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COMPARATIVE ANALYSIS OF COAL & MIXED COAL BIOMASS WITH RESPECT TO SELECTED BIOMASS SPECIES IN THERMAL POWER PLANT

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ABSTRACT

In view of energy and environmental problems connected with the use of fossil fuels (coal, petroleum and gas) in power generation, an increasing awareness is being paid world-over by the scientists and technocrats for the utilization of renewable energy sources in power generation, metallurgical industries etc. There is an assortment of type of renewable energy sources such as solar, wind, hydropower, biomass energy etc. out of these renewable energy sources biomass is more proficiently viable for almost all the continents in the world. Biomass is a carbonaceous material and provides both the thermal get-up-and-go and diminution for oxides, where as other renewable energy sources can meet our thermal need only. The present work is a positive step towards energy and conservation problems facing the world. The presently selected forestry biomass species has no any for profit use and are underutilized. Presently, co-firing (coal + biomass) has been proved to be more attractive and economically viable technique for power production. In the present work, briquettes were organized by mixing non-coking coal from Singaji power plant and the related biomass species in the ratio (coal: biomass = 95:05). The objectives have been to inspect their energy values and power production prospective. The outcome has indicated that Cassia Tora biomass species has to some scope higher ash and lower predetermined carbon padding then these of Gulmohar biomass species, energy values of Gulmohar biomass variety were found to be little bit higher than that of Cassia Tora biomass. The immediate analysis results of studied coal proved it of F- grade. While it is apparent from outcome, an increase in biomass content (wood/leaf/nascent branch), in general, in the briquetted increase the energy values of the resulting briquettes. Among the four AFTs (IDT, ST, HT & FT), softening temperature of ash is most important for boiler operation. The results have indicated that both biomass species have more or less they are softening temperature but lower than that of coal. The Increases in biomass content is to slightly reduce the softening temperature. The softening temperature results of the briquettes also indicated that the boiler may well be safely operated up to about 1100 ^{0}C with studied (Coal + Biomass) briquette.

Keywords: *adjacent analysis, ash fusion temperature, current generation, liveliness content, non-woody biomass* species.

1. INTRODUCTION

India being an increasing nation, sustainable development is more important. Energy is a basic requirement for trade and industry development. Every sector of Indian economy agriculture, industry, transport, commercial and house needs inputs of energy. Energy is an important factor for any developing country. Ever increasing consumption of fossil fuels and rapid depletion of known reserves are matters of serious apprehension in the country. This upward spending of energy has also resulted in the kingdom becoming all the time more dependent on fossil fuel such as coal and oil and gas. Rising prices of oil and gas and potential shortage in future lead to concern about the safety measures of energy supply needed to sustain our trade and industry growth. Increased use of fossil fuels also causes ecological problems both locally and internationally. Biomass has always been an important energy source for the country making an allowance for the remuneration it offers. Biomass provides both, thermal energy as well as decline for oxides. It is renewable, widely available and carbon-neutral and has the potential to provide of no consequence employment in the rural areas. Biomass is also capable of provided that firm energy. About 32% of the total primary energy use in the country is still derived from biomass. Ministry of New and Renewable Energy has realize the potential and role of biomass energy in the Indian context and hence has initiate a number of program for promotion of efficient technology for its use in various sectors of the economy to ensure derivation of maximum benefits Biomass power generation in India is an industry that attracts investments of over Rs.600 crores every year, generating more than 5000 million units of electricity and yearly employment of more than 10 million man-days in the rural areas. For efficient utilization of biomass, bagasse based cogeneration in sugar mills and biomass power generation have been taken up under biomass power and cogeneration program me.

1.1 Different Renewable Energy Sources

Renewable energy sources are continuously replenished by natural processes. For example, solar energy, wind energy, bio-energy – bio fuels, hydropower etc., are some of the examples of renewable energy sources. 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 forms of renewable energy sources having a potential to be utilized in power generation are as follows:

1. Wind energy
2. Solar energy
3. Hydropower
4. Geothermal
5. Nuclear energy
6. Biomass & Bio energy

1.2 Biomass and Bio-energy

Biomass is renewable organic matter derived from trees, plants, crops or from human, animal, municipal and industrial wastes. Biomass can be classified into two types, woody and non-woody. Woody biomass is derived from forests, plantations and forestry residues. Non-woody biomass comprises agricultural and agro industrial residues and animal, municipal and industrial wastes. 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. Its advantage is that it can be used to generate electricity with the same equipment that is now being used for burning fossil fuels. Biomass is an important source of energy and the most important fuel worldwide after coal, oil and natural gas. Bio-energy, in the form of biogas, which is derived from biomass, is expected to become one of the key energy resources for global sustainable development. Biomass offers higher energy efficiency through form of Biogas than by direct burning.

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.

Power Generation Potential from Biomass and Bagasse Based Cogeneration

Biomass resources are potentially the world's largest and most sustainable energy sources for power generation in the 21st century (*Hall & Rao, 1999*). The current availability of biomass in India is estimated at about 500 million metric tonnes per year. Studies sponsored by the Ministry has estimated surplus biomass availability at about 120 – 150 million metric tonnes per annum covering agricultural and forestry residues corresponding to a potential of about 17,000 MW. This apart, about 5000 MW additional power could be generated through bagasse based cogeneration in the country's 550 Sugar mills, if these sugar mills were to adopt technically and economically optimal levels of cogeneration for extracting power from the bagasse produced by them (Ministry of New and Renewable Energy). The details of the estimated renewable energy potential and cumulative power generation in the country have been outlined in Table1.1 (*MNRE, 2011*), indicating that the available biomass has a potential to generate around 17,000 MW of electricity

Biomass: Classification and Properties

The overall biomass resources can be broadly categorized into two parts based on its availability in the natural form.

1. Woody biomass

Woody biomass is characterized by high bulk density, less void age, low ash content, low moisture content, high calorific value. Because of the multitude of advantages of woody biomass its cost is higher, but supply is limited. Woody biomass is a preferred fuel in any biomass-to energy conversion device; however its usage is disturbed by its availability and cost.

2. Non-woody biomass

The various agricultural crop residues resulting after harvest, organic fraction of municipal solid wastes, manure from confined livestock and poultry operations constitute non-woody biomass. Non-woody biomass is characterized by lower bulk density, higher void age, higher ash content, higher moisture content and lower calorific value. Because of the various associated drawbacks, their costs are lesser and sometimes even negative.

Biomass properties

An understanding of the structure and properties of biomass materials is necessary in order to evaluate their utility as chemical feed stocks. Chemical analysis, heats of combustion and formation, physical structure, heat capacities and transport properties of biomass feed .The major physical data necessary for predicting the thermal response of biomass materials under pyrolysis, gasification and combustion reactions are shape, size, void age, thermal conductivity, heat capacity, diffusion coefficient and densities viz. bulk density, apparent particle density and true density. The values of these properties are different for different biomass especially in the case of loose biomass.

1.2 Bio-Energy Technologies for Decentralized Power Generation

The advances in bio-energy technologies (BETs) over the last few decades have enabled a significant increase in the utilization of biomass for power generation. Key technologies available for promoting power generation from biomass in India are gasification, combustion, co-firing and bio-meth nation.

Gasification

Biomass gasifies are devices promoting thermo-chemical conversion of biomass into high energy combustible gas for burning in gas turbine (BIG / GT). Biomass, particularly woody biomass, can be converted to high-energy combustible gas for use in internal combustion engines for mechanical or electrical applications. Biomass gasifies are devices performing thermo-chemical conversion of biomass through the process of oxidation and reduction under sub-stoichiometric conditions. Gasifies are broadly classified into updraft, downdraft and cross draft (shown in Figs. 1.1 - 1.3) types depending on the direction of airflow. Gasified systems with various capacities in the range of 1 kg/h to about 500 kg/h are presently in use. These systems are used to meet both power generation using reciprocating engines or for direct usage in heat application. The prime movers are diesel engines connected to alternators, where diesel savings up to 80% are possible. Among the biomass power options, small-scale gasify (of 20–500 kW) have the potential to meet all the rural electricity needs and leave a surplus to feed into the national grid. The total installed capacity of biomass gasified systems as of 2011 is nearly 130 MW.

2. OBJECTIVES

Following are the aims and objectives of the present investigation:

1. Selection of non-woody biomass kind and inference of their yield by field trial.
2. Determination of proximate analysis (% moisture, % volatile matter, % ash and % fixed carbon contents) of their poles apart components, such as wood, leaf and nascent branch.
3. Mixed these biomass workings separately with coal sample in different-different ratio.
4. Categorization of these biomass components for their energy values (calorific values).
5. Characterization of coal mixed biomass components for their energy values (calorific values).
6. Determination of ash fusion temperatures (IDT, ST, HT and FT) of ashes obtain from these biomass genus and coal-biomass mixed sample.
7. Comparative study of coal and mixed coal-biomass in different ratio of 95:05 with respect to selected biomass species.

3. METHODOLOGY

Selection of Materials

In the present thesis work, two different types of non-woody biomass species Cassia Tora (Local Name: Chakunda) and gulmohar (Local name: Krishnachura) where procured from the local area. These biomass species were cut into different pieces and there different component like leaf, nascent branch and main branch were separation from each other. These biomass materials were air-dried in cross ventilator room for around 20 days. When the moisture contains of these air-dried biomass sample came in equilibrium with that of the air, they were crushed in mortar and pestle into powder of -72 mess size. The coal sample for making the blend was collected from Sant Sri Singaji thermal power plant Mundi, Khandwa. These materials were than processed for the determination their proximate analysis and Energy values.

Figure 1: Sample of biomass component, component powder and coal powder

Proximate Analysis

Proximate Analysis consist of moisture, ash, volatile matter, and fixed carbon contents determination were carried out on samples ground to -72 mess size by standard method. The details of this analysis are as follows;

Determination of Moisture

One gm. (1 gm.) of air dried -72 mess size powder of the above said materials was taken in borosil glass disc and heated at a temperature of 105^0C ± 5^0C for one hour in air oven. The discs were then taken out the oven and the materials were weight. The percentage loss in weight was calculated which gives the percentage (%) moisture contains in the sample.

Determination of Ash Content

One gm. (1 gm.) of -72 mess size (air dried) was taken in a shallow silica disc and kept in a muffle furnace maintained at the temperature of 775^0C ± 5^0 C. The materials were heated at this temperature for one hour or till complete burning. The weight of the residue was taken in an electronic balance. Weight of obtained gives the ash contained in the sample.

% Ash
= Wt. of residue obtained × 100 / Initial wt. of sample.

Determination of Volatile Matter

One gm. (1 gm.) of -72 mess size (air dried) powder of the above said materials was taken in a volatile matter crucible (cylindrical in shape and made of silica). The crucible is covered from top with the help of silica lid. The crucible were placed in a muffle furnace, maintained at the temperature of 925^0 C ± 5^0 C and kept there for 7 minute. The volatile matter crucibles were then taken out from the furnace and cooled in air. The devolatized samples were weighted in an electronics balance and the percentage loss in weight in each of the sample was calculated. The percentage volatile matter in the sample was determined by using the following formula.

% volatile matter (VM)
= % lass in weight - % moisture

Determination of Fixed Carbon

The fixed carbons in the simple were determined by using the following formula.

$$\% \ FC = 100 - (\% M + \% VM + \% Ash)$$

Where, FC: Fixed carbon, M: Moisture, VM: Volatile Matter

Calorific value determination

The calorific values of these species (-72 mesh size) were measured by using an Oxygen bomb calorimeter (BIS, 1970, shown in Fig.2); 1 gm. of briquetted sample was taken in a nicron crucible. A 15 cm long cotton thread was placed over the sample in the crucible to facilitate in the ignition. Both the electrodes of the calorimeter were connected by a nicrom fuse wire. Oxygen gas was filled in the bomb at a pressure of around 25 to 30 atm. The water (2 lit.) taken in the bucket was continually starred to homogeneous the temperature. The sample was ignited by switching on the current through the fussed wire and the rise in temperature of water was automatically recorded. The following formula was used to determine the energy value of the sample.

Gross calorific value (GCV)
= {(2500 × ΔT) / (Initial wt. of simple) − (heat released by cotton thread + Heat released by fused wire)}

Where, 2500 is the water equivalent water apparatus and DT in the max^{im} rising temperature.

Figure 2: Oxygen Bomb Calorimeter

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 and coal-biomass (in ratio) mixed sample were determined by using Leitz Heating Microscope (LEICA shown in Fig.3) in Material Science Centre of the Institute. The appearance of ash samples at IDT, ST, HT and FT are shown in Fig. 3

Figure 3: Leitz Heating Microscope

4. RESULT & DISCUSSIONS

The results obtained from proximate analysis and calorific value of non-woody biomass species, coal, coal-biomass mixed briquettes and Ash fusion temperatures of selected biomass species and coal-biomass mixed (in ratio) during the course of this thesis work have been summarized I the diagram me.

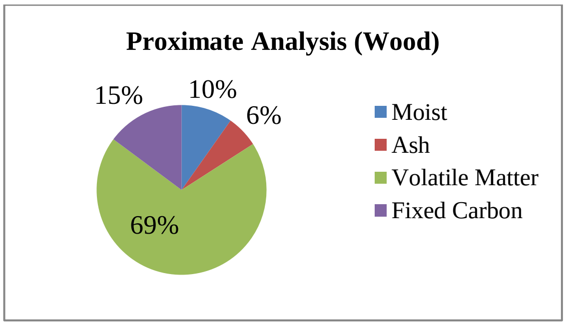

CHART 1: Proximate analysis of Gulmohar wood by Pie Chart

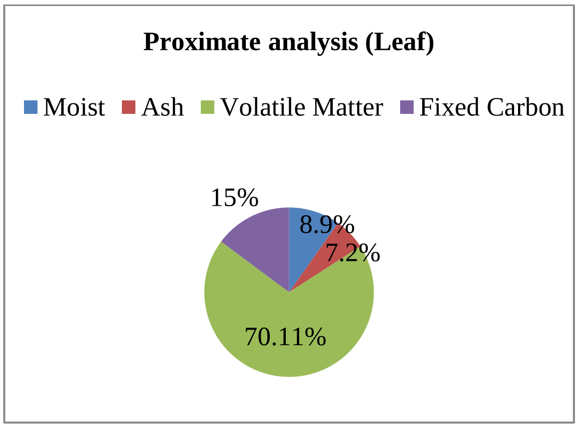

CHART 2: Proximate analysis of Gulmohar Leaf by Pie Chart

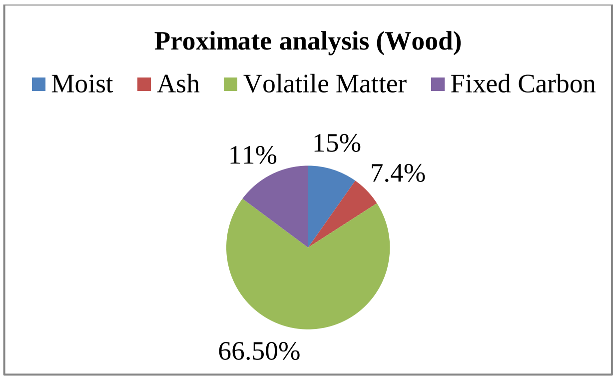

CHART 3: Proximate analysis of Cassia Tora (local name: Chakunda) Wood by Pie Chart

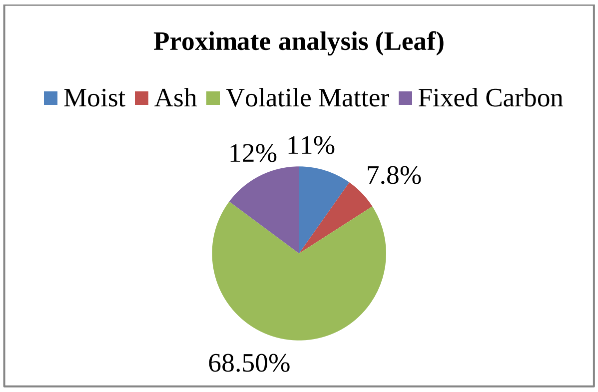

CHART 4: Proximate analysis of Cassia Tora (local name: Chakunda) Leaf by Pie Chart

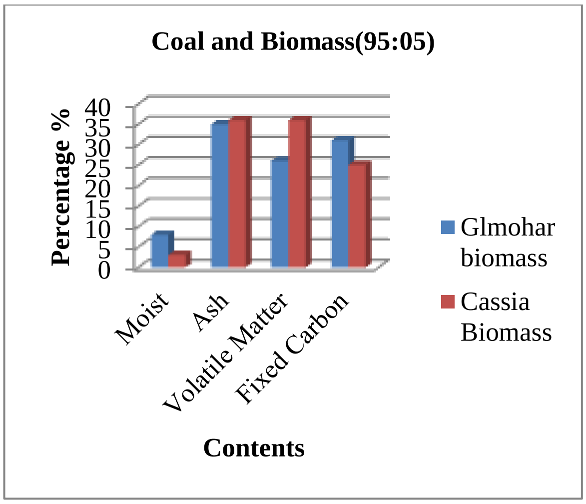

CHART 5: Ratio of coal and biomass

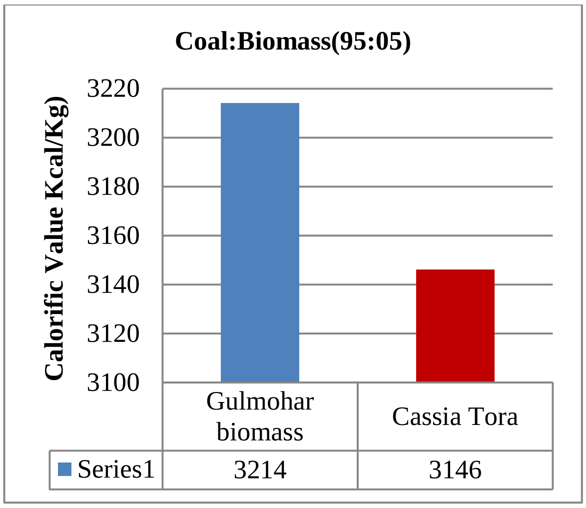

CHART 6: Calorific value of coal and biomass

Table 1: Ash Fusion Temperatures

	Ash Fusion Temp. (°C)			
Biomass Species / Coal-Biomass Mixed Ratio	**IDT**	**ST**	**HT**	**FT**
Cassia Tora	893	1245	>1400	>1400
Gulmohar	1058	1249	>1400	>1400
Coal: Biomass (90:10)	1160	1297	>1400	>1400

IDT: Initial Deformation Temperature
ST: Softening Temperature
HT: Hemispherical Temperature
FT: Flow Temperature

5. CONCLUSIONS

The present study was concentrated on two non-woody biomass species such as Gulmohar and Cassia Tora. The following works are suggested to be carried out in future.

1. Similar type of study need to be extended for another non-woody biomass species available in the local area.
2. 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.
3. Pilot plant study on laboratory scale may be carried out to generate electricity from biomass species.
4. The powdered samples of these biomass species may be mixed with cow dunk and the electricity generated potential of the resultant mixed briquettes may be studied.
5. New techniques of electricity generation from biomass species may be developed.

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