STUDY OF THE CHEMICAL COMPOSITION AND ENERGY VALUE OF WOODY BIOMASS SPECIES

A THESIS SUBMITTED IN PARTIAL FULFILMENT
OF THE REQUIREMENT FOR THE DEGREE OF

Bachelor of Technology

in

Metallurgical and Materials Engineering

By

SURAJEET KUMAR DUTTA

Department of Me

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Under the Guidance of
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2008

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Rourkela

CERTIFICATE

This is to certify that the thesis entitle, “STUDY OF THE CHEMICAL COMPOSITION AND ENERGY VALUES OF BIOMASS SPECIES” submitted by Mr. SURAJEET KUMAR DUTTA in partial fulfillment of the requirements for the award of Bachelor of Technology Degree in Metallurgical and Materials Engineering at the National Institute of Technology, Rourkela is an authentic work carried out by him under my supervision and guidance. To the best of my knowledge, the matter embodied in the thesis has not been submitted to any other University / Institute for the any Degree or Diploma.

Date:

Prof. M.KUMAR

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CONTENTS

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ABSTRACT:-

In spite of its natural sources, India depends on other countries in terms of energy production, and a transfer from conventional fossil sources to sustainable energy sources is strongly necessary because due to the increasing demand of the energy. Among the sustainable energy sources, biomass is the subject of this study. The characteristics, logistic aspects, environmental aspects, economical, legal and technical aspects are investigated in order to show that the possible biomass co-firing is very important for the construction of economic, sustainable and environmentally friendly energy systems. The aim of the present project work is to determine the calorific value and the proximate analysis of different component of the woody biomass species such as eucalyptus and chakunda. The calorific value and the proximate analysis of the different component of the biomass will help in estimating its future utilization in different industries such as thermal power plant, iron making industries, other metallurgical industries, for generation of energy etc. The aims of the present project works have been to analyze the proximate analysis and calorific value of the woody biomass species. From the proximate analysis we came to the conclusion that ash content of the woody biomass is very low and the volatile matter content is very high as compared to Indian Coal. The calorific value of the biomass species is quite comparable to that of the coal. Any approach towards utilizing the woody biomass species would be positive step towards the energy and environmental crisis.

LIST OF TABLES:-

LIST OF FIGURES:-

CHAPTER:-1

INTRODUCTION

INTRODUCTION

Although India has most of the energy resources, it is an energy importing country, since its resources are limited. More than one third of its main energy uses is share by imports and its share is increasing continuously. Therefore, if the country wants to supply its demand of energy by its own resources and become less dependent on foreign resources, the policy about using conventional energy resources (i.e. fossil fuels, such as hard coal, lignite, oil and natural gas) should be converted to renewable energy resources, and this must be realized in a reasonable period of time.

Continuity of industrial and social life strongly depends on the energy supply. Although energy is indispensable in our lives, consumption of the large amounts of fossil fuels causes many serious problems. Most significant critical environmental problems are global warming which is due to the absorption of infrared radiations by greenhouse gases (CO_2, H_2O, CH_4 etc.), acid rains due to SO_2 and NO_x emissions and carbonaceous particulate matter and other emissions. One possibility to reduce greenhouse-gas, SO_2 and NO_x emissions of coal is co-firing; to burn low-sulfur and low-nitrogen-biomass together with coal in pulverized coal-fired boilers or fluidized beds. In order to decide the type of the biomass that will be used in the industries, determination of the combustion characteristics of the biomass such as, calorific value, ash properties and elemental analysis, is very important. On the other hand, the final decision on the usage of the biomass is closely related with the economical feasibility of the biomass.

1.1 ENERGY SOURCES

It is well known that fossil fuel reserves are very limited in nature and these reserves are expected to last for a maximum of 100 years from now. Thermal power and metallurgical industries are considered to be the major consumers of coals. Thermal power plants emit a large amount of pollutants, such as carbon dioxide, sulphur oxide, fly ash, etc which are hazardous for human survival on the earth planet. Hence, scientists and technocrat's world over are in search of alternative sources of energy whose exploitation is not harmful for the human beings. There are many alternative energy sources and Biomass is one of them. In view of fast depletion of fossil fuel resources for power generation and growing concern over the environmental degradation caused by conventional power plants, electricity generation from biomass is becoming attractive through out the world. Sustainable production and utilization of biomass in power generation can solve the vital issues of atmospheric pollution, energy crisis, wasteland development, rural employment generation and power transmission losses. Thus, the development of biomass-based power generation system is thought to be favorable for majority of the developing nations including India. Unlike other renewable, biomass materials, predried up to about 15% moisture, can be stored for a considerable period of time without any difficulty. Besides electricity supply to the national grids, biomass offers tremendous opportunities for decentralized power generation in rural areas at or near the points of use and thus can make villagers/ small industries self dependent in respect of their power requirements. Literature (Indian energy sector, 2000) reveals the decentralized power generation systems reduce peaking loads and cost of maintenance of transmission and distribution network.

For exploitation of biomass species in electricity generation, characterization of their various properties like energy values, chemical compositions, reactivities towards oxygen, bulk densities, etc. is essential. The present project work deals with the studies on proximate analysis, and energy value of different components of eucalyptus and chakunda. Till recently, these biomass species have no commercial value and are under-exploited. However, they have several advantages as fuel crops. They are fast growing and reach maturity in three to four years only. They can grow on poor and semi-desert land surviving with relatively little water.

1.2 ALTERNATE SOURCES OF ENERGY

In view of energy and environmental problems associated with the use of fossil fuels in power generation, scientist and technocrats, world over, are in search of the suitable substitute of fossil fuels for power generation. The various alternative sources of energy having a potential to be utilized in power generation are as follows:

1.2.1 SOLAR ENERGY

Solar Energy is the radiant energy produced in the sun as a result of nuclear fusion reactions. It is transmitted to the earth through space in quanta of energy called photons, which interact with the earth's atmosphere and surface. The strength of solar radiation at the outer edge of the earth's atmosphere when the earth is taken to be at its average distance from the sun is called the solar constant, the mean value of which is 1.37 × 106 ergs per sec per cm2, or about 2calories per min per cm2. Out of the energy transmitted from the Sun, the upper atmosphere of Earth receives about 1.5 × 1021 watt-hours (thermal) of solar radiation annually. This vast amount of energy is more than 23,000 times that used by the human population of this planet, but it is only about two-billionth of the Sun's massive outpouring—about 3.9 × 1020 MW. Solar radiation is attenuated before reaching Earth's surface by an atmosphere that removes or alters part of the incident energy by reflection, scattering, and absorption. In particular, nearly all ultraviolet radiation and certain wavelengths in the infra-red region are removed. However, the solar radiation striking Earth's surface each year is still more than 10,000 times the world's energy use. Radiation scattered by striking gas molecules, water vapor, or dust particles is known as diffuse radiation. Clouds are a particularly important scattering and reflecting agent, capable of reducing direct radiation by as much as 80 to 90%. The radiation arriving at the ground directly from the Sun is called direct or beam radiation. Global radiation is all solar radiation incident on the surface, including direct and diffuse. Solar research and technology development aim at finding the most efficient ways of capturing low-density solar energy and developing systems to convert captured energy to useful purposes. Solar energy can be converted to useful work or heat by using a collector to absorb solar radiation, allowing much of the Sun's radiant energy to be converted to heat. This heat can be used directly in residential, industrial, and agricultural operations; converted to mechanical or electrical power; or applied in chemical reactions for production of fuels and chemicals.

1.2.2 WIND ENERGY

Wind energy systems generate electrical energy by harnessing the power in wind using machines called wind turbines. Wind energy can be stand-alone applications or can be produced centrally and distributed to the electric grid. Wind is a form of solar energy, caused by the uneven heating of the earth's surface. This occurs at local, regional and global scales. Wind which flows close to the earth's surface is slowed down due to friction, which causes turbulence and gusting. The higher above the ground one goes, the faster the wind travels due to less resistance. Wind plants or wind turbines are available in a variety of configurations with various outputs. Typically, these plants produce either direct current (DC) or alternating current (AC) electricity. DC wind plants are used to charge batteries or produce heat/electricity without storage. AC wind plants are used to produce electricity for direct use or to supply energy to a utility grid. Water-pumping wind energy systems are another type of wind energy application; these use wind to produce mechanical energy to pump water, typically for agricultural applications. There are several types of wind systems in use. Some wind plants have a vertical axis wind turbines (VAWT) and others have a horizontal axis (HAWT). HAWTs are most common; VAWTs may look something like an egg-beater. Various wind plant designs use gearboxes, belts or direct drives. Some have rotor blades which change pitch to reduce loads and speed in high winds. Others have fixed pitch blades. Some HAWT designs face upwind and have tails, others face downwind with no tails.

1.2.3 GEOTHERMAL ENERGY

Geothermal energy is produced by the internal heat of the Earth. This heat rises towards the surface, warming volumes of water between a few hundred and about 3,000 metres down. These volumes of hot water (called “geothermal deposits”) can be used to provide heat or electricity depending on their temperature. Very low-energy deposits – water between 10 and 50°C at a shallow depth – can be used to heat greenhouses, swimming pools and sometimes buildings (e.g., the Maison de la Radio in Paris). Low-energy deposits – water between 50 and 90°C at a depth of between 1,500 at 2,000 metres – can be used to supply district heating (in France, the largest deposit is in the Paris region). Medium-energy deposits – water between 90 and 150° C at a depth of between 2,000 and 2,500 metres – are used to supply electricity in certain countries (in France, there are only two small deposits). High-energy deposits – pressurized steam or water at a temperature of 150 to 350°C not far below the surface – can be used to run turbines directly and supply electricity (in France, there is such a facility in Guadeloupe).

1.2.4 OCEAN ENERGY

Ocean thermal energy conversion, or OTEC, is a way to generate electricity using the temperature difference of seawater at different depths. The method involves pumping cold water from the ocean depths (as deep as 1 km) to the surface and extracting energy from the flow of heat between the cold water and warm surface water. OTEC utilizes the temperature difference that exists between deep and shallow waters — within 20° of the equator in the tropics — to run a heat engine. Because the oceans are continually heated by the sun and cover nearly 70% of the Earth's surface, this temperature difference contains a vast amount of solar energy which could potentially be tapped for human use. If this extraction could be done profitably on a large scale, it could be a solution to some of the human population's energy problems. The total energy available is one or two orders of magnitude higher than other ocean energy options such as wave power, but the small size of the temperature difference makes energy extraction difficult and expensive. Hence, existing OTEC systems have an overall efficiency of only 1 to 3%. The concept of a heat engine is very common in engineering, and nearly all energy utilized by human beings is used in some form or other. A heat engine involves a device that operates between a high temperature source and a low temperature sink. As heat flows from one to the other, the engine extracts some of the heat in the form of work. This same general principle is used in steam turbines and internal combustion engines, while refrigerators reverse the natural flow of heat by consuming some energy in the form of either heat or work. Rather than using heat energy from the burning of fuel, OTEC draws power on temperature differences caused by the sun's warming of the ocean surface.

1.2.5 NUCLEAR ENERGY

Nuclear energy is the energy stored in the nucleus of an atom and released through fission, fusion, or radioactivity. In these processes a small amount of mass is converted to energy according to the relationship $E = mc2$, where E is energy, m is mass, and c is the speed of light. The most pressing problems concerning nuclear energy are the possibility of an accident at a nuclear reactor or fuel plant, such as those which occurred at Three Mile Island of USA (1979), Chernobyl of Russia (1986), and Takaimura of Japan (1999), and the potential threat to the continued existence of the human race posed by nuclear weapons.

1.2.6 BIOMASS AND BIOENERGY

Biomass, in the energy production industry, refers to living and recently dead biological material which can be used as fuel or for industrial production. Most commonly, biomass refers to plant matter grown for use as biofuel, but it also includes plant or animal matter used for production of fibers, chemicals or heat. Biomass may also include biodegradable wastes that can be burnt as fuel. It excludes organic material which has been transformed by geological processes into substances such as coal or petroleum. It is usually measured by dry weight. Biomass contains stored energy from the sun. Plants absorb the sun's energy in a process called photosynthesis. The chemical energy in plants gets passed on to animals and people who eat these plants. Biomass is a renewable energy source because we can always grow more trees and crops, and waste will always exist. Some examples of biomass fuels are wood, crops, manure, and some garbage. When burned, the chemical energy in biomass is released as heat. In a fireplace, the wood that is burnt is a biomass fuel. Wood waste or garbage can be burnt to produce steam for making electricity, or to provide heat to industries and homes. Burning biomass is not the only way to release its energy. Biomass can be converted to other usable forms of energy like methane gas or transportation fuels like ethanol and biodiesel. Methane gas is the main ingredient of natural gas. Smelly stuff, like rotting garbage, and agricultural and human waste, release methane gas - also called "landfill gas" or "biogas." Crops like corn and sugar cane can be fermented to produce the transportation fuel, ethanol. Biodiesel, another transportation fuel, can be produced from left-over food products like vegetable oils and animal fats. Biomass fuels provide about 3 percent of the energy used in the United States. People in USA are trying to develop ways to burn more biomass and less fossil fuel. Using biomass for energy can cut back on waste and support agricultural products grown in the United States. Biomass fuels also have a number of environmental benefits.

1.3 BIOMASS: A REMEDY TO COMBAT ENVIROMENTAL POLLUTION

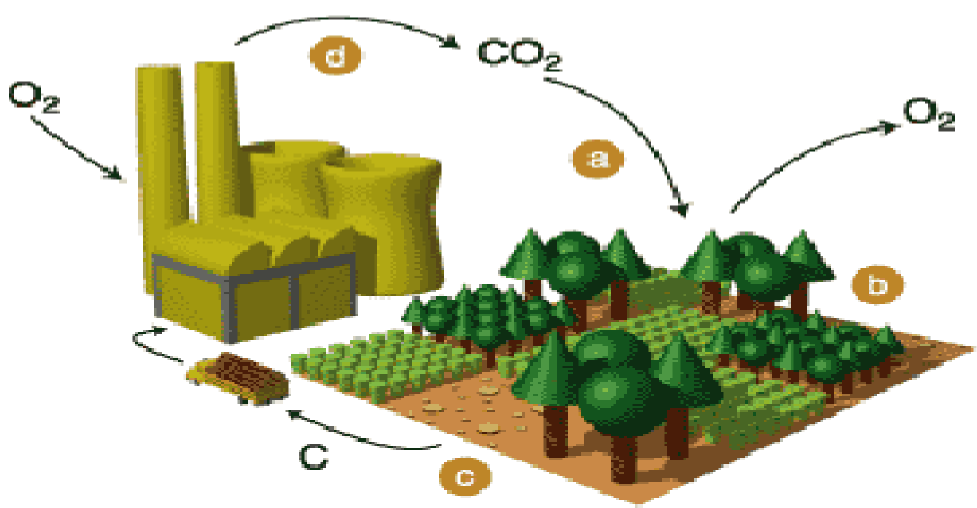
Air/Atmospheric Pollution is a major challenge faced by the world today and impacts all of us in so many different ways. Importantly, our ability to effectively address air pollution is fundamental to our pursuit of promoting sustained economic growth and sustainable development. Our approach in dealing with pollution issues is, therefore, built around the high priority accorded by developing countries to economic growth and poverty eradication. The decisions concerning the fight against air/atmosphere pollution should be guided by the understanding that economic development, social development and environmental protection are interdependent and mutually reinforcing components of sustainable development. Air pollution has serious negative impacts on human health, socio-economic development, ecosystems and cultural heritage. Urgent and effective actions are, therefore, required in regard to both indoor air pollution from traditional biomass cooking and heating and ambient air pollution from all sources. Indoor air pollution, we believe, must be accorded high priority, as it is in its worst form, a poverty-related manifestation. Air pollution is also increased by factors such as: natural disasters including volcanic eruptions, sand storms, desertification and land degradation, which cause health problems and disrupt peoples’ daily lives. Burning fossil fuels also releases air

Table 1.1: Biomass energy potentials and current use in different regions (Parikka, 2003)

Region	Biomass energy potentials (EJ/a)		Use (%)
	Woody	Non-Woody	
North America	12.8	7.1	16
Latin America	5.9	15.6	12
Asia	7.7	13.7	108
Africa	5.4	16.0	39
Europe	4.0	4.9	22
Former USSR	5.4	4.6	5
Middle East	0.4	0.3	7
World	41.6	62.2	38
Non – Woody biomass = Energy crops + straw + others(EJ = 10^{18} J)			

pollutants- sulphur oxides (SOx), nitrogen oxides(NOx), volatile organic compounds (VOCs; there are many), carbon monoxide (CO), and othertoxic compounds. SOx and NOx react in the atmosphere to produce particulate matter. NOx and some VOCs react in the atmosphere to produce ground-level ozone. Particles and ozone together make smog, which can travel long distances on the prevailing winds, or can be clamped close to the ground during a weather inversion (often little wind). Thus air pollution and weather are also linked. All of these air pollutants can cause serious health effects. Health effects are best understood for particulate matter smaller than 2.5 mg/m3 and ground-level ozone. There is no safe level of exposure to either of these substances. Increased levels of exposure may cause congestion, difficulty breathing, asthma attacks and occasionally death. PM2.5 is associated with an increase in heart attacks. Long-term exposure to PM2.5 is associated with low birth weight and reduced lung development in children. Health risks are higher in vulnerable populations – the very young, the elderly, those with pre-existing respiratory (such as asthma or COPD) or cardiovascular disease, or those exercising or doing strenuous work in locations with elevated air pollution. With rising temperatures associated with climate change air pollution may increase as a result of increased use of air conditioners which will cause power plants to burn more fuel. In those regions that have air pollution associated with warm weather (i.e. locations that have warm wind directions coming from heavily industrialized areas) a greater number of hot days will also mean a greater number of days with elevated air pollution and associated deleterious impacts on health. There have been an increasing number of instances where people have been exposed to the combination of unusually high temperatures and elevated air pollution. Days with these combined threats are likely to become more frequent as a result of climate change. High temperatures, especially over several days, and elevated air pollution have resulted in high mortality rates in some regions, for example in France in 2003 where thousands of deaths were attributable to air pollution and heat. Environmentally, biomass has some advantages over fossil fuels such as coal and petroleum. Biomass contains little sulfur and nitrogen, so it does not produce the pollutants that cause acid rain. Growing plants for use as biomass fuels may also help keep global warming in check. That's because plants remove carbon dioxide--one of the greenhouse gases-from the atmosphere when they grow. The combustion (direct or indirect) of biomass as a fuel also returns CO_2 to the atmosphere. However this carbon is part of the current carbon cycle: it was absorbed during the growth of the plant over the previous few months or years and, provided the land continues to support growing plant material, a sustainable balance is maintained between carbon emitted and absorbed. Biomass is practically free from sulphur, nitrogen and heavy metals (Hg, etc.), and has much lower ash content (1-3 wt. %) than coal (Kumar and Gupta, 1993). Hence, unlike fossil fuels, biomass use in electricity generation is not likely to pollute the atmosphere with SOx, NOx, SPM, etc.

Fig. 1.3 Carbon cycle



1. As trees in the energy plantation grow, they absorb carbon dioxide from the atmosphere.

2. During photosynthesis the trees store carbon in their woody tissue and oxygen is released back to the atmosphere.

3. At harvest, wood fuel is transported from the plantation to the heat or power generating plant.

4. As the wood is burned at the heat or power generating plant the carbon stored in the woody tissue combines with oxygen to produce carbon dioxide, this is emitted back to the atmosphere in the exhaust gases. The amount of additional biomass that grows over the course of a year in a given area is known as the annual increment. Provided the amount consumed is less than the annual increment its use can be sustainable and biomass can be considered a low carbon fuel and biomass CO_2 absorption and emission is in balance. For forestry in the UK, the annual timber increment is of the order of 20 million tonnes. On top of this is the increment of all the agricultural crops and other vegetation.

CHAPTER:-2

LITERATURE REVIEW

2.1 BIOMASS

Biomass is the term used to describe all the organic matter, produced by photosynthesis that exists on the earth's surface. Biomass is a renewable energy resource derived from the carbonaceous waste of various human and natural activities. It is derived from numerous sources, including the by-products from the timber industry, agricultural crops, raw material from the forest, major parts of household wastes and wood. With its zero emission of CO2, biomass is one of the most potentially rich resources of energy that is yet to be tapped to the utmost extent. The source of all energy in biomass is the sun, thus biomass acts as a kind of chemical energy store. Biomass is constantly undergoing a complex series of physical and chemical transformations and being regenerated while giving off energy in the form of heat to the atmosphere. Biomass does not add carbon dioxide to the atmosphere as it absorbs the same amount of carbon in growing as it releases when consumed as a fuel. Biomass recycles carbon from the air and spares the use of fossil fuels, reducing the need to pump additional fossil carbon from ground into the atmosphere. Biomass comes from green plants which actively absorbs carbon dioxide from the atmosphere and converts it into sugars, which are then stored in long molecules like cellulose. Eventually this plant carbon is returned to the atmosphere by natural decay process including the breakdown of cellulose. We can intervene in this process by breaking down cellulose to glucose in bio mass processing plants, and then converting the sugars to ethanol, which is a substitute for gasoline. Using ethanol made from biomass, sugars reduce the need for fossil fuels like gasoline. Ethanol can also be used to power fuel cells and is easier to store and distribute than gaseous hydrogen. Its advantage is that it can be used to generate electricity with the same equipment or power plants that are now burning fossil fuels. Biomass is an important source of energy and the most important fuel worldwide after coal, oil and natural gas.

2.2 BIOFUEL FROM BIOMASS

Traditionally the extraction of energy from biomass is split into 3 distinct categories:

2.2.1 SOLID BIOFUEL

These include the use of trees, crop residues, animal and human wastes (although not strictly a solid biomass source, it is often included in this category for the sake of convenience), household or industrial residues which are used for direct combustion to provide heat. Often the solid biomass will undergo physical processing such as cutting, chipping, briquetting, etc. but retains its solid form. Also compressed peat and dry bagasse come under this category which can be burnt to get heat as a form of energy.

2.2.2 LIQUID BIOFUEL

These are obtained by subjecting organic materials to one of various chemical or physical processes to produce a usable, combustible, liquid fuel. Biofuels such as vegetable oils or ethanol are often processed from industrial or commercial residues such as bagasse (sugarcane residue remaining after the sugar is extracted) or from energy crops grown specifically for this purpose. Biofuels are often used in place of petroleum derived liquid fuels. Liquid biofuels basically consist of liquid extracted from biomass and used for the production of other useful chemicals. This liquid stream consists of bio fuels called BIOOIL .It is dull black-brown liquid and remains in liquid form at room temperature. This consists of many chemicals mainly ethanol, acetone, acetic acid etc.

2.2.3 GASEOUS BIOFUEL

Gaseous fuels such as biogas are obtained by anaerobically (in an air free environment) digesting organic material to produce a combustible gas known as methane. Animal waste and municipal waste are two common feedstocks for anaerobic digestion. Gaseous bio-fuels obtained from biomass decomposition contain primarily hydrogen, methane, carbon monoxide, ammonia and other gases depending upon the organic nature of biomass and the process condition.

2.3 BIOMASS RESOURCES

As mentioned earlier, natural biomass resources vary in type and content, depending on geographical location. For convenience sake, we can split the world’s biomass producing areas into three distinct geographical regions:

2.3.1 TEMPERATE REGION

These provide wood, crop residues, such as straw and vegetable leaves, and human and animal wastes. In Europe short rotation coppicing (SRC) has become popular as a means for supplying wood fuel for energy production on a sustainable basis. Fast growing wood species, such as willow are cut every two to three years and the wood chipped to provide a boiler fuel. In the UK there is a functioning 12.6 Megawatt power plant which burns poultry litter (which has relatively low moisture content) as fuel and others which burn wheat straw. There are also many non-woody crops which can be grown for production of biofuels and biogas, and investigation of energy crops for direct combustion is underway. In western countries, where large quantities of municipal waste are generated, this is often processed to provide useful energy either from incineration or through recovery of methane gas from landfill sites.

2.3.2 ARID AND SEMI ARID REGION

These produce very little excess vegetation for fuel. People living in these areas are often the most affected by desertification and often have difficulty finding sufficient wood as fuel.

2.3.3 HUMID TROPICAL REGION

These produce abundant wood supplies, crop residues, animal and human waste, commercial, industrial and agro- and food-processing residues. Rice husks, cotton husks and groundnut shells are all widely used to provide process heat for power generation, particularly. Sugarcane bagasse is processed to provide ethanol as well as being burned directly; and many plants, such as sunflower and oil-palm are processed to provide oil for combustion. Many of the world's poorer countries are found in these regions and hence there is a high incidence of domestic biomass use. Tropical areas are currently the most seriously affected by deforestation, logging and land clearance for agriculture.

2.4 BIOMASS AND ITS GENERATION

It can be said that carbons obtained from biofuels are better than those emitted by that of fossil fuels because it does not lead to a net increase in atmospheric carbon concentrations. The carbon released by biofuels to the atmosphere was originally derived through photosynthesis by plants that used CO2 from the atmosphere's carbon sink.

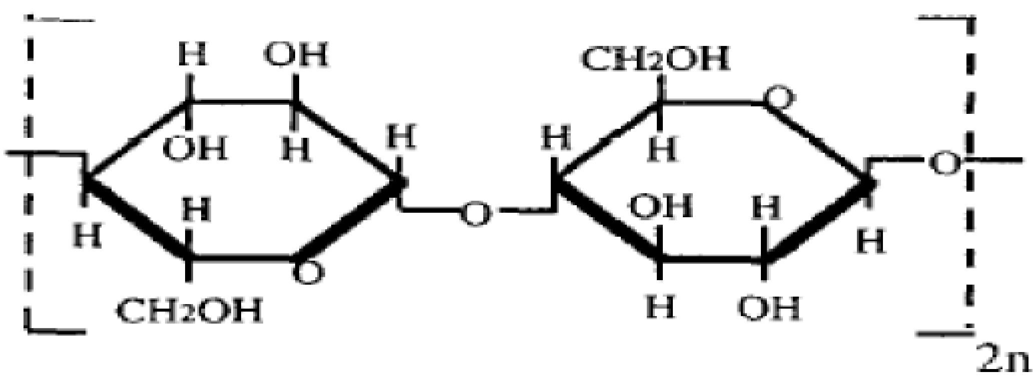


Fig. 2.1. The structure of cellulose, (C 6H 100 5) "3 the primary polymer in wood.

2.4.1 PHOTOSYNTHESIS

$$6CO_2 + 6O_2 + \text{Solar Energy} = C_6H_{12}O_6 + 6O_2$$

Fossil fuels on the other hand increase atmospheric CO2 because the carbon is from the prehistoric carbon that over time and under pressure accumulated in the form of coal, petroleum and natural gas. It can be said that the carbon of fossil fuels comes from a separate, older sink than the terrestrial and atmospheric sinks and therefore leads to net increase in carbon and carbon dioxide levels in the atmospheric sinks. Carbon obtained from biomass is naturally converted back to CO2 through respiration and degradation.

2.4.2 RESPIRATION

$$C_6H_{12}O_6 + 6O_2 = 6H_2O + 6CO_2 + \text{energy}$$

Through other means biomass can be converted to CO2 while providing energy for human usage. Thus one can say that biofuels are forms of renewable sources of energy and alternatives to fossil fuels. Biomass, like coal can be burned to produce steam, heat and electricity, or it can be converted to a liquid fuel such as bioethanol.

2.5 TRANSFORMATION OF BIOMASS INTO DIFFERENT FUEL

Biomass can be converted into biofuels by three main processes:-

1. Physical Process.
2. Biological Process.
3. Thermo Chemical Process.

2.5.1 PHYSICAL PROCESS

In this process, the biomasses used are oil rich seeds. Oils are extracted from oilseeds and the extracted oil is refined by etherification with alcohol to reduce viscosity and improve the quality of biofuels.

2.5.2 BIOLOGICAL PROCESS

In biological process, wet biomass is used as raw materials. The wet biomass is treated with micro-organisms in the presence or absence of oxygen for a longer time. The main products obtained in this process are Bioethanol and Bio-Gas. Biological processes are of two types:- Fermentation and Anaerobic Digestion

2.5.2.1 FERMENTATION

Bio-ethanol is generally produced by fermentation of sugar components of Biomass

Feedstocks for the process are sugar cane and sugar beets which store the Energy as simple sugars, baggase, other plants which store the energy as more complex sugars like starch, cellulosic biomass that is made of very complex sugar polymers, etc. Complex polysaccharides are converted to simple sugars by hydrolysis. During Hydrolysis, acids and catalysts are used to catalyze the reaction. Then sugars are converted to ethanol by the fermentation process using yeast or bacteria as catalyst.

2.5.2.2 ANEROBIC DIGESTION

In this process, the biomass is treated with micro-organisms like yeast in absence of oxygen to produce biogases, the main product being Methane. Depending upon the solid content in biomass, the anaerobic digestion process is classified into two categories:- Dry Digestion and Wet Digestion

In dry digestion process, solid content is 25-30% while in wet digestion the solid content should be less than 15%. Solid content of biomass play an important in designing the reactor and the economy of the process.

2.5.3 THERMO CHEMICAL PROCESS

In these processes, the feedstock is heated in the presence (or absence) of oxygen or water for a considerable amount of time. The products thus obtained are fuel gases and bio-oils, which can used as fuels directly or are blended with other fuels to increase the efficiency or can be treated by various processes to produce a myriad of energy rich and useful chemicals of various proportions. The different thermo-chemical processes are:-

2.5.3.1 COMBUSTION

It involves complete oxidation of carbon to CO2 accompanied by release of substantial amount of energy which is used up as soon as possible. It includes direct burning of wood, bark of wood, burning of bagasse in boilers, cow dung cakes and detritus of other animals which results in release of energy. This is a very common method of obtaining energy and this practice has been followed by humans for centuries and it is still being followed up. But the thermal efficiency of this process is very low and it is behest with emission related problems.

2.5.3.2 GASIFICATION

Biomass can be converted into Synthesis Gas consisting mainly of Carbon monoxide, Carbon Dioxide and Hydrogen by a high temperature heating process. In this process, the temperature range is high and so is the residence time and the products is mainly gaseous in nature. Normally the gases produced using gasification processes are either used in boilers or for the production of valuable chemicals.

2.5.3.3 PYROLYSIS

Pyrolysis is the chemical decomposition of organic materials by heating in the absence of oxygen or any other reagents, except possibly steam. In some cases catalysts are used to enhance the efficiency. The temperature ranges from around 350^{o}C to 700^{o}C and the products are vapours, char and bio-oil which can further decompose into tar. It is a thermally initiated depolymerization process also known as "Thermolysis**",** which doesn't involve any oxidizing agent. Sometimes with limited supply of oxidizing agent and controlling the reaction leads to partial gasification.Pyrolysis products basically consist of gases like CH4, CO2, and NH3.and liquids like acetone, acetic acid etc. and solid char. With increasing research in this field, it is believed by various research personnel that pyrolysis (to be specific fast pyrolysis) is one of major areas of development and with slight modification in the process or the process condition, it might act as a proper methodology for the conversion of biomass into biofuels in order to make up the shortcomings, arising due to the depletion of fossil fuels.

2.5.3.4 DIRECT HYDROTHERMAL LIQUEFACTION

Direct hydrothermal liquefaction involves converting biomass to an oily liquid by contacting the biomass with water at elevated temperatures (300-350°C) with sufficient pressure to maintain the water primarily in the liquid phase (12-20 MPa) for residence times up to 30 minutes. Alkali may be added to promote organic conversion. The primary product is an organic liquid with reduced oxygen content (about 10%) and the primary byproduct is water containing soluble organic compounds.

2.8 ADVANTAGES OF BIOMASS OVER OTHER ALTERNATE ENERGY SOURCES

1. Biomass can be used as a necessary source on decentralized basis.
2. Very clean fuel i.e. the ash content varies between 1.0-3.0%
3. Energy resource like nuclear power plant or hydroelectric power requires high installation cost.
4. Again production of wind energy and solar energy is not viable in all the places.

2.7 IMPORTANT APPLICATION OF BIOMASS

1. Biomass can be used for production of metallurgical coke, which has great importance in metallurgical industries. Ex: - for iron making, gold extraction, for production of some alloys.
2. Chemical industries: -in manufacture of ink, activated carbon ,pyrolytic carbon.
3. Pharmaceutical industries: -for manufacture of medicines.
4. Biomass can have tremendous application in power generation in thermal power plant and other industries.

CHAPTER: - 3

EXPERIMENTAL PROCEDURE

3.1 AIMS AND OBJECTIVE OF THE PRESENT PROJECT WORK

- Selection of agricultural based biomass species and estimation of their generation by field trial.
- Determination of proximate analysis (% moisture, % volatile matter, % ash and % fixed carbon contents) of their different components, such as stems, branch, leaf and bark..
- Characterization of these biomass components for their energy values (calorific values).
- Comparative study of the data with the fossils fuel to be use in various industries**.**
- To investigate and study the technological, logistic and environmental aspect of the biomass species.

3.2 AIM OF THE PRESENT PROJECT WORK

- The aims of the present project work have been to characterize the proximate analysis of different components of woody biomass like Chakunda and Eucalyptus.
- The second aim was to calculate the calorific value of different components of the woody biomass species.

3.3 EXPERIMENTAL PROCEDURE

- Selection of the woody biomass, the species like eucalyptus and chakunda are collected from the local areas and different component like stem, bark, leaves and trunk are separated for further procedure.
- Separated components are then air dried for around fifteen days.
- Preparation of the samples of different component for the proximate analysis and calorific value determination, separated component are grounded to mesh size of less than 72.

3.4 Materials selections

In the present project work, four different types of non-woody biomass species were collected from the local area and their components (stump, bark, leaf, flower and branch) were removed separately and kept for air drying in a cross ventilated room for about a month. The moisture contents of these components reached in equilibrium with that of the atmospheric air in one month. Three non-coking coal samples of three different mines of Orissa were also collected for comparative study. The local and botanical names of the biomass species, selected for present project work, have been outlined in the table. The air dried biomass samples were crushed into powders and then processed for their proximate and ultimate analysis and calorific value determination.

3.5 Proximate Analysis

Analysis for moisture, volatile matter, ash and fixed carbon contents were carried out on samples ground to -72 mess size by standard method Table 4.5. The details of these tests are as follows.

3.5.1 Moisture Determination

One gram of air dried powdered sample of size -72 mess was taken in a borosil glass crucible and kept in the air oven maintained at the temperature 110°C.The sample was soaked at this temperature for one hour and then taken out from the furnace and cooled in a dessicator. Weight loss was recorded using an electronic balance. The percentage loss in weight gave the percentage moisture content in the sample.

Percentage of moisture= loss in weight *100/Wt. of sample taken

3.5.2 Volatile Matter Determination

One gram of air dried powdered sample of size -72 mess was taken in a volatile matter crucible (made of silica) and kept in the muffle furnace maintained at the required temperature of 925°C.The sample was soaked at this temperature for seven minutes and then crucible was taken out from the furnace and cooled in air. Weight loss in the sample was recorded by using an electronic balance having a sensitivity of 0.001grams.The percentage loss in weight – moisture present in the sample gives the volatile matter content in the sample.

Percentage of volatile matter= loss in wt. due to removal of V.M/wt. of sample taken.

3.5.3 Ash Content Determination

One gram of air dried powdered sample of size -72mess was taken in a shallow silica disc and kept in the muffle furnace maintained at the temperature of 775-800°C.The sample was kept in the furnace till complete burning. Weight of ash formed was noted down and the percentage ash content in the sample was determined.

Percentage of ash= wt. of ash left *100 /Wt. of sample taken

3.5.4 FIXED CARBON CONTENT

The fixed carbon content in the sample was determined by using the following formula:

Percentage of fixed carbon=100- % of (moisture + volatile matter + ash)

3.6 CALORIFIC VALUE

For the determination of the calorific value pellets are prepared from the fine powder of the different component.The Calorific Values of the biomass samples were measured in a Bomb Calorimeter Apparatus. In this test an over dried sample briquette of weight 1gm(approx.) was taken in a bomb and oxygen gas was filled into this bomb at a pressure of 25-30 atm. The sample was then fixed inside the bomb and rise in temperature of water was noted with the help of Beckman Thermometer. The calorific value was calculated by using the following formula:

- Gross Calorific Value = (W.E X Δ T) / W_o – (fuse wire + thread connections)

  Where, W.E = water equivalent of the apparatus(2350 kcal/kg)

  ΔT = Maximum rise in temperature in °C.

  W_o = Initial weight of briquette sample.

CHAPTER: - 4

RESULT AND DISCUSSION

4.1 RESULT AND DISCUSSION

On the basis of the proximate analysis done on different component of the woody biomass species, chakunda and eucalyptus the result obtained are listed in the table 4.1

TABLE:-4.1 PROXIMATE ANALYSIS OF DIFFERENT COMPONENTS OF WOODY BIOMASS SPECIES CHAKUNDA AND EUCAPLPTUS

Sl no:	Different components:-	Moisture content (%)	Volatile Matter Content (%)	Ash Content (%)	Fixed Carbon Content (%)
1	Chakunda Leaves	8.0	68.0	9.0	15.0
2	Chakunda Bark	6.0	67.0	9.0	18.0
3	Chakunda Trunk	7.0	71.0	9.0	13.0
4	Chakunda Stems	5.0	69.0	5.0	21.0
5	Eucalyptus Leaves	7.0	70.0	6.0	17.0
6	Eucalyptus Trunk	7.0	66.0	10.0	17.0
7	Eucalyptus Bark	4.0	67.0	8.0	21.0
8	Eucalyptus Stems	7.0	69.0	1.0	23.0

The Proximate Analysis of the different component of the woody biomass such as Eucalyptus and Chakunda reveals that the biomass component have a very low ash content compared to that of coal. It is also found that the moisture content of the biomass is very low that is less than 10 % and studies reveal that it can be further reduced to a very low level of around less than 3% through air drying in the sun and oven drying. Ash content and the moisture content are the most undesirable component of a fossil fuel and since biomass possesses a very low ash and moisture content and hence it can be used economically in place of fossil fuels.

From the above results it is found that the biomass species like chakunda and eucalyptus have very high volatile matter content, low ash content, appreciable calorific value. These properties are highly desirable for the biomass to be used for the production of biogas for generation of electricity, for production of methane by digestion, for production of biodiesel, in the thermal power plant etc. It can be economically used in Iron Making by by converting into charcoal, i.e. its carbon content can be improved by carbonization. Freshly filled non-woody biomass components contain a large amount of free moisture, which must be removed to decrease the transportation cost and increase the calorific value. In the plant species selected for the present study, the time required to bring their moisture contents into equilibrium with that of atmosphere was found to be in the range of 2-2.5 weeks during the summer season (temperature :37-42°C and humidity:10-25%).

TABLE 4.2. CALORIFIC VALUES OF DIFFERENT COMPONENTS OF WOODY BIOMASS SPECIES CHAKUNDA AND EUCALYPTUS.

Sl no:	Different components:-	Calorific Value (kcal/kg) (on air dried basis)
1	Chakunda Leaves	4113.45
2	Chakunda Bark	4344.07
3	Chakunda Trunk	3947.02
4	Chakunda Stems	3421.04
5	Eucalyptus Leaves	4549.82
6	Eucalyptus Trunk	4594.31
7	Eucalyptus Bark	3300.75
8	Eucalyptus Stems	3697.31

The calorific values of the fuels/energy source are important criteria for judging its quality and it gives an idea about the energy value of the fuel. Calorific values table 4.2 clearly indicates that among the two studied biomass species Chakunda and Eucalyptus, Eucalyptus components (trunk and leaves) have the highest energy values. The pattern of variation of calorific value in the components like stem, bark, leaves and trunk is not identical for all the presently studied biomass species. The elements which are responsible for imparting calorific value to the fuel are carbon, hydrogen and sulphur. The calorific values of carbon; hydrogen and sulphur are 8,080 K cal/kg, 34,500 K cal/kg, and 2,200 K cal/kg respectively. Therefore variations in calorific values of these four biomass species and their components are clearly due to the difference in the contents of these elements.

TABLE:- 4.3 PROXIMATE ANALYSIS AND CALORIFIC VALUE OF COAL OBTAINED FROM DIFFERENT MINES OF ORISSA(INDIA)

Coal mine	Proximate analysis (wt.%, dry basis)			Calorific value (Kcal/kg) dry basis
	Volatile matter	Ash	Fixed carbon	
Lakhanpur	21.21	52.24	26.55	3938
Siding	30.62	44.30	25.08	4952
Hingola	21.90	59.83	18.27	3355
Yeurve	35.66	38.90	25.44	4682
Kalinga	24.77	50.77	24.46	4237
Jagannath	31.10	52.68	16.22	4660

Comparison of data listed in Tables 4.1 to 4.3 indicates that in contrast to coals included in the present study, woody biomass materials have comparable calorific values and much lower ash contents and also having moisture content less than 10%. This is definitely an advantage over fossil coals. It is thus obvious that these biomass materials will result in higher power output in the Power Plant and can be used economically in the Iron Making industries and can thus help in overcoming the environmental and energy crisis in India.

CHAPTER-5

CONSTRAINTS AND SUGGESTIONS

5.1 CONSTRAINTS IN PROMOTING ENERGY CULTIVATION

In view of the vast natural resources in the form of wasteland, sunshine, etc., the most promising solution to energy crisis in tropical countries (including India) appears to be the utilization of solar energy through energy plantations. Until recently, biomass production and conversion have attracted little attention from scientists and technologists. The following could be some of the reasons for the lack this lack of interest.

• Research and development on the production and utilization of biomass falls under different disciplines of science, i.e., agriculture, chemical and metallurgical engineering. The lack of encouragement and recognition of interdisciplinary research in the past might have left a gap, and thus certain areas of science remained neglected.

• With cheap and abundant supplies of fossil fuel, there has been little incentive to explore renewable energy sources in past. It is the combined effect of awareness of energy and environment problems in the recent past that has led to the development of alternative energy sources. However, a higher pace of development is needed to solve the problem within a certain time frame, before it is too late.

• Many times, concern is expressed that utilization of wood will further reduce forest cover and spoil the ecology of the region. This concern is unfolded. The present study does not propose the use of existing forest cover but, instead, suggests utilizing wasteland for energy plantation. This energy cultivation in wasteland will aid natural forest cover. From the total man made forest, only 33% of the area would be harvested at one time on a 2-year rotational basis. This process would leave 67% of the area to be added to the natural forest cover, which will help in improving the environment of the region.

• To design the best use of wastelands, more information is needed regarding topology, climate, existing vegetation, type of soil, the water situation, etc. This information will help determination what type of fast growing plant will thrive in a particular region.

5.2 SUGGESTIONS

(1) Important knowledge and new technical information related to sustainable biomass production and its efficient utilization need to be synthesized and transferred to the share holders.

(2) The economic, environmental and social aspects of biomass production systems need to be assessed and examined, and the criteria helping to ensure their sustainability must be examined.

(3) A system should be developed for successful collection and transportation of biomass species to energy generation plants.

(4) Care must be taken to ensure that the intrinsic values and benefits, derived from our natural resources, must remain unchanged over multiple generations.

(5) Interdisciplinary research works on production; conversion and utilization of biomass need to be encouraged.

(6) Energy cultivation in wasteland and a system for successful collection and transportation of biomass materials to the power plants and furnaces need to be developed.

(7) Village energy committees may be set up to look after and ensure the sustainability of biomass-based power plants need for energy plantation etc. should be created.

(8) Awareness among the people about the various aspects of biomass-based power plants, need for energy plantations, etc. should be created.

(9) Financial assistance from the government need to be provided to encourage the development of such projects.

CHAPTER:-6

CONCLUSION

6.1. CONCLUSION

In the present work two woody biomass species chakunda and eucalyptus were selected. Experiments to determine the proximate analysis and calorific values was done on each of the components of the selected species such as leaves, stem, bark and trunk, were performed.

The following are the different conclusions drawn from the present work:

1. From the above results it is found that the biomass species like chakunda and eucalyptus have very high volatile matter content, low ash content, appreciable calorific value. These properties are highly desirable for the biomass to be used for the production of biogas, for generation of electricity, for production of methane by digestion, for production of biodiesel, in the thermal power plant etc..

2. In contrast to locally available coals, all the studied plant species showed higher and in some case nearly similar energy values but much lower ash and high volatile matter contents. This indicates higher power generation potential in biomass than coals.

3. The present study could be useful in the exploitation of woody biomass species in different furnaces and power plants etc.

4. Due to its low carbon content it will be not economical for the iron making industries as it cannot be used for the reduction of iron ores. But its carbon content can be improved from the by carbonization.

6.2 SUGGESTIONS FOR THE FUTURE WORK

The present study was concentrated on two woody biomass species, such as Chakunda and Eucalyptus. The following works are suggested to be carried out in future.

- Similar type of study need to be extended for another woody biomass species available in the region.
- The powdered samples of these biomass species may be mixed with coal in different ratios and the electricity generated potential of the resultant mixed briquettes may be studied.
- The biomass species may be mixed with cow dunk, sewage wastes, etc in different ratios and the electricity generated potentials of the mixtures may be determined.
- New techniques of electricity generation from biomass species may be developed. The present study was concentrated on two-woody biomass species such as chakunda and eucalyptus. The following works are suggested to be carried out in future.

- Similar type of study need to be extended for another woody biomass species available in the region.
- The powdered samples of these biomass species may be mixed with coal in different ratios and the electricity generated potential of the resultant mixed briquettes may be studied.
- The biomass species may be mixed with cow dunk, sewage wastes, etc in different ratios and the electricity generated potentials of the mixtures may be determined.
- New techniques of electricity generation from biomass species may be developed.

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