stage process is identical to the ‘in-situ’ theory. The ‘drift’ theory describes the growth of trees in high regions, and these are transported by river water after they die and get uprooted down to estuary where they get deposited as peat due to lower velocity of water. This deposited peat gets converted to coal by long geological action of the earth.

The process of coal formation could be divided in two periods:

- Peat formation and
- Conversion of peat into coal.

Peat Formation (Biochemical Period):

- The forests grow in tropical climate. The swamps provide ideal place for the thick growth of the vegetation.
- The trees germinate from the fallen seeds on the soil. The tender tree grows fast in tropical climate and dies on maturity. When the tree dies, it falls on the ground and starts decomposing or decaying.
- This decomposition (or rotting) process is the disintegration of plant molecular structure aided by bacteria, moisture and air. When the process of decay of the dead tree is in progress and if another dead tree falls over it then the partially decayed tree gets buried in the soft swamp soil and the decay process is slowed down or arrested depending on the supply of oxygen necessary for the bacterial growth. This partially decayed vegetal matter is termed as peat.
- During the process of peat formation, the various constituents decay at different rate. The protoplasm and oils in the plant

matter decay rapidly. The carbohydrates like cellulose, lignin, etc. decay slowly, whereas the spores, pollens, resins and waxes resist decay action.

- Thus, the nature of vegetation, its constituent and extent of decay will decide the peat composition and properties. This process of tree germination, growth, maturity death and partial decay process continues to form peat and its accumulation as layers buried under soft swamp soil.
- The peat layer thickness depends on the period of peat formation which may be hundreds of years. This peat layer awaits some geological action to cause its conversion into coal.

Conversion of Peat into Coal (Dynamo-chemical Period):

- The earth crust is dynamic in nature, and it undergoes depression or elevation at any given point due to movement of plates in the earth crust. It may be possible that at some time the area having peat deposit underwent depression causing peat layer buried at considerable depth with a formation of large depression of surface on its top.
- This depressed land filled with rain water would destroy all growing vegetation and would look like a huge water lake.
- In every rainy season, the flowing water to the lake would bring soil and get deposited at the bottom of lake. This soil silting process may continue for long time to eventually fill the lake and make it a plain ground over which the vegetation may start growing again with peat formation and accumulation to give another layer of peat deposit.
- It may also happen that another earth movement may push the buried layer of peat upward creating a mountain like elevated topology. In this process of geological action, the peat layer

buried in the soil may be subjected to considerable pressure and temperature, rendering chemical and physical changes in peat properties.

- The chemical changes due to application of temperature and pressure would be the loss of moisture and evolution of carbon dioxide and methane.
- The oxygen content of the carbonaceous matter would be decreased with increase in temperature and time. These conversion changes get reflected in physical nature of the deposit.
- The colour, hardness and density keep changing with the advancement of the conversion from peat to anthracite.
- The peat has more than 90 percent of water and can be squeezed by hand. This water content is reduced in lignite which can be felt as wet.
- The bituminous and anthracite coal have very little moisture to be felt by hand. The brown colour of the peat becomes dark brown in lignite which further turns black when it becomes bituminous and anthracite.
- The coal hardness also increases with conversion from lignite to anthracite stage.
- The lignite is friable in nature, while bituminous is hard, but soils the hand with black carbon. Anthracite is quite hard and does not soil hand on rubbing on its surface.