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Solid Fuel Sources- The Fundamental Study on the Carbonization Characteristics of Low Rank Coal under Low Temperature

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INTRODUCTION

Keywords:-
Carbonization; petrography; GCV; NCV; Weathering; Anthracite; Ash content; Beneficiation of coal; coke; Caking of Coal; Lignin and peat, Low rank coal, carbonization, carbon content and iron quality.

Solid Fuel
Solid fuels contain significant amounts of ash-forming content, which in consequence leads to a harsh environment for the hot gas path parts of a gas turbine.
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, hexamine fuel tablets, dry dung, wood pellets, corn, wheat, rye, and other grains. Solid fuels are extensively used in rocketry as solid propellants.[1] Solid fuels have been used throughout human history to create fire[2] and solid fuel is still in widespread use throughout the world in the present day.

Coal

Coal is a combustible black or brownish-black sedimentary rock usually occurring in rock strata in layers or veins called coal beds or coal seams. Throughout history, coal has been used as an energy resource, primarily burned for the production of electricity and heat, and is also used for industrial purposes, such as refining metals. Coal is the largest source of energy for the generation of electricity worldwide, as well as one of the largest worldwide The extraction of coal, its use in energy production and its byproducts are all associated with environmental and health effects. Variations such as smokeless coal can be formed naturally in the form of anthracite, a metamorphosed type of coal with a very high carbon content that gives off a smokeless flame when set alight. It is an important type of smokeless fuel.

Coke

Coke is a fuel with few impurities and a high carbon content, usually made from coal. It is the solid carbonaceous material derived from destructive distillation of low-ash, low-sulfur bituminous coal. Cokes made from coal are grey, hard, and porous. While coke can be formed naturally, the commonly used form is man-made. The form known as petroleum coke, or pet coke, is derived from oil refinery coker units or other cracking processes.

Lignin

Lignin is a class of complex organic polymers that form key structural materials in the support tissues of most plants.[1] Lignins are particularly important in the formation of cell walls, especially in wood and bark, because they lend rigidity and do not rot easily. Chemically, lignins are polymers made by cross-linking phenolic precursors.

Lignin fills the spaces in the cell wall between cellulose, hemicellulose, and pectin components, especially in vascular and support tissues: xylem tracheids, vessel elements and sclereid cells.

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Lignin plays a crucial part in conducting water and aqueous nutrients in plant stems. The polysaccharide components of plant cell walls are highly hydrophilic and thus permeable to water, whereas lignin is more hydrophobic. The crosslinking of polysaccharides by lignin is an obstacle for water absorption to the cell wall. Thus, lignin makes it possible for the plant's vascular tissue to conduct water efficiently.[10] Lignin is present in all vascular plants, but not in bryophytes, supporting the idea that the original function of lignin was restricted to water transport.It is covalently linked to hemicellulose and therefore cross-links different plant polysaccharides, conferring mechanical strength to the cell wall and by extension the plant as a whole.Lignin is a highly heterogeneous polymer derived from a handful of precursor lignols that crosslink in diverse ways. The lignols that crosslink are of three main types, all derived from phenylpropane: coniferyl alcohol (4-hydroxy-3-methoxyphenylpropane) (G, its radical is sometimes called guaiacyl), sinapyl alcohol (3,5-dimethoxy-4-hydroxyphenylpropane) (S, its radical is sometimes called syringyl), and paracoumaryl alcohol (4-hydroxyphenylpropane) (H, its radical is sometimes called 4-hydroxyphenyl).

Peat

Peat , also known as turf (/tɜːrf/), is an accumulation of partially decayed vegetation or organic matter. It is unique to natural areas called peatlands, bogs, mires, moors, or muskegs. The peatland ecosystem covers 3.7 million square kilometres (1.4 million square miles)[3] and is the most efficient carbon sink on the planet, because peatland plants capture carbon dioxide (CO_2) naturally released from the peat, maintaining an equilibrium. In natural peatlands, the "annual rate of biomass production is greater than the rate of decomposition", but it takes "thousands of years for peatlands to develop the deposits of 1.5 to 2.3 m [4.9 to 7.5 ft], which is the average depth of the boreal [northern] peatlands",[2] which store around 415 gigatonnes (Gt) of carbon (about 46 times 2019 global CO_2 emissions).Globally, peat stores up to 550 Gt of carbon, 42% of all soil carbon, which exceeds the carbon stored in all other vegetation types, including the world's forests.Across the world, peat covers just 3% of the land's surface, but stores one-third of the Earth's soil carbon.Sphagnum moss, also called peat moss, is one of the most common components in peat, although many other plants can contribute. The biological features of sphagnum mosses act to create a habitat aiding peat formation, a phenomenon termed 'habitat manipulation'.Soils consisting primarily of peat are known as histosols. Peat forms in wetland conditions, where flooding or stagnant water obstructs the flow of oxygen from the atmosphere, slowing the rate of decomposition. Peat properties such as organic matter content and saturated hydraulic conductivity can exhibit high spatial heterogeneity.

Caking of Coal

Coal that softens and agglomerates on heating and after volatile matter has been driven off at high temperatures; produces a hard gray cellular mass of coke. All caking coals are not good coking coals.This is a unique property of coals in the bituminous group of coals and is an essential property for coals which are required for coking. As a caking coal is heated it passes through a region where it becomes very plastic, softens, swells and then re solidifies. The caking behaviour is critical to coke making.A coking coal is quite simply a coal that, when heated in the absence of air, will melt vesiculate and harden into a sponge like mass of almost pure carbon.

Metallurgical coal, also known as coking coal, is used to produce coke, the primary source of carbon used in steelmaking. Metallurgical coal differs from thermal coal, which is used for energy and heating, by its carbon content and its coking ability.

Ash Content

It is defined as inorganic residue that remains after combustion of the oil in air at specific high temperature. Ash ranges from 0.1–0.2%. The ash content of a fuel is a measure of the amount of Carbonisation is a particular form of that process in chemical technology called pyrolysis that is the breakdown of complex substances into simpler ones by heating. The term carbonisation is also applied to the pyrolysis of coal to produce coke.inorganic noncombustible material it contains. The ash content of petroleum products came from the carbon residue of oil.Ash content represents the incombustible component remaining after a sample of the furnace oil is completely burned.

Carbonization

Carbonization is the conversion of organic matters like plants and dead animal remains into carbon through destructive distillation.Carbonisation is a particular form of that process in chemical technology called pyrolysis that is the breakdown of complex

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substances into simpler ones by heating. The term carbonisation is also applied to the pyrolysis of coal to produce coke.Carbonization is a process in which a fuel is heated without air to leave solid porous carbon. Coke is produced commercially by carbonization of coal, either at high or low temperatures. The main purpose in the carbonization of coal is to produce coke, and any chemicals produced are of secondary importance.

Anthracite

Anthracite, also known as hard coal, is a hard, compact variety of coal that has a submetallic luster. It has the highest carbon content, the fewest impurities, and the highest energy density of all types of coal and is the highest ranking of coals.Carbon content (%): 92 – 98

Ash content (%): 12 – 20
Heat content (MJ/kg): 26 – 33
Coloration: Submetallic Luster
Uses: Automatic stoker furnaces, Hand-fired stoves, Domestic fuel, Charcoal briquettes, Power generation.
Anthracite coal is the hottest burning fuel in comparison to the most common ones in use. Environmentally cleaner than other fossil fuels. Due to its low sulfur content, Anthracite coal produces virtually no smoke or particulate emissions. This is a major problem with cord wood and pellet burning stoves.

Weathering

Weathering is the breaking down or dissolving of rocks and minerals on Earths surface. Once a rock has been broken down, a process called erosion transports the bits of rock and minerals away. Water, acids, salt, plants, animals, and changes in temperature are all agents of weathering and erosion.
There are three types of weathering, physical, chemical and biological.
Weathering causes the disintegration of rock near the surface of the earth. Plant and animal life, atmosphere and water are the major causes of weathering. Weathering breaks down and loosens the surface minerals of rock so they can be transported away by agents of erosion such as water, wind and ice.

Petrography

Petrography is a branch of petrology that focuses on detailed descriptions of rocks.Someone who studies petrography is called a petrographer. The mineral content and the textural relationships within the rock are described in detail. The classification of rocks is based on the information acquired during the petrographic analysis. Petrographic descriptions start with the field notes at the outcrop and include macroscopic description of hand specimens. However, the most important tool for the petrographer is the petrographic microscope. The detailed analysis of minerals by optical mineralogy in thin section and the micro-texture and structure are critical to understanding the origin of the rock. Electron microprobe or atom probe tomography analysis of individual grains as well as whole rock chemical analysis by atomic absorption, X-ray fluorescence, and laser-induced breakdown spectroscopy are used in a modern petrographic lab. Individual mineral grains from a rock sample may also be analyzed by X-ray diffraction when optical means are insufficient. Analysis of microscopic fluid inclusions within mineral grains with a heating stage on a petrographic microscope provides clues to the temperature and pressure conditions existent during the mineral formation.

Coal Beneficiation

Coal beneficiation is a process by which the quality of raw coal is improved by either reducing the extraneous matter that gets extracted along with the mined coal or reducing the associated ash or both.

Coal beneficiation processes prior to utilization may also serve as a means of reducing the levels of at least some trace elements.Coal beneficiation, or coal preparation as it is also termed, refers to the processes through which inorganic impurities are separated from raw mined coal, thereby providing improved combustion characteristics to the fuel produced. The separation processes used are primarily based on exploiting the physical differences between the organic (i.e., coal) and inorganic (i.e., ash) components. Given the low unit value of coal, it is imperative for these separation processes to be both efficient and cost effective. The most commonly used processes are jig washing, density separation, sizing, and froth flotation. Typical configurations divide the run of mine coal into size fractions and utilize different separation processes for each size fraction.

GCV OF COAL

The best equation has the following form: GCV= 25.284 (M) + 30.572 (Ash) + 62.127 (VM) + 138.117 (FC) - 2890.095. The result is in agree with previous work that equation involving four independent variables i.e. moisture (M), ash, volatile matter (VM) and fixed carbon (FC) provides the most accurate estimation of GCV.

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NCV OF COAL

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. The calorific value of coal varies considerably depending on the ash, moisture content and.

Procedure to Calculate Calorific Value

Net Calorific Value (NCV) means lower heating value (LHV) i.e. lower calorific value (LCV) is determined by the subtraction of heat of vaporization of the water vapour from the higher heating value. Latent heat corresponding to the partial pressure of water vapour in Kcal/kg.

FUNDAMENTAL STUDY ON CARBONIZATION

Process Biometrics:-

The fundamental study on carbonization characteristic of low rank coal under low temperature was investigated by using a laboratorium scale electric furnace. In this experiment, the mass decreasing fraction of coal during carbonization, the bahaviour of volatile matter and the changes of fixed carbon as well as gas composition during carbonization was carried out. The effect of fixed carbon content in fuel on iron quality is also investigated. The experimental method for investigation of low rank coal carbonization characteristic was selected by variation of the carbonization temperature and nitrogen was introduced as a carrier gas. The

experimental result shows that the mass decreasing fraction of coke was increased with the carbonization period. The fixed carbon content in coke was increased with the carbonization temperature. The gas composition during carbonisation shows consist of argon (Ar), carbon monoxide (CO) and methane (CH 4). It shows that the CO gas is dominated of the amoung them. It is shown that the iron surface hardness may affect on carburizing media.

CONCLUSION

The effect of carbonization temperature on coal mass reduction. During the carbonization process is taking place. N2 is injected to the furnace at flow rate 10 L/min. N2 is used as carrier gas to protect air goes into the furnace, that possibly occur because of leakage. Carbonization process is accomplished for 30 minutes. As the carbonization temperature increases, the coal content will be decomposed. As a result, the coal mass will reduce as carbonization process.

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