Al-Mustaqbal University / College of Engineering & Technology
Chemical Engineering and Petroleum Industries Department
2nd Class
Subject (Fuel Technology) / Code (UOMU0102036)
Lecturer (Rusul Ahmed)
1st/2nd term – Lecture No. & Lecture Name (2 & ORIGIN OF COAL)

ORIGIN OF COAL

Coal is a complex mixture of plant substances altered in varying degree by physical and chemical processes. These processes which changed plant substances into coal has taken millions of years and has been achieved by bacteria, heat and pressure inside the earth's crust.

At various times in the geologic past, the Earth had dense forests in low-lying wetland areas. Due to natural processes such as flooding, these forests were buried under the soil. As more and more soil deposited over them, they were compressed.

Under high pressure and high temperature, dead plant was slowly converted to coal. As coal contains mainly carbon.

Different stages in the formation of coal from plant/vegetable debris (called peat to anthracite series) is as follows:

Plant debris → peat → lignite → sub-bituminous → bituminous coal → anthracite

These classifications are based on the amount of **carbon, oxygen, and hydrogen** present in the coal.

In this series from peat to anthracite; each member is more mature or of higher 'rank' than the one which precedes in the series. Thus anthracite coal is of higher rank than bituminous coal. Bituminous coal is of higher rank (i.e., more mature) than lignite. With the progress of coal forming reaction, moisture and oxygen content reduces and percentage of carbon increases.

Composition of coal

It is expressed in terms of :

- Proximate Analysis.
- Ultimate Analysis .

Proximate Analysis of coal means determined the percentage of:
- moisture
- volatile matter
- fixed carbon
- ash

Proximate Analysis with sulfur content and heating value of coal helps in deciding the mode of utilization of particular coal.

Ultimate analysis: It means determination of:

- Total carbon
- Hydrogen
- Oxygen
- Nitrogen

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- Sulfur

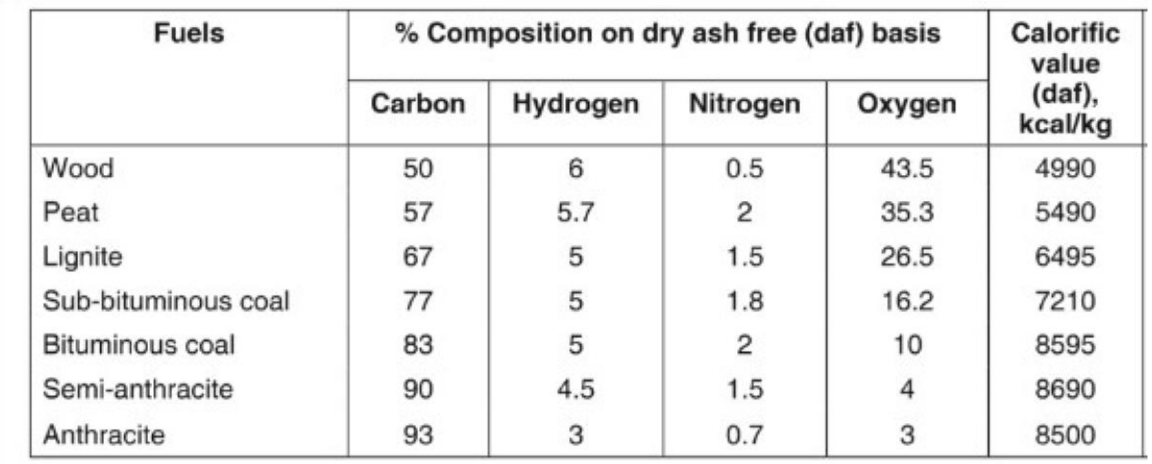
It gives analysis in terms of the elementary constituents and is helpful in combustion calculations for design of furnaces.

The changes in average composition from:

$$\text{wood} \rightarrow \text{peat} \rightarrow \text{lignite} \rightarrow bitmonious\ \text{coal} \rightarrow \text{anthracite.}$$

The changes in average composition from wood to anthracite is given in table 2.1.

Table 2.1: Typical Composition Change from Wood to Anthracite



Fuels	% Composition on dry ash free (daf) basis				Calorific value (daf), kcal/kg
	Carbon	Hydrogen	Nitrogen	Oxygen	
Wood	50	6	0.5	43.5	4990
Peat	57	5.7	2	35.3	5490
Lignite	67	5	1.5	26.5	6495
Sub-bituminous coal	77	5	1.8	16.2	7210
Bituminous coal	83	5	2	10	8595
Semi-anthracite	90	4.5	1.5	4	8690
Anthracite	93	3	0.7	3	8500

First Stage – Peat

This is the first stage in the formation of coal from wood. It is an organic substance which is formed due to the partial decomposition of dead matter. It appears light brown and fibrous at the surface of peat deposits but with increase in depth the colour becomes darker.

- It varies from place to place depending upon the nature of original vegetable matter, depth in the deposit and age.
- Chemically it is very rich in moisture.
- Peats contain about 55 to 60 per cent carbon.
- Its heating value is very less due to high moisture content and is only slightly greater than wood.
- The ash of peat is high.
- It is mainly used as a domestic fuel. Moreover peat is largely used in steam boilers, power stations and gas producers.

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Second Stage – Lignite

This is the second stage in the coal formation. It is a dark brown matter formed due to the pressure exerted by the sediments overlying the organic matter. Compositions and properties of lignite:

- Dark brown coal.
- The carbon content is 70-75% - Moisture content is high.
- Low calorific value (6500-7000 kcal/kg).
- The ash of lignites is generally low.
- It is used for manufacture of producer gas, for generation of electrical power, and for gasification to produce nitrogenous fertiliser.

Third Stage – Bituminous Coal

This is the third stage in the formation of coal. It is formed due to the added pressure. This is also called as soft coal.

- Dense, compact, and is usually of black colour.
- Most widely available and used coal. - The carbon content is 80-92%
- Low moisture content (about 15 %)
- Calorific value is very high due to high proportion of carbon and low moisture (7500 - 8900 kcal/kg) .
- Ash is often low.
- Most of the coking coals are essentially bituminous coal. It is used for power generation, coke making, gasification, domestic heating, etc.

Fourth Stage – Anthracite Coal

This is the fourth stage in the coal formation. It is formed due to the high pressure and high temperature for a long period of time. It is hard, and has the highest percentage of carbon. This is also called as hard coal.

- Best quality; hard coal, Semi-metallic lustre.
- 85 to 95 per cent carbon.
- Negligibly small proportion of moisture.
- The calorific value may be up to 8000-8500 kcal/kg which is slightly lower than that of bituminous coal due to its **lower hydrogen content**.
- The chief uses of anthracites are: in boilers, domestic ovens, metallurgical furnaces. It is also used in small quantities as a component of coke oven charges. On calcining it gives thermo-

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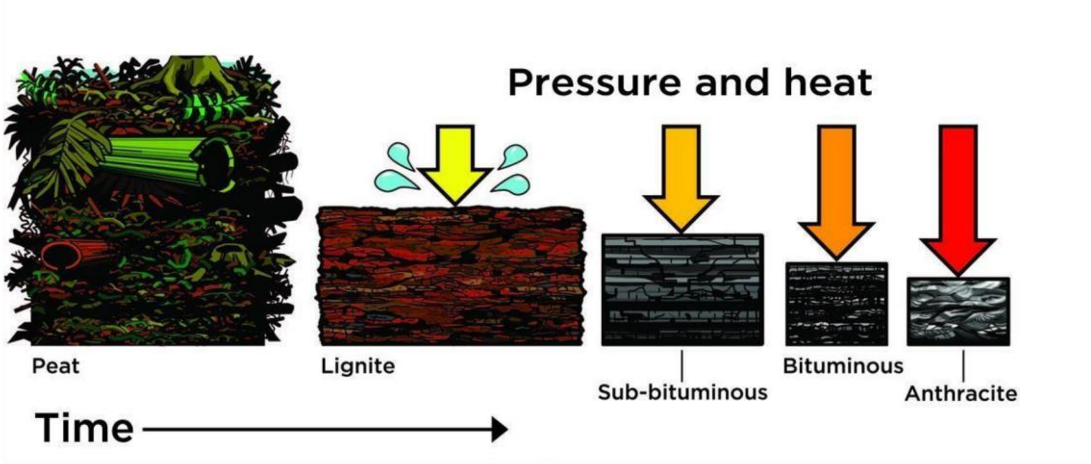
anthracite which is a raw material for the production of carbon electrodes.



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Characteristic	**Peat**	**Lignite**	**Bituminous**	**Anthracite**
Colour	light brown	dark brown	black	Greyish black, semi-metallic lustre
Carbon content	Lowest	Relatively lower	High	Highest
Hardness	Softest	Softer	Soft	Hardest
Moisture	Highest	High	Relatively Lower	Lowest
Calorific value	Very less due to high moisture content and is only slightly greater than wood	Low calorific value (6500-7000 kcal/kg)	Calorific value is very high due to high proportion of carbon and low moisture (7500 8900 kcal/kg)	The calorific value may be up to 80008500 kcal/kg which is slightly lower than that of bituminous coal due to its lower hydrogen content

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Units Fundamentals, Definitions

1 - **Coalification (or metamorphism)**: The process of conversion of lignite to anthracite is called coalification or metamorphism of coal.

2 - **Rank of coal**: is the measure of the degree of organic metamorphism (coalification) of a coal or degree of maturity, ranging from low-rank peat to high-rank meta-anthracite, the ranking depends on the types and amounts of carbon the coal contains and on the amount of heat energy the coal can produce. Rank of coal is the most important variable in the nature of coal.

3 - **Carbonisation of Coal**: Heating of coal in absence of air at high temperature to produce a residue coke, tar and gas is called its carbonization.

4 - **Gasification of Coal**: Heating of coal with insufficiently less quantity of air plus steam to produce a gas rich in CO and H_2 is called its gasification. This is done to produce gaseous fuel from solid and liquid fuel.

5 - **Combustion:** It is an exothermic chemical reaction of a fuel with oxygen or air at high temperature to liberate heat.

Fuel + Air → Products of Combustion + Heat

6 - **Calorific value:** The quantity of heat (kcal) liberated by the combustion of unit mass in the case of solid and liquid fuel (kg) or unit volume in the case of a gaseous fuel (m^3) is called its calorific value.
Units:

- Solid or Liquid fuels - kcal/kg or J/kg
- Gaseous fuels - kcal/m^3 or J/m^3

Higher calorific value (HCV): refers to the amount of heat evolved when a unit weight (or volume in the case of gaseous fuels) of the fuel is completely burnt and the products of combustion cooled to the normal conditions (with water vapor condensed as a result and the heat contained in the water vapor is recovered). It is also known as **gross calorific value** (GCV).

Lower calorific value (LCV): refers to the amount of heat evolved when a unit weight (or volume in the case of gaseous fuels) of the fuel is completely burnt and water vapor leaves with the combustion products without being condensed (side products are allowed to escape with some heat). It is also known as **net calorific value (NCV)**. These definitions explain the main difference between HCV and LCV.

LCV = HCV – heat carried away by the system

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Coal Preparation

Coal as mined, called "Run of mine" coal, varies in size from fine dust to large lumps and contains much impurity in the form of inorganic material present in the coal seam or introduced during mining operations. Every combustion appliance burning coal requires a quality and size grading within well-defined limits. **The object of coal preparation is to provide each user with fuel of optimum specification for the appliance used.**

Coal preparation is the removal of undesirable material from the Run of Mine (ROM) coal by employing separation processes which are able to differentiate between the physical and surface properties of the coal and the impurities. Through coal preparation, a uniform product is achieved.

Procedure:

Coal Preparation includes some or all of the following:

- Separation of coal types at the coal face e.g. into Hards and Brights.
- Screening or grading into fraction of different size.
- Hand- picking of large sizes to remove separate lumps of impurity.
- Crushing of larger sizes to provide the smaller size mostly required by industry.
- Cleaning to remove inorganic impurities when low- ash coal is required.
- Drying, when small- sized coals are washed to remove impurities.
- Blending to modify the properties of a coal.

Washing of coal

Most of the coals when mined contain impurities associated with which must be removed before the coal is used. Impurities are removed from coal by washing.

Objective of coal washing:

1- Reduces its ash content.
2- Reduces its sulphur and phosphorous contents and other harmful elements.
3- Increases its heating value.
4- Improves its coking properties.
5- Reduces its clinkering tendency.

6- Increases its efficiency in use.
7- economy of transport and storage.

Principle of coal washing

Coal washing is accomplished by one of two major processes, by **density separation** or by **froth flotation**. Both processes depend on the fact that the particles of which a coal sample are made have different densities (The specific gravity of pure coal varies from 1.2 to 1.7 and that of free impurities from 1.7 to 4.9). When water is added to the sample, particles sink to various depths depending on their densities. The impurities being heavier will sink in it, whereas the pure coal will float. The various components of the sample can be separated from each other. A number of devices and systems have been developed for extracting the various components of coal once they have been separated with a water treatment. One of these devices is the jig. **In a jig, the column of water is maintained in a constant up-and-down movement by means of a flow of air**. Clean coal particles are carried to the top of the jig by this motion, while heavier refuse particles sink to the bottom.

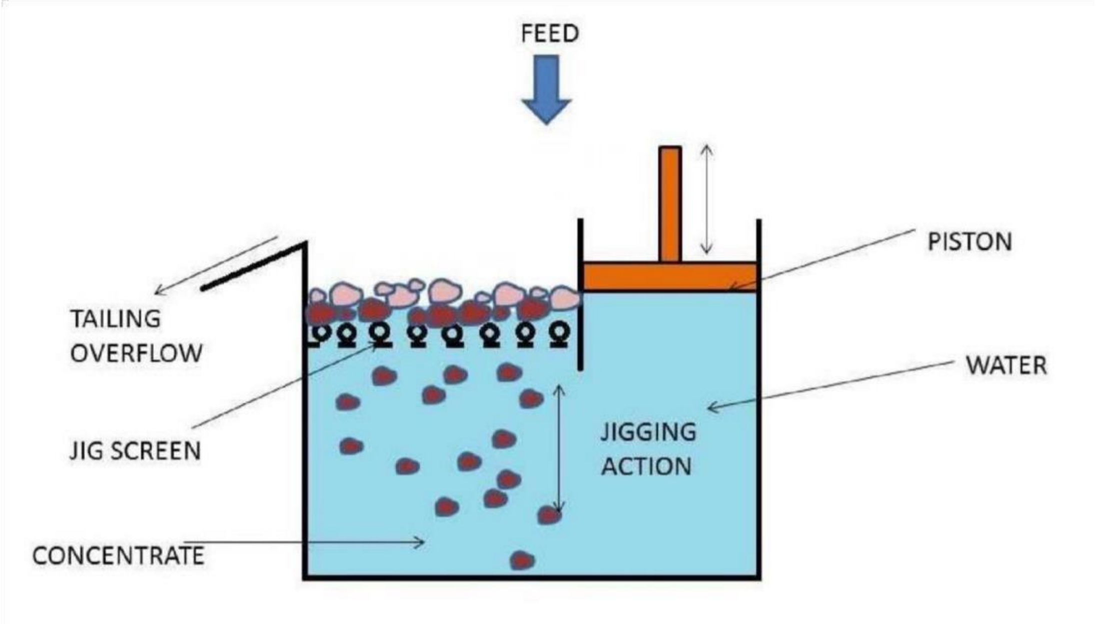

Figure 2.2 Conceptual diagram illustrates the basic principles of a jig