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Determination of Agricultural by Products Potential

Sumit kumar Dewangan
Student
Department of Mechanical Engineering
Kalinga University, Raipur (C.G), India

Abstract:
In view of high energy potential in agricultural residues species and an increasing interest in their utilization for power generation an attempt has been made in this study to assess the proximate analysis and energy content of different components of four selected agricultural residues such as maize, coconut, paddy and arhar, and their impact on power generation and land requirement for energy plantations. The net energy content in coconut plant was found to be higher than other studied agricultural residues. The result shows that approximately 717 hectares, 1123 hectares, 1511 hectares and 4319 hectares of land are required to generate 20,000 kWh/day electricity from, coconut, maize, paddy and arhar pulse residues respectively. Coal samples, obtained from six different local mines were also examined for their qualities and the results were compared with those of studied biomass materials. This comparison reveals much higher power output with negligible emission of suspended particulate matter (spm) from biomass materials. It has been observed that coconut, paddy and arhar agricultural residue can be carried out safely (without clinker formation) up to the temperature of 950°C.in case of use of maize agricultural residue, it may be more safe to operate the boiler at temperature below 800°C.Since it has been observed that maize has lowest IDT (Initial deformation temperature) and lowest FT (Flow temperature), while coconut and paddy have highest IDT and FT.

1. INTRODUCTION:

1.1 INTRODUCTION

Fossil fuel reserves are very limited in nature and these reserves are expected to last up to 100 years more. Thermal power and metallurgical industries are considered to be the mammoth consumers of fossil coals. Thermal power plants produce a large amount of pollutants, such as carbon dioxide, sulphur oxides, fly ash, etc which are hazardous for human survival on the earth planet. Hence, scientists and technocrat's world-wide are in search of alternative sources of energy whose exploitation is not harmful for the human beings. There are many alternative sources of energy including Biomass. To exploit 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, ultimate analysis, ash fusion temperature and energy value of different components of Coconut, Maize, Paddy and Arhar biomass species (agricultural residues) and their impacts on power generation. Few times ago, 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 two years only. They can be produced on poor and semi-desert land surviving with relatively little water.

1.2 Different Sources of Energy

Having energy and environmental problems associated with the use of fossil fuels in electricity generation, scientist and technocrats, worldwide, are in search of the suitable option of fossil fuels for power generation. The various different sources of energy having a potential to be used in electricity generation are as follows:

(a) Nuclear Energy

The energy stored in the nucleus of an atom and released through fission, fusion, or radioactivity is known as nuclear energy. In these processes a small amount of mass is converted to energy according to the relationship $E = mc^2$, where E is energy, m is mass, and c is the speed of light. The most difficult problems concerning nuclear energy are the probability 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 arms.

(b) Ocean Energy

Ocean thermal energy conversion, or OTEC, is a tool to generate power using the temperature difference of sea water at various 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. As the oceans are continually heated by the sun and cover nearly 70% of the Earth's surface, this temperature difference contains a huge 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 humans uses it in some form. A heat engine involves a device that operates between a high temperature source and a low temperature sink. As heat flows from source to sink, 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 energy in the form of either heat or work. Instead of using heat energy by the burning of fuel, OTEC draws power on temperature differences caused by the sun's warming of the ocean surface.

(c) Geothermal Energy

Internal heat of the Earth produces geothermal energy. 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). Turbines can be operated directly and supply electricity using high-energy deposits, pressurised steam or water at a temperature of 150 to 350°C not far below the surface (in France, there is such a facility in Guadeloupe).

(d) Wind Energy

Wind turbines are used by Wind energy systems to generate electrical energy by diminishing the power in wind. Wind energy can in 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. Winds which flow close to the earth's surface are slowed down due to friction, which causes turbulence and gusting. The higher above the ground you go, the faster the winds travel 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 different systems used. 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 eggbeater. 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. Few HAWT designs face downwind with no tails, others face upwind and have tails.

(e) Solar Energy

The radiant energy produced in the sun as a result of nuclear fusion reactions is known as Solar Energy. 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 1.37×10^6 ergs per sec per cm^2, or about 2 calories per min per cm^2. Out of the energy transmitted from the Sun, the upper atmosphere of Earth receives about 1.5×10^{21} watt-hours (thermal) of solar radiation annually. This huge 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 3.9×10^{20} 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 infrared 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.

(f) Biomass and Bio-energy

Biomass is organic material made from plants and animals. 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 that eat them. 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. If you have a fireplace, the wood you burn in it is a biomass fuel. Wood waste or garbage can be burned 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 bio-diesel. 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 the USA are trying to develop ways to burn more biomass and less fossil fuels. 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 POTENTIAL IN POWER GENERATION

The U.S. based economy uses biomass-based materials as a source of energy in many ways. Wood and agricultural residues are burned as a fuel for cogeneration of steam and electricity in the industrial sector. Biomass is used for power generation in the electricity sector and for space heating in residential and commercial buildings. Biomass can be converted to a liquid form for use as a transportation fuel, and research is being conducted on the production of fuels and chemicals from biomass. Biomass materials can also be used directly in the manufacture of a variety of products. In the electricity sector, biomass is used for power generation. The Energy Information Administration (EIA), in its projects reveals that biomass will generate 15.3 billion kilowatthours of electricity, or 0.3 percent of the projected 5,476 billion kilowatthours of total generation, in 2020. In scenarios that reflect the impact of a 20 percent renewable portfolio standard (RPS) and in scenarios that assume carbon dioxide emission reduction requirements based on the Kyoto Protocol, electricity generation from biomass is projected to increase substantially. Therefore, it is critical to evaluate the practical limits and challenges faced by the U.S. biomass industry. This paper examines the range of costs, resource availability, regional variations, and other issues pertaining to biomass use for electricity generation. The technology by which the National Energy Modeling System (NEMS) accounts for various types of biomass is discussed, and the underlying assumptions are explained. Both dedicated biomass co-firing and biomass are used in the power generation sector. New dedicated biomass capacity is represented in NEMS as BIGCC technology. It is assumed that hot gas filtration will be used for gas cleanup purposes in this technology.

Hot gas cleanup technology is relatively new, and the U.S. Department of Energy (DOE) and many industrial partners are conducting tests to demonstrate the technology. The alternative to hot gas cleaning is low-temperature gas cleaning. In low-temperature cleaning the gas is quenched with water, and particulates are removed in a series of cyclone vessels. There are advantages and disadvantages associated with both processes. The advantages of cold gas cleaning are that it is commercially available, the capital cost is relatively low, and the systems are easier to operate than hot gas cleanup systems. The disadvantages of cold gas cleanup are that the cooling process, the cold gas cleanup system, and fuel gas recompression systems reduce the overall process efficiency by up to 10 percent. The gas turbines downstream of the gasifier require the gas at high temperatures and pressure, and therefore the gas that has just undergone cooling for cleanup purposes must be depressurized and reheated in order to confirm to gas turbine inlet specifications. The advantages of the newer hot gas cleanup technology are that it allows the process to be operated at higher efficiencies and it generates less waste water than the cold gas cleanup processes. The disadvantages of the hot gas cleanup methodology are that it has higher costs, operational experience is limited, and it adds complexity to the process, however, it is considered to be the technically more advanced choice for new dedicated biomass plants. The McNeil Generating Station demonstration project in Burlington, Vermont, is an example of a biomass gasification plant. It has a capacity of 50 megawatts and supplies electricity to the residents of the City of Burlington. This is an existing wood combustion facility whose feedstock is waste wood from nearby forestry operations, including forest thinnings and discarded wood pallets. To this existing wood combustion facility a low-pressure wood gasifier has been added that is capable of converting 200 tons per day of wood chips into fuel gas. The fuel gas, fed directly into the existing boiler as shown in Fig. 1 augments the McNeil Station's capacity by an additional 12 megawatts. The system was designed and constructed in 1998 and attained completely operational status in August 2000. Having the Vermont project, DOE has funded five new advanced biomass gasification research and development projects beginning in 2001. Emery Recycling in Salt Lake City, Utah, will test new IGCC and integrated gasification and fuel cell (IGFC) concepts based on a new gasifier that uses segregated municipal solid waste, animal waste, and agricultural residues. Sebesta Blomberg in Roseville, Minnesota, has begun a project on an atmospheric gasifier with gas turbine at a malting facility, using barley residues and corn stover. Alliant Energy in Lansing, Iowa, is developing a new combined-cycle concept that involves a fluidized-bed pyrolyzer and uses corn stover as a feedstock. United Technologies Research Center in East Hartford, Connecticut, has begun a project that will test a biomass gasifier coupled with an aero-derivative turbine with fuel cell and steam turbine options, using clean wood residues and natural gas as feedstocks. Carolina Power and Light in Raleigh, North Carolina, will develop a biomass gasification process that will produce a reburning fuel stream for utility boilers, using clean wood residues.

After end of research and development tests, these projects are candidates for commercialization over the next few years. Biomass co-firing includes combining biomass material with coal in existing coal-fired boilers. Coal-fired boilers can handle a pre-mixed combination of coal and biomass in which the biomass is combined with the coal in the feed lot and fed through an existing coal feed system. Alternatively, boilers can be retrofitted with a separate feed system for the biomass such that the biomass and coal actually mix inside the boiler. The portion of biomass consumed varies from less than 1 percent to about 8 percent of total heat input, with two exceptions: Excel Energy's Bay Front plant in Ashland, Wisconsin, and Tacoma Steam Plant Number 2, owned by Tacoma Public Utilities. The Bay Front Station can generate electricity using coal, wood, shredded rubber, and natural gas. Experience has shown that it is better to operate units 1 and 2 on 100 percent coal during periods of high load and on 100 percent biomass during off-peak periods. A blending of coal and biomass can cause ash fouling and slagging problems. So, the heat input from biomass averages about 40 percent in this plant.

1.4 BIOMASS – A SOURCE OF ELECTRICITY GENERATION IN SMALL SCALE INDUSTRIES

There are over 11 million small-scale registered industrial units that provide employment to more than 27 million people [6], in India. They contribute to 40% of the country's industrial production and 34% of exports. A significant number of these units require large quantities of electrical energy. The high cost supply, which is mostly erratic and unreliable on account of scheduled / unscheduled power cuts, drives industries to invest in captive power generation. As fossil fuels are limited and polluting, such demand provides an attractive platform to renewable alternative energy solutions to industrial and commercial establishments, particularly small and medium enterprises. Biomass energy systems can be deployed to meet power requirement in industries. This power generation will help industries in becoming self-reliant and reduce pressure on fossil fuels. The available biomass-based energy units having capacity ranging from about 100 KW to few MW can be set-up by an industrial unit. In general, combustion-based systems are suited for MW-scale projects, whereas gasifiers are appropriate for small and decentralized power projects up to 1 MW capacity. In addition to power generation, the bio-power plant is also likely to produce activated carbon (a valuable product) that further offsets the operating cost of the plant. Under a wide rural development policy, the increase in agricultural productivity, crop diversity and the production of rural profit and employment have been given high priority in many developing countries. Promoting and improving rural industries, naturally, is an important strategy for attaining such policy objectives. The majority of small industries are in peri-urban and rural areas. For fuel, majority still uses wood and agricultural residues. The traditional processes in small-scale industries are often traditional and operate under highly competitive conditions. They must compete with both similar scale producers as well as larger scale producers using more modern and technically advanced production facilities. They are relatively isolated from the source of skills, know-how, and technology that would allow improvements in their operations, energy, etc. In addition, the very nature and location of the small industries often reinforce their separation from formal sources of financial, technical, and other assistance. Yet, small industries have been recognized to have important role in the development and stability of national, rural economies and the survival of subsistent economies. The sector provides income and/or local employment to many people. It has also been found that biomass energy typically generates 10 times more employment than oil and coal. For developing countries, the use of biomass energy sources could also reduce dependency on imported energy sources. On the other hand, it is also true that shortage of fuels, in the forms of fuel wood and other biomass are threatening the sustainability of small industries. For example, there have been cases in Cambodia of small enterprises closing down due to fuel shortage. It was also reported that some areas in Nepal where small industries were concentrated, suffered from environmental degradation due to fuel wood extraction for industrial operations. Thus, technology that could provide them in increasing their efficiency and output, accurate study and documentation of industrial stoves is a necessary tool at this time. Different types of products produced by small-scale enterprise are considered familiar and popular products in many countries in Asia. For example, noodles, soybean sauce, and tofu in Indo-China and Southeast Asian Countries, palm sugar in Sri Lanka, Indonesia, Bangladesh, Thailand, Myanmar; Cotton/Fabrics or silk dying in India, Pakistan, Nepal, Bhutan, Thailand, and Indonesia. In many Asian countries a large proportion of food preparation in institutional kitchens such as in schools, barracks, canteens, hostels, prisons and community kitchens also use biomass fuel. Stoves are one component in the production process that may affect the level of economic benefit of rural producers and entrepreneurs. With the use of better stoves for industrial or institutional production technique can be improved. Their use can save time and fuel, improve quality of their products and also improve the working conditions which influence the health of workers who spend most of their time in the kitchen with smoky stoves. The largest resulting benefit especially for small producers will be an increase in their income, the greatest concern of entrepreneurial producers. At a closer look, it is increasingly obvious that biomass stove issue is not solely the concern at the household level and that industry and institutions are also important stakeholders in the biomass issue. Fuel wood and other biomass fuels are also extensively used for institutional and small industrial activities in most countries. Different types of publications and information on domestic cook stoves are available, but unfortunately very few are on stoves for industrial and institutional use. Relatively simple technical information consisting of pictures and drawings will be appropriately useful as information source for field workers and practitioners as a base from which to start to advance the development of small-scale industries and institutions in their respective areas. It is in this regard that RWEDP and ARECOP jointly embarked to compile necessary information and compiled as compendium. This compendium is a compilation of basic information, designs of improved and traditional stoves for small industries and institutions. This compendium is to give ideas or inspiration to field workers or stove practitioners about various stove designs and technologies used in institutions and small industries in the Asian countries. For policy makers, it will provide clear picture of the development of energy policy and intervention for rural industries in terms of giving an alternative approach to income generation and distribution, employment, resource allocation and environmental conservation within rural economies. Gasification-based small modular biomass systems are emerging as a promising technology to supply power and heat to rural areas, businesses, and the billions of people who live without electricity worldwide. Biomass Program support through subcontracted efforts with private sector companies over the past several years, has advanced several versions of the technology to the point where they are now approaching commercialization. By adopting a standardized modular design, these 5 kW-to-5 MW systems are expected to lend themselves to high volume manufacturing techniques to bring them on a competitive level with large stand- alone plants. Using locally available biomass fuels such as wood, crop waste, animal manures, and landfill gas, small modular systems can be brought to the source of the fuel rather than incurring transportation costs to bring biomass fuels to a large centrally located plant. Small modular biomass systems also fulfill the great market potential for distributed, on-site, electric power and heat generation throughout the world. Small modular biomass systems typically convert a solid biomass fuel into a gaseous fuel through a process called gasification. The resulting gas, comprised primarily of carbon monoxide and hydrogen, is then cleaned before use in gas turbine or internal combustion engine connected to an electrical generator. Waste heat from the turbine or engine can also be captured and directed to useful applications. Small modular systems allow themselves to such combined heat and power operations much better than large central facilities. A small Modular biomass system provides many benefits to potential customers. They have minimal environmental impact when compared to other existing technologies using coal or biomass as the fuel. On the flip side, economics can be attractive when owners connect the unit to a power grid that will buy unused power. On the other hand, small modular systems can electrify separated areas for which the cost of connection to the grid is prohibitive. Another economic benefit may be realized if the customer has a biomass waste stream that can be converted into a source of energy instead of being an economic burden. The flexibility to use more than one fuel also appeals to many users. Modern microprocessor control has been coupled to gasification technology to result in systems requiring minimal operator attention. And, in off- grid locations small modular biomass systems provides the potential for lights, refrigeration, heat and power to enable small cottage industries to become economically viable.

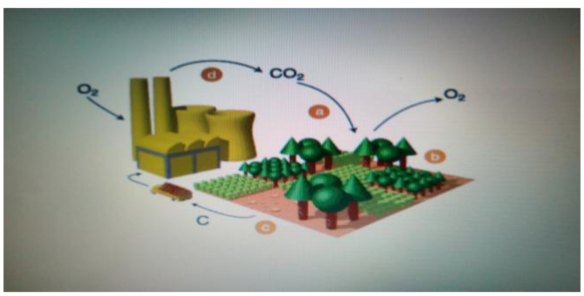

Figure.1. Re-Cycle of C, CO_2 and O_2 in the Atmosphere

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.

1.5 USE OF BIOMASS: A REMEDY TO COMBAT POLLUTION EMISSIONS FROM POWER GENERATION INDUSTRIES

Air Pollution is a huge concern 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 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 and another disease which cause health problems and disturb people's daily lives. Burning fossil fuels also releases air pollutants- sulphur oxides (SOx), nitrogen oxides (NOx), volatile organic compounds (VOCs; there are many), carbon monoxide (CO), and other toxic 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/m^3 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 increased 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 sulphur 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 [7]. Hence, unlike fossil fuels, biomass use in electricity generation is not likely to pollute the atmosphere with SOx, NOx, SPM, etc.

1.6 MERITS IN THE USE OF BIOMASS IN POWER GENERATION:

(1) Growth of biomass occurs through photosynthesis reaction. Here, the biomass absorbs carbon dioxide from the atmosphere and gives out oxygen. Thus the sustainable generation and use of biomass in power plants will definitely help in reducing carbon dioxide concentration in the atmosphere and thus the green house effect.
(2) In comparison to coal, the ash content in biomass is very less (2-6% approx as against 20-50% in coal). Thus, the use of biomass in power generation will lead to substantial decrease in the amount of suspended particulate matters in the atmosphere.
(3) Energy content in biomass is more than those of E and F grade coals (mostly exploited coals in Indian power plants).
(4) Reactivity of biomass towards oxygen and carbon dioxide is much higher than that of coal. This permits the operation of boiler at lower temperatures resulting in greater saving of energy.
(5) Sustainable plantation and use of biomass in electricity generation will afford tremendous employment opportunity to the people who are highly advantageous for populous countries like India, China, etc.
(6) Electricity generation on decentralized basis is possible by the use of biomass. This will certainly help in uplifting the socio-economic development of the rural areas.
(7) Power generation on decentralized basis will reduce the transmission losses.
(8) Exploitation of biomass in power generation will lead to better utilization of barren lands of India (67 million hectares approx).
(9) Biomass plantation will prevent the soil erosion from floods.

1.7 PLANNING OF THE ELECTRICITY GENERATION STRUCTURE

In planning the electricity generation from biomass on decentralized basis, the following points should be taken into account:

- Kind, quality, quantity, feasibility of transportation and storage, sustainability and cost of biomass to be used.
- Level of customer demand.
- Method and cost of biomass drying.
- Method of electricity generation and its economic viability.
- Costs and qualities of locally available fossil fuels.

1.8 AIMS AND OBJECTIVES OF THE PRESENT PROJECT WORK

The aims and objectives of the present investigation are as follows:

1. Selection of agricultural based biomass species and estimation of their generation by field trial.
2. Determination of proximate analysis (% moisture, % volatile matter, % ash and % fixed carbon contents) of their different components, such as stump, branch, leaf and bark.
3. Characterization of these biomass components for their ultimate analysis (carbon and hydrogen)
4. Determination of ash fusion temperatures (IDT, ST, HT and FT) of ashes obtained from these biomass species
5. Characterization of these biomass components for their energy values (calorific values).
6. Estimation of power generation potentials of these biomass species for a small thermal power plant on decentralized basis.

2. EXPERIMENTAL WORK:

2.1 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.

2.2 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 [3]. The details of these tests are as follows.

(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.

(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.

(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.

(4) Fixed Carbon Determination
The fixed carbon content in the sample was determined by using the following formula:

Fixed Carbon Content (Wt. %) =100-Wt %(Moisture + Volatile matter + Ash)

2.3 Calorific Value Determination

The calorific values of the biomass samples were measured in a Bomb calorimeter apparatus by the method outlined in reference [8].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) / Wo – (fuse wire + thread connections)

Where,

W.E. = water equivalent of the apparatus.
ΔT = Maximum rise in temperature in ˚C.
Wo = Initial weight of briquette sample.

2.4 Ash Fusion Temperature Determination

The ash fusion Temperature, softening Temperature, Hemispherical temperature and Flow temperature) of all the ash samples ,obtained from the presently selected non-woody biomass species were determined by using Leitz Heating Microscope (LEICA) in Material Science Centre of the Institute. The appearance of ash samples at IDT, ST, HT and FT are shown in figure.

3. CONCLUSION:

3.1 CONCLUSION

1. In case of coconut residue, shell has higher calorific value, which is slightly higher than pitch and bark, respectively.
2. In case of maize residue corn pad has higher calorific value which is higher than bark, stump and leaf respectively.
3. In case of paddy residue stump and leaf have approximately the same calorific value.
4. In case of arhar residue stumps has higher calorific value followed by leaf, sheed cover, branch respectively.
5. In case of ash fusion temperature coconut has higher IDT, and FT. Arhar has higher ST followed by paddy, coconut and maize. Arhar has highest HT.
6. Calculation result have demonstrated that nearly 717 hectares, 1123 hectares, 1511 hectares, 4319 hectares of land would be required for continuous generation of 20,000KWh electricity per day from coconut, maize, paddy and arhar agricultural residue respectively.
7. In contrast to locally available coals, the studied agricultural residue plant showed higher energy values and much higher energy value and much lower ash contents. This indicates higher power generation potentials in Biomass than coals.
8. The present study could be useful in the exploration of agricultural residue based biomass species for power generation.

3.2 SUGGESTIONS FOR THE FUTURE WORK

The present study was concentrated on four agricultural residue biomass species such as Coconut, Maize, Paddy and Arhar. The following works are suggested to be carried out in future.

(1) Similar type of study need to be extended for another agricultural residue biomass species available in the region.
(2) Pilot plant study on laboratory scale may be carried out to generate electricity from biomass species.
(3) 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.
(4) 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.
(5) New techniques of electricity generation from biomass species may be developed.

✓ **Process of Electricity Generation by using Biomass Species:-**

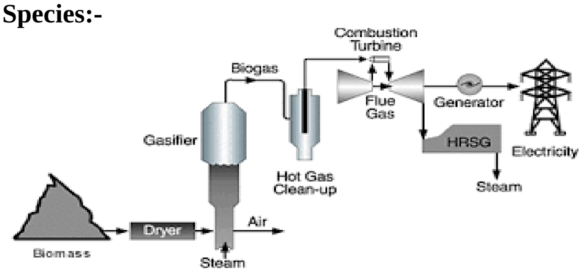

Figure.2. Biomass integrated gasification combined cycle system schematic

✓ **Small Modular Application:-**

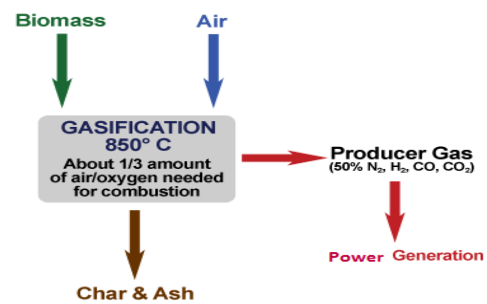

Figure.3. Biomass Gasification via Partial Oxidation (Auto Thermal)

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