STUDY OF BIOMASS GASIFICATION TO INCREASE ITS CALORIFIC VALUE

[1]Anant Kumar, ,[2]Vivek Singh
1 M.TECH Scholar, SRK University, Bhopal
2 Asst. Professor, SRK University, Bhopal
E Mail: anant.kumar710@gmail.com, viveksinghrkdf1995@gmail.com

ABSTRACT:

In view of energy and environmental problems associated with the use of fossil fuels (coal, petroleum and gas) in power generation, an increasing attention is being paid world-over by the scientists and technocrats for the utilisation of renewable energy sources in power generation, metallurgical industries etc. There are various type of renewable energy sources such as solar, wind, hydropower, biomass energy etc. out of these renewable energy sources, biomass is more economically viable for almost all the continents in the world. Biomass is a carbonaceous material and provides both the thermal energy and reduction for oxides, where as other renewable energy sources can meet our thermal need only. Amongst all the solid fuel like coal etc. biomass is the purest fuel consisting of very lesser amount of ash materials. The power generation potential data for renewable energy sources in India clearly indicates that the biomass has potential to generate more than 17000 MW of electricity per year in India. However, the country is locking in exploitation of biomass in power generation. Till date, India has been capable to generate only 2000 MW (approx.) of electricity per year in spite of declaration of several incentives by the govt. of India. Hence, there is an argent need to increase the utilization of biomass in power generation. The present project work is a positive step towards energy and environmental problems facing the world. The presently selected forestry biomass species has no any commercial use and are underutilized.

Presently, co-firing (coal + biomass) has been proved to be more attractive and economically viable technique for power generation. In the present work, briquettes were prepared by mixing non-coking coal from Orissa mines and the related biomass species in different ratio (coal: biomass = 95:05, 90:10, 85:15, 80:20). The objectives have been to examine their energy values and power generation potential.

Keywords: proximate analysis, ash fusion temperature, electricity generation, energy content, non-woody biomass species.

INTRODUCTION:

India being a developing nation, sustainable development is more important. Energy is a basic requirement for economic development. Every sector of Indian economy – agriculture, industry, transport, commercial and domestic – 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 concern in the country. This growing consumption of energy has also resulted in the country becoming increasingly dependent on fossil fuels such as coal and oil and gas. Rising prices of oil and gas and potential shortages in future lead to concerns about the security of energy supply needed to sustain our economic growth. Increased use of fossil fuels also causes environmental problems both locally and globally. Biomass has always been an important energy source for the country considering the benefits it offers. Biomass provides both, thermal energy as well as reduction for oxides. It is renewable, widely available, carbon-neutral and has the potential to provide significant employment in the rural areas. Biomass is also capable of providing 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 realised the potential and role of biomass energy in the Indian context and hence has initiated a number of programmes for promotion of efficient technologies 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 programme.

1.2 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:

- Wind Energy
- Solar Energy
- Hydropower
- Geothermal Energy
- Nuclear Energy
- Biomass and Bio-energy

1.2.1 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.

1.3 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.

The Ministry has been implementing biomass power/co-generation programme since mid-nineties. A total of 288 biomass power and cogeneration projects aggregating to 2665 MW capacity have been installed in the country for feeding power to the grid consisting of 130 biomass power projects aggregating to 999.0 MW and 158 bagasse cogeneration projects in sugar mills with surplus capacity aggregating to 1666.0 MW. In addition, around 30 biomass power projects aggregating to about 350 MW are under various stages of implementation. Around 70 Cogeneration projects are under implementation with surplus capacity aggregating to 800 MW. States which have taken leadership position in implementation of bagasse cogeneration projects are Andhra Pradesh, Tamil Nadu, Karnataka, Maharashtra and Uttar Pradesh. The leading States for biomass power projects are Andhra Pradesh, Chhattisgarh, Maharashtra, Madhya Pradesh, Gujarat and Tamil Nadu

LITERATURE REVIEW

Ravindranath et al India's energy challenges are multi–pronged . They are manifested through growing demand for modern energy carriers, a fossil fuel dominated energy system facing a severe resource crunch, the need for creating access to quality energy for the large section of deprived population, vulnerable energy security, local and global pollution regimes and the need for sustaining economic development. Renewable energy is considered as one of the most promising alternatives. Recognizing this potential, India has been implementing one of the largest renewable energy programmes in the world. Among the renewable energy technologies, bioenergy has a large diverse portfolio including efficient biomass stoves, biogas, biomass combustion and gasification and process heat and liquid fuels. India has also formulated and implemented a number of innovative policies and programmes to promote bioenergy technologies. However, according to some preliminary studies, the success rate is marginal compared to the potential available. This limited success is a clear indicator of the need for a serious reassessment of the bioenergy programme. Further, a realization of the need for adopting a sustainable energy path to address the above challenges will be the guiding force in this reassessment. In this paper an attempt is made to consider the potential of bioenergy to meet the rural energy needs: (1) biomass combustion and gasification for electricity; (2) biomethanation for cooking energy (gas) and electricity; and (3) efficient wood-burning devices for cooking. The paper focuses on analysing the effectiveness of bioenergy in creating this rural energy access and its sustainability in the long run through assessing: the demand for bioenergy and potential that could be created; technologies, status of commercialization and technology transfer and dissemination in India; economic and environmental performance and impacts; bioenergy policies, regulatory measures and barrier analysis. The whole assessment aims at presenting bioenergy as an integral part of a sustainable energy strategy for India. The results show that bioenergy technology (BET) alternatives compare favourably with the conventional ones. The cost comparisons show that the unit costs of BET alternatives are in the range of 15–187% of the conventional alternatives. The climate change benefits in terms of carbon emission reductions are to the tune of 110 T C per year provided the available potential of BETs are utilized.

Pillai et al, A majority of the Indian population does not have access to convenient energy services (LPG, electricity). Though India has made significant progress in renewable energy, the share of modern renewables in the energy mix is marginal. This paper reviews the status and potential of different renewables (except biomass) in India. The trends in the growth of renewables in India and establishes diffusion model as a basis for setting targets. The diffusion model is fitted tot the past trends for wind, small hydro and solar water heating and is used to establish future targets. The economic viability and greenhouse gas (GHG) saving potential is estimated for each option. Several renewables have high growth rates, for example wind, Photovoltaic (PV) module manufacture and solar water heaters. New technologies like Tidal, OTEC, Solar thermal power plants and geothermal power plants are at the demonstration stage and future dissemination will depend on the experience of these projects.

Ravindranath et al, Bio-energy technologies (BETs) are presented as potential carbon abatement opportunities substituting fossil fuel or traditional (less efficient) biomass energy systems. Cost of energy (produced or saved) of BETs is compared with fossil fuel and traditional biomass energy systems to estimate the incremental cost (IC). The

IC of carbon abatement for each of the selected BETs (in $\$kWh^{-1}$ or $\$GJ^{-1}$) is estimated using

the carbon emission ($tCkWh^{-1}$ or $tC\ GJ^{-1}$) reduction obtained by substituting fossil fuel and traditional biomass alternatives. The abatement costs are estimated and compared for ten combinations of BETs (with seven technology alternatives) substituting conventional technologies. The analysis indicates that out of the ten project cases six have negative ICs in the range of 37 to 688 $\$\ tC^{-1}$ and four have positive ICs in the range of 52–162

$ tC^{-1} mitigation. The negative ICs indicate that the suggested alternatives are cheaper than the original technologies. Thus, results indicate that the chosen BETs are cost-effective mitigation opportunities and are currently aggressive candidates under Clean Development Mechanism.

Kumar and Patel, In view of high energy potentials in non-woody biomass 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 *Ocimum canum* and *Tridax procumbens* biomass species (both non-woody) and their impact on power generation and land requirement for energy plantations. The net energy content in *Ocimum canum* was found to be slightly higher than that in *Tridax procumbens*. In spite of having higher ash contents, the barks from both the plant species exhibited higher calorific values. The results have shown that approximately 650 and 1,270 hectares of land are required to generate 20,000 kWh/day electricity from *Ocimum canum* and *Tridax procumbens* biomass species. 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 matters (SPM) from biomass materials.

RESULT AND ANALYSIS

PROXIMATE ANALYSIS OF PRESENTLY SELECTED NON-WOODY BIOMASS PLANT COMPONENTS AND COAL BIOMASS MIXED BRIQUETTES

Freshly chopped non-woody biomass components have a large amount of free moisture, which must be removed to decrease the transportation cost and increase the calorific value. In the plant species selected for the present study, the time required to bring their moisture contents into equilibrium with that of atmosphere was found to be in the range of 15 to 20 days during the summer season (temperature :35-45°C and moisture: 6-14%).
The studies of the proximate analysis of fuels /energy sources are important because they give an approximate idea about the energy values and extent of pollutants emissions during combustion. The proximate analysis of different components of Gulmohar and Cassia Tora plant and these biomass species component briquettes with coal are presented in Tables 4.1 –
4.5. The data for proximate analysis of the components of these species are very close to each other and hence it is very difficult to draw a concrete conclusion. However, it appears from these tables that Cassia Tora biomass species has somewhat higher ash and lower fixed carbon contents than these of Gulmohar biomass species and the ash contents being more and volatile matter is less when 95% coal mixing with 5% biomass and 90% coal mixing with
10% biomass but when 85% coal mixing with 15% biomass and 80% coal mixing with 20%

biomass then ash content is being less and volatile matter is more.

CALORIFIC VALUES OF PRESENTLY SELECTED NON-WOODY BIOMASS PLANT COMPONENTS

The calorific values of the fuels/energy source are important norms for judging its quality to be used in electricity generation in power plants. It provides an idea about the energy value of the fuel and the amount of electricity generation.

Calorific values data listed in Table 4.1 & 4.2 indicate that among all the studied biomass species, calorific values of wood component of both biomasses have higher in comparison to leaf and nascent branch. Gulmohar biomass species were found to be little bit higher than that of Cassia Tora biomass. Table 4.4

& 4.5 are shows that calorific value of coal mixed Gulmohar biomass (different component in different ratio) were found to be higher than that of coal mixed cassia tora biomass (different component in different ratio).

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 both biomass in respect to other two ratios (95:05 and 90:10).

Comparison of data listed in Table 4.1-4.3 shows that in difference to coals included in the present study, both non-woody biomass materials have considerably higher calorific values and very lower ash contents. Table 4.4 & 4.5 indicates that calorific values of biomass species are something lower but ash content are also lower in compare to coal. This is definitely an benefit over fossil fuels. It is thus clear that these non-woody biomass resources will result in higher power production in the plant with slight emission of suspended particulate matters (SPM).

ASH FUSION TEMPERATURE OF PRESENTLY STUDIED NON-WOODY BIOMASS SPECIES

It also experimentally finds out the ash fusion temperatures to confirm its safe operation in the boiler. Ash fusion temperature of solid fuel is an important parameter affecting the operating temperature of boilers. Clinker creation in the boiler usually occurs due to low ash fusion temperature and this hampers the operation of the boiler. Hence the study of the ash fusion temperature of solid fuel is essential before its operation in the boiler. The four characteristic ash fusion temperatures were identified as: (i) initial deformation temperature (IDT) – first sign of change in shape; (ii) softening temperature (ST) – rounding of the corners of the cube and shrinkage; (iii) hemispherical temperature (HT) – deformation of cube to a hemispherical shape; and (iv) fluid temperature (FT) – flow of the fused mass in a nearly flat layer. The shapes of the initially taken cubic ash samples at IDT, ST, HT and FT are shown in Fig. 3.3. Identical shapes at these temperatures were obtained for all the studied non-woody biomass species like Gulmohar, cassia tora and coal mixed these biomass. Data for the ash fusion temperatures (IDT, ST, HT and FT) for have been listed in Table 4.6.

ELECTRICITY GENERATION SYSTEM

The biomass based electricity generation method is outlined in Figure 1.6 freshly cut wood holds a large amount of moisture, which must be removed to decrease the transportation cost and to increase the energy density (i.e. calorific value). The carbonization of biomass yields charcoal as main product and generates a large amount (approximately 65-
75 % of the weight of biomass) of volatile matter (pyrolytic gas). For the biomass energy system to be competitive and to increase energy conversion efficiency, technologies available

for promoting power generation from biomass are gasification, combustion, co-combustion and bio-methanation. The pyrolytic gas should also be combusted to generate electricity. The ash obtained would be transported back to the plantation centre and used as a fertilizer, or it could be utilized as building material.

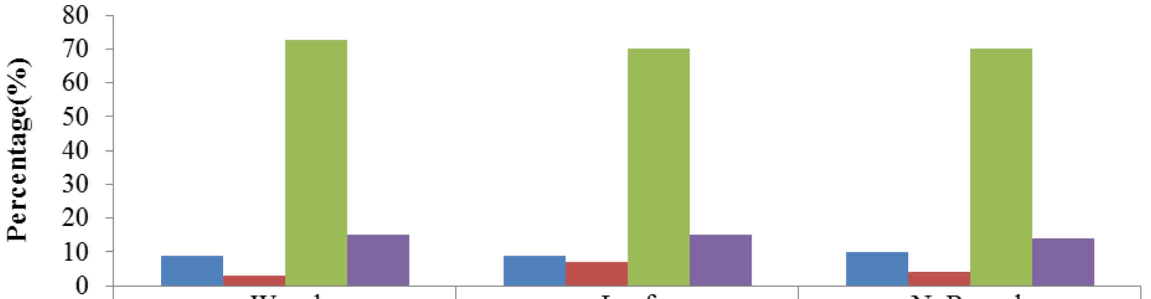
PROXIMATE ANALYSIS AND CALORIFIC VALUE OF DIFFERENT COMPONENTS OF NON-WOODY BIOMASS SPECIES AND COAL

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 and presented graphically in Figs. 4.1-4.9.

Proximate Analysis of Gulmohar (Local name: Krishnachura)

Component	Proximate Analysis (Wt. %, air-dried basis)				Gross Calorific Value (Kcal/ kg, Dried Basis)
	Moisture	Ash	Volatile Matter	Fixed Carbon	
Wood	9.00	3.00	72.68	15.00	4549
Leaf	8.90	7.20	70.11	15.00	3947
Nascent branch	9.80	4.20	70.05	14.22	4061

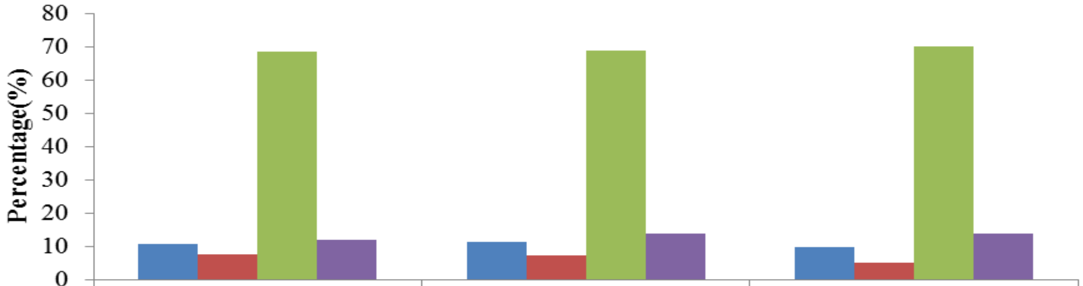


	Wood	Leaf	N. Branch
Moist	9	8.9	9.8
Ash	3	7.2	4.2
V.M	72.68	70.11	70.05
F.C	15	15	14

Fig. 4.1: Variation of Proximate Analysis of Gulmohar Biomass

Table 4.2: Proximate Analysis of Cassia Tora (local name: Chakunda)

Component	Proximate Analysis (Wt. %, air-dried basis)				Calorific Value (Kcal/ kg, Dried Basis)
	Moisture	Ash	Volatile Matter	Fixed Carbon	
Wood	11.00	7.80	68.50	12.00	4344
Leaf	11.50	7.40	69.00	14.00	4113
Nascent branch	10.00	5.20	70.00	14.00	3697



	Wood	Leaf	N. Branch
Moist	11	11.5	10
Ash	7.8	7.4	5.2
V.M	68.5	69	70
F.C	12	14	14

Fig.4.2: Variation of Proximate Analysis of Cassia Tora Biomass

CONCLUSIONS

1. Amongst the both biomass species Gulmohar has the highest energy value compared to Cassia tora.
2. Amongst the four different ratio, ratio 80:20 gives the highest energy value compared to 95:05, 90:10, 85:15.
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 177 and 872 hectares of land would be required for continuous generation of 41242.38 kWh per hectares from Gulmohar and 8371.05 kWh per hectares from Cassia tora biomass species.
5. The ash fusion temperature of all the species are coming above the range of boiler operation, this would avoid clinker formation in the boiler.
6. the results recommended exploitation of non woody biomass species for power generation.

REFERENCE

[1]. Angelis-Dimakis A., Biberacher M. and Dominguez J., Methods and tools to evaluate the availability of renewable energy sources, Renewable and Sustainable Energy Reviews, 15 (2011): pp. 1182-1200

[2] Boudri J.C., Hordijk L., Kroeze C. and Amann M., The potential contribution of renewable energy in air pollution abatement in China and India, Energy Policy, 30 (2002): pp. 409–424

[3]. Demirbas A., Potential applications of renewable energy sources, biomass combustion problems in boiler power systems and combustion related environmental issues, Progress in Energy and Combustion Science, 31 (2005): pp. 171–192

[4]. Goldemberg J. and Teixeira Coelho S., Renewable energy—traditional biomass vs. modern biomass, Energy Policy, 32 (2004): pp. 711–714

[5]. International Energy Agency (IEA): www.iea.org/Textbase/techno/essentials.html

[6] . http://www.ireda.gov.in

[7]. Kumar M. and Patel S.K., Energy Values and Estimation of Power Generation Potentials of Some Non-woody Biomass Species, Energy Sources, Part A: Recovery, Utilization and Environmental Effects, 30:8, (2008): pp. 765 – 773

[8]. Kumar A., Kumar K. and Kaushik N., Renewable energy in India: Current status and future potentials- Renewable and Sustainable Energy Reviews, 14 (2010): pp. 2434–