Module 1: History of Fuels

Lecture 1: History of solid fuels

Keyword**:** coal, rank of coal, moisture content, use of fuel

Introduction

Any naturally occurring carbon-containing material, when burned with air (or oxygen) produces heat or energy (directly or indirectly). Fossil fuels can be classified according to their respective forms at ambient conditions. Thus, there are solid fuels (coals), liquid fuels (petroleum) and gaseous fuels (natural gas, LPG etc.).

1.1.1 History of solid fuels

Coal is a brown to black naturally occurring combustible organic rock that originated by accumulation and subsequent physical and chemical alteration of plant material over long period of time. The plant debris accumulated in various wet environments, commonly called peat swamps, in which trees, ferns and the like are deposited, and buried by sand, silt and mud. As a result of temperature and pressure effects, metamorphosis of the woody material occurs to produce the various types of coal. The initial transformation of vegetable materials probably includes various types of degradation and decay due to some fungal and bacterial action. Slow atmospheric oxidation may also take place. The course and rapidity of the vegetal decay are the function of local conditions, either dry or wet.

The accumulating spongy, water-saturated, plant-derived organic material, known as peat, is called the precursor of coal. This is primary transformation. The secondary transformation which is rather a slower process of aging under substantially anaerobic condition, higher pressures and elevated temperature.

This progressive transformation of peat to higher coals is called coalification process.

Increasingly deeper burial under hundreds to thousands of feet of younger sediment is required to advance coalification to the bituminous and anthracite stages. The pressure exerted by the weight of the overlying sediments and the heat that increases with depth, as well as the length of exposure to them, determines the degree of coalification, as well as the rank of coal.

There are two theories proposed for the mode of accumulation of the plant materials to transform into coal.

1) *In-situ theory*-According to this theory, the coal seams are observed where once forest grew. As the land was sinking slowly, the accumulated vegetation matters went under water slowly and did not decompose and destroyed. In the course of time, the rate of sinking of land was increased and coal forest was submerged under water. Again, land along with the coal forest emerged out of water after sufficient time and this cycle went on again and again, which is responsible of formation of coal strata and seams. The evidence of this phenomenon is observed in the coal seam that the stem of fossil trees is found standing erect with their roots protruding into the underclays. The uniformity in thickness and composition of coal seams over wide areas suggests that the deposition of plant material took place in still water.
2) *Drift theory*- This theory tells that, the plant material was transported with the stream of water from one place to another, and finally get deposited in a place of swamp having suitable condition like sediments. The coal seams of India are of drift origin. The evidence of drift theory that the rocks associated with the coal seams are of distinctly

sedimentary. The coal seam itself behaves like a sedimentary bed and they are observed to branch out.

Peat transforms into coal by the sequence, as shown in Fig1,

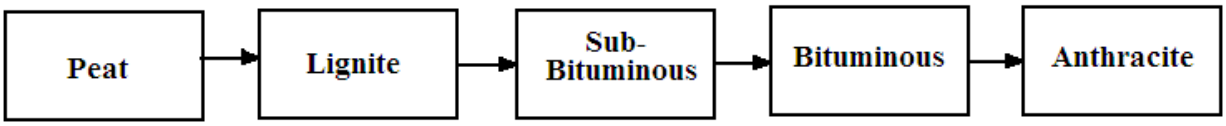

Fig 1. Rank of coal

It is assumed that, at least some of the natural graphites are produced from anthracite by the effect of very high temperature (not shown in figure).

Although samples of each rank of coal have distinct physical and chemical characteristics, the border line between two consecutive ranks of coal is difficult to determine. The first four samples in the series have a nearly continuous gradation of a given physical and chemical properties, such as moisture content, carbon content, heat content etc.

Peat is the result of insufficient transformation. The composition and properties of peat vary greatly from one place to another, depending on the nature and type of the original plant material and the extent of decay. It contains very large amount of water. Peat is not regarded as coal, but it is an important fuel in those countries which have large deposits of peat. It is mainly used as a domestic fuel. Moreover peat briquettes are largely used in steam boilers, power stations and gas producers. It ignites easily with a long flame.

Lignite, may be termed as Brown coal, is lowest in rank and readily identified by its colour and texture. It is soft, has a woody structure and disintegrates on drying. Dark brown or black colour

is observed in lignite, having woody and amorphous nature. Lignite breaks in slabs after long time exposure to weather. It is characterized by a high percentage of moisture, ranging from 30-50% with high oxygen content.

Black lignite grades are the preliminary stage of sub-bituminous coal, having of lower oxygen content and higher heating value than lignite. Sub-bituminous coals are not distinguishable as a class by appearance or physical properties. They are intermediate between black lignite and bituminous products. Sub-bituminous coals slowly disintegrate on exposure to atmosphere.

Different bituminous coals vary in their appearance and properties. In general, they are harder than sub-bituminous samples and exhibit cubical fracture in most of the time.

Next rank is anthracite coal which is again harder than bituminous and having an amorphous texture. Anthracite is relatively dustless solid coal and burns with a smokeless flame. High carbon content and low volatile matter and oxygen are the characteristics of anthracite coal.

As the rank of coal increases from peat to anthracite, the carbon content increases but, moisture, volatile matter and oxygen contents decrease. The carbon content increases from 70% to 95% from lignite to anthracite coal.

The chemical composition of coal is not very clearly known. It is generally said that, coal components are macromolecular with complex structures. The reason for appearance of different components in different rank of coal is the variation of the structures of these macromolecules. Waxes, resins, pectin, hemicelluloses, lignite etc. are found in low rank coal as peat and lignite.

The major coal fields in India are Gondwana coal field and Tertiary coal field. Gondwana coal field covers the areas of West Bengal, Bihar, Orissa, Madhya Pradesh, Maharastra, Andra

Pradesh etc. Tertiary coal field covers North East India, Tamilnadu, Rajasthan, J&K, Gujarat etc. More than 98% coal is obtained from Gondwana coal field. Vast reserves of bituminous coal are found in Raniganj and Bokaro-Ramgarh-Karanpura deposits in Gondwana coal field. Raniganj coal measures are high in moisture (3-10%) and high in volatile matter (30-36%). The coals of Gondwana basins are mainly of sub-bituminous type. Coalfields of the Damodar valley of Jharkhand and Bihar are the chief source of metallurgical coal in the country and most of the iron and steel plants get coking coal from these fields.

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