New Frontier in Energy, Engineering, Environment & Science (NFEEES-2018) Feb - 2018

RESEARCH ARTICLE OPEN ACCESS

Determination of Energy Potential of Biomass & Coal Ratios by Proximate Analysis

Ritesh Mathur[1], Jitin Yadav[2]
1(Department of Mechanical Engineering, ACEIT, Jaipur)
Email: rit75math@gmail.com)
2 (Department of Mechanical Engineering, ACEIT, Jaipur)
Email: jtinrao@gmail.com)

Abstract:
Different distributed power generation models based on combustion technology can help in faster expansion of rural energy access in the most economical manner. Every MW generated from such plants would be able to cover about 6000 rural household. In this research, determination of Proximate Analysis (PA) and Gross Calorific Value (GCV) of Gulmohar and its biomass species component with coal has been done. Among the four different ratios, ratio 80:20 gives the highest energy value in all mixed component, and 85:15 also gives higher energy value except leaf component of biomass in respect to other 95:05 and 90:10 ratios. Comparison of data also shows that biomass material have considerably higher calorific values and very lower ash contents. It indicates that both calorific values and ash content of biomass species are lower as compare to coal.

Key words ---- Proximate Analysis, Gross Calorific Value, Biomass, Combustion, Fossil Fuel.

I. INTRODUCTION

The energy conservations are highest for the households belonging to the poorest region with majority of them depending on direct biomass burning for cooking and more than 50% living without access to electricity. For the rural households having good income, the numbers were approximately 50% and 15% for cooking and electricity access respectively. They cannot afford electricity or other resources due to lower and no income, and difficult to approach due to insufficient infrastructure available to them because of illiteracy rate.

This lack of energy access has major emphasis on economic development, livelihoods, social dignity, and eco-friendly. As per a recent study, biomass residue close to more than 50% is not harvested due to various reasons. In India, around 20000 MW power can be generated from plantation which is not used as a useful wood for other applications by using part of the waste land[1].

The present and possible biomass energy scenario up to 11th Plan and planned during 12th and 13th Plan period given by the Ministry is shown in Table-2, and various biomass power projects set up in different states and projects in pipeline are shown in Fig. 1 & 2[2].

Sectors	As on 2011	During 2011-12	By end of 2017*	By end of 2022*
Biomass Power (Facility addition)	1000 MW	1150 MW (150 MW)	1650 MW (500 MW)	2250 MW (600)
Sugar Industries Co-Generation (Facility addition)	1650 MW	1950 MW (300 MW)	3350 MW (1400 MW)	4050 MW (700 MW)
Required Plantation	-	1000 ha	1 lakh ha	0.6 million ha
Plantation based power (New Initiative)	-	5 MW	500 MW	3000 MW
Co-generation in other Industries (Facility addition)	300 MW	380 MW (80 MW)	780 MW (400 MW)	1180 MW (600 MW)
Total (Facility Addition)	2950	3485 (535)	5780 (2300+500 from plantation)	7480 (1900+3000 from plantation)

Table-1 Present and possible biomass power scenario

Andhra Pradesh, Chattisgarh and Maharastra have maximum conversion for projects based on rice husk. States have not made any progress with straw resources.

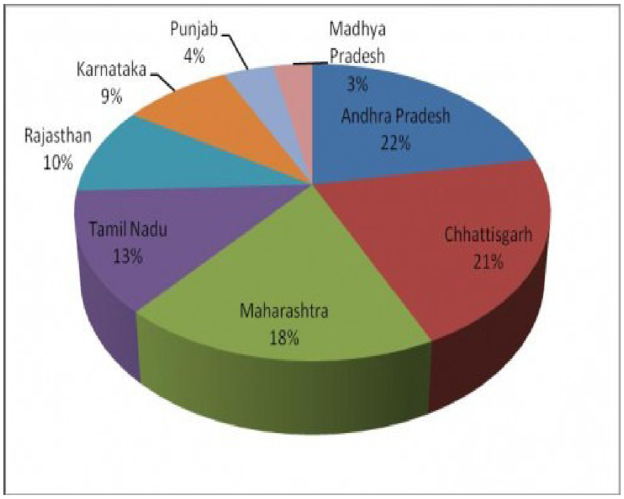

Fig.1: State Wise Installed Capacity, MW

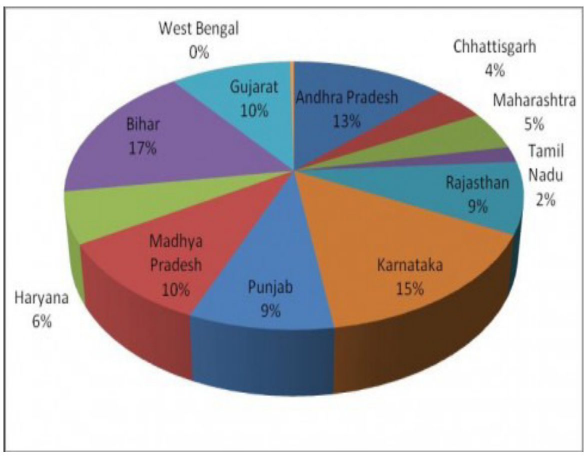

Fig.2: State Wise Pipeline, MW

In the last 10 years, India has been making tremendous progress. The total renewable grid capacity has increased by nearly up to four times. According to the latest government numbers, India has nearly touched 15% renewable energy as a percentage of total energy generation. During the first three years of the 12th plan period and the year up to 2012, renewable power capacity addition has been increased by more than 600 MW, while the conventional power capacity addition has been reached upto 30,000 MW, which is 25% of the total facility addition[3-4].

In present research work, Gulomhar has been selected as a biomass due to mass availability in the local area and the available weather condition to grow this crop in all year long. This crop is not being used in any effective wood work. Usually, all the rural area population is using this as a fuel for cooking applications only. Energy potential has been studied at the different mixing ratio of different components of the biomass.

II. EXPERIMENTAL SET UP & PROCEDURE

Gulmohar collected from the local area. This biomass was chopped and three different components like leaf, little branch and main branch (wood) were separated from each other. These materials were dried in air for 30 days in well ventilated room in indirect sun light in the month of June when there is near to no humidity in Jaipur region. When the moisture contains of these air-dried biomass sample came in equilibrium with that of the air, they were crushed to prepare powder. These were than processed for the determination their proximate analysis and energy values.

A. Proximate Analysis: The proximate analysis of biomass comprises of determination of volatile matter (VM), moisture, ash and fixed carbon content. A simple equation based on proximate analysis is presented which permits calculations of the heating values of biomass plant and its component as well as the charcoal resulting from their carbonizations [6-8].

A.1 Moisture determination: Dish made up of silica was used after drying it in oven and weighted before and after putting about 1 gm of sample on it. Now the dish is being heated for one hour at nearly constant temperature of 105±5^{o}C. Than the sample is cooled down with lid and weighted again to find the loss in weight of sample due to presence of moisture.

A.2 Volatile Matter: A volatile product obtained by the pyrolysis of sample in the absence of air is known as volatile matter. The pyrolysis, temperature of coal lie in the range 600-800^{o}C. Volatile matter does not contain the moisture of sample but it contains water that is formed by decomposition of hydrogen and oxygen.

A clean crucible with lid was heated at 900±15^{o}C for 7 minutes in furnace (muffle) and allowed it to cool for a minute. The 1gm sample than weighed on the crucible and heat it up to 900^{o}C for next 7 minutes weighed again after cooling to expulsion of volatile matter.

Volatile Matter (%) = Percentage Loss in weight - Percentage Moisture.

A.3. Ash determination: The ash contains mainly of silica, alumina, iron oxide and lime. During heating, sample does not melt sharply at any temperature, but begins to soften at much lower temperature than that required melting. The ash content in coke is much higher than in coal.

The dish without lid was heated in the furnace up to 820°C for an hour than it allowed to cool for 10 minutes on the slab and 15 minutes in the desiccators. Now the mass left which was the ash content of the coal after weighing the dish.

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

A.4 Fixed carbon: Fixed carbon is obtained by deducting the sum of moisture, ash and volatile matter percentage from 100.

B. Calorific value: Calorific values of forest waste originating from forestry works such as woodland cleaning, reforestation and, all other silviculture tasks, were measured by static Bomb Calori-Meter [9]. When hydrogen is present in the sample, it is converted to stream. Thus, gross calorific value is the total amount of heat liberated when one unit of fuel is burnt completely and the combustion products are brought to their standard state (25°C) [10]. Lower heating value or net calorific value is

= Net calorific value = Gross calorific value – latent heat of condensation

GCV = {(2500 × ΔT) / (Initial wt. of sample) ─ (heat released by cotton thread + Heat released by fused wire)}

III. RESULT AND DISCUSSION

A. Proximate Analysis of Gulmohar and Coal in Selected Ratios:

Proximate analysis gives an approximate idea about the energy values and extent of pollutants emissions during combustion. The removal of moisture increases the calorific value and decreases transportation cost. The time required for Gulmohar was estimated to be in the range of 20 to 30 days at temperature 35 - 47°C and moisture: 5-10%.

The proximate analysis of different components of gulmohar and these biomass species component briquettes with coal are presented. Results shows that gulmohar has the appropriate value for the power plants in which the ash contents being more and volatile matter is less when the ratios were 95:5 and 90:10, but in case of 85:15 and 80:20 ratios then ash content was less and volatile matters were more.

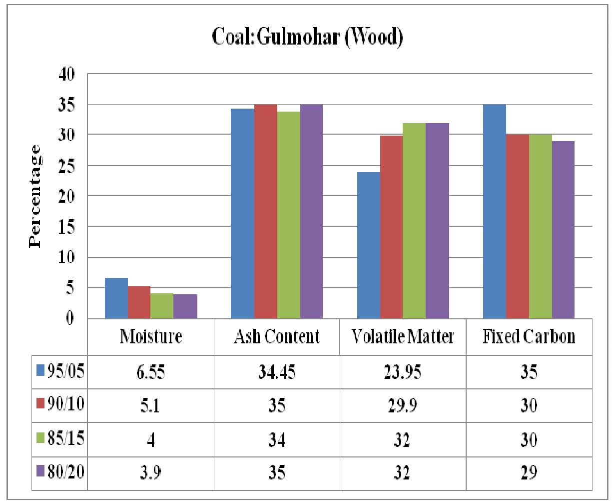

Fig.3: Variation of wood of gulmohar & coal in different ratios.

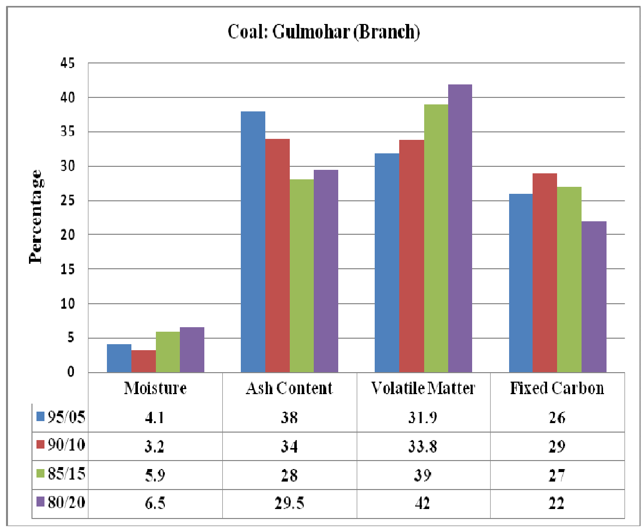

Fig.4: Variation of branch of gulmohar & Coal in different ratios

B. Calorific Values of Gulmohar's Different Components:

Calorific values of the fuels or energy source provides ideas about the energy value of the fuel and the amount of electricity generation. Calorific values data given in Table – 2 indicate that among all the studied biomass species, calorific values of wood component of biomass found to be highest as compare to leaf and little branches. Amongst the four different ratios, ratio 80:20 gives the highest energy value in all mixed component, and 85:15 also gives higher energy value except leaf component of biomass in respect to other two ratios (95:05 and 90:10).

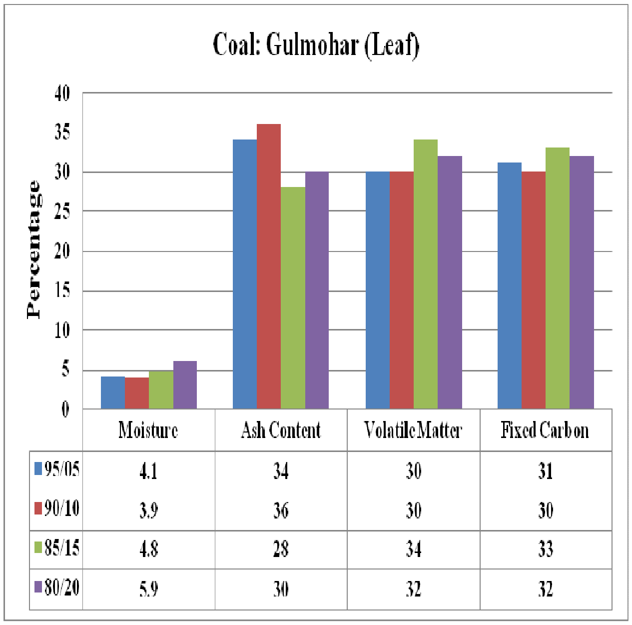

Fig.5: Variation of leaf of Gulmohar & Coal in different ratios

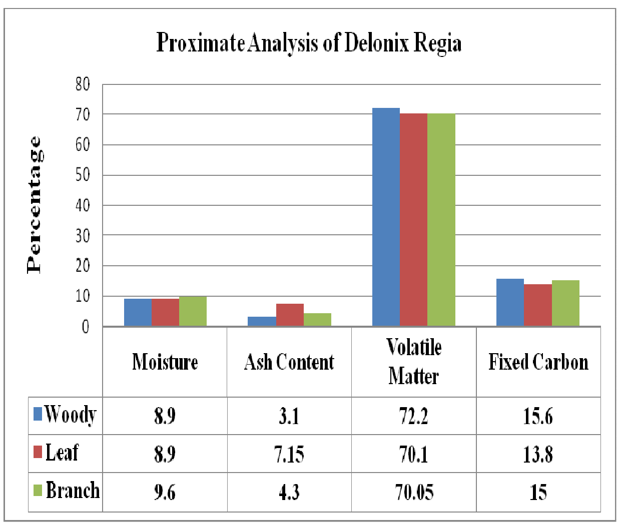

Fig 6: Variation in Proximate Analysis of Gulmohar Biomass

Components of Gulmohar	GCV Kcal/kg
Wood	4485
Leaf	3926
Branch	4023

Table-2 Gross Calorific Value of Gulmohar

Comparison of data that both calorific values and ash content of biomass species are lower as compare to coal, which is definitely a benefit over fossil fuels. It is thus concluded that gulmohar biomass will result in higher power production in the plant with slight higher emission of Suspended Particulate Matters (SPM).

IV. CONCLUSIONS & FUTURE SCOPE

Experiments were done on Gulmohar for the determination of proximate analysis, calorific values, and ash fusion temperature on each of the components of the selected species such as main wood, leaf and branch were performed. We found the following conclusions:-

- The selected biomass showed nearly similar results of proximate analysis for their components, the ash contents were more in its leaves and there was less volatile matter.
- Mixed ratio of biomass with coal also showed the same proximate analysis results. The ash contents being more in the ratio of 95:5 and volatile matter is more when ratio was 80:20.
- The non-wood biomass species showed highest energy values for their wood, followed by branches and leaves.
- Among four ratios, ratio 80:20 gives the highest energy value compared to 95:05, 90:10 and 85:15.

Similar study can be done for another biomass species available in the local area. The biomass species may be mixed with other bio sources like animal's dunk, sewage wastes, etc. in different ratios and the electricity generated potentials of the mixtures may be determined.

ACKNOWLEDGEMENT

The authors would like to thanks Departments of Mechanical Engineering of both NIMS University & Arya college of Engineering and I.T., Jaipur for their cooperation for conducting successful work in their labs. Special thanks to Mr. Shyam Sunder Sharma for guiding us for this project during our research work.

REFERENCES

1. Goldemberg J. and Teixeira Coelho S., Renewable energy—traditional biomass vs. modern biomass, Energy Policy, 32 (2004): pp. 711–714
2. Ministry of New & Renewable Energy (MNRE): http://mnre.gov.in/
3. http://www.ireda.gov.in

4. Ravindranath N.H. and Balachandra P., Sustainable bioenergy for India: technical, economic and policy analysis, Energy, 34 (2009): pp. 1003–1013
5. Mukunda H.S., Dasappa S., Paul P. J., Rajan N.K.S. and Shrinivasa U., Gasifiers and combustors for biomass technology and field studies, Energy for Sustainable Development.1 (1994): pp. 27-38.
6. Ioannis Gravalos, A study on calorific energy values of biomass residue pellets for heating purposes, Forest Engineering: Meeting the Needs of the Society and the Environment, Padova – Italy, July 11 – 14, 2010.
7. T.Coredero, Predicting heating value of lignocellulosics & Carbonaceous materials from proximate analysis, Fuel 80 (2001), pp. 1567-1571
8. Regueira L.N., Anon J. A. R., Castineiras J. P., Diz A. V. and Santovena N. M., Determination of calorific values of forest waste biomass by static bomb calorimetry, Thermochimica Acta, 371 (2001): pp. 23-31
9. Regueira L.N., Castineiras J. P. and Anon J. A., Design of an experimental procedure for energy evaluation from biomass, Thermochemica Acta, 420 (2004): pp. 29-31