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Power Generation Estimation of Non-Woody and Coal-Biomass Mixed Briquettes

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Abstract – The process of power generation burning fossile fuels (Coal, Petroleum, and Gas) creates huge environmental problems. This is making scientist and technocrat's world over attentive to utilize renewable energy sources in power generation and metallurgical industries. Renewable energy sources consist of solar, wind, hydropower, biomass energy etc. while in almost all parts of world biomass energy is found to be most economically viable. All renewable energy sources excepting biomass provide thermal energy only. Biomass is carbonaceous and serves double objective of availability of thermal energy and reduction of oxides. Biomass being the purest fuel produces for less ash in comparison to all other solid fuels including coal. It is estimated that in India, biomass possesses potential for generation of more than 17000 MW of electricity annually. The country is lagging behind to utilize this potential, being able to generate approximately only 2000 MW in spite of Govt. declaration of various incentives. This calls for immediate necessity of producing more power from biomass.

In the present work the principle that burning of coal and biomass together (co-firing) offers on excellent an economically variable power generation procedure followed. Non-coking coals (C) from Jharkhand mines were mixed with related biomass (B) species in different ratio (C:B= 90:10, C:B= 80:20, C:B= 70:30, C:B= 60:40) in order to prepare briquettes.

Keywords: Proximate Analysis, Ash Fusion Temperature, Electricity Generation, Energy Content, Non-Woody Biomass Species.

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1. INTRODUCTION

Sustainable development is essential in developing countries like India and economic development demands energy for every section of the Indian wealth – industry, farming, convey, domestic and commercial which makes it significant for any developing country. Rapid decrease of fossil fuels due to the ever increasing consumption of known reserves is a serious issue in the country as it made the country excessively reliant on fuels like gas, coal and oil. Concerns have been raised about the energy supplies needed to sustain our economic growth because of potential shortages due to rising prices of gas and oil. Environmental problems have also been linked to excessive use of fossil fuels on local and global levels. Evaluating the goodness offered, Biomass has been considered an evergreen source of energy for the country as both, thermal energy and reduction for oxides are taken care of by it. Its renewability, wide availability, carbon-neutrality and the potential to generate employment in rural areas makes it even more desirable. It provides firm energy and approximately 32% of country's overall primary energy consumption continues to be extracted from biomass. Ministry of New and Renewable Energy has initiated a number of initiatives for promoting judicious techniques to use it in several economic sectors to ascertain utmost extraction of its benefits.

2. LITRATURE REVIEW

Raju et al. [2014] This work has proximate analyzed different components, such as wood, leaf and nascent branch and energy content of different components of paddy husk hypogeal. Medical wastes from hospitals and items that can be recycled are generally excluded from MSW used to generate electricity. These biomass components were separately mixed with coal dust and MSW in different-different ratio and also their proximate analysis was done and their energy values were determined to find out the best suitable mixture for power generation.

T.T. Al-Shemmeri et al. [2015] In this paper, the authors attempted to investigate the performance of a small-scale biomass combustor for heating, and the impact of burning different biomass fuels on useful output energy from the combustor. The test results of moisture content, calorific value and combustion products of various biomass samples were presented. Results from this study were in general agreement with published data as far as the calorific values and moisture contents are concerned.

G.M. Joselin Herbert et al. [2016] Due to Literature survey the world needs an enormous amount of energy to maintain the future economic developments. India has facile ways to overcome the immediate demand on energy supply by renewable energy resources. It has a huge potential of biomass resources to reduce the dependence on fossil fuels and to produce electrical and heat energy. The biomass energy can contribute to social and economic development. It has been identified as an alternative for the future energy demand in India. As part of furthering the development of biomass technology, it is essential to understand the environmental merits and demerits of biomass. It also aimed to increase the use of biomass energy for domestic purposes.

3. EXPERIMENTAL WORK

1. SELECTION OF MATERIALS

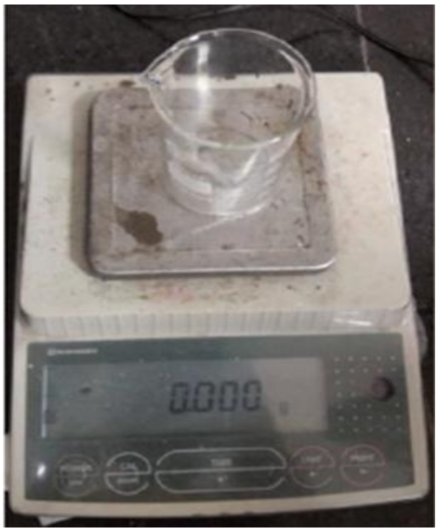
In the present thesis work, two different types of non-woody biomass species Cassia Tora and Gulmohar were procured from the local area. These biomass species were cut into different pieces and their different component like leaf, nascent branch and main branch were separated from each other. These contents 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 mesh size

Fig. 3.1: Sample of biomass component, component powder and coal powder

3.1 Proximate Analysis

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

3.1.1 Determination of Moisture



ELECTRONIC BALANCE

HOT AIR OVEN HOT

AIR OVEN (105 C)

One gm. (1 gm.) of air dried 72 mesh size powder of the above said materials was taken in borosil glass disc and heated at a temperature of 105°C ± 5°C for 60 Minutes in air oven. The discs were then taken out from the oven weight of materials was done.

3.1.2 Determination of Ash Content

ELECTRONIC BALANCE

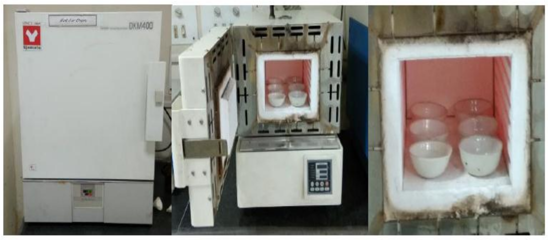
MUFFLE FURNACE

MUFFLE FURNACE (105 C)

One gm. (1 gm.) of 72 mesh size (air dried) was taken in a shallow silica disc and kept in a muffle furnace maintained at the temperature of 775°C ± 5°C. The materials were heated at this temperature for 60 Minutes or till complete burning. The weight of the residue was taken in an electronic balance.The percentage weight of residue. Give the ash contained in the sample.

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

3.1.3 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°C ± 5°C and kept there for 7 minute. The volatile matter crucibles were then taken out from the furnace and cooled in air. The devitalized 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

Percentage volatile matter (VM) = % loss in weight - % moisture

3.1.4 Determination of Fixed Carbon

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

Percentage FC = 100 – (% M + % VM + % Ash)

3.2 CALORIFIC VALUE DETERMINATION

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

4. RESULT AND DAASCISION

PROXIMATE ANALYSIS AND CALORIFIC VALUE OF DIFFERENT COMPONENTS OF NON-WOODY BIOMASS SPECIES AND COAL

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 project work have been summarized in Tables 4.1–4.6.

Table 4.1: Proximate Analysis of Gulmohar

Component	Proximate Analysis (Wt. %, air-dried basis)				Gross Calorific Value (Kcal/ kg, Dried Basis)
	Moisture	Ash	Volatile Matter	Fixed Carbon	
Wood	8.32	4.10	72.58	15.00	4590
Leaf	9.90	6.60	71.30	15.00	3992
Nascent branch	9.31	4.60	70.00	14.09	4170

Table 4.2: Proximate Analysis of Cassia Tora

Component	Proximate Analysis (Wt. %, air-dried basis)				Gross Calorific Value (Kcal/ kg, Dried Basis)
	Moisture	Ash	Volatile Matter	Fixed Carbon	
Wood	11.90	7.10	68.00	12.00	4387
Leaf	9.50	7.50	69.10	14.00	4209
Nascent branch	11.30	4.60	70.10	14.00	3609

Table 4.3: Proximate Analysis of Non-coking coal

Component	Proximate Analysis (Wt. %, air-dried basis)				Gross Calorific Value (Kcal/ kg, Dried Basis)
	Moisture	Ash	Volatile Matter	Fixed Carbon	
BCCL Mines	9.20	40.80	22.00	28	4398

Table 4.4: Coal: Gulmohar Biomass Different Component

Ratio (Coal: Biomass)	Proximate Analysis (Wt. %, Air Dried Basis)				Gross Calorific Value (Kcal/ kg, Dried Basis)
	Moisture	Ash	Volatile Matter	Fixed Carbon	
Main Wood					
90:10	8	35	26	31	3315
80:20	6	35	33	31	3595
70:30	3	38	36	33	3850
60:40	5	35	37	33	4210
Leaf					
90:10	5	33	30	32	3422
80:20	4	35	30	31	3510
70:30	5	30	34	31	3197
60:40	5	32	30	32	3910
Nascent Branch					
90:10	5	36	33	26	3605
80:20	6	30	35	29	3599
70:30	5	30	38	27	3610
60:40	8	29	43	20	3890

Table 4.5: Coal: Cassia Tora Biomass Different Component

Ratio (Coal: Biomass)	Proximate Analysis (Wt. %, Air Dried Basis)				Gross Calorific Value (Kcal/ kg, Dried Basis)
	Moisture	Ash	Volatile Matter	Fixed Carbon	
Main Wood					
90:10	4	37	34	35	3149
80:20	5	35	31	29	2989
70:30	5	38	37	20	3497
60:40	7	37	42	16	3320
Leaf					
90:10	4	38	28	30	3210
80:20	5	38	28	29	3640
70:30	5	30	40	25	3110
60:40	5	32	35	28	4199
Nascent Branch					
90:10	5	40	30	25	3482
80:20	7	37	29	27	3211
70:30	4	30	38	28	3698
60:40	4	35	40	22	3682

5. CALCULATIONS

Table 5.1: Total Energy Contents and Power Generation Structure from 6 Months old (approx.), Gulmohar Plants.

Component	Calorific Value (kcal/t, dry basis)	Biomass Production (t/ha, dry basis)	Energy Value (kcal/ha)
Main wood	4410×10^3	20.00	96160 × 103
Leaf	4057×10^3	7.50	28490× 103
Nascent branch	4009×10^3	10.00	37989.5 × 103

Energy Calculation:

On even dried basis, total energy from one hectare of land

$$= (96160+28490+37989.5) \times 10^3$$

$$= 162639.5 \times 10^3 \text{ kcal}$$

It is assumed that conversion efficiency of wood fuelled thermal generators = 26 % and mechanical efficiency of the power plant = 85 %.

Energy value of the total functional biomass obtained from one hectare of land at 26%

Conversion efficiency of thermal power plant

$=162639.5 \times 10^3 \times 0.26$

$= 42286.27\times 10^3$

$= 42286.27\times10^3 \times4.186\div 3600$

= 49169.54 kWh

Power generation at 85 % mechanical efficiency

$= 49169.54 \times0.85$

= 41794.11 kWh/ha

Land required supplying electricity for entire year

$=73\times10^5/ 49794.11$

= **175 hectares**

Table 5.2: Total Energy Contents and Power Generation Structure from 3 Months old (approx.), Cassia Tora Plants.

Component	Calorific Value (kcal/t, dry basis)	Biomass Production (t/ha, dry basis)	Energy Value (kcal/ha)
Main wood	4409 × 103	5.50	18425 × 103
Leaf	4095× 103	1.90	6129× 103
Nascent branch	3605 × 103	3.00	9275 × 103

Energy Calculation:

On even dried basis, total energy from one hectare of land

$= (18425+6129+9275) \times10^3$

$= 33829 \times10^3$ kcal

It is assumed that conversion efficiency of wood fuelled thermal generators = 26 % and mechanical efficiency of the power plant = 85 %.

Energy value of the total functional biomass obtained from one hectare of land at 26%

Conversion efficiency of thermal power plant

$= 32575.5 \times10^3 \times 0.26$

$= 8795.54\times10^3$ kcal

$= 8795.54\times10^3 \times4.186\div 3600$

= 10227.26 kWh

Power generation at 85 % mechanical efficiency

$= 9848.30\times0.85$

= 8693.18 kWh/ha

Land required supplying electricity for entire year

$=73\times10^5/ 8693.18$

= 840 hectares

6. CONCLUSIONS

In the present work two non-woody biomass species Gulmohar and Cassia Tora were selected. Experiments to determine the proximate analysis, calorific values and ash fusion temperature was done on each of the components of the selected species such as main wood; leaf and nascent branch were performed. Estimation was done to analyze how much power can be generated in one hectare of land from each of these species.

1. Amongst the both biomass species Gulmohar has the highest energy value compared to Cassia Tora.

2. Amongst the four different ratios, C:B 60:40 gives the highest energy value compared to 90:10, 80:20, 70:30.

3. Energy values of coal mixed Gulmohar biomass component were found to be little bit higher than that of coal mixed Cassia Tora biomass component.

4. Calculation results have established that nearly 175 and 840 hectares of land would be required for continuous generation of 49794.11kWh per hectares from Gulmohar and 8693.18 kWh per hectares from Cassia Tora biomass species.

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