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Biomass an Alternate of Coal

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ABSTRACT *Gasification is the thermochemical conversion of biomass into heat or electricity. Biomass gasification means incomplete combustion of biomass resulting in production of combustible gases consisting of Carbon monoxide (CO), Hydrogen (H2) and traces of Methane (CH4). This mixture is called producer gas. Producer gas can be used as a fuel for IC engine for electricity generation. Composition of producer gas depends on properties of feedstock biomass material .Therefore it is necessary to analyse the properties of biomass used for gasification. Three biomass material namely Soybean, pigeon pea, Lantana camera and wood were taken for gasification and Their proximate, heating value and ultimate composition were compared with bituminous coal. Ash contents of the three samples ranged from 3% to 6.5%. Higher heating values ranged from 17.1 MJ/kg -19.24 MJ/kg. Nitrogen was present in all fuel sample at levels ranging from 0.95 to 1.05%. Sulfur concentrations were an order of magnitude lower, varying from 0.03to 0.2%, consistent with the low sulphur quality of biomass fuels as compare to fossil fuel.*

1. Introduction
In India the availability of biomass is about 500 million tons per year including residues from agriculture, agricultural industries, and forest products. A survey by the Ministry of New and Renewable Energy indicated that 15-20 percent of total crop residues could be used for power generation, without altering their present uses. Biomass materials used for power generation include bagasse, rice husk, straw, cotton stalks, coconut shells, soy husk, oilseed cakes, coffee waste, jute wastes, peanut shells, and sawdust (MNRE).

Biomass material can be converted into energy using a number of different conversion routes [6]. Gasification as well as anaerobic digestion processes seems to be most attractive in Indian scenario. Wood and agricultural residues are major choices as feedstock for energy production and they can either be used directly as fuel or thermochemically converted. Most of these biomass materials are, however, not suitable for direct utilization, because they are bulky, heterogeneous in size and shape and might differ in density. These differences not only make it difficult to handle, transport and store the biomass, but also to combust it, as most gasifiers cannot handle heterogeneous particle sizes. There are numerous ways to resolve these problems, of which briquetting and/or pelleting are the most commonly utilized technologies [4]. This pre-processing of biomass into briquettes improves the handling characteristics, as well as the bulk density and ultimately the volumetric calorific value [10]. Densification of loose, small and high moisture content biomass increases the calorific value of the fuel [7]. The bulk density of loose biomass, which is typically about 40 - 200 kg/m^3 can be increased to densities as high as 600 – 800 kg/m^3.

Chemical composition, moisture content and final briquette density are the most important parameters affecting the combustion efficiency of any type of biomass. Moisture affects the combustion efficiency negatively and the moisture content should typically be as low as possible. On the other hand a certain amount of moisture is necessary to press briquettes and make sure that the biomass particles adhere to each other via hydrogen bonds [2]. If the briquettes are pressed too dry, they will disintegrate which leads to biomass loss and makes it difficult to handle the briquettes. Agricultural residues typically have high moisture content and calorific values different from wood [9]. The moisture content of chipped wood that has been air dried for several weeks varies between 10 and 20%, whereas agricultural biomass contains between 50% and 85% moisture [3] depending on the type of feedstock. A moisture content of about 12% is acceptable in biomass fuels used for combustion, which means that most biomass has to be dried before it can be processed. Typical energy contents range from 0.5 to 17 MJ/kg at 10-15% moisture content, depending on the type biomass feedstock [5]. An additional consideration with regards to the biomass fuel choice is the ash content. This is the inorganic matter that cannot be combusted and will remain in the form of ash and has to be discarded after combustion. Wood fuels typically have low ash contents around 0.5%, whereas many other agricultural residues can have ash contents as high as 20% or even more. The amount of inorganic matter in biomass also affects its ultimate calorific value [8]

2. Material and methods
For determination of suitability of biomass for gasification, four biomass namely soybean, lantana and wood were taken for its physical and chemical analysis and compared with coal.

2.1 Physical properties of crop residues
Physical properties are very important to determine the fuel quality. Study of proximate analysis of biomass was

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carried out for of determination of moisture content, volatile matter, fixed carbon, ash content.

2.1.1 Moisture content

In most fuels there is very little choice in moisture content since it is determined by the type of fuel, its origin and treatment. It is desirable to use fuel with low moisture content because heat loss due to its evaporation before gasification is considerable and the heat budget of the gasification reaction is impaired.

The moisture content of a solid is defined as the quantity of water per unit mass of the wet solid. The moisture content plays an imp role in the formation of briquette and subsequently its combustion. Moisture content of biomass at the time of harvesting varies drastically. The moisture of biomass was measured by Oven dry method initially the sample with the known weight was kept in oven at 105°C for 24 hours. The oven dry sample is than weighed. The moisture content of sample was calculated according to following formula.

$$M.C = \frac{W_1 - W_2}{W_1} \times 100$$

Where

W_1 = Weight of sample before drying,

W_2 = Weight of sample after drying, gm

2.1.2. Volatile matter

The same sample from previous determination of moisture is used to determine the percentage of volatile matter. The sample in the covered crucible is than heated in the muffle furnace of temperature of 950 $\pm$ 20°C for 7 minutes. Crucible was first taken out and first brought down its temperature to room temp. rapidly (to avoid oxidation of its contents) by placing in a cold iron plate and then transferred warm crucible to desiccators to bring it to room temperature. Take the final weight of crucible and contents. Percentage of volatile matter of the sample is determined by following formula.

$$\textbf{Volatile matter, \%} = \frac{(b-c)}{a} \times 100$$

Where a=initial weight of sample,gm

b=final weight of sample after cooling (heating temp 107±3 ^{0}C for one hour)

c= final weight of sample after cooling (heating temp 950±2 ^{0} C for seven minute)

2.1.3. Ash content

Ash is the non-combustible residue left after complete combustion. Ash content and its properties have an impact on the combustion systems. The amount and nature of ash and its behavior at high temperatures affect the design and type of ash-handling system installed in biomass-burning equipment.

The same sample from previous determination of volatile matter content is used to determine the percentage of ash content. The sample from in the crucible was then heated without lid in a muffle furnace at 625 ±50 °c for an hour. The crucible was then taken out, cooled first in air, then in desiccators with and weighed. Heating, cooling and weighing is repeated till a constant weight is obtained. The residues were reported as on percentage basis. Percentage of ash can be determined by using the following formula

$$\% \text{ of Ash} = \frac{\text{Weight of ash left}}{\text{Weight of sample taken}} \text{ X } 100$$

2.1.4. Fixed Carbon

The residue remaining after volatile matter release has been expelled, contains the minerals substance originally present as non volatile or fixed carbon. The fixed carbon was thus calculated as follows.

Fixed Carbon (%)=100 – (%Moisture+%Ash+%Volatile Matters)

2.1.5. Calorific Value

Calorific value is the amount of heat energy evolved by burning unit mass of fuel. This is most imp parameter of biomass in the point of view of energy conversion. According to the ASDM D 3286 standers, the bomb calorimeter was used for determination of the calorific value of the biomass The biomass in the form of briquette was placed in a closed bomb and bomb was filled with oxygen at the pressure 25 atm and placed in the bucket full of water. The bomb get ignite with the help of nickel wire by supplying electricity. The initial temp of water was noted and then the change in temp was recorded for continuous 20 min with an interval of 1 min.The max temp rise was used for calculating the heat of combustion of sample mathematically. It is represented as

H=W*t/m

Where W = water equivalent of calorimeter, cal/°c.

T= rise in temp , °c

H=calorific value of fuel (heat of combustion of material) Cal/gm.

M = mass of sample burnt in gm

2.2 Chemical analysis of biomass

Ultimate analysis of biomass(CHNS) were done by CHNS analyser.

3. Result

The main material properties of interest of biomass as an energy source are also taken into investigation. Tables 1 and 2 list characteristics of the reference fuels. Table 1 lists the moisture content, ash content, proportions of volatile matters and fixed carbon. Table 2 lists the elemental analysis of N, C, S, H and O together with calorific value. The reference biomass fuels are presented with their average characteristics compositions. Moisture content is of considerable importance with regard to selection of energy conversion process technology.

Biomass fuels with low moisture content are more suited for thermal conversion technology while biomass fuels with high moisture content are more suited for biochemical process. On this basis, from Table 1, it can be seen that biomass fuels under this investigation are most favorable biomass feedstock for thermal conversion technologies with

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their moisture content in the range 6–9%.

Table-1 Characteristics of the reference fuels—proximate analysis

References fuel	Moisture (wt%)	Volatile matter (%)	Fixed carbon (%)	Ash (% db)
Soybean	8-9	67-69	14-15	6.0-6.5
Pigeon pea	8-10	68-70	12-14	5.0-5.5
Lantana Camara	7-8	72-74	16-17	3.0-4.0
Wood	6-7	76-78	17-18	1.5-2.5
Bituminous coal	2-3	28.33	49.08	18-22

Table-2 Characteristics of the reference fuels—ultimate analysis

References fuel	C	H	N	S	O	calorific value(MJ/kg)
Soybean	43.2	6.9	0.95	0.2	44.76	17.1
Lantana Camara	45.9	6.4	1.05	0.14	44.65	18.53
Wood	48.2	6.2	0.1	0.03	43.5	19.24
Bituminous coal	63.4	3.9	1.13	0.97	12.48	34.0

The ash content of biomass affects both the handling and processing costs of the overall biomass energy conversion cost. The chemical compositions of the ash are closely related to operational problems such as slagging, fouling, sintering and corrosion. From Table 1, it can be seen that ash content ranged from 1.5%–6.5% depending on biomass type. Forestry species have much lower ash content comparing with agricultural species. Volatile matter is in the range of 67–78%, forestry biomass has a somewhat higher volatile matter than agricultural biomass. While the ash content and volatile matter in bituminous coal is 18-22% and 28.33%, respectively. So, Biomass fuels have the advantages of low ash content and high volatile matter that make them the ideal feedstock for gasification.

4. Conclusions

i. Biomass fuels have significantly different elemental characteristics compared with those of coal. It is clear that biomass fuels can reduce the environmental impact of burning fossil fuels to produce energy determined by their intrinsic properties.

ii. Biomass fuels are composed of very heterogeneous constituents. Biomass fuel contain less amount of nitrogen and sulphur .

iii. Agricultural biomass contain less amount of ash compare to coal .Therefore no problem of ash handling in biomass gasification compare with thermal power plant.

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